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LOW PRESSURE EXHAUSTER

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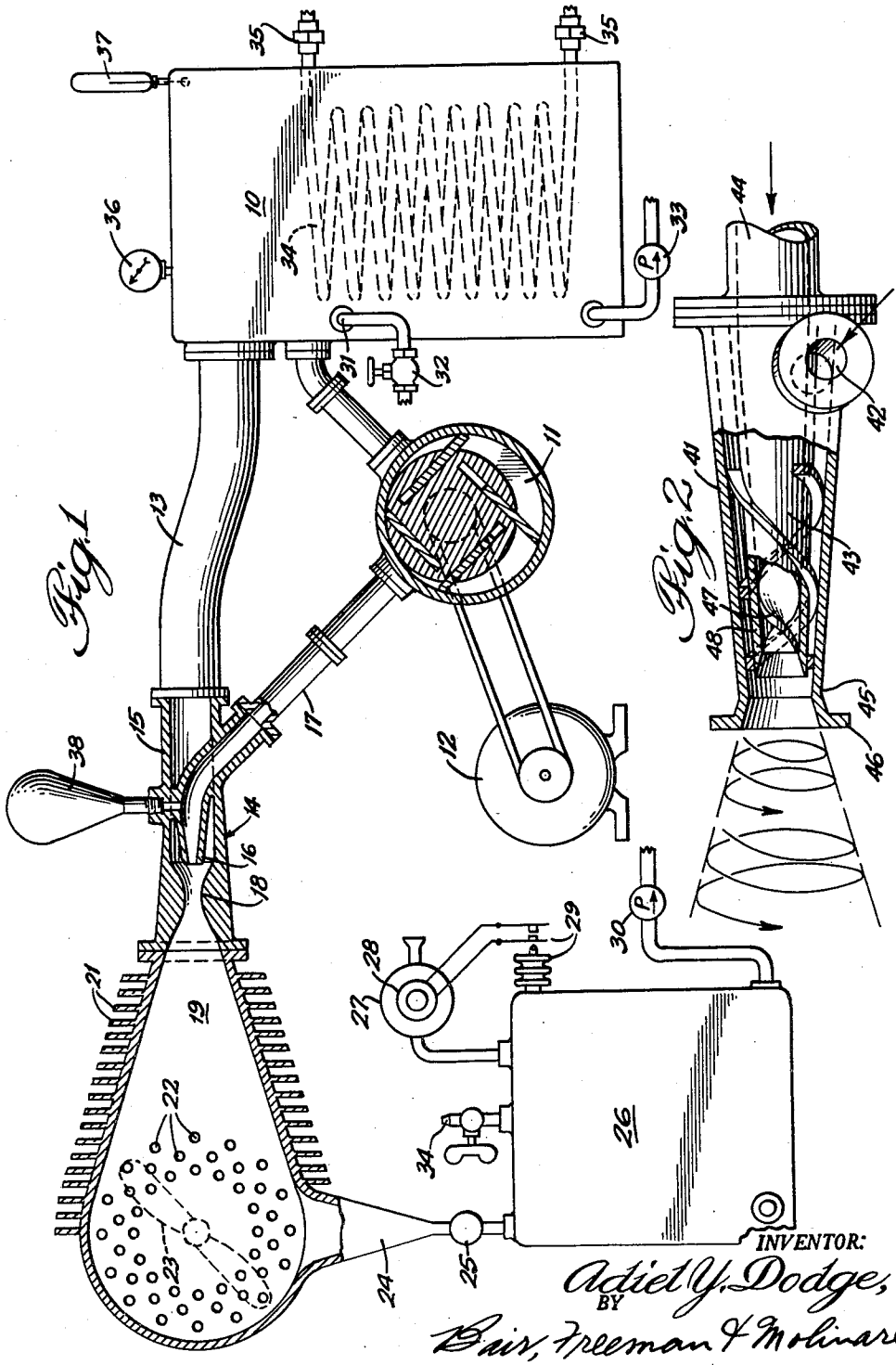


Fig. 1

Fig. 2

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LOW PRESSURE EXHAUSTER

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This invention relates to a low pressure exhauster and more particularly to an apparatus for pumping large volumes of vapor or the like at low absolute pressures.

