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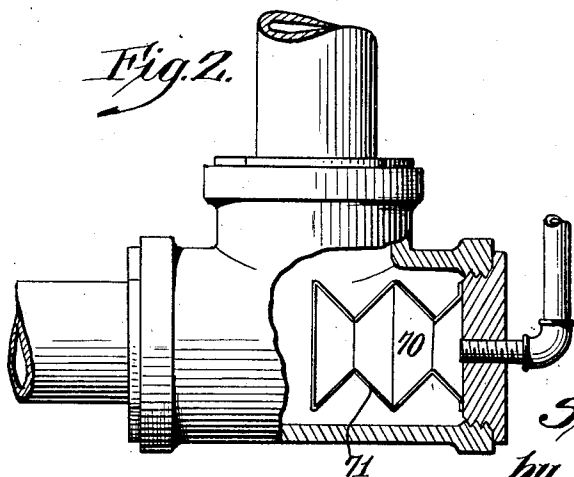
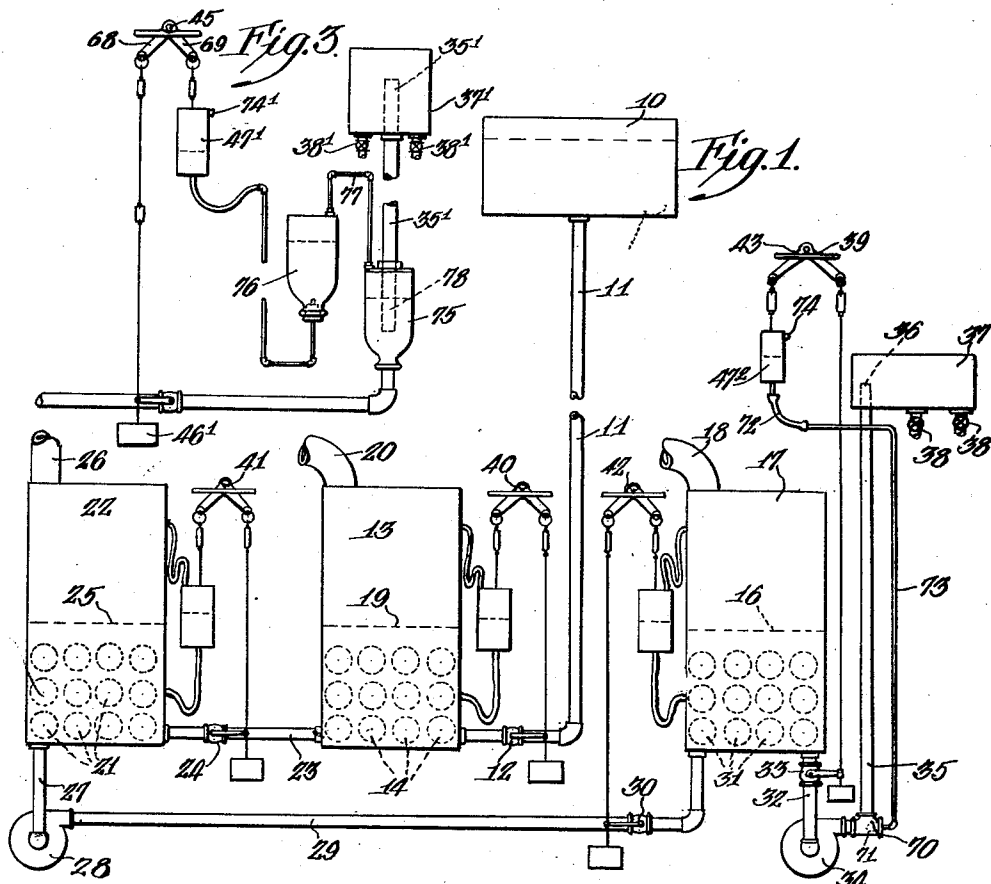
S. F. GROVE

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ADJUSTER EQUIPMENT FOR EVAPORATORS

Filed May 1, 1929

2 Sheets-Sheet 1



Inventor:
Samuel F. Grove
by Wm. J. Crowell
Attorney.

