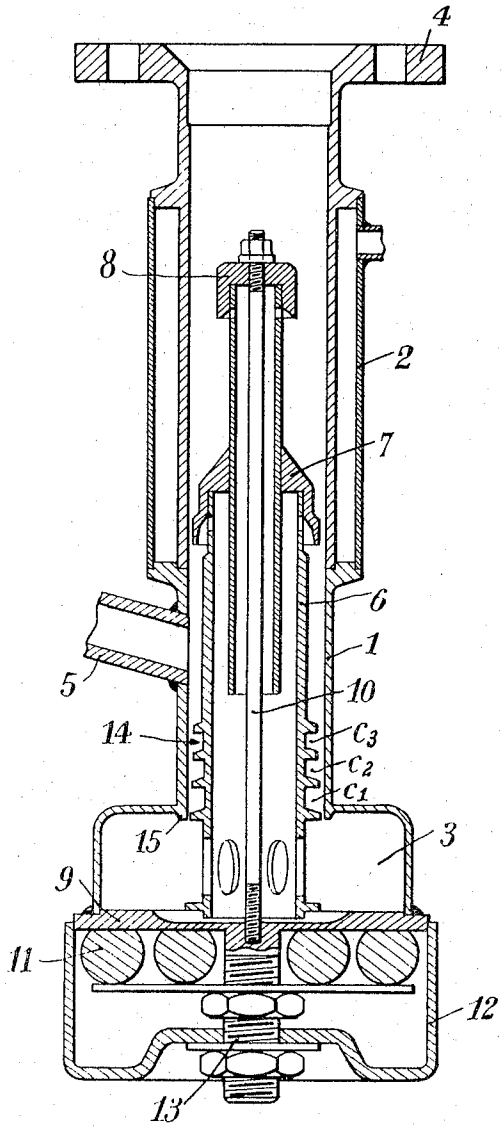
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OIL-VAPOR DIFFUSION VACUUM PUMP

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Fig. 1



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OIL-VAPOR DIFFUSION VACUUM PUMP

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Fig. 3.

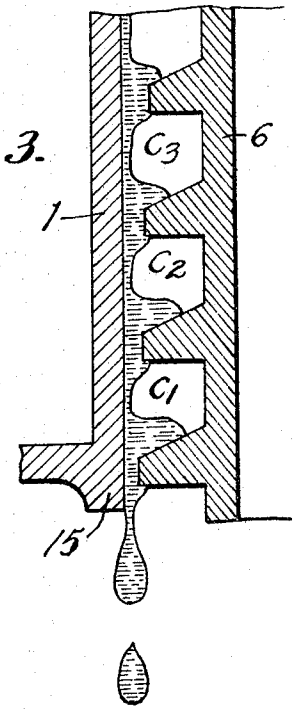
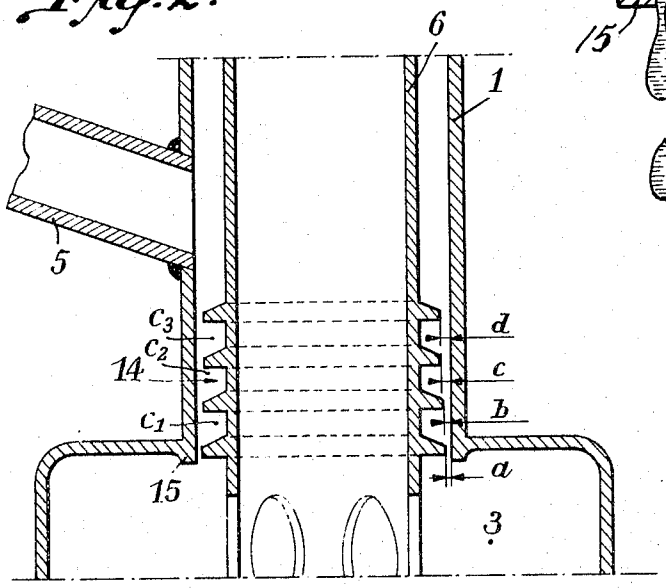


Fig. 2.



