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ELECTRIC LIQUID HEATING APPARATUS

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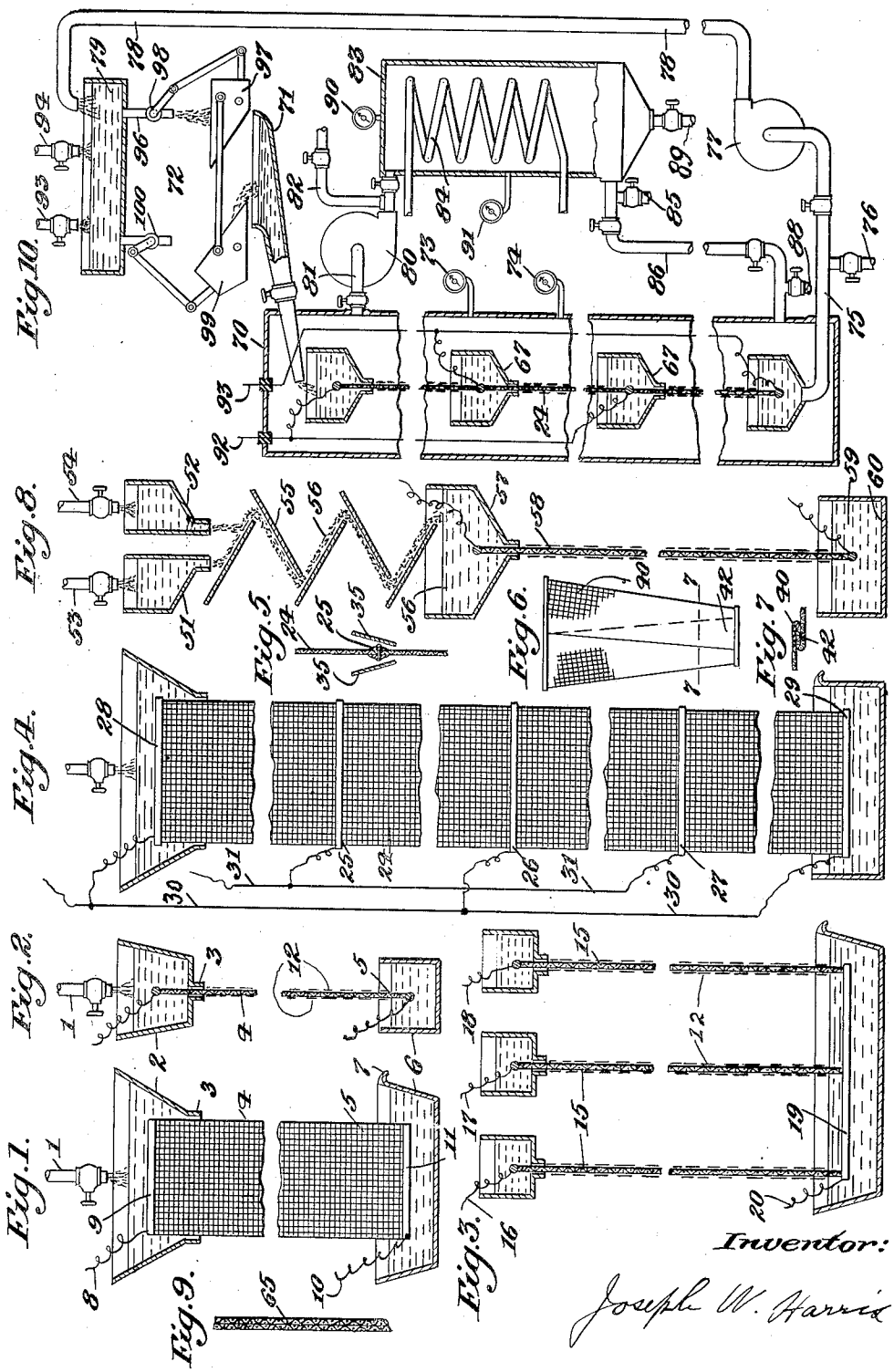

Fig.10.

Fig.8.

Fig.5.

Fig.6.

Fig.7.

Fig.4.

Fig.2.

Fig.1.

Fig.9.

Fig.3.