In handling vapors and the like at low absolute pressures for evaporating a liquid from a container, or similar closed space, it becomes necessary to pump extremely large volumes of very low density fluid. Piston pumps and rotary vane pumps become too large to be practical for this purpose and centrifugal pumps are extremely inefficient due to the low density of the fluid.

It is therefore one of the objects of the present invention to provide a low pressure exhauster which functions with a high degree of efficiency to pump large volumes of vapor and the like at an extremely low absolute pressure.

Another object is to provide a low pressure exhauster in which a portion of the vapor to be pumped is withdrawn from a container by a mechanical pump and is compressed thereby, the compressed vapor being supplied to a jet ejector connected to the same container to withdraw an additional and larger volume of vapor therefrom.

According to a further feature of the invention, the principles thereof may be incorporated in a closed cooling system using water or similar liquid as a cooling medium by evacuating vapor from a container under low pressure, condensing the vapor and returning the condensate to the original container. In such a system an auxiliary vacuum pump is preferably provided and is automatically controlled to maintain a predetermined degree of subatmospheric pressure in the system.

The invention is also applicable in evaporating systems either for dehydration or distillation by supplying a liquid to be evaporated to a container and collecting the condensate in a second container from which it may be removed by a pump.

Various other applications of the invention as well as other objects and advantages thereof will be more readily apparent from the following description when read in connection with the accompanying drawing, in which:

FIGURE 1 is an elevation with parts in section of a low pressure exhauster system embodying the invention; and

FIGURE 2 is an enlarged partial sectional view through an alternative form of jet ejector.

As shown in FIGURE 1, a liquid or similar material to be subjected to low pressure is contained in a closed container **10**. The upper part of the container above the normal level of liquid therein is connected to the inlet of a mechanical pump **11** which is driven by a motor **12**. The upper part of the container is also connected through a conduit **13** to a jet ejector, indicated generally at **14**. As shown in FIGURE 1, the jet ejector comprises an outer tubular casing **15** defining an outer passage communicating with the conduit **13** and a central nozzle **16** connected through a conduit **17** to the discharge opening of the pump **11**. A reduced throat **18** is provided beyond the discharge nozzle **16** and communicates with a tapered diffuser chamber **19** which is preferably provided with cooling fins **21** on its exterior and with a series of cooling tubes **22** extending thereacross and through which a cooling medium, such as air, may be circulated by a fan **23**. Cooling of the tapered diffuser chamber **19** by the fins and by the cooling tubes **22** will condense vapor entering the diffuser chamber and the condensate

will drain from the bottom of the diffuser chamber through a conduit **24** past a check valve **25** and into a second container **26**. A vacuum pump **27** is connected to the upper part of the second container **26** and is driven by a motor **28** controlled by a switch **29** responsive to the pressure in the container **26** to maintain a constant static pressure therein. Condensate collecting in the container **26** may be withdrawn therefrom by a liquid pump **30**.

The container **10** may be supplied with liquid to be evaporated through an inlet connection **31** controlled by a valve **32** and communicating with any desired source of liquid. A pump **33** may be connected to the lower part of the container **10** to remove liquid therefrom when desired.

For various uses of the exhauster, the container **10** may form a part of a heat exchanger which is completed by a coil **34** in the container **10** and having external connections **35**. A second fluid may be circulated through the coil **34** in heat exchanging relation with the material in the container **10** for various processes employing the exhauster.

One useful purpose of the exhauster is to provide a secondary cooling system for use in cooling apparatus, as more particularly disclosed and claimed in my co-pending application Serial No. 49,661. For this purpose, water can be used as the cooling medium and the container **10** will be filled with water to a level below the connection to the pump **11**. In this case, the outlet port of the pump **30** will be connected through the valve **32** to the supply port **31** of the container **10** to recirculate the condensate in a cooling cycle. Preferably for cooling, the static pressure in the system is reduced by the vacuum pump **27** to approximately 2.5 p.s.i.a. When the pump **11** is operating, it will reduce the pressure in the upper part of the container **10** to about .5 p.s.i.a. and will compress the vapor so withdrawn to about 10 p.s.i.a. The compressed vapor discharged through the nozzle **16** will induce flow of a substantially larger volume of vapor from the upper part of the container **10** at about .5 p.s.i.a. and the mixture of vapors will discharge into the diffuser chamber **19** at about 2.5 p.s.i.a. As the vapors are condensed, they will flow by gravity into the second container **26** and can be returned by the pump **30** to the first container **10** in a closed cycle. The pressure and temperature in the first container may be indicated by a suitable gauge **36** and thermometer **37** and fluctuations in the compressed vapor discharged by the pump **11** may be damped out by an equalizer **38**.

