(No Model.)

2 Sheets—Sheet 1.

S. M. LILLIE.

EVAPORATING APPARATUS.

No. 440,231. Patented Nov. 11, 1890.

Fig. 2

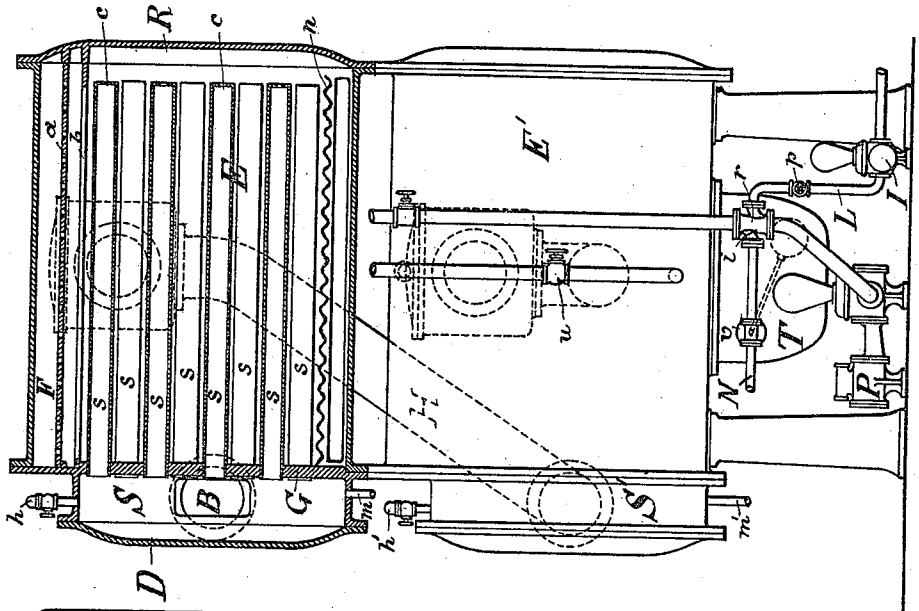
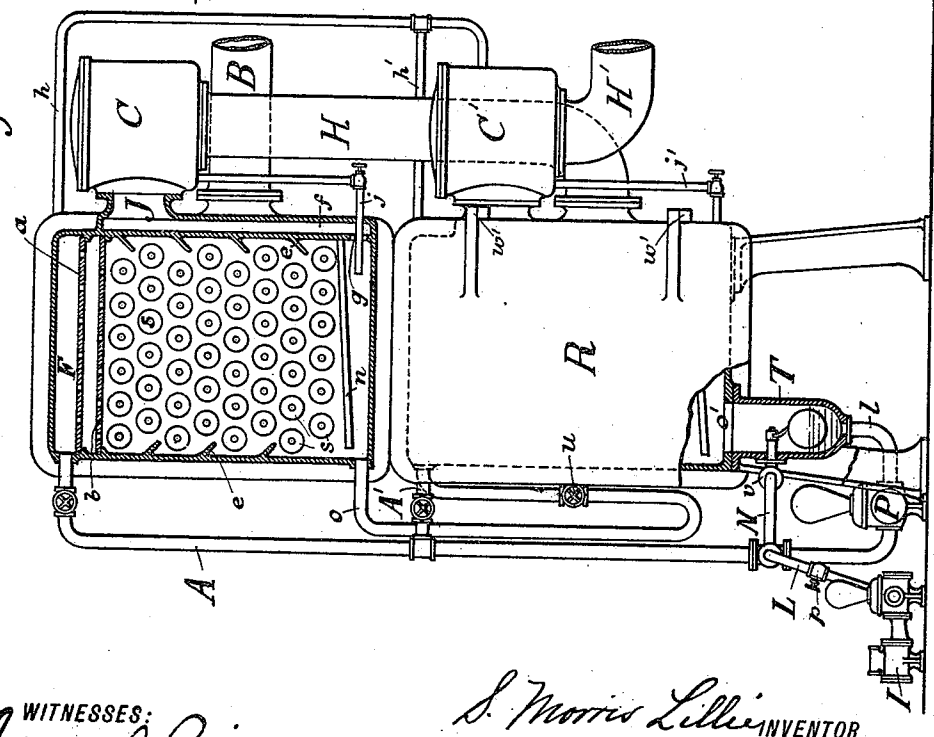


Fig. 1



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(No Model.) 2 Sheets—Sheet 2.

