H. H. DOW.

APPARATUS FOR MULTIPLE EFFECT VACUUM EVAPORATION.

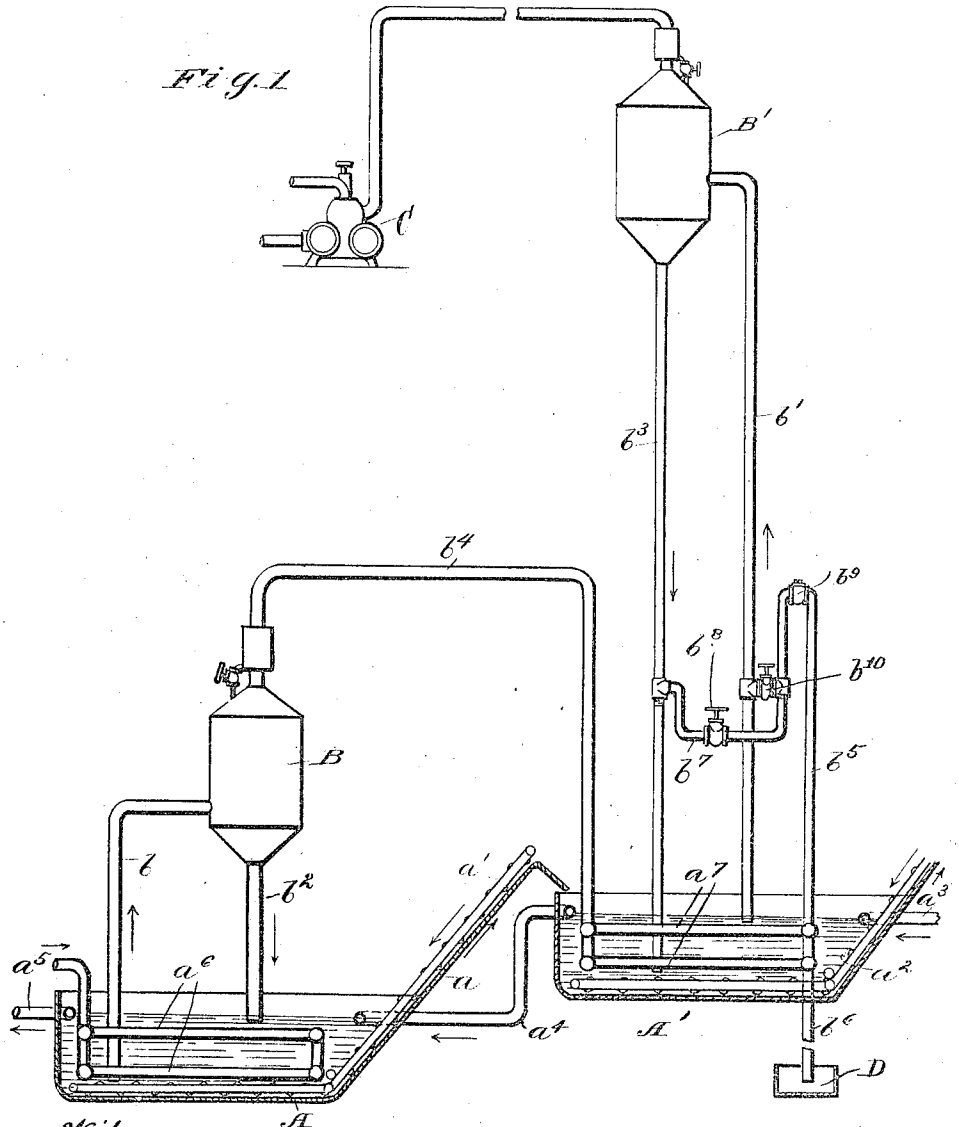
APPLICATION FILED DEC. 26, 1907.

1,004,686.

Patented Oct. 3, 1911

2 SHEETS—SHEET 1.

Fig. 1.



