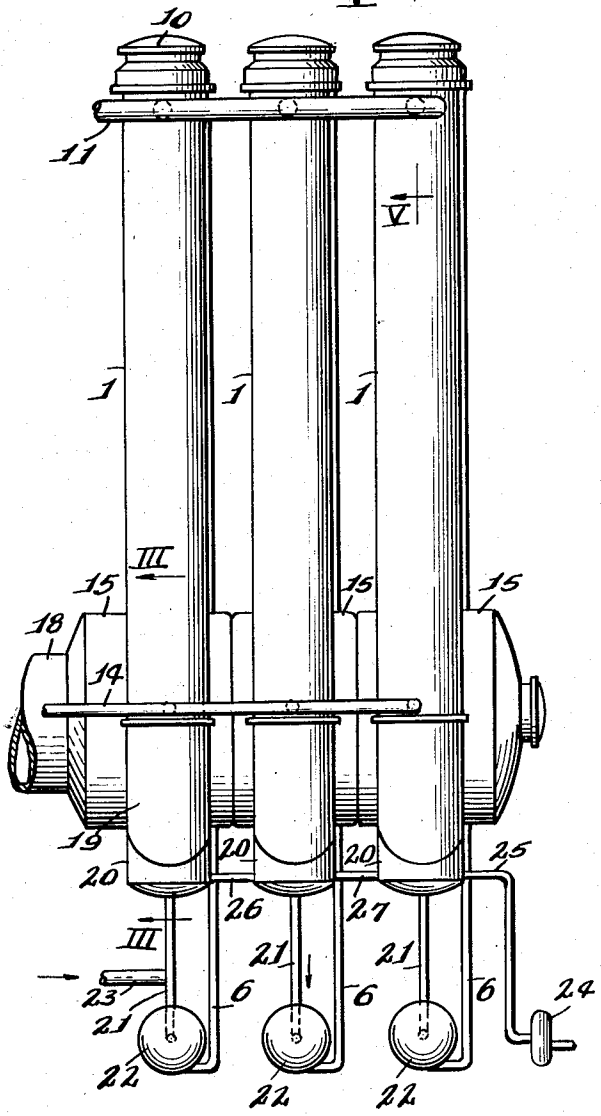
March 23, 1954 J. A. CROSS 2,672,926

EVAPORATOR

Original Filed Sept. 9, 1946 3 Sheets-Sheet 1

Fig. 1.



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EVAPORATOR

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Fig. 2.

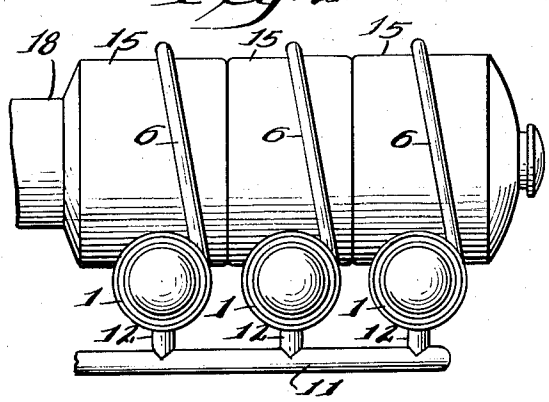
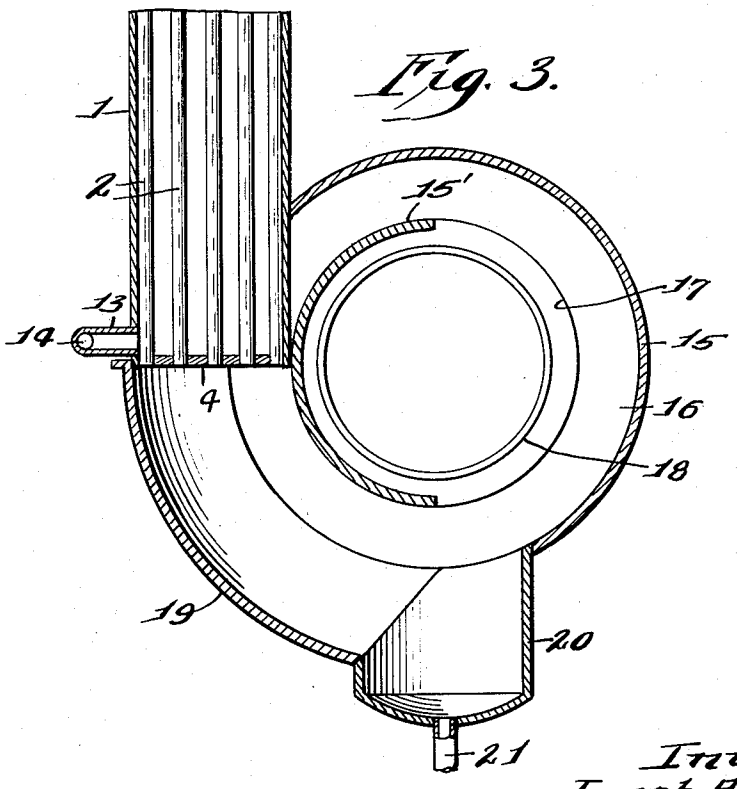


