E. SHAW.

APPARATUS FOR EVAPORATING OR CONCENTRATING LIQUIDS.

APPLICATION FILED DEC. 28, 1909.

965,759.

Patented July 26, 1910.

4 SHEETS—SHEET 1.

Fig 1.

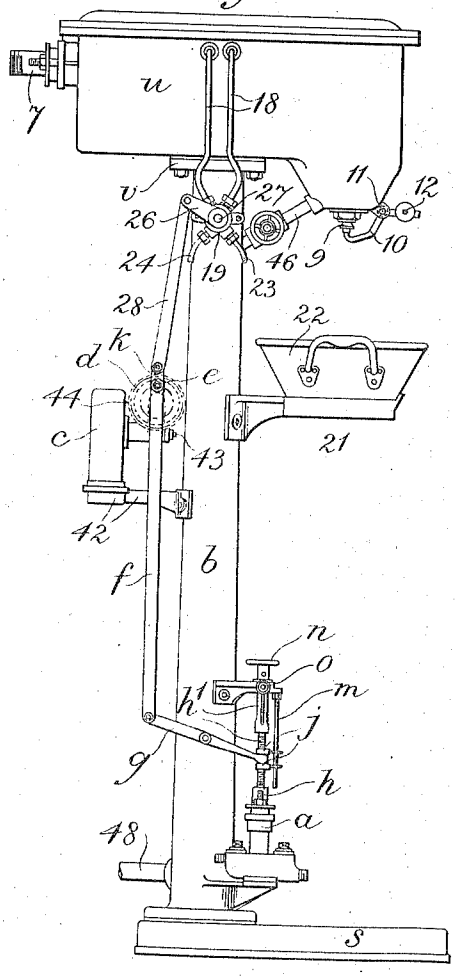
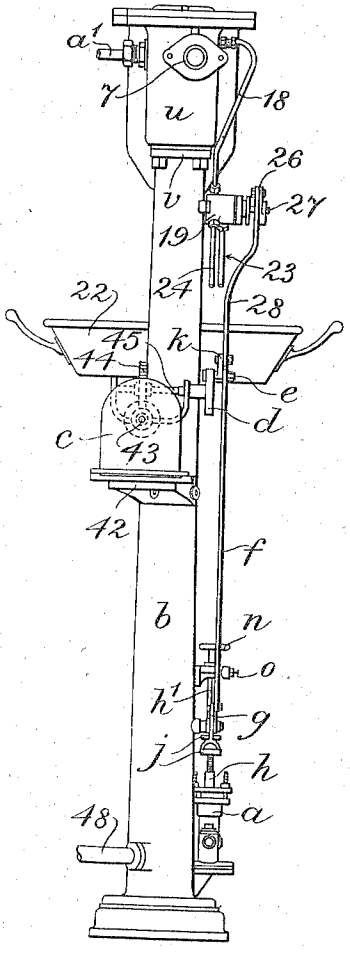


Fig 2.



Witnesses.
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L. L. Burket.

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4 SHEETS—SHEET 2.

Fig. 3.