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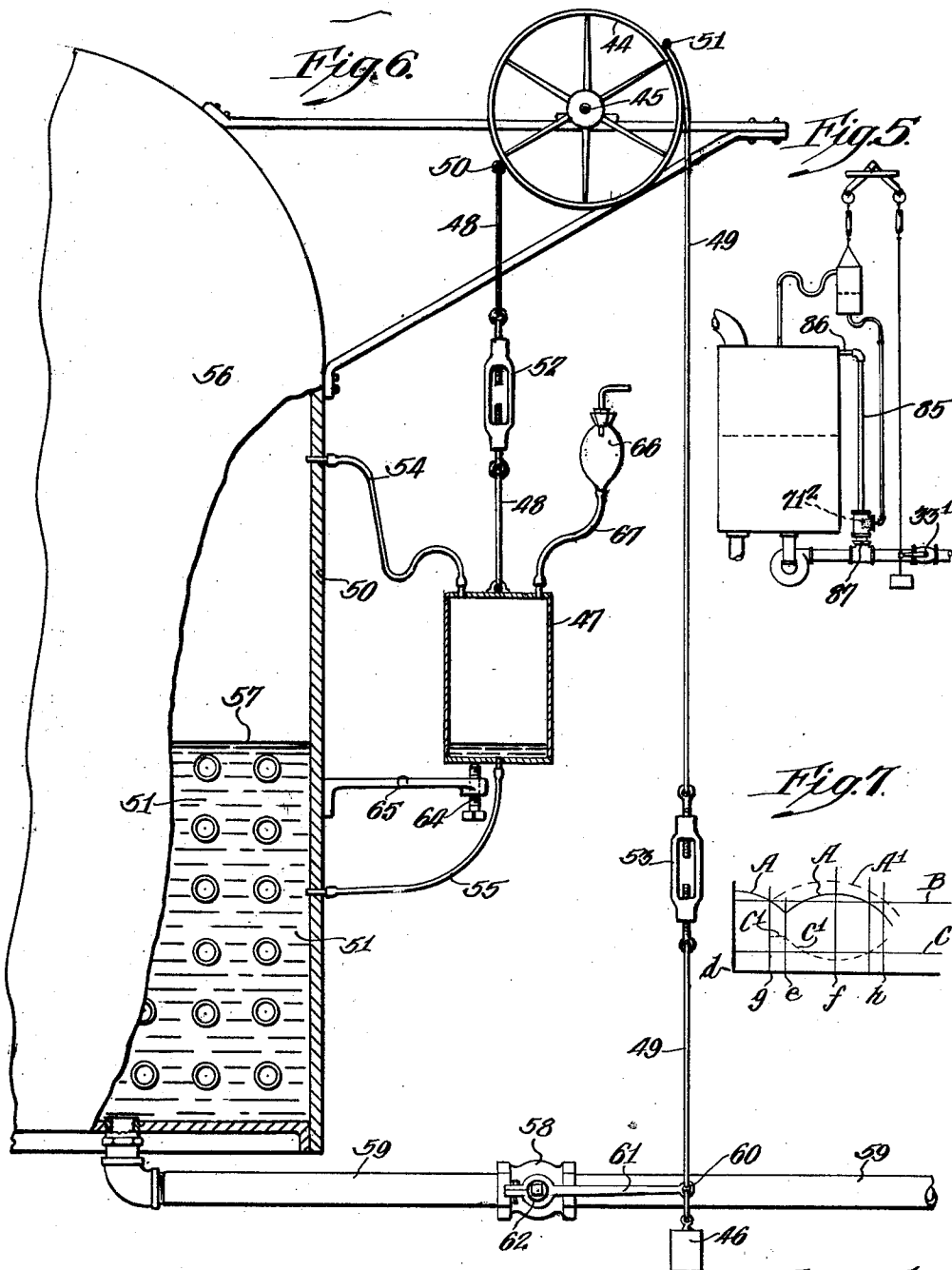
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2 Sheets-Sheet 2



Inventor
Samuel F. Grove
 by *J. F. Crowell* Jr.
 Attorney.

