

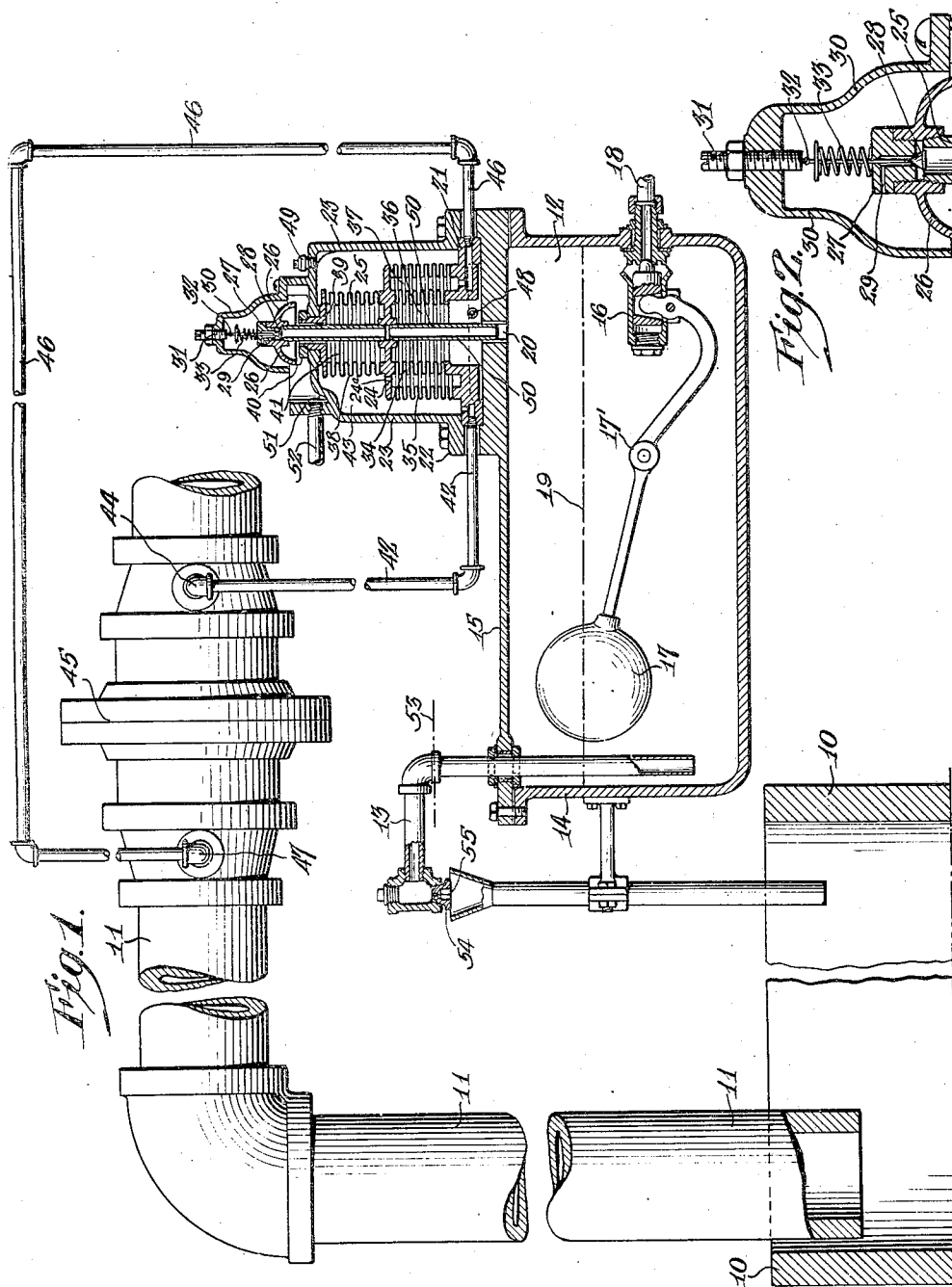
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APPARATUS FOR CONTROLLING RATE OF FLOW OF A LIQUID

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APPARATUS FOR CONTROLLING RATE OF FLOW OF A LIQUID

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My invention relates to improvements in method and apparatus for controlling the rate of flow of a liquid.

In accordance with my invention, the rate of flow of a liquid is controlled by varying fluid-pressure on a free surface of the liquid, such fluid-pressure being varied in accordance with variation in a condition such, for example, as the rate of flow of a fluid.

Further in accordance with my invention, improved apparatus of the character referred to is provided which is simple, reliable in operation, and which is adaptable to handle chemical solutions such as sulphuric acid without deterioration of parts or impairment of operation of the apparatus after long and continuous service.

