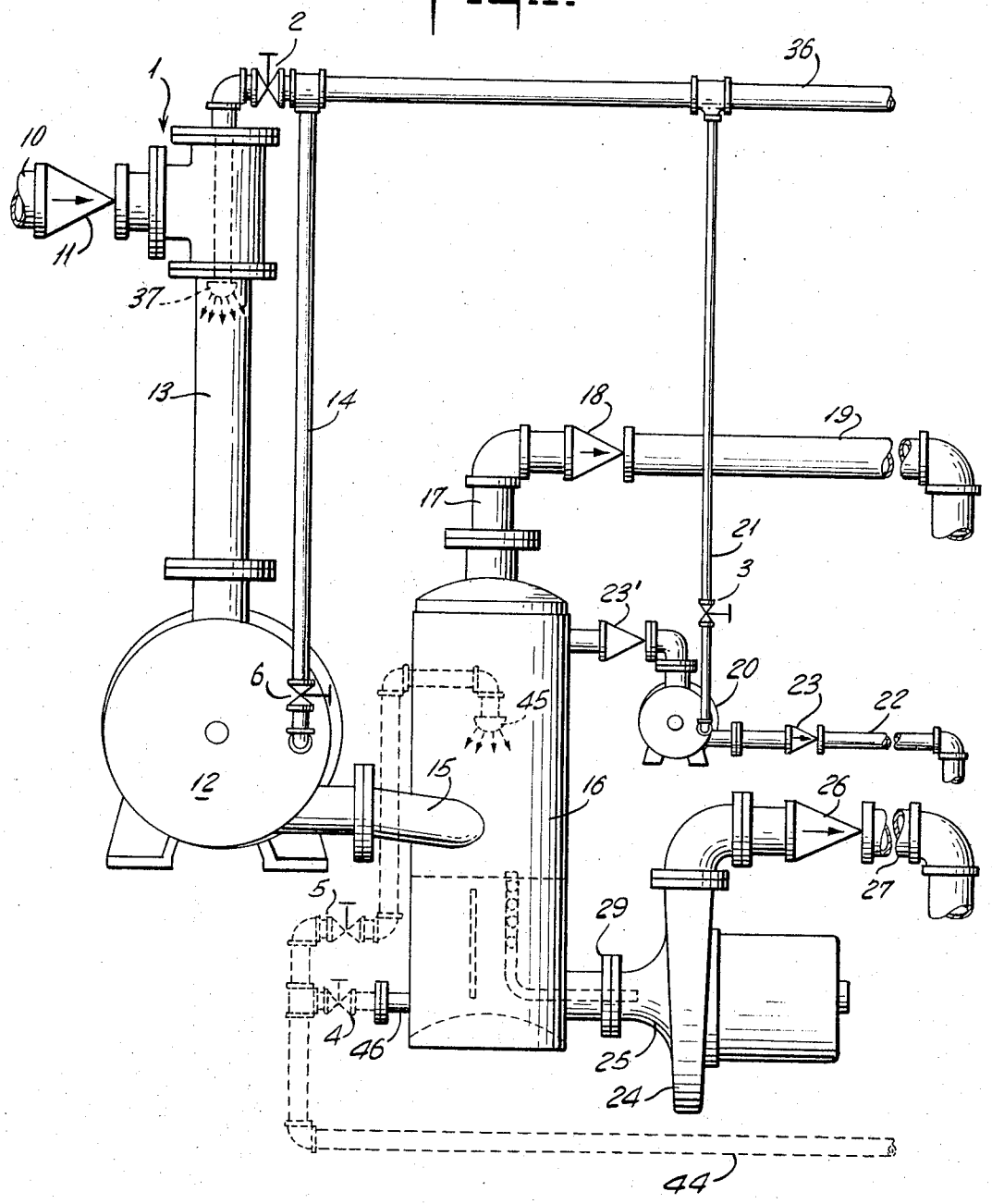
Jan. 30, 1968 H. E. ADAMS 3,366,061

DEVICE FOR PUMPING LIQUID AND GAS

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Fig. 1.



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Fig. 2.

