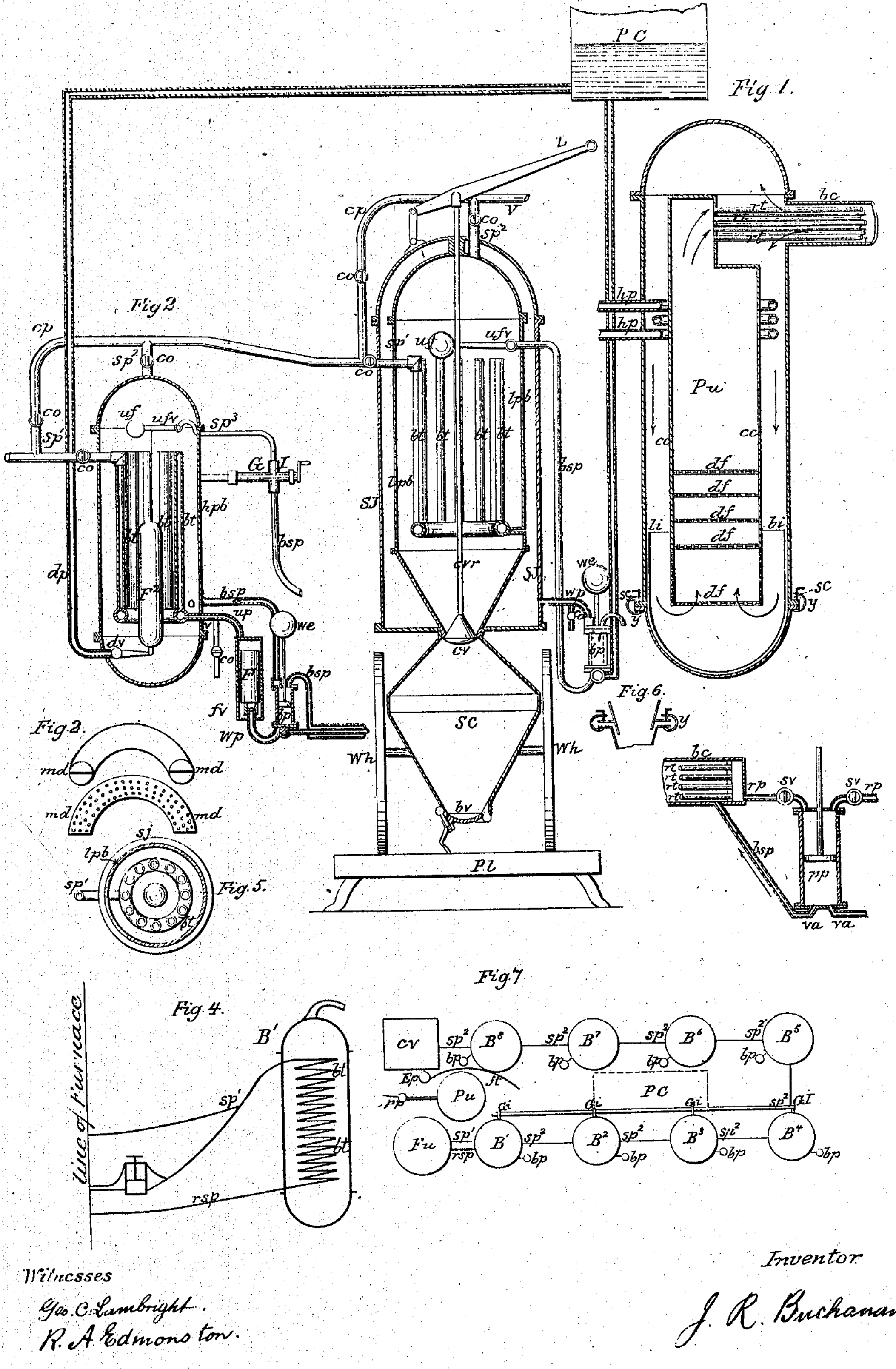
J. R. Buchanan.
Evaporating Pan.

No. 107,866. Patented Oct. 4, 1870.



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IMPROVEMENT IN THE MANUFACTURE OF SALT.

Specification forming part of Letters Patent No. **107,866**, dated October 4, 1870.