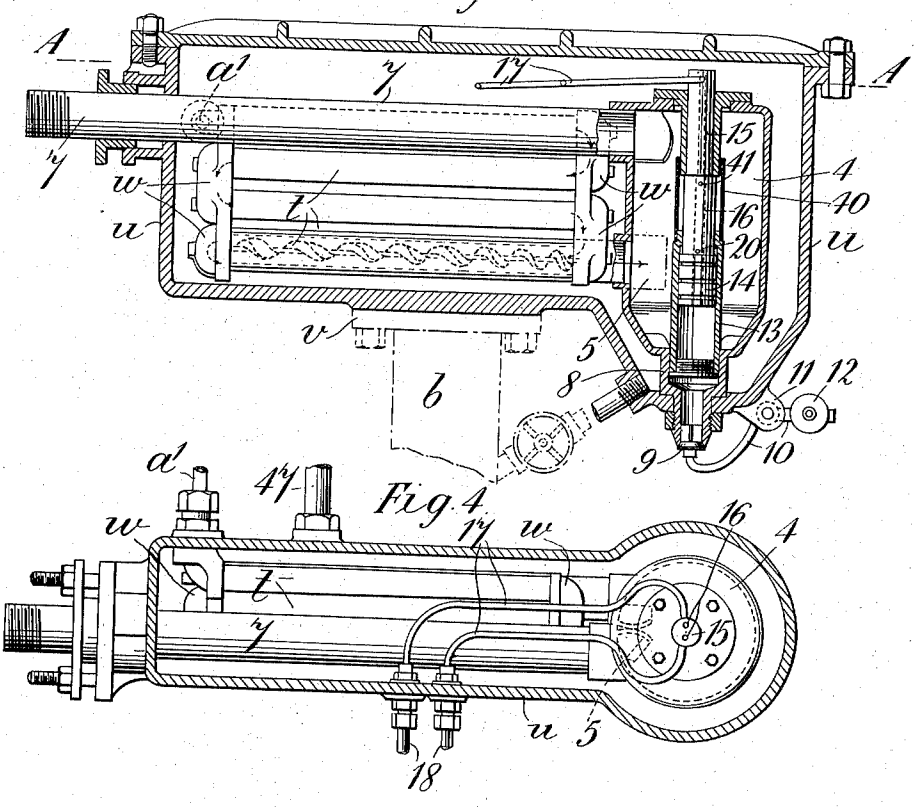

Fig. 4.

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4 SHEETS—SHEET 3.

Fig. 5.

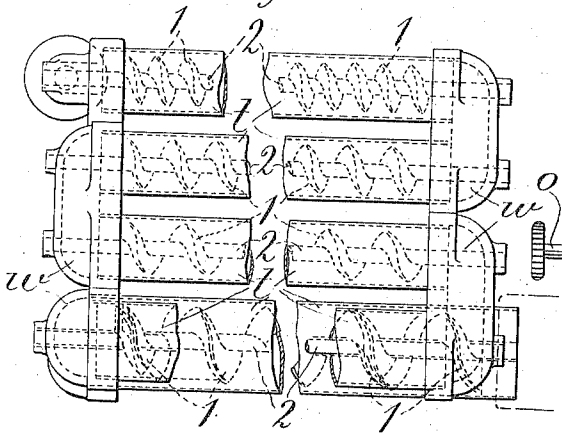


Fig. 7.

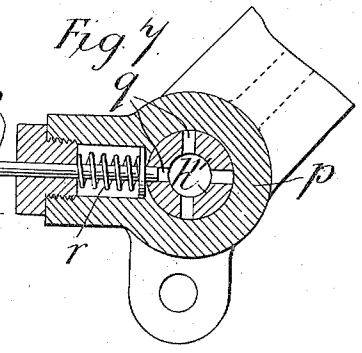


Fig. 6.

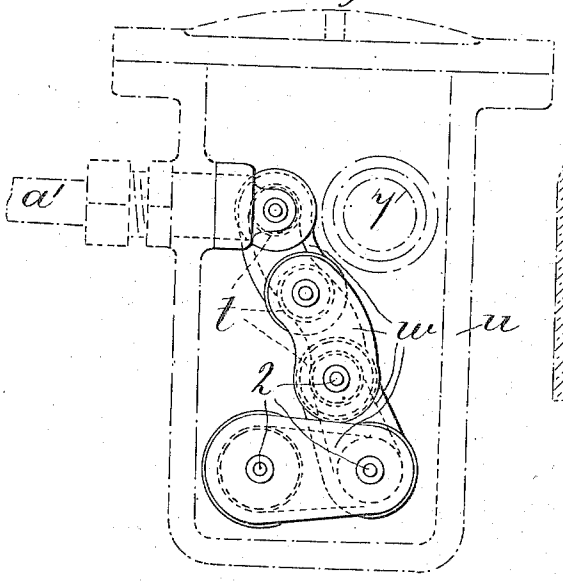
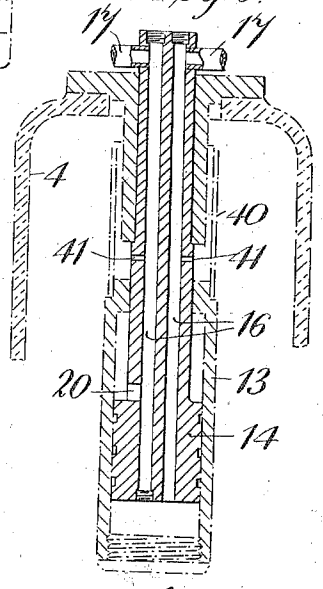


Fig. 8.



