(No Model.)

2 Sheets—Sheet 1.

S. M. LILLIE.

EVAPORATING APPARATUS.

No. 422,235. Patented Feb. 25, 1890.

Fig. 2

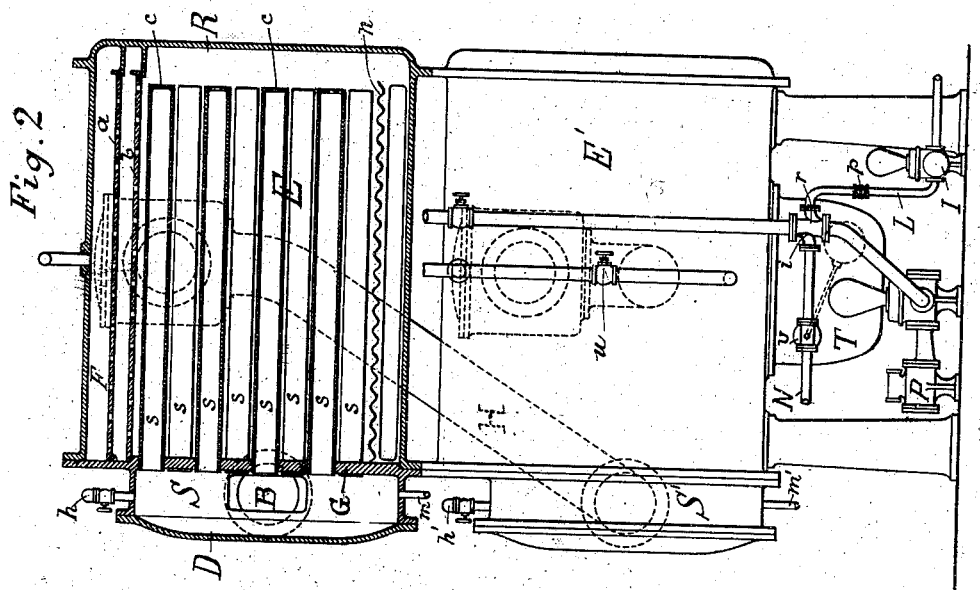
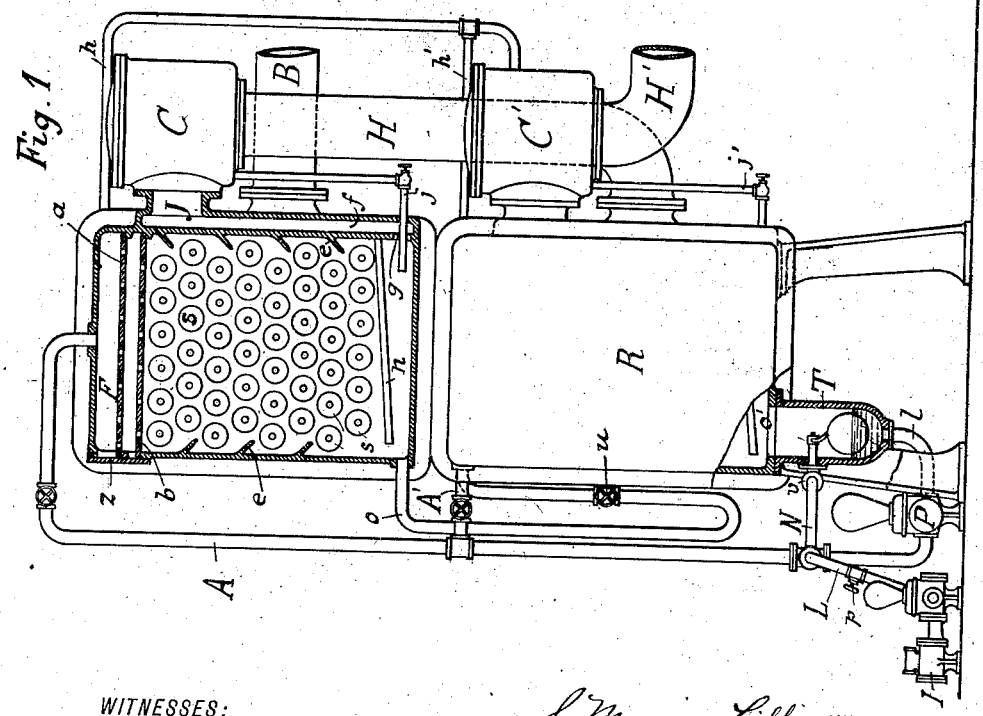


Fig. 1



WITNESSES:

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S. Morris Lillie INVENTOR

(No Model.)