For this use of the exhauster, the coil **34** may serve as a condenser for a primary refrigerant which is circulated therethrough in a closed refrigerating cycle. The water in the container **10** will be maintained at a relatively low temperature by evaporation with the heat ultimately being dissipated to the air from the condenser.

In one example of this use, let it be assumed that it is desired to exhaust 120 cubic feet per minute of water vapor from the container **10** at a pressure of .5 p.s.i.a. at 80° F. Water vapor at the .5 p.s.i.a. and 80° F. weighs $\frac{1}{633}$ pound per cubic foot and is at very low density. The pump **11** will pump about 30 cubic feet per minute of water vapor from the container **11** and will discharge compressed vapor at 10 p.s.i.a. and about 220° F. This hot vapor is mixed with two to three volumes of cool vapor in the ejector and due to this mixing and to the subsequent reconversion of flow to pressure, the vapor will discharge into the condenser at about 130° F. The hot vapor will be cooled by the condenser to approximately atmospheric temperature and the condensate will be collected in the container **26** and returned to the first container **10** at a temperautre some 10° above ambient temperature. Therefore, with the present apparatus a

pump having a capacity of about one-fourth of the total volume of vapor to be pumped can be employed so that the apparatus does not become excessive in size and can function with a high degree of efficiency.

In using the invention for evaporating as, for example, in a distilling operation, the liquid to be distilled is supplied to the container **10** through the valve **32** and inlet port **31** and is evaporated under the same conditions as described above in connection with cooling. In this operation, heat may be supplied to the coil **34** as, for example, by circulating hot water or steam therethrough to increase the rate of evaporation. The condensate collected in the second container **26** may be withdrawn therefrom by the pump **30** and taken to a desired point of use. The enriched liquid remaining in the container **10** may be withdrawn therefrom by the pump **33** either periodically or continuously, depending upon the material being evaporated.

The apparatus may also be used for dehydrating or concentrating operations by placing the liquid to be dehydrated or concentrated in the container **10** and proceeding in the same manner as in an evaporating operation. When the material has reached the desired degree of dehydration or concentration, it may be withdrawn from the container **10** by the pump **33**. Alternatively, where the material is dehydrated to complete dryness, the container **10** could be opened and the dried material removed therefrom in a batch process.

It will be apparent that in addition to the operations specifically described, the invention could be employed in any process wherein it is desirable to pump large volumes of vapors or similar fluids at low pressure and the specific uses enumerated above are intended only to be examples of those to which the invention may be applied.

FIGURE 2 illustrates an alternative form of ejector which may be used with advantage to provide somewhat improved efficiencies. In this construction, the ejector comprises an outer tapered casing **41** to provide it with a tangential inlet opening **42** adjacent to its large end and with a tapered nozzle **43** extending coaxially therewith. The nozzle is provided with a conduit connection **44** extending through the large end of the casing **41** for connection, for example, to the outlet of the pump **11**. The casing **41** tapers to a reduced throat **45** formed with a connecting flange **46** through which it may be connected to the diffuser chamber **19**.

In this construction, the nozzle has a helically twisted strip **47** therein to cause the fluid flowing therethrough to swirl in a counterclockwise direction viewed in the direction of flow of the fluid. Similar vanes or guide strips **48** are provided in the space between the nozzle **43** and the casing **41** to cause the fluid flowing through this space to swirl in the same direction.

In operation of this form of nozzle, the fluid flowing through both of the passages thereof will be caused to swirl at an extremely high angular velocity thus tending to produce a low pressure core at the center of the swirling vortex. As the swirling material enters the diffuser chamber, it expands outward radially thus tending to accent the low pressure existing at the axis of the vortex and increasing the effectiveness of the ejector so that a smaller quantity of high pressure fluid will be required flowing through the nozzle (outer annular space) to eject the same quantity of fluid flowing through the inner passage.

