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F. W. STALLMANN

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PUMP

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Fig. 1.

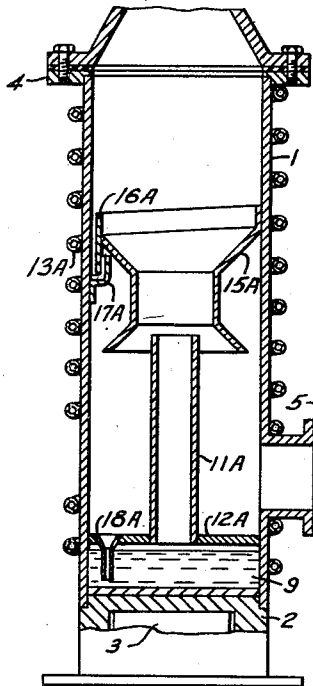


Fig. 2.

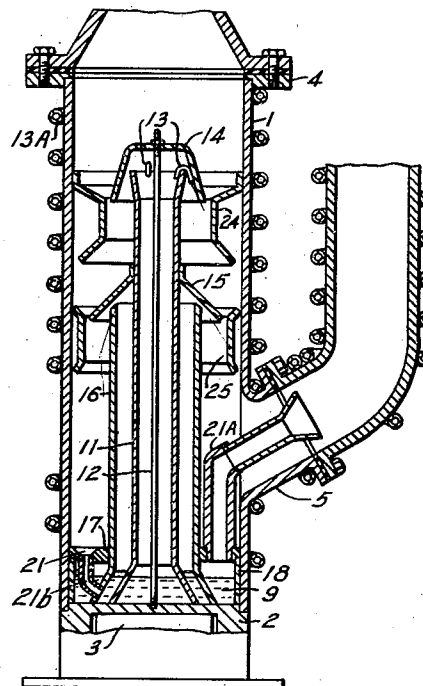
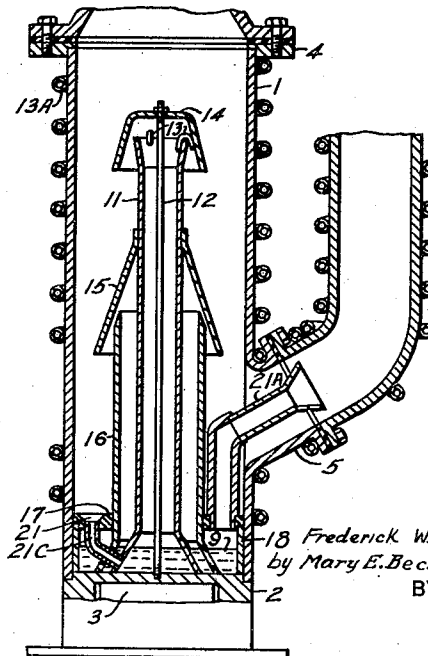


Fig. 3.



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PUMP

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Application August 18, 1945, Serial No. 611,415

3 Claims. (Cl. 230-101)

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This 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, the invention is illustrated 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 Patent No. 2,361,245, granted October 24, 1944, for Vacuum pumps, and assigned to the Westinghouse Electric Corporation, 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 transitory 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 reevaporates the oil.

In accordance with the prior art practice, as illustrated in the 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. It has been found, however, that in certain instances higher pumping effectiveness is attained if the condensed oil is drained back into the lowest pressure stage.

It is also prior practice to surround the nozzles of such diffusion pumps with walls cooled artificially with water or the like. It has been discovered that better results are obtained if the walls immediately adjacent the nozzles are at least partially heat-insulated, thereby preventing too rapid condensation of the working vapor too close to the orifice of the nozzle.

It is, accordingly, an object of the 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 the invention to produce

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a structure for diffusion pumps employing a fluid made up of a number of components of different vapor pressures which shall be capable of producing a higher vacuum than was possible with diffusion pumps of the prior art.

It is a still further object of the 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.

It is a further object of the invention to control the vapor condensation in the region of the nozzle outlet.

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

Figure 1 shows an elevation view partly in section of an embodiment of the invention in which a single stage pump has an upwardly directed nozzle which is surrounded by a heat-insulated wall.

Fig. 2 shows a similar view of an embodiment of the invention in which a multi-stage pump with downwardly-directed nozzles is surrounded by a similar wall; and

Fig. 3 shows a similar view of an embodiment of the invention in which condensed vapor in a multistage pump is returned to the lowest pressure stage.

Referring in detail to Fig. 1, the main body of the 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 a vacuum tight connection to a backing-up pressure (not shown). At roughly one fifth the height of the flange 4 above the base 2, pipe 5 leading to an intake for gases from the piping system which is to be evacuated is connected vacuum tight 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 3 to a sufficient temperature to cause a copious off-flow of vapor.

Spaced above the surface of the liquid 9 is a horizontal partition 12A which may be screw-threaded into the interior wall of the container 1, and centrally positioned extending upward from the partition 12A is a cylinder 11A through which the vapor of the fluid 9 may be emitted upon heating the latter.

