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S. G. NOBLE ET AL

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SOLUTION CONCENTRATION CONTROL SYSTEM

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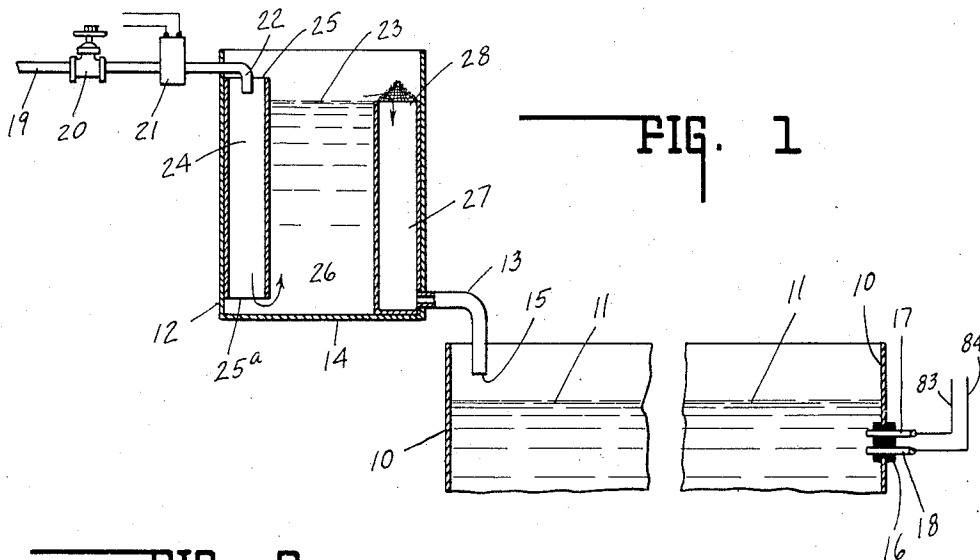


