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[72] Inventor **Henry G. Joel**
New York, N.Y.

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[73] Assignee **Ing. C. Olivetti & C. S. p. A.**
Ivrea, Italy

[54] **APPARATUS FOR AGITATING AND ADDING A LIQUID TO A LIQUID FLOW SYSTEM**
21 Claims, 1 Drawing Fig.

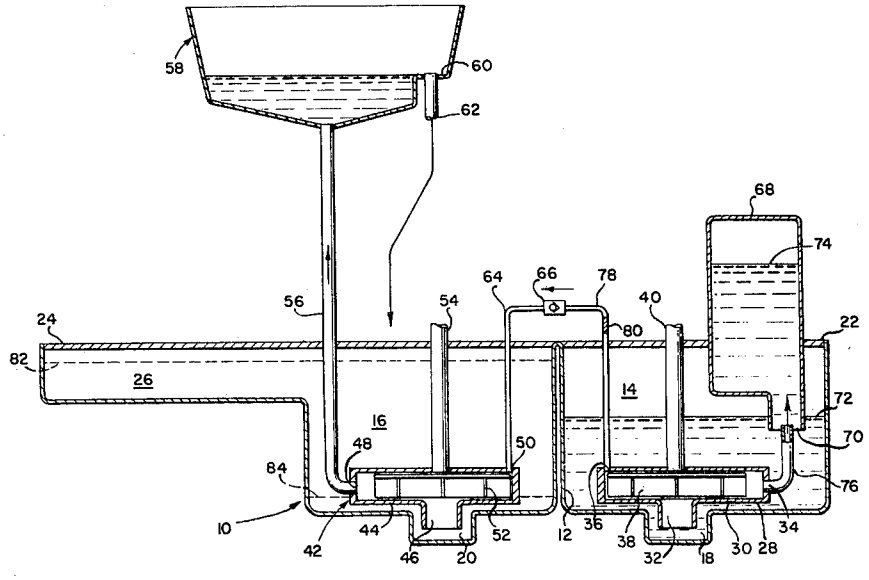
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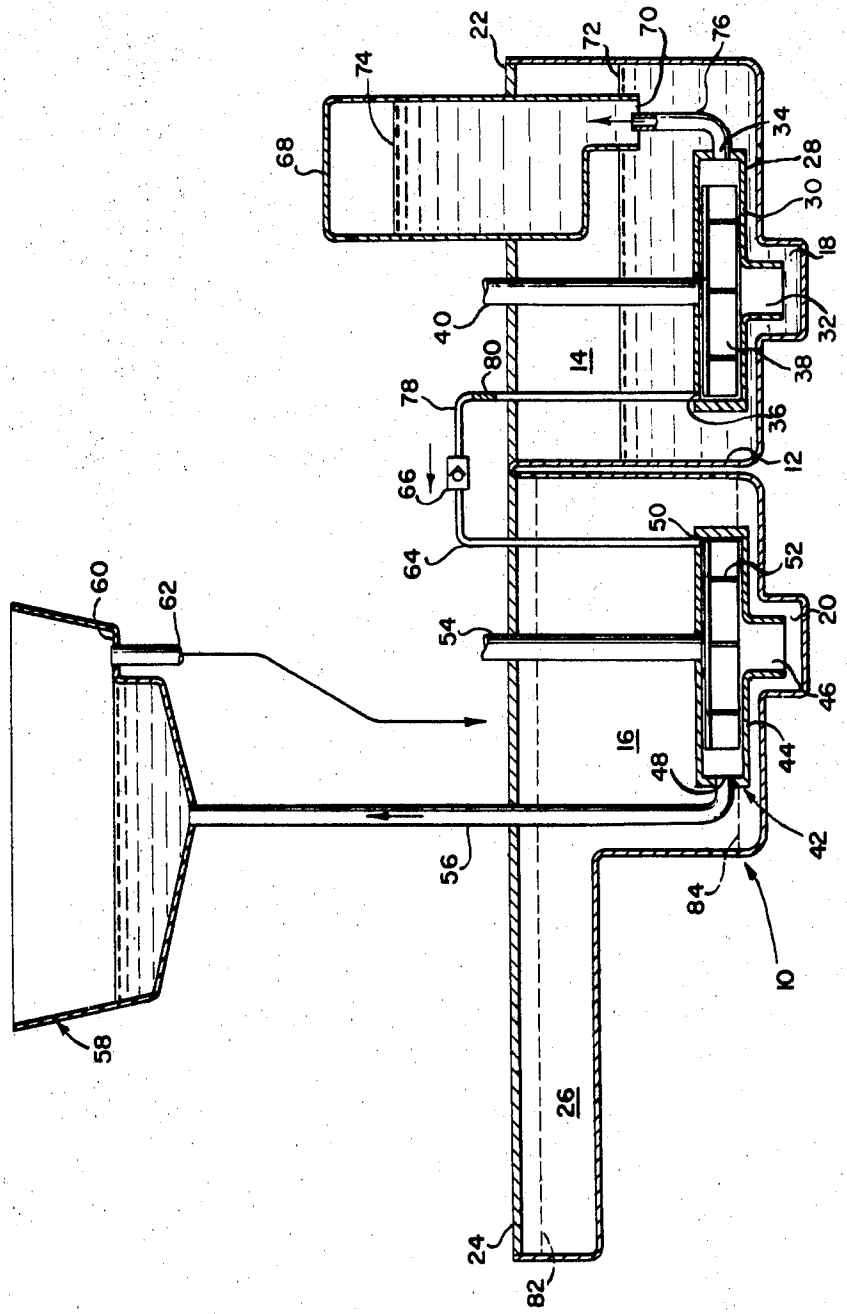
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Primary Examiner—Jordan Franklin
Assistant Examiner—George V. Larkin
Attorney—Kevin McMahon