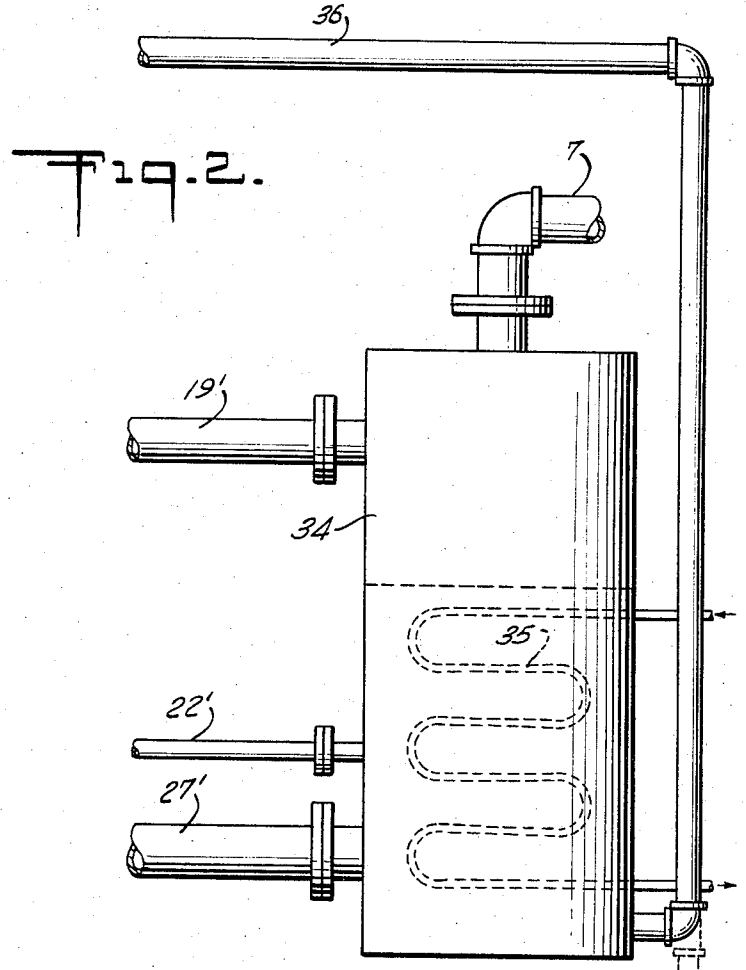
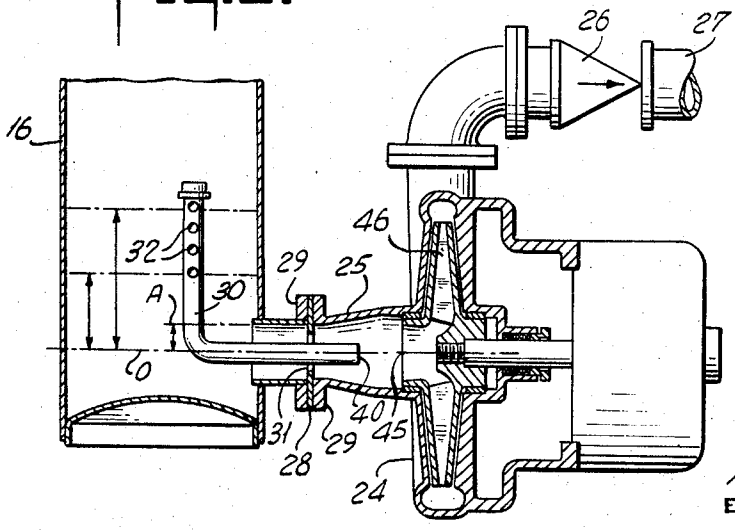


Fig. 3.



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DEVICE FOR PUMPING LIQUID AND GAS

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15 Claims. (Cl. 103—6)

This invention relates to the pumping of liquid, vapor and gas together in as expeditious and efficacious a manner as possible, and has particular reference to pumping for the purpose of producing a pressure, which is less than atmospheric, on the inlet side of the pump means involved.

In the use of steam for heating at low pressure, in power plant condensers, and with various stills and evaporates, as well as with cookers and other vessels which are periodically opened, it is necessary to rid the system being pumped of large volumes of fixed gas, such as air, and, once the bulk of such air has been removed, to continuously remove leaking or evolving gas, as well as vapor and liquid, such as steam and water.