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ELECTRIC LIQUID-HEATING APPARATUS

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15 Claims. (Cl. 219—38)

This invention relates to the electrical heating of liquids, and aims to provide an apparatus which may be used for the heating, concentration, or evaporation, of liquids of all kinds, including water, solutions of chemicals, and organic liquids, such as alcoholic solutions, petroleum products, etc., and is a further development of the invention disclosed in my application filed June 27, 1928, Serial Number 288,792.

An object of the invention is to provide a liquid heating apparatus which is simple in operation, and which may be readily inspected and maintained in an efficient operating condition.

A further object is to provide an electrical liquid heater which will support a flowing, long, thin, wide stream of liquid under conditions to expose a relatively enormous surface on both sides of the stream for evaporation, and which is adapted to quickly heat a relatively large quantity of liquid to a high temperature.

A further object is to provide an apparatus in which the electrical heating of the liquid may be effected within an enclosure under controlled conditions of temperature and pressure, and in which the liquid may be circulated, and when desired in the presence of controlled atmospheres.

Other objects of the invention will be apparent to those skilled in the art upon reading the specification.

In the accompanying drawing,

Fig. 1 illustrates a view partly in plan and partly in section showing a preferred type of electrical heating element, consisting of a capillary cellular or foraminous surface such as a fine mesh screen, with means to supply a stream of liquid over the entire surface, the liquid being supported upon and distributed over the entire screen and flowing downward, collecting in the receiver at the bottom;

Fig. 2 is a vertical transverse sectional view of the screen heater in Fig. 1, showing a liquid stream flowing over each side of the screen;

Fig. 3 illustrates a plurality of heating units similar to Fig. 2, with the bottom ends of the heaters connected to a common electrical terminal, the upper ends being connected to separate electric terminals, for operation on a three phase system of electric supply;

Fig. 4 resembles Fig. 1 in which an extra long electric heating unit is used, and a suitable source of electric current connected at several points thereon;

Fig. 5 illustrates one type of distributor which may be placed upon the heating unit shown in Fig. 4, on each side of the intermediate bus bar; for the purpose of preventing splashing and of insuring a proper distribution of the liquid over the screen after it passes the bus bar;

Fig. 6 illustrates diagrammatically a form of screen heater resembling that shown in Fig. 1, in which the heater screen is folded or "pleated" or "scolloped" at the bottom, to reduce its width and corresponding area exposed to the flowing liquid, the width of the screen gradually decreasing from the top toward the bottom, so that the screen will be kept covered by the gradually decreasing quantity of liquid flowing over it, thereby allowing for the loss of liquid by evaporation during its flow over the heater surfaces;

Fig. 7 is a sectional view of Fig. 6 on the line 7—7.

Fig. 8 illustrates diagrammatically supplying a plurality of separate liquids to a series of mixing baffles, the mixed liquids thereafter flowing over the surfaces of an electric heating unit of any of the types shown in Figs. 1, 2, 3, 4, 6, and 9;

Fig. 9 is a sectional view of a modified type of heating element, shown as a wire cloth thicker than that illustrated in Fig. 2, the cloth constituting a wick-like structure capable of holding greater quantities of liquid than that shown in Fig. 2.

Fig. 10 illustrates diagrammatically an installation in which a liquid may be evaporated under controlled conditions of pressure and temperature, or in the presence of special atmospheres, with means to circulate the liquid, and means to remove, or condense the vapors.

In Figs. 1 and 2, a liquid is shown flowing from the valved pipe 1 into a distributor 2, the latter being provided with a long narrow outlet 3 at the bottom, through which passes a capillary support consisting of a ribbon-like or sheet-like body constituting an electric heater, having a highly porous or cellular surface, and preferably consists of a foraminous wick-like structure, for example a suitable screen mesh 4, made with any suitable resistance material, for example nichrome wire, and which may be of any suitable mesh depending upon the viscosity of the liquid being treated; screens from 16 to 20 mesh size have been found to be effective for a large variety of liquids of low viscosity. The cellular heater is constructed so as to develop a substantially uniform heat over its active surface. While it is preferred to supply the liquid from a distributor such as shown at 2, it is obvious that the liquid may be supplied to the heater 4 from a plurality