My invention resides in the method and features of structure and combination of the character hereinafter described and claimed.

For the purpose of illustrating the invention, one embodiment thereof is shown in the drawing, in which

Figure 1 is a fragmentary view of apparatus employing the present improved method of control and embodying the present structural improvements, one of the units making up the apparatus being shown in section; and

Fig. 2 is an enlarged fragmentary view taken from Fig. 1.

The illustrated embodiment of the invention is useful where it is desired to supply chemical, such as sulphuric acid, to a mixing tank 10 supplied with raw feed water for a boiler by way of pipe line 11, the sulphuric acid being first supplied to the tank or container 12 and discharged therefrom by way of outlet connection 13 at a rate corresponding to the rate of flow of the liquid or raw feed water through line 11. The arrangement is such that increase in the rate of flow of raw feed water will be accompanied by a corresponding increase in the rate of discharge of the sulphuric acid solution from outlet connection 13 into tank 10, while decrease in the rate of flow of feed water will be accompanied by a corresponding decrease in the rate of discharge of the solution from connection 13. The improved apparatus pro-

vides, therefore, that regardless of occurring variation in the rate of supply of the raw feed water, there will always be addition of the proper amount of sulphuric acid solution to insure a safe and proper relation between the sodium sulphate and sodium carbonate contents of the feed water supplied to the boiler from tank 10. The control apparatus, designated generally by reference numeral 14, includes the container 12 provided with the closure or cover plate 15 and suitable valve mechanism 16 controlled by float 17 in such wise that sulphuric acid solution is admitted to the container by way of the supply or inlet connection 18 when the liquid in the container drops below the level 19 upon discharge of the solution from the tank by way of connection 13. In other words, the valve mechanism 16 and associated float 17 operate to maintain the liquid contents of container 12 substantially at the level 19. An adjustable joint 17' of any suitable construction provides for angular adjustment of the float arm if desired to place level 19 higher or lower, as the case might be.

The cover plate is provided with the opening 20 over which is disposed the base plate 21 clamped in the position shown between the cover plate and the outwardly extending flange 22 of the housing or casing 23. The floating plate or disc 24 is disposed as shown and carries the vent tube 25 communicating with the interior of container 12 and carrying at its upper end the deflector 26 into which is screwed plug 27 providing a seat for the vent valve 28 and having the vent or outlet opening 29. The bonnet or cap 30 is secured as shown to housing 23 and carries the adjustable screw 31 arranged to engage the end of the valve stem 32 in such wise that upon upward movement of plate 24 the valve seat is moved away from valve 28, the compression spring 33 operating at all times to urge valve 28 upwardly with respect to the valve seat and into seating relation therewith.

Downward movement of plate 24 is accompanied by similar movement of valve seat 27 downwardly with respect to valve 28 to de-

crease the effective vent opening, while upward movement of plate 24 has the opposite effect and causes increase of the effective vent opening.

5 The bellows 34 and 35 are disposed between base 21 and plate 24 and one within the other, as shown, and are secured to the base and plate to provide chambers 36 and 37.

10 The bellows 38 is disposed about vent tube 25 between plate 24 and the top of housing 23. One end of bellows 38 is secured to plate 24, the other end being secured to the end piece 39 extending through the top of housing 23 and receiving the nut 40 which operates to clamp the end piece securely to the housing.

15 The vent tube 25 passes loosely through end piece 39 to permit free upward and downward movement of the tube with plate 24 and to permit free fluid-flow between the atmosphere exterior of the apparatus and chamber 41.

20 The chamber 41, interior of bellows 38, is therefore always under atmospheric pressure, the loose fit between vent tube 25 and end piece 39 providing against any retarding or dash-pot action of bellows 38 to interfere with upward and downward movement of plate 24 under the influence of forces herein-
30 after referred to. The connection 42 provides communication between chamber 43 and supply line 11 at the point 44 on the up-stream side of a suitable orifice plate 45. The connection 46 provides communication between
35 chamber 37 and supply line 11 at the point 47 on the down-stream side of orifice plate 45.

40 An air pressure supply connection 48 extends between cover plate 15 and housing flange 22 in the same manner as connections 42 and 46, but unlike those connections extends entirely through 21 to supply air or other gas under pressure to chamber 36 and by way of opening 20 to the interior of container 12. The air flow is reduced to a suitable value below the capacity of the escape
45 valve 28 by an orifice plate in the supply connection 48, or the connection itself may be of small diameter. As hereinafter explained, the release of air from chamber 36 is controlled by valve 28 to maintain a pressure which balances the differential pressure on plate 24, which in practice, never exceeds the pressure effecting flow of the acid solution to container 12 through connection 18.
55 After balance is effected, air is released by valve 28 at the same rate that it is supplied, which maintains the balance between the air pressure and the existing differential pressure.

