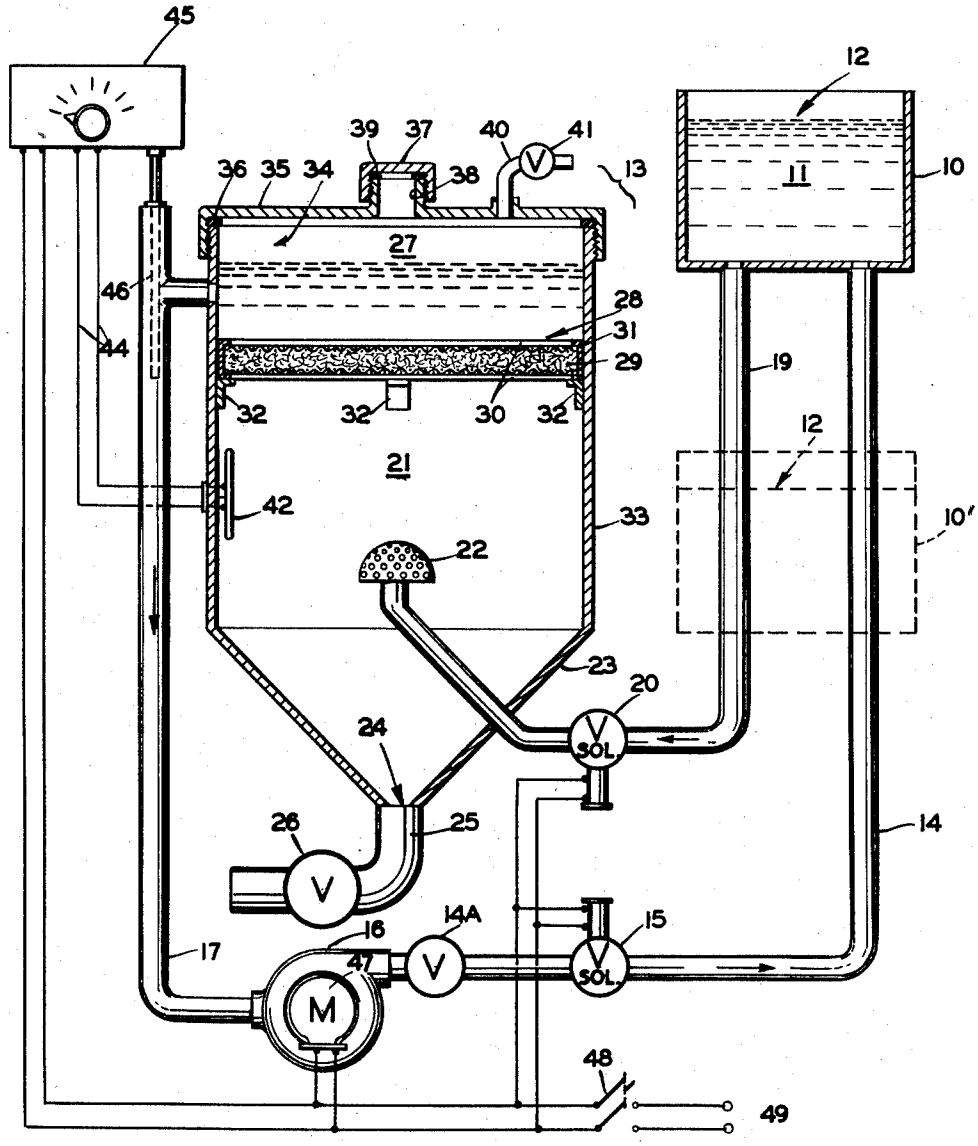
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LIQUID RECIRCULATION SYSTEM

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# LIQUID RECIRCULATION SYSTEM

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This invention relates to recirculatory liquid supply systems. In such systems it is generally desirable to maintain a uniform rate of liquid feed to the point of use, and to balance the feed and return flows to keep the system in equilibrium. It is also usually necessary to subject the returned liquid to treatment of some kind, such as the removal of impurities. A supply tank may be associated with the system.