FIG. 1

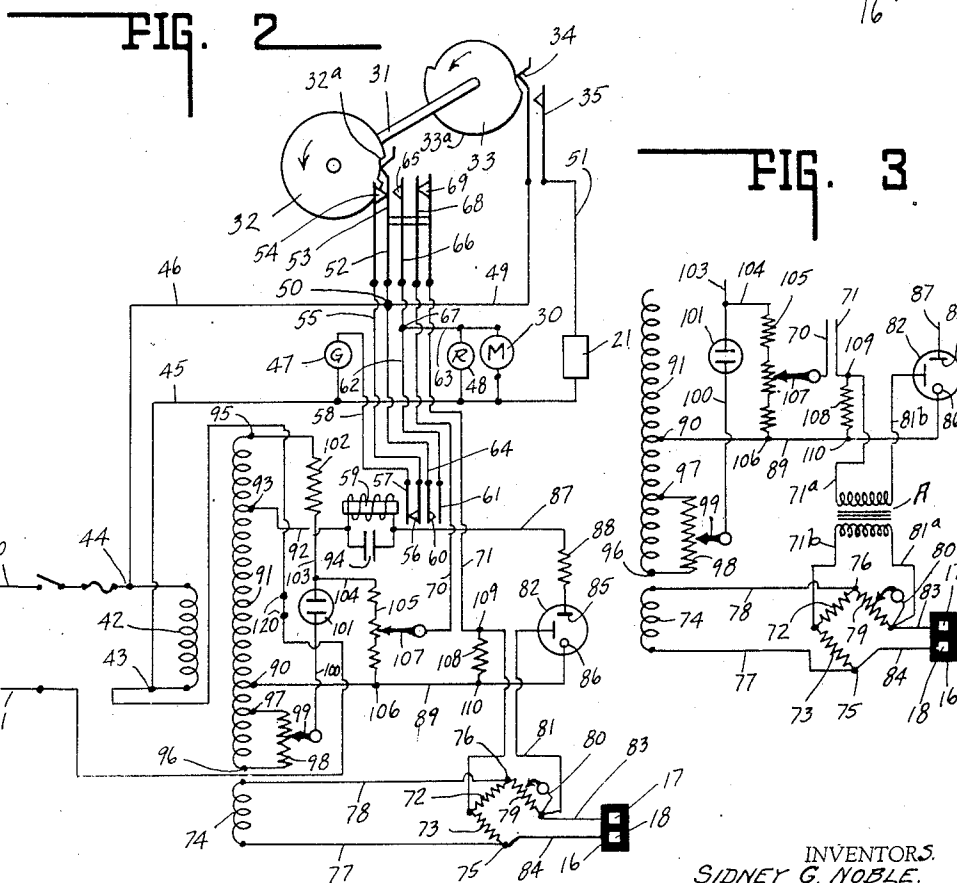


FIG. 3

INVENTORS.
SIDNEY G. NOBLE.
WILLIAM L. WOLGEMUTH.
BY
Lockwood, Coldsmith & Calt,
ATTORNEYS.

UNITED STATES PATENT OFFICE

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SOLUTION CONCENTRATION CONTROL SYSTEM

Sidney G. Noble, Oak Park, and William L. Wolgemuth, La Grange, Ill.

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10 Claims. (Cl. 137-78)

This invention relates to a system of maintaining proper concentration in a liquid.

The invention contemplates maintaining the concentration of an alkaline (cleaning) solution (but not necessarily restricted thereto) between certain predetermined limits by utilizing the unbalance developed across an alternating current bridge circuit, one leg of which is composed of the resistance offered by the solution to the passage of current between electrodes submerged in the solution.

Specifically this unbalance is used to trip a gaseous type, grid controlled vacuum tube which operates the control equipment.

The voltage applied to the control element of the tube is maintained at the required value by means of an adjustable voltage taken from a regulated source of voltage and applied to the controlling element of the tube in series with the unbalance voltage of the bridge circuit.

One object of the present invention is to provide a concentration responsive arrangement which is of such character that continuous operation of the control tube is unnecessary, thereby eliminating such tube variable factors as may be occasioned by heating of such tube incident to continuous use. Specifically this may be expressed as follows: The control is dependent upon the ionization point of the tube which is constant and not upon the deionization point which is variable.

The feature of the invention which is a corollary to this object is that the control is initiated by the tube but not maintained thereby.

Another object of the invention is to provide a system including a tube for control purposes which breaks down at a point independent of the supply voltage, and same may be utilized in an over-regulated arrangement or an under-regulated arrangement with equal facility, as hereinafter pointed out.

The feature of the invention which is a corollary to this object is that since the regulated voltage increases when the supply voltage decreases and vice-versa, the unbalance voltage which causes breakdown of the control tube adds to the regulated voltage to produce over regulation when the bridge polarity and regulator are properly adjusted or the unbalance voltage subtracts from such voltage to produce under-regulation.

A feature of the invention is that the voltage regulating system can be adjusted to produce overall consistency of operation with varying supply voltage not merely a constant voltage at a given point. The voltage regulating system when

adjusted as described hereinafter to produce a perfectly regulated voltage at a value equal to the breakdown voltage of the control tube, is left that way. The operation of the device in service is dependent upon the amount of unbalance in the bridge circuit and regulation is not involved.

A still further feature of the invention is the overflow type of solution concentrate formation and its supply to the cleaning solution such that a mixing occurs and the control is responsive to the mixture and not the concentrate solution supply.

Briefly, the system operates as follows: When the cleaning solution concentration becomes sufficiently weak, the current flow through same from one electrode to the other, both being exposed to the solution, causes the control system to operate. This is of cyclic character in that for each energization of the system a predetermined amount of solution concentrate is supplied to the cleaning solution.

If after such supply the concentration in the cleaning solution is sufficient, no further energization of the control is effected until the concentration again reaches the critical low limit incident to normal use of such cleaning solution.

If, however, after initial energization of the control and solution concentrate supply, the cleaning solution concentration be not sufficient, the system is reenergized, and automatically, for an additional supply of solution concentrate to the cleaning solution and this cycle is repeated as often as necessary to finally provide the cleaning solution with a desired maximum concentration after which no further concentrate supply is effected until by normal use of the cleaning solution the cleaning solution concentration is reduced to that low limit for which the control system is adjusted to provide replenishment of concentrate and to the desired amount and by repetitious or cyclic operation, if necessary, as described.

Other objects and features of the invention will be set forth more fully hereinafter.

