(No Model.)

S. M. LILLIE.

APPARATUS FOR EVAPORATING LIQUIDS.

No. 344,586. Patented June 29, 1886.

Fig. 1.

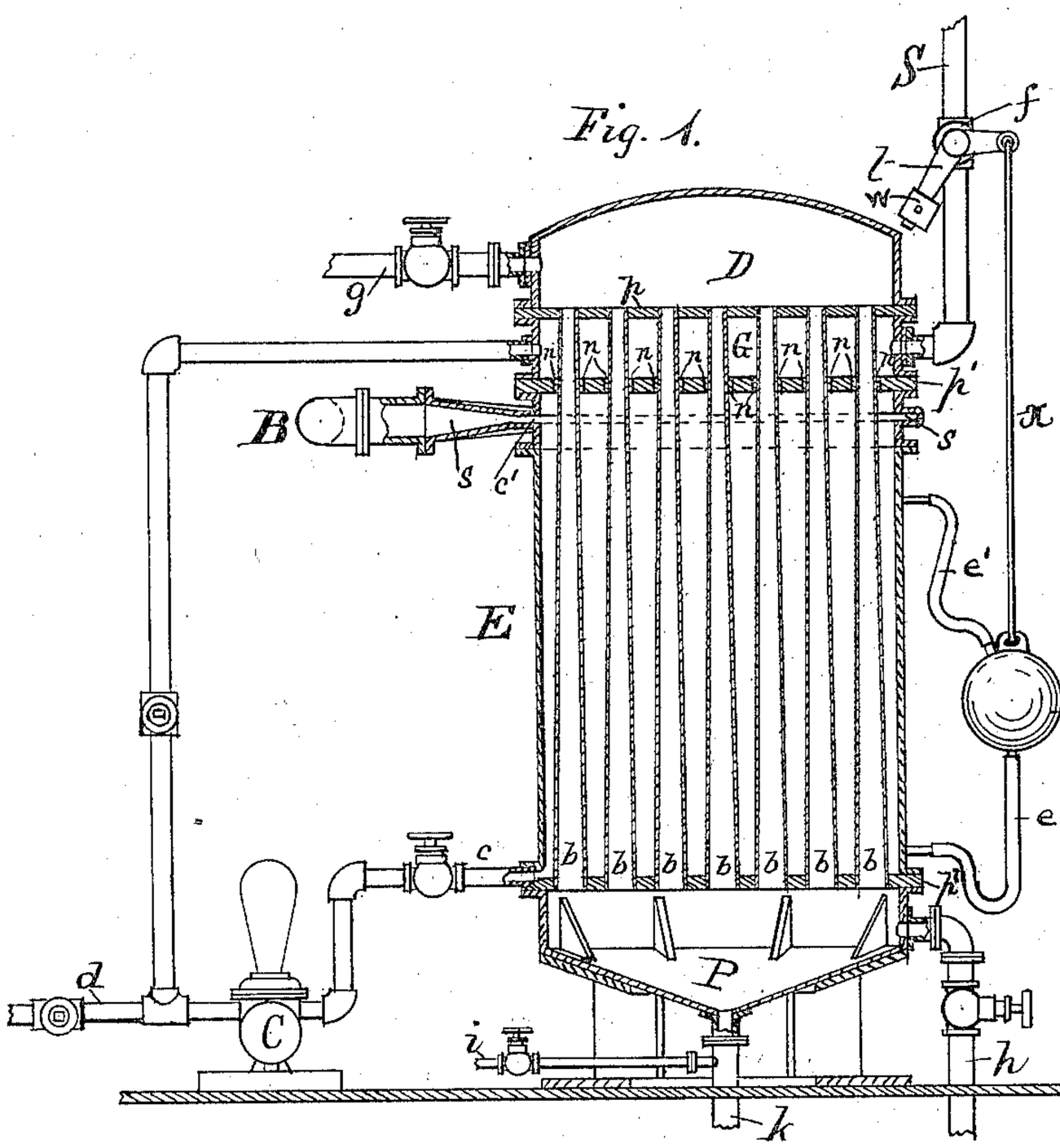
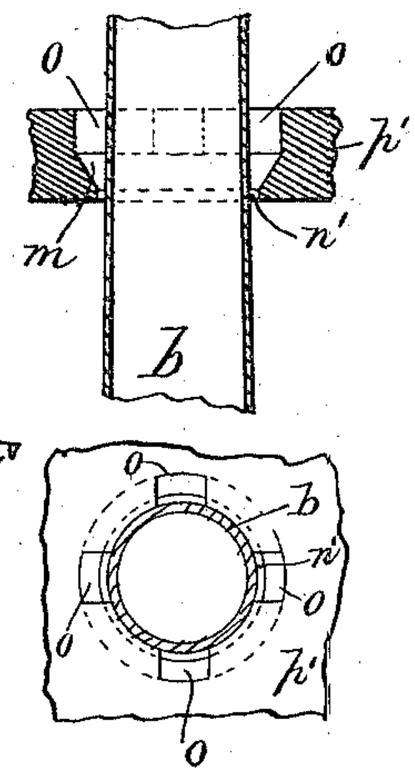