UNITED STATES PATENT OFFICE

SAMUEL FELTON GROVE, OF SWARTHMORE, PENNSYLVANIA

ADJUSTER EQUIPMENT FOR EVAPORATORS

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My invention relates to multiple evaporators or the like with particular reference to equipment thereof for effecting automatic adjustments of inlet and outlet valves, either or both.

A purpose of my invention is to maintain uniformity in the product from an evaporator and uniformity in the operating conditions inside an evaporator, either or both.

A further purpose is to make the density of the concentrated liquor flowing away from an evaporator automatically adjust an outlet valve controlling the outlet flow of the liquor product in a way to secure a liquor product of substantially uniform density.

A further purpose is to combine a density control of an outlet valve from an evaporator with a constant level control of an inlet valve to the evaporator preferably operating the evaporator continuously, making any increase in density effect an increased opening in the outlet valve and the resultant fall in level inside the evaporator effect an increased opening in the inlet valve to the evaporator and vice versa when the density of the liquor output decreases.

A further purpose is to suspend a liquid container and an operating weight upon opposite sides of a pivoted balance at horizontal distances from the pivot that are relatively variant with variation in the angular deflection of the balance, making the ratio of the horizontal length of the arm of the suspended container to that of the suspended weight decrease with increased downward deflection of the container and vice versa, and to use the balance to adjust an inlet or an outlet valve to an evaporator or other reservoir by using a characteristic of the liquid going to or coming from or within the reservoir to vary the weight of the liquid in the suspended container.

A further purpose is to send a small stream of diluting liquid into the suspended container element of a valve adjuster in order to avoid crystallization of the liquid inside the container.

Further purposes will appear in the specifications and in the claims.

I have elected to illustrate my invention in

one main form only, with minor modifications and show it applied to a multiple evaporator, showing the evaporator diagrammatically and my balance valve adjuster equipment applied to maintain constant liquid levels inside the different evaporator units, and to maintain uniform density in the discharge liquor from the last unit evaporator.

Figure 1 is a diagrammatic elevation of structure embodying my invention and shows my balance valve adjusters applied to a multiple evaporator, the showing of the evaporators being intended as a conventional showing for any structure to which my equipment is adapted to be applied.

Figure 2 is an enlarged fragment of Figure 1.

Figure 3 is a broken elevation corresponding to part of Figure 1 but showing a detail modification.

Figure 5 is a fragment of Figure 1 but showing different connections for adjusting the outlet valve to maintain an output of constant density.

Figure 6 is a fragmentary elevation partly sectioned and to an enlarged scale showing a desirable form of my valve adjuster applied to adjust an inlet valve of an evaporator, the balance mechanism shown connected to adjust an inlet valve to maintain constant liquid level inside the evaporator being equally adapted to adjust an outlet valve to maintain a liquor output at a constant density.

Figure 7 is a diagrammatic curve used to illustrate that a balance embodying one form of my valve adjuster is desirably operated at either one of two different ranges of deflection.

Like numerals refer to like parts in all figures.

Describing in illustration and not in limitation and referring to the drawings,—

Figure 1 shows a multiple evaporator equipment that embodies my invention indicated more or less diagrammatically in the operation of concentrating a dilute chemical liquor, for example, a solution of sodium ferrocyanide, preparatory to obtaining the crystallized salt when the concentrated liquor

discharging from the last evaporator unit cools.

The weak liquor is fed by gravity from a suitable container 10 through a pipe 11 having a control valve 12 into the first evaporator 13.