The full nature of the invention will be understood from the accompanying drawing and the following description and claims:

In the drawing,

Fig. 1 is a diagrammatic view of the liquid, et cetera, portion of the system and the electrodes of the electrical control system.

Fig. 2 is a diagrammatic view of the electrical control system and associated part, including the electrodes and control valve exposed to the liquid

portion of the system and the solenoid valve controlling the concentrate supply.

Fig. 3 is a view similar to Fig. 2 and of a portion of the circuit shown therein and modified by the inclusion of a step-up transformer.

Having briefly described the basic operation of the system, reference will first be had to Fig. 1. Therein 10 indicates a container or vessel of the desired capacity and if desired, provided with hot and/or cold water supplies and a drain of controlled character. None of which is illustrated because obvious and conventional. This vessel contains the cleaning solution 11.

At a higher elevation is another container or vessel 12. A conduit 13 from the bottom 14 thereof leads to vessel 10 and discharges therein by gravity at 15 substantially opposite the electrode unit 16 having solution exposed electrodes 17 and 18 to which reference will be had later.

The numeral 19 indicates a pressure fresh water supply. Usually this is at city pressure of about 40 lbs. The numeral 20 indicates a metering valve in said line. The numeral 21 indicates an electrical operable valve structure which is normally constrained to closed position but which when electrically energized is held full open in opposition to its constraint for so long a period as energy is applied thereto. As previously stated, this is a predetermined interval in the control cycle.

The end 22 of said dual valve controlled fresh water supply line 19 terminates above the liquid level 23 in container 12. However, end 22 does not discharge directly into the container but into chamber 24 therein open at its upper end 25 and terminating above level 23.

The lower end 25a terminates above the bottom 14; hence, fresh water supplied to chamber 24 flows into the vessel 12 near the bottom and percolates upwardly through the powdered chemical material 26.

The vessel 12 contains another chamber 27, the upper end 28 of which determines the level 23. Conduit 13 communicates with the lower end of chamber 27 and is the sole communication with vessel 12. There may be applied to end 28 suitable guards, screens et cetera, to prevent overflow of powdered chemical to chamber 27.

When valve 21 is opened, a regulated continuous supply of fresh water enters chamber 24 and in passing upwardly through chemical 26 becomes saturated therewith. The saturated or nearly saturated solution (solution concentrate) thus continuously overflows, by fresh water displacement, into chamber 27 from which it flows by gravity to vessel 10.

This constitutes the liquid portion of the system. As stated such overflow supply is repeated as often as necessary or required. Note that the concentrate enters vessel 10 opposite terminals or electrodes 17—18 and hence, concentrate dispersion in the cleaning solution unit occurs before the electrical system is responsive to concentrate addition.

Reference will now be had to Fig. 2, wherein the preferred embodiment of the electrical portion of the system is illustrated diagrammatically.

Before proceeding to a detail description of the control system, proper, it is to be observed that there is provided a motor 30 which through a reduction drive slowly rotates shaft 31 on which is mounted two cams 32 and 33. Cam 33 is associated with a switch 34—35 controlling current supply to the electrically operable valve 21. When the motor stops rotating, the cam 33 is positioned

as illustrated and switch 34—35 is open and the valve is not energized. This may be a solenoid valve and is preferably connected directly across the supply mains so that it does not affect the constants of control circuit. The high point 32a of the cam 33 moves open circuit constrained switch member 34 to contact member 35 and as long as the high point is effective, the valve is energized and hence, open to supply fresh water as previously described.

The other cam 32 has a relieved portion 32a. When the motor is first energized, as hereinafter described, the cam 32 moves the relieved portion from adjacent the motor circuit maintaining switch and the cam then closes that switch to maintain motor operation until the motor circuit maintaining switch again registers with relieved portion 32a of cam 32. The motor circuit is then broken. The timing is such that the valve is deenergized at this time. The interval of open valve operation is determined by the arcuate length of portion 32a and the rate of rotation of shaft 31. This is about one revolution per minute. The concentrate solution supply, as illustrated by portion 33a, is about thirty seconds. It may be greater or less as determined by the length of said cam portion 33a. A satisfactory motor is a synchronous motor operating at about 3600 R. P. M. and the reduction gear ratio is about 3600:1 relative to the cam shaft 31.