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The wall of the cylinder 1 is cooled by some suitable means, such as the helical pipe 13A, maintained in good heat exchanging relation therewith, and carrying a cooling fluid.

Affixed to the inside wall of the container 1 and supported above the outlet of the cylinder 11A is a cylinder 15A outwardly flared at both its upper and its lower end. The flared lower end is separated from the cylindrical wall 1 by an annular gap, and the cylinder 15A is so positioned that the cylinder 11A extends into the flared lower end to a distance not quite as high as its junction with the cylindrical wall of 15A. The flared upper end of member 15A makes contact with the wall of the cylinder 1 throughout the circumference of the latter except for a small gap at one point where a vertical lip 16A extends downward below the flared upper wall. The upper edge of the member 15A which lies adjacent to the wall portion is bevelled so as to form what may be termed an annular trough; and is likewise cut at a slight angle so that the highest portion of this trough lies diametrically opposite to the center of the lip 16A and the lowest portion of the trough conducts any liquid which may find its way into said trough to the opening between the lip 16A and the wall 1.

Spaced slightly away from the lower end and side wall of the lip 16A is a member 17A which is attached to the wall 1A, and forms therewith a small trough in which liquid conducted downward by the lip 16A may accumulate.

In the partition 12A, preferably directly beneath the lip 16A is positioned a funnel-shaped duct 18A positioned to conduct any liquid accumulating above the partition 12A downward into the fluid 9.

The member 15A preferably has its outwardly flared upper portion composed of some material such as the alloy comprising substantially 32% nickel, 18% cobalt and the remainder iron which is described and claimed in Scott Patent 1,942,261. Whether made of this alloy or not, the flared upper portion of the member 15A is made as poor a conductor of heat as is feasible, and this objective may be assisted by making this flared portion as thin as is consistent with mechanical strength.

The arrangement of Fig. 1 is as follows: The fluid 9 is vaporized by heat from the heater 3 and flowing out of the upper end of the cylinder 11A passes through the member 15A; comes in contact with the cooled wall of cylinder 1 above the top of member 15A and condenses there. By reason of the poor heat conductivity between the central and lower portions of the member 15A and the portion of that member which is attached to the wall of cylinder 1, the said central and lower portions soon become heated to such a temperature that the vapor issuing from cylinder 11A will not condense upon them.

The condensed liquid forming on the upper portion of the cylinder 1 flows down the wall thereof into the annular trough at the upper edge of member 15A; is conducted thereby through the lip 16A into the trough at 17A. Here it soon accumulates in sufficient quantity to submerge the lower end of lip 16A and thereby seal the upper portion inside cylinder 1 above the member 15A from the region in that cylinder below the member 15A and above the partition 12A. When sufficient fluid accumulates in the trough portion 17A, it overflows the upper edge thereof, falls down to the partition 12A and thence

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through the funnel 18A is returned to the fluid 9.

Turning now to Fig. 2, it shows a two-stage pump embodying the principles of Fig. 1 but applied to jets issuing downwardly instead of upwardly from their off-take ducts. This pump comprises a vertical cylinder 1 provided with a bottom member 2 and heater 3 substantially similar to those of Fig. 1. The upper end of cylinder 1 is provided with a flange 4 for connection to a piping system to be evacuated, and roughly $\frac{1}{2}$ the height of flange 4 above base 2, is provided with an offtake pipe 5 leading to a backing pump not shown. The bottom portion of the cylinder 1 contains the working fluid 9 for the pump, the latter being heated by the electrical heater 3 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 is supported, 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.

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.

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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 5.

The exterior wall of the casing 1 and 5 is surrounded by a helical pipe 13A through which water or other cooling fluid flows to maintain the temperature of such walls at a sufficiently low temperature to condense the vapor flowing from the orifices and nozzles already described.

Attached to the inner wall of the cylinder 1 is a member 24 of similar type to and performing similar functions to the member 15A already described in Fig. 1. The member 24 is, however, located so that the junction between its flared upper portion and its straight cylindrical mid-portion are approximately at the lower edge of the cap 14. It should be noted, however, that the member 24 differs from the member 15A in Fig. 1, in that the lip 16A together with the bevelled trough is omitted from the upper edge.

A second member 25 performing the same function relative to the annular orifice about the upper end of cylinder 16 as the member 24 performs in connection with the annular orifice about the upper edge of cylinder 11 is connected to the wall of cylinder 1 with the junction between its flared upper portion and its cylindrical central portion approximately at the level of the lower edge of umbrella 15. The upper edge of the member 25 is, however, provided with a bevelled portion forming an annular trough similar to the bevelled upper edge of the member 15A in Fig. 1. The member 25 is likewise provided with a lip portion (not shown) capable of conducting condensed fluid to a trough (not shown) substantially similar to the lip 16A and trough 17A shown in Fig. 1.

