Oct. 16, 1934. S. D. CLITHERO ET AL 1,977,171

METHOD AND APPARATUS FOR PROPORTIONING LIQUIDS

Filed Sept. 6, 1932 2 Sheets-Sheet 1

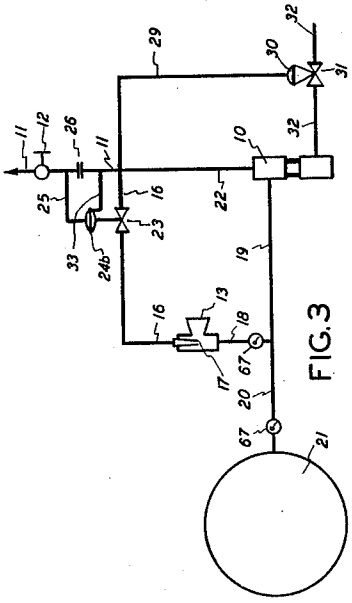


FIG. 3

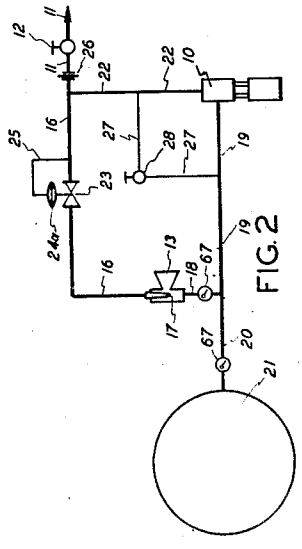


FIG. 2

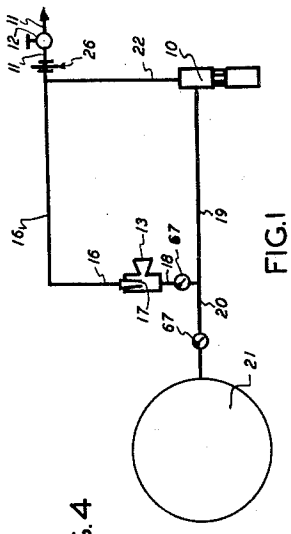


FIG. 1

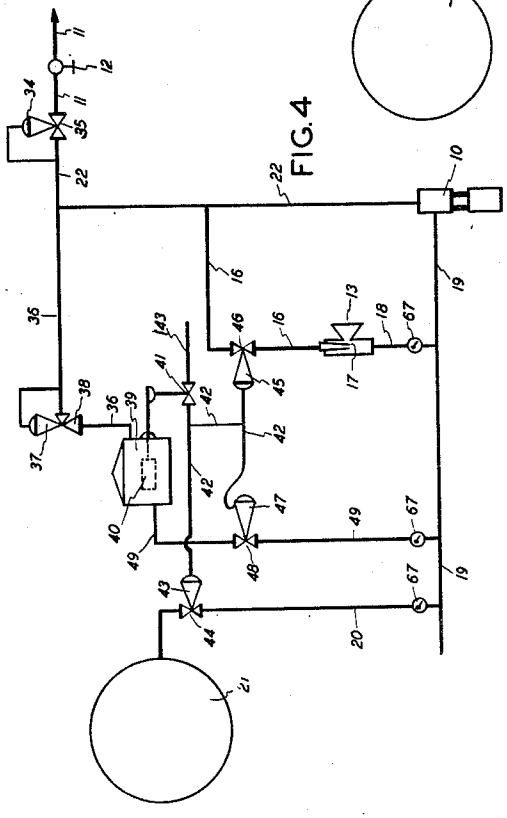


FIG. 4

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Filed Sept. 6, 1932 2 Sheets-Sheet 2