Fig. 2.



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APPARATUS FOR EVAPORATING LIQUIDS.

SPECIFICATION forming part of Letters Patent No. 344,586, dated June 29, 1886.

Application filed June 5, 1884. Serial No. 133,989. (No model.)

To all whom it may concern:

Be it known that I, S. MORRIS LILLIE, of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Apparatus for Evaporating Liquids, of which the following is a specification.

My apparatus consists of a battery of approximately vertical tubes extending through a suitable steam-tight case, and of means for causing the liquid to be evaporated to flow in thin films down the exterior surfaces of the tubes in the said case, while the carrier of the heat for the evaporation—as steam or heated gaseous products of combustion, for example—are introduced into or are made to pass through the interiors of the tubes.

The drawings forming a portion of this specification consist of two figures, of which Figure 1 is a vertical section of the evaporating apparatus, and Fig. 2 a view of a detached part.

In the drawings, *b b b*, &c., Fig. 1, are a series of tubes, which extend from the chamber P vertically through the interior of the case E, and chamber G, above it, into the dome D. The tubes are expanded or otherwise tightly fitted into the tube-plate *p*, which divides the dome D from the chamber G, pass loosely through passages *n* in the tube-plate *p'*, which divides the chamber G from the interior of the case E, and, extending through the latter, are expanded or tightly fitted into the tube-plate *p²*, dividing the chamber P from the interior of the case E. The passages through the tube-plate *p'* are made slightly larger than the exteriors of the tubes *b*, which pass through them, thus forming an annular passage, *n*, between the chambers G and E, around each tube, through which any liquid introduced into the chamber G will flow from the same through the passage *n* upon the exterior surface of all of the tubes *b* in the case E, down which it will flow to the bottom of the case. A main, S, delivers into the chamber G and serves to conduct the liquid to be evaporated into the chamber. The main is provided with a cock, *f*, by which the flow of liquid into the chamber G is automatically regulated, by means of devices to be described, so as to maintain the level of the liquid collected on the bottom of the chamber E at a certain level. The chamber E has a conduit, B, opening into it near the top through the horizontal narrow passage *c'* from the chamber *s*, surrounding E, with which the conduit B connects. This conduit serves to carry off the vapors formed in the chamber E during the process of evaporation.

From the bottom of the chamber E a draining-pipe, *c*, leads to a pump, C, whose eduction-main delivers either into the chamber G or through a branch pipe, *d*, to some other destination apart from the apparatus.

The plug of the cock *f* in the main S bears a lever, *t*, having two arms, making an obtuse angle with each other. One arm of the lever is weighted and tends to revolve the plug to open the cock, while the other arm supports a hollow globe, F, suspended from it by a cord, rod, or chain, *x*, whose weight tends to revolve the plug of the cock in the opposite direction—*i. e.*, to close it. The interior of the globe F communicates from underneath through a flexible connection, *e*, with the bottom of the chamber E, and from above through the flexible connection *e'* with the chamber at a point above the highest level to which it will ever be desired to have the liquid rise in the chamber when the apparatus is in use. The weight of the counterpoise *w* on the lever *t* is sufficient to revolve the plug of the cock into and to retain it in the position shown, which is its position when the cock is wide open, against the combined weights of the cord *x*, globe F, flexible connections *e e'*, and of sufficient of the liquid to fill the connecting-tube *e* up to the globe. If, however, the globe is nearly filled with the liquid, the weight of these parts is sufficient to overbalance the counterpoise *w*, and to revolve the plug of the cock into the closed position.