What is required for such service is a system which can operate, over the range of atmospheric down to the vapor pressure of the water at the temperatures of the cooling medium employed if any. At the same time, the weight rate of gas, vapor and liquid required to be handled varies over a wide range, as does the percentage relationship of each phase to be handled.

Also, the system should be capable of operating with a minimum of supervision, and preferably without elaborate control mechanisms as the fluid pumping requirements change over the range for which it is designed.

In view of the above considerations, it is a primary object of the present invention to provide a pumping system which can efficiently handle gas, vapor and liquid phases over a wide range of pressures and percentages of the fluid handled.

It is a further object of the present invention to provide a pumping system capable of removing large volumes of air delivered at relatively high absolute pressure during the initial pumping down and of continuously purging air upon reaching the desired operating pressure.

Referring now to the drawings:

FIG. 1 is a view, largely diagrammatic, of a preferred system in accordance with the present invention;

FIG. 2 is a similar view of additional apparatus capable of addition to the apparatus of FIG. 1, for the purpose of conservation and recirculation of some of the fluids handled by the apparatus of FIG. 1; and

FIG. 3 is an enlarged view partly in section of part of the apparatus shown in FIG. 1, exhibiting in greater detail the construction thereof.

Referring specifically to FIG. 1, a line 10 is connected to the space from which it is desired to remove water, vapor and gas, as for instance, a heating system, a condenser or larger cooker or evaporator. A check valve 11 permits flow in the direction of the arrow but prevents flow in the opposite direction. An inlet T 1 connects line 10 to the inlet line 13. In order to produce such flow, a pump 12 of the liquid ring type is connected by line 13 to communicate with the check valve 11. This pump 12 is supplied with water for cooling and operating purposes through line 14 and adjusting supply valve 6.

The discharge of pump 12 is through line 15 to an interstage separator 16, and the vapor and gaseous components are discharged through line 17 and check valve 18 to the line 19. In addition, a second-stage pump 20, which is also preferably of the liquid ring type, may be provided to evacuate the separator 16. This pump draws gas and vapor through check valve 23'; and is also supplied with water for operating and cooling purposes through line 21 and valve 3, and discharges through line 22 past the check valve 23. It will be noted that the pump 20 is of considerably less capacity than the pump 12, for a reason which will appear later.

In order to withdraw the liquid from separator 16, a centrifugal pump 24 is provided, having an inlet 25 connected to the lower part of the separator 16, and discharging past the check valve 26 to the line 27. For a purpose which will later appear, the inlet 25 is modified from conventional structures as shown in detail in FIG. 3. A restriction is formed in the inlet by any suitable means, perhaps the simplest being an orifice plate 28 between the coupling flanges 29, although, if desired, a more elaborate structure, such as a throat is perfectly feasible. Supported within the inlet 25 is an L shaped tube or inlet moderator 30 having a horizontal run extending downstream of the orifice 31 of the plate 28, and terminating in the immediate proximity of inlet eye 45 of the impeller 46. The vertical run of tube 30 extends upwardly into the separator, and is preferably plugged or closed at the top, as by a cap. A series of perforations 32 is provided in the walls of the tube for a purpose also to appear later.

For the purposes of one aspect of this invention, the lines 19, 22 and 27 could discharge to waste, air and vapor, leaving the system through the line 19, and lines 22 and 27 discharging liquid as well. In certain installations, especially large ones, this arrangement is preferably modified by connecting the lines to a closed vessel for conserving the water to permit recirculation thereof. Such a vessel can also be provided with cooling means. In FIG. 2 there is shown such a vessel 34, with lines 19', 22', and 27' corresponding to lines 19, 22 and 27, in proper relation to discharge the contents of the separator to the vessel 34. Cooling means for the vessel contents, indicated by the coils 35, may also be provided. It will be noted that lines 14 and 21, which require a supply of water for operation and cooling of the pumps 12 and 20, can be conveniently supplied from the common line from vessel 34. The air separated out of the mixture is discharged to the atmosphere through line 7.

The line 36, along with adjusting supply valve 2, may also be utilized to provide cooling water to a condensing spray head 37, located upstream from the inlet of pump 12, in order to condense the influx to the pump, as much as possible, which will become clearer as the description proceeds.