of pipes, or a manifold, or any other liquid distributing device. The liquid is preferably distributed to both sides of the heater, as shown, and flows over both surfaces thereof as indicated by the dotted lines 12 in Fig. 2, filling the cells or meshes of the heater surfaces, providing capillary surfaces to maintain a wide distribution of the liquid over the entire surface or surfaces of the heater, the liquid flowing as a wide sheet over a great length of heater surface. With a continuous smooth surface heater, for example a smooth metal sheet, the flowing liquid would not be distributed over the entire surface of the sheet for the same volume of liquid at the same pressure, because a capillary surface having the property of distributing the liquid is absent. The quantity of flowing liquid supplied by the distributor is maintained sufficient to keep the entire screen covered and allow for loss by evaporation, so that the bottom section 5 of the heater surfaces will also be maintained covered, thereby operating under conditions of maximum efficiency. Owing to the relatively small mass of the thin heating element, when compared with the enormous surface exposed on both sides to liquid contact, the efficiency of the apparatus as a heating agent is very high, and owing to the small thickness of the layer of liquid between outside surfaces, the mechanical resistance to the discharge of vapors therefrom is enormously reduced. The liquid is heated and concentrated during its flow over the heated screen and is finally collected in a receiver 6, from which it may flow over the spout 7. A suitable source of controlled electric supply is connected by the wires 8 and 10 to the bus bars 9 and 11 at the ends of the screen heating unit 4.

The flowing liquid covers the screen heater 4 on both sides, in layers 12, Fig. 2, of controlled thickness, and constantly washes out and replaces the small drops of liquid held in the capillary cells or meshes, so that the electrically heated capillary surface of the screen 4 is constantly being washed by relatively fresh liquid, the flowing stream being concentrated during its descent. With conducting liquids and an uninsulated screen heater, some of the electric current will pass through the liquid in accordance with the well known law of shunt circuits, and be directly electrically heated thereby, in addition to the thermal heating by contact with the heated screen, an increasing proportion of the current being diverted to the liquid as the temperature of the latter increases. With completely insulated screen heaters, for example by covering the heater body with an insulating and corrosion resisting enamel while leaving the cells or meshes open to facilitate the distribution of the liquid over the entire surface as above described, so as to retain the peculiar function of this construction, and also using insulated wire leads and bus bar connectors, the current supplied to the heating unit will not flow through the liquid, the latter then being heated thermally, and not both thermally and electrically. The liquid collected in the receiver 6 may be circulated as often as required over the screen heater 4 until a desired concentration is obtained.

In the modification shown in Fig. 3, a plurality of screen heaters 15, 15, 15, resembling in principle the heating unit shown in Fig. 1 are connected to a poly-phase electric supply system, the upper ends being shown connected to wires 16—17—18, and the lower ends of the screen heaters being connected to a bus bar 19, which latter is connected to a lead wire 20. The operation of heating and concentrating the liquid flowing over the several screen heaters is otherwise as described above.

In the modification shown in Fig. 4, a long screen heater 24 is shown as provided with a plurality of intermediate bus bars 25, 26, 27, and end bus bars 28, and 29. Alternate bus bars along the screen heater are connected to one side 30 of an electric circuit, while the intermediate bus bars are connected to the other side 31 of the circuit. The process of evaporating the liquid is otherwise the same as described under Fig. 1. If desired, on each side of the intermediate bus bars 25, 26, 27, there may be placed a small hopper having side walls 35, 35, shown in Fig. 5, which conduct the flowing liquid around the bus bar 25 (Fig. 5) and feed it immediately below to the screen heater, thereby preventing loss of liquid due to splashing; or a larger hopper such as shown in Fig. 10 at 67 may be used.

In the modification shown on a reduced scale in Fig. 6, a screen heater 40, similar in principle of operation to that shown at 4 in Fig. 1, is folded or "pleated" or "scolloped" by overlapping a portion at the bottom, shown at 42 in Fig. 7, but not at the top, and pressing the screen down nearly flat, but without crushing the woven structure, thereby producing an area of heating surface having a gradually reduced width from the top to the bottom, so that a quantity of liquid which is gradually reduced in volume by evaporation as it passes over the screen heater will keep the screen completely covered; the folding of the screen maintaining the electrical characteristics of the screen heater substantially constant whereby the heater will be operated at its highest efficiency. The heater 40 of Figs. 6 and 7 may be substituted for the screen heater 4 of Fig. 1, or screen heater 24 of Fig. 4; and as shown in Fig. 4, intermediate bus bars may be placed on the heater 40 of Figs. 6 and 7 is desired.