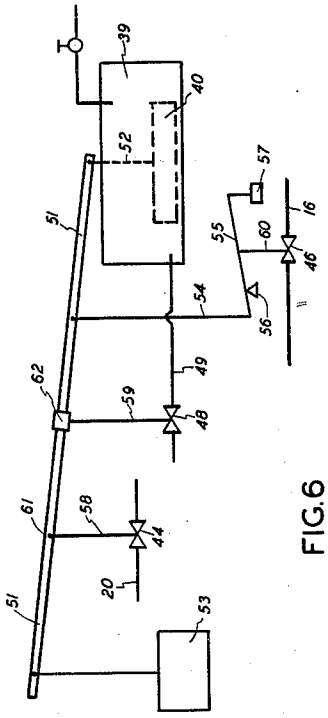


FIG.6

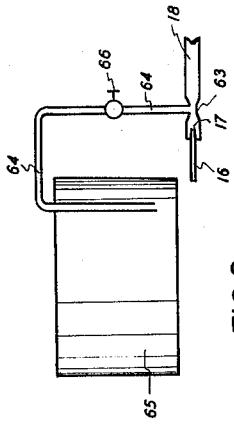


FIG.8

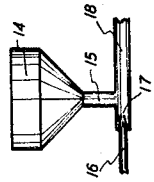


FIG.7

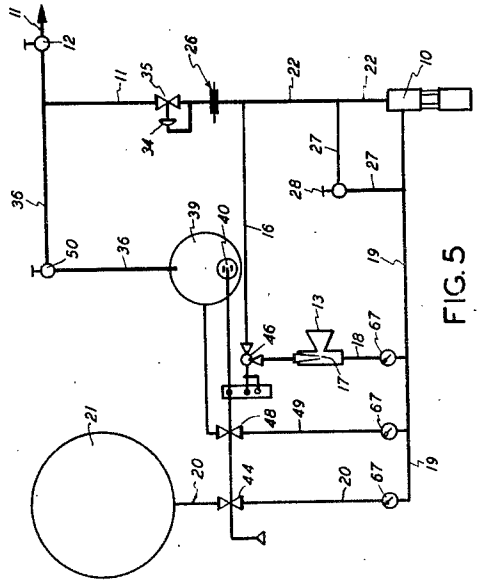


FIG.5

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METHOD AND APPARATUS FOR PROPORTIONING LIQUIDS

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Application September 6, 1932, Serial No. 631,840

9 Claims. (Cl. 137—165)

The object of our invention is to provide means and a method for mixing or combining two liquids at fixed ratios at variable rates and/or pressures of delivery to a point of consumption.

The method lends itself to varied uses, such as the blending of oils of different characteristics directly into packages, trucks, or tank cars, or the preparation of solutions and their dilution to constant strength, as in supplying foam solution to fire-fighting apparatus.

With reference to its application to the production of fire extinguishing foam, this system overcomes the disadvantages of certain inherent limitations in the operation of so-called "foam generators" or ejectors and enhances their value for use in combination with the more general type of "two solution storage" foam system to eliminate the need and expense of storing large quantities of deteriorating and corrosive solutions.

One inherent disadvantage of foam generators is that the maximum pressure at which solution may be discharged is limited to approximately forty per cent of the water pressure of the inlet end. In actual operations it is frequently necessary to operate at higher pressures than are available from generators.

A second disadvantage is that the entire maximum volume which the generator is designed to discharge must be used, throttling of the discharged volume being impossible except as the inlet volume may be reduced to a relatively fixed minimum at which the generators work efficiently.

A third disadvantage of the generators is that the range of practical operating pressure is from about 50 per cent to 125 per cent of their normal rating. Within these limits the present generators will combine proper amounts of powder and water to produce good fire extinguishing foam solutions.

The ordinary two-solution foam system comprises two storage tanks (one containing an acid solution, the other an alkali solution), twin pumps to discharge these solutions through twin pipelines to the point of consumption.

Considerable expense, deterioration, and corrosion is entailed during the storage of solutions and new developments have made it practical to store the dry chemicals used for making solutions in powdered form and dissolving them in water at the time of fire to produce the two solutions, thus eliminating the disadvantages of the two solution storage system. Generators are commonly used to dissolve these powdered chemicals but when discharging direct to the point of consumption, their scope is limited by the above mentioned disadvantages.

When generators discharge to a tank from which the two-solution system pumps take suction, an outside source of water pressure is required to operate the generators and the rates at which solutions are produced and consumed are not synchronized.

Experience has shown that the most efficient alkali solution commonly used in producing fire foam contains about 3 per cent by volume of bicarbonate of soda. Therefore, to be most efficient, generators must be designed to combine chemical and water in the right proportion to produce a solution of about this degree of saturation. In our device, to be hereinafter disclosed, an ejector may be designed to combine more than the usual proportion of soda to water, yet an alkali solution of satisfactory concentration is ultimately produced, since means are provided to dilute a concentrated solution back to any desired proportion of chemical and water.