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4 SHEETS—SHEET 4.

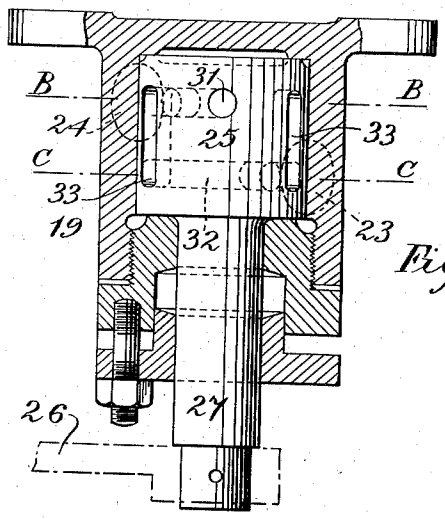


Fig. 9.

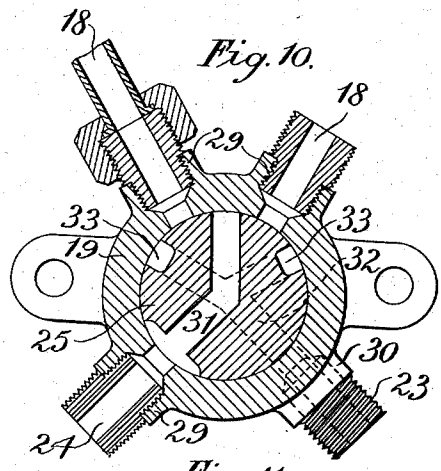
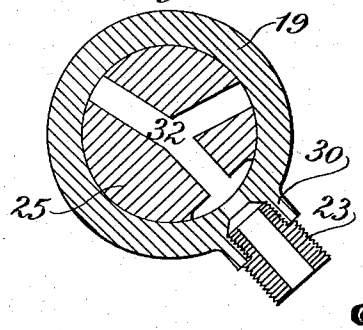


Fig. 10.

Fig. 11.



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UNITED STATES PATENT OFFICE.

EDWARD SHAW, OF DARTFORD HEATH, ENGLAND.

APPARATUS FOR EVAPORATING OR CONCENTRATING LIQUIDS.

965,759. Specification of Letters Patent. Patented July 26, 1910.

Application filed December 28, 1909. Serial No. 535,320.

To all whom it may concern:

Be it known that I, EDWARD SHAW, a subject of the King of Great Britain and Ireland, residing at Dartford Heath, in the county of Kent, England, have invented Improvements in Apparatus for Evaporating or Concentrating Liquids, of which the following is a specification.

This invention has reference to apparatus for evaporating or concentrating liquids generally, for example cane juice, sugar solutions, alkaline solutions, etc., and for the treatment of syrups in the manufacture of confectionery, of the type in which the liquid is forced, as by a pump, through an externally heated tube, from which the product is discharged into a chamber wherein separation of the steam from the boiled product is effected.

In such machines it has been heretofore proposed to force the liquid through the heated tube by means of an adjustable pump which provides a positive control of the rate of flow of the liquid. Moreover, for the purpose of providing in an externally heated evaporating tube a passage way increasing in area toward the exit end according to the increasing volume of vapor, it has been proposed to constitute such a tube of a simple coil, or of simple coils in series, of increasing diameter throughout the coil or coils; of a series of sets of simple tubes the number of tubes in each set increasing from set to set; and also of a number of tubes each having an internal spiral of increasing pitch toward the outlet of the tube.

