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Fig.1.

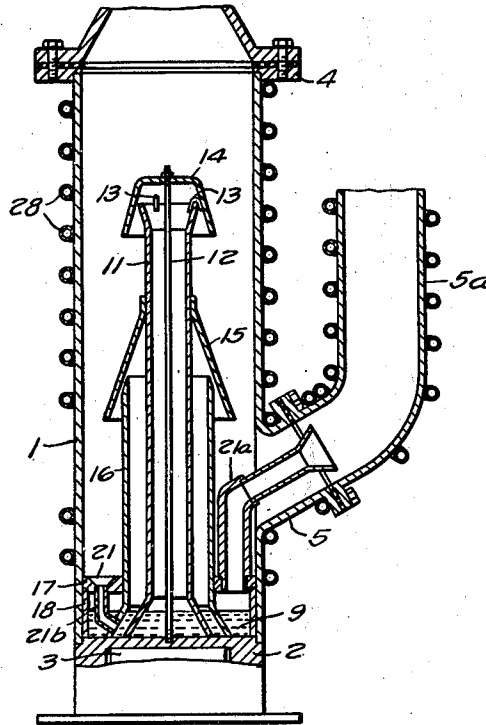
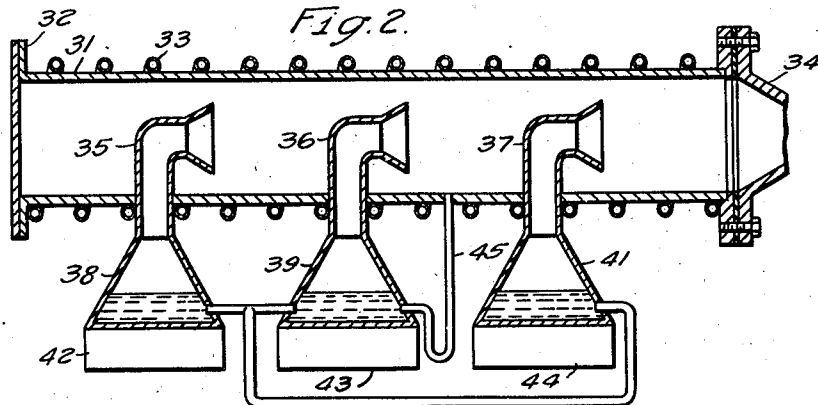


Fig. 2.



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2 Claims. (Cl. 230—101)

My invention relates to vacuum pumps for producing the high vacua which are needed for certain types of electronic discharge apparatus, and in particular relates to vacuum pumps of the diffusion type. While the principles are of broader application, I illustrate the invention by an embodiment in which the working fluid producing the diffused vapor comprises an oil or other hydrocarbon.

A diffusion pump of this general type is shown in my U. S. Patent No. 2,361,245, dated October 24, 1944, which issued on my copending application, Serial No. 480,723, filed March 27, 1943, for Vacuum pumps, and assigned to the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania. The oil diffusion pump shown in that application comprises a plurality of stages in which oil vapors issue from a plurality of nozzles positioned at different heights along the axis of a vertical water-cooled container, the jets of oil vapor issuing from the nozzle exerting a pumping action on gases present in the container by entraining and imparting a translatory velocity to them which carries them to a backing-up pump issuing to the atmosphere. The oil vapors from each jet are, however, condensed on the cool walls of the container, and are then run back through a suitable drain to a boiler which re-evaporates the oil.

In accordance with the prior art practice, as illustrated in my above-mentioned application, the boiler is subdivided into a number of sections equal to the number of stages of the pump; the condensed oil is drained into the boiler section connected to the highest pressure stage of the pump, is then passed to the intermediate stage or stages and ends up in the section of the boiler which supplies vapor to the lowest pressure stage of the pump. I have found, however, that higher pumping effectiveness is attained if the condensed oil is drained back into an intermediate stage; specifically in the case of a three-stage pump, the condensed oil should be drained back into the single intermediate stage.

It is, accordingly, an object of my invention to provide a vacuum pump of the diffusion type, employing a fluid having a number of components of different vapor pressures, which shall have higher pumping efficiency than did similar diffusion pumps of the prior art.