In the modification shown in Fig. 8, a plurality of tanks 51, 52, are supplied with controlled quantities of different liquids from pipes 53, 54, the liquids flowing from the tanks 51, 52, pass over mixing baffles 55, the mixed liquid 56 collecting in the distributor 57 from which is passes over a suitable type of screen heater 58 where its temperature is raised to a point which will facilitate chemical reactions between the components of the mixed liquids 56, forming new chemical compounds which may be in solution in the liquid 59, or may consist of said liquid, or, depending upon the new compound formed, may separate from said liquid 59 as a precipitate, the mass indicated by the liquid 59 collecting in the receiver 60. The conditions governing the chemical reaction or reactions may be controlled by the temperature of the screen heater, or by the velocity of flow of the mixed liquids 56 over the screen heater, or by the independent control of the quantities of the separate liquids supplied by the pipes 53, 54.

The modification shown in Fig. 9, illustrates a transverse sectional view of a capillary structure 65; in this case a relatively thick wick-like wire cloth screen, resembling for example a section of a piece of cloth, may be used in place of the wire screen heater 4 of Fig. 1, or in place of the screen heaters shown in any of the other figures. With a thick capillary screen heater of this type, a greater quantity of liquid will be retained in the body of the heater, the increased quantity of liquid facilitating the distribution of

the flowing liquid over the entire surface of the heater, and also serving to retard the downward flow of the liquid, thereby evaporating an increased proportion of liquid during its flow over the heater.

In Fig. 10, is shown, diagrammatically, a continuously operating installation comprising an electrically heated distilling, evaporating, or concentrating apparatus 70, in which may be placed any of the types of capillary surface heaters described herein, for example, as shown in Figs. 1 to 9, inclusive, supplied with electric current from any suitable source 92, 93. The liquid may be delivered from a suitable launder 71, which is supplied by any suitable intermittent supply device 72 described hereafter. The apparatus shown at 70 is provided with a pressure gauge 73, and a thermometer 74. The treated liquid is removed at the bottom through the pipe 75, and may be discharged through pipe 76; or may be pumped by pump 77 through pipe 78 to the vat 79. Gases or vapors may be pumped by the pump 80 from the electrical heating apparatus 70 through the pipe 81 and discharged to the atmosphere, or otherwise disposed of through pipe 82; or may be sent through a condenser 83, cooled by pipe 84, the condensed liquid being withdrawn through pipe 89, and any uncondensed products either discharged to the atmosphere, through pipe 85, or returned to the electrical heating apparatus 70 through pipe 86 to be re-passed through the condenser along with additional gases or vapors from the heating apparatus. When desired, controlled quantities of any suitable gas or vapor, for example controlled quantities of air, may be admitted through the pipe 88, either alone or mixed with the returned gases from the condenser. A pressure gauge 90 and a thermometer 91 are shown on the condenser 83. The intermittent supply device 72 may be of any type which interrupts the supply of liquid, and thereby electrically insulates this part of the system, delivering separated and insulated quantities of liquid to the launder 71. All of the parts of the intermittent supply device are preferably made of glazed stone ware, or other approved insulating material. The vat 79 also receives additional controlled quantities of liquid through the pipes 93, 94, when desired. The intermittent supply 72 is shown delivering liquid through pipe 96 to bucket 97; when this bucket is filled, it tilts, thereby closing valve 98, resetting bucket 99 and opening valve 100, also discharging the contents from bucket 97 into the launder 71; the intermittent supply device is continuous in operation, buckets being filled and discharged in succession automatically.

The method and apparatus described herein may be used for the heating of water, concentration of chemical solutions such as sulphuric acid, sodium hydroxide, or many other solutions; or the distillation of alcohol and water solutions, the recovery of alcohol and other solvents from solutions of chemicals, the distillation of petroleum products, or of many other liquids, and as a means for effecting chemical reactions, such as the manufacture of ether by heating a flowing stream of ethyl-sulphuric acid, and other reactions.

The process and apparatus described may also be used for the evaporation and concentration of solutions of various chemical compounds and salts, the concentrated liquor may be withdrawn and be allowed to precipitate crystals of salts in separate crystallization tanks, the mother liquor being then returned to the system for further treatment. When distillation is practiced in the apparatus, the vapors may be subjected to fractional condensation by controlling the temperature in the condenser, the uncondensed vapors being returned if desired, for further treatment with additional vaporized products.