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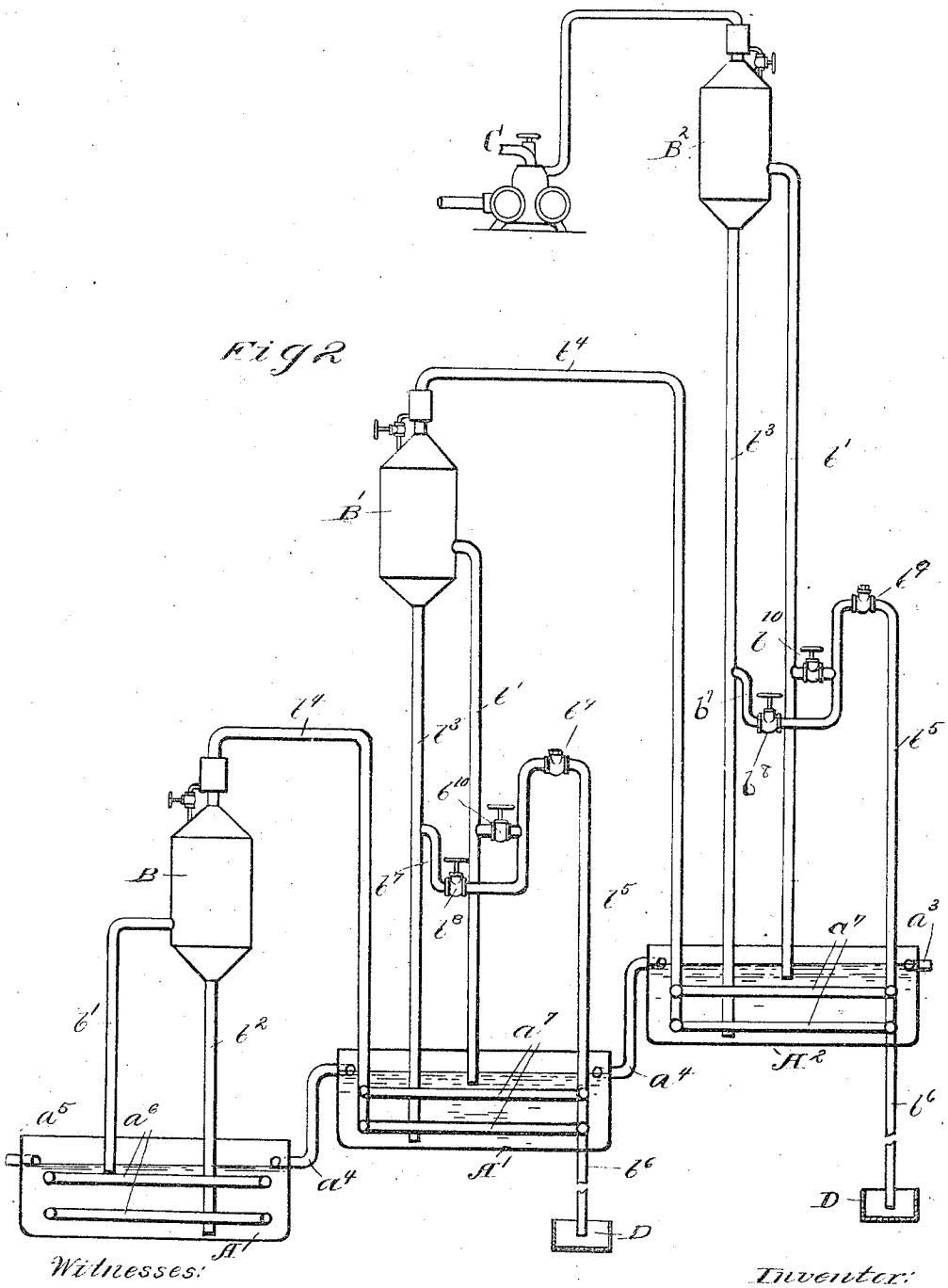
2 SHEETS—SHEET 2.

