Sept. 26, 1939. K. E. STUART 2,173,986

APPARATUS FOR INCREASING THE SOLUTE CONTENT OF SOLVENTS

Filed May 28, 1937

Fig. 3

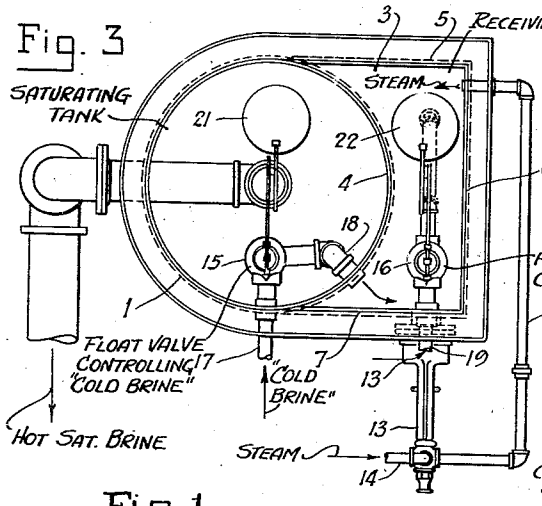


Fig. 4.

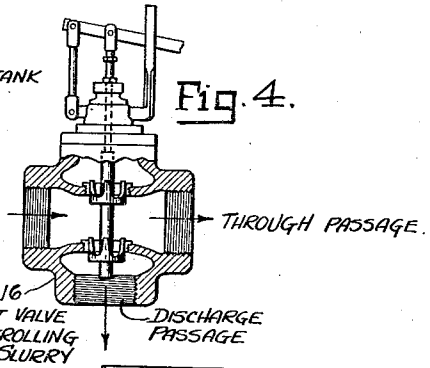
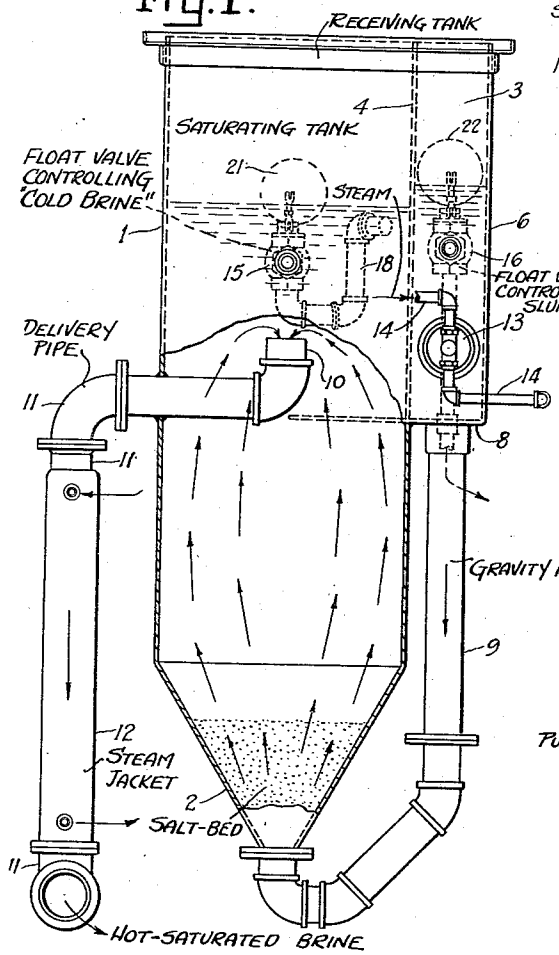


Fig. 1.