Thus, the volume of liquid supplied to the inlet of a generator used in our system need be only a portion of the ultimate volume of desired solution, whereas the present generators will produce only slightly more finished solution than the volume of liquid introduced at the generator inlet. As an illustration, the generators commonly used combine about one pound of powdered chemical to one gallon of water, and produce slightly more than a gallon of foam solution. In our system it is possible to combine more than one pound of chemical per gallon of water, say three or four pounds per gallon, and this concentrated solution is diluted back to the degree of saturation that has proved most satisfactory.

In order to adequately supply the generator inlet in our system, the volume available need be only a portion of the ultimate volume of solution produced, whereas most generators as used at present require that their inlet be supplied with a volume nearly equal to that which will be ultimately produced.

In the attached drawings the invention is shown in five forms, each of which is susceptible to two modifications, according to whether it is desired to produce a solution of some predetermined concentration and then dilute it to a lower concentration, as in the preparation of standardized foam solutions, or to mix two existing liquids in predetermined proportions, as in the blending of oil.

Fig. 1 illustrates diagrammatically a very simple form of the invention, in which the mixture

is proportioned only so long as the outlet valve is fully opened;

Figs. 2 and 3 illustrate a somewhat more elaborate arrangement in which the outlet may be throttled without disturbing the proportioning of the liquids, uniform pump pressure being maintained on the pump discharge;

Figs. 4 and 5 illustrate modifications of the form shown in Fig. 3, in which a surge tank and automatic control valves are provided for completely preventing any variation in the quality of the blend delivered.

Fig. 6 illustrates an arrangement of float and valves which may advantageously be used in connection with the forms shown in Figs. 4 and 5;

Fig. 7 illustrates a device which may be used in all the forms, Figs. 1 to 5 inclusive, for so dissolving dry soluble powders as to yield a concentrated solution of constant strength, and

Fig. 8 illustrates an arrangement which may alternatively be used in all five forms of the invention in the blending of two liquids.

Referring to Fig. 1, 10 is a pump, 22 is a pump discharge pipe, 11 is a branch pipe conducting the blended liquid from pipe 22 to a point of use not shown, 16 is a branch pipe leading to the inlet of the dissolving device 13, and 12 is a valve controlling the outlet of blended liquid from the system. 26 is a fixed orifice in branch pipe 11 for maintaining sufficient pressure on branch pipe 16 to operate the dissolving device 13 at a normal rate.

13 is the powder dissolving device shown in fuller detail in Fig. 6 and consisting of a hopper 14 in which the powder is placed, a powder conducting pipe 15, an inlet pipe 16 for solvent fluid under pressure, this pipe terminating in a jet or nozzle 17 which acts as a flow-controlling orifice, this jet discharging into a pipe 18. This device, which is not of our invention, permits the powder to flow downwardly into the stream of liquid passing out of the jet 17 and solution takes place under a high degree of turbulence in the pipe 18. Within limits, ranging usually from 50 per cent to 125 per cent of its normal capacity rating, this device will draw into the stream leaving the jet 17 a quantity of powder closely proportionate to the quantity of fluid discharged by the jet, and within these limits will produce in the pipe 18 a solution of approximately constant strength. This strength may be predetermined by varying the areas of the jet 17 and the feed pipe 15, in view of the physical characteristics of the powder which is to be dissolved.

Referring again to Fig. 1, 19 is a pump suction pipe having a branch pipe 20 communicating with a tank 21 containing a supply of the liquid in which the powder is to be dissolved. The pump is provided with a discharge pipe 22 which branches to the outlet pipe 11 and to the pipe 16 which supplies fluid to the dissolving device.

This device functions in the following manner. The pump 10 being a direct displacement pump, operating at constant speed to deliver a constant volume when the valve 12 is open, a portion of the pump discharge is passed by orifice 26 through pipe 11 to the point of consumption. The remainder of the pump discharge passes through pipe 16 to the orifice jet 17 in dissolving device 13. In this device a quantity of powder proportionate to the flow through jet 17 is drawn into the system and passes through pipes 18 and 19 to the suction of pump 10. The discharge of the dissolving device 13 is thus concentrated by the addition of powder or other miscible substance with the normal solution or mixture delivered to it by the pump.

As the return to the pump is less in volume than the discharge, liquid will flow into the system through pipe 20 to make up the deficiency and to dilute the concentrated solution or mixture back to its original concentration.

