Nov. 22, 1949 G. R. STOLTENBERG 2,489,058

DIFFUSION PUMP

Filed May 26, 1944 2 Sheets-Sheet 1

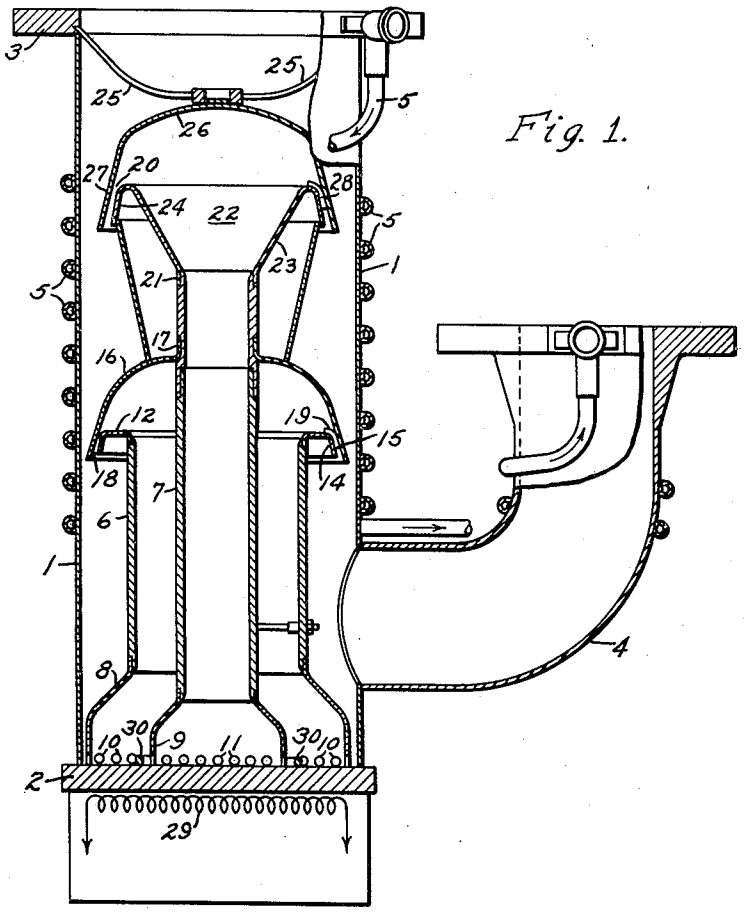


Fig. 1.

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Fig. 2.

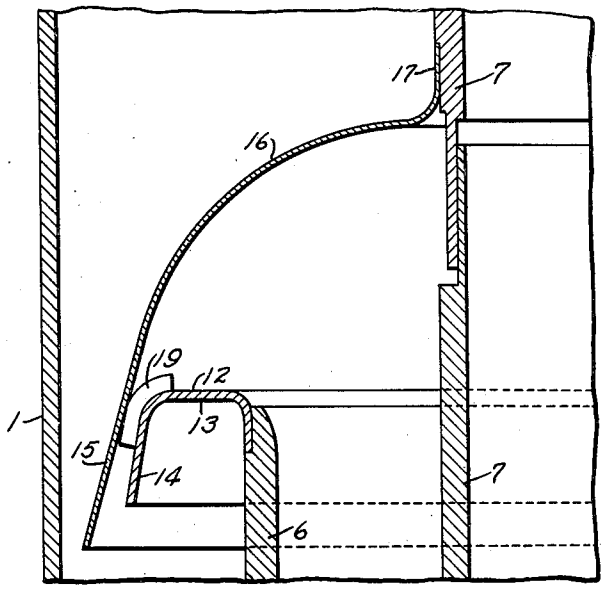
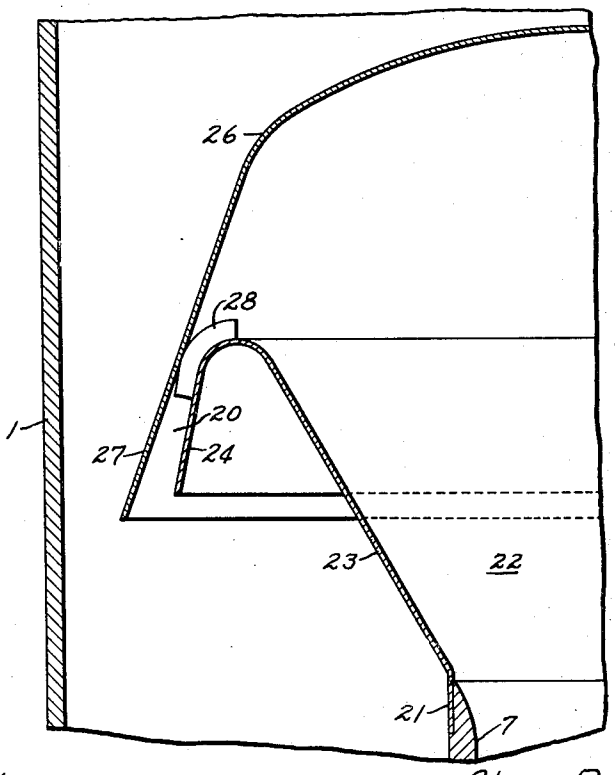