The first evaporator is heated by hot pipes 14 that are preferably heated by steam vaporized from the partially concentrated liquor 16 in the third evaporator 17. This steam leaves the third evaporator through a suitable vapor outlet pipe 18 and passes through suitable connections not shown to the pipes 14 in the first evaporator.

The steam vaporized from the surface of the liquid 19 inside the evaporator 13, passes off through a vapor outlet main 20 by connections not shown to heating pipes 21 in side the second evaporator 22.

The first evaporator discharges its partially concentrated liquor through a pipe 23 having a control valve 24 to the second evaporator 22 where it is evaporated down by the hot pipes 21, the vaporized steam from the liquor 25 in the second evaporator being led away through a suitable vapor outlet pipe 26 to a vacuum pump and condenser not shown.

The additionally concentrated liquor passes out of the second evaporator down through a pipe 27, centrifugal pump 28, pipe 29 having a control valve 30 into the third evaporator 17 which is heated by low pressure steam pipes 31.

In usual operation there may be a vacuum of about eighteen inches of mercury in the first evaporator, a vacuum of about twenty-six inches of mercury in the second and a vacuum of about ten inches of mercury in the last evaporator.

It will be seen that with this condition the liquor tends to flow from the first evaporator to the second, but that a pump 28 is required to deliver the liquor from the second evaporator to the third.

The concentrated liquor from the third evaporator is shown led out through pipe 32, control valve 33, centrifugal pump 34 and discharge pipe 35 to an overflow at 36 into a raised distribution tank 37 whence it flows by gravity through valves 38 to different cooling tanks not shown, the dissolved salt crystallizing out of the concentrated liquor as the liquor cools.

The operation is desirably continuous and uniform, and I connect a valve adjuster unit 40 to maintain the level of liquor inside the first evaporator constant by suitable adjustments of the valve 12.

I connect a second valve adjuster 41 to the control valve 24 so as to maintain the liquor level in the second evaporator 22 constant.

I connect a third valve adjuster 42 so as to maintain the liquor level in the third evaporator constant by adjustment of the valve 30, and I connect a fourth valve adjuster 43

to control the outlet valve 33 from the last evaporator to secure a discharge liquor of substantially constant density.

The operation of the individual adjuster units is best illustrated in Figure 6.

A balance 44, shown as a wheel, has pivot support at 45 and suspends on opposite sides and at relatively variant horizontal distances from the pivot, a weight 46 and a hollow container 47.

The container and weight are respectively supported upon opposite sides of the wheel by chains or flexible metal ribbons 48 and 49.

The flexible connection 48 suspending the container 47 is fastened to the wheel circumference at a point 50 lower than the horizontal through the pivot 45, while the connection 49 suspending the weight is fastened to the wheel circumference at a point 51 higher than this horizontal.

Turnbuckles 52 and 53 are inserted in the suspending members 48 and 49.

The container 47 has upper and lower flexible tube connections 54 and 55 into the evaporator 56, respectively above and below the surface of the liquor 57 that is to be maintained at a constant level by adjustments of a valve 58 in an inlet pipe 59, the evaporator having a continuous outlet not shown.

The weight 46 and suspending member 49 have operating connection at 60 with the outer end of the valve handle 61 which is shown provided with an angularly adjustable connection with the movable element 62 of the valve.

The weight 46 on one side of the balance exerts a turning moment that is substantially constant and that is adapted to be balanced by the oppositely directed turning moment exerted by the combined container and liquid on the other side of the balance at angular positions of the balance that are variant according to the height of the liquor in the evaporator.

Any rise of the liquor inside the evaporator 56 results in a corresponding rise of the liquor inside the container 47, and the resultant increase in weight tends to move the container 47 downward, turning the balance upon its pivot to partially close the valve against the retractive force of the weight 46.