To all whom it may concern:

Be it known that I, JOSEPH R. BUCHANAN, of the city of Louisville, in the county of Jefferson and State of Kentucky, have invented a certain new and valuable Apparatus for Evaporating Brine, of which the following is a specification.

The object of this invention is to render the production of salt by boiling more economical by removing all the difficulties in the way of using the latent heat of steam as the agent for successive evaporations, transferring the same heat from one boiler to another; also, to carry this process of transfer of latent heat through successive evaporations farther than it has been carried before by an apparatus so constructed as to effect evaporations at very high and very low temperatures, and thereby render possible more numerous transfers of the same caloric. The higher temperatures and pressures are practicable by using strong tubular structures to contain the condensing steam, and the lower temperatures are made practicable by the reduction of pressure in the condensing-vessels until it approximates a vacuum. The incrustation of calcareous matter is prevented by removing the sulphate and carbonate of lime from the lime by heat before evaporation commences, and the incrustation of salt is prevented in a portion of the boilers by stopping at saturation, and in the remainder by the elongated vertical structure of the boilers and condensing-tubes which secures a free and rapid current along the evaporating-surfaces. The delivery and removal of the salt are also effected with greater economy and convenience by means of the vertical evaporators and the salt-carrier which is described. The brine, after undergoing such chemical treatment as its peculiar composition may require, the details of which are well known and need not be described, is purified by carrying it through a high-pressure heating apparatus, Figure 1, in which its calcareous elements are precipitated, and is then carried through high-pressure and low-pressure boilers, in the former of which it is concentrated by evaporation nearly to the state of saturation, and in the latter is evaporated completely and deposits the salt. The steam formed in each boiler by the process of evaporation is conveyed to the boiler next in succession, and enters a tubular structure, in which it is condensed, and as it condenses causes ebullition by the heat it gives off. It is then discharged as water by the expulsive force of the steam through an automatic pump arrangement, by which it heats and returns to the boiler an amount of brine equal to what has been evaporated.

My apparatus consists of—

First, the purifier, Fig. 1, consisting of a cylindrical vessel, in which the brine is heated and deposits its calcareous elements, and a pump which propels the brine through tubes to and from the heating-vessel. The pump *p p* propels the brine through the supply-pipe *b s p* and the brine-channel *b c* into the heated cavity of the purifier, and as it passes it is heated by the pipes *r t r t r t*, which convey the returning brine. As it enters it descends around the central cylinder, C C, receiving additional heat from a coil of heating-pipe, *h p h p*, by which its temperature is maintained at or above 300° Fahrenheit. This temperature compels the precipitation of the sulphate and carbonate of lime, which, falling to the bottom, are received, for convenience, upon a lining of cloth or other suitable substance, which may be removed as often as the accumulation may render it necessary. The brine, then ascending through the central cylinder, C C, is prevented from carrying up any of the precipitated calcareous matter by a set of diaphragm-filters of fibrous material, *d f d f d f*, through which it is compelled to pass. It then passes through the returning-tubes *r t r t r t* and heats the incoming brine, and is received by the pump *p p*, which it enters through a slide-valve, *s v*, and leaves through another, by the operation of which the pressure is maintained and the generation of steam prevented, as the same quantity of brine must be propelled to the purifier by each stroke of the piston, which is withdrawn by the same stroke, during which the escape of the brine through the pump is prevented by the valves.

Second, the furnace and heater. I construct a furnace on an economical and peculiar plan, and place in it a boiler or heater of tubular construction, capable of enduring a very high pressure—say one thousand pounds to an inch—and generating steam with economy. The steam-pipe S *p'* from this heater conveys steam to the interior of the spiral coil of tubes *b t b t* in the first boiler, which, as it condenses, returns through the pipe *r s p*, which connects with the lower extremity of the tubing. (See Fig. 4.) The furnace-boiler and the steam-heaters of each brine-boiler are constructed in this powerful manner of tubes capable of bearing very high pressures, which structure renders it possible to use high temperatures, and thus effect greater economy. When it is desired to increase the rapidity of evaporation and the economy resulting from the use of very high temperatures, I use in place of steam a pyrostatic liquid capable of undergoing without ebullition a temperature of over 550° Fahrenheit. For this purpose I use the residuary fluid from the distillation of petroleum, commonly called "petroleum-tar," after the lighter oils, the solids, and the paraffine have been removed by distillation and other means, and the crude carbonaceous impurities are removed by filtration; and in order to improve the pyrostatic qualities of the said liquid I add caustic soda or potassa, or other saline and alkaline mixtures producing nearly the same effects, so that high temperatures may be used without the production of vapor or pressure or decomposition into gases. When a pyrostatic liquid is used in place of steam I cause its circulation by a suitable pump (piston or rotary) through the tubing in the furnace and in the first boiler, with the effect of procuring a higher temperature and more rapid ebullition than can be produced by steam even of a thousand pounds pressure to the inch.