Fig. 3.



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UNITED STATES PATENT OFFICE

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DIFFUSION PUMP

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8 Claims. (Cl. 230—101)

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This invention relates to new and useful improvements in vacuum pumps, and more particularly to vacuum pumps of the vapor diffusion type.

The usual vapor diffusion pump comprises a chamber connected between a backing pump and to an envelope or member to be evacuated, and containing one or more nozzles or jets so directed that vapor ejected by the jets entrains gas molecules entering the chamber from the envelope and expels them in the direction of the outlet from the chamber to the backing pump. The minimum pressure obtainable at the inlet to the pump chamber is limited to the vapor pressure of the most volatile constituent of the liquid from which the entraining vapor discharged from the jets is generated, and such pumps generally comprise, also, a boiler for generating the vapor and one or more chimneys for conducting the vapor to the jets or nozzles.

In the past, certain oils have been employed as the working or pumping fluid in such pumps, and it has been the practice generally to construct the jets of the pump so that the oil vapors expand as rapidly as possible and with the resultant jet velocity parallel to the axis of the pump in order to obtain the highest possible pumping speed. In prior diffusion pumps, however, the various designs of jets or nozzles employed, generally have been characterized by a relatively large amount of oil migration or diffusion back into the envelope or member being exhausted, and they have not afforded any substantial directional control over the oil vapors. In addition, the length of the jets or nozzles generally has been such as to require more power to generate and discharge the vapors through the jets, and the vapor concentration in the working area of the jets usually is not sufficient to produce a maximum exhaust pressure.

With the foregoing in mind, the present invention contemplates the provision of a vapor diffusion pump having one or more jets or nozzles so constructed and arranged that the oil vapors discharged therefrom will expand in a direction slightly toward the pump axis and therefore have a velocity vector towards the axis of the pump that must be overcome before the oil molecules can migrate or diffuse back into the envelope or member being exhausted. The invention also contemplates a jet or nozzle construction that is operable to maintain a maximum density and concentration of the vapor stream in order that the pump may operate effectively against high exhaust pressures, or in conjunction with a backing pump. Furthermore, the present invention contemplates the provision in a vapor diffusion pump of a jet or nozzle in which the length of the restriction in the jet opening is comparatively short in length so that the power requirements to generate and discharge the vapors may be substantially reduced, and, at the same time will cause the random expansion of the oil vapors to take place in the direction of, or toward, the center or axis of the pump. Finally, in the case of multiple chimney diffusion pumps, it is desirable that the oil entering the boiler of the inner or high vacuum jet stage be substantially free of sediment and, therefore, the present invention contemplates the provision of suitable means for de-entraining or removing sediment and other foreign particles from the oil prior to entrance thereof into the inner, or high vacuum stage, of the pump.

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Accordingly, it is an object of the present invention to provide a jet or nozzle for vapor diffusion pumps that is constructed and arranged to provide adequate directional control over the oil vapors discharged therethrough.

Another object of the invention is to provide a novel diffusion pump jet construction as set forth whereby expansion of the vapors after leaving the pump takes place in a direction toward the axis of the diffusion pump.

Another object of the invention is to provide a novel jet for diffusion pumps that is constructed and operable to substantially minimize migration or back diffusion of the molecules of the discharged oil vapors.

A further object of the invention is to provide a novel jet construction having the attributes set forth wherein the length of the restriction in the jet opening is comparatively short in length thereby reducing the power required to generate and discharge the vapors therethrough at the required velocity.

A still further object of the invention is to provide a multiple chimney vapor diffusion pump having suitable means for de-entraining and removing sediment and other particles from the oil prior to entrance thereof into the inner or high vacuum stage of the pump.