This device is initially balanced by so proportioning orifices 17 and 26 that the quantity of powder necessary to maintain the solution delivered through orifice 11 at the desired strength will be drawn into the system, the pump discharge being constant and being sufficient in volume to feed both orifices at a desired rate.

This form of the device is of little practical utility because of its entire lack of flexibility. The outlet valve 12 cannot be closed to less than the full opening of orifice 26, as in so doing, the fixed relation between these two openings would be disturbed, an excessive amount of liquid would be returned to the dissolving device, drawing in an excessive amount of powder.

The description is introduced as being the simplest illustration of the principle embodied in all the forms shown, this being the circulation of a standardized solution or mixture through a pipe ring (the pipes 22, 16, 18, and 19) including a dissolving or injection means (13), a branch from this ring (pipe 11) withdrawing mixture for use, and another branch from the ring (pipe 20) serving to introduce make-up liquid.

Referring now to Fig. 2, the description of the parts and functions named in the above description of Fig. 1 need not be repeated, but additions to that system are made which enable the operator controlling the outlet (at valve 12) to shut off against the pump discharge and to resume full consumption without disturbing the proportioning of the elements of the mixture or shutting down the pump. As in the previous form, the output cannot be throttled without disturbing the proportioning.

In pipe 16 we place a valve 23 which is actuated by a diaphragm regulator 24 which, in turn, is actuated by fluid conducted by a small pipe 25 communicating with that portion of pipe 16 lying between the two valves 23 and 12. The diaphragm should be so connected to the valve 23 as to cause it to close completely in response to any material increase in pressure in pipe 16 and to open completely when the pressure again decreases; in other words, valve 23 should be a trip valve and not adapted to throttle the stream flowing through pipe 16.

Between the discharge pipe 22 and the suction pipe 19 we place a bypass pipe 27 provided with a weighted relief valve 28.

This arrangement of apparatus is first set in the following manner. Pump 10 is a constant delivery pump and the combined area of the orifices 17 and 26 is so adjusted as to pass the full discharge of the pump at some predetermined pressure which is materially higher than the back pressure on the outlet pipe 11, valves 12 and 23 being wide open. The relative areas of orifices 17 and 26 are further so adjusted that a predetermined proportion of the pump discharge will pass through each orifice.

For example, the pump delivery at constant speed may be, say, 200 gallons per minute, the combined area of the two orifices may be such that a pressure of 100# gauge will be maintained at this delivery rate, and the relative areas of the two orifices may be such that orifice 17 will pass

50 gallons per minute and orifice 26 will pass 150 gallons per minute.

The diaphragm regulator 24 is then adjusted so that it will trip and close valve 23 when the pressure increases slightly above normal, or, say, at 105 pound gauge, and relief valve 28 is so adjusted that it will open at a slightly higher pressure, as at 110 pounds.

This arrangement functions in the following manner, using the above assumed figures for illustration. Assuming a flow to be already established through the system, valves 12 and 23 being fully open, 150 gallons per minute of liquid is being discharged through pipe 11 to some point of use, the pump is lifting 200 gallons per minute of which 50 gallons per minute is being ejected through jet 17. This return flow through the dissolving device 13 draws in a predetermined proportion of soluble powder, producing a highly concentrated solution or, if there be an excess of the powder, a partial suspension, which returns to the pump suction through pipes 18 and 19.

The quantity so returned is, however, only slightly more than 50 gallons per minute. The difference between this quantity and the 200 gallons per minute discharged by the pump is therefore drawn from tank 21, which floats on the pump suction and supplies any deficiency.

On closing outlet valve 12 the entire pump discharge is forced against the single orifice 17 and the pressure in pipe 16 is sharply increased. The diaphragm 24 then closes valve 23, relief valve 28 opens and the entire pump discharge passes around to the suction end through bypass pipe 27.

Referring now to Fig. 3, the pump 10 is adapted to maintain constant pressure instead of constant volume, and to this end may be a centrifugal pump which will operate against a closed or throttled discharge, or may be a direct acting steam pump having a branch pipe 29 leading from the pump discharge pipe 22 to a diaphragm regulator 30 actuating a throttling valve 31 in the pipe 32 which supplies steam to the pump.

