

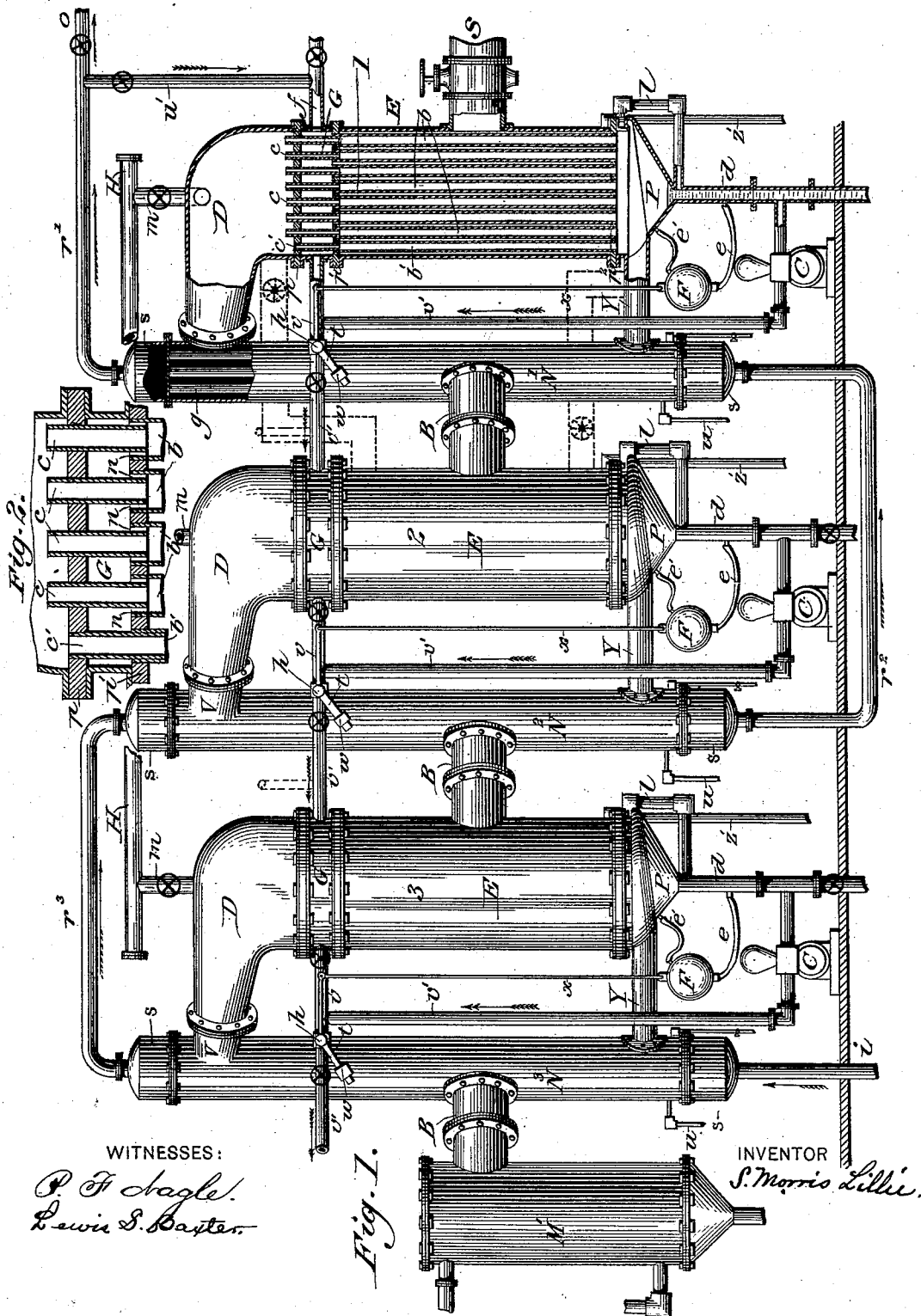
(No Model.)

S. M. LILLIE.

VACUUM APPARATUS FOR EVAPORATING LIQUIDS.

No. 378,843.

Patented Feb. 28, 1888.



UNITED STATES PATENT OFFICE.

S. MORRIS LILLIE, OF PHILADELPHIA, PENNSYLVANIA.

VACUUM APPARATUS FOR EVAPORATING LIQUIDS.