Third, the concentrators. To produce salt with the greatest convenience and economy I use a set of high-pressure boilers to concentrate the brine to the point of saturation, or near it, and a set of low-pressure boilers or evaporators to complete the process with the concentrated brine. The high-pressure boilers or concentrators may be from two to four in number, or, if very high temperatures and pressures are used, (as with the use of pyrostatic caloriferous liquids,) as many as twelve or fifteen may be combined in succession, all sustained in operation from one furnace. This more extensive combination and economical transfer of heat will be adopted when the price of fuel is very high in proportion to the cost of construction of the apparatus. The low-pressure boilers, as a general rule, should not exceed three or four in number, as they operate nearly at or below the atmospheric pressure. If the brine should be very weak, a larger number of the concentrators will be required in proportion; if half saturated, the concentrators and evaporators should be equal in number; if fully saturated, evaporators alone are used.

The operation of the apparatus in making salt may thus be described:

The boilers being properly arranged and connected in succession from the first to the last, those nearest to the furnace are used as concentrators, as those most remote as evaporators, the relative number being determined by quality of the brine. If the requisite number of evaporators be more than three or four, those of the highest pressure will be more compactly and strongly constructed. The furnace being fired, the heating-tubes in boiler No. 1, B′, (see ground plan, Fig. 7,) carry a temperature of from 400° to 800°, according to the plan adopted, and evolve with great rapidity high-pressure steam, which, as it ascends, passes from the top of the boiler through the steam-pipe S p^2 to boiler No. 2, B^2, in which it enters the boiling-tubes *b t b t*, and generates an equal quantity of steam of a lower pressure and temperature as it condenses in the tubes, and that steam, passing in the same manner to the third boiler, reproduces steam again, and this process is thus repeated from boiler to boiler to the end of the series with successively-diminishing temperature. The steam thus condensed in the boiling-tubes, forming hot water, is expelled by the pressure of the steam through the brine-pump *b p*, Fig. 2, which receives the hot water whenever the valve *f v*, governed by the float, opens as the water accumulates. When the water has been expelled the float F descends and keeps the valve closed until the water again accumulates. As the pressure of the outgoing hot water propels the piston from one end of the brine-pump, an equal amount of brine is propelled from the other end of the brine-pump into the boiler, the expulsive force of the water from the steam-pipes being greater than the resistance of the pressure in the boiler. The brine being concentrated nearly to saturation, the discharging float-valve *d v* is opened by the float F^2, which is so adjusted in its gravity as to rise whenever the brine has nearly reached saturation. The outflow of the saturated brine is compensated by the inflow of fresh brine, automatically impelled by a Giffard injector or other suitable automatic device, whenever the level of the brine descends, and opens by the upper float, *u f*, the valve of the steam-pipe which supplies the injector *u f v*. The saturated brine, impelled by the pressure of the boiler, flows through a discharging-pipe, *d p*, to a pressure-reservoir, P C, from which it flows into the low-pressure boilers when their valves open to receive it. The boiling-tubes of the high-pressure boilers or concentrators may be constructed like those of the evaporators—viz., a horizontal circular tube in the lower part of the boiler, with vertical tubes inserted in it by their lower extremities; or they may be constructed in a single spiral coil, which latter arrangement will necessarily be adopted in the first boiler when pyrostatic liquids are used. Another peculiarity will be embodied in the boiling-tubes on account of the difference between boiling saline solutions and boiling simple water—viz., a horizontal perforated diaphragm will be inserted in the middle of the horizontal boiling-tube, and the steam-pipe which enters the boiler will be connected with the bottom of said tube, so that the steam shall enter in the water of condensation and bubble through the perforations of the diaphragm. If it is connected directly to one of the vertical tubes, that tube must pass in beneath the diaphragm. This arrangement is necessary to facilitate the evaporation of saline solutions, as it reduces the superheated steam of such solutions to the saturated condition, and thereby removes an obstacle to the rapid transfer of the latent heat. The respective temperatures and pressures of the different boilers may be arbitrarily fixed and regulated by pressure-valves located on each steam-pipe before entering the boiler at *v* or on each water-pipe for condensed steam at its exit from the boiler *v;* but these valves are not essential or necessary, as the temperatures and pressures in such a series of boilers will spontaneously arrange themselves in regular gradation from the highest to the lowest, the gradation being equal except where the extent of evaporating-surfaces differs from one boiler to another. In the present sketch the interval of gradation will be smaller between the large boilers or evaporators than between the small boilers or concentrators.

