3 Sheets—Sheet 1.

P. PICCARD.

Process and Apparatus for Evaporating Saline Solutions.

No. 219,874. **Patented Sept. 23, 1879.**

Fig. 1.

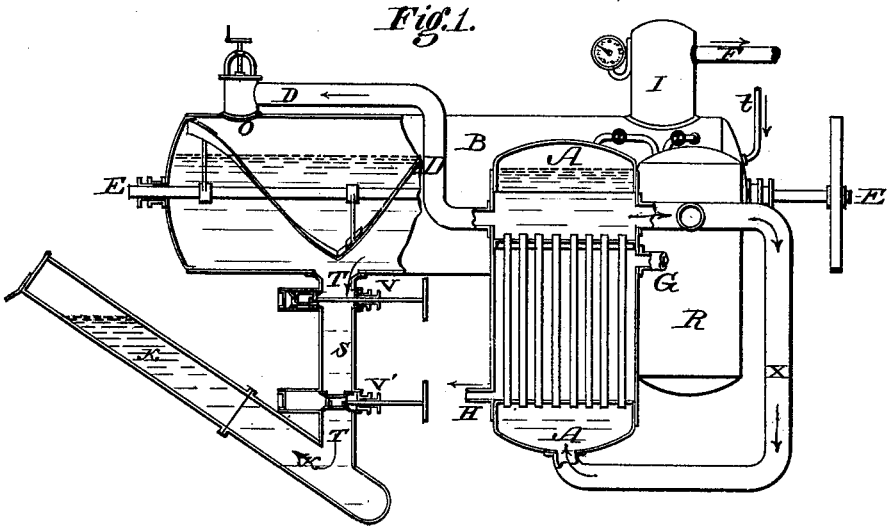

Fig. 2.

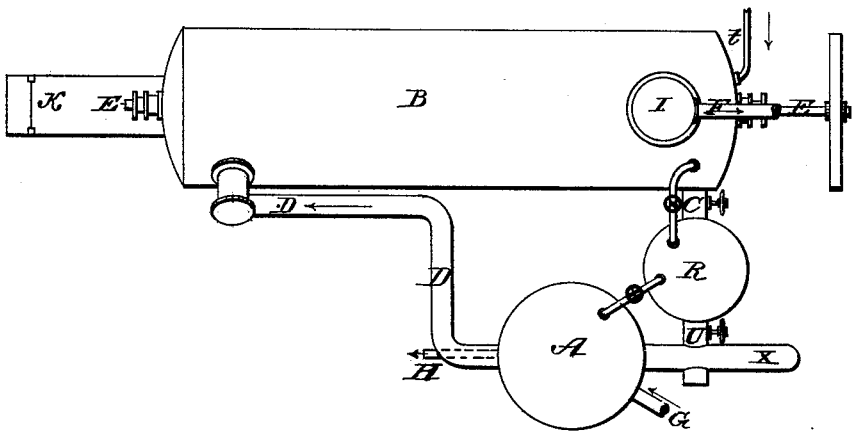

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Fig. 5.

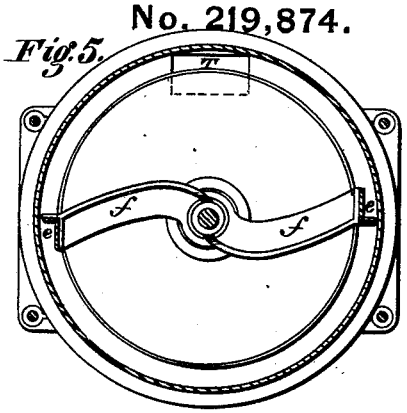

Fig. 3.

Fig. 7.

Fig. 6.