When the container moves downward the effective length of its arm with respect to the balance pivot shortens in that its point of suspension 50 moves inward, tending to lessen the turning moment exerted by the container, while the additional liquid which enters the container by reason of its downward movement increases the weight upon the arm, tending to increase the turning moment exerted by the container.

The moment exerted by the container 47 thus either increases or diminishes when the container moves downward according to whether the increase in the suspended weight

by reason of the additional liquor entering the container is proportionately greater or less than the diminution of the horizontal arm of the suspended container by reason of the point of suspension 50 moving inward.

If the point of suspension 50 is near a position horizontally outward from the balance pivot, any change in the angular position of the balance effects a change in the length of the arm that is proportionately small compared to the oppositely effective change in weight unless the container be of very small sectional area, while the reverse is true if the point 50 is near a position vertically downward from the balance pivot.

I may operate the balance in either one of two different ways which will be best understood from a consideration of the curves shown in Figure 7.

The abscissæ on this curve represent different angular positions of the balance as determined by the angular position of the point of suspension 50 of the container measured from a point horizontally outward from the balance pivot, the point *d* on the curve corresponding to the position of the balance at which the point 50 is horizontally outward from the balance pivot.

Curve A indicates the torque or turning moment exerted by the container and its liquid at these different angular positions, assuming the balance moved by hand to these positions and assuming a constant level of liquor inside the evaporator.

The horizontal line B indicates the opposing and substantially uniform torque exerted by the counterweight 46.

Wherever the curve A is above the curve B, the balance if free to move will deflect in direction to lower the container 47; wherever the curve A is below the curve B, the balance if free to move will deflect in direction to raise the container 47, and at positions corresponding to points of intersection between the curves A and B, the balance will have no tendency to move in either direction.

In accord with the curve A, the container 47 is wholly above the surface of the liquor in the evaporator between the points *d* and *e*, the liquor first entering the container with a resultant sharp increase in torque when the container is moved downward beyond the position *e*.

As the torque A is equal to the product of the total weight suspended at the point 50 times the horizontal distance of this point outwardly from the balance pivot the torque increases when the container is moved downward beyond the point *e* until at about the point *f* the rates of weight increase and arm decrease are equal.

Beyond the point *f* the arm decreases faster than the weight increases, resulting in a pro-

gressively decreasing torque for all positions progressively beyond the point *f*.

The horizontal line C indicates the assumed level of the liquor in the evaporator, and the curve C' shown dotted indicates the requisite change from this level to make the torque exerted by the container and its liquor equal to the opposing torque exerted by the counterweight 46.

I may operate the balance in either one of two ways, both ways giving excellent satisfaction and either being preferable according to circumstance.

If the container is lowered by suitable adjustment of the turnbuckle 52 so that with the given level of liquor in the evaporator the liquor begins to enter the container at the point *g*, the curve of torque exerted by the container and its liquor for positions downwardly beyond the point *g* will be about as indicated by the curve A'.

If the container in its lowered position is deflected downwardly from the point *g*, or if while the container is at the point *g* the level of liquor in the evaporator rises, the balance will tend to keep on deflecting and if free to move will ultimately come to rest at the point *h*.

In Figure 6 I have limited the downward movement of the container by means of an adjustable stop 64 underneath the container and carried by a bracket 65 from the evaporator.

With normal continuous operation, there is a continuous flow into the evaporator and another continuous flow out of it.

I may give the valve 58 a setting such that when the container 47 is down upon its stop 64 the inflow through the valve is slightly less than that needed to maintain the level inside the evaporator constant, and when the container is in its high position corresponding to the point *g* on Figure 7 the valve is open far enough to make the flow through the valve slightly in excess of that needed to maintain the liquor in the evaporator at constant level.

In operation the container then has a small range of vertical movement.