ABSTRACT: Apparatus for accurately adding a liquid to a flow system, where the additive liquid is continuously agitated by a recirculating device which is connected to the flow system. Discharge from the recirculating device is set against discharge from the prime mover of the liquid in the flow system so that additive liquid will enter the flow system when the pressure of the liquid in the flow system drops below the pressure of the additive liquid.





INVENTOR
HENRY & JOEL
BY Kevin McMahon
ATTORNEY

APPARATUS FOR AGITATING AND ADDING A LIQUID TO A LIQUID FLOW SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to liquid flow systems adaptable for use in coating processes and, more specifically, to a liquid flow system for recirculating an ingredient in a coating system.

2. Description of the Prior Art

It has long been a problem to maintain proper and uniform conditions in processing systems which recirculate a working liquid. Typical working liquids recirculated in processing systems usually include an active ingredient suspended or dissolved in a carrying liquid. As the process operates, the active ingredient is consumed by the process and the carrying liquid is depleted by absorption in the material processed or evaporation, or leaks in the system. In order to maintain the proper quantity and uniformity of the working liquid in the system, it is necessary to replenish the same quantities of the carrying liquid and the active ingredient which have been used up in the operation of the process.

These problems with working liquids have been particularly pronounced in the electrostatic photographic copying art where the developing systems in the copying apparatus often use a recirculating inklike working liquid referred to as developer to fix the copied image on paper. The developer liquid includes a carrier liquid and a special opaque ingredient referred to as toner which coacts with previously processed paper to form an image on the paper. The carrier liquid evaporates shortly after the developer has been applied to the paper, leaving the paper dry and with a distinct image.

In many of the developing systems a proportionately greater ratio of toner to carrying liquid is used up in the developing processes than is present in the composition of the developer liquid. Therefore, as the developing process continues to operate, the composition of the recirculated developer will vary as the concentration of toner decreases, resulting finally in the nonoperativeness of the entire electrostatic photographic copying device.

Prior efforts to maintain the proper composition of the developer liquid have not been fully successful. Concentrated replenisher liquids were formulated which contained toner and carrier liquid in the same proportion these materials were used up in the developing process. However, the replenisher liquid had to be most carefully and accurately added to the developer liquid. If too little replenisher were added, the toner concentration of the developer would be low. If too much replenisher were added to the developer, the toner concentration would be too high. Further, it was often necessary to insure that the replenisher was added to the developer without any contamination of the replenisher by the developer, since the adding of developer to replenisher would adversely effect the properties of the replenisher liquid.

Because of the accuracy required in adding the replenisher liquid to the developer, the obvious expedient of adding a fixed quantity of replenisher to the developer at a given point in the developing process was unsuitable. Any error in the fixed quantity of replenisher to be added would be continually repeated, eventually producing a large imbalance in the composition of the developer.

Apparatus used in other processing arts could not completely eliminate the problems mentioned above. For example, the apparatus shown in U.S. Pat. No. 2,235,336 issued Mar. 1941 to F. Schuster for Apparatus for Maintaining a Liquid in Uniform Condition could not solve all of the problems mentioned above. In the Schuster patent, a float valve **20** actuated by a float **21** permits replenisher liquid from a reservoir **17** to flow to a container of working liquid **14** until the level of the working liquid in the container is sufficiently raised.

However, the float valve arrangement disclosed by Schuster is not very precise nor is it responsive to minor changes in the level of the liquid. Therefore, if the Schuster apparatus were applied to add replenisher to a developer, large quantities of developer would have to be circulated in the system to dilute the effect of adding improper quantities of replenisher. Additionally, the system presents certain space problems for applying it in limited areas, since the reservoir **17** must be mounted above the container **14** in order to provide the head to cause the flow from the reservoir to the container when the float valve opens.

An example of an attempt to solve the above mentioned problems in the electrostatic photographic copying art is shown in U.S. Pat. No. 3,299,787 issued to E. R. Kolb, et al. in Jan. 1967 for Electrophotographic Micro-Copy Printer. However, as can be clearly seen from Fig. **13** of the this patent, an elaborate system is necessary to separately supply the required quantities of carrier liquid from storage container **230** and toner from storage container **233**. The toner is released from its container **233** by an electrically actuated valve **237** which is triggered by a photocell **241** when the amount of toner in the developing liquid diminishes to the point that light from light source **242** can pass through the developer liquid to be sensed by the photocell **241**.