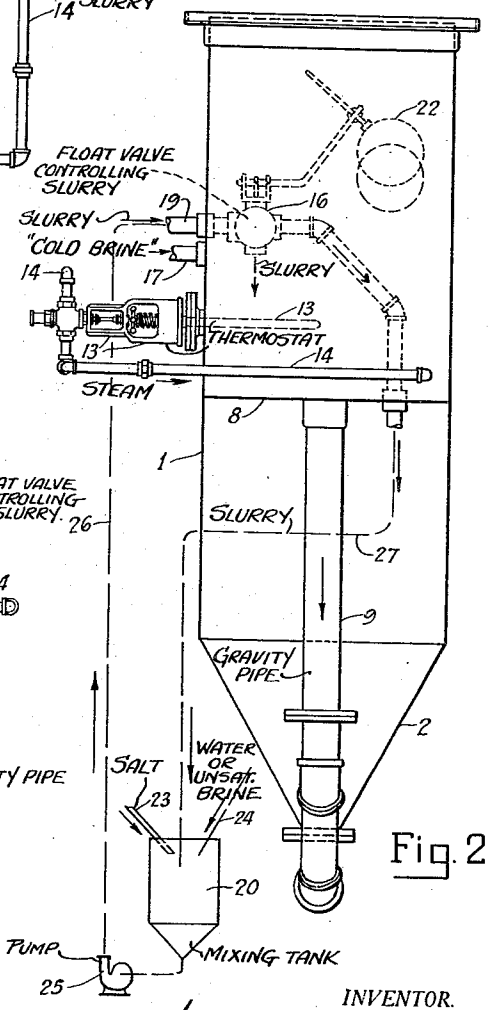


Fig. 2

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APPARATUS FOR INCREASING THE SOLUTE CONTENT OF SOLVENTS

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7 Claims. (Cl. 23—272)

My invention relates to an apparatus for saturating, with soluble solids, solvents therefore, or solutions thereof that were previously unsaturated, or resaturating at higher temperatures solutions that were previously saturated at lower temperatures; and more particularly for producing substantially fully saturated aqueous solutions of soluble salts, such as sodium chloride, at temperatures above ordinary atmospheric temperatures.

In the operation of electrolytic alkali chloride cells, as for the production of caustic soda, an aqueous solution of sodium chloride, constituting the anolyte, is caused to percolate through a diaphragm, where it comes into contact with the cathode and is broken down into sodium hydroxide and hydrogen. The chlorine of the salt is liberated at the anode. Notwithstanding that the solution is fed to the cell continuously there is a depletion of the salt in the anolyte, due to electrolytic causes that need not be discussed here. Thus, if the solution be saturated at 0° C. it may contain 26.4 per cent salt. After operating for several hours, however, assuming that the feed is regulated so that fifty per cent of the brine decomposes in the cell, it will be found that the anolyte contains only 23.4 per cent salt. This depletion causes the current to fall or, if the current be kept constant, the voltage that must be impressed upon the cell to rise. In either case there will be a loss in yield efficiency, due to the formation in the cell of sodium chlorate, as well as of power efficiency, due to the increased voltage. To obviate this difficulty, in Patents Nos. 1,388,474 and 1,432,584 there is illustrated a method of feeding to the cell in suspension in the brine a certain quantity of salt in excess of that which can be taken into the solution. Another way of accomplishing the same object is to saturate the brine at an elevated temperature at which the solubility of salt is greater than at ordinary temperatures. The hot-saturation of brine, however, presents difficulties. The object of the present invention is to overcome these difficulties and to provide a relatively simple apparatus by the use of which saturated brine can be fed to the cell at any desired temperature, the saturation of the brine being accomplished automatically by the apparatus at the temperature for which it may have been regulated. Thus, if the apparatus be adjusted for 70° C., the brine will contain 27.5 per cent salt and if fifty per cent of the salt is decomposed the anolyte will contain 23.4 per cent salt. This will produce caustic soda of a concentration of 10.65 per cent, as compared with 10.22 per cent if the brine were saturated at 0° C. This, however, is not a full measure of the advantages accruing, as it will be found that both the yield efficiency and the power efficiency have at the same time been improved.

Referring to the drawing:

Fig. 1 is a side elevation of my apparatus, partly broken away.

Fig. 2 is an end elevation of my apparatus.

Fig. 3 is a plan view of the same.

Fig. 4 is a side elevation, partly in section, of a float valve of special type, used in connection with my apparatus.

