June 23, 1953 F. B. DOYLE 2,643,052

THREE-STAGE CONDENSER

Filed March 23, 1949

Fig. 1.

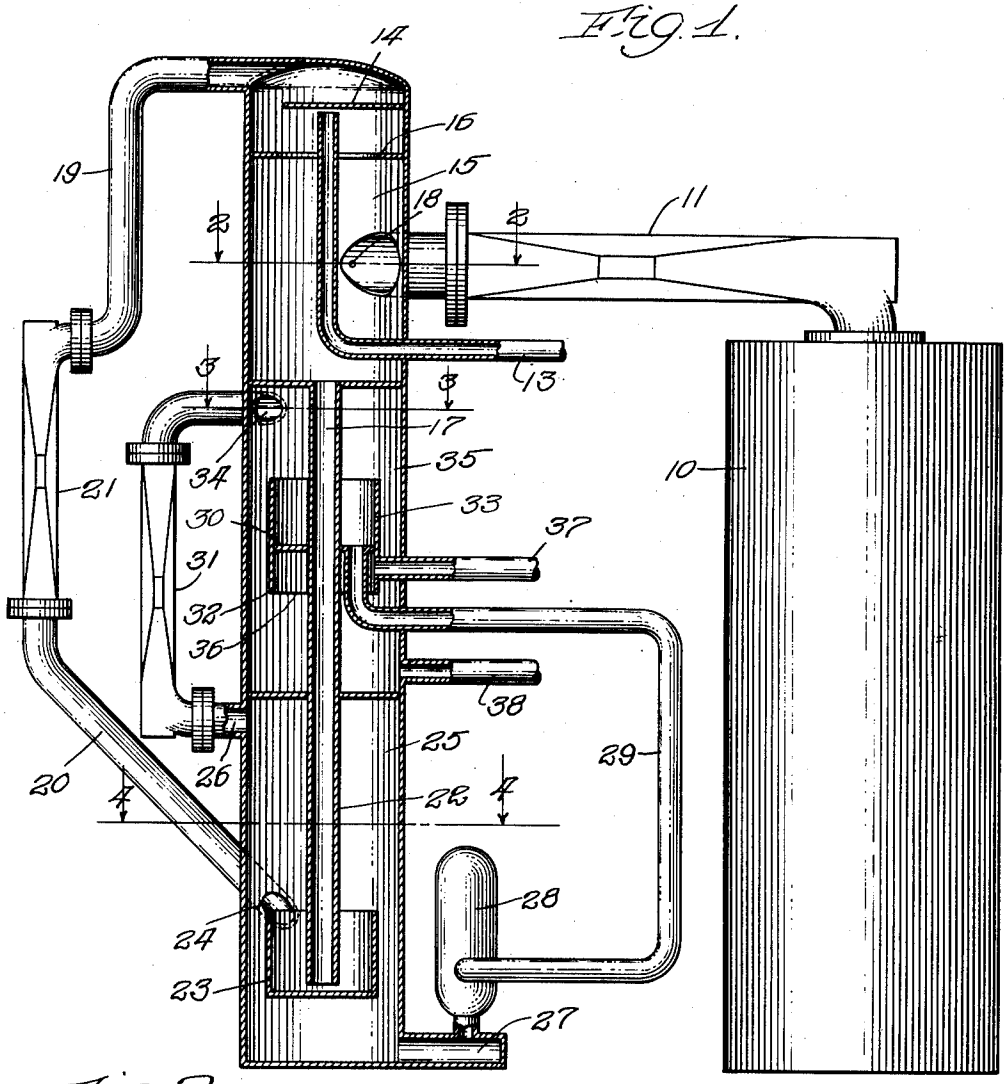


Fig. 2.

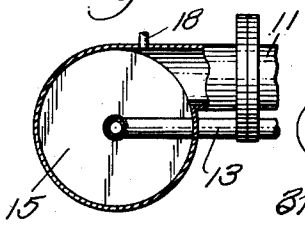


Fig. 3.