In systems of this kind the provision of uniform liquid feed to the point of use presents problems. It may be accomplished by employing a positive displacement pump; but changes in feed rate then require changes in pump speed, which is sometimes open to serious objections. Moreover, automatic flow control, such as is required to maintain a uniform level in a container feed by the pump, requires special apparatus, usually rather complicated. Centrifugal pumps, on the other hand, produce flows that vary with variations in output pressure, input pressure and applied power, so that they are not generally adapted for producing uniform flow under varying conditions of use.

An object of the invention is to provide a novel liquid recirculation system, including uniform liquid feed to and return from a point of use, which employs centrifugal pumping means. Another object is to provide a novel arrangement of this type in which the feed rate from the centrifugal pumping means is automatically regulated in accordance with requirements at the point of use.

A related object is to maintain automatically in a novel manner a uniform liquid level in a container through which liquid is circulated by centrifugal pumping means; and a specific object is to accomplish this result without the use of mechanical regulating means. A further purpose is to utilize hydraulic means for regulating the output of a centrifugal pumping means to obtain uniform output. A specific object is to utilize pressure conditions in a liquid supply container to provide such regulation.

Another purpose is to provide in a system of this type novel means for adjusting such liquid level, and in particular, adjusting means that does not involve the use of mechanism.

The invention is illustrated in its application to a recirculation system in which the return liquid is treated to remove solid particles before return to the point of use. An object of the invention is to provide a novel arrangement for this purpose, employing an efficient combination of sedimentation and filtration. A related object is to utilize a supply tank containing a volume of liquid many times the amount required at the point of use, arranged to combine the advantages of greater uniformity of temperature and other characteristics in the liquid supply with improvements in the removal of solid particles which are made possible by such an arrangement.

The foregoing and other objects and advantages of the invention will appear more fully from consideration of the detailed description which follows, in conjunction with the accompanying drawing wherein one embodiment of the invention is illustrated. It is to be expressly understood, however, that the drawing is for the purposes of



illustration and description, and is not to be construed as defining the limits of the invention.

The drawing is a schematic diagram of an embodiment of the invention, with liquid containers shown in vertical central section.

The functioning of an arrangement embodying the invention is based on the fact that the output of a centrifugal liquid pump varies with the back pressure at the discharge and the suction head at the inlet. The volume of pump discharge will increase and decrease as the back pressure increases and decreases, while such volume will likewise go up and down as the suction head at the pump inlet goes down and up. This fact is utilized in accordance with the invention by connecting the pump feed and tank return pipes with a tightly sealed supply tank having an air space at the top, the pump discharge and tank return pipes advantageously operating under substantially equal head.

When a system of this type is in equilibrium, the suction head and back pressure at the pump will be correct for supplying liquid at the proper rate to the point of use, and the rate at which liquid is withdrawn from the tank will exactly equal the rate at which it is returned. If for some reason the rate of liquid feed should increase, the resulting withdrawal of liquid from the tank at a higher rate will lower the liquid level in the tank, causing increased vacuum in the air space and suction head on the pump, and correspondingly reducing the rate of liquid discharge. Similarly, if the return flow should be greater than that at equilibrium, the liquid level in the supply tank will rise, reducing the volume of the air and decreasing the suction head at the pump, which will thereupon increase its output. This arrangement automatically maintains a uniform balanced rate of supply and return flow, once equilibrium has been established. Moreover, it is independent of the elevation of the point of liquid use relative to the liquid level in the supply tank.

An embodiment operating on this principle has been illustrated. In this form of the invention liquid is supplied to and withdrawn from a point of use, illustrated diagrammatically as an open treatment tank **10** filled with liquid **11** up to a predetermined level **12**, which is to be maintained. Treatment tank **10** is connected by a liquid circulation system to a supply tank **13**, proportioned to contain a volume of liquid many times greater than the capacity of tank **10**, for instance at least five times as great. The liquid supply pipe **14** to tank **10** is connected through solenoid valve **15** to the discharge outlet of centrifugal pump **16**, whose inlet is connected through pump feed pipe **17** to the upper part of supply tank **13** below the liquid level therein. The return pipe **19** from tank **10** extends through solenoid valve **20** to the lower part of supply tank **13**.