Now according to this invention the evaporation is effected in an externally heated tube having a spiral passage way of increasing area formed therein by means of an internal worm or spiral, the increasing area of the passage being obtained in any suitable way as by increasing the pitch of the screw or the diameter of the tube or both, and in combination therewith there is employed a pump adapted to force into and through the heated tube definite quantities of the liquid per unit of time and thus to insure such a rate of flow as may be necessary to obtain the required product, irrespective of variations of resistance that may occur in the tube during the process. To enable the rate of flow to be controlled to suit varying conditions of the liquid thus introduced preferably the pump is rendered readily adjustable for example as hereinafter referred to. Preferably the heated tube comprises a number of tubes connected in series and with the spiral passage way formed in the series of tubes increasing in area from tube to tube. Thus each tube of the series may be of greater diameter than the preceding tube in the series and the worms or spirals in each tube be of uniform pitch, or the tubes may be of uniform diameter and the pitch of the worms or spirals be greater in successive tubes, or by both the diameters of successive tubes and the pitch of their contained worms or spirals increasing. The worm or spiral within the heated tube or each tube may extend nearly, but not quite, to the inner wall of the tube so that the liquid is partly compelled to travel through the tube in a spiral direction and partly caused to pass over the edge of the worm or spiral so that the liquid completely covers the inner surface of the tube instead of tending to travel along in the angle between the tube and the back of the worm or spiral and leave the wall of the tube near the front of the worm or spiral more or less uncovered, which uncovered surface reduces efficiency and renders probable discoloration of the product by the overheating of parts of it. The worm or spiral extends to the axis of the tube or to a rod or core which is fixed axially in the tube.

In order to exactly control the quantity of liquid forced through the heated tube or tubes, the pump is preferably driven through a lever or the like that is moved by the motor a certain definite amount at each stroke but which is so connected to the pump that only any desired portion of its stroke is effective in working the pump, that is to say it is connected through a lost motion device which is capable of being accurately regulated with ease and certainty.

The exit from the tube or tubes is in a chamber in which, preferably by centrifugal action, separation takes place between the steam and the boiled product. This chamber or separator either communicates with the air or with a condenser, the latter being employed in cases where it is necessary to reduce as far as possible the pressure on the liquid being boiled so that the water can be removed in the form of steam at a low temperature.

When the machine is used without a con-

denser the steam escapes upward while the product flows by gravity from the bottom of the chamber or separator. When a condenser is employed the separator is surrounded by steam or other heating agent which is found in some cases to be necessary.

The solution may be delivered from the separating chamber by a plunger which at each stroke positively forces a certain quantity of the boiled product out, it may be past a spring pressed or weighted valve as well as against the pressure of the atmosphere. The plunger is or may be actuated by steam, the supply and exhaust of the steam being controlled by a mechanically operated valve, preferably a rotary valve, which is driven from the same motor that actuates the pump for forcing the liquid through the heated tube.

Figures 1 and 2 show, in elevations at right angles to each other, an evaporating or concentrating machine embodying this invention. Fig. 3 shows to a larger scale the upper portion of such machine in section. Fig. 4 is a horizontal section corresponding to the line A A of Fig. 3. Figs. 5 and 6 show the heated tube, removed from the machine, in side elevation and end elevation, respectively. Figs. 7 and 8 are detail views. Fig. 9 is a central horizontal section of a controlling valve. Figs. 10 and 11 are vertical sections respectively corresponding to the lines B B, C C of Fig. 9.

In the machine illustrated the pump a is of the reciprocating plunger type, is mounted on the machine standard b and is driven from a water motor c (it might however be a steam motor, electric motor, a belt pulley and belt from an independent driving shaft, or other convenient source of power) also mounted on the machine standard b, through a crank disk d, crank pin e, link f, and a lever g the movement of which is constant and one end of which, in order to actuate the pump plunger h, extends between two nuts or screwed collars j mounted to work on right and left hand screwed portions of the plunger h or a rod h^1 connected thereto. The nuts j are prevented from rotating by a suitable guide rod m and the screwed rod h^1 or plunger is provided with a hand wheel n whereby it can be rotated in order to move the nuts or collars j toward and away from each other in order to regulate the amount of lost motion between the lever g and the pump plunger h and so control the effective stroke of the pump. Normally the screwed rod h^1 or plunger is prevented from rotation by a spring catch, shown more clearly in Fig. 7 and comprising a spring pressed pin o adapted to work in a bearing p through which the rod h^1 extends; normally the inner end of such pin extends into any one of four slots q formed in the upper part of the rod h^1 which at this part is hollow, as shown. In order to turn the rod h^1 the pin o must be first withdrawn by pulling it outwardly against the action of the spring r.