In Fig. 2 the numeral 40 indicates one supply main and 41 another of a 110-volt conventional alternating current source. A transformer primary 42 is directly connected thereto at 44 and 43, respectively. This is the source of power for the control. Line 45 from junction 43 connects to one terminal of a green signal 47, one terminal of a red signal 48, one terminal of the motor 30 and one terminal of the electrically operable valve 21.

Line 46 from junction 44 connects to junction 50 from which extends line 49 to valve switch member 34. Valve switch member 35 is connected by line 51 to the other terminal of the electrically operable valve 21. A line 52 from junction 50 connects to switch member 53 normally constrained to contact with switch member 54 so long as switch member 53 has its cam actuable portion seated in relieved portion 32a of cam 32.

Switch member 54 is connected by line 55 to contact 56 of a relay or solenoid operable switch. The other contact 57 thereof herein normally contacts contact 56 and connects by line 58 to the other terminal of the green light. Hence, when the motor is not energized and the relay or solenoid 59 controlling said switch is not energized, the green signal light is energized.

Another switch normally in open circuit relation includes contacts 60 and 61. It is closed when the solenoid or relay 59 is energized. Contact 61 is connected by line 62 to line 63 connecting to the other terminals of the red signal light 48 and the motor 30. Hence, the motor and red signal light are in multiple.

Contact 60 of the second relay switch connects by line 64 to junction 50. When the relay 59 is energized the green signal light is deenergized because switch 56—57 is open, and the motor and red signal light are energized because switch 60—61 is closed, this circuit being junction 44, line 46, junction 50, line 64, switch 60—61, line 62, the line 63, the red light and motor, line 45 and junction 43.

Upon relay energization, therefore, motor 30 rotates cam 32 and 33 counterclockwise to open

valve 21 and open the green light circuit at 53—54 as well as close the red signal circuit. Slight motor rotation simultaneously closes switch 53—55 which by line 66 leads to junction 67 of lines 62 and 63. This is the motor maintaining circuit and is as follows:

Junction 50, line 52, switch 53—55, line 66, junction 67, line 63, red light and motor and line 45 to junction 43. So long as the cam contacting portion of switch 53 rides the cam 32 and does not seat in the notch 32a, the motor and red light will be energized and the motor will rotate cam 32 until notch 32a again registers with switch member 53 whereupon the motor maintaining circuit will be opened.

At this point attention is called to another normally closed switch 68—69, contact 68 being connected to line 70 and contact 69 being connected to line 71. When switch 53 is associated with notch 32a of cam 32 switch 54—53 (green light circuit) is closed as well as switch 68—69. When switch member 53 does not register with notch 32a, switches 53—54 and 68—69 are open and switch 53—55 is closed. Hence, when the motor maintaining circuit is closed the circuit through lines 70 and 71 is open at the switch 68—69. Herein members 53 and 69 are electrically insulated from each other but mechanically connected for simultaneous movement.

Reference will now be had to the central and lower portions of Fig. 2. In the lower right portion is illustrated a Wheatstone bridge having two fixed legs 72 and 73. The line 71 connects to the junction of these two legs.

A secondary 74 of the transformer is connected by lines 77 and 78 to the other ends 75 and 76 of the legs 73 and 72, respectively. A third leg 79, has an adjustment 80 and is connected by line 81 to the starting anode of tube 82. Line 83 at one end connects to said line 81 at the adjustment 80 and at the opposite end to terminal 17 of the plug 16 before mentioned. The other terminal 18 is connected by line 84 to junction 75 of the bridge. Hence, the lines 83—84 and terminals 17—18 and the cleaning solution between said terminals constitutes the other or fourth leg of the bridge.

Tube 82 has the anode 85 and cathode 86. This tube is normally cold and when energized or ionization occurs therein, current flows to the relay 59 because line 87 therefrom through resistance 88 is connected to the anode 85. Line 89 is connected to the cathode 86 at one end and tap 90 on secondary 91 of the transformer. Line 92 is connected to tap 93 on said secondary as well as the other terminal of relay 59. Hence, when the tube is conditioned, the relay is energized which as before stated initially closes the motor pick-up circuit or starting circuit. A condenser 94 may bridge the relay as shown being connected across lines 87 and 92.