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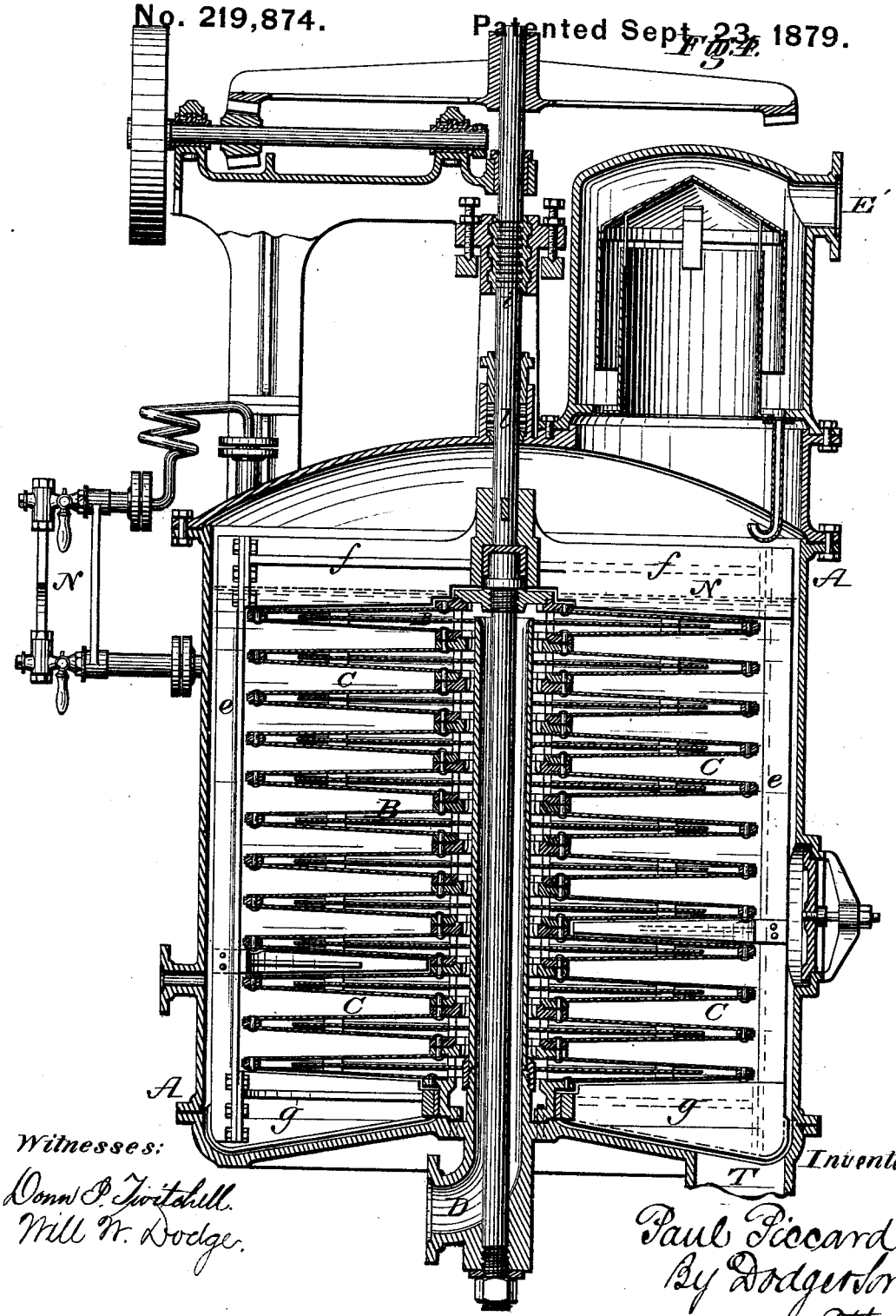
Process and Apparatus for Evaporating Saline Solutions.

No. 219,874. Patented Sept. 23, 1879.

Fig. 4.



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UNITED STATES PATENT OFFICE.

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IMPROVEMENT IN PROCESSES AND APPARATUS FOR EVAPORATING SALINE SOLUTIONS.

Specification forming part of Letters Patent No. **219,874**, dated September 23, 1879; application filed October 26, 1878; patented in France, November 26, 1877, and in England, August 6, 1878.

To all whom it may concern:

Be it known that I, PAUL PICCARD, of Lausanne, in the Republic of Switzerland, have invented certain Improvements in the Process of Evaporating Saline Solutions and in Apparatus Used for that Purpose, of which the following is a specification.

My invention has for its object improvement in the process of evaporating saline solutions, and in apparatus used for that purpose.