Fig 2



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR MULTIPLE-EFFECT VACUUM EVAPORATION.

1,004,686. Specification of Letters Patent. Patented Oct. 3, 1911.

Application filed December 26, 1907. Serial No. 408,179.

To all whom it may concern:

Be it known that I, HERBERT H. DOW, a citizen of the United States, resident of Midland, county of Midland, State of Michigan, have invented a new and useful Improvement in Apparatus for Multiple-Effect Vacuum Evaporation, of which the following is a specification, the principle of the invention being herein explained and the best mode in which I have contemplated applying that principle, so as to distinguish it from other inventions.

As indicated, my invention relates to apparatus for evaporation by vacuum process. Said invention has more particular regard to the improvement of apparatus of the above class known as multiple effect vacuum apparatus, in which the steam arising from the evaporation of a quantity of solution thus held under reduced pressure, is employed to heat an additional quantity of the solution, the object of the invention being the provision of apparatus of this sort that will be simple and economical in operation, utilizing a single pump in the production of a vacuum in a plurality of chambers.

To the accomplishment of this and related ends said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims.

The annexed drawings and the following description set forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawings: Figure 1 represents in more or less diagrammatic form, portions appearing in cross section, a plant for double effect vacuum evaporation embodying the several improvements comprehended in my invention; and Fig. 2 similarly shows apparatus designed for triple effect evaporation.

The apparatus thus chosen for illustrative purposes is primarily designed for the evaporation of salt brine, but may be used equally well, either in its present or in slightly modified form, for the evaporation of sugar syrup or any other solution from which it is desired to separate the solid, or for the concentration of liquors from which the solid does not separate on concentration. The illustrated apparatus is furthermore designed to carry out an improved process in the making of crystals from solutions, particularly salt brine, that forms the subject-matter of a co-pending application filed by me November 11, 1907, Serial No. 401,580. Such apparatus, then, consists essentially of a plurality of open evaporting pans A A′, there being two here shown, the second of which is elevated slightly above the first so that its liquid contents may be passed on to said first pan by gravity. The process of making crystals above referred to involves, in addition to such flow of the brine, a transfer of the salt separated from the more highly concentrated solution, in the first pan to the less highly concentrated solution in the second pan. To this end the wall a of such first pan A contiguous to the second A′ is inclined and a conveyer a' provided to gather the salt as it settles onto the bottom and carry the same up such inclined side whence it is deposited or dropped into the second pan to be carried through the latter by a corresponding conveyer a^2 operating in such pan. The latter pan has also an inclined discharge end either connected with the succeeding pan or with conveying means (not shown), for removing the product to any desired point. Suitable connections a^3 a^4 a^5 respectively provide for a supply of fresh brine to pan A′, a flow from such second pan to the first pan A, and a discharge thence of the highly concentrated solution or "mother liquor." The heating of the brine in the respective pans is had by means of steam coils a^6 a^7 consisting of sections of pipe disposed longitudinally of the pan and having their ends suitably connected together. Steam is supplied to the coils in the first pan from any convenient source in the usual manner; but for the heating of the second coil the steam derived from the evaporation of the contents of the first pan under vacuum is utilized by means now to be described.

Elevated above the respective evaporating pans are vacuum chambers B B′, which have ascending pipes b b' for drawing the contents from the corresponding pans, and descending pipes b^2 b^3 for discharging separated crystals. In the apparatus illustrated such discharge is had directly into the pan again, but obviously this is immaterial, and, if found desirable such discharge may be made into a separate receptacle, as in my Patent No. 554,916, February 18, 1896. A pipe b^4 conducts the steam from vacuum chamber B to the steam coil a^7 of the second