2 Sheets—Sheet 2.

S. M. LILLIE.

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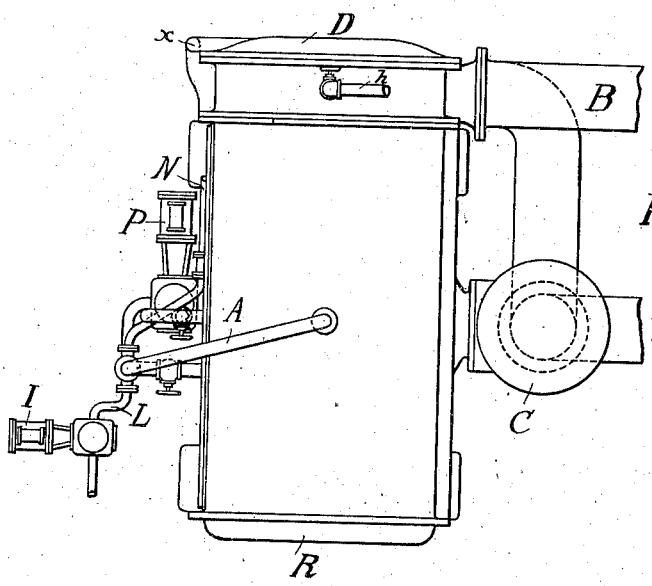

Fig. 3

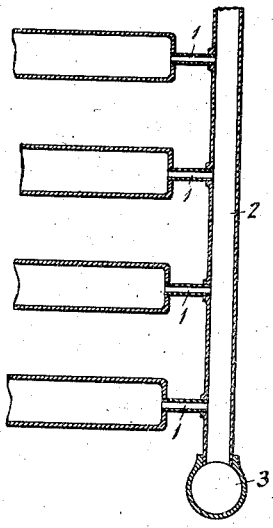

Fig. 4

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UNITED STATES PATENT OFFICE.

SAMUEL MORRIS LILLIE, OF PHILADELPHIA, PENNSYLVANIA.

EVAPORATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 422,235, dated February 25, 1890.

Application filed December 26, 1889. Serial No. 334,951. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL MORRIS LILLIE, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented new and useful Improvements in Evaporating Apparatus, of which the following is a specification.

My invention relates to in transit evaporating apparatus—namely, apparatus in which the evaporation is effected from a liquid while flowing in comparatively thin films or sheets over the heated evaporating-surfaces.

It consists, as regards a single pan or "effect" of a battery of horizontal evaporating-tubes contained in an evaporating-chamber, which tubes are closed at their ends fronting one end of the chamber, and at their other extremities connect with steam-supply conduits, from which their interiors are supplied with steam. Above the evaporating-tubes in the chamber is arranged a spraying or distributing device or devices, fed by suitable conduit with the liquid to be evaporated, and by which the liquid is distributed over the surfaces of the evaporating-tubes, and then flows downward over the same to the floor of the evaporating-chamber. The tubes are provided with means for the escape of air or incondensable gases that may collect in them and tend to exclude the steam and so lessen the efficiency of the apparatus, and the evaporating-chamber is provided with proper escapes for the vapors resulting from the evaporation and for the concentrated liquid.

In the drawings is shown in double effects apparatus illustrative of my invention, Figure 1 being an end elevation of a double effect with the front end of the evaporating-chamber of one of the effects removed, so as to expose the closed ends of the evaporating-tubes to view. Fig. 2 is a side view of the double effect, one of the pans being shown in vertical longitudinal section—*i. e.*, a section parallel to the axes of the evaporating-tubes; Fig. 3, a plan of the double effect, and Fig. 4 a view of a modified construction of portions of the apparatus.

Referring to the figures, *s s*, &c., are a battery of horizontal tubes contained in a chamber E, having their ends toward one end R of the chamber tightly closed, save for a small perforation *c*, in each looking toward the end R of the chamber. The other ends of the tubes open through the opposite end plate G, in which they are tightly expanded and by which they are supported into a steam-fed chamber S, closed by a door D, and having a steam or vapor supplying main B and a valved pipe *h*, which leads through suitable connections to the vacuum-pump used in connection with the apparatus.

The evaporating-tubes are arranged in horizontal rows, which break spaces with each other vertically, and the two side walls have horizontal ribs *e e*, &c., which break spaces between the two side rows of the tubes and the said side walls.