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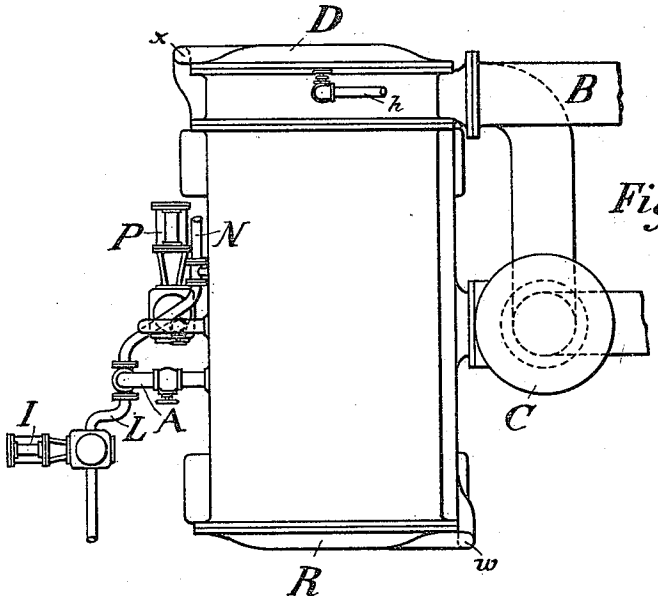


Fig. 3

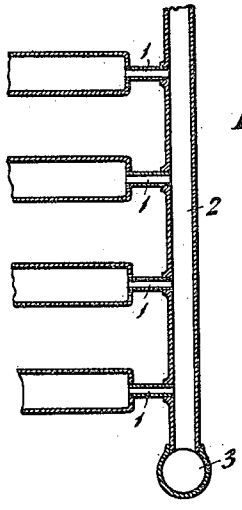


Fig. 4

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UNITED STATES PATENT OFFICE.

SAMUEL MORRIS LILLIE, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE SUGAR APPARATUS MANUFACTURING COMPANY, OF SAME PLACE.

EVAPORATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 440,231, dated November 11, 1890.

Application filed September 26, 1890. Serial No. 366,198. (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, in the State of Pennsylvania, have invented new and useful Improvements in Evaporating Apparatus, of which the following is a specification.

My invention relates to "intransit 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 a 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 a double-effect apparatus illustrative of my invention, Figure 1 being an end elevation of a double effect with the front plate of the evaporating-chamber of one of the effects removed so as to expose the sealed ends of the evaporating-tubes to view; Fig. 2, a side view of the double effect with one of the pans shown in vertical longitudinal section—*i. e.*, 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 portion 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 sealed, save for a small perforation *c* in each, looking toward the plate R. 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 supply main B and a valved pipe *h*, which leads through suitable connections to the vacuum-pumps 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 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 tubes and pierced by longitudinal slots, one directly over the axis of each tube of the uppermost row. Above the slotted 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 the 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 catchall C, from which the vapor-escape 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 dischage-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 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-pumps, 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 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 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 valve branch-connection A' to the feed-space of the second effect, permitting liquor to be returned to both effects simultaneously, if desired.

The operation of this double effect may be described as follows, it being first supposed that all air has been exhausted from the apparatus by means of the vacuum-pump and connections, and that steam is being continuously led into the steam-chamber S of the first effect, and that the vacuum-pumps 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 from 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 slotted plate *b* below, through whose slots 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 through the discharge-pipe L at a rate regulated by the valve *p* in the said pipe. The steam affording the 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 evaporation of the first effect escape from its evaporating-chamber into the vapor-passage S at one side and thence through the catchall 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 catchall all particles of entrained liquid are separated from the vapor and remain in the catchall, from which said liquid flows by a drain-pipe *j* back into the chamber E. The vapors resulting from the evaporation in the second effect escape through its catchall C' and vapor-pipe H' to the condenser and vacuum-pumps, which are 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 from the liquid takes place from the exteriors of the tubes. Any air that 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 the 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-pumps. 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-pumps, respectively, form parts of the said intermediate connections. In this manner the enemy—stagnant air and incondensable gases, which is met and has to be overcome in every form of multiple-effect evaporating apparatus—is easily and entirely avoided and the entire surface of each evaporating-tube made efficient. The inner and outer surfaces of the tubes are readily cleaned. By opening the door of the steam-case S the open ends of the tube are exposed, which permits their inner surfaces being cleaned by means of a flue-cleaner. The opening of the door R at the front end of the evaporating-chamber exposes the closed ends of the evaporating-tubes and the spaces between them and permits the exterior surfaces of the tubes being cleaned with the greatest ease by means of scrapers or swabs. During this cleaning of the exterior surfaces a circulation of water or other liquid may be maintained over the tubes by means of the circulating-pump P, which will serve both to assist cleaning and to wash the dirt from the chamber and effect. Opening the door of the evaporating-chamber also permits the perforated plates *a b* to be removed and cleaned, if necessary. The corrugated false bottom *n* in each effect assists in separating the thickened liquid and the vapors resulting from evaporation by delivering the liquid as far as possible away from the vapor-outlets *g*, and also by collecting the liquid into the depressions of the corrugations, from which it flows in solid 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 *f*.

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*.