Fourth, the evaporators, Fig. 3. The boilers, which operate on the concentrated brine, are of lower temperatures and pressures, and therefore more convenient for the delivery of the salt, and may be of a lighter and cheaper structure. The evaporators employ the heat of the steam not only in their boiling-tubes, but on the exterior surfaces of the boilers. The steam passes through the boiling-tubes into the space between the boiler and the steam-jacket S J, and is condensed on the outer surface of the boiler also. The condensed water at the bottom of the steam-space is removed by the brine-pump, which is impelled, not by the force of the water passing out, but by the force of the brine passing in from the pressure-chamber P C. These evaporators, having both exterior and interior condensing-surfaces, and being larger in diameter, have more evaporative power and require less elevation of temperature for their heating-steam. The tension of the steam becoming in some of them less than atmospheric pressure, they must be constructed to resist external instead of internal pressure. From the last evaporator the vapor is conducted into a coil of tubing, which descends into a vat of brine, C N, and surrenders its heat, the water of condensation being pumped out. The admission of brine to the evaporators is governed by a float-valve, *f v*, which opens as the float descends on the surface of the brine and allows the brine from the pressure-chamber P C to force its way in through brine-pump *b p*. The force with which the brine enters enables the brine-pump to extract the water of condensation from the bottom of the steam-space, where it collects. The steam-jackets of the low-pressure evaporators may be constructed of wood or any convenient material, as they require no great strength, and a non-conducting investment of sawdust or other slow conductor should be placed around each of the boilers and the purifier, the strength of the boilers increasing as they approach the furnace, and the first concentrator may be reduced to from eight to twelve inches in diameter when the highest temperatures are used.

Fifth, the salt-carrier. The salt formed in the evaporators may be produced more rapidly or slowly by changing the amount of surface in each, and the quality of salt, as fine or coarse, determined accordingly. In the ordinary operation the rapid current of ebullition carries the salt upward as it is formed, and causes its descent in the center of each evaporator. The salt, descending, falls to the bottom and passes through the funnel-shaped outlet and is caught in the salt-carrier S C. This is constructed so that it may be readily discharged by opening the bottom valve, B *v*. It connects with the evaporator by a sliding joint, *j*, or neck, and the junction is effected by lifting the platform P *l*, on which the salt-carrier stands, by a suitable lever. When a boiler of positive pressure, above the atmosphere, is used as an evaporator, the joint is secured by flanges pressed together, as shown at Fig. 6. The communication of the evaporator with the salt-carrier is closed when the latter is filled by lifting the conical valve *c v* with the valve-rod *c v r* by the lever L. If the pressure in the boiler be more than atmospheric, it is suspended by shutting off the supply of steam through the steam-pipe S *p′* and directing it to the next succeeding boiler, for which purpose a connecting-pipe, *c p*, unites the steam pipes of the adjacent boilers, and cocks *c o* are suitably placed to control and change the connection. As one salt-carrier is disconnected another completely filled with brine is put in its place and the loaded one is removed on the wheels which support it, as shown in the drawings. This method of isolating boilers from the series to which they belong removes all the difficulty of using a detachable salt-carrier in connection with a system of high-pressure boilers. Saturated brine may therefore be treated by an apparatus consisting exclusively of evaporators constructed with the strength necessary for bearing high pressures, and all the external surfaces convex.