The liquid-distributing device above the tubes consists in the construction shown of a horizontal plate *b*, located immediately above the tube and pierced by lines of perforations—one directly over the axis of each tube of the uppermost row. Above this plate *b* are one or more perforated distributing-plates *a*, above and upon the uppermost one of which the return feed-pipe A delivers through the walls of the case.

One of the side walls of the evaporating-chamber E is formed with a passage *f* in it, which communicates below through a horizontal narrow opening *g* with the interior of the chamber E beneath the tubes and above through the nozzle J to a catch-all C, from which the vapor-escape main H leads to a suitable condensing apparatus.

Below the lower row of evaporating-tubes the chamber E contains a corrugated false bottom *n*, which touches the hollow side wall above the narrow horizontal opening *g* and extends slightly inclined downward to within a few inches of the opposite wall, the corrugations extending in the same direction.

From below the false bottom *n* and from the side of the chamber E opposite the vapor-outlet *g* a discharge-conduit *o* leads through suitable connections to a circulating-pump P, whose discharge-pipe A, which I will term the "return-pipe," delivers back into the space F above the upper perforated plate *a*. In the double effect shown in the drawings and hereinafter described these connections of the discharge-pipe *o* of the first pan to the circulating-pump P' are through the second effect and

its connections, and those of the discharge-opening *o'* of the second effect are through the float-chamber T and the connecting-pipe *l*. A conducting-pipe N for the liquid to be evaporated delivers into the return-pipe A at a point *i*, and a pipe L for the thickened liquid leaves the return-pipe at *r*—a point between where the feed-pipe N joins the return-pipe A and the circulating-pump—and leads to the tail-pump I, which is provided for drawing away the concentrated material.

In the drawings two pans, constructed as above described, are placed one above the other and connected so as to form a double effect, the upper pan being the first effect and the lower pan the second effect. The various parts hereinbefore referred to are indicated in the first effect by the letters stated and in the second effect by the same letters primed. The steam-case S of the first effect is supplied with steam from an extraneous source by the main B. The vapor-main H of the first effect leads into the steam-chamber S' of the second effect, and the vapor-main H' of the second effect leads to a condenser and vacuum-pump, by which a proper vacuum is maintained in the evaporating-chamber E' of the second effect. The liquid-discharge pipe *o* of the first effect delivers through a steam-trap (that shown in the drawings consisting of a U-tube with a valve *u* in it) above and upon the distributing-plates of the second effect. The discharge for liquid from the evaporating-chamber of the second effect is by the opening *o'* through the floor of the latter into the float-box T, from which a connection *l* leads to the suction-port of the circulating-pump P. The float-box T contains a float having a stem the end of which is keyed on the arbor of a butterfly-valve *v*, located in the thin liquor-supply pipe N, which stem extends through the side of the box into the interior of the same. The rising and falling of the float, respectively, closes and opens the butterfly-valve. The return-pipe A in the pump delivers into the feeding-space F of the upper effect, and also has a valved branch connection A' to the feed-space of the second effect, permitting the liquor to be returned to both effects simultaneously, if desired. The upper effect is shown provided with a longitudinal opening through one of the side walls into the feeding-space F and closed by a plate *z*, by removing which the distributing-plates *a b* may be gotten at and removed from the case for cleaning purposes.