It is another object of my invention to produce a structure for diffusion pumps employing a fluid made up of a number of components of different vapor pressures which shall be capable of pro-

ducing a higher vacuum than was possible with diffusion pumps of the prior art.

It is a still further object of my invention to produce a structure for oil diffusion pumps which shall enable them to pump against a higher backing-up pressure than pumps of the prior art.

Other objects of my invention will become apparent upon reading the following description, taken in connection with the drawing, in which:

Figure 1 shows an embodiment of my invention in which the various stages of the pump are positioned one above the other; and

Fig. 2 shows an embodiment of my invention in which the various stages of the pump are positioned substantially in the same horizontal plane.

Referring in detail to Figure 1, the main body of my pump comprises a vertical cylindrical casing 1 closed at its lower end by a base 2 having an electrical heating element 3 of a type too well-known to need a detailed description in good thermal contact with the floor of the cylinder 1. If desired, the elements 1 and 2 may be made of iron or steel, although either may alternatively comprise aluminum. The upper end of the container 1 is provided with a flange 4 to which can be bolted by a vacuum tight connection an intake for gases from the piping system which is to be evacuated. Roughly one fifth of the height of the flange 4 above the base 2, an offtake pipe 5 leading to a backing-pump (not shown), is connected vacuum tight through a flanged connection 5a to the cylinder 1.

The bottom portion of the cylinder 1 contains the working fluid 9 for the pump, the latter being heated by the electrical heater already described to a sufficient temperature to cause a copious off-flow of vapor.

Centrally positioned in the cylinder 1 is a cylindrical vertical pipe 11 which may, if desired, be of the same material as the cylinder 1, and which is preferably flared outward at its lower end to rest on the base 2. The cylinder 11 is likewise provided with an outwardly flared portion at its upper end as will be described in more detail below. A tie rod 12 may be positioned in the central axis of the cylinder 11, its lower end screwing into the base 2.

Upon the upper end of the cylinder 11 I support, preferably by means of three small spacing pieces 13 overlapping its edges, a cap 14 roughly in the form of a truncated cone. The precise form of the cap will be discussed in detail below. The cap 14 is held firmly against the spacers 13 by a nut threaded on the end of the tie rod 12.

It will be evident that the upper portion of the cylinder 11 together with the cap 14 constitutes what may be termed an annular nozzle or orifice from which vapor emitted by a central part of the liquid 9 and flowing through the cylinder 11 is discharged into the annular space between the walls of the cylinder 11 and the cylindrical container 1. The diameter of the inner cylinder 11 is made roughly of the order of one-fourth of that of the cylinder 1 in order to provide a suitably large volume for the annular space into which the vapor issues from the above-mentioned annular orifice. While it might be possible to make the cylinder 11 of a diameter smaller than that just mentioned, such reduction in diameter would not greatly add to the available annular space surrounding the cylinder 11 but would materially reduce the pressure of the vapor at the inlet side of the above-mentioned annular orifice. Beyond these general limitations the diameter of the cylinder 11 is not a critical dimension but failure to realize the importance of even these general limitations has resulted in inefficiency in many pumps of the prior art, of which I am acquainted.

A hood or umbrella 15 of conical form is fastened to the cylinder 11 at a distance below the lower end of the cap 14 which is roughly equal to the mean free path of the molecules of the vapor issuing from the upper end of cylinder 11.

Surrounding the cylinder 11 is a second and shorter cylinder 16 which may be of the same material as cylinder 11 and the lower end of which rests on the base 2. The diameter of the cylinder 16 should be in the neighborhood of two-thirds that of the cylinder 1, the principal limitation on this dimension being that, if too small, it will reduce the vapor pressure at the orifice issuing from its upper end, and that if too large it will leave too little space for gases to flow from the space above the umbrella 15 to the offtake conduit 5.

The upper end of the cylinder 16 is bevelled and spaced slightly away from the umbrella 15 to provide an annular orifice from which vapors rising from the surface of the liquid 9 into the space between the cylinders 11 and 16 can be ejected into the annular space intervening between the cylinders 16 and 1.