The apparatus described is economical in use in that the desired amount of heat is generated in a controlled and limited volume of a flowing liquid having a relatively enormous surface exposed for evaporation, the flowing stream being exposed to a circulating atmosphere of controlled composition, under controlled conditions of temperature, pressure, velocity, and to a controlled quantity of heat.

I claim:

1. An electric heating element for heating liquids flowing longitudinally thereover, comprising a cellular foraminous structure constructed to expose said flowing liquid as a thin sheet exposed on both sides, and conductors adapted to supply evenly dstributed electric current over said structure.

2. An electric heating element for heating liquids flowing longitudinally thereover, said heating element provided with a capillary surface consisting of a multiplicity of cells, said multiplicity of cells having the property of maintaining a flowing liquid as a thin sheet exposed on both sides substantially uniformly distributed over the surface of said heating element.

3. An electric heater for longitudinally flowing liquids in sheet like form exposed on both sides consisting of a highly foraminous screen-like structure, and conductors to distribute electric current through said heater to uniformly heat the same.

4. An electric liquid heating apparatus, comprising an exposed capillary support having a highly porous surface, means to supply an electric current to said support to heat the same, and means to supply a longitudinally flowing stream of liquid thereto and exposed on both sides thereof.

5. An electric liquid heating apparatus comprising an exposed relatively thin substantially vertical wick-like structure, means to supply an electric current to said wick-like structure, and means to supply a flowing stream of liquid to said wick-like structure.

6. An electric liquid heating apparatus comprising an exposed relatively thin substantially vertical screen-like resistor, means to supply an electric current to said resistor, and means to supply a flowing stream of liquid to said resistor.

7. An electric liquid heating apparatus comprising an exposed relatively thin substantially vertical screen-like resistor, means to supply an electric current to said resistor, and means to supply a flowing stream of liquid to both sides of said resistor.

8. An electric liquid heating apparatus comprising a plurality of separate relatively thin substantially vertical screen-like resistors, said resistors connected to a source of poly-phase electric supply.

9. An electric liquid heating apparatus comprising a relatively thin substantially vertical screen-like heater, means to supply an electric current to said heater, means to supply a flowing stream of liquid to said heater, said heater adapted to retain a quantity of liquid within its meshes, said heater adapted to distribute said flowing liquid over its entire mesh-like surface and to expose a large area of flowing liquid surface.

10. An electric liquid heating apparatus comprising means to supply controlled quantities of a plurality of liquids, means to mix said liquids, a relatively thin substantially vertical screen-like heater, means to supply an electrc current to said heater, and means to supply said mixed liquids to said heater.

11. An electric liquid heating apparatus comprising a wide thin sheet-like exposed foraminous heater, means to supply a flowing stream of liquid to said heater, said heater adapted to distribute said flowing liquid over its exposed surfaces as wide thin sheets exposed on both sides.

12. An electric liquid heating apparatus comprising an exposed wide thin sheet-like foraminous heater, said heater coated with an insulating and corrosion-resistant film-like protecting material, said coated foraminous heater having the property of retaining a quantity of liquid in its meshes, means to supply a flowing stream of liquid to said coated heater, said coated heater having the property of distributing said flowing liquid over its exposed surfaces as wide thin sheets exposed on both sides.

13. An electric liquid heating apparatus comprising a chamber, an exposed wide thin sheet-like foraminous electric heater therein, means to supply an electric current to said heater, means to supply a flowing stream of liquid to said heater as a thin wide sheet exposed on both sides, means to remove vaporous and liquid products from said chamber, means to control the temperature and pressure in said chamber, and means to selectively circulate liquids and gases through said chamber.

14. The method of heating a liquid which comprises distributing a flowing stream thereof as a thin wide sheet exposed on both sides over a capillary cellular surface heater, and heating said exposed wide sheet of flowing liquid by heat generated in said heater, the thickness of said flowing stream being maintained low enough to reduce the resistance to escape of vapors from both sides to a minimum.

15. The method of heating mixed liquids and of effecting chemical changes therein which comprises passing a flowing stream of said mixed liquids as a thin wide sheet exposed on both sides over a heater having a cellular capillary surface, whereby said flowing liquid spreads and is maintained as a wide stream over the surface of said heater, and heating said flowing liquid to a temperature desired to effect the chemical changes, the thickness of said flowing stream being maintained low enough to reduce the resistance to escape of vapors from both sides to a minimum.

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