60 Housing 23 may be provided with a vent plug 49 which is removed during installation of the apparatus to permit complete displacement of any entrained air in chamber 43 by the liquid which will flow into this
65 chamber by way of connection 42, after

which plug 49 is replaced. The pressure on the upper surface of that portion of plate 24 extending outwardly beyond bellows 38 will, therefore, be substantially the same as the pressure at point 44 in line 11, and will follow closely any variation in the pressure at point 44. 70

For the purpose of permitting complete displacement of any entrained air in chamber 37 by the liquid which will flow into this chamber by way of connection 46, a small vent opening 24a may be made in plate 24 to permit flow of such entrained air from chamber 37 into chamber 43 and thence to atmosphere by way of the opening for plug 49. The pressure on the under surface of plate 24 between bellows 34 and 35 will, therefore, be substantially the same as the pressure at point 47 in line 11, and will follow closely any variation in the pressure at point 47. The vent opening in plate 24 is made just large enough for the purpose explained, and does not permit any appreciable liquid-flow between chambers 37 and 43 such as might otherwise prevent proper movement of plate 24 responsive to variations in pressure conditions in these chambers. 85

A tube 50 is threaded at its upper end into plate 24 and arranged as shown in alignment with vent tube 25, the diameter of the tube being appreciably less than that of opening 20 to permit free fluid flow between chamber 36 and container 12. 95

The operation of the improved apparatus is as follows. The floating plate 24 is acted upon by a downwardly directed force on its upper face equal to the area of that portion of the plate extending outwardly beyond bellows 38 multiplied by the liquid pressure at point 44 in line 11. This plate is also acted upon by an upwardly directed force equal to the area of that portion of the plate intermediate bellows 34 and 35 multiplied by the liquid pressure at point 47 in line 11. This plate is also acted upon by an upwardly directed force equal substantially to the area of the plate between tube 50 and bellows 34 multiplied by the air pressure in chamber 36 and container 12. As is well known, the difference between pressure conditions at points 44 and 47 in supply line 11 is a measure of the rate of liquid flow in the line. From the foregoing it will be seen that the floating plate 24 is responsive to the joint influence of fluid-pressure conditions in container 12 and the condition of the rate of liquid-flow in line 11. 100 105 110 115 120

For any given rate of liquid-flow in line 11, within the operating range, there will obviously be a force acting downwardly on plate 24 due to the pressure in chamber 43 and a force acting upwardly on the plate due to the pressure in chamber 37, the downwardly directed force being greater than the 125 130

upwardly directed force, in amount corresponding to the rate of liquid-flow in line 11. This difference is balanced by the upwardly directed force on plate 24 due to the air pressure in chamber 36. The air pressure acting on the free surface of the sulphuric acid solution in container 12 operates at the same time to force the solution from the container at the proper rate by way of outlet connection 13. Upon increase in the rate of flow of the raw feed water in supply line 11, the pressure in chamber 43 will increase correspondingly over the pressure in chamber 37, and the floating plate 24 forced downwardly to effect closing operation of the valve means 27—28, whereupon the air pressure in container 12 and chamber 36 is permitted to build up until the upwardly directed force on plate 24 due to the pressure in chamber 36 is increased sufficiently to balance the increased difference between the forces due to the pressures in chambers 43 and 37, at which time the valve means 27—28 reopens to permit escape of air as fast as supplied to maintain the higher air pressure. The air pressure in container 12 therefore increases by such amount as to provide for discharge of the solution by way of outlet connection 13 at a correspondingly greater rate to supply the greater amount of raw feed water now being discharged into mixing tank 10 with a correspondingly greater amount of sulphuric acid solution.

Upon decrease in the rate of flow of raw feed water in supply line 11, the action is just the opposite, that is, the difference between the respective pressures in chambers 43 and 37 will decrease to cause unbalancing of the forces acting on plate 24 and corresponding upward movement of the same to effect opening operation of the valve means 27—28 whereby the air pressure in chamber 36 and container 12 is permitted to drop until the forces acting on plate 24 are again balanced, at which time the valve means 27—28 in a new position permits escape of air as fast as supplied to hold the air pressure on the free surface of the solution in container 12 at a lower value. Accordingly, the solution is forced from container 12 at a lower rate corresponding to the lower rate at which the raw feed water is being discharged into tank 10 from supply line 11.