SPECIFICATION forming part of Letters Patent No. 378,843, dated February 28, 1888.

Application filed March 25, 1887. Serial No. 232,366. (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 Evaporating and Heating Apparatus, of which the following is a specification, reference being had to the accompanying drawings.

This invention consists in combining a series of evaporating-pans, each having a construction substantially as shown in Letters Patent No. 341,669, issued to me May 11, 1886, to form a multiple-effect evaporating apparatus; and it consists, further, in a series of surface-heaters arranged in connection with the pans of the multiple effect and operating to use a portion of the vapors from the several pans for heating either a single liquid passed in succession through the several heaters in the direction from the coolest to the hottest, or for heating different liquids in the several heaters, respectively.

Referring to the drawings, Figure 1 is an elevation of a triple effect and connected surface-heaters illustrative of my invention, one of the pans—viz., 1—being shown in vertical section, and one of the heaters—viz., N'—having a portion of its shell broken away to expose its interior construction to view. Fig. 2 is a view of a detached part, showing on an enlarged scale tubes *c* and *b*, with the annular passages *n* between them, which passages do not distinctly appear in Fig. 1 on account of the greater number of tubes in the latter and of the smallness of the scale to which it is drawn.

The individual pans of the multiple effect shown in the drawings have each the general construction of that shown in Patent No. 341,669, dated May 11, 1886, to which reference may be had for a detailed description of the same.

The *modus operandi* of the individual evaporators is briefly as follows: The liquid to be evaporated is delivered continuously from the supply-pipe *f* (or *v'*) upon the inner surfaces of the evaporating-tubes *b* through connections consisting of the passages among the tubes *c* in the chamber G and the annular passages *n* (see Fig. 2) between the tubes *c* and *b*, down which surfaces it flows into the collecting-chamber P, suffering an evaporation

in its course due to a heating agent—such as steam—supplied to the case E by the main S. The liquid which falls into the chamber P is drawn continuously from the latter by a pump, C, which delivers it either through the pipe *v* back into the chamber G, to pass again through the tubes *b*, or by a main, *v'*, to some other destination, which, in the case of a multiple effect, is into the evaporating-tubes *b* of the next pan. The vapors resulting from the evaporation escape from the tubes *b*, from their upper extremities, through the tubes *c*, into the dome D, and from their lower extremities into the collecting-chamber P, and, lastly, pass from the dome D and chamber P through the conduits V and Y. Any liquid that may be projected from the tubes *c* into the dome D falls upon the tube-plate *p* and flows back through the tubes *c'* and *b'* into the chamber P.

In the drawings three pans, numbered 1, 2, and 3, respectively, each having the construction and method of operation above described, are connected together to work as a multiple effect. The collecting-chamber P of each pan is connected, through the pipes *d*, pump C, pipe *v'*, and passages among the tubes *c* in the chamber G of the next pan of the series, with the feed ends of the evaporating-tubes *b* of the latter, excepting that of the last pan, which communicates through its pump C and pipes *d* and *v'* with the receptacle for the evaporated liquid. The dome D and the chamber P of each pan communicate through the connections V and Y, respectively, and in the particular construction shown through the case of a surface-heater, N', with the heating-chamber E of the next pan of the series, excepting in the case of the last pan—viz., pan 3—whose vapors pass from the case of its surface-heater N³ to a condenser, M', provided with the usual vacuum-pumps, (not shown,) in which they are condensed by cold water passing through the same. Each pipe *v'* has a branch, *v*, leading into the feeding-chamber G of the pan from whose pump C it leads, so that each pump C may deliver from the chamber P of its own pan back into the evaporating-tubes *b* of the same, or into the tubes *b* of the next pan, or into both.