In this form of the invention valve 23 is a throttling instead of a trip valve and the diaphragm regulator 24 which actuates it is connected with the two sides of the orifice 26 by means of pipes 25 and 33, being thus responsive to difference in pressure between the two sides of the orifice.

Using the same figures as in the illustration of Fig. 2, we will assume that the delivery of orifices 17 and 26 is 50 gallons per minute and 150 gallons per minute respectively at 100 pound pressure on line 22 and valves 23 and 12 wide open. If now valve 12 be partially closed, reducing the flow through orifice 26, the pressure differential between the two sides of the orifice is reduced and regulator 24 acts on valve 23 to throttle the flow through pipe 16 and the stream passing through jet 17. The function of regulator 24 (and its operation of valve 23) is to maintain a fixed ratio of discharge through the two pipes 11 and 16. Its setting would be such that when the minimum allowable rate of flow to jet 17 is reached, the valve 23 closes completely, this increasing the pressure on line 29 and causing the pump to stop. Tank 21 supplies any difference between discharge through pipe 22 and circulation through pipes 16 and 18, as before. The increase in pressure on pipe 22 which would result from throttling valves 12 and 23 is cared for by the steam regulator 30—31 which causes the pump to slow down or to stop completely.

This form of the invention will supply mixtures of constant proportion at reduced rates but is less sensitive and less accurate than either the fourth or the fifth form about to be described.

Referring now to Fig. 4, the pump 10 is of the constant volume type, as in the form of Fig. 1. The discharge pipe 22 branches to outlet pipe 11 and this branch is provided with a back pressure regulator 34 actuating a valve 35 for maintaining a constant minimum pressure on pipe 22. Another branch pipe 36 provided with a similar regulator and valve 37 and 38 respectively leads into a surge tank 39. This regulator 37 is set slightly higher than regulator 34. The solution discharged into the surge tank is at all times of the predetermined finished blend.

The surge tank is provided with a float 40 operating a pilot valve 41 which controls a supply of air or other fluid under pressure entering a fluid pressure system 42—42 through a pipe 43 from any source not shown.

Variations of pressure in this pilot control system operate three regulators and valves, to-wit: a regulator 43 and valve 44 controlling pipe 20 which connects tank 21 with the pump suction 19; a regulator 45 and a valve 46 controlling circulation through pipe 16 and the dissolving device 13; a regulator 47 and valve 48 controlling a pipe 49 connecting surge tank 39 with pump suction pipe 19. All three of these valves should be arranged as trip valves, to positively and immediately open or close with changes in the pressure in system 42, and valve 48 should be arranged to open as valves 44 and 46 close, and vice versa.

In the arrangement of Fig. 4, partial closing of outlet valve 12 diverts a portion of the pump delivery into the surge tank, and the total delivery of the pump being constant and within a constant pressure range, the flow through the jet 17 is practically unchanged by any variations in the degree of opening of outlet valve 12.

When surge tank 39 fills to a predetermined level, float 40 actuates pilot valve 41, closing valves 44 and 46, and opening valve 48. This movement causes the pump to be supplied solely with blended liquid from the surge tank until the latter has been sufficiently reduced in level, when a reverse movement of the valves reestablishes circulation through dissolving device 13 and the supply of solvent liquid from tank 21. Sufficient lost motion should be provided in the linkage between float 40 and pilot valve 41 to prevent too rapid reversals of valves 44, 46, and 48.

In the form shown in Fig. 5 the pump 10 is of the constant volume type, an orifice 26 is placed in the outlet pipe 11 which is also provided with a back pressure regulator and valve 34 and 35 to maintain a constant pressure on orifices 17 and 26, which are proportioned in area as above described. A branch pipe 36 provided with a pressure relief valve 50 connects pipe 11 with the surge tank 39. This valve could also be of the regulator actuated type.

In place of the pilot valve and regulators shown in Fig. 4 the fifth form may utilize the mechanical valve tripping system shown in Fig. 6, it being understood that either method of operating valves 44, 46, and 48 may be used in either the fourth or the fifth form of the invention.

Referring now to Fig. 6, float 40 actuates a lever arm 51 by means of a pull rod 52, the outer end of the arm carrying a counterweight 53. The arm 51 is connected by means of a rigid vertical member 54 to a second lever arm 55

which is supported on a fulcrum 56, this arm having a counterweight 57. The two arms described are connected to valves 44, 48, and 46 in the order shown in Fig. 5 (which is not intended to indicate any particular space relation) by means of rigid vertical members 58, 59, and 60 respectively, these members being attached to the actuating stems of the respective valves. Member 58 is pivoted on arm 51 as at 61 and member 59 is provided at its upper end with a yoke 62, within which the arm has a limited vertical play.