The action, therefore, is such that increase in the rate of discharge of the raw feed water into mixing tank 10 is accompanied by a corresponding increase in the rate of discharge from outlet connection 13 of the sulphuric acid solution into tank 10, while decrease in the rate of discharge of the raw feed water into tank 10 is accompanied by a corresponding decrease in the rate of discharge of the sulphuric acid solution into the tank, the proportion being maintained substantially constant such that the proper relation between

the sodium sulphate and sodium carbonate contents is maintained. In other words, in the disclosed embodiment of the invention, the control apparatus proportions the flow of chemical to the flow of raw feed water by maintaining a liquid pressure on orifice 55 which is proportional at all times to the differential pressure on orifice 45 in the feed water line.

Where the apparatus is to handle chemicals such as sulphuric acid solution, the tank and associated connections will be lined with suitable material known to be resistive to the action of acid. The valve mechanism 16 will, in such case, also be made of suitable acid-resisting material. By making the air supply connection 48 at the point shown, that is, above cover plate 15 and at a point within chamber 37, there will always be an air pocket in bellows 34 and there will be constant flow of air from chamber 36 into container 12 by way of opening 20. Acid fumes are therefore prevented from entering chamber 36 by way of opening 20. The bellows 34 may therefore be made of copper or other suitable material, and need not, necessarily, be made of acid-resistive material.

If, for any reason, the valve mechanism 16 should fail to shut off the supply of acid solution from supply connection 18 at conditions whereat there is no flow of raw feed water in line 11, container 12 will fill up with the solution and the same forced upwardly through tubes 50 and 25 and out through vent opening 29 from which the escaping solution will drop down upon deflector 26 and into the basin 51 from which it will flow by way of a suitable connection 52 to a selected point where the discharge of the solution from this connection will be observed. The connection 52, therefore, provides indication of the condition of flooding of the control apparatus due to possible failure of valve mechanism 16 to operate properly. This, of course, is merely a safety measure. Should the apparatus be flooded for the reason explained, the acid solution escaping by way of vent opening 29 is prevented by deflector 26 from passing downwardly along vent tube 25 and collecting in chamber 41. Further, if the apparatus should be flooded, the acid will be prevented from rising into chamber 36 by reason of the air pocket therein.

In installing the apparatus, the supply of liquid to line 11 is shut off, at which time the pressure in chambers 43 and 37 will be equal. The screw 31 is then adjusted to position vent valve 28 such that the air pressure in chamber 36 and container 12 is just sufficient to force the solution in the container upwardly in outlet connection 13 to about the level indicated by the dash line 53. It will, therefore, be seen that immediately upon occurrence of any flow in supply line 11, the apparatus will be immediately responsive and the chemical

solution discharged from connection 13 at the proper rate under the influence of the increased air pressure condition on the free surface of the solution in container 12.

5 The apparatus may be calibrated by selecting the plug 54 with an orifice 55 of such size as to provide for discharge of the chemical at the proper rate for the known concentration thereof and for a given rate of discharge
10 of raw feed water into tank 10. For this purpose, a number of the plugs 54 may be provided, each having an orifice of different diameter than the other.

Variation in the proportion of chemical
15 supply to feed water supply may also be effected by increasing or decreasing the concentration of the chemical solution.

From the foregoing it will be seen that an improved method has been provided for controlling the flow of a liquid in accordance
20 with variation in a given condition, the method consisting in varying the fluid-pressure on a free surface of the liquid in accordance with variations in a condition. For example,
25 in the embodiment of the invention disclosed, the air pressure on the free surface of the chemical solution in container 12 is varied in accordance with variations in the condition of fluid-flow in supply line 11. It will be
30 appreciated, in this connection, that such condition need not necessarily be a condition of fluid-flow in a pipe line, but might be any variable condition in accordance with which it is desired to control the rate of flow of a
35 liquid, such, for example, as the rate of flow of the chemical solution through orifice 55. Further, it will be seen that air is supplied to the apparatus at a substantially constant rate,
40 and discharged at the same rate by way of vent valve 28, the vent valve being adjusted to vary the backpressure and, accordingly, the pressure on the free surface of the liquid
45 in container 12. The dimensions are such that when vent valve 28 is in its extreme open position, discharge of air from the apparatus at a rate greater than the rate of air supply to the apparatus by way of connection 48, is possible.

It will, further, be seen that improved apparatus of the character referred to has been
50 provided which is accurate and immediately responsive to variations in the rate of flow in feed water supply line 11, which has few parts with which the liquid in container 12
55 comes into contact, and which is dependable and will operate satisfactorily over a long period of continuous service and without the necessity of attention or adjustment.