The operation of this double effect may be described as follows, it being first supposed that the air has been exhausted from the apparatus by means of the vacuum-pump and connections, and that steam is being continuously supplied to the steam-chamber S of the first effect, and that the vacuum-pump and condenser are at work maintaining the proper vacuum in the case E' of the last effect: The double effect contains during normal working about, say, fifty gallons of liquid, which is continuously circulated through the two effects by the circulating-pump P at a rate sufficient to keep the surfaces of the tubes thoroughly covered with films of liquid. The liquid passes through the circulating-pump by the return-pipe A up into the feeding-space F of the first effect, falls through the perforated plates, evenly distributed upon the plate *b*, below through whose longitudinal lines of perforations it flows upon the upper surface of each of the tubes of the uppermost row, and thence flows down over the battery of tubes from tube to tube to the floor of the evaporating-chamber, whence it passes through the pipe *o* and trap upon the distributing feed-plates of the second effect, and thence upon and down over the exterior surfaces of the tubes of the second effect onto the floor of the evaporating-chamber of the same, and thence through the float-chamber T to the circulating-pump again. The tubes in each vertical row serve as deflecting-surfaces for the liquid which falls from the adjacent vertical rows, throwing the liquid which does not adhere to and wet themselves back onto the tubes of the adjacent rows, and the ribs *e* on the side walls of the evaporating-cases serve to throw back upon the tubes the liquid which would otherwise leave them and run down the surfaces of the walls. The thin liquid which is to be thickened is continuously fed by the feed-pipe N into the return-pipe A and mixes with and thins the ascending liquid, which, in flowing down over the evaporating-tubes in the two effects, is thickened again. The concentrated circulating liquid is constantly being drawn off through the discharge-pipe L at a rate regulated by the valve *p* in the said pipe. The steam affording original heat is fed to the steam-chamber S of the first effect, and thence flows into the tubes of the same. The vapors resulting from evaporating in the first effect escape from its evaporating-chamber into the vapor-passage *f* at one side, and thence through a catch-all C, and pass from the latter by the vapor-pipe H into the steam-chamber S' of the second effect, and thence into the tubes of the latter. During its passage through the catch-all all particles of suspended liquid are separated from the vapor and remain in the catch-all, from which it flows by a drain-pipe *j* back into the chamber E. The vapors resulting from the evaporation in the second effect escape through its catch-all C' and vapor-pipe H' to the condenser and vacuum pumps. (Not shown in the drawings.)

The regulation of the density of the concentrated material—that is, the flow of liquid through the double effect—is effected entirely by means of the valve *p* in the discharge-pipe L, the inflow of thin liquid by the feed-pipe N being maintained proportional to the outflow through the discharge-pipe L by the automatic action of the level of the liquid in the float-chamber, and the float and the butterfly-valve in the feed-pipe N, operated by

the same. Opening the valve in the discharge-pipe L permits the more rapid flow of the liquid through the apparatus, and consequently diminishes the density of the finished product. Closing the valve lessens the flow of liquid through the double effect and increases the density of the finished product.

The rate of evaporation in the double effect is varied by increasing or diminishing the pressure of steam in the chamber S of the first effect, supposing the vacuum to remain constant. While in operation steam or vapor is constantly flowing into and being condensed on the interior surfaces of the tubes, while evaporation of the liquid takes place from the exteriors of the tubes. Any air which may leak into the effects, which must be expected to occur to a greater or less extent in all vacuum evaporating apparatus, will collect in the tubes at their closed ends, and if not allowed to escape, or if not occasionally exhausted, would in time materially diminish the efficiency of the apparatus. To permit this escape of air, the closed end of each tube has a perforation *c* through it, by which the air which reaches the ends of the tubes continuously passes into the surrounding evaporating-chamber, and thence through the intermediate connections to the vacuum-pump.

In the case of the tubes of the first effect of a multiple-effect evaporating apparatus the tubes and evaporating-chambers of the pans between it and the vacuum-pump respectively form parts of the said intermediate connections. In this manner the danger of stagnant air and incondensable gases, which is met and has to be overcome in every form of multiple-effect apparatus, is easily and entirely avoided and the entire surface of each evaporating-tube made efficient. The corrugated false bottom *n* in each effect assists in separating the thickened liquid and the vapors resulting from evaporation, first, by delivering the liquid as far as possible away from the vapor-outlets *g*, and, second, by collecting the liquid into the depressions of the corrugations, from which it flows in streams upon the floor of the chamber E, leaving free intermediate spaces, through which the vapors may flow back under the plate toward the vapor-outlet *g*.

I omitted to state in the preceding that the water of condensation resulting during the working of the apparatus flows from the evaporating-tubes *s* back into the chamber S, and thence away by the drain-pipe *m*.

There are many modifications which may be made in the construction of this apparatus without departing from the essence of my invention. For example, I do not limit myself to any particular means for drawing off the air and non-condensable gaseous products of evaporation from the sealed evaporating-tubes *s*. One way is by means of the simple perforations *c*. (Shown in Figs. 1 and 2.) Another way is illustrated in Fig. 4, which shows the sealed ends of the vertical rows of tubes, each communicating by a small pipe-connection 1 with a vertical manifold pipe 2, which communicates through pipe 3 and its connections with exhausting apparatus. (Not shown in figure.) This latter construction is specifically claimed in pending application, No. 299,218, filed February 8, 1889. Again, the tubes may be entirely closed at their ends—*i*, *e.*, without openings there of any kind—the accumulated air being exhausted from the tubes and the chamber S through the exhaust-pipes *h* as often as may be found desirable, the evaporation being stopped each time to allow of its being done. In supplying the steam to the tubes *s* a different construction may also be used. For example, the steam-chamber S, common to the tubes of an effect, may be replaced by a system of steam-supply manifolds having connecting branches to the interiors of the several tubes.