Instead of the perforations *c* in the closed ends of the evaporating-tubes for permitting the escape of air and incondensable gases from the interiors of the tubes, which means are broadly claimed in Letters Patent No. 422,235, issued to me February 25, 1890, the construction illustrated in Fig. 4 of the drawings may be used for the purpose. This construction consists in connecting the closed ends of a number of the evaporating-tubes together to form a nest of tubes by small connecting-pipes contained within the evaporating-chamber and having a single escape for the air from the pipes. Thus in Fig. 4 a number of evaporating-tubes *s*, representing a row of tubes, are shown thus joined by the small air-escape pipe 1 1, &c., in connection with a common manifold 2, located in the evaporating-chamber, which manifold in turn opens into a cross-pipe 3, into which other similar manifolds of other rows of tubes may open, which in turn connects with any suitable exhausting apparatus, (none shown in the figures,) by which the air and incondensable gases are drawn from the evaporating-tubes—*e. g.*, the cross-pipe 3 might open into the evaporating-chamber, which, in combination with its connections to the condenser and pump, would in that case be the "exhausting apparatus." By thus joining the tubes into nests by connecting air-pipes each tube receives some support at its free end from the other tubes of the nest to which it belongs, which is an advantage in cases where a hard and refractory scale is being cleaned from the exterior surfaces of the tubes by means of scrapers introduced through the opened door R.

In constructing the individual effects the plate R, forming the front end of the evaporating-chamber, is hung on hinges *w*, as a door, and also the plate D, forming the cover of the steam-case S, by hinges *x*, for convenience in opening. When closed, these doors are caused to make air-tight bearings against the end flanges of the 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 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 proper 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.

Thus having described my invention, I claim as new—

1. In an evaporator operating substantially as described, the combination of the following elements, viz: a horizontal evaporating-chamber, a battery of horizontal evaporating-tubes contained in the chamber and having their ends toward one end of the same closed and connecting at their other ends with suitable steam-supply conduits, means for delivering the liquids to be evaporated upon the evaporating-tubes in the evaporating-chamber, suitable escape-passages leading from the evaporating-chamber for the vapors formed and for the unevaporated liquid, and a door or removable plate closing the end of the horizontal evaporating-chamber which faces the closed ends of the evaporating-tubes, the door when opened exposing the closed ends of the evaporating-tubes and the spaces between them, thus permitting access to the exterior surfaces of the tubes for cleaning purposes, substantially as specified.

2. In an evaporating-pan, the combination of a horizontal evaporating-chamber containing a battery of horizontal evaporating-tubes, a horizontal feed-chamber above the evaporating-chamber, and a door or removable plate R, forming a cover common both to an end of the evaporating-chamber and to the same end of the feed-chamber, substantially as specified.

3. In an evaporating-pan constructed and operated substantially as described, the combination of a horizontal evaporating-chamber, with a feed-chamber above the evaporating-chamber and separated from it by a perforated distributing-septum, a vertical removable tube-plate forming a common cover to the evaporating and feed chambers at one end, a battery of horizontal steam-fed tubes in the evaporating-chamber opening through the tube-plate and closed at their other ends, and a door or removable plate forming a cover common to the evaporating and feed chambers at the end opposite the tube-plate, substantially as specified.

4. In an evaporating-pan, the combination of a horizontal evaporating-chamber having suitable vapor and liquid escapes, a removable vertical tube-plate covering one end of the evaporating-chamber and carrying-tubes projecting horizontally into the evaporating-chamber and which have their ends in the latter closed, a door or removable plate closing the other end of the evaporating-chamber, which when opened exposes the ends and exterior surfaces of the tubes, means for distributing the liquid to be evaporated over the exterior surfaces of the tubes, and means for supplying steam to the interiors of the tubes, substantially as specified.

5. In an evaporating-pan constructed and operating substantially as described, the combination of evaporating-tubes, each closed at one end and supplied with steam at the other end, and small air-escape tubes, one leading from each tube at or near the closed end of the same, the said air-escape tubes affording means for the continuous escape of the air or incondensable gases which collect at the closed ends of the evaporating-tubes in the interior of the latter during the working of the apparatus, substantially as specified.

6. In an evaporating-pan having a battery of horizontal evaporating-tubes contained in an evaporating-chamber and opening at one end through a tube-plate to steam-supply connections, and having their other ends in the evaporating-chamber closed, and means for delivering the liquid to be evaporated upon the exterior surfaces of the tubes, all substantially as set forth, the combination, with the evaporating-tubes, of small pipes connecting the closed ends of the tubes to form nest of tubes and an air-escape for each nest connecting to suitable exhausting apparatus, substantially as specified.

7. In an evaporating-pan having a battery of evaporating-tubes arranged in rows in an evaporating-chamber and opening at one end through a tube-plate to steam-supply connections, and having their other ends in the evaporating-chamber closed, and means for delivering the liquid to be evaporated upon the exterior surfaces of the tubes, all substantially as set forth, the combination, with the rows of tubes, respectively, of manifolds contained in the evaporating-chamber with intermediate connections to suitable exhausting apparatus and small air-escape connections between each manifold and the closed ends of the tubes of its row, substantially as specified.

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