United States Patent Office 3,302,864 Patented Feb. 7, 1967

3,302,864

OIL-VAPOR DIFFUSION VACUUM PUMP

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Filed Nov. 5, 1964, Ser. No. 409,265
Claims priority, application France, Nov. 8, 1963, 953,126, Patent 1,382,330
2 Claims. (Cl. 230—101)

This invention relates to improvements in seal devices for use in vacuum pumps, operating according to the oil-vapor diffusion principle, to permit return to the boiler of the oil condensed in the pump body while preventing any flow in the opposite direction of oil vapor generated in the boiler. Thus, the vapor, according to the conventional principle of operation of these vacuum pumps, will necessarily flow through the intermediate member or ejector from which this vapor is caused to diffuse into the pump body before condensing on the cooled wall of said body.

In conventional oil-vapor diffusion vacuum pumps this return flow of condensed oil to the boiler is effected in most instances through a pipe immersed in the liquid-oil charge of the boiler; therefore, this device has a considerable length in proportion to the total length of the pump, thus increasing inasmuch the over-all dimensions of the pump and consequently its weight. Now, for various reasons to be set forth presently it is particularly desirable to reduce both the weight and the over-all dimensions of oil-vapor diffusion vacuum pumps notably in the specific field of automatic pumping units such as those used in the mass-production of electron tubes and other sealed enclosures for vacuumizing and degasifying same.

Such automatic units, mainly of the rotary turret type, may comprise a relatively high number of working positions or stations (for example 16, 24, 30, 36 or more), each position or station having its diffusion pump, this requirement being of primary interest for combining high-quality products with high pumping rates.

The use of a diffusion pump at each working station is obviously attended (for the same search for higher production rates and higher pumping efficiencies) by the necessity of providing a direct connection between said pump and the enclosure to be vacuumized; this requirement is met by mounting at each working position the diffusion pump in direct alignment with the nozzle through which the enclosures loaded on the unit are vacuumized, these enclosures being disposed on the outer periphery of the circular rotary turret in order not only to have the maximum relative peripheral spacing between them but also for obvious reasons of convenience in operating the machine, notably as to loading and unloading.

Since it is essential that the angular movement corresponding to the positioning of the unit takes place as rapidly as possible, in order to reduce the resulting idle period, it is necessary that the higher the pumping rate, the lower the moment of inertia of the turret.

Now, due to the compulsory mounting of the diffusion pumps at the outermost periphery of the rotary turret the greater part of the turret weight is transferred to its periphery; therefore, the lighter the diffusion pumps equipping the pumping units, the lower the moment of inertia of the turret.

On the other hand, the mechanical construction of these units and their operation are greatly facilitated by lowering the working level of the turret (thus providing a more compact assembly). Furthermore, an easier access can thus be had to the turret plate for loading and unloading the enclosures to be vacuumized and for adjusting the working stations; therefore, the diffusion pumps which, for the aforesaid reasons of mounting in

direct alignment with the enclosure pumping nozzles, can only be mounted underneath said plate, must be relatively short (which is consistent with the search for lighter weight for meeting the above-mentioned requirement of reduction in the moment of inertia of the turret).

Finally, the relatively high number of working stations and therefore of pumping units leads to the use of an electric commutator for feeding the heating elements of these pumps which has definitely prohibitive dimensions if the heating power of these elements is relatively high; thus, to reduce this heating power within reasonable limits the diffusion pumps to be mounted on the automatic pumping units must necessarily have a very high thermal efficiency.

It is the essential object of this invention to provide a device adapted to impart to oil-vapor diffusion pumps the three advantageous features set forth hereinabove.

It is known in oil-vapor diffusion pumps to take advantage of the position of the ejector concentric to the pump body for providing an annular gap or space between its outer wall and the inner wall of the pump body. Thus, the oil having condensed will drip along the cooled wall of the pump body and accumulate in the lower portion of the annular space in the form of a liquid ring which, being retained by surface tension in said space, constitutes a kind of liquid seal therein, thus preventing the diffusion of the oil vapor from the boiler to the working chamber, or, in other words, forcing this oil vapor to flow through the ejector.