Referring to FIGS. 1 and 2, if the assemblage of machines above described is considered as connected to any space which is periodically to receive and condense vapors, such as a condenser the operation can now be described in detail. In starting up, the space connected to the line 10 is ordinarily full of air or other fixed gases which must be removed to permit the influx of vapor. Accordingly, the pump 12 is started in operation, together with pump 24, and removes air through line 10 and 13, discharging it to the separator 16. Any water coming down line 10, together with the cooling water supplied through the line 14, is also discharged by the pump 12 into the separator 16. The air or gas leaves the separator through check valve 18, flowing either to the atmosphere or through line 19 to the cooler 34. The liquid leaves the separator through the pump 24, being ejected past the check valve 26 to waste or to the cooler 34 via the line 27.

During this first hogging operation, the pump 24, purposely made oversize, could readily withdraw all of the water from separator 16, which would result in the cessation of pumping by pump 24, except for the special arrangements shown in FIG. 3. Or, to be more precise, the fall of the water level to below line A would cause the pump 24 to gulp air, lose its prime, until the static head

became great enough to again fill the eye of the pump and repeat this cycle. This, of course, has a destructive effect on the pump and its drive, and even on the associated piping.

Because of the orifice 31, the exit end 40 of the tube 30 is located in a region of lower pressure than that prevailing in the separator at point O. Accordingly, as the pump 24 lowers the level of the water to uncover one of the holes 32, the water within the tube 30 is immediately drawn into the inlet of the pump, and air flows down the tube and into the pump inlet. However, because of the relatively small size of the tube and its central position, this air becomes entrained in the liquid passing into the eye of the impeller in what might be called an effervescent manner, and the bubby liquid passes to the passages of the impeller without any suggestion of shock characteristic of slugs of water separated by slugs of air.

However, because the air-water mixture has a lower density than water alone, the net result is to decrease the pumping capacity of the pump 24. This decreases delivery, and thus lowers the rate of withdrawal of water from the separator 16. If this decreased delivery is sufficient to prevent further lowering of the level of water in the separator the level will stay there, but if not, a second opening in the tube 30 will be uncovered, and so on until enough openings are uncovered so that the air entrained in the pump input decreases delivery enough to halt lowering of the level in the receiver. It will be understood, of course, that changes in the rate of delivery of water into the separator will be accompanied by a rise and fall of the water in the separator which will cover and uncover openings in the tube and automatically regulate the rate of withdrawal of water by the pump 24 to that delivered by the pump 12.

After pumping down has proceeded for a time, the pressure at the inlet of the pump 12 will have fallen considerably. At this point, the pump 20 may be started in order to lower the pressure within the separator to below atmospheric. When this is done, the check valve 18 closes, and air is delivered through line 22 and water through pump 24 as above described.

As the pressure at 10 is lowered, vapor will begin to appear at this point. It then becomes advantageous to deliver water, preferably as cool as possible, through line 36 and valve 2 to the spray head 37, to condense as much as possible of the vapor. At the same time, the partial pressure of the air at 10 will have decreased considerably. Under these conditions, the partial air pressure within the separator will have fallen to a relatively low value.

It is a characteristic of liquid ring pumps that if there is a relatively small amount of gaseous matter to be pumped, a large volume of liquid can pass through them without overloading. Accordingly, the volume of water coming from the spray head and through the line 14 can be increased, to increase as much as possible the effective condensation of vapor before it reaches the pump and as it passes therethrough to the slightly higher pressure obtaining in the separator.

Under such conditions of operation, the pump 24 and the tube 30 cooperate with the pump 12 in a particularly effective manner. The centrifugal pump 24 readily removes the large quantity of water delivered by the pump 12 from the line 10, the condenser spray 37 and the line 14. At the same time, the relatively small amount of air coming into the separator is readily removed by entrainment through the tube 30.

It should be noted at this point that the pump 20 cannot reduce the pressure within the separator 16 to as low a value as can centrifugal pump 24 operating with an effective air withdrawal action, because centrifugal pump 24 is more effective than pump 20 when operating at a large pressure differential and handling a relatively small amount of air. Under such conditions, the pump 20 can be shut down.