These and other objects of the invention, and the various features and details of the construction and operation thereof, are hereinafter fully set forth and described with reference to the accompanying drawings, in which:

Fig. 1 is sectional view taken vertically through a multi-stage vapor diffusion pump embodying a

jet or nozzle construction according to the present invention.

Fig. 2 is an enlarged fragmentary view of the disclosure of Fig. 1 showing the details of construction and arrangement of the discharge jet of the first or primary stage of the pump, and

Fig. 3 is a view similar to Fig. 2 showing the details of construction and arrangement of the discharge jet of the second or high vacuum stage of the pump.

Referring now to the drawings, and more particularly to Fig. 1 thereof, the present invention is shown, for example, in conjunction with a vapor diffusion pump of generally conventional type comprising a cylindrical pump casing 1, the lower end of which is closed by a base plate 2. The upper end of the casing 1 is provided with a flange 3 for connection to the system or structure (not shown) that is to be evacuated, and the upper end, therefore, represents the high vacuum or intake side of the pump, while the low vacuum, or exhaust, side of the pump is indicated by conduit 4 that leads from the casing 1 adjacent the bottom end thereof, and is connected, for example, to the usual backing pump (not shown). The chamber enclosed by the casing 1 is cooled by circulating water within a tube or pipe 5 that is coiled externally of the casing 1, and the conduit 4, near its outer end, is similarly cooled by passing thereabout a relatively small number of turns of the cooling water tube 5 as shown in the drawings. Water is circulated through the cooling tube 5, for example, in the direction indicated by the arrows.

Arranged vertically within the casing 1, in spaced concentric coaxial relation with respect thereto and with respect to each other, is an outer chimney structure 6, and an inner chimney structure 7, the latter being somewhat taller than the outer chimney 6 as shown. The chimneys 6 and 7 each have their bottom end portion flared outwardly as indicated at 8 and 9, respectively, and the bottom edges thereof are fixedly secured to the base plate 2, suitable openings 10 and 11 being provided adjacent the bottom of the chimneys 6 and 7, respectively, to permit flow of the vacuum pump oil radially inward to the bottom portions of said chimneys from the periphery of the casing 1.

As more clearly shown in Fig. 2 of the drawings, there is secured to the upper end of the outer chimney 6 an annular ring member 12 of generally inverted U cross-section shape that has a portion 13 extending radially outward horizontally from the chimney 6 and terminates at its outer edge in an outwardly offset reversely directed flange portion 14 that extends angularly outward from said outer chimney at an acute angle with respect to the vertical wall surface of the pump casing 1.

Overlying the member 12 and surrounding the flange portion 14 thereof in outwardly spaced relation, is the depending outer peripheral edge portion 15 of an annular dome-shaped hood member 16 that has its inner peripheral edge portion fixedly secured to the exterior of the inner chimney 7 as indicated at 17. The outer peripheral edge portion 15 of the hood 16 extends downwardly to a point a short distance below the edge of the flange portion 14 and is preferably disposed angularly with respect to the wall surface of the pump casing 1 at an acute angle that is slightly greater than the angular disposition of the flange portion 14 of the member 12.

The portions 14 and 15 of the members 12 and 16, respectively, thus are cooperatively disposed with respect to one another and define therebetween an annular jet or orifice 18 for the discharge of the vapors generated in the outer chimney 6. Suitable spacers 19, of generally accurate configuration, are secured at intervals between the jet defining portions 14 and 15 of the members 12 and 16, respectively, to secure and maintain the said portions 14 and 15 in predetermined spaced relation with respect to each other, thereby positively fixing the radial dimension of the jet or orifice 18 through which the outer chimney vapors are discharged.

A generally similar discharge jet or orifice 20 is provided at the upper end of the inner chimney 7 for the vapors generated therein. To this end, there is secured to the upper end of the inner chimney 7 the lower end edge 21 of a funnel-shaped member 22 having a side wall portion 23 that flares upwardly and outwardly and terminates at its upper end in a portion that curves outwardly and then downwardly, as shown, to provide an outwardly offset depending flange portion 24 that extends angularly outward from said inner chimney 7 and preferably at an acute angle with respect to the wall surface of the pump casing 1.