The secondary 90 of the transformer has end tap 95, opposite end tap 96 and another intermediate tap 97. A resistance 98 bridges taps 96—97 and a manually adjustable contact 99 determines the adjustment at said resistance. Contact 99 connects by line 100 to a voltage regulator tube 101. Tap 95 is connected to a resistance 102 and by line 103 to the other terminal of tube 101.

A line 104 connects one end of resistance 105 to line 103 at tube 101. The other end of said resistance is connected at 106 to line 89 before mentioned. A manually adjustable contact 107 is associated with resistance 105 and connected to

line 70 before mentioned, including cam operable switch member 68. A resistance 108 is connected at 109 to line 71 and at 110 to line 89.

The foregoing constitutes the several circuit elements and connections.

The voltage applied to the control element of the tube 82 is maintained at the required value by means of an adjustable voltage taken from a regulated source of voltage and applied to the controlling element of the tube in series with the unbalance voltage of the bridge circuit.

In a voltage regulating system, proper, or normal regulation is accomplished when the output voltage is constant regardless of whether the input voltage rises above or drops below normal input voltage. Over-regulation occurs when the output voltage decreases as the result of an increase in the input voltage or vice-versa. Under-regulation occurs when the output voltage increases as the result of an increase in the input voltage or vice versa, that is, under-regulation does not completely eliminate the normal change in the output of the regulating device while over-regulation more than compensates for such a change.

In the present device, two voltages are added—(1) a regulated voltage which is obtained from the voltage divider (resistance 105) between points 106 and 107, and (2) an unregulated voltage which is the unbalanced voltage taken from the bridge circuit between the junction of resistances 72 and 73 and the junction of lines 81 and 83. In order that the sum of these two voltages shall be constant with either a rising or a dropping supply voltage, it is necessary that the regulated portion of the voltage be properly adjusted to compensate for the change occurring in the unregulated portion of the voltage. This can be accomplished in two ways: (1) if the polarity of the two voltages is such that the unregulated voltage adds to the regulated voltage, the regulating system must be so adjusted (by means of the variable resistance 98) that the regulated voltage is over-regulated, that is so that the regulated voltage drops slightly when the supply voltage rises and vice-versa; (2) if the polarity of the two voltages is such that the unregulated voltage opposes (or subtracts from) the regulated voltage the regulating system must be so adjusted that the regulated voltage is under-regulated.

If it is considered that the algebraic sum of the two voltages mentioned above is the output of a regulating device, both of the conditions mentioned above produce perfect regulation, that is both produce a total output voltage which is independent of the line voltage.

It might be well to keep in mind that the term "voltage" is not an exact term, as there are several kinds of voltage: namely, effective voltage, average voltage, peak voltage, et cetera. The voltage with which the present invention is concerned is that which causes the tube to ionize and this is practically the peak value of the voltage. It is this fact which makes possible the use of so simple a form of voltage control device as this method of voltage control produces a badly distorted wave form.

The control of the solution within the required range is accomplished by electrically operating a solenoid 21 controlling a supply of concentrated solution. The valve and certain indicating lights 47 and 48 are operated from contacts controlled by motor-driven cams 32 and 33 operating in conjunction with the contacts of relay 59 con-

nected into the anode circuit of the controlling tube 82. The circuit is so devised and the cams so constructed as to provide a three-step process consisting of a test period, a replenishing period, and a mixing period, the replenishing and mixing periods occurring only when the results of the test indicate a deficiency in the concentration of the solution in vessel 10. The test period may be of long or short duration. It will be long if concentration reduction is slight. It will be short if such reduction is rapid. It may be infinitesimal if after one cycle, the cleaning solution is still too low in concentration.

The control voltage is supplied to the tube 82 through contacts 68—69 in the cam controlled circuit, including lines 70—71, which operating in conjunction with a grounding resistor 108 permits extinguishing the tube 82 as soon as the cam 32 has moved far enough to cause the motor driving the cam to be "locked in" through contacts 53—55 operated by the cam. This type of operation results in the control being dependent only upon the breakdown or ionization point of the tube 82 (which is stable for a cold tube) and is independent of the extinguishing or deionization point of that tube (which is unstable). It also eliminates error due to shifting of the breakdown point of the tube 82 by virtue of heating occurring within the tube 82 when the tube is passing current; as the period of operation of the tube 82 is but a few seconds long, therefore, the tube remains cold. This arrangement also has the advantage of appreciably increasing the life of the tube 82.