It remains only to add that I propose to construct my entire apparatus of enameled iron, and to invest it with a non-conducting layer of sawdust (rendered incombustible when used near the furnace by alkaline silicates) contained in an investment of tin-plate, Russia sheet-iron, wood, or any other suitable material.

To complete my specification I annex a description of the drawings. Figure 1 represents the purifying apparatus for removing the sulphate and carbonate of lime by heat; *p p*, the pressure-pump, which throws the brine to the purifier through the supply-pipe *b s p*, and which receives the purified brine in return through the pipe *r p* and discharges it through *r p*. The two slide-valves *s v s v*, which are moved by appropriate machinery, (not exhibited,) prevent the brine from escaping through the pump by force of the interior pressure produced by the high temperature. *b c*, the brine-channel, conveys the cold brine to the purifier, and the returning-tubes *r t r t* convey the returning and heated and purified brine, which is withdrawn through the pipe *r p*; *h p h p*, the heating-pipe, which is heated by steam from the furnace-boiler, (or by circulation of pyrostatic fluids,) maintaining the requisite heat in the brine as it passes downward in the purifier. C C, the central cylinder, receives the ascending brine as it rises from the bottom and passes out through the returning-tubes *r t r t*. *l i l i*, the lining of cloth, receives the precipitated calcareous matter which falls upon it, and is removed, when necessary, by opening the purifier, the bottom being detached by unscrewing the hinged fastenings *y y*. *d f d f*, the diaphragm-filters, remove from the ascending brine all impurities which are in suspension. They are constructed of any suitable fibrous material.

Fig. 2 exhibits the concentrator or high-pressure boiler, of which *h b p* is a vertical section. The number of these vessels combined in an apparatus may vary from three or four to eight or ten, according to the quality of the brine and the temperature employed in boiling. S p' is the steam-pipe, which imparts steam and caloric to the tubular structures of the boilers. The boiling-tubes *b t b t* and S p^2 carries the steam generated in the boiler to the next succeeding boiler. C *p* is the connecting-pipe, by means of which, when the steam is shut off from the boiler through S p^2, by turning a cock, *c o*, it may pass around into the vent S p^2 and be delivered into the next succeeding boiler. M *d* is a metallic diaphragm or perforated metal plate, located in the horizontal boiling-tube and designed to compel the steam which is admitted under it to pass through the water of condensation contained in the said tube, whereby it is reduced from superheated to saturated steam and its condensation facilitated. W *p* is the water-pipe, which conducts the water from the horizontal tube just mentioned toward the brine-pump *b p*, and carries it on from *b p* through the tube which brings in the cold brine. F is a float, and *f v* the float-valve, which allows the water to be discharged when it accumulates, and which closes when a certain amount has been discharged from the boiling-tubes. *b p*, the brine-pump, moves whenever the expelled water reaches it, impelled by the steam-pressure of the boiler. *b s p*, the brine-supply pipe, conveys the brine from the pump to the boiler at each upstroke of the piston in quantity equal to that of the water of condensation. W *e*, the weight on the piston-rod, causes its descent by gravity and expels the water of condensation below as it draws in the brine above. The water-tube *w t*, it will be observed, passes out through the center of the brine-supply tube and imparts the heat of the water to the incoming cold brine. F^2 is a float in the boiler, which is adjusted to rise when the water approximates saturation and open the discharge-valve *d v*, by which the brine passes into the discharging-pipe *d p*, by which it is conducted to the pressure-chamber P C, which supplies the evaporators. G I represent a Giffard injector for the supply of brine to the boiler. S p^3 is its steam-pipe, and *b s p* is its supply-pipe for brine. U *f* is the upper float, which governs the admission of steam to the injector by the upper float-valve, *u f v*.