While two embodiments of the invention have been shown and described herein, it will be understood that they are illustrative only and not to be taken as a definition of the scope of the invention, reference being had for this purpose to the appended claims.

What is claimed is:

1. A low pressure exhauster comprising a container defining a space to be exhausted, a pump having an inlet and an outlet, a first conduit connecting the upper part of the space to the pump inlet whereby the pump will withdraw vapor therefrom and increase the pressure on the vapor, a jet ejector including two passages, a second conduit connecting one of the passages to the pump outlet to receive vapor under increased pressure therefrom, and a third conduit separate from the first conduit connecting the other of said passages directly to the space, discharge of the vapor under increased pressure through said one of the passages inducing flow of a larger volume of vapor from the space through the third conduit and the other of the passages.

2. A low pressure exhauster comprising a container defining a space to be exhausted, a pump connected to the space to withdraw vapor therefrom and to increase the pressure on the vapor, a jet ejector including two passages, a conduit connecting one of the passages to the pump to receive vapor under increased pressure therefrom, and a conduit connecting the other of said passages directly to the space, discharge of the vapor under increased pressure through said one of the passages inducing flow of a larger volume of vapor from the space through the last named conduit and the other of the passages, a condenser receiving the vapor from the jet ejector, and means for maintaining the condenser under subatmospheric pressure.

3. A low pressure exhauster comprising a container defining a space to be exhausted, a pump connected to the space to withdraw vapor therefrom and to increase the pressure on the vapor, a jet ejector including two passages, a conduit connecting one of the passages to the pump to receive vapor under increased pressure therefrom, and a conduit connecting the other of said passages directly to the space, discharge of the vapor under increased pressure through said one of the passages inducing flow of a larger volume of vapor from the space through the last named conduit and the other of the passages, a condenser receiving the vapor from the jet ejector, a second container receiving condensate from the condenser, and means to maintain the second container and the condenser under subatmospheric pressure.

4. The low pressure exhauster of claim 3 in which the last named means comprises a pump connected to the second container to pump condensate therefrom and a vacuum pump connected to the upper part of the second container to maintain a predetermined subatmospheric pressure therein.

5. In a cooling system, a first container adapted to contain a liquid to be cooled, a pump having its inlet connected to the upper part of the container to withdraw vapor therefrom and to compress the vapor, a jet ejector including two passages, a connection from one of said passages to the upper part of the container to receive vapor therefrom, a connection from the outlet of the pump to the other of said passages, a condenser receiving vapor discharged from the jet ejector and condensing it, a second container receiving condensate from the condenser, a connection from the second container to the first container to return condensate to the first container, the containers and connections forming a closed system, and a vacuum pump connected to said system to maintain a predetermined static pressure therein.

6. The system of claim 5 including means in the first container to circulate a fluid therethrough separate from but in heat exchanging relationship with the liquid in the first container.

7. In an evaporating system, a first container adapted to contain a liquid to be evaporated, a pump having its inlet connected to the upper part of the container to withdraw vapor therefrom and to compress the vapor, a jet ejector including two passages, a connection from the upper part of the container to one of said passages for flow of vapor therethrough, a connection from the outlet of the pump to the other of said passages to supply compressed vapor thereto, a condenser receiving vapor discharged from the jet ejector and condensing it, means to supply liquid to be vaporized to the first container, and means to remove condensate from the condenser under subatmospheric pressure.

8. In an evaporating system, a first container adapted to contain a liquid to be evaporated, a pump having its inlet connected to the upper part of the container to withdraw vapor therefrom and to compress the vapor, a jet ejector including two passages, a connection from the upper part of the container to one of said passages for flow of vapor therethrough, a connection from the outlet of the pump to the other of said passages to supply compressed vapor thereto, a condenser receiving vapor discharged from the jet ejector and condensing it, means to supply liquid to be vaporized to the first container, a second container receiving condensate from the condenser, a vacuum pump connected to the upper part of the second container to maintain a subatmospheric pressure therein, and a liquid pump connected to the lower part of the second container to withdraw condensate therefrom.

9. The evaporating system of claim 7 including means in the container to circulate a fluid therethrough separate from but in heat exchanging relationship with the liquid in the container.

10. The evaporating system of claim 8 including a control for the vacuum pump responsive to the pressure in the second container.

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