The circuit operating the lights is so arranged that the only time the green light can be on and the red light off is when the cam is in the "normal" position and the main control relay 59 is not energized. This combination occurs only when the control circuit is in the "test" condition and the resistance offered by the electrodes 17—18 and associated solution is of such value as to indicate a satisfactory concentration in the solution in vessel 11.

The electrolytic condenser 94 of rather high capacity (10 mf. to 100 mf., depending upon the constants of the relay) and the relay 59 is a D. C. relay operating on A. C. and it prevents relay chatter, thereby eliminating noise and it provides a time delay of a fraction of a second so that if the ionization tube flashes or has a tendency to flash, the control circuit is not operated unless and until the concentration condition positively requires operation that causes the tube to ionize and remain ionized for a sufficient interval to insure setting up the control for motor and valve operation, et cetera.

It has been established that when the line voltage varies from a normal voltage of 115 volts by as much as 10 volts, either above or below normal, the voltage applied to the control element of the tube does not vary more than a few hundredths of a volt. The tube 82 illustrated can be of RCA-OA4-G type. Tube 101 can be of VR-105-30 type or VR-150-30 type. The first mentioned tube in each instance is preferred in the specific circuit diagram illustrated.

The line 41 may include points 120 which is a jumper connection in the base of the regulator tube 101. Removal of tube 101 thus opens the primary circuits and prevents the application of excessive voltages to the secondary circuits. This is a protective factor.

Whenever desired, a small step-up transformer A may be inserted in the output of the bridge

circuit. This is merely a means of increasing the overall sensitivity and does not affect the basic operation. This is illustrated in Fig. 3.

Various modifications of the regulated voltage system may be utilized, if desired. However, that herein illustrated to date has furnished the best results; hence, same is illustrated by way of example.

By the aforesaid percolation-overflow type of flow with fresh water supply control, valve life is substantially indefinite despite the fact the concentrate may be highly caustic.

While the invention has been illustrated and described in great detail in the drawing and foregoing description, the same is to be considered as illustrative and not restrictive in character.

The several modifications described herein as well as others which will readily suggest themselves to persons skilled in this art, all are considered to be within the broad scope of the invention, reference being had to the appended claims.

The invention claimed is:

1. In a concentration control system comprising a solution container, a pair of electrodes exposed to the solution therein, the latter with the electrodes comprising part of a control circuit, and a second container including a concentrated make-up solution, the combination of a liquid supply to the second container and discharging thereto near the bottom thereof, an overflow discharge from the second container to the first container, said second container between the bottom discharge thereto and overflow discharge therefrom containing soluble chemical for concentrated solution formation, electrically actuated valve means for controlling the liquid supply from the second container to the first container, the liquid supplied to the second container percolating upwardly through the chemical, and a control circuit for electrically actuating said valve means, said circuit including the aforesaid electrodes and being so arranged as to respond to the first mentioned container solution concentration falling below a predetermined minimum value to begin cycles of valve operation comprising the opening, holding open for a predetermined interval of time and closing of the valve means, the cycles of valve operation continuing until the concentration in said first mentioned container exceeds the predetermined minimum value.

2. A system as defined by claim 1 wherein a pick-up circuit is included in the control circuit and is actuated by electric energy across the electrodes, same being directly responsive to electrode exposed solution concentration, a predetermined minimum solution concentration to which the electrodes are exposed actuating the pick-up circuit, a power circuit for the valve means, and a maintaining circuit responsive to pick-up circuit control and having a predetermined maintaining interval for maintaining the valve means power circuit for the maintaining interval, the valve means power circuit being responsive to both pick-up and maintaining circuits for initial closing and subsequent maintaining of said valve means power circuit.