For the above purpose I conduct the heating of the liquid to be evaporated and its evaporation in distinct vessels, so that the solution, during the operation of heating, whether it be by circulation of vapors in a tubular, lenticular, or other apparatus, or by other means, cannot deposit any part of the salt which it contains, and so that the deposit of the salt shall take place in a separate vessel by rapid vaporization. This is effected by the application of a well-known principle; and consists in maintaining in the heating apparatus an artificial pressure, and causing expansion to take place at the entrance of the vaporizing-vessel; further, and it is an essential part of the process, the delivery of the salt deposited in the vaporizing-vessel takes place gradually, as well as its extraction from the apparatus, without ever allowing any admittance of the atmospheric air or any exit of vapor.

In the accompanying drawings, Figure 1 represents a side elevation of my improved apparatus, partially in section; Fig. 2, a top-plan view of the same; Fig. 3, a vertical section of a modified form of my apparatus; Fig. 4, an enlarged vertical central section of the lenticular heating-chamber employed in the same; and Figs. 5, 6, and 7 views illustrating certain details of construction.

The apparatus consists of a boiler, A, which may be of any desired form, and a vessel, B, called the "evaporator." A discharge-pipe, T T, furnished with two valves, V and V′, placed one above the other, and having a space, S, between them, is fixed at the bottom of the evaporator, so that by alternately closing one valve and then opening the other the salt deposited in the evaporator can be withdrawn without putting the evaporator into communication with the exterior air.

The lower end of the discharge-tube is prolonged by means of a branch, K K, ascending obliquely to the same height as that of the valves, and is open at the top. The column of water in this branch thus balances that of the tube T, and prevents any discharge of vapor. The salt that falls in the elbow is drawn out by any suitable means.

The tubes and ends of the tubular boiler A are, by preference, filled with the solution to be vaporized, and the evaporator is partially filled with the same solution.

Between the evaporator B and the boiler A is placed an intermediate vessel, R, which serves to permit the solution to pass from the evaporator B to the boiler without allowing the pressure which exists in the boiler to be transmitted to the evaporator. To this effect a pipe, C, starts from a point of the evaporator situated below the surface of the liquid in the same, leading to the inside of the intermediate vessel R, which, in turn, communicates with the boiler A below the surface of the liquid by means of a pipe, U. Pipes are also provided at the top or vapor chamber of the intermediate vessel, placing it in communication, respectively, with the top or vapor spaces of the boiler A and evaporator B.

Suitable valves are provided for closing and opening alternately ports that establish communication of the intermediate vessel with the vapor and solution spaces of the boiler and evaporator alternately. Thus when the solution must be passed from the evaporator to the intermediate vessel, the needful ports being opened, both vapor and solution are equalized in both vessels. The ports are then closed. The other ports communicating with both vapor and solution spaces in the boiler are now opened, and the pressure of vapor being equalized, the excess of solution in the vessel R runs out freely into the boiler.

In place of this arrangement a direct pipe may be provided for leading from the evaporator (as does the pipe C) to the boiler, passing through a pump that would force the solution into the boiler; but this is objectionable, and I prefer to use the intermediate vessel.

From the upper part of the boiler A a pipe, D, leads to the evaporator B through an orifice, O, the size of which may be regulated in

any suitable manner, either by a needle, or by a valve or plug, or may be kept uniformly of the same size.

The evaporator B is furnished with a dome, I, from which a pipe, F, passes for the escape of the vaporized products, and it is also furnished with a gage and with a pipe, *t*, branched off at any convenient point on the part filled with liquid for the introduction of any requisite addition of salt-solution.

The evaporator B is traversed by a shaft, E E, which carries one or more screw-blades, which, by their rotation, carry into the tube T T the salt deposited by the evaporation. This may, however, be modified.

The boiler A carries two pipes, G and H, which communicate with the space between the tubes—the pipe G for receiving the vapor used for heating the solution, and the pipe H for allowing escape of water produced by condensation of the heating vapor.

A large pipe, X, branching off from the solution top space of the boiler and re-entering it at the bottom, allows a free circulation of the liquor, the hotter portion escaping at the top and re-entering at the bottom.