Fig. 3.



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Fig. 4.

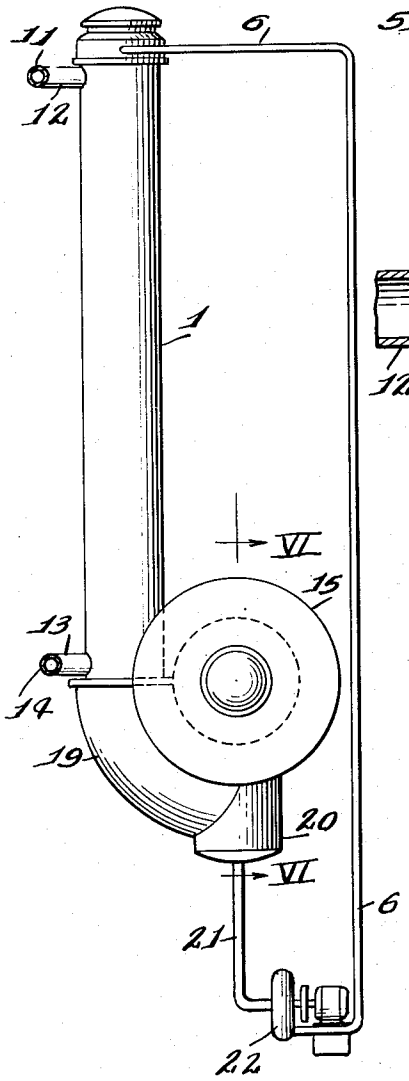


Fig. 5.

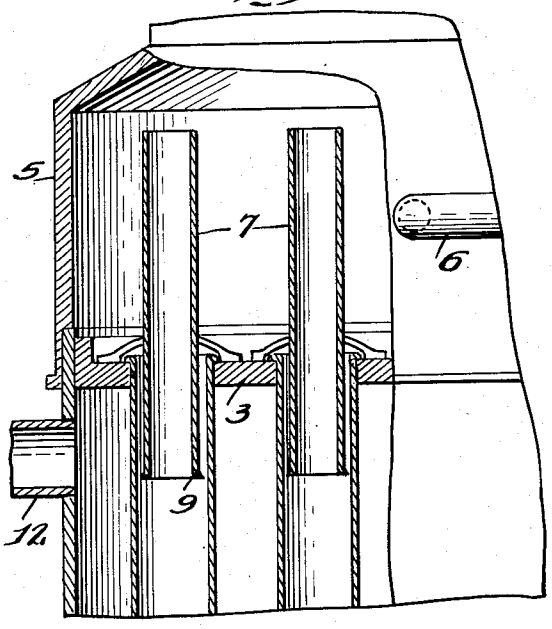
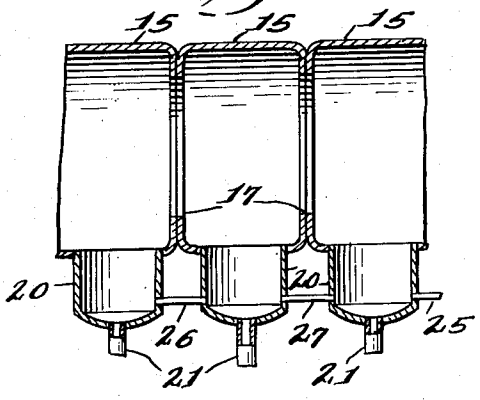


Fig. 6.