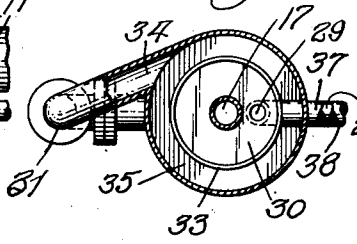
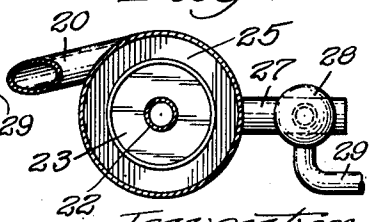


Fig. 4.



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Patented June 23, 1953

2,643,052

UNITED STATES PATENT OFFICE

2,643,052

THREE-STAGE CONDENSER

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Application March 23, 1949, Serial No. 82,963

12 Claims. (Cl. 230—104)

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This inventon relates to a multiple stage condenser and more particularly to a three stage condenser adapted to be contained within a single housing and to employ a single condensing fluid passing sequentially from one chamber to the next and communicating sequentially with the stages of a multiple ejector system.

The processes described in Merriam and Wiles Patent No. 2,080,179, issued May 11, 1937, require the handling of large quantities of condensable gas and the establishment of high vacuum within a very short period of time. Previous to this invention these results have been accomplished by the use of multiple stage steam evacuation systems. There are usually three stage steam ejectors. The first stage communicates directly with the chamber to be evacuated and is capable of establishing vacuums therein as low as 0.1 of an inch of mercury absolute or less. The steam from this ejector is, of course, directed to a water condenser. The pressure in the condenser will vary according to the temperature of water available from as low as about one inch up to as much as two inches or slightly more. Normally it is considered that a condenser chamber design for two inches is substantially correct.

The second stage ejector takes the material which is not condensed within this chamber and increases the pressure thereon generally to around four to six inches of mercury absolute. These materials are passed to a second condenser chamber where the pressure is of that order.

Material not condensed in the second condenser chamber passes through a third stage steam ejector where the pressure is raised to substantially atmospheric or slighty above. Gases coming from the third stage ejector are passed to a third condenser chamber having a substantially atmospheric pressure, but normally slightly above. Effluent gases from this chamber are normally passed to the atmosphere.

More steam ejection stages may be employed if desired, but three are sufficient for most purposes.

In the past a separate condenser has been employed in general for each stage of the ejector system, using individual water connections. Usually one or more barometric legs are employed to draw off liquid from the condensing system. The necessity of employing a barometric leg introduces space and layout requirements which are frequently burdensome.

The present system provides a single integrated condenser system which is capable of using a single supply of water introduced to the first condenser chamber and then passed to the second and from there to the third condenser chamber. No barometric leg is required. The resulting preferred form provides a compact chamber which may be placed in almost any limited space. As will be shown, the preferred form provides a single casing within which the three condenser chambers are mounted one above the other, the first chamber being on top, the second on the bottom and the third in the middle. Drain water flows from the first to the third chamber by gravity and is pumped from the third to the second by suitable mechanical means.

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The invention is illustrated in the drawings in which:

Figure 1 is a side elevation partially in section of the evacuation system. This figure is somewhat diagrammatic since the steam connections, being conventional, are not shown in order that the device may be clearly understood. Figure 2 is a horizontal section taken along the line 2—2 in Figure 1; Figure 3 is a similar view taken aolng the line 3—3 in Figure 1; and Figure 4 is a similar view taken along the line 4—4 in Figure 1.

These three views illustrate respectively the horizontal sections of the first, third and second condenser chambers.

As shown in the drawings, the ejector system communicates with a chamber 10 which is to be evacuated to the desired extent. The first stage steam ejector 11 communicates through an opening with the vacuum chamber. The operation of a steam ejector is well known and is not here claimed. Therefore, the steam connections to the various steam ejectors are not shown since they would merely complicate the drawings. However, of course, each steam ejector is provided in conventional form with the necessary steam connections and valve controls therefor. In actual operations automatic controls for pressure temperature and other conditions are provided at appropriate points in the system.