As soon as the liquor level falls far enough for the liquor to leave the container, the container rises and slightly increases the opening of the valve which in due course results in a sufficient raising of the level of the liquor in the evaporator to again flood the bottom of the container, causing the container to sink and again sufficiently lessen the inflow of liquor through the valve to start the level inside the evaporator to gradually sink, the sequence of operations repeating itself over and over with a very narrow corresponding fluctuation of the level of the liquor in the evaporator.

If the instrument is operated at a position corresponding to the point *h*, Figure 7, the container 47 is never empty and automatically finds a position at which there is sub-

stantially no fluctuation in the level inside the evaporator.

Any increase in the height of the liquor increases the angular deflection of the balance and slightly closes down the valve, and vice versa, any decrease in the height of the liquor decreases the weight inside the container and slightly opens the valve.

As a result, the valve gravitates to the position for maintaining the liquor in the evaporator at constant level, and there may be no visible change in either the setting of the valve or in the level of the liquor in the evaporator over long periods.

When used to control the level of a hot liquor that will deposit crystals on cooling I provide the container with a small inlet flow of diluting liquid so as to maintain the liquor in the suspended container sufficiently dilute to avoid the formation of crystals in the container.

In the illustration I connect the bottom of a suitably supported glass funnel 66 to the top of the suspended container 47 by a suitable flexible tube 67 and flow a small stream of diluting liquid into the funnel and thence to the container 47, thus providing a small sight-feed delivery of diluting liquid into the liquor within the container.

I have found in practice that the wheel form of balance shown in Figure 6 gives excellent satisfaction. Obviously however, I may widely vary the detail construction of the balance and in Figures 1, 3, and 5 show the valve adjusters each including a balance in which the weight 46 and container 47' are respectively suspended upon arms 68 and 69 that diverge downwardly from opposite sides of the pivot 45'.

In this arrangement downward deflection of the container simultaneously decreases the length of the arm of the container and increases the length of the arm of the weight, and any range of unstable equilibrium such as that indicated by an intermediate portion of the curves of Figure 7, will be non-existent unless the container is of abnormally large sectional area.

The two forms of balance illustrated are to be understood as merely examples of many forms in which the ratio of the horizontal arm of the weight to that of the container will increase when the container moves downward and vice versa when the container moves upward.

An important feature of my invention is the adaptation of the balance to control the outlet valve of the last evaporator in a way to maintain the density of the discharging liquor from the last evaporator substantially constant.

I use the density of the discharging liquor to control a water level that in turn controls the outlet valve from the evaporator.

I provide means for balancing a column

of water of variable depth against a column of the discharging liquor of definite and preferably constant depth, transmitting the pressure from the foot of the column of the liquor to the foot of the balanced column of water in any suitable way; either by a suitable diaphragm (Figures 1, 2 and 5) or by an air trap (Figure 3).

In Figures 1 and 3 the column of liquor used to support a balancing column of water that in turn controls the operation of the valve adjuster is obtained by discharging all of the liquor through a vertical overflow pipe 35 into an elevated distributing tank 37.

In Figure 1 the adjuster 39 is operated by variation in the density of the column of liquor in the pipe 35.

A column of water or of other suitable liquid (herein called water) has its lower end at 70 inside a collapsible diaphragm member 71 that is surrounded by the liquor, and has its upper end in the container 47², suitable flexible connection being provided at 72 between the bottom of the container and the top of a pipe 73 ending at its lower end in the diaphragm member.

The container 47² is open to atmosphere at 74 and contains a variant quantity of water according to the variant pressure transmitted against the collapsible diaphragm member 71 by the liquor in the pipe 35.

Any increase in density of the discharging liquor increases the pressure at the foot of the column and partially collapses the diaphragm member, thereby increasing the quantity of water in the container 47² and deflecting the balance to adjust the valve 33 in direction to reduce the density of the discharging liquor.

This adjustment is one to somewhat open the valve which initially lowers the level of the liquor 16 in the evaporator and thereby results in an opening adjustment of the valve 30 to maintain the level 16.