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UNITED STATES PATENT OFFICE

2,672,926

EVAPORATOR

Joseph A. Cross, Westerville, Ohio, assignor to Mojonnier Bros., Inc., Chicago, Ill., a corporation of Illinois

Original application September 9, 1946, Serial No. 695,641. Divided and this application September 28, 1951, Serial No. 248,748

3 Claims. (Cl. 159—13)

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This application is a division of my co-pending application Serial Number 695,641, filed September 9, 1946 now Patent No. 2,570,211.

This invention relates to evaporators and particularly to those designed for continuous rather than batch operations.

A feature of the invention resides in the provision of multi-stage evaporation, not according to the usual multiple effect wherein the hot vapors of one stage heat the liquor in the next, but rather by maintaining segregated bodies of liquor of different densities heated from a common heat supply source and connected to a common vapor exhaust.

While the apparatus is suitable for evaporation at various pressures and temperature levels, it offers especial advantages at the low temperatures obtainable under vacuum.

One of the objects of the invention is to provide evaporation apparatus suitable for continuous operation and using tubular evaporators of the falling film type.

Another object of the invention is to provide a multi-stage evaporator system in which the liquor progresses through connected bodies of the liquor maintained at different densities and subjected to evaporation by heat supplied from a common source of condensible vapor.

Other objects and advantages of the invention will be apparent from a perusal of the following specification wherein a preferred and a modified embodiment of the invention are described.

In the drawings:

Figure 1 is a side elevation of an evaporator made in accordance with this invention;

Figure 2 is a top plan view of the same evaporator;

Figure 3 is a sectional view on the line III—III of Figure 1;

Figure 4 is an end view of the evaporator;

Figure 5 is a partial sectional view of one of the elements of the evaporator taken on the plane of line V—V of Figure 1; and

Figure 6 is a partial sectional view taken on the plane of line VI—VI of Figure 4.

Referring first to Figs. 1 to 6 of the drawings, the evaporator is comprised of an assembly of substantially identical units interconnected in order to afford a system of multi-stage evaporation. Each unit includes a vertical tube chest such as the chest 1. Each tube chest contains a plurality of tubes such as 2 held in the upper and lower tube sheets indicated as 3 and 4, in Figures 5 and 3, respectively. The upper ends of the tubes open into a chamber 5 at the top of each tube chest,

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into which the liquor to be evaporated is introduced by means of a pipe 6.

As stated before, the evaporator units are of the falling film type. Accordingly, in order to feed the liquor into the evaporator tubes in the form of films, I provide a removable tube 7 inserted into the top end of each evaporator tube 2, and supported by spiders 8 which may be welded or otherwise secured to their outer surfaces, the three or more legs of the spiders resting upon the upper tube sheet 3. The lower end of each tube 7 is flared out at 9 to restrict and deflect the downwardly flowing liquor against the tube walls. The rate of flow of liquor into the tubes 2 of each evaporator may be varied by increasing the depth of the body of liquor maintained above the upper tube sheet 3, by regulating the rate of delivery of liquor through the pipes 6 into the chambers 5. The static head thus will determine the rate of flow of the film and may be controlled to assure the maintenance of a film in each tube to its bottom end. Of course, overflowing the top of the tubes 7 is to be avoided. The top of each chamber 5 will be closed by a cap 10.

The heating medium, such as steam, a refrigerant gas, or other condensible vapor is preferably introduced into the upper portion of each tube chest from a common supply pipe 11 connected with an individual supply pipe 12 leading to each tube chest. The condensate which may be drained from the space around the tubes at the bottom of each tube chest may be withdrawn from each tube chest through a pipe 13 into a common pipe 14.