While the entire invention is here discussed as applied to a steam ejector system, the principle may be applied to systems wherein other condensable gases are empoyed as the evacuating force.

The effluent gases from the first stage ejector enter the first condenser chamber 15 tangentially as indicated in Figure 2. Condensing water is supplied to this chamber through the line 13 which passes centrally upwardly through the chamber 15 and terminates immediately below a plate 14. Inasmuch as the water is under pressure and the chamber is under a substantial vacuum, one of about one to two inches of mercury

absolute, the water enters with considerable force and impinging upon the plate produces an umbrella shaped sheet which then impinges upon the wall of the chamber. The fluid loses most of its velocity in the turbulence thus created and falls to the ring 16 which is in the upper part of the condenser chamber. From the ring 16 the water falls in annular sheets into the tangential stream of effluent gases. These gases are, of course, normally steam and non-condensable gases, such as air. When the fluid entering is entirely steam, the efficiency of the system shown is so great that the water leaving the chamber through the drain 17 at its bottom may have a temperature higher than that corresponding to the boiling temperature of water at the pressure measured at the point 18 in Figure 2. In the art this is known as a negative approach. It has heretofore been the aim of the art to accomplish a zero approach and even that is seldom accomplished. A negative approach is believed to be an entirely new result.

Uncondensed steam and non-condensable gases from the first condenser chamber pass through the line 19 to the second stage steam ejector 21 wherein additional steam is used as a propelling force to increase the pressure and direct the gases through the line 20 to the second condenser chamber 25. The water from the first condenser chamber passes through the drain 17 down the pipe 22 to a reservoir 23 maintained somewhat above the bottom of the chamber. This reservoir is maintained full of liquid and, of course, a sufficient head of liquid is maintained within the pipe 22 to balance the pressure difference between the first and second condensing chambers. In actual practice using a pressure of one to two inches in the first chamber and four to six inches in the second chamber it has been found that a pipe approximately five feet long is satisfactory and water is the condensing medium.

The effluent gases from the second stage ejector 21 enter the second condenser chamber through the opening 24 and are directed tangentially in to the chamber as shown in Figure 4. The reservoir 23 and the outlet 24 are so arranged that the gases passing through the condenser chamber will pass through the waterfall of liquid overflowing the reservoir 23. After passing through this waterfall the gases exit through the opening 26 and pass to the third stage steam ejector 31 within which the pressure is increased by the compulsion of added steam, the pressure being brought to substantially atmospheric at the discharge point 34 within the third stage condenser chamber 35.

The water overflowing from the reservoir 23 is collected at 27 and driven by suitable mechanical means such as the pump 28 through the line 29 into the overflow pot 33. This pot comprises a vertical ring member 32 and a horizontal dividing member 30 near the middle of the ring. The plate 30 divides the ring into the reservoir section 33 and a baffle portion 36 through which the out gases pass in order to reach the exit opening 37.

The water in the overflow pot overflows into an annular waterfall on the outside of the ring 32 and thus provides good contact for gases exiting from the third stage ejector 31. The overflow pot also provides a sealing reservoir in case the pump should pump itself dry.

The cooling water ultimately exits through the line 38. During the travel through the condenser system the temperature of the water increases according to the heat load in the valve sections of the condenser system. If the incoming cooling water is approximately 75° F., the heat loads usually supplied by the ejector when used in a process for moistening tobacco will cause the exit chamber to be 105° F. The exit temperature from the second chamber is approximately 115° F. and from the third chamber 150° F. These figures are well within the margin of safety required in connection with the discharge pressures from the valve stages.

One of the advantages of the system is the short path of non-condensables in the first condensing zone 15 to the drawing off line 19. The chamber is free from the usual baffle plates, water condensers, weir boxes and restricted flow areas. For this reason the chamber has a very low pressure drop of friction loss. Indications are that this is less than one inch of water for normal air loads. In theory such obstructions are provided in order to control the outgoing gases. In the present system it is found that better results are obtained without the obstructions and, of course, the cost of construction is much less without them.