Overlying the funnel-shaped member 22, and supported or carried by one or more struts 25 secured to the casing 1, is a dome-shaped hood member 26 that has its peripheral edge portion 27 surrounding the flange portion 24 of the member 22 in predetermined outwardly spaced relation with respect thereto. The peripheral edge portion 27 of the hood member 26 preferably extends a short distance below the edge of the flange 24 of member 22 and is disposed at an acute angle with respect to the wall of casing 1 greater than the angular disposition of the flange portion 24 of said member 22. The flange and edge portions 24 and 27 thus are cooperatively disposed with respect to one another and define therebetween an annular jet or orifice 28 for the discharge of vapors generated in the inner chimney 7, suitable spacers 28, similar to spacers 19, being secured between the jet defining portions 24 and 27 to secure and maintain the same in predetermined spaced relation thereby fixing the radial dimension of the jet or orifice through which the vapors from the inner chimney are discharged.

The angular disposition and relationship of the flange and peripheral edge portions that define the several discharge jets is important, and, for example, in the particular embodiment of the diffusion pump illustrated, the flange portion 14 of the member 12 preferably is disposed at an acute angle of about 10° with respect to casing 1, and the surrounding peripheral edge portion 15 of the hood 16 preferably is disposed at an angle of about 16° with respect to said casing. In generally similar arrangement, the flange portion 24 of member 22 preferably is disposed at an angle of about 12° with respect to the casing 1, and the surrounding peripheral edge portion 27 of hood 26 preferably is disposed at an angle of about 20° with respect thereto. Jets of the construction shown and described may be employed effectively on any size of diffusion pump with only slight modifications of the angular disposition and relationship of the respective jet defining elements to meet the requirements of the particular pump.

In addition to the angular disposition of the jet forming elements with respect to each other and the casing 1, it will be observed that the vapor jets are spaced inwardly from the pump casing 1,

a relatively short distance, for example, of from about $\frac{3}{16}$ inch to a maximum of about 1 inch, depending upon the size of the particular pump.

In operation of the pump, the conduit 4 is connected to the intake of a suitable backing pump (not shown), and the intake end of the pump casing 1 is connected, by its flange 3, to the system or vessel that is to be evacuated. A quantity of a suitable volatile oil, for example, an organic hydrogenated diphenyl compound sold under the trade name "HB40," is supplied to the bottom of the diffusion pump at the inner periphery of the casing 1, and this oil flows inwardly over the surface of the base plate 2, and successively through the openings 10 and 11 into the bottom of the outer and inner chimneys 6 and 7, respectively, where it is heated and vaporized by heat applied to the base plate 2, for example, by means of an electric or other type of heater 29.

In order that the oil entering the inner chimney 7 may be substantially free from sediment and other foreign particles, there is provided upon the base plate 2 an annular barrier or ring 30 that surrounds the base of the inner chimney 7 and functions as a dam to de-entrain and remove from the inwardly flowing oil substantially all particles of dirt and other material. The inflowing oil builds up and flows over the barrier or ring 30 in the course of which the particles settle out and collect outwardly adjacent the barrier 30 with the result that the oil that flows over the barrier and enters the inner chimney 7 through its openings 11 is substantially free from particles of dirt and other foreign particles.

Oil is admitted to the proper depth in the lower ends of the chimneys 6 and 7 and the oil is heated and vaporized by the heater 29. The oil vapors rise within the chimneys and discharge therefrom through the jets or orifices 19 and 20 respectively, in a generally downward direction with the result that gas molecules entering the pump casing 1 through its intake end from the vessel or envelope to be exhausted, are entrained by the downwardly directed vapor jets and impelled thereby to or toward the exhaust conduit 4. The discharged oil vapors are condensed upon the interior wall surface of the casing 1 by the cooling pipe 5, thus releasing the gas molecules which are withdrawn from the casing 1 through the exhaust conduit 4 by the backing pump (not shown) connected thereto, the condensed vapors ultimately draining down the inner wall surface of the casing 1 to the periphery of the base plate 2 over which they again flow inwardly through the openings 10 and 11 into the bottoms of the inner and outer chimneys 6 and 7, respectively, to be again vaporized. Preferably, the openings 10 and 11 are of such size that the flow of oil therethrough to the chimney 6 and ultimately to the chimney 7 takes place substantially at the rate at which vaporization of the oil takes place in each chimney so that the most volatile constituents of the oil have sufficient time to vaporize in the outer chimney 6 and be conducted away to the lower jet 19 before the constituents of intermediate and low volatility reach the inner chimney 7.