Directing attention now to the construction at the lower end of each tube chest, it will be noted that a generally cylindrical device is associated with each of the tube chests at their lower ends. These devices are a series of drums 15 having abutting inwardly extending flanges 16 which preferably will be welded together. These flanges do not extend across the entire diameter of each drum but instead are apertured at 17 thus providing a common passage through which vapors from the evaporating liquor may be withdrawn rapidly from the respective drums and tube chests to a common duct or pipe 18. At the bottom end of each tube chest is a curved hood 19 which opens into the adjoining drum 15 and also into the associated sump 20, there being one such hood and one such sump for each tube chest.

Each chamber 15 preferably will have an arcuate baffle 15' secured to the margin of opening 17, which will assist in imparting centrifugal motion about a horizontal axis to the vapors and

prevent their more direct escape through the ports 17. Thus, the vapors being extracted from the falling film of liquor are deflected in a circular path from the lower open ends of the tubes into the related drums 15, while any unvaporized liquor is allowed to fall through the hood 19 into the sump 20.

As indicated, there is connected with the bottom of each sump a pipe 21 leading to a pump 22, each pump being preferably driven by an electric motor and delivering its output to a riser pipe 6, which as noted before delivers the liquor into the chamber 5 at the top of each tube chest.

The fresh dilute liquor to be evaporated will be introduced through a pipe 23 into the down-flow pipe 21 of the first evaporator unit where it will be drawn through the pump 22 and thence delivered upwardly through the riser pipe 6 into the top of the first evaporator chamber 5. It is contemplated that some of the liquor will recirculate through the first evaporator unit many times as the vapor is being extracted from it in the falling film tubes.

A draw-off pump 24 connected with the draw-off pipe 25 maintains a continuous discharge of concentrated liquor from the last evaporator. Between the first and second units, that is, connected with their sumps, is a pipe 26 and between the sump of the second unit and the sump of the third unit is another pipe 27. The operation of the draw-off pump and the feed of fresh liquor through the pipe 23 will therefore induce a continuous flow of liquor from the first unit to the second and from the second to the third and from the third to the draw-off pump or to such other units as may be connected between that point and the draw-off pump.

While three connected units are shown in the evaporator herein described, it is contemplated that as many as are necessary for high output and efficiency of operation will be employed. In view of the fact that the units are identical in construction, the cost of manufacture and assembly is thereby simplified. Also, the use of identical units simplifies the determination of ideal operating conditions and facilitates the determination, by experiment or by calculation, of the number of units required for the most efficient operation on any proposed installation.

The operation of the device, briefly, is as follows:

Fresh liquor is supplied through a pipe 23 to the down-flow pipe leading to the pump connected with the first unit. This liquor along with other liquor already in the system is delivered to the top of the first unit and under the controlling effect of the static head and the tubes 7 will cause a film of the liquor to flow downwardly along the entire inside of each of the tubes in the first unit. While liquor is being recirculated through the falling film unit the vapor released from the films flows from the lower ends of the tubes into the vapor separation drum. The circular motion imparted to the vapor will cause entrained droplets to sweep along the walls of the drum and fall back into the sump of each drum while the vapor, free from droplets, may be evacuated through the vapor outlet pipe 18.

The rate of evaporation will be highest in the first unit and lowest in the last evaporator unit. As a result the second unit will be operating on a liquor of considerably higher density than the fresh liquor introduced into the first unit. The liquor flowing from the second unit to the third unit will have an even higher density, and during its recirculation and subjection to evaporation in the third unit may be caused to attain the final desired density. The rate of withdrawal of liquor through the draw-off pipe 25 will be maintained at such a rate as to make certain that liquor of the desired density only is withdrawn.

It is clear that a large number or a small number of identical units may be connected in series, as described, in order to obtain a desired concentration under efficient operating conditions.