Each pipe *v'* is fitted with a valve, *h*, whose stem bears two levers, one of which inclines

from the stem below the horizontal and carries a weight, w , which tends to revolve the stem to close the valve, while the other, which stands horizontal while the valve is closed, supports, by the suspending rod or cord x , the hollow globe F, whose interior communicates at the top and bottom, through the flexible tubes $e e'$, with the collecting-chamber P at different levels, respectively above and below the globe, and whose weight tends to revolve the stem of valve h so as to open the valve. The effect of the weight w , acting on its lever, is sufficient to overbalance that of the empty globe F and its lever, and to close the valve h and to keep it closed as long as the globe remains empty. As in the operation of the apparatus, to be hereinafter described, liquid rises in the collecting-chamber P above the level of the bottom of the globe, the latter becomes weighted by the rising liquid, which maintains the same level in the globe as in the chamber P, more and more, until finally the combined weight of the globe and its contained liquid will slightly overbalance the weight w , and will cause the stem of the valve to revolve to open the valve until the leverage of the weight w is increased by the motion of its lever t toward the horizontal sufficiently to enable it to counterbalance the increased weight of the partially-filled globe F. As the liquid continues to rise in the chamber P and globe F the valve h will be more and more opened by the increasing weight of the globe, until finally it will be wide open when the liquid has risen in the chamber and globe so as to, say, two-thirds fill the latter. It is apparent that by this device the flow of liquid away from a pan by the main v' will be regulated automatically by the height of the liquid in P, and that, as the globe F is above the connection leading from the pipe d to the pump C, the valve h will be closed before the surface of the liquid in the chamber P and pipe d sinks to the said outlet to the pump C, and so nothing but liquid—i. e., no vapors—can ever pass from the pan by the pipe v' .

The surface-heaters used in connection with the several pans of the multiple effect may be of any of the common and suitable constructions, those shown in the drawings being in the form of a vertical cylinder having induction and eduction chambers s at its two ends, respectively, for the liquid to be heated, which communicate with each other by a battery of tubes, g , which extend through a heating-chamber, N, forming the middle section of the cylinder.

The dome D and chamber P of each pan of the multiple effect communicate with the heating-chamber of its surface-heater by means of the conduits V and Y, respectively, and the said heating-chamber of the surface-heater has a connection through B with the heating-chamber E of the next coolest pan, excepting in the case of the surface-heater of the last pan of the series, which connects with a condenser, M', in which cold water is used as the

condensing agent. The several surface-heaters N' N' N' of the multiple effect are connected together by means of the pipes $r' r'' r'''$, so that a liquid may be passed through them in succession.

Each surface-heater is provided with a pipe, u , for conducting away its water of condensation, and the heating-chamber E of each of the pans is provided with similar condensed-water pipes, z' , all of which pipes u and z' are fitted with the usual steam-traps, although they do not appear in the drawings. The collecting-chamber P of each pan is provided with a gage-glass, l , for indicating the level of the liquid in the chamber. The pans are fitted with the usual fittings, vacuum-gages, thermometers, and the like, although they do not appear in the drawings. The vapor-spaces of all the pans are connected together by the main H, having valved branches m , one to the dome D of each pan.

The method of using this apparatus for the evaporation of a liquid is as follows: The valves in the branches m of the main H are opened, the vacuum-pumps of the condenser M' started, and the cold condensing-water turned into the condenser M', in virtue of all of which the air is exhausted from all of the elements of the apparatus. The valves in branches m are then closed, and steam is allowed to flow into the chamber E of pan No. 1 from the main S, and the liquid to be evaporated is delivered continuously into the evaporating-tubes b from the supply-pipe f through the connecting-passages in the chamber G and between the walls of the tubes c and b , (see Fig. 2,) and is allowed to flow down the inner surfaces of the evaporating-tubes into the collecting-chamber P. When the level of the liquid in P has risen sufficiently to weigh down the globe F and open the valve h in the pipe v' to a degree, the pump C draws the liquid from the chamber P and delivers it continuously into the feeding-chamber G of pan No. 2, whence it flows down the inner surfaces of the tubes b of the same into its collecting-chamber P, whence, having attained a sufficient level in the latter to act through its globe F to open the valve h in its pipe v' , the liquid is delivered into the feeding-chamber G of pan 3, thence to flow down the inner surfaces of the tubes b of the latter into the collecting-chamber P, whence, having attained a sufficient altitude to operate the valve h of the third pan, it is delivered by the pump C of the same through its pipe v' to any destination desired. As long as the liquid is continued running into the feeding-chamber G of the first pan and the pumps C are continued moving, the liquid will continue running from the discharge-pipe v' of the third pan (or of the last pan, whatever may be the number of pans in the series,) and the liquid will be maintained at certain levels in the chambers P through the automatic operation of the valves h by the liquid in the said chamber, as hereinbefore described. The steam supplied to the heating-chamber E of