Approximately one-tenth of the length of the cylinder 1 above the base 2 is provided a horizontal partition 17 which may conveniently be screwed into threads cut on the interior wall of the cylinder 1 and which covers the space between the cylinder 16 and the outer wall of the cylinder 1. This partition 17 is provided with a groove in its lower face which fits the upper end portion of a liner 18 for the interior wall of the lower portion of cylinder 1.

The partition 17 is likewise provided with a bevelled hole 21 issuing into a small duct 21b which connects with a hole in the cylinder 16 below the surface of the oil therein. By this arrangement, the condensed oil is returned to the portion of the boiler immediately below, and which issues vapor into, the interior of the cylinder 16. This vapor issuing through the orifice at the upper end of the cylinder 16 constitutes the intermediate stage of the pump.

A bent cylinder or nozzle 21a is removably inserted in the disc 17 and extends to eject vapor into off-take 5a.

The exterior wall of the casing 1 and 5 is surrounded by a helical pipe 28 through which water or other cooling fluid flows to maintain the temperature of such walls at a sufficiently low tem-

perature to condense the vapor flowing from the orifices and nozzles already described.

The general mode of operation of the above-described pump structure is as follows: The fluid 9 which may be any suitable material described in the art as useable in diffusion pumps, but for which I preferably employ a hydrocarbon of the ring-compound type such as molecular lubricant is heated and the resulting vapor flows up from its surface through the respective cylinders 11, 16 and 21a.

It will be evident from the foregoing that the vapor jets flowing respectively from the upper end of cylinders 11, 16 and 21a constitute various stages of a pump for evacuating any containers connected to the flange 4; that the stream flowing from cylinder 11 constitutes the first, or lowest pressure, or highest vacuum stage of this pumping system; that the vapor flowing from the upper end of cylinder 16 constitutes an intermediate stage; and that the vapor flowing from the upper end of cylinder 21a constitutes the highest pressure or lowest vacuum stage.

In actual practice, it is found impossible to obtain pumping fluids which are literally and absolutely devoid of impurities; and in particular, while the hydrocarbon fluids such as I have proposed using have nearly uniform constitution, they are nevertheless found to have components of slightly different vapor pressures at any given temperature. The result of this is that the components having higher vapor pressures tend to boil away first and leave the components of lower vapor pressure behind. The ultimate vacuum obtainable about the outlet of the orifices in any stage of the pump is no greater than the vapor pressure of the material issuing from the orifice, and hence it is obviously desirable that the higher vapor pressure materials shall issue from the orifice at the top of the cylinder 16 rather than from the higher vacuum stage constituted by the orifice at the top of cylinder 11. With this in mind, I have arranged the cylinder 16 to have an opening in its lower wall beneath the level of the liquid 9 at one side of the pump, and the cylinder 11 to have a similar opening at a different point. The duct 21b and the two openings just mentioned may, for instance, be positioned 120 degrees apart about axial rod 12. In this way any liquid flowing down the walls of cylinder 1 to duct 21b must first flow into the space within cylinder 16 and be heated there before it can flow through the respective openings into the interior of cylinder 11 and into the annular space communicating with nozzle 21a.

The umbrella 15 is made to extend a considerable distance below the upper end of the cylinder 16 and in designing a pump for use of the hydrocarbon molecular lubricant, I have found it desirable to flare the umbrella 15 at an angle of approximately 15° to the vertical. I have found a width of about one-sixteenth of an inch for the throat of this orifice to give good results. However, the form and dimensions of the orifice constituted by the cylinder 16 and umbrella 15 are not so critical a matter as is the shaping of the members constituting the orifice at the upper end of cylinder 11.

In the case of the last-mentioned orifice, I have effected a great improvement over prior art devices by flaring the upper end of the cylinder 11 outwardly and also flaring the lower end of the cap 14, each at an angle of approximately 12½° to the vertical. I have found that with the

particular hydrocarbon present mentioned above, an annular spacing of about one-sixteenth of an inch between the end of cylinder 11 and cap 14 gives good results, and that the distance from the throat of this one-sixteenth space to the lower edge of the cap 14 may suitably be made about one inch. In this way, it will be noted that the central line of the vapor jet is substantially parallel to the axis of tube 1.