pan. This steam coil is furthermore connected by means of a pipe b^5 and its extension b^7 through the valves b^{10} and b^8 with the pipes b' and b^3 respectively and by means of the descending pipe b^6 with the open receptacle D disposed on a lower level than said pans, as shown. Connected with vacuum chamber B′ is a pump C adapted to maintain in said chamber any desired degree of vacuum, while a check valve b^9 prevents any backward or downward movement in pipe b^5. It will be observed that the lower ends of pipe b' and b^2 dip below the level of the water in the pans, as does also the lower end of pipe b^6 below the level of the water in the tank D. Such pipe b^6, it will be understood, is intended to drain away from the coil b^7 the condensation formed therein, such tank D forming a water seal and trap, since the length of pipe b^6 below the coils is made sufficient so that the vacuum therein may not draw the water in said tank D up into the coils, but leave them free to drain into said pipe b^6.

Having thus described with what it is thought sufficient detail the structure embodied in my improved type of vacuum apparatus, its method of operation may be briefly set forth. When the apparatus is started and during its operation, brine is supplied through connection a^3 to pan A′ and thence by connection a^4 to pan A, the rate of such supply being so controlled, having due regard to the rapidity of the evaporation, as to leave the mother liquor escaping from discharge pipe a^5 of the desired concentration. Steam is at the same time admitted into the coils a^6 in the first pan A, the temperature of the brine therein being raised and held a few degrees above the boiling point referred to the vacuum maintained in chamber B. The exhaust pump C is now set in operation, the valve b^{10} between the ascending pipes b' b^5 of the second vacuum chamber B′ being temporarily open. The immediate effect of such suction accordingly is the production of a vacuum in chamber B corresponding to the height of the column of liquid from the point of junction of pipe b^{10} with pipe b' to the level of the brine in pan A′. Further pumping, by increasing the vacuum in chamber B′, serves to raise the contents of the pan A′ into said chamber B′ without, however, varying the vacuum in chamber B, as will be evident. The level of vessel D being sufficiently depressed, a counter-balancing column of liquid will rise in pipe b^6 at the same time that the vacuum is produced in chamber B in the manner just set forth.

It will be understood of course that pipe b' constitutes in effect a barometric column, the height to which the brine rises in such pipe measuring the degree of vacuum in chamber B′. If a series of vacuum gages were connected to this pipe at intervals, the one at the top would show the highest vacuum, that at the bottom would show the lowest, and those between would show intermediate degrees of vacuum. For this reason, if the pipe b^5 (and in the case of Fig. 2 this remark applies also to pipe b^7) be tapped into this barometric column at any height, the vacuum in said pipe b^5, or b^7 as the case may be, will correspond in degree to that in the barometric column at the point tapped. This will be evident when it is considered that the brine in pipe b' above the junction therewith of said pipe b^5 rests upon such point of junction and diminishes by its weight the total vacuum in pipe b', so that the higher such point of junction with pipe b', the greater the degree of vacuum in pipe b^5; and conversely, the lower the point of entrance, the lower the degree of vacuum in such pipe b^5. As a result of the vacuum maintained in heating coils a^7 of the second evaporating pan A, the steam from the low vacuum chamber B is drawn therein where it heats the brine in such second pan, the water of condensation escaping into the pipe b^6.

The height of the vacuum chamber B′ and the degree of vacuum maintained therein is chosen, both as to its absolute value and its relation to the height of the chamber B and the vacuum maintained therein, so that the temperature of the vapor coming from B will be sufficient to raise the temperature of the brine in A′ to above its boiling point under vacuum in B′.

I do not ascribe novelty to the utilization of steam derived in this manner to heat the second evaporating vessel, but it will be noted that by means of my apparatus I am enabled to maintain the desired vacuum in such first system without the employment of an additional pump, or a reducing valve, as has always been the case heretofore, so far as I am aware. In other words a single pump connected with the high-vacuum chamber is effective in maintaining the vacuum, not merely in such chamber, but also in the low-vacuum chamber corresponding with the first evaporating pan without the introduction of a mechanically operated reducing valve. The simplification and cheapening of operation thus accomplished need not be further dwelt upon. At the same time it will be observed that a constant vacuum is maintained in the first rig determined by the height of the column of liquid in the ascending pipe b' up to the point of its junction with pipe b^5; this, irrespective of the degree of vacuum in chamber B′, which may vary within reasonable limits without harm so long at is does not thus affect the vacuum in such first chamber. As explained in my Patent No. 554,916 before referred to, the flow of brine during the operation of

the vacuum evaporator B′ is up the pipe b' and down b^3.