pan 1 causes evaporation from the liquid running down the interior surfaces of its tubes *b*, the resulting vapors escaping from the tubes into the dome *D* and collecting-chamber *P* of the pan, and thence pass into the case of the surface-heater *N'*, whence the portion not condensed in the latter, as presently to be described, passes by pipe *B* into the heating-chamber *E* of pan 2 and causes evaporation from the liquid flowing down the interior surfaces of its tubes *b*, the vapors from which pass into the dome *D* and chamber *P* of the pan, and from them into the case of the surface-heater *N'*, and the portion uncondensed in the latter passes to the chamber *E* of the third and, in this case, last pan of the series and effects evaporation from the liquid flowing down the interior surfaces of its tubes, the vapors from which pass through the dome *D*, chamber *P* of the pan, and through the case of the heater *N'* to the condenser *M'*, in which they are condensed. The temperatures and pressures in the several pans will vary with the pressure of steam in the case *E* of the first pan, and with the degree of vacuum or pressure maintained in the vapor-spaces *D* and *P* of the last pan by the condenser *M'* and its pumps.

By the above-described operation of pans, pumps *C*, and automatically-regulated valves *h*, the dilute liquid entering pan 1 continuously from the supply-pipe *f* is made to flow as continuously, but in a diminished quantity and concentrated form, from the pipe *v'* of pan 3—the last pan of the series. The density of the liquid flowing from the last pan—viz., 3—will, other things being equal, vary with the rate of flow of the dilute liquid into the first pan, and may be varied to suit by opening or closing the valve in supply-pipe *f* to the proper degree.

If at any time the liquid passing into any feed-chamber *G* is insufficient to keep the surfaces of the evaporating-tubes *b* below it properly covered with the liquid, the valve in the pipe *v* leading into that chamber is opened to a degree, and the want is met by liquid returned from the collecting-chamber *P* of the same pan by its pump *C* and pipes *v'* *v*. This return is maintained constantly, or as long as needed. This circulation of liquid from the chamber *P* of a pan into the chamber *G* and back again by the tubes *b* into *P* does not affect the level of the liquid in the latter, and so does not influence at all the workings of valve *h* and its regulating devices, their operations being influenced entirely by the rate of flow of the dilute liquid from the supply-pipe *f* into the first pan, 1. If this flow be diminished, the valves *h* will be in succession automatically closed to a degree. If the rate be increased, the valves will be in succession opened wider to a degree.

If the feed-chamber *G* of each pan had an independent supply-connection, as indicated by the dotted lines leading to the pipe *v'* in the

case of pans 2 and 3, it could be supplied with its own liquid, to the exclusion of any from the preceding pan of the series, and concentrate it to any degree, the concentrated liquid being drawn by the pump *C* from the collecting-chamber *P* and delivered by a separate pipe (not shown) to any destination desired, all as described in Letters Patent No. 341,669, issued to me May 11, 1886.

The surface-heaters *N'* *N'* *N'*, used in combination with the pans, are intended for using a portion of the vapors from each pan for heating the liquid to be evaporated prior to its passing into the feed-chamber *G* of the first pan. The course of this liquid through the combination of surface-heaters and pans is indicated by the arrows, the arrows having but one barb showing its course through the surface-heaters and those having two barbs indicating its course through the pans. The cool liquid enters the heater *N'* at the bottom by the pipe *i*, flows from the top of the same, by the pipe *r'*, into the top of heater *N'*, from the bottom of *N'*, by the pipe *r''*, into the bottom of heater *N'*, and from the top of latter, by the connecting-pipes *r'*, *u'*, and *f*, into the feed-chamber *G* of pan 1, whence it flows through the series of pans, and away concentrated from the last of the latter, as hereinbefore described. In its passage through the heating tubes of the surface heaters it is heated in *N'* to a degree by the vapor from pan 3. During its passage through *N'* it is further heated by the hotter vapors from pan 2, and, finally, in passing through *N'* it is still further heated by the still hotter vapors from pan 1, and, if the condensers are of sufficient size, it will leave *N'* heated nearly to the temperature at which it will be evaporated in pan 1. The heated liquid may flow from the heater *N'* of the first pan directly into the feeding-chamber *G* of the latter *via* the pipes *r'*, *u'*, and *f*; or it may pass by the pipe *o* to apparatus in which it suffers a preliminary treatment, such as a defecation or filtration, as is the case in the treatment of cane or beet juice, in which event the heating in the heaters *N'* *N'* *N'* would be preparatory to the said preliminary treatment. In either case the heating is very economically done by heat which has been used from one to three times in the pans of the multiple effect.