Another feature of importance, probably also effecting a decrease of turbulence in the vapor stream is that of making the distance between the lower edge of the cap 14 and the umbrella 15 of the order of the mean free path of the vapor molecules flowing from the lowest pressure orifice. The mean free path of molecules of the vapor for the pressure corresponding to its vapor pressure at the temperature of the wall of cylinder 1 can readily be calculated from known data of physical chemistry. In the case of the four-inch pump above mentioned, I have found this mean free path to be of the order of five or six inches.

Referring now to the modification of my invention shown in Fig. 2, a cylinder 31 which may be of steel has a connection 32 at one end, suitable for attachment of an enclosure to be evacuated. The cylinder is preferably surrounded by a pipe 33 for cooling water similar to the pipe 28 in Fig. 1; and at its opposite end is provided with a connection for a duct 34 leading to a backing-up pump analogous to that attached to the offtake pipe 5a in Fig. 1.

Projecting through one side of the cylinder 31 are a series of ducts 35, 36, 37, each of which is bent over and provided with an expanded portion to form a nozzle having an axis substantially coincidental with the axis of the cylindrical casing 31. The lower ends of the pipe 35, 36, 37 connect to a series of chambers 38, 39, 41, adapted to contain oil or other working fluid for the diffusion pump, and respectively provided on their lower surfaces with heaters 42, 43, 44 which are analogous to the heater 2 in Fig. 1. The ducts 35, 36, 37 will be seen to provide a series of nozzles which will act by projecting vapor of the working fluid, as three stages of a diffusion pump analogous to the vertically disposed stages of the pump in Fig. 1. The fluid vapor issuing from the three nozzles are condensed upon striking the cooled wall of the cylinder; and will thereafter run by gravity to a duct 45 projecting from the lower wall of the cylinder 31 and connected to the chamber 39 which supplies vapor to the intermediate nozzle 36. The chamber 39 has an opening beneath the surface of the oil therein which has branches running respectively to the chambers 38 and 41 by pipe lines which are maintained everywhere below the level of the oil surface in the chamber 39. In order to facilitate the draining of the condensed oil from the walls of the cylinder 31 through the duct 45, the walls of the cylinder may be deformed slightly so that

the outlet to the duct 45 is at the lowest point in the wall of chamber 31.

It will be evident that in the modification shown in Fig. 2, the condensed oil is first returned to the boiler section which supplies vapor to the intermediate stage of the pump, and then flows out therefrom to the boiler sections supplying the high-pressure and low-pressure stages of the pump.

While I do not wish to be bound by any theory as to mode of operation, it is my present belief that the embodiments of my invention shown in Figs. 1 and 2 have the following advantages over prior art diffusion pumping systems:

1. Since the oil is returned to a jet of intermediate pressure, the fractionation is done with the aid of the pumping action of the previous stage. This leads to better fractionation.

2. The pumping of the oil vapor by the first stage gives less condensation of the high vapor pressure fractions of the oil since it is being pumped by a jet having low vapor pressure fractions of the oil.

3. While the intermediate jet will operate at slightly reduced efficiency the following jet or the one pumping against the forevac operates at increased efficiency due to the higher quality oil vapor supplied to it and so the overall efficiency of the pump will not be decreased.

4. The lower vapor pressure constituents supplied to the last jet will actually increase its efficiency to the point where it will pump against a higher backing pressure than conventional pumps.

While in accordance with the patent statutes, I have described a particular embodiment of the principles of my invention, those principles are capable of realization in various alternative arrangements which will be evident to those skilled in the art.

I claim as my invention:

1. A diffusion pump of the type having at least three stages comprising, a boiler subdivided into a number of sections equal to the number of said stages, means defining an orifice for projecting vapor from the boiler section of each stage, a common collection-space for condensed vapor from said stages, and a drain from said space directly to the boiler section which supplies vapor to an intermediate stage.

2. A diffusion pump of the type having at least three stages comprising, a boiler subdivided into a number of sections equal to the number of said stages, means defining an orifice for projecting vapor from the boiler section of each stage, a common collection-space for condensed vapor from said stages, a drain from said space directly to the boiler section which supplies vapor to an intermediate stage, and connections leading from the last-mentioned boiler section respectively to the other stages of said pump.

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