Tank **13** is arranged to provide in its lower part a sedimentation chamber **21**, into which pipe **19** discharges, advantageously through a distributing head, such as rose **22**, which will introduce the liquid with a minimum of agitation. The dimensions of chamber **21** are selected when possible in accordance with the sedimentation rate of at least a major part of the solid particles to be removed from the returning liquid, its cross-section being proportioned with reference to the rate of liquid discharge from pipe **19** so that the rate of upward flow in chamber **21** will be less than the sedimentation rate of such solid particles. The height of the chamber will be sufficient to provide a relatively quiescent condition in which normal sedimentation may take place. The bottom **23** of the supply tank **13** advantageously converges downwardly to a restricted central solids discharge outlet **24**, forming a sediment hopper connected to waste pipe **25**, controlled by valve **26**, through which accumulated solids may be withdrawn. The outlet from pipe **19**, such as

rose 22, is advantageously located sufficiently above bottom 23 to avoid disturbance of the sediment collecting therein, and preferably is located at least as high as the margin of the tapering bottom.

A suitable filter is located in supply tank 13 above chamber 21, through which the liquid from said chamber passes upwardly into a supply chamber 27. In the form illustrated, the filter consists of a flat disc 28, fitting against the walls of the tank 13 and formed of fibrous filtering material 29 retained between sheets of wire mesh 30 in a channel frame 31 removably supported by brackets 32 on the side wall 33 of tank 13.

The supply chamber 27 is arranged and proportioned so that it will maintain a liquid level above the connection with pump feed pipe 17, with an air space 34 above the liquid. The top of supply chamber 27 is heremetically sealed, the form shown employing a removable cover 35 threaded on the upper end of wall 33 and screwed down tightly against gasket 36 to provide an air-tight seal. A small cap 37 screwed onto a neck 38 extending around an opening in the cover is sealed by gasket 39. Since the rest of tank 13 is sealed, having tight connections with pipes 17 and 19 (pipe 25 being closed by valve 26) the entire tank 13 constitutes a sealed supply container. A regulating pipe 40 mounted on cover 35, connected to air space 34 and closed by valve 41, is provided for reasons hereafter set forth.

An arrangement is provided for controlling or regulating the rate of liquid supply to the point of use. In the form illustrated, this function is performed by a control valve 14A in feed pipe 14 which may be manually operated.

Suitable devices and apparatus of known types for treating or adjusting the condition of the liquid in the supply tank 13 may be employed. These are exemplified by a thermostatically controlled heating system, the form illustrated including heating means in chamber 21, exemplified by heating unit 42 mounted in the tank side 33 and connected electrically through leads 43 to a thermostatic control box 44 of standard type, actuated by a connected thermostat 45 extending into the upper part of the pump feed pipe 17 adjacent to its connection with supply chamber 27. The control box 44, the drive motor 46 of the centrifugal pump 16, and the solenoid valves 15 and 20 are all connected through switch 48 to a suitable source of electrical energy 49.

The illustrated arrangement operates in the manner already set forth, and is shown as being used to maintain the level of liquid in a tank higher than the supply tank 13, which may be located at any distance from the latter. It is particularly adapted for use in connection with cleaning operations in which solid particles of dirt are removed from articles in a tank such as tank 10, one type of operation of this kind utilizing an ultrasonic cleaner such as that described in Patent Application Serial No. 405,756, Gilbert G. Brown, filed January 25, 1954, now Patent No. 2,815,193. In this arrangement the supply pipe 14 and return pipe 19 are liquid circulation pipes connected to the ultrasonically operated cleaning tank.

The solids in the liquid withdrawn through pipe 19 and distributed in sedimentation chamber 21 will settle to a great extent, and in particular all of the larger particles will be effectively removed by sedimentation during the slow upward flow of liquid in said chamber. The residue will be removed by filter disk 28, through which the liquid will flow upwardly into supply chamber 21 and thence through pipe 17 back to pump 16. Filter disk 28 will be selected in accordance with the type and quantity of solids to be removed; and since the filtration is upward, solids accumulating on this lower face of the disk may tend to aggregate and fall to the bottom. There will be a minimum tendency of such solids to penetrate the disk against gravity, and such disk may of course be readily removed, cleaned and replaced.