The feeding-tube U is by preference branched on X, as shown.

The boiler and evaporator A and B and the tubes are cased or covered with any non-conducting substance, and are made of sheet or cast iron or other suitable material, according to the nature of the solution to be heated.

The boiler A may be vertical or horizontal, tubular, or of any construction which will attain the same ends. Thus the liquid to be heated may be on the exterior of the tubes, or a boiler heated externally may be used in the same way.

The evaporator may be horizontal, as represented, or it may be vertical, or of any other form, provided the salt can fall into the pipe T T, or can be brought to it by mechanism. This mechanism, in place of being rotative, as shown, may be formed to have a rectilinear, reciprocating, or to-and-fro motion or other movement given to it, or it may in some cases be entirely omitted, according to the shape of the evaporator, or according to the greater or less adherence of the salt produced.

Pressure can be maintained upon the liquid by means of a pump as aforesaid. Elevation of temperature is, however, the best means to be resorted to, and the use of the intermediate vessel as a means of communication from the evaporator to the boiler is the best means of keeping it up.

The action of the apparatus is as follows: Vapor at a higher temperature than the liquid in the evaporator is introduced to the boiler into the space around the exterior of the tubes. At the same time the apparatus which brings the solution to be evaporated from the evaporator B to the boiler A is set in action. The solution is heated by traversing the tubes of the boiler, and then escapes into the evaporator B through the pipe D and orifice O, either by reason of pressure from a pump or by pressure due to partial vaporization of the liquid, or otherwise.

The size of orifice O is so regulated that the pressure of the liquid behind said orifice shall be higher than in the evaporator B. The use of a pump will serve to prevent evaporation, and thus any depositing of salt prior to passing orifice O. When the pressure is caused by the evaporation itself the volume of the vapor should be regulated so that no deposit may take place. The augmentation of solubility may be obtained by an elevation of the temperature of the solution, as it will then be capable of dissolving a larger quantity of salt than would be deposited in consequence of the formation of a certain quantity of vapor.

In the evaporator the pressure is less than in the pipe D, which leads to it from the boiler, from the loss of pressure caused by the passage of the liquid through orifice O. The vaporization caused by the sudden change of pressure causes a deposit of the salt contained in the solution, while the part of the solution which is not vaporized circulates gently in the evaporator until it is returned to the boiler A, and then again to orifice O, as before.

The solution is thus maintained in a continuous circulation between boiler A and evaporator B. The portion of salt deposited is continually drawn into the discharge-pipe T T by the screw-blades on the shaft E E; then it is extracted, as above described, through the slide-valves V V′ and pipe K K. When the extraction of the salt is finished the said valves are replaced to their former position until the next removal.

During the working of the apparatus care should be taken to maintain the level of the solution in the evaporator B at approximately the same point. The water condensed between the tubes of the boiler, being usually at a temperature higher than that of the solution coming up from the supply-pipe, may be used to heat the latter by means of a worm or other apparatus. (Not shown in the drawings.)

Hydraulic power or other motive power can be applied to this apparatus in the well-known manner, which consists in compressing the vapor resulting from the evaporation in order to again raise its temperature.

The vapor which escapes from the dome of the evaporator is drawn away by a pump, which compresses it and forces it thus compressed into the boiler A. This raises the temperature between the tubes above that of the solution within the tubes, and a continuous evaporation of the solution may take place without expense of fuel. The liquid condensed between the tubes of the boiler escapes at the bottom either by the influence of interior pressure or by means of a pump.

When there is no cheap motive power at

hand a continuous series of apparatus may be used, the boiler of first apparatus being heated by steam from an ordinary steam-generator, and the steam issuing from the vaporizing-solution being afterward caused to pass to the boiler of the next apparatus, and so on until from the last evaporator it passes to a condenser.

Although I have found it in practice preferable to use the apparatus as above described and shown, yet I wish it to be understood that in some cases it may be found quite as well to combine together the heating and depositing processes, in which case I use apparatus illustrated in Figs. 3 to 7. This apparatus is composed of a closed boiler, A, within which is an evaporator, B. This latter never contains anything but steam, and it is entirely surrounded or submerged by the solution to be evaporated, which fills up to the level N N the space C C comprised between the evaporator and the boiler.