The purpose of the combination just described is to automatically regulate the flow of liquid through the main S into the apparatus by means of the level of the liquid in the chamber E. Thus as long as the level of the liquid in the chamber E is below that of the bottom of the globe the cock *f* remains wide open; but in proportion as the liquid rises above that level, and, consequently, flows into the globe F, the plug of the cock is revolved by the increasing weight of the globe in the direction to close the cock, until finally, if the liquid continues to rise, the cock will be entirely closed. The level to which the liquid

may rise will depend, therefore, upon the height of the globe F, which may be varied as desired by increasing or diminishing the length of the suspending cord or chain *x*.

The construction of the dome D and of the well P will vary with the agent used as the source of heat for effecting the evaporation. Supposing the agent to be steam, they may be constructed as shown in the drawings, and as hereinafter described. If heated gases or products of combustion are to be used, they are led into the dome D and out of the well P by suitable flues, the gases flowing downward through the tubes *b*, or vice versa, the gases are led into the well P, up through the tubes *b*, and out of the dome D; or the apparatus may be used as a vertical boiler, in which case the well P is fashioned as a fire-box, in which the fuel may be burned, and the dome D communicates with a suitable chimney or flue. Supposing, however, that steam is the agent to be used, the construction of the dome D and well P may be as shown in Fig. 1, in which both are steam-tight and have communications through the mains *g* and *h*, respectively, with a steam-supply. The well P has an air-vent, *i*, and an escape for the water of condensation through the pipe *k*, which leads to a suitable steam-trap.

The method of using the evaporator shown in Fig. 1 is as follows: The air-vent *i* of the chamber P having been opened, steam is let into the dome D from the main *g*. When the air has been well driven out of the dome, tubes, and well P, and steam issues from the air-vent *i*, the latter is closed and the valve in the steam-main *h*, leading into the well P, opened. The liquid to be evaporated is then allowed to pass into the chamber G through the main S, whence it flows through the narrow passages *n* in the tube-plate *p'*, around the tubes *b*, upon the exterior surfaces of the heated tubes in the chamber E, down which it flows, reaching the bottom of the chamber more or less evaporated by its passage down the tubes. If once flowing down the surfaces of the tubes does not sufficiently concentrate the liquid, (supposing concentration to be the object,) it is delivered from E by the pump C into the chamber G again, whence it flows a second time over the tubes, either by itself, or, as would usually be the case, together with fresh liquid entering the chamber G from the main S. When the liquid is sufficiently concentrated, it is delivered by the pump C through the pipe *d* into a suitable receptacle.

As before pointed out, the flow of liquid from the main S into the chamber G is regulated by the level of the liquid in the chamber E in such manner, by means of the globe F and its connections, that as this level falls the cock *f* opens wider, and as it rises the cock closes, from which it results that the flow of liquid into the apparatus from the main S is just sufficient to replace the liquid delivered from the evaporator either as vapor through the main B or as liquid through the pump C and pipe *d*. Liquid delivered by the pump from the chamber E into the chamber G does not affect the flow of liquid from the main S, as it does not leave the apparatus, and so does not have to be replaced by fresh liquid from S to maintain the level of the liquid in E, and so when no liquid is being delivered away from the apparatus the influx of liquid into it from S will be only sufficient to replace that lost by evaporation.

When the apparatus is constructed and used for a steam-generator—as when the chamber P is replaced by a furnace or fire-box and the dome D connects with a chimney—the pump C serves only to transfer water from the chamber E into the chamber G, as a rule, and the flow of water into the apparatus from the pipe S is simply that necessary to replace that escaping from the generator as steam.

It is apparent that the main S may deliver into the chamber E, instead of into G, in which case the pump C would be relied upon to deliver liquid into the chamber G, and so onto the tubes *b*. As arranged in the drawings, the chamber G serves as a species of feed-heater, heating the liquid entering from S.

When this evaporator is used for the concentration of liquids—such as sugar solutions, the evaporation of which it is desirable should be carried on at as low temperatures as possible—the main B, designed for conducting the vapors away from the chamber E, should communicate with proper condensers and air-pumps, whereby a more or less perfect vacuum may be maintained in the chamber E, in which the evaporation takes place.

It will be seen that the tubes *b*, Fig. 1, have greater diameters at their lower ends than at their upper ones, and that they thus present surfaces slightly inclined to the vertical for the liquid to flow down. This construction promotes a greater firmness of contact, so to speak, between the surfaces of the tubes and the liquid flowing down them, and also permits a somewhat freer escape from the liquid for the vapors of evaporation than would be the case were the walls of the tubes strictly vertical. Tubes of uniform bore may be used, however, with good results.