As stated hereinbefore, the present invention is especially suitable for evaporation of liquors at low temperatures such as are made possible by evaporation under vacuum. In such case, suitable equipment is connected with the vapor outlet pipe 18, that is, such as pumps or condensers or both, to maintain as high a degree of vacuum in the vapor space within the drums and within the tubes as may be desired.

Obviously, the means for evacuating the vapors will be suited to whatever vapor pressures, positive or vacuum, prevail in the system. Variable speed pumps, valves, or other devices may be employed for maintaining uniform or providing variable operating conditions.

While I have shown and described herein, for illustrative purposes, a preferred embodiment of the invention, it should be understood that considerable variation in the details of construction may be employed without departing from the spirit and scope of the invention, as defined in the following claims.

I claim as my invention:

1. An evaporator comprising a vertical tube chest having vertical tubes and top and bottom plates retaining said tubes, an inlet port for admission of heating fluid into the space surrounding the tubes and an outlet port for said fluid, a centrifugal vapor separator having a horizontal axis and positioned and connected with the bottom of said tube chest to receive liquid solution and vapor from the bottom ends of the tubes tangentially into said separator, said separator having a vapor outlet concentric with said axis and a liquid outlet eccentric to said axis, an upper chamber at the top of said tube chest with which the chest tubes communicate, open ended film feed control tubes extending concentrically downwardly into said chest tubes and upwardly into said upper chamber, means for recirculating liquid solution from said vapor separator liquid outlet into said upper chamber for film flow downwardly past the film feed tubes through said chest tubes, said upper chamber having an outlet for vapor only through said control and chest tubes into said separator, means for introducing a solution to be concentrated into said evaporator for flow through said chest tubes and means for withdrawing concentrated solution from said evaporator.

2. An evaporator comprising a series of vertical tube chests, each chest having vertical tubes and top and bottom plates retaining said tubes, an inlet port for admission of heating fluid into the space surrounding the tubes and an outlet port for said fluid, a centrifugal vapor separator having a horizontal axis and positioned and connected with the bottom of said tube chest to receive liquid solution and vapor from the bottom ends of the tubes tangentially into said separator, said separator having a vapor outlet concentric with said axis and a liquid outlet eccentric to said axis, an upper chamber at the top of said tube chest with which the chest tubes communi-

cate, open ended film feed control tubes extending concentrically downwardly into said chest tubes and upwardly into said upper chamber, means for recirculating liquid solution from said vapor separator liquid outlet into said upper chamber for film flow downwardly past the film feed tubes through said chest tubes, said upper chamber having an outlet for vapor only through said control and chest tubes into said separator, means for continuously introducing into the first chest of said series a solution to be concentrated by flow through the chest tubes, means for continuously advancing partially concentrated solution from the first chest to the second chest and in like manner to subsequent chests in the series for similar recirculating and concentration in each chest and means for continuously withdrawing solution at a desired concentration from the last chest of the series.

3. An evaporator comprising a series of vertical tube chests, each chest having vertical tubes and top and bottom plates retaining said tubes, an inlet port for admission of heating fluid into the space surrounding the tubes and an outlet port for said fluid, a centrifugal vapor separator having a horizontal axis and positioned and connected with the bottom of said tube chest to receive liquid solution and vapor from the bottom ends of the tubes tangentially into said separator, said separator having a vapor outlet concentric with said axis and a liquid outlet eccentric to said axis, an upper chamber at the top of said tube chest with which the chest tubes communicate, open ended film feed control tubes extending concentrically downwardly into said chest tubes and upwardly into said upper chamber, means for recirculating liquid solution from said vapor separator liquid outlet into said upper chamber for film flow downwardly past the film feed tubes through said chest tubes, said upper chamber having an outlet for vapor only through said control and chest tubes into said separator, the separators associated with the several chests being axially aligned providing a common vapor passage through them concentric with their vapor outlets, means for continuously introducing into the first chest of said series a solution to be concentrated by flow through the chest tubes, means for continuously advancing partially concentrated solution from the first chest to the second chest and in like manner to subsequent chests in the series for similar recirculating and concentration in each chest and means for continuously withdrawing solution at a desired concentration from the last chest of the series.

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