Despite the fact that under conditions of low pressure in the separator 16 and a low partial air pressure at line 10,

the pump 12 is capable of handling a large amount of water, which, as has been set forth above, can be withdrawn by the centrifugal pump 24, a further increase in the efficiency of the system can be obtained by adding water to the separator without passing it through the pump 12. For this purpose, the line 44, shown in dotted lines, may be provided. Water controlled from this line by valve 4 can be added through inlet 46 to the bottom of separator 16 and/or by valve 5 to a spray nozzle 45 placed in the upper part of separator 16, in the event that the efflux from pump 12 is insufficient to properly entrain the air coming from the line 10, or for the purpose of lowering the vapor pressure in the separator to a minimum.

What is claimed is:

1. A system for removing gas, and vapor from a space comprising a liquid ring pump connected to the space and discharging gas, vapor and liquid into a receptacle, a centrifugal pump withdrawing liquid from the receptacle, and means entraining gas in the receptacle with the discharge to the centrifugal pump.

2. A system for evacuating a space containing gas, and vapor including a first pump connected to the space, a source of liquid for the pump, a receptacle for receiving the gas, liquid and vapor discharge of said pump, a second pump of a capacity greater than the rate of delivery of liquid by said first pump, and means responsive to the amount of liquid in said receptacle injecting gas and vapor from said receptacle into the inlet of said second pump to thereby limits its liquid discharge.

3. The system of claim 2 in which the decrease in height of liquid in the receptacle causes an increase in the flow rate of gas and vapor into the inlet of the centrifugal pump.

4. A system for evacuating a space containing gas and vapor including a first pump connected to the space, a source of liquid for the pump, a source of liquid for injection upstream of the pump, a receptacle for receiving the discharge of said first pump, a second pump for removing liquid from said receptacle, means producing a region of reduced pressure at the inlet of said second pump, a conduit within said receptacle opening into said region and having an opening above the inlet of said second pump, to cause injection of gas or vapor into said second pump inlet upon lowering of the liquid level in the receptacle to said opening.

5. A system for removing gas and vapor from a space comprising a receptacle, a first pump delivering gas, vapor and liquid to the receptacle, a second pump for removing gas and vapor from said receptacle, a third pump adapted to remove liquid from the receptacle, a restriction in the inlet of said third pump, and means forming communication between point downstream of said restriction and the space within said receptacle above the liquid therein.

6. The system of claim 5 in which the communication is of an effective cross section which increases the gas and vapor flow to the third pump as the level of the liquid falls in the receptacle.

7. A system for removing gas and vapor from a space including a first pump connected to the space, a receptacle connected to said first pump to receive the discharge thereof, a second pump operatively connected to the receptacle for removing liquid therefrom, a container having cooling means, means connecting the discharge of said second pump to said container, means connecting the upper part of the receptacle to the container for flow of gas and vapor therebetween, and means preventing flow of gas and vapor from the container to the receptacle.

8. The system in accordance with claim 2 wherein said first and second pumps are a liquid ring pump and a centrifugal pump respectively.

9. A system in accordance with claim 4 wherein said first and second pumps are a liquid ring pump and a centrifugal pump respectively.

10. The system in accordance with claim 5 wherein said first and second pumps are liquid ring pumps and said third pump is a centrifugal pump.

11. The system in accordance with claim 5 wherein said second pump is of a smaller capacity than said first pump.

12. A system in accordance with claim 7 wherein said first and second pumps are a liquid ring pump and a centrifugal pump respectively.

13. The system in accordance with claim 2 including vapor condenser means acting on the vapor evacuated from the space at a point upstream of the input of said first pump.

14. An arrangement for removing liquid from a receptacle at rates equal to a varied inflow comprising a pump having a capacity larger than the maximum inflow rate to the receptacle, said pump having the inlet thereof connected to said receptacle, a restriction in the length of said inlet and automatic pump regulating means having a first section in communication with the inlet downstream of said restriction and a second section having a plurality of vertically spaced means disposed in the receptacle above

the inlet of said pump, whereby the said pumping capacity of said pump decreases upon a lowering of the liquid level in said receptacle.

15. The arrangement of claim 14 wherein said regulating means is a conduit having a plurality of vertically spaced openings in a wall of the second section thereof.

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