This assembly functions in the following manner. When the float 40 is in the lower position shown the arm 51 rests in the bottom of yoke 62, valve 48 being thus closed; member 54 is depressed, raising the weighted end of arm 55 and opening valve 46; the weighted end of arm 51 is raised, opening valve 44.

When the float rises, the weighted end of arm 51 is depressed, the yoke 62 still acting as a fulcrum, and valves 44 and 46 are simultaneously closed. When valve 44 is completely closed, the fulcrum point for arm 51 is transferred to pivot 61, the arm then rises until it engages the upper end of yoke 62, and further upward movement of the float then opens valve 48. All of these valves are arranged to wholly open and close with a relatively small vertical movement of the float; so that they will function as stop valves rather than as throttling valves. It is permissible and desirable to arrange all of these valves to trip sharply from an open to a closed position by well-known means, it being remembered that the movements of valves 44 and 46 should be simultaneous while the movement of valve 48 should lag behind the foregoing.

The arrangement shown in Fig. 5 functions in the same manner as that of Fig. 3 with the exception that the discharge through orifice 26 may be taken entirely through valve 12 or may be diverted by partial closing of this valve into the surge tank through relief valve 50. This valve is set to open at a pressure slightly above that maintained in discharge pipe 22. Relief valve 28 in the bypass pipe 27 is set to open at a pressure still slightly higher and during such times, as valve 46 is closed, the normal delivery through this valve bypasses through valve 28.

For blending two liquids in place of dissolving a powder and diluting the solution as above described, we substitute for the dissolving device 13 the assembly shown in Fig. 8. This device has a pressure inlet pipe 16, a jet 17, and an enlarged outlet pipe 18 as in Fig. 6, but pipe 18 is provided with a Venturi throat 63, producing an inspirating effect in the suction pipe 64 which is carried over the top of a supply tank 65 and controlled by a manual valve or an orifice 66. By regulation of the opening 66 the inspirator may be caused to induce a flow of liquid from tank 65 in any required proportion to the liquid passing through the jet 17 which, in turn, is proportioned to the total flow of liquid withdrawn from outlet valve 12 as above described in any form of the invention.

In the above figures 67 indicates a check valve to prevent return flow of liquid, the object in each case being evident without further description.

We claim as our invention:

1. A method of continuously blending a liquid with a miscible substance to produce a mixture of substantially constant proportions, which comprises: circulating a stream of said mixture in a closed ring; withdrawing from said ring a desired proportion of said stream; utilizing the energy of the remainder of said stream to draw into said ring a controlled quantity of said miscible substance; automatically proportioning the volume of said withdrawn stream to the volume of said remainder, thereby establishing a fixed relation between the quantity of said mixture withdrawn and the quantity of said miscible substance drawn into said ring and further admitting to said ring sufficient of said liquid to restore said stream to its original volume.

2. A method of continuously blending a liquid with a solid substance miscible therewith to produce a mixture of substantially constant proportions, which comprises: circulating a stream of said mixture in a closed ring; withdrawing from said ring a desired proportion of said stream; utilizing the energy of the remainder of said stream to draw into said ring a controlled quantity of said solid substance; automatically proportioning the volume of said withdrawn stream to the volume of said remainder, thereby establishing a fixed relation between the quantity of said mixture withdrawn and the quantity of said miscible substance drawn into said ring and further admitting to said ring sufficient of said liquid to restore said stream to its original volume.

3. A method of continuously blending a first liquid with a second liquid miscible therewith to produce a mixture of substantially constant proportions, which comprises: circulating a stream of said mixture in a closed ring; withdrawing from said ring a desired proportion of said stream; utilizing the energy of the remainder of said stream to draw into said ring a controlled quantity of said second liquid; automatically proportioning the volume of said withdrawn stream to the volume of said remainder, thereby establishing a fixed relation between the quantity of said mixture withdrawn and the quantity of said second liquid drawn into said ring and further admitting to said ring sufficient of said first liquid to restore said stream to its original volume.