However, the seal thus obtained in the form of a single ring of liquid oil cannot be effective unless this ring is of relatively great height or thickness, for example of the order of one inch. Thus, although this dimension is acceptable in the case of relatively large diffusion pumps not limited by maximum over-all dimensions, it cannot be contemplated in the case of pumps to be mounted on automatic pumping units due to the essential requirements set forth hereinabove. On the other hand, the magnitude of the total area of the registering metal surfaces on either side of the oil ring implies, for the ejector, a loss of heat which is proportional to said area. This loss of heat occurs as a matter of fact through the hot oil towards the cooled pump body. As in the preceding case, although this loss of heat is relatively immaterial in the case of a diffusion pump of relatively high heating power capacity, the same relative loss is on the other hand extremely detrimental in the case of pumps having desirably (as already explained hereinabove) the best possible thermal efficiency for a minimum heating power.

Another feature characterizing this invention is that it permits reducing not only the height of the ring of condensed oil but also the surface area of the ejector and pump bodies. The height of the oil ring is reduced by splitting the ring into at least two rings or sub-rings, and the surface area is reduced by forming the ejector body with a splined or castellated section by machining at least three collars regularly spaced in the axial direction, these collars having different diameters so as to leave gradually increasing gaps between themselves and the inner wall of the pump body, two adjacent collars forming therebetween an annular cavity. Under these conditions the device considered as a whole has at least two such annular cavities wherein the oil condensing along the pump body flows towards the boiler to constitute a seal in the form of said liquid rings or sub-rings.

The relative spacing of said collars is determined by the trial and error method so that between two adjacent collars or rings (with due consideration for the volumes occupied by these rings) there is an oil-free space, the above-defined annular cavities thus forming behind said rings what may be termed "expansion chambers," whereby, throughout the height of the zone bounded by said rings, a pressure gradient is created which, in conjunction

with the temperature drop produced at this level as a consequence of the presence of condensed oil, causes any oil vapor molecule tending to escape from the boiler along the pump body and the ejector body to be compulsorily condensed at least in the second cavity (as proved experimentally by observing the phenomenon in a pump provided with the device constituting the subject-matter of this invention but having a glass and therefore transparent body) so that the assembly actually corresponds to the desired sealing device, the provision of a third cavity (by machining a fourth collar on the ejector body) being merely an additional safety measure; therefore, the fourth collar or ring is considered just as supplementing or doubling the third one and may have exactly the same shape and dimensions, thus providing the same gap between its outer periphery and the inner wall of the pump body, whereas the second and first collar (counted in this order from the boiler outwards or upwards) form with the inner wall of the body gaps of gradually decreasing width.

As the volumes of the successive liquid rings depend on the oil viscosity, the geometrical shape of the device taken as a whole, is subordinate to the quantity of oil utilized. In the case of the geometrical arrangement contemplated by the invention the dimensions of the gaps left between each collar and the inner wall of the pump body are respectively 0.03" in the case of the fourth and third rings or collars, 0.02" in the case of the second collar, and 0.012" in the case of the first collar, the height of the zone covered by these four collars being ¾" and, corresponding to a relative spacing of 0.20" between adjacent rings or collars and a thickness of 0.04" for each collar, these dimensions being given by way of example, of course, without limiting in any way the present invention.

Apart from its reduced length the device of this invention, which is easy to manufacture and maintain, is characterized by the following advantageous features:

(a) During its flow the oil is retained in the proximity of the primary pumping orifice and therefore subjected to a temperature ranging from 160° C. (320° F.) to 190° C. (374° F.); therefore, this oil is partially freed by fractional distillation of any occluded impurities;

(b) The oil will drip not along the ejector (which it would cool while re-evaporating) but under a gutter-forming rib proved to this end at the junction of the pump body with the boiler;

(c) The seal consisting of the liquid oil kept between the ejector and the outer wall of the pump is essentially, due to its nature, a poor heat conducting substance; therefore, no undesired cooling of the ejector is likely to be produced thereby.

These two last advantageous features play to a considerable extent an essential part in the improvement of the thermal efficiency of the pumps provided with the device of this invention, thus imparting to these pumps the third desired property among the three ones listed and explained hereinabove.

In order to afford a clearer understanding of this invention and of the manner in which the same may be carried out in practice, reference will now be made to the accompanying drawings illustrating diagrammatically by way of example a typical form of embodiment of this invention.