It is apparent that any liquid other than that to be evaporated may be heated by being passed through the heaters *N'* *N'* *N'*, and that by having proper connections to the several heaters a different liquid may be heated in each, and also that when the dilution of the liquid to be heated is no objection the heaters may be of the jet or spray pattern instead of being surface-condensers, as shown. The vapors which pass from a pan uncondensed through its heater to the next pan of the series play no part in the heater, and so it is not necessary that they should pass through it. They might therefore be led directly from one pan to the other by a separate conduit between the

two—as, for example, by that indicated by dotted lines joining the dome D of pan 1 with the chamber E of pan 2, or by that connecting the chamber P of the former with the chamber E of the latter, also as indicated by dotted lines—the heater in that case being connected only with the pan furnishing steam or vapors to it.

As the evaporators are shown in the drawings, the vapors escape from the tubes of each pan to the next one in the series *via* both the dome D and the collecting chamber P. Should the conduit Y, leading from the chamber P, be closed, the vapors would all pass from the tubes of the pan by the dome D and conduit V. Should the conduit V be closed, the vapors would all pass from the tubes of the pan to the next one in the series by the collecting-chamber and its conduit Y; and I consider the construction to be included within the scope of my invention whether the vapors escape from the tubes *via* both D and P, or from either alone, to the next pan of the series. I consider it advantageous in some respects to have the vapors escape from both ends of the evaporating-tubes *b*; but without departing from my invention the dome D and tubes *c* may be dispensed with and all the vapors be made to escape from the opposite ends of the tubes into the common collecting-chamber, P, and from thence by the conduit Y, the liquid to be evaporated being delivered into the feed ends of the tubes by suitably arranged channels.

The distribution of the liquid to be evaporated from the feed-pipe (*f* or *v'*) of each pan to the different tubes of the pan may be accomplished in various ways—in that shown in the drawings, for example, by a system of distributing-tubes with branches respectively delivering the liquid to the different tubes, as described on page 3 of the specification of Patent No. 341,669, or in any one of a variety of conceivable manners. In many instances the difference in pressure between consecutive pans will be sufficient to cause a suitable flow of liquid from the chamber P of one pan into the evaporating-tubes *b* of the next pan, and in such cases a separate pipe-connection might be made for this purpose between the two pans, the pump C and connections only being employed to return liquid from the collecting-chamber of the pan to the chamber P of the same. When, however, the difference in pressure between consecutive pans is small, the power of a pump or equivalent device is desirable for forcing the liquid through the restricted feed-passages into the evaporating-tubes.

I do not limit myself either to any particular number, size, shape, or disposition of tubes in the individual pans, or to any special form of feeding device for the evaporating-tubes, or of other details connected with the same, or to any particular number of pans in a series, the principle of the operation of the apparatus being that the liquid to be evaporated is delivered, in the case of each pan, from

a supply-pipe, such as *f*, in limited quantities into the tubes of the pan at one end, through which tubes the liquid flows into a collecting-chamber common to all the tubes, such as P, suffering evaporation during its passage by contact with the heated walls of the tubes, that the vapors are allowed to escape from one or both ends of the tubes and are led to the heating-chamber E of the next pan, while the unevaporated liquid is delivered, as a rule, from the collecting-chamber P to the feeding device for the evaporating-tubes of the next pan.

It is apparent that the series of surface-heaters *N' N'*, &c., may be used in connection with the pans of a multiple effect of which the individual pans have other constructions than those shown in the drawings, each surface-heater, whatever may be the construction of the pans, being connected with the vapor-space of its pan by a vapor conduit and the heaters with each other by suitable pipes for conducting the liquid to be heated from heater to heater through the series, substantially as hereinbefore described; and therefore, in respect to this part of my invention, I do not limit myself to a combination of the surface-heaters with a series of pans having the particular construction shown in the drawings and hereinbefore described.