The operation is exactly the reverse if the density of the discharging liquor lessens. The reduced pressure upon the diaphragm member 71 then permits the diaphragm member to expand which reduces the amount of liquid in the container 47² resulting in a movement of the balance to partially close the valve 33 which in turn effects an adjustment of the valve 30 toward closure, due to the level of the liquor in the evaporator beginning to rise.

The diaphragm 71 is shown diagrammatically and in practice may have very considerably greater internal volume as compared to that of the container 47² than would appear to be indicated by Figures 1 and 2.

It will be apparent that almost any desired delicacy of adjustment may be obtained by suitable increase in the lengths of the columns of liquor and water respectively.

Figure 3 shows a detail modification of the

structure in Figure 1 for adjusting the discharging liquor to constant density.

As in Figure 1 the liquor from the evaporator 16 discharges through an overflow pipe 35¹ into the elevated distributing tank 37¹ whence it flows by gravity to the cooling tanks not shown.

Instead of the diaphragm member 71 for transmitting the pressure of the column of liquor to the foot of a balancing column of water that has its upper end in the container 47¹ I provide any suitable air trap between the two columns.

The air trap, preferably glass, is shown comprising inverted bottle members 75 and 76, there being a tubular connection 77 between the trapped air in the upturned bottom of one bottle and the air in the upturned bottom of the other bottle.

The bottle 75 forms a portion of the overflow conduit to the distribution tank, being in effect a coupling member between vertically spaced portions of the pipe 35¹ which extends downwardly through the bottom for some distance at 78 into the bottle. The pipe has a suitable seal with the bottom of the bottle and the liquor rising up around the end of the pipe forms a liquor seal for the trapped air.

The operation is as already described except that the variations of pressure incident to small changes of liquor density are transmitted to the foot of the water column through the air trap instead of through the diaphragm. It will be seen that an increase in density will in both forms increase the back pressure upon the pump and the pressure transmitted to the foot of the water column that rises into and variantly deflects the container 47¹, increasing the amount of water in this container and effecting an increased deflection of the balance 68.

In the structure of Figure 5, I permit a by-passing stream of liquor to flow into the vertical pipe 85 which overflows at 86 into the top of the evaporator.

The inlet 87 into the vertical pipe is very small as compared to the pipe area so that there is a constant head of liquor upon a diaphragm member 71² which may be in every way similar to the diaphragm member 71 of Figure 2 and is used to adjust the valve 33¹ exactly as in the structure shown in Figure 1.

In view of my invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art and I claim all such in so far as they are reasonably covered by the spirit and scope of the invention and claims.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:—

1. In a regulator for controlling the height of a hot liquid solution in a recep-

tacle having an inlet valve and an outlet, a closed liquid container, flexible connections from near the top and bottom thereof adapted to connect into the interior of the receptacle above and below the surface of the liquid in the receptacle, connections adapting the container to control the inlet valve, in combination with means continuously delivering a small stream of non-precipitating liquid into the container to prevent precipitation within the container.

2. In evaporator equipment, a valve, means adapting adjustment of the valve to adjust the density of the evaporator output, a valve adjuster operatively connected to the valve, a column of liquid having an upper end inside and operatively controlling the movement of the adjuster, and means operative by variations in the density of the liquor in the evaporator for controlling the elevation of the said upper end.

3. An evaporator for concentrating dilute liquor, an inlet valve adapted to continuously feed dilute liquor to the evaporator and an outlet valve adapted to continuously discharge concentrated liquor from the evaporator in combination with connections for varying the elevation of a column of liquid according to the density of the discharging liquor, and a valve adjuster containing and operatively controlled by the upper end of the column adapted to partially close the valve when the elevation of the column decreases due to diminution in the density of the liquor and to partially open the valve when the elevation of the column rises due to increase in the liquor density.

SAMUEL F. GROVE.

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