In Fig. 2 is shown an arrangement of the conduits through the tube-plate *p'*, which deliver the liquid from the chamber G upon the surfaces of the tubes *b* in the chamber E, different from that shown in Fig. 1.

Fig. 2 is a limited vertical section of a tube, *b*, or tube-plate *p'*, and a plan of the same not in section. The tube *b* fits tightly in the hole through the plate, excepting where contact is broken, as about to be described. In the sides of the hole through the plate *p'* is formed the horizontal groove *m*, having the four vertical grooves *o*, extending to the upper surface of the plate. When the tube *b* is in place, conduits are formed through the plate consisting of the vertical grooves *o*, horizontal groove *m*, and the annular passage *n'*, formed by slightly enlarging the bore of hole

through the plate below the horizontal groove *m*, through which conduits any liquid delivered onto the plate *p'* will be delivered upon and uniformly distributed over the surface of the tube *b*.

This evaporator may be constructed without the dome D. In this case the chamber G only is above the chamber E, and the tubes *b* only extend above the plate *p'*, and have their upper ends closed. The passages for the tubes through the plate *p'* may be constructed as in Fig. 2. Steam has access to the interiors of the tubes only from the chamber P. Before starting the evaporation in an apparatus thus constructed—viz., without the dome D—it is well to exhaust the air from the chamber P and tubes *b*, when practicable, before admitting the steam into the chamber P, in order that the steam may have free access to the interiors of the tubes *b*.

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

1. In an evaporator or steam-generator, the combination of the chamber or furnace P, chamber E, dome D, tubes *b*, extending from the chamber or furnace P, through the chamber E, to the dome D, and means for causing a flow of liquid down the exterior surfaces of the tubes *b* in the chamber E, substantially as specified.

2. In an evaporator or steam generator, the combination of the chamber or furnace P, chamber E, dome D, tubes *b*, and means for drawing liquid from the chamber E and for delivering the same upon the external surfaces of the tubes *b* in the chamber E, substantially as specified.

3. In an evaporator or steam-generator, the combination of the chamber or furnace P, chamber E, dome D, tubes *b*, extending from the chamber P, through the chamber E, to the dome D, means for delivering a liquid into the evaporator upon the surfaces of the tubes *b* in the chamber E, and means for drawing liquid from the chamber E, and for delivering the same upon the surfaces of the said tubes *b*, substantially as described.

4. In an evaporator or steam-generator, the combination of the chamber or furnace P, chamber E, chamber G, dome D, tubes extending from the chamber or furnace P, through the chambers E and G, to the dome D, and passages through the plate or septum *p'*, between the chambers E and G, adapted to deliver liquid from the chamber G upon the exterior surfaces of the tubes exposed in the chamber E, substantially as specified.

5. In an evaporator constructed substantially as described, the combination, with the chamber E and chamber G, of a pump, C, or equivalent apparatus, connecting with the chamber E and with the chamber G by suitable mains, and operating to draw liquid from the chamber E and to deliver it into the chamber G, substantially as specified.

6. In an evaporating apparatus, the combination of the chamber P, connected with and receiving steam from a suitable steam-supply, chamber E, tubes *b*, extending into or through the chamber E from the chamber P, but not opening into the chamber E, and means for causing a flow of the liquid to be evaporated down the exterior surfaces of the tubes *b*, substantially as specified.

7. The combination, with the chamber E, of the surrounding annular chamber *s*, communicating with E through a continuous narrow opening extending around E, or through a series of small passages, the said annular chamber and connections with E serving to deliver steam or vapors from the latter into the main B, substantially as described.

8. The within-described devices for regulating the flow of feed water or liquid into an evaporator or steam-generator by means of the variations of level of the liquid in the same, consisting of the hollow globe F, communicating from below through a flexible connection with the interior of the evaparator below the water-line, and from above communicating through a flexible connection with the steam-space above the level of the liquid, and mechanism connecting the globe with a valve in the feed-pipe, and operating to close the said valve more and more as the globe is weighed down by a rising of the liquid in the same, and also operating to open the valve in proportion to the lightening of the globe by a sinking of the liquid in the same, substantially as specified.

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Witnesses:
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