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

1. The combination, with an evaporating-pan having the dome D, collecting-chamber P, heating-chamber E, pipes *b*, and feeding devices for said pipes, of a second evaporating-pan having the same construction, vapor-conduits between the dome D and chamber P of the first pan and the heating-chamber E of the second pan, and a liquid-conducting main connecting the chamber P of the first pan with the feeding devices of the tubes *b* of the second pan, substantially as specified.

2. The combination of two or more evaporating-pans to form a multiple-effect apparatus, each pan being provided with a heating-chamber, E, containing evaporating-tubes *b*, which tubes communicate at one end with the dome D and with a feeding device, G, having restricted connections to the several tubes, and at the other end with the collecting-chamber P, a vapor-conduit for each pan, excepting the last one of the series, leading from the dome of the same to the heating-chamber of the next cooler pan, and a liquid-conducting pipe leading from the collecting-chamber of the former pan to the feeding device of the evaporating-tubes of the latter pan, substantially as described.

3. The combination of the battery of evaporating-tubes, their surrounding heating-chamber E, and collecting-chamber P, common to the said tubes of an evaporating-pan operated substantially as described, the heating-chamber and its contained evaporating-tubes of a second similarly-operating pan, a vapor-conduit leading from the collecting-chamber P of

the first pan to the heating-chamber E of the second pan, and a liquid-conducting pipe and connections leading from the chamber P of the former to the feed ends of the evaporating-tubes of the latter, substantially as and for the purpose described.

4. The combination of the battery of evaporating-tubes *b*, their surrounding heating-chamber E, and collecting-chamber P, common to the said tubes of an evaporating-pan operating substantially as described, the heating-chamber E and tubes *b* of a second similarly-operating pan, and a vapor-conduit leading from the collecting-chamber P of the first pan to the heating-chamber E of the second pan, substantially as and for the purpose specified.

5. The combination, with two consecutive pans of a multiple-effect evaporating apparatus, each pan being provided with the evaporating-tubes *b* and collecting-chamber P, of a pump, C, having its suction-pipe connected with the chamber P of the first of the two pans and its eduction-pipe *v' v* with the feed ends of the evaporating-tubes *b* of each pan, the pump and its connections operating to draw liquid from the chamber P of the first pan and to deliver it to the evaporating-tubes of the same pan or to the tubes of the second pan, or to both, substantially as specified.

6. The combination, with two consecutive pans of a multiple-effect evaporating apparatus, each pan being provided with the evaporating-tubes *b* and collecting-chamber P, of a pump, C, having its suction-pipe connected with the chamber P of the first of the two pans and its eduction-pipe *v'* with the feed ends of the evaporating-tubes of the second pan, the pump and its connections operating to draw liquid from the chamber P of the first pan and to deliver it to the evaporating-tubes of the second pan, substantially as specified.

7. The combination, with an evaporating-pan, of a surface-heater adapted to heat a liquid, and a second evaporating-pan, each connected with the first pan by a suitable vapor-conduit, the surface-heater operating to utilize a portion of the vapors generated in the first pan for heating a liquid passing through the said heater, and the second pan operating to utilize another portion of the vapors for evaporating a liquid, substantially as specified.

8. The combination, with an evaporating-pan constructed and operating substantially as set forth, of a surface-heater and a second evaporating-pan, the collecting-chamber of the first pan being connected by suitable vapor-conduits with the surface-heater and with the heating-chamber of the second pan, substantially as specified.

9. The combination, with an evaporating-pan constructed and operating substantially as set forth, of a surface-heater and a second evaporating-pan, the dome of the first pan being connected by suitable vapor-conduits with the surface-heater and with the heating-chamber of the second pan, substantially as specified.

10. The combination, with an evaporating-pan constructed and operating substantially as set forth, of a surface-heater and a second evaporating-pan, the dome and the collecting-chamber of the first pan each being connected by suitable vapor-conduits with the surface-heater and with the heating-chamber of the second pan, substantially as specified.

March 23, 1887.

S. MORRIS LILLIE.

Witnesses:

AUGUSTUS B. STOUGHTON,
MORRIS R. BOCKIUS.