The pump draws liquid from a supply tank, not shown, supported it may be on a suitable part s of the machine standard base, and delivers it through a pipe a^1 into the first of a nest of five tubes t which are located in a steam chest or chamber u mounted on the standard head v. The tube ends, excepting the inlet and exit ends are connected together in pairs by being brazed into junction boxes or headers w, also located in the steam chest u and left free therein in order to allow freely for expansion and contraction, and the arrangement is such that the liquid must take a to and from course along the tubes in succession from the inlet to the outlet. The first three tubes t of the series are of smaller diameter than the fourth tube and the fourth tube is itself of smaller diameter than the fifth tube of the series and each tube is fitted with a worm or spiral l having a rod 2 arranged centrally within the tube, such worm or spiral extending nearly, but not quite, to the inner wall of the tube. With this construction, the tendency of the liquid and steam to move straight through the tube under the influence of the difference of pressure is resisted by the worm or spiral which compels the greater portion of the liquid to have a movement in a spiral path. In all cases whether the tube be horizontal, vertical or inclined the resultant of the forces due to pressure difference, centrifugal action, or gravity, on the liquid is more or less liable to drive it along in the angle between the spiral and tube and leave part of the wall of the tube uncovered. Now the space between the edge of the worm or spiral and the tube, enables some of the liquid, which is compelled to travel through the tube mainly in a spiral direction, to pass the edge of the worm or spiral, and so maintain the inner surface of the tube completely covered.

Under some circumstances, as when the tube is vertical and the movement is downward, gravity will also tend to cause the liquid to travel along on the top face of the spiral, the steam rushing along underneath the spiral face, and it is inevitable that, under some conditions of working, the surface of the tube near the under side of the spiral will not be properly covered with liquid and that some parts of the liquid will be overheated and in some instances such as gelatin solutions, damaged. In all such cases, great advantage is found in limiting the action of the spiral by leaving a space between its edge and the tube so that the liquid partly travels in a spiral path with great advantage in efficiency of heat transfer and perfection of what is known as film

evaporation, and partly travels more or less axially along the tube, thus keeping the whole surface covered by leaking from that part of the spiral passage where a tendency to thicken up takes place to that part where the tendency is for the liquid to leave the surface of the tube bare or only thinly covered. The clearance between the spiral and the tube is of less importance when the tube is horizontal and the diameter is relatively large in relation to the pitch, because gravity is not then assisting in causing unequal spreading of liquid over the tube surface and the effect of the steam pressure axially is reduced, so that a sufficiently mobile liquid will spread more or less evenly over the whole heating surface. The clearance between the worm or spiral and the tube will vary somewhat according to the viscosity of the liquid.

It is evident that thick liquids such as sugar solutions of say 90° Brix at 220° F. might be unevenly distributed and leave part of the tube surface imperfectly covered, with a consequent bad effect of heat on the sugar, and in such a case the modified action of the spiral due to the leakage space is of importance.

The pitch of the worm or spiral 1 in each of the tubes *t* is shown greater than that in the preceding tube but it may increase gradually in some or all of the tubes so that, in the latter case, the spiral passage way will be of gradually increasing area from the inlet of the first tube to the outlet of the last tube of the series. The dotted lines in Fig. 3 indicate a worm or spiral the pitch of which increases from the inlet end of the tube in which it is contained to the outlet end thereof. The last heating tube *t* of the series discharges in a tangential direction into a cylindrical chamber 4 also located in the steam chest *u*, a curved guide plate or web 5 within the chamber adjacent to the exit of the tube assisting in leading the outflowing steam and boiled liquid against the wall of the chamber 4 so that a whirling or centrifugal action is thereby set up which facilitates the separation of the steam from the product as well understood. The upper end of the separator chamber 4, hereinafter called a separator, is connected to a condenser by a pipe 7 that extends through the steam chest above the nest of tubes 1 therein.

The lower end of the separator 4 is formed with a tubular extension 8 that extends through and terminates just below the steam chest *u* where its lower end is normally closed by a valve 9 carried on one end of a lever 10 pivoted at 11 to lugs on the steam chest and whose other end is so weighted at 12 as to constantly press the valve 9 toward its seat.