The bottom of the boiler carries the vertical tube T, the two valves V V′, with intermediate free space S, and ascending branch K, the same as above described.

When steam is introduced by the tube D into the evaporator B at a temperature above that of the solution, the vessel B yields its heat to the liquid which surrounds it. This evaporates, and the steam introduced into the condenser condenses. The water from condensation runs away by the pipe M, while the vapor which is disengaged from the solution escapes by the tube E′.

The salt produced by the evaporation forms a crystalline precipitate, which, in part, passes to the bottom of the boiler A, and in part remains attached to the sides of the evaporator. To detach it therefrom, rakes move with a slow rotary motion in the midst of the liquid to be evaporated, and pass within a few millimeters of the surface in contact with the saline solution. The salt, after it has been detached, falls onto the bottom of the boiler, and from there it is carried on by the rotary motion of the cross-piece *g g* until it falls by the opening V into the lock-chamber S, from which it is removed, as above described.

The evaporator, in order that it may present an extended heating-surface within a small compass, is formed of a series of lens-like sections of sheet metal, placed one over the other and bolted together with sound joints.

The steam is introduced at the bottom of the boiler by the tube D, which opens into the uppermost lens-like section. Each section is furnished with a horizontal diaphragm, which allows the passage of the steam only around the periphery, so that it is forced to pass over the entire surface of the evaporator, the water from condensation which collects at the lower part of the condenser running off by the tube M.

The rakes are fixed to a frame formed of an upper cross-piece, *f f*, a lower cross-piece, *g g*, and the uprights *e e*. The frame is fixed upon the lower end of the axis *l*, which is held suspended in the abutment-bearing *i*, and has a slow rotary movement communicated to it by means of a driving belt and pulley or bevel-gear arranged outside of the boiler. Within the boiler the frame is guided by the two cross-pieces *f f* and *g g*. The rakes, of which two only are seen in Fig. 4, have by preference the form of a spiral arc, so that the salt may be drawn by their movement toward the circumference of the sections of the evaporator. The rakes do not touch the sections, the clearance left between the surface of the evaporator being occupied by a crust of salt adhering to the sections, which prevents accumulations from forming upon the metallic surfaces, and prevents them from oxidizing.

This lenticular apparatus may be occasionally objectionable in consequence of the possible crushing of the salt by the action of the rakes, which does not occur with the apparatus first described.

By the above-described arrangement of the apparatus the solution is caused to pass continuously through the same without the aid of pumps or similar devices, the solution being repeatedly acted upon, and thus the thorough and complete extraction of the salt secured—a result which cannot be attained with certainty by a single evaporation.

I am aware that it is not new to heat saline solutions under pressure, and subsequently evaporate the solution in open vats; and I am also aware that it is old to permit a deposit of salt in the heating-chamber.

Having thus described my invention, what I claim is—

1. The herein-described continuous process of evaporating saline solutions, consisting in heating the same in a closed boiler under pressure, then conducting it from said boiler into a closed evaporator, in which it is relieved from pressure, and finally returning it to the boiler through closed conductors.

2. In an apparatus for reducing saline solutions, the combination, substantially as described and shown, of a closed boiler, a closed evaporator, and two closed conductors, connecting said boiler and evaporator, and provided with valves for closing them, whereby the heated solution may be transferred from the boiler to the evaporator, there relieved from pressure, and the partially-exhausted solution returned to the boiler, all without exposure to the atmosphere.

3. The combination of a closed boiler, A, a closed evaporator, B, an intermediate closed vessel, R, and valved connecting-pipes, arranged and operating substantially as described.

4. The combination of the boiler, evaporator, and intermediate vessel R, all closed

and connected with each other by valved pipes, and the discharge-pipe S, applied to the evaporator and provided with the two valves V V′.

5. In combination with the evaporator, having the discharge-pipe S, provided with valves V V′ and extension K, a scraper or conveyer arranged to deliver the salt into the pipe, as shown.

6. An evaporator having a discharge-pipe, S, provided with two independent valves and with a lateral extension, K, substantially as and for the purpose described.

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