In starting the system, I open valve b^{10} admitting the air and vapor from b^5 to the ascending column of brine, by which it is delivered to the chamber B′ whence it is drawn out by the pump. In order to lessen the work of the pump after the system has attained its normal working condition, I open the valve b^8, at the same time closing valve b^{10}, thus admitting the said air and vapor from b^5 into pipe b^3, where it is entrained by the descending column of brine and is carried down into the pan and discharged to the atmosphere by bubbling up through the brine contained therein.

It should be plainly evident, without further delineation than that shown in Fig. 1, how the double effect there illustrated can be extended to triple and higher multiple effects by suitable adaptation of parts. It has been deemed advisable, however, to illustrate one such modification, Fig. 2, wherein a triple effect vacuum evaporation is had. To this end merely a third open heating pan A^2 together with a third vacuum chamber B^2 require to be employed, these being joined with each other and with the preceding pan A′ and chamber B′ of the series by connections corresponding with those previously described as joining such pan A′ and chamber B′ with pan A and chamber B. These connections have accordingly had applied to them the same reference characters and their identification thus rendered possible without further description. In this apparatus as the other, one pump C will suffice to maintain vacua in all of the evaporators, the degree of vacuum in each being controlled by the corresponding heights at which the pipes b^5 b^7 are connected into pipes b b' and b^3. In the same manner additional "effects" may be secured as desired or found advisable.

In this specification, and the claims which follow, the term "open" as applied to the heating vessels is employed to denote that the same are operated under atmospheric, or substantially atmospheric, pressure, in contradistinction to the prevailing practice in which the liquid being heated is subjected to reduced pressure during the heating.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any one of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. In apparatus of the class described, the combination of two open heating vessels; vacuum chambers respectively adapted to receive the contents of said vessels; and an exhausting device connected with the second of said chambers for maintaining the desired degree of vacuum therein, said second chamber being connected with said first chamber so as simultaneously to maintain a vacuum therein.

2. In apparatus of the class described, the combination of two open heating vessels; vacuum chambers respectively adapted to receive the contents of said vessels; an exhausting device connected with the second of said chambers for maintaining the desired degree of vacuum therein; and connections between said two chambers, said connections being so arranged and constructed as simultaneously to maintain a vacuum in said first chamber, but of a lower degree.

3. In apparatus of the class described, the combination with two open evaporating pans, steam heating devices for said pans, and vacuum chambers respectively adapted to receive the contents of said pans, the heating device of the second pan being connected to receive steam from the chamber attached to the first pan; of a pump connected with the chamber attached to said second pan for maintaining the desired degree of vacuum therein, said second chamber being connected with such heating device so as simultaneously to maintain a vacuum therein.

4. In apparatus of the class described, the combination with two open evaporating pans, steam heating devices for said pans, and vacuum chambers respectively adapted to receive the contents of said pans, the heating device of the second pan being connected to receive steam from the chamber attached to the first pan; of a pump connected with the chamber attached to said second pan for maintaining the desired degree of vacuum therein; and connections between said last named chamber and such heating device, said connections being so arranged and constructed as simultaneously to maintain a vacuum in said first named chamber, but of a lower degree.

5. In apparatus of the class described, the combination of two open evaporating pans; steam heating coils therein; an elevated vacuum chamber for each of said pans, each of said chambers having an ascending pipe for drawing the contents from the corresponding pan and a descending pipe for discharging separated crystals, the heating coils of the second pan being connected to receive steam from the chamber corresponding with the first pan; and a single exhausting device adapted simultaneously to create a vacuum in such coils and in the chamber corresponding with said second pan.