In the drawings:

FIG. 1 is a longitudinal or axial section showing a pump assembly equipped with the device constituting the subject-matter of this invention;

FIG. 2 is another axial sectional view showing on a larger scale the pump portion constituting the aforesaid device; and

FIG. 3 is a fragmentary enlarged view of the pump portion of FIG. 2 provided with a seal device according to the invention and illustrates the formation of the seals by the seal device.

The pump body **1** with its cooling jacket **2** carries at its lower portion a boiler **3** and at its upper portion a flange **4** for connecting the pump to a pipe, duct or enclosure to be vacuumized and not shown. A nozzle **5** permits connecting the pump to a primary pump (not shown) for priming and maintaining the preliminary vacuum. An ejector **6** (with its steam deflection cones or jet means such as **7** and **8**) is centered on a bottom plate **9** of the boiler **3** by means of a simple central rod arrangement **10** permitting a convenient assembling and disassembling for maintenance purposes. A heating element **11** (consisting for example of a shielded resistance of adequate configuration contacting the outer surface of boiler plate **9** by means of a flat face increasing considerably the heat transfer from said heating element and the boiler), and a protective case **12** are both secured to the boiler by means of a screw-threaded rod **13**. A set of collars or rings **14** machined on the outer surface of the ejector provides in conjunction with the pump body and the ejector body three annular cavities constituting as many expansion chambers C_1, C_2 and C_3.

The configuration of these rings or collars is shown more in detail in FIGS. 2 and 3 together with the dimension of the corresponding radial annuli or gaps *d, c, b, a,* formed between each collar and the inner wall of the pump body. The actual values of these gaps, which, decrease towards the boiler have already been given hereinabove by way of example in the case of a specific oil grade used by the applicant, namely silicone fluids Si 703 and 704.

A drip rib **15** is provided at the lower end of the pump body, around the aperture thereof opening into the boiler, whereby the condensed oil will return to the boiler from this rib, that is, from the pump body, instead of from the lowermost ring of the ejector, thus avoiding, as already set forth hereinabove, the cooling of the ejector by re-evaporation of oil in this zone and therefore further increasing the thermal efficiency of the assembly. Besides, the fact that the ejector, due to its specific mounting, is completely independent of the pump body (as contrasted with pumps of relatively moderate over-all dimensions of prior art arrangements) further improves the thermal efficiency of the assembly.

Moreover, it will be seen that with the arrangement contemplated herein the pumps thus equipped are characterized by an improvement of the limit vacuum, this improvement being apparently ascribable to a kind of fractional distillation adapted to promote the separation of the gaseous molecules included in the oil used in the pump.

An alternate form of embodiment of this invention consists in forming the annuli on the inner wall of the pump body instead of on the outer wall of the ejector body which in this case is smooth, the same relative spacings and gaps being provided between the corresponding portions of said annuli registering with the outer wall of the ejector; however, to simplify the machining operations the preferred disposal is that described hereinabove and shown in the attached drawings.

Of course, the device of this invention, while developed and applied herein to pumps of moderate size and therefore of moderate capacity is also applicable to large-capacity pumps.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

What I claim is:

1. In a vapor diffusion vacuum pump having a boiler containing and heating an organic working fluid to a vapor, an ejector comprising an inner tubular element mounted in

communication with said boiler for receiving vapor of the working fluid and means defining vapor jet means for developing a vacuum with said ejector in operation, an outer wall circumferentially of said inner tube extending axially of said inner tube and spaced outwardly therefrom defining an annular space in communication with said boiler for returning condensed vapor of said working fluid to said boiler, the improvement which comprises seal means in said space to preclude working fluid in a vapor phase from said boiler entering said annular space and allowing working fluid in a condensed state to return to said boiler, said seal means comprising a plurality of collars disposed axially spaced in said tubular space extending inwardly defining in said space annular gaps of different dimensions between the inner tube and said outer peripheral wall effective to entrap condensed working fluid in a liquid phase to form respective seal rings of liquid working fluid at each of said gaps, and said gaps being of different respective dimensions and the different dimensions thereof decreasing in a direction toward said boiler.

2. In a vapor diffusion vacuum pump according to claim 1, in which said collars being disposed on said inner tubular element coaxial therewith and axially spaced thereon, each collar having a peripheral surface defining a respective one of said gaps in conjunction with outer peripheral wall.

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