Fig. 3 represents the evaporator or low-pressure boiler, of which there may be a greater or less number, in proportion to the strength of the brine. If the number be more than three or four, the steam-jacket may be omitted from the additional ones of higher pressure, or must be made in a strong and substantial manner to bear higher pressure, the exterior being entirely convex. *l p b* shows the section of the boiler; *s j*, the steam-jacket; *b t b t*, the boiling-tubes; S p', the steam-pipe to supply them; S p^2, the steam-pipe to discharge steam from the boiler to the boiling-tubes of the next one; C *p*, the connecting-pipe to carry the steam beyond the boiler; W *p*, the condensed water-pipe; *b p*, the brine-pump, which in this case is impelled, not by the water of condensation, but by the brine from the pressure-chamber; *b s p*, the brine-supply pipe; *u f*, the upper float, and *u f v* the upper float-valve, which govern the admission of brine, allowing its admission as the level of the brine descends. S C, the salt-carrier, receives the salt as formed, which descends through the funnel-shaped bottom of the boiler. C *v*, the conical valve, closes the passage when lifted by the conical-valve rod *c v r*, moved by the lever L; W *h* W *h*, the wheels on which the salt-carrier rests, and on which it is removed when filled; *b v*, the bottom valve for dropping out the contents of the salt-carrier; *j*, the sliding joint by which the salt-carrier connects with the evaporator.

In Fig. 6, F *j* is a flange-joint, to be used between the salt-carrier and the evaporator when the steam in the latter is much above the atmospheric pressure; *y*, the yoke, and S *c* the screw to hold the flange-joint tight; P *l*, the platform on which the wheels of the salt-carrier rest, and is lifted by a lever to connect the joint.

Fig. 4 represents the first salt-boiler. S p' is the steam-pipe leading from the boiler or heater in the furnace to the first salt-boiler; P, the location of the pump that may be used when hydrocarbons are required for heating; *r s p*, the return-steam-pipe, by which the water of condensation returns to the heater or boiler in the furnace; *b t b t*, the boiling-tubes, consisting of a spiral coil, which is a convenient form for the boiling-tubes, and may be used in place of the vertical tubes when preferred, but offers greater obstruction to the movement of the water and escape of the steam, and would be objectionable in the salt-making boilers. The use of an extremely high-pressure tube-boiler in the furnace and of high-pressure condensing-tubes in the series of boilers is the leading practical feature of this invention.

Fig. 7 is the ground plan for an apparatus of eight boilers. F *u* is the furnace; B^1 B^2 B^3 B^4 B^5 B^6 B^7 B^8, the boilers, the first four being high-pressure; P *u*, the purifier; P *c*, pressure-chamber; C *v*, the condensing-vat; E *p*, an exhausting-pump for the condensing-vat and other structures; *f t*, a flexible tube, to be used from the pump for exhausting any of the steam spaces or tubes when necessary.

What I claim as new, and desire to secure by Letters Patent, is—

1. The process of the production of salt from brine by high-pressure concentrators, and the combination therewith of low-pressure evaporators, constructed substantially as described.

2. The evaporation of brine for the production of salt in high-pressure boilers at temperatures between 300° and 600° Fahrenheit, and the transmission of the caloric by successive evaporations and transfers from these high temperatures down to temperatures below 150° Fahrenheit.

3. The construction of the vertical boilers and vertical system of tubing, in combination, substantially as described, to produce rapid and unobstructed evaporation of brine.

4. The construction of the purifier and its associate parts, substantially as described, whereby to produce the removal of the sulphate and carbonate of lime at the temperature of about 300° with but a small expenditure of heat.

5. The construction of the evaporators, substantially as described, with interior steam-tubes and exterior steam-spaces, to produce evaporation.

6. The combination of brine-pumps with the high and low pressure salt-boilers in such a manner as to inject the brine automatically by the same movement which removes the water of condensation, substantially as described.

7. The combination, with the low-pressure evaporator, or with the high-pressure boiler which evaporates by heating-tubes, but may be promptly relieved of its pressure, of a detachable salt-carrier connected by a sliding joint and moving on wheels, substantially as described.

8. The use of purified petroleum-tar and its combination with alkalies or their equivalents as a medium for transmitting heat from a furnace to a boiler.

9. The combination of a pressure-chamber with a system of high-pressure and low-pressure brine-boilers, substantially as and for the purposes described.

10. The reduction of superheated brine-vapor in a condensing steam-heater to saturated steam by forcing it through the water of condensation, and the combination of the metallic diaphragm *m d*, or any equivalent device, with the condensing-vessel to effect that object.

11. The use of high-pressure steam-condensing tubes and the combination of a series thereof to produce successive evaporations of brine by transfer of the same caloric at temperatures above the ordinary boiling-point.

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Witnesses:

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