6. In apparatus of the class described, the

combination of two open evaporating pans; steam heating coils therein; an elevated vacuum chamber for each of said pans, each of said chambers having an ascending pipe for drawing the contents from the corresponding pan and a descending pipe for discharging separated crystals, the heating coils of the second pan being connected to receive steam from the chamber corresponding with the first pan; a connection between such coils and the ascending pipe of the chamber corresponding with said second pan; and a pump connected with said last named chamber for maintaining a vacuum therein.

7. In apparatus of the class described, the combination of two open evaporating pans; steam heating coils therein; an elevated vacuum chamber for each of said pans, each of said chambers having an ascending pipe for drawing the contents from the corresponding pan and a descending pipe for discharging separated crystals, the heating coils of the second pan being connected to receive steam from the chamber corresponding with the first pan; a connection between such coils and the ascending pipe of the chamber corresponding with said second pan; a valve-controlled pipe adapted to connect the descending pipe of said last named chamber with such coils; and a pump connected with said last named chamber for maintaining a vacuum therein.

8. In apparatus of the class described, the combination of two open evaporating pans; steam heating coils therein; an elevated vacuum chamber for each of said pans, each of said chambers having an ascending pipe for drawing the contents from the corresponding pan and a descending pipe for discharging separated crystals, the heating coils of the second pan being connected to receive steam from the chamber corresponding with the first pan; a connection between such coils and the ascending pipe of the chamber corresponding with said second pan; a valve-controlled pipe adapted to connect the descending pipe of said last named chamber with such coils; another connection between such coils and a receptacle depressed below the level of said pans; and a pump connected with said last named chamber for maintaining a vacuum therein.

9. In apparatus of the class described, the combination of a series of open heating vessels; vacuum chambers respectively adapted to receive the contents of said vessels; and an exhausting device connected with the last of said chambers for maintaining the desired degree of vacuum therein, said last chamber being connected with the remaining chambers in the series so as simultaneously to maintain a vacuum therein.

10. In apparatus of the class described, the combination of a series of open heating vessels; vacuum chambers respectively adapted to receive the contents of said vessels; and an exhausting device connected with the last of said chambers for maintaining the desired degree of vacuum therein, said last chamber being connected with the remaining chambers in the series, the connections between said chambers being so arranged and constructed as simultaneously to maintain vacua therein but of lower degree in each succeeding chamber.

11. In apparatus of the class described, the combination with a series of open heating vessels having steam heating devices for said vessels; of a corresponding series of vacuum chambers respectively connected to receive the contents of said vessels; a pump connected to the last of said chambers and adapted to maintain the desired degree of vacuum therein; of connections adapted to lead steam from each chamber, except the last, to the next succeeding heating device and of connections between each chamber, except the first, and the heating device corresponding thereto, said last connections being so arranged and constructed as to reduce in a predetermined manner the degree of vacuum in each succeeding chamber.

12. In apparatus of the class described, the combination of a series of open heating vessels having steam heating elements therein; a corresponding series of vacuum chambers placed at serially increasing elevations respectively above the said vessels directly related thereto; connecting pipes adapted to lead steam from each said chamber into the heating element of the said vessel directly related to the next higher chamber; an exhausting device connected to the last and higher chamber and adapted to maintain therein the desired degree of vacuum; circulating pipes connecting the directly related chambers and vessels respectively and adapted to circulate the contents of the latter through the former; watersealed drip pipes adapted to discharge the water of condensation from the heating elements when working under vacuum; and valve controlled pipes connecting the respective heating elements with the directly related circulating pipes at such elevations above their corresponding vessels as thereby to automatically reduce the initial vacuum in the highest chamber to vacua of lower degree in each succeeding lower chamber.

Signed by me this 25 day of November, 1907.

HERBERT H. DOW.

Attested by—
THOS. GRISWOLD,
E. O. BARSTOW.