Multiple effects having a greater number of effects than two may be formed by increasing the number of effects in the column to three or more and connecting each effect with the next effect beneath it in the same manner as the first effect in the drawings is connected with the second effect. In forming multiple effects again, the several pans may be placed side by side with a circulating-pump for each pan, if preferred, as in the case of the multiple effect shown in United States Patent No. 378,843, issued to me February 28, 1888; or to form a multiple effect which is a multiple of two a number of double effects—such as shown in the drawings—equal to that multiple may be placed side by side with a vapor-main H′ of each double effect (excepting the last, whose vapor-main H′ would lead to the condenser and vacuum-pump of the system) with the steam-chamber S of the next double effect and its liquid-discharge pipe L with the feed-pipe N of the next, the feed-pipe N of the first pair being the original feed-pipe of the series, and the discharge-pipe L of the last pair being the final discharge-pipe for the thickened material.

In constructing individual effects the plate D, forming the cover of the steam-case S, is hung by hinges for convenience in opening. When closed, this door is caused to make air-tight bearings against the flanges of the steam-case by any of the methods usually employed for the purpose in similar constructions.

When practicable, the chamber E is cast in one piece, the perforated plates *a b* being supported in position on ledges formed on the interiors of the walls of the chamber at the proper places. The plate G forms at once one end of the chamber E and also the tube-plate, and with it the side walls of the steam-chamber S are formed in one piece, all as shown in the drawings. A feature of this construction is that the tube-sheet and the sealed evaporating-tubes form a distinct and

separable element of the construction, and may be removed from and replaced in position at will after loosening the fastenings which hold it in place. In larger apparatus, the tube-plate might form but a portion of the end of the body E of the pan, simply covering and closing an opening in the end wall, through which the battery of tubes supported in the tube-plate project into the interior.

In a pending application, Serial No. 299,218, filed February 8, 1889, I have shown, described, and claimed an apparatus similar to the above, but provided with facilities for cleaning or permitting the cleaning of the exterior surfaces of the evaporating-tubes *s*, and in pending application, Serial No. 278,055, filed June 23, 1888, I have shown other constructions of multiple effect in transit evaporating apparatus, in which the evaporating-tubes are heated from the interior, and in which the liquid to be evaporated flows downward over the exterior surfaces of the same, and I claim therein the combination of two or more such effects with circulating-pumps to form a multiple effect, and also means for regulating the flow of liquid through the effects. I give notice of above-mentioned applications in order that nothing contained in the foregoing specification may serve as a dedication to the public of the matters claimed in the said applications.

Thus having described my invention, I claim as mine and desire to secure to myself by Letters Patent of the United States—

1. In an evaporating-pan, the combination of a battery of horizontal evaporating-tubes, each closed at one end and contained in a chamber closed practically air-tight, and connected at their other ends with a supply conduit or conduits for steam or other condensable heating agents, means above the tubes for distributing the liquid to be evaporated in thin films over the exterior surfaces of the tubes, means for continuously removing from the said evaporating-tubes closed at one end the incondensable gases which may flow into the same with the condensable heating agents, and vapor and liquid escape conduits leading from the chamber containing the tubes, substantially as specified.

2. In an evaporating-pan, the combination of an evaporating-chamber constructed practically air-tight, but with vapor and liquid escape conduits leading from the same, substantially as described, a steam-chamber at one end of the evaporating-chamber, a battery of horizontal evaporating-tubes contained in the evaporating-chamber, each opening at one end into the steam-chamber and having the other end closed, a conduit for supplying steam or other condensable heating agents to the steam-chamber, means above the tubes for distributing the liquid to be evaporated over the exterior surfaces of the same in thin films, and means for continuously removing from the said steam-chamber and evaporating-tubes closed at one end the incondensable gases which may flow into the same with the condensable heating agent, substantially as specified.

3. In an evaporating-pan constructed and operated substantially as described, the evaporating-tubes, each closed at one end and supplied with steam at the other end, and having perforations through the wall of each tube at or near the closed end of the same, the said perforations forming communication between the interiors of the tubes and the surrounding chamber, and permitting the escape of incondensable gases from the former into the latter, substantially as specified.