While the present invention has been disclosed as embodied in a system or apparatus
60 more particularly adapted to provide for supply of a chemical solution proportional to the supply of raw feed water for a boiler, it will be appreciated that the invention is
65 of much broader adaptation, and that the

same might be embodied in other systems where there is the same general requirement, that is, where the rate of flow of a liquid is to be controlled in accordance with variations
70 in a certain condition. It will be appreciated, further, that in the particular embodiment of the invention disclosed, various changes might be made such as in the size, shape and arrangement of the parts without departing from the spirit of the invention or
75 the scope of the claims.

The invention claimed is:

1. In apparatus of the character described, a closed container, means operable to provide for supply of liquid to said container and
80 maintenance of the liquid contents at substantially a predetermined level, a fluid-pressure supply connection communicating with said container, valve means operable to control fluid pressure conditions in said container, and means responsive to fluid-pressure
85 conditions in said container and operable in accordance with such conditions to control operating action of said valve means.

2. In apparatus of the character described, a closed container, means operable to provide for supply of liquid to said container and maintenance of the liquid contents at substantially a predetermined level, a fluid-pressure supply connection communicating with
90 said container, valve means operable to control fluid-pressure conditions in said container, and means responsive to fluid-pressure conditions in said container and operable upon increase in such conditions to effect opening operation of said valve means and
95 operable upon decrease in such conditions to effect closing operation of said valve means.

3. In apparatus of the character described, a closed container, valve means for controlling fluid-pressure conditions in said container, and means responsive to fluid-pressure
105 conditions to which said apparatus is subjected and operable in accordance with such conditions to control operating action of said valve means, said valve-actuating means including bellows disposed one within the other.

4. In apparatus of the character described, a closed container, valve means for controlling fluid-pressure conditions in said container, and means responsive to fluid-pressure
115 conditions to which said apparatus is subjected and operable in accordance with such conditions to control operating action of said valve means, said valve-actuating means including a plate, a vent tube carried by said plate and communicating with said container, bellows secured to said plate and communicating with said container, second bellows secured to said plate and disposed about said
120 first-named bellows in spaced relation with respect thereto, a casing enclosing said bellows and having an opening through which one end of said vent tube loosely passes, and third bellows disposed about said vent tube
125 130

and secured at its respective ends to said plate and said casing, said valve means carried by said end of said vent tube.

5. In apparatus of the character described, a liquid supply line, a closed container, means operable to provide for supply of liquid to said container and maintenance of the liquid contents at substantially a predetermined level, a fluid-pressure supply connection communicating with said container, valve means operable to control fluid-pressure conditions in said container, and means responsive to the joint influence of fluid-pressure conditions in said container and at different points in said line and operable in accordance therewith to control operating action of said valve means.

6. In apparatus of the character described, a liquid supply line, a closed container, means operable to provide for supply of liquid to said container and maintenance of the liquid contents at substantially a predetermined level, a fluid-pressure supply connection communicating with said container, valve means operable to provide a vent for said container, and means responsive to conditions of increased liquid-flow in said line and operable thereupon to effect closing operation of said valve means and responsive to conditions of decreased liquid-flow in said line and operable thereupon to effect opening operation of said valve means.

7. A system for adding a liquid reagent to liquid under treatment comprising a closed container for said reagent, an outlet therefrom for discharge into said liquid under treatment, means for continuously supplying air under pressure to said container to produce a pressure effecting discharge of said reagent, and means responsive to rate of flow of said liquid under treatment controlling release to the atmosphere of said air from said container at a rate to maintain a pressure therein of magnitude effecting flow of reagent proportional to flow of liquid under treatment.

8. A system for adding a liquid reagent to liquid under treatment comprising a closed container for said reagent, an outlet therefrom for discharge into said liquid under treatment, means for continuously supplying gas to said container to produce a pressure effecting discharge of said reagent, and means having expansible and contractable portions responsive to rate of flow of said liquid under treatment controlling release of said gas from said container at a rate to maintain a pressure therein of magnitude effecting flow of reagent proportional to flow of liquid under treatment.

9. A system for adding a liquid reagent to liquid under treatment comprising a closed container for said reagent, an outlet therefrom for discharge into said liquid under treatment, means for continuously supplying

gas to said container to produce a pressure effecting discharge of said reagent, and means comprising bellows structure in communication with said liquid under treatment responsive to rate of flow of said liquid under treatment controlling release of said gas from said container at a rate to maintain a pressure therein of magnitude effecting flow of reagent proportional to flow of liquid under treatment.

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