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 usable in diffusion pumps, but for which is preferably employed a hydrocarbon of the ring-compound type, 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

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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.

The member 24 and the member 25 will be seen from the description of Fig. 1 to prevent condensation of the vapor issuing from the respective stages of the pump until this vapor has left the immediate vicinity of the members 24 and 25 and the walls of cylinder 1 immediately surrounding them, and has struck against the cooled portion of the walls of cylinder 1 below the lower edges of the members 24 and 25. The vapor condensing on the walls of cylinder 1 above member 25 will flow down into the annular trough formed by the upper edge thereof and be conducted by the lip and trough (not shown) associated with member 25 into the annular space below member 25 and above partition 17. The condensed fluid from both stages of the pump will, accordingly, be conducted by duct 21b to the intermediate stage of the boiler between cylinder 11 and cylinder 16.

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 are proposed herein for use having nearly uniform construction, 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. With this in mind, the cylinder 16 is arranged 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.

Fluid vaporized from the boiler outside the confines of cylinder 16 flows through the member 21A into contact with the cooled walls of the off-take pipe 5 and assists in carrying away any gas which has been transported by the vapor jets constituting the pump stages from the intake space above flange 4 to the annular space below member 25.

Referring in detail to Fig. 3, it will sometimes be found that the primary feature desired of the pump is ability to rapidly pump against a relatively high back pressure in the off-take duct 5. In such cases, it has been found desirable to employ the arrangement of Fig. 3, in which a pump otherwise substantially similar to that described in the patent above-mentioned is arranged to return condensed vapor to the lowest pressure stage of the boiler rather than to a higher pressure stage. Since the members 1, 2, 3, 4, 5, 9, 11, 12, 13, 13a, 14, 15 and 16 in Fig. 1 and 17, 18 and 21a in Fig. 3 are precisely similar to those already described in connection with Fig. 2, they need no separate description here. However, the duct

21C which conducts fluid from the annular region surrounding cylinder 16 to the fluid 9 passes through the lower portion of cylinder 16 and enters through a hole in the walls of the lower portion of cylinder 11, thus replacing the arrangement of the duct 21b in Fig. 2. Condensed fluid is accordingly returned directly to the lowest pressure stage at the pump inside the cylinder 11. Suitable apertures in the lower portions of cylinders 11 and 16 permit the fluid introduced into the interior of cylinder 11 to pass outward successively into the intermediate pressure stage of the pump between cylinders 11 and 16 and to the higher pressure stage of the pump outside cylinder 16.

A pump of the type shown in Fig. 3 is found to have the following characteristics:

1. A high ultimate vacuum such as 10^{-6} mm. of mercury.

2. A substantially flat pumping characteristic, i. e., the pumping speed does not decrease between a relatively low vacuum and a fairly high vacuum in the biasing system being evacuated.

3. Ability to work rapidly when the pressure in the offtake duct 5 is by no means low.

4. The possibility of collecting highly volatile materials undergoing fractional distillation in the pump, whereas in prior art types of pumps they are exhausted by the last stage.

5. The use of mixtures of oils, one of a lower boiling point but lower vapor pressure at condensation temperature and the other of a high boiling point but higher vapor pressure at the condensing temperature. The use of such composite oils permits the attainment of high vacuum even with a high backing pressure in the offtake 5.

What is claimed is:

1. In a diffusion pump, a boiler, a duct leading vapor therefrom to a chamber enclosing a region surrounded by a relatively cooled wall, and a wall surrounding the outlet of said duct and spaced away from said cooled wall portion, means for supporting said wall from said cooled wall portion by a relatively poor heat conducting material, and an inlet passage to said chamber and an

outlet passage from said chamber for said pump on opposite sides of said outlet.

2. In a diffusion pump, a boiler, a duct leading vapor therefrom to a chamber enclosing a region surrounded by a relatively cooled wall, a member comprising two outwardly and oppositely flared walls surrounding the outlet of said duct, the upper flared portion being supported against said cooled wall portion, an offtake channel extending from the upper edge of said upper flared portion below the lower face of said upper flared portion, a trough cooperating with said cooled wall portion to seal the lower end of said channel, means for returning fluid overflowing said trough to said boiler, and an inlet passage to said chamber and an outlet passage from said chamber for said pump on opposite sides of said outlet.

3. In a diffusion pump, a boiler and a heater therefor, a central duct for conveying vapor from the central portion of said boiler to an annular orifice, a chamber having a cooled wall surrounding said orifice, an annular duct for conducting vapor from the annular space surrounding said central portion of said boiler to a second annular orifice, a partition separating the space above said boiler from the space within said cooled wall portion, and a duct for conveying liquid from the last mentioned space to the central portion of said boiler, an inlet passage for said pump to said chamber and an outlet passage from said chamber for said pump on opposite sides of said two orifices.

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REFERENCES CITED

The following references are of record in the file of this patent:

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