In normal steam evacuation systems as usually operated, evacuation is continuous. Consequently, the air removing equipment is small and air velocity through the condenser is low. In the present case the machine is designed to accommodate batch operation in which large volumes of air are moved at some times and small ones at others. The equipment is, therefore, built for high air velocities.

The foregoing detailed description is given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

I claim:

1. In an ejector system having at least three successive stages of evacuation, a three chambered condenser system, the chambers of which are connected sequentially to the outlets of the first, second and third stages of the ejection system and are provided with a single source of condensing liquid; an inlet for said liquid to the first condenser chamber, drain means below said inlet means for said liquid passing directly to the second condenser chamber, mechanical means for carrying said liquid from the second to the third condenser chamber, and means in each chamber for securing contact between said liquid and gas passing through said chamber.

2. A system as set forth in claim 1 in which the first condenser chamber is above the second condenser chamber and liquid passes from one to the other by gravity.

3. A system as set forth in claim 1 in which the first condenser chamber is above the second condenser chamber and liquid passes from one to the other by gravity and in which a sealing pool is maintained within the second chamber within which said drain is adapted to be sealed.

4. In an ejector system having at least three successive stages of evacuation, a three chambered condenser system, the chambers of which are connected sequentially to the first, second and third stages of the ejector system and are provided with a single source of condensing liquid; said three condenser chambers being arranged within a single shell and vertically superimposed above each other, the first chamber being at the top, the second chamber at the bottom and the

third chamber intermediate between the two; an inlet for said liquid to the first condenser chamber, drain means for said liquid passing directly to the second condenser chamber, mechanical means for carrying said liquid from the second to the third condenser chamber, and means in each chamber for securing contact between said liquid and gas passing through said chamber.

5. A three stage condenser system comprising three condenser chambers provided with a single source of condensing liquid, the first chamber being above the second, a condensing liquid inlet to the first chamber, gravity drain means for draining the liquid from the first chamber to the second chamber, mechanical means for withdrawing liquid from the second chamber and forcing it into the third, means for supplying steam and non-condensable gases to the first condenser chamber and means for taking the gases from the first chamber and passing them sequentially through the second and third chambers.

6. In a three stage evacuation system, a condenser system having a series of at least two chambers one of which is connected to the first stage of evacuation, the second of which is connected to the second stage of evacuation and to the third stage of the evacuation system, a single source of condensing liquid for said chambers having an inlet into the first chamber and an outlet from the last chamber of the series, open drain means in the first chamber for passing liquid directly to the second chamber, means in the second chamber for liquid sealing said open drain, the overflow level of the open drain in the first chamber being below the connection between the chamber and the first stage of the evacuation system.

7. A system as set forth in claim 6 in which the two chambers are directly superposed.

8. A system as set forth in claim 6 in which the seal in the second chamber is independent of the connection of the second stage of the evacuation system with said chamber.

9. A system as set forth in claim 6 in which the parts are constructed and arranged so that the temperature of the liquid entering the open drain is higher than that corresponding to the boiling temperature of water at the pressure as measured at the connection of the first stage of the evacuating system to the first chamber.

10. A system as set forth in claim 6 in which the drain is vertical and is of sufficient height to balance the pressure difference between the first and second chambers.

11. A system as set forth in claim 10 in which the drain pipe is approximately five feet long.

12. A three stage condenser system comprising an upright shell of substantially circular cylindrical form, means for dividing the shell into a plurality of superimposed condenser chambers each having gas inlet and gas outlet openings, the first chamber being in the top, the second in the bottom and the third interposed between the two, means passing through the third chamber for passing liquid from the first chamber to the second chamber, means associated therewith for maintaining a sealing pool of liquid in the second chamber, means for pumping liquid from the second chamber to the third, means within the third chamber for maintaining a sealing pool of liquid therein and shaped and positioned to provide an annular curtain of liquid through which gases to be condensed must pass, and means for supplying liquid to the first chamber and withdrawing it from the third chamber.

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