Referring to the figures, it will be seen that my apparatus consists in an elongated vertical circular tank 1, which serves as the main saturating tank, having a hopper bottom 2 and, attached at one side and extending from the top downwardly to about the middle of the tank, a receiving tank or compartment 3 of which the wall 4 of the tank 1 forms one side. The other sides of the compartment, 5, 6 and 7, may be formed of flat walls forming three sides of a rectangle, as shown in Fig. 3. The bottom 8 of the compartment may likewise be flat. From the bottom of the compartment 3 a gravity pipe 9 connects to the bottom of the hopper 2. From about the middle of the tank 1 a delivery pipe 10, preferably vertical and co-axially located with respect to the tank, opens upwardly. The pipe 10 after a short distance is carried outwardly through the side of the tank and then downwardly in the leg 11. The leg 11 is provided with a steam heating jacket 12.

The operation of the apparatus is as follows:

Water (or unsaturated brine or brine that has been saturated at ordinary temperatures, which will be referred to as "cold brine") and slurry (consisting of brine with finely divided salt in suspension) are fed into the compartment 3, whence they pass through pipe 9 into tank 1. There any excess salt remains behind, only the brine, saturated by contact with the salt, flowing on upward at low velocity through tank 1, and thence through pipes 10 and 11 to the circuit of electrolytic cells (not shown). Steam under control of the thermostat 13 is also admitted to compartment 3 through the pipe 14. The thermostat is adjusted for the temperature at which the brine is to be saturated. The water or "cold brine" fed into compartment 3 is controlled by the float valve 15 in response to liquid level in tank 1. This float valve is regulated so that the desired head of brine will be maintained upon the

header (not shown) which supplies the circuit of cells. The float valve 15 is connected through pipe 17 to a source of water (or "cold brine", not shown) and through the pipe 18 to the compartment 3. Therefore, although the rate of admission of water (or "cold brine") is controlled by the level of the liquid in tank 1, the water or brine is not admitted directly to tank 1, but reaches tank 1 indirectly through compartment 3 and pipe 9. The float valve 16 is connected through pipe 19 to a source of slurry, illustrated at 20. This valve discharges directly into compartment 3.

In operation, the float 21 of float valve 15, as before stated, is set to maintain the desired head upon the circuit of cells. The float 22 of the float valve 16 is set to shut off at a level about three inches higher. Under these conditions the slurry may continue to flow after the brine has been shut off by valve 15. The tank 1 being of such cross-section that the upward velocity of the brine through it when supplying the circuit of electrolytic cells is less than the settling velocity of salt in brine, none of the salt carried down through pipe 9 will rise beyond the hopper bottom 2 of tank 1. It will therefore build up a bed of salt in this hopper, as illustrated in Fig. 1. This bed of salt will continue to build up until the resistance which it interposes to flow of the brine stream through it equals the difference in level for which the two float valves were set. Thereafter, brine and slurry will be admitted continuously in such proportion that the salt bed in hopper 2 will be maintained constant. All brine passing to the cells will thus have been heated by steam entering the compartment 3 and the hot brine will have further filtered upward through the bed of salt, thus assuring its substantial saturation. The steam condensate will of course be saturated at the same time.

The hot-saturated brine passing out through pipe 11 is further heated by means of steam jacket 12 so that salt shall not settle out and clog the header during passage to the cells.

If the float valve 16 were at the dead end of a pipe line, when it was closed the flow of the slurry would cease entirely and the salt normally carried by it would settle to the bottom of the pipe line. As salt crystals tend to cake or consolidate, this would eventually obstruct the line. To avoid this, I cause the slurry to circulate continuously through the float valve. In Fig. 2, the method of doing this is illustrated diagrammatically. In this figure 20 is a tank which in practice is relatively quite large, since it serves for storage of salt introduced through the chute 23. Unsaturated brine or water is at the same time introduced through pipe 24. This passes downward through the bed of salt and is circulated by the pump 25, through float valve 16 and thence back to tank 20, through the pipes indicated by the broken lines at 26, 27, in the directions shown by the arrows. In the operation of alkali chloride cells, for reasons that need not be discussed here, only about half the salt passing through is decomposed. The balance is precipitated in the evaporators (not shown) in which the caustic soda is concentrated. It is this finely divided precipitated salt that is supplied to tank 20. The stream returned from float valve 16 causes an agitation in the salt bed, so that when it passes downward to the pump again it carries salt in suspension. The salt carried in suspension must be more than sufficient to fully saturate the brine which is to be fed to the cells. When a proper excess of salt is carried by the slurry, the apparatus will automatically bleed off the proper amount of slurry to saturate the steam and water or brine admitted to compartment 3, and thus deliver to the cells brine that is substantially fully saturated at the temperature for which the thermostat was adjusted.