4. A method of continuously blending a liquid with a miscible substance to produce a mixture of substantially constant proportions, which comprises: circulating a stream of said mixture in a closed ring, said ring including a pumping means; withdrawing from said ring a desired part of said stream; utilizing the energy of a further part of said stream proportioned in quantity to said withdrawn part to draw into said ring a proportionate quantity of said miscible substance; bypassing the remainder of said stream through a secondary ring including said pumping means; automatically proportioning the volume of said withdrawn stream to the volume of said remainder, thereby establishing a fixed relation between the quantity of said mixture withdrawn and the quantity of said miscible substance drawn into said ring and further admitting to first said ring sufficient of said liquid to restore said stream passing through said pumping means to its original volume.

5. A method of continuously blending a liquid with a miscible substance to produce a mixture of substantially constant proportions, which comprises: circulating a stream of said mixture in a closed ring including a pumping means and pressure-responsive means for controlling the operating speed of said prime mover; withdrawing from said ring a desired proportion of said stream; utilizing the energy of the remainder of said stream to draw into said ring a proportionate quantity of said miscible substance; admitting to said ring a quantity of said liquid equal to the volume of mixture withdrawn less the volume of said misci-

ble substance drawn into said ring, and controlling the speed of said pumping means in response to the pressure at the discharge end thereof, said speed being reduced as said pressure increases.

6. A method of continuously blending a liquid with a miscible substance to produce a mixture of substantially constant proportions, which comprises: circulating a stream of said mixture in a closed ring including a pumping means; continuously withdrawing from said ring a desired proportion of said stream; utilizing the energy of a controlled portion of said stream to draw into said ring a proportionate quantity of said miscible substance; diverting the remainder of said stream to storage extraneous to said ring and admitting to said ring sufficient of said liquid to restore said stream to its original volume; and intermittently interrupting said circulation through said ring and the additions of said miscible substance and said liquid to said stream while withdrawing mixture from storage to maintain the stream delivered by said pumping means.

7. Apparatus for continuously blending a liquid with a substance miscible therewith to produce a mixture of substantially constant composition, comprising: a pump; a pipe system arranged in a closed ring which includes said pump; a conduit arranged to withdraw a stream of said mixture from said ring injection means interposed in said ring arranged to utilize the energy of the remainder of said discharge to draw a proportionate quantity of said substance into said ring; means in said conduit for restricting said stream to less than the total discharge of said pump and for establishing a predetermined relation between the quantity withdrawn and the quantity returned to actuate said injection means, and means for admitting a stream of said liquid into said ring at a point between said injection means and the suction side of said pump.

8. Apparatus for continuously blending a liquid with a substance miscible therewith to produce a mixture of substantially constant composition, comprising: a pump; a pipe system arranged in a closed ring which includes said pump; means for withdrawing a stream of said mixture from said ring and for restricting said stream to less than the total discharge of said pump; injection means interposed in said ring arranged to utilize the energy of the remainder of said discharge to draw a proportionate quantity of said substance into said ring; a valve interposed in said ring between said injection means and the discharge end of said pump and pressure-responsive means controlling said valve, said means arranged to respond to pressure in the portion of said ring between said valve and said pump; means for bypassing an excess of said mixture discharged by said pump into the suction thereof; and means for admitting a stream of liquid into said ring at a point between said injection means and the suction side of said pump.

9. Apparatus for blending a liquid with a substance miscible therewith to produce a continuous supply of a mixture of substantially constant composition, comprising: a pressure pump; a pipe system arranged in a closed ring including said pump; injection means interposed in said ring arranged to utilize the energy of a portion of the discharge of said pump to draw a proportionate quantity of said substance into said ring; a branch supplied from said ring between the discharge end of said pump and said injection means for withdrawing a portion of said pump discharge from said ring, and means in said branch for controlling the quantity so withdrawn; means for admitting a stream of said liquid into said ring at a point between said injection means and the suction side of said pump; a second branch supplied from said ring between the discharge end of said pump and said injection means and pressure-actuated relief means in said branch; a tank arranged to receive mixture delivered by last said branch and said relief means; a pipe affording communication between said tank and the suction side of said pump, and means actuated by changes of level in said tank to stop the flow of mixture through said ring and the admission of said liquid to said ring and to open said communication between said tank and said pump when the mixture in said tank rises to a predetermined level, and to reverse the aforesaid movements when the mixture in said tank falls to a lower level.

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