Arranged to work in the tubular extension 8 is the lower closed end of a cylindrical plunger 13 which is located centrally within the separator 4 and which is guided on a piston 14 that is formed in one with or fixed to a fixed piston rod 15 depending from the top of the separator 4. The piston rod 15 is formed with two longitudinal passages 16 each connected to a pipe 17 that extends through the steam chest 4 and is connected by an external pipe 18 to a valve casing 19 hereinafter described. One of the piston rod passages 16, Fig. 8, is in communication through a lateral port or passage 20 with the cylindrical space within the plunger 13 above the piston 14 and the other passage 16 extends right through the piston 14 and is in communication with such space, below the piston. The stroke of the plunger 13 is such that when in its raised position, to which it is moved by steam admitted above the fixed piston 14, the boiled solution can flow into the tubular extension 8 at the lower end of the separator and, when it is afterward forced down by steam admitted below the piston, the boiled solution is thereby forced out of the tubular extension past the weighted valve 9.

21 is a bracket bolted to the standard *b* in position to support a suitable receiving pan 22 below the valve 9.

It will be understood that the piston rod passages 16 alternately constitute steam and exhaust passages, and to control the supply of steam thereto and therefrom the valve casing 19 before mentioned is fitted with two other pipes, one a main steam supply pipe 23, the other an exhaust pipe 24 communicating with the condenser, not shown, and within the casing 19 is arranged a rotary valve 25 which is constantly partly rotated to and fro by a lever arm 26 on the valve spindle 27 and a link 28 connecting such arm to the crank pin *e* of the pump motor driving disk *d* through an intermediate link *k*. The branches 29 of the casing 19 leading to the pipes 18 and the pipe 24 are on one level and the branch 30 leading to the main steam pipe 23 is at another level, see Figs. 9, 10 and 11. The valve 25 is formed with an angle passage 31 at the level of the branches 29 adapted to place either of the pipes 18 in communication with the exhaust pipe 24, and at the level of the branch 30 the valve is formed with a Y passage 32 adapted to place one or other of the pipes 18 in communication with the steam pipe 23 through longitudinal grooves 33 formed in the periphery of the valve 25 and leading from the extremities of two of the arms of the Y passage 32 to the level of the branches 29 of the pipes 18.

In one position of the valve, one of the piston rod passages 16 is connected to the steam supply pipe 23 through one of the branches 29, the corresponding groove 33,

valve passage 32, and the branch 30, and the other to the condenser through the other branch 29, valve passage 31 and corresponding branch 29; in the other position of the valve the passage 16 that was connected to the steam supply is connected to the condenser and the other passage 16 is cut off from the condenser and connected to the steam supply, in each case in the manner described.

To prevent concentrated solution such as syrup from lying on the metal surface of the piston rod 15 and thereby causing or tending to cause crystallization or graining of such solution, the upper end of the plunger 13 is fitted with an upwardly extending tubular sleeve 40 that surrounds the piston rod, and the piston rod is formed with two small holes 41 each communicating with one of the piston rod passages 16 so that steam under pressure is always passing through one or other of the small holes 41 into the space between the piston rod 15 and the sleeve 40.

The motor *c* is mounted on a bracket 42 bolted to the standard *b* and its shaft 43 has fixed on it a worm that gears into a worm wheel 44 fixed on the shaft 45 of the driving disk *d*.

The lower part of the steam chest or chamber *u* is fitted with a drain pipe 46 furnished with a valve and which discharges into the hollow machine standard *b*. This standard is closed at top and bottom and near its lower end has connected to it a discharge pipe 48. 47 is the steam supply pipe to the chamber *u*.

What I claim is:—

1. In apparatus for evaporating and concentrating liquids an externally heated evaporating tube having fixed within it a spiral which extends nearly but not quite to the inner surface of the tube, and is adapted to form a spiral passage-way of increasing area, as set forth.

2. In apparatus for evaporating or concentrating liquids a tubular conduit having a spiral passage way within it of increasing area from the inlet to the outlet, means for heating said tubular conduit externally, and a pump adapted to force into and through the passage way of said tubular conduit definite quantities of the liquid per unit of time.