By virtue of the relatively close spacing of the vapor discharge jets with respect to the casing 1, and the angular disposition thereof relative to said casing, the vapors discharged from said jets are caused to impinge against the inner wall of the casing almost as soon as they emerge from the jets with the result that not only is a maximum density and concentration of the vapor stream provided across the gap between the jets and casing 1 that enables the pump to operate effectively against high exhaust pressures, but also causes the discharged vapors to expand in a direction inwardly toward the pump axis thereby creating a velocity or force vector in that direction that must be overcome by the oil molecules before they can migrate or diffuse upwardly past the jets and back into the envelope or vessel being exhausted.

Therefore, from the foregoing, and in fulfillment of the several objects herein set forth, it will be observed that the present invention provides a novel jet construction and arrangement for vapor diffusion pumps whereby the oil vapors are discharged therefrom at a relatively small acute angle with respect to the wall of the casing 1 with the result that expansion of the vapors occurs in a direction slightly toward the pump axis and produces a velocity vector in that direction that must be overcome by the oil molecules before they can migrate or diffuse upwardly and back into the vessel or system being evacuated. The invention also provides a jet construction and arrangement that produces a maximum density and concentration of the vapor stream so that the pump operates effectively against high exhaust pressure, or in conjunction with a backing pump. The invention also provides a jet construction for diffusion pumps wherein the length of the jet restriction is comparatively short in length with the result that less power is required to force the oil vapors therethrough.

While a particular embodiment of the invention has been illustrated and described herein, it is not intended that the invention be limited to such disclosure but that changes and modifications may be made and incorporated therein without departing from the spirit of the invention within the scope of the following claims.

I claim:

1. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, a vapor chimney disposed coaxially within said casing and extending from the lower end thereof upwardly to a point intermediate said intake and outlet, said chimney terminating at its upper end in an outwardly offset reversely directed flange portion extending angularly outward from said chimney at an acute angle with respect to said casing, and a hood member positioned above said chimney having a peripheral edge portion surrounding said flange portion in predetermined circumferentially spaced relation with respect thereto, said peripheral edge portion of the hood being disposed at a greater acute angle with respect to said casing than said chimney flange portion and cooperating with said chimney flange portion to form therewith a discharge jet for vapors rising through said chimney.

2. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, a vapor chimney disposed coaxially within said casing and extending from the lower end thereof upwardly to a point intermediate said intake and outlet, said chimney terminating at its upper end in a reversely directed flange portion extending angularly outward from said chimney, a hood member positioned above said chimney having a peripheral edge portion surrounding said flange portion in predetermined circumferentially spaced relation with respect thereto,

said peripheral edge portion of the hood cooperating with said chimney flange portion to form therewith a discharge jet for vapors rising through said chimney, and spacer members interposed between said hood edge and chimney flange portions operable to secure the same in predetermined spaced relation with respect to each other.

3. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, a vapor chimney disposed coaxially within said casing and extending from the lower end thereof upwardly to a point intermediate said intake and outlet, said chimney terminating at its upper end in an outwardly offset reversely directed flange portion extending angularly outward from said chimney at an acute angle with respect to said casing, and a hood member positioned above said chimney having a peripheral edge portion surrounding said flange portion in predetermined circumferentially spaced relation with respect thereto, said peripheral edge portion of the hood being disposed at a greater acute angle with respect to said casing than said chimney flange portion and cooperating with said chimney flange portion to form therewith a discharge jet for vapors rising through said chimney, and spacer member interposed between said hood edge and chimney flange portions operable to secure the same in predetermined spaced relation with respect to each other.

4. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, a vapor chimney disposed coaxially within said casing and extending from the lower end thereof upwardly to a point intermediate said intake and outlet, said chimney terminating at its upper end in an outwardly offset reversely directed flange portion extending angularly outward from said chimney at an acute angle with respect to said casing, and a hood member positioned above said chimney having a peripheral edge portion surrounding said flange portion in predetermined circumferentially spaced relation with respect thereto and extending a short distance below the edge of said flange portion, said peripheral edge portion of the hood being disposed at a greater acute angle with respect to said casing than said chimney flange portion and cooperating with said chimney flange portion to form therewith a discharge jet for vapors rising through said chimney, and spacer members interposed between said hood edge and chimney flange portions operable to secure the same in predetermined spaced relation with respect to each other.

5. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, an outer and an inner chimney extending in spaced concentric relation coaxially within the casing from the lower end thereof upwardly to points spaced axially of said casing between said intake and outlet thereof, said outer and inner chimneys respectively terminating at their upper ends in reversely directed flange portions extending angularly outward therefrom, a first hood member surrounding said inner chimney and overlying the upper end of said outer chimney having a peripheral edge portion surrounding the flange portion of said outer chimney in predetermined circumferentially spaced relation with respect thereto and extending a short distance below the edge of said flange portion, said peripheral edge portion of said hood member cooperating with said outer chimney flange portion to form therewith a vapor discharge jet for vapors rising through said outer chimney, and a second hood member positioned above said inner chimney having its peripheral edge portion surrounding the flange portion of said inner chimney in circumferentially spaced relation with respect thereto and extending a short distance below the edge of said flange portion, said peripheral edge portion of the second hood member cooperating with said inner chimney flange portion to form therewith a discharge jet for vapor rising through said inner chimney.

6. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, an outer and an inner chimney extending in spaced concentric relation coaxially within the casing from the lower end thereof upwardly to points spaced axially of said casing between said intake and outlet thereof, said outer and inner chimneys respectively terminating at their upper ends in outwardly offset reversely directed flange portions extending angularly outward therefrom at an acute angle with respect to said casing, a first hood member surrounding said inner chimney and overlying the upper end of said outer chimney having a peripheral edge portion surrounding the flange portion of said outer chimney in predetermined circumferentially spaced relation with respect thereto at an acute angle with respect to said casing greater than the angle of said outer chimney flange portion, said peripheral edge portion of said hood member cooperating with said outer chimney flange portion to form therewith a vapor discharge jet for vapors rising through said outer chimney, and a second hood member positioned above said inner chimney having its peripheral edge portion surrounding the flange portion of said inner chimney in circumferentially spaced relation with respect thereto at an acute angle with respect to said casing greater than the angle of said inner chimney flange portion, said peripheral edge portion of the second hood member cooperating with said inner chimney flange portion to form therewith a discharge jet for vapor rising through said inner chimney.

7. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, an outer and an inner chimney extending in spaced concentric relation coaxially within the casing from the lower end thereof upwardly to points spaced axially of said casing between said intake and outlet thereof, said outer and inner chimneys respectively terminating at their upper end in reversely directed flange portions extending angularly outward therefrom, a first hood member surrounding said inner chimney and overlying the upper end of said outer chimney having a peripheral edge portion surrounding the flange portion of said outer chimney in predetermined circumferentially spaced relation with respect thereto, said peripheral edge portion of said hood member cooperating with said outer chimney flange portion to form therewith a vapor discharge jet for vapors rising through said outer chimney, and a second hood member positioned above said inner chimney having its peripheral edge portion

surrounding the flange portion of said inner chimney in circumferentially spaced relation with respect thereto, said peripheral edge portion of the second hood member cooperating with said inner chimney flange portion to form therewith a discharge jet for vapor rising through said inner chimney, and spacer members interposed between said hood edge and chimney flange portions operable to secure the same in predetermined spaced relation with respect to each other.

8. In a vapor diffusion pump comprising a tubular casing having an outlet adjacent the lower end thereof and an intake spaced above said outlet, an outer and an inner chimney extending in spaced concentric relation coaxially within the casing from the lower end thereof upwardly to points spaced axially of said casing between said intake and outlet thereof, said outer and inner chimneys respectively terminating at their upper ends in outwardly offset reversely directed flange portions extending angularly outward therefrom at an acute angle with respect to said casing, a first hood member surrounding said inner chimney and overlying the upper end of said outer chimney having a peripheral edge portion surrounding the flange portion of said outer chimney in predetermined circumferentially spaced relation with respect thereto at an acute angle with respect to said casing greater than the angle of said outer chimney flange portion, said peripheral edge portion of said hood member cooperating with said outer chimney flange portion to form therewith a

vapor discharge jet for vapors rising through said outer chimney, and a second hood member positioned above said inner chimney having its peripheral edge portion surrounding the flange portion of said inner chimney in circumferentially spaced relation with respect thereto at an acute angle with respect to said casing greater than the angle of said inner chimney flange portion, said peripheral edge portion of the second hood member cooperating with said inner chimney flange portion to form therewith a discharge jet for vapor rising through said inner chimney, and spacer members interposed between said hood edge and chimney flange portions operable to secure the same in predetermined spaced relation with respect to each other.

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