4. In a multiple effect evaporating apparatus, the combination of two consecutive pans of the same, each comprising an evaporating-chamber and a battery of steam-fed evaporating-tubes contained therein, with means for delivering the liquid to be evaporated upon the exterior surfaces of the tubes, means whereby the interiors of the evaporating-tubes of the first pan are connected with an evaporating-chamber in which they are contained, a vapor-conduit and connections leading from the said evaporating-chamber of the first pan to the interiors of the evaporating-tubes of the second pan, and connections leading from the interiors of the evaporating-tubes of the second pan to suitable exhausting apparatus, the combination affording means for conducting air and incondensable gases which may collect in the tubes of the first pan away from the same to the exhausting apparatus, substantially as specified.

5. In an evaporator operated substantially as described, the combination of a steam-chamber, horizontal evaporating-tubes closed at one end and receiving steam from the steam-chamber at the other end, and exhausting apparatus and a valved pipe-connection *h* between the steam-chamber and exhausting apparatus, through and by which pipe-connection and exhausting apparatus the air may be exhausted from the steam-chamber and tubes, substantially as specified.

6. In an evaporator operating substantially as described, the combination of a battery of horizontal steam-fed evaporating-tubes, their containing-chamber, means above the battery of tubes for distributing the liquid to be evaporated over their exterior surfaces, a vapor-escape conduit opening from the tube-containing chamber below the battery of tubes, and a liquid-escape opening from the chamber near the bottom of the same, substantially as specified.

7. In a tube-containing chamber of an evaporator constructed and operated substantially as described and having a vapor-escape conduit leading away near the bottom thereof, the partial false bottom *n*, located below the battery of evaporating-tubes and extending the length of the same and touching along one of its edges the wall through which the vapor-escape conduit opens along a line above

the opening of the latter and extending nearly to the opposite wall, substantially as specified.

8. In the tube-containing chamber of an evaporator constructed and operated substantially as described and having a vapor-escape conduit leading out near the bottom thereof, the corrugated partial false bottom *n*, located below the battery of evaporating-tubes in the evaporating-chamber and extending the length of the same and touching along one of its edges the wall of the evaporating-chamber, through which the vapor-escape conduit opens at a level above the opening of the latter and extending nearly to the opposite wall, the corrugations of the false bottom having the direction transverse to the length of the tubes, substantially as specified.

9. In an evaporator operated substantially as described, the combination of a horizontal evaporating-chamber containing a battery of horizontal steam-fed evaporating-tubes, a feed-chamber above the evaporating-chamber, with a conduit for the liquid to be evaporated opening into it, a horizontal distributing-plate forming the floor of the feed-chamber and the roof of the evaporating-chamber and extending from side wall to side wall of the evaporating-chamber, and operating to distribute the liquid to be evaporated over the evaporating-tubes, and a vapor-escape conduit through one of its vertical walls below the feed-chamber and leading from the evaporating-chamber, substantially as specified.

10. In an evaporating-pan, the combination of a horizontal evaporating-chamber containing a battery of horizontal steam-fed tubes, a feed-chamber above the evaporating-chamber, a horizontal distributing-plate *b*, separating the feed-chamber from the evaporating-chamber, distributing-plates *a* in the feed-chamber above the distributing-plate *b*, a conduit for the liquid to be evaporated opening into the feed-chamber above the upper distributing-plate *a*, and a vapor-escape conduit leading from the evaporating-chamber, substantially as specified.

11. In an evaporating-pan, the combination of a chamber containing a battery of horizontal evaporating-tubes, horizontal perforated distributing-plates supported above the tubes on ledges formed on the walls of the chamber, means for delivering the liquid to be evaporated upon the distributing-plates, and a removable plate closing an opening into the chamber above the tubes, through which the distributing-plates may be removed or inspected, substantially as specified.

12. In an evaporating-pan, the combination, with a horizontal evaporating-chamber, of a removable tube-plate closing one end of the chamber and held in place by suitable fastenings between it and the walls of the latter, a steam-fed chamber supported upon the outer surface of the tube-plate independently of the fastenings between the latter and the walls of the evaporating-chamber, and a battery of horizontal evaporating-tubes extending from the steam-chamber through (and firmly supported in) the tube-plate into the evaporating-chamber and having their ends in the latter closed, the tube-plate steam-chamber and evaporating-tubes forming together an independent construction, separable as an entirety from the horizontal evaporating-chamber after loosening the fastenings between the walls of the latter and the tube-plate, substantially as specified.

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