3. In apparatus for evaporating and concentrating liquids, a tubular conduit, means for heating said tubular conduit externally, a spiral located within said conduit extending nearly but not quite to the inner surface of said conduit and adapted to form a spiral passage way of increasing area from the inlet to the outlet of said conduit and means adapted to force into and through the passage way of said conduit definite quantities of liquid per unit of time.

4. In apparatus for evaporating and concentrating liquids, a tubular conduit, means for heating said conduit externally, a spiral located within said conduit extending nearly but not quite to the inner surface of said conduit and adapted to form a spiral passage way of increasing area from the inlet to the outlet of said conduit, and an adjustable pump adapted to force into and through the passage way of said conduit definite quantities of liquid per unit of time.

5. In apparatus for evaporating or concentrating liquids a tubular conduit having a spiral passage way within of increasing area from the inlet to the outlet of the conduit, means for heating said conduit externally, and an adjustable pump adapted to force into and through the passage way of said conduit definite quantities of the liquid per unit of time.

6. In apparatus for evaporating and concentrating liquids, a tubular conduit, means for heating said conduit externally, spirals located within said tubular conduit, adapted to form a spiral passage way of increasing area from the inlet to the outlet, and means adapted to force into and through the passage way of said tubular conduit definite quantities of liquid per unit of time.

7. In apparatus for evaporating and concentrating liquids, a number of tubes connected in series, means for heating said tubes externally, spirals located within said tubes adapted to form a spiral passage way of increasing area from the inlet to the outlet, and means adapted to force into and through the passage way of said tubes definite quantities of liquid per unit of time.

8. In apparatus for evaporating and concentrating liquids, a series of tubes, junction boxes connecting the outlet of each tube except the last of the series to the inlet of the next tube, a spiral located within each tube of said series the pitch of the spiral of the first tube being smaller than that of the next tube of the series and so on, means for heating said series of tubes externally, and means adapted to force into and through the passage way formed in said series of tubes by said spirals definite quantities of liquid per unit of time.

9. In apparatus for evaporating and concentrating liquids, a series of tubes the tubes constituting the last of the series being of greater diameter than those constituting the first of the series, junction boxes connecting the outlet of each tube except the last of the series to the inlet of the next tube, a spiral located within each tube of said series the pitch of the spiral of the first tube being smaller than that of the next tube of the series and so on, means for heating said series of tubes externally, and means adapted to force into and through the passage way formed in said series of tubes by said spirals definite quantities of liquid per unit of time.

10. In apparatus for evaporating and concentrating liquids, a series of tubes, junction boxes connecting the outlet of each tube except the last of the series to the inlet of the next tube, a spiral located within each tube of said series extending nearly but not quite to the inner surface of the tube the pitch of the spiral of the first tube being smaller than that of the next tube of the series and so on, means for heating said series of tubes externally, and means adapted to force into and through the passage way formed in said series of tubes by said spirals definite quantities of liquid per unit of time.

11. In apparatus for evaporating and concentrating liquids, a series of tubes the tubes constituting the last of the series being of greater diameter than those constituting the first of the series, junction boxes connecting the outlet of each tube except the last of the series to the inlet of the next tube, a spiral located within each tube of said series extending nearly but not quite to the inner surface of the tube the pitch of the spiral of the first tube being smaller than that of the next tube of the series and so on, means for heating said series of tubes externally, and means adapted to force into and through the passage way formed in said series of tubes by said spirals definite quantities of liquid per unit of time.

12. In apparatus for evaporating and concentrating liquids, a series of tubes the tubes constituting the last of the series being of greater diameter than those constituting the first of the series, junction boxes connecting the outlet of each tube except the last of the series to the inlet of the next tube, a spiral located within each tube of said series extending nearly but not quite to the inner surface of the tube the pitch of the spiral of the first tube being smaller than that of the next tube of the series and so on, means for heating said series of tubes externally, and an adjustable pump adapted to force into and through the passage way formed in said series of tubes by said spirals definite quantities of liquid per unit of time.

Signed at London England this 17th day of December 1909.

EDWARD SHAW.

Witnesses:
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