An arrangement is provided for conveniently raising the level of the liquid in the remote tank 10. After the system has reached equilibrium, at which the air in air space 34 will be below atmospheric pressure due to the pump suction, valve 41 may be opened for a brief period to allow more air to enter space 34; and while the pressure of the air in said space is being reduced by the pump suction to that at which equilibrium takes place, a greater amount of liquid will be supplied to tank 10 than that which is withdrawn, since the suction head on pump 16 will be reduced during that period, resulting in a corresponding rise in the liquid level 12. A corresponding lowering of the latter liquid level can of course be obtained by applying suction to pipe 40 when valve 41 is open.

Solenoid valves 15 and 20 assure the maintenance of equilibrium pressure conditions in the system when the latter is not in operation. When motor control switch 47 is open, the solenoid valves are released and close feed pipe 14 and return pipe 19, so that the necessary reduced pressure in air space 34 is maintianed, and assures uniformity of liquid supply and withdrawal at the point of use when switch 47 is closed, motor 46 and pump 16 start, and valves 15, 20 open. However, if maintenance of a uniform liquid level or volume at the point of use when the system is not in use is not important, valves 15 and 20 may be dispensed with and the liquid allowed to drain back into the supply chamber 21 until the vacuum is satisfied. Upon resumption of operation the resultant increased pump input pressure will produce an increased rate of liquid feed, so that the level will be restored as equilibrium conditions are again established.

Although but one embodiment of the invention has been illustrated and described in detail, involving a circulation system connected to a treatment tank 10 above the level of supply tank 13 for maintaining a uniform liquid level in the former tank, it is expressly understood that the invention is not limited thereto. Various changes can be made in the design and arrangement of the parts without departing from the spirit and scope of the invention, as the same will now be understood by those skilled in the art. By way of illustration of such changes, tank 10 may be at any desired level, its location below the liquid level in supply tank 13 being indicated at 10'. Moreover, it will be evident that as long as the type of use at the point to which pipes 14 and 19 are connected is such that the return flow will balance the supply under equilibrium conditions, the way in which the liquid is employed or handled at the point of use will not materially affect the functioning of the system.

It will be noted that systems incorporating the invention regulate the uniformity of circulating flow hydraulically wihout requiring the use of special apparatus or mechanisms. Moreover, this substantial simplification is combined with the use of a supply tank large enough to contain such a large volume of liquid that the condition of the liquid can be regulated and made uniform between the time when it returns to the tank and the time when it is sent back through the pump.

I claim:

1. A liquid recirculation system, comprising a liquid supply container, an open liquid treatment container, means for recirculating liquid from the supply container to the treatment container and back to the supply container, and means for automatically maintaining the liquid level in the open treatment container comprising means including a centrifugal pump in the recirculation means for supplying liquid from the supply container to the treatment container and means for sealing the supply container except at the connections to said recirculation means.

2. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, a supply passage connecting the pump discharge to a liquid use zone, and a return passage connecting the use

zone to the supply container, said container being sealed except at its connections with the feed and return passages and having an air space above the liquid surface.

3. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, a supply passage connecting the pump discharge to a liquid use zone, a return passage connecting the use zone to the lower part of the container, the container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface; and a filter in the supply container extending horizontally across the container and located between the connections to the return passage and to the feed passage.

4. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, a supply passage connecting the pump discharge to a liquid use zone, a return passage connecting the use zone to the container, the container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface, and means for varying the suction head on said pump.

5. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, a supply passage connecting the pump discharge to a liquid use zone, a return passage connecting the use zone to the container, the container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface, and means for varying the suction head on said pump, said varying means comprising a valved air passage at the top of the container connected to said air space.

6. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, a supply passage connecting the pump discharge to a liquid use zone, a valve in said supply passage, a return passage connecting the use zone to the container, a valve in said return passage, the container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface, and means for opening said valves when the pump is operating and closing said valves when the pump is not operating, said means including an electric pump drive motor, a motor operating circuit, and valve controlling solenoids located in said operating circuit.

7. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, an open liquid treatment container, and means for maintaining the uniform liquid level in the treatment container, including a supply passage connecting the pump discharge to the treatment container, and a return passage connecting the treatment container to the supply container, the supply container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface.

8. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, an open liquid treatment container, means for maintaining a uniform liquid level in the treatment container, including a supply passage connecting the pump discharge to the treatment container, and a return passage connecting the treatment container to the supply container, the supply container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface, and means for changing the amount of air in said air space and thereby adjusting the liquid level in the treatment container.

9. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, an open liquid treatment container, means for maintaining a uniform liquid level in the treatment container, including a supply passage connecting the pump discharge to the treatment container, and a return passage connecting the treatment container to the supply container, the supply container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface, and means for changing the amount of air in said air space and thereby adjusting the liquid level in the treatment container, said means including a pipe carried by the supply container and connected to the air space, and a valve in said pipe.



10. A liquid circulation system, comprising a liquid supply container, a continuously operating supply pump, a pump feed passage connecting the upper part of the container with the pump intake, a supply passage connecting the pump discharge to a use zone in which solid particles are picked up by the liquid, a return passage for said liquid connecting the use zone with the lower part of the container, said container forming a sedimentation chamber having a cross-section which maintains an upward flow of liquid from the return passage to the pump feed passage during pump operation at a rate less than the settling rate of a substantial proportion of said particles, and a sediment discharge outlet in the lower part of the sedimentation chamber.

11. A liquid circulation system, comprising a liquid supply container, a continuously operating supply pump, a pump feed passage connecting the upper part of the container with the pump intake, a supply passage connecting the pump discharge to a use zone in which solid particles are picked up by the liquid, a return passage for said liquid connecting the use zone with the lower part of the container, said container forming a sedimentation chamber having a cross-section which maintains an upward flow of liquid from the return passage to the pump feed passage during pump operation at a rate less than the settling rate of a substantial proportion of said particles, a sediment discharge outlet in the lower part of the sedimentation chamber, and a filter extending across the supply container above the sedimentation chamber and below the pump feed passage.

12. A liquid circulation system, comprising a liquid supply container, a continuously operating supply pump, a pump feed passage connecting the upper part of the container with the pump intake, a supply passage connecting the pump discharge to a use zone in which solid particles are picked up by the liquid, a return passage for said liquid connecting the use zone with the lower part of the container, said container forming a sedimentation chamber having a cross-section which maintains an upward flow of liquid from the return passage to the pump feed passage during pump operation at a rate less than the settling rate of a substantial proportion of said particles, and having a sediment collecting zone at the bottom of the sedimentation chamber, and a liquid distributor centrally located in said chamber above said collecting zone and connected to the return passage.

13. A liquid circulation system, comprising a liquid supply container, a centrifugal supply pump, a pump feed passage connecting the pump intake with the upper part of the container, a treatment container, a supply passage connecting the pump discharge with the treatment container, a solenoid valve in the supply passage, a return passage for liquid and solid particles connecting the treatment container with the lower part of the supply container, said lower part forming a sedimentation chamber having a cross-section which maintains an upward flow of liquid from the return passage at a rate less than the settling rate of a substantial proporation of said particles, a solenoid valve in the return passage, a sediment collecting zone in the bottom of the sedimentation chamber, a liquid distributor centrally located in said chamber above the sediment collecting zone and connected to the return

passage, a filter extending across the container above the sedimentation chamber and below the feed passage, the container being sealed except at its connections to the supply and return passages and having an air space above the liquid surface, a pump drive motor, and an operating circuit for said motor connected to said solenoid valves, arranged to close said valves when the motor and pump are not operating and to open said valves during operation.

14. A liquid recirculation system, comprising a liquid supply container, a centrifugal pump, a pump feed passage connecting the pump intake with the container, a supply passage connecting the pump discharge to a liquid use zone, a valve in said supply passage, a return passage connecting the use zone to the container, a valve in said return passage, the container being sealed except at its connections to the feed and return passages and having an air space above the liquid surface, and means for initiating operation of said pump and simultaneously opening said valves and for closing said valves and simultaneously terminating operation of said pumps and thereby maintaining pressure conditions in the supply container.




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