Since no float valve is commercially available that will permit of through circulation, the details of such a valve are illustrated in Fig. 4. This valve differs from the ordinary float valve only in that a double pipe connection is provided, thus affording a through passage for circulation.

If cold brine be introduced through pipe 17 less slurry will be required than if water be used. This is preferred, as there would obviously not be sufficient salt precipitated from the evaporators to carry on the operation of the plant indefinitely. In practice the fresh make-up salt is continuously supplied as purified brine through pipe 17 and a constant quantity of precipitated salt is returned through the cells and evaporators to tank 20.

Instead of introducing steam directly into compartment 3, obviously the brine and/or slurry could be preheated.

By making the apparatus pressure tight, the brine could be saturated at temperatures above its atmospheric boiling point.

While I have described my apparatus in connection with electrolytic alkali chloride cells, it is to be understood that the same type of apparatus is applicable wherever it is desired to increase the solute content of unsaturated solutions to the point of substantial saturation and the solute can be reduced to granular form and suspended in the solution.

While I have described the operation of the apparatus for the purpose of resaturating at higher temperature liquids that were previously saturated at lower temperature, this is only because the greatest complication is experienced under those conditions. The apparatus is obviously suitable for bringing up to substantial saturation liquids or solutions that were previously unsaturated at the same temperature.

I claim as my invention:

1. In a system for producing substantially fully saturated solutions carrying substantially no undissolved excess of the solute, a source of supply of solvent, a source of supply of a finely divided solute, a mixing tank, means including a conduit for causing a flow of said solvent into said mixing tank, means including a conduit causing flow of said finely divided solute into said mixing tank in excess of the quantity that is soluble in said solvent flowing into said mixing tank, means for agitating said solvent and said solute together to produce a slurry of said finely divided solute in suspension in a solution of said solute in said solvent, means including a conduit for causing flow of said slurry from said mixing tank into a receiving tank through a float valve controlling the admission of said slurry to said receiving tank in response to liquid level therein, a saturating tank adapted as to dimensions and position to receive gravity flow from said receiving tank, a gravity conduit connecting said receiving tank with said saturating tank near their bottom portions, means including a conduit for causing flow of more of said solvent into said receiving tank through a second float valve controlling admission of said solvent to said receiving tank in response to liquid level in said saturating tank, said

float valves being relatively adjustable to maintain a liquid level in said receiving tank slightly higher than that in said saturating tank, and a delivery conduit communicating with the interior of said saturating tank below the lowermost liquid level determinable by said float valves but substantially above the mouth of said gravity conduit.

2. A system as claimed in claim 1, in which the source of supply of solvent is adapted to supply an aqueous solvent and the source of supply of a finely divided solute is adapted to deliver a finely divided salt to the mixing tank.

3. A system as claimed in claim 1 in combination with means for heating the contents of the receiving tank and means for controlling the temperature thereof.

4. A system as claimed in claim 1 in which the slurry and solvent are delivered to the receiving tank at ordinary temperatures, in combination with means for heating the contents of said receiving tank and means for controlling the temperature of the solution and solute leaving said receiving tank.

5. A system as claimed in claim 1 in which the slurry and solvent are delivered to the receiving tank at ordinary temperatures, in combination with means for supplying steam directly to the contents of the receiving tank and a thermostat controlling the admission of steam to and the temperature within said receiving tank.

6. A system as claimed in claim 1 in which the slurry-controlling float valve is provided with a discharge passage and a through passage, in combination with means for circulating a considerable proportion of said slurry through said through passage and back to the mixing tank.

7. A system as claimed in claim 1 in combination with means for heating the solution drawn off from the saturating tank above the temperature at which said solution was saturated in said saturating tank.

KENNETH E. STUART.