3. A system as defined by claim 1 wherein a pick-up circuit is included in the control circuit and is actuated by electric energy across the electrodes, same being directly responsive to electrode exposed solution concentration, a predetermined minimum solution concentration to which the electrodes are exposed actuating the pick-up circuit, a power circuit for the valve means, and a

maintaining circuit responsive to pick-up circuit control and having a predetermined maintaining interval for maintaining the valve means power circuit for the maintaining interval, the valve means power circuit being responsive to both pick-up and maintaining circuits for initial closing and subsequent maintaining of said valve means power circuit, and having a predetermined period of operation less than the maintaining circuit period, the difference between periods constituting a dispersing period for concentration discharge dispersion in the container.

4. In a concentration control system comprising a solution container, a pair of electrodes exposed to the solution therein, the latter with electrodes constituting part of a control circuit, a second container including a concentrated make-up solution and arranged for discharge to the first mentioned container, and electrically operable valve means controlling the discharge of concentrate solution to the first mentioned container, the combination of a pick-up circuit in the control circuit, actuated by electric energy across the electrodes, the pick-up circuit being directly responsive to and actuated by a minimum value of electrode exposed solution concentration, a power circuit for the valve means, and a maintaining circuit responsive to pick-up circuit control and having a predetermined maintaining interval for maintaining the valve means power circuit for the maintaining interval, the valve means power circuit being responsive to both pick-up and maintaining circuits for initial closing and subsequent maintaining of said valve means power circuit closed when the solution concentration in said first mentioned container falls below the predetermined value to effect cycles of operation of the valve means which comprises opening, holding open for a predetermined interval of time and closing said valve means, the cycles of operation continuing until the concentration in said first mentioned container exceeds the predetermined minimum value.

5. A concentration control system as defined by claim 4 wherein the power circuit has a predetermined period of operation less than the maintaining circuit period, the difference between periods constituting a dispersing period for the make-up supply to the container to disperse therein.

6. A system as defined by claim 1 wherein a pick-up circuit is included in the control circuit and is actuated by electric energy across the electrodes, same being directly responsive to electrode exposed solution concentration, a predetermined minimum solution concentration to which the electrodes are exposed actuating the pick-up circuit, a power circuit for the valve means, and a maintaining circuit responsive to pick-up circuit control and having a predetermined maintaining interval for maintaining the valve means power circuit for the maintaining interval, the valve means power circuit being responsive to both pick-up and maintaining circuits for initial closing

and subsequent maintaining of said valve means power circuit, and having a predetermined period of operation less than the maintaining circuit period, the difference between periods constituting a dispersing period, the control circuit including signal means for selectively indicating sufficient and insufficient concentrations in said first container.

7. A concentration control system as defined by claim 4 wherein the power circuit has a predetermined period of operation less than the maintaining circuit period, the difference between periods constituting a dispersing period, the control circuit including signal means for selectively indicating sufficient and insufficient concentrations in said first container.

8. In a concentration control system, the combination of a Wheatstone bridge arrangement, one leg of which includes a pair of electrodes exposed to a solution, variation in the concentration thereof varying current flow through the electrode leg, a control tube connected to said bridge arrangement and responsive to electrode leg current variation, a concentrate liquid supply, a valve controlling such liquid supply to the solution, means controlling said valve, and electrically operable means responsive to tube operation for predetermined operation of the valve controlling means, the tube being of ionizable character, the electrically operable means including a pick-up circuit receiving electrical energy from said tube, and a maintaining circuit for supplying electrical energy to the electrically operable means, the pick-up circuit being responsive to tube operation for closing the maintaining circuit, the latter having a predetermined interval of operation, the control tube being ionizable when the solution concentration drops to a predetermined minimum, the valve holding open for the predetermined interval, the cycle of valve opening and closing continuing until the solution concentration exceeds the predetermined minimum value.

9. A system as defined by claim 8 wherein said circuits are arranged to discontinue tube operation by automatically opening the pick-up circuit after the maintaining circuit has been established, the latter having a predetermined maintaining interval for energizing the electrically operable means for a predetermined interval only.

10. A system as defined by claim 8 wherein said circuits are arranged to discontinue tube operation by automatically opening the pick-up circuit after the maintaining circuit has been established, the latter having a predetermined maintaining interval for energizing the electrically operable means for a predetermined interval only, and means automatically operable at the end of the maintaining interval for not only opening the maintaining circuit but simultaneously reconditioning the pick-up circuit for tube operation and control.

SIDNEY G. NOBLE.
WILLIAM L. WOLGEMUTH.