Additionally, neither the Kolb patent nor the Schuster patent disclose or suggest a method for insuring that replenishing liquid will be maintained in a uniform condition while it is kept in reserve for adding to the liquid flow system. The uniformity of the replenisher is particularly important in applications relating to the electrostatic photographic copying art, since the developer liquid and the replenishing liquid are usually not true solutions but rather suspensions of toner in the carrier liquid. When the developing liquid or the replenishing liquid is allowed to stand for extended periods of time the toner ingredient tends to settle out from the liquid. Therefore, the density of the liquid and the toner concentration will vary with the height of the liquid in the container.

SUMMARY OF THE INVENTION

In order to overcome the problems set forth above, the present invention sets forth apparatus for accurately adding a liquid to a flow system, including flow systems of the type used in electrostatic photographic copying devices. The apparatus includes a prime mover to circulate the working fluid in the flow systems, and a separate device to constantly agitate and recirculate the replenishing liquid. Discharge from the recirculating device for the replenishing liquid is set against discharge from the prime mover which circulates the working liquid. When the discharge pressure of the prime mover decreases due to a decrease in the quantity of working liquid in the flow system, the recirculating device for the replenishing liquid will force replenishing liquid into the flow system until sufficient working liquid has been added.

Accordingly, it is an object of the present invention to provide apparatus for accurately adding a liquid to a liquid flow system.

Still another object of the present invention is to provide apparatus for maintaining the composition of a consumable multicomponent working liquid circulating in a flow system.

Yet another object of the present invention is to provide apparatus for automatically replenishing the working liquid consumed in a processing system.

Still another object of the present invention is to provide apparatus of simplified construction for automatically replenishing working liquid consumed in a processing system, which apparatus is highly reliable and not prone to failure during operation of the processing system.

Yet another object of the present invention is to provide apparatus for maintaining the proper level of liquid in a flow system.

Still another object of the present invention is to provide apparatus for maintaining the composition of a multicomponent working liquid in a processing system without having to separately add the individual components which make up the working liquid.

A further object of the present invention is to provide apparatus for automatically adding a replenishing liquid to a working liquid of a flow system without working liquid contaminating the replenishing liquid.

Still another object of the present invention is to provide apparatus for automatically adding a replenishing liquid to a working liquid in a flow system while maintaining replenishing liquid in a uniform condition.

Yet another object of the present invention is to provide apparatus to automatically replenish working liquid in a flow system and continuously agitate both the working liquid in and the replenishing liquid to be added to the flow system.

Various other objects and advantages will be apparent from the following description of the embodiment of the invention and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing depicts a liquid flow system incorporating the features of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The FIGURE shows a liquid flow system and apparatus for adding a liquid to the flow system which are adapted for use in the developing system of an electrostatic photographic copying device.

A vessel generally indicated at **10** is partitioned by a partition **12** into a right hand or first receptacle **14** and a left hand or second receptacle **16**. Sumps **18** and **20** are formed in the bottom of the first and second receptacles respectively. Covers **22** and **24** are positioned at the top of receptacles **14** and **16** respectively to retard evaporation of liquid from either receptacle. Left-hand receptacle **16** has a large storage portion **26** whose function will be explained in more detail below.

A pump generally indicated at **28** is mounted in receptacle **14** by mounting means which are not shown. Pump **28** has a pump casing **30** with an inlet **32** extending down into sump **18** of receptacle **14**, and two pump discharge outlet means, a primary discharge outlet **34**, and a secondary discharge outlet **36**. An impeller **38** is mounted within the pump casing **30** and is driven by drive shaft **40** which extends through the cover **22** of receptacle **14** to a motive source, not shown.

In like manner, a second pump generally indicated at **42** is similarly mounted in second receptacle **16**, and has a casing **44**, inlet **46** disposed in sump **20**, primary discharge **48** and secondary discharge **50**, impeller **52**, and drive shaft **54** connected to a source of motive power, not shown, in a manner similar to the first pump **28**.

A conduit **56** is connected at one end to primary discharge **48** of pump **42** and connects at its other end to the bottom of a processing bin generally indicated at **58**, to carry liquid from the primary discharge to the processing bin. When the level of liquid in the processing bin rises above a shelf **60** in the bin, it will pass through return conduit **62** (shown partially schematically) to the receptacle **26**, where it will again be circulated by the pump **42** which is the prime mover for the liquid in receptacle **16**.

A conduit **64** is connected at one end to secondary discharge outlet **50** of pump **42**. The other end of conduit **64** leads to a check valve **66** which prevents any liquid from passing from conduit **64** through check valve **66**.

A closed container **68** holding a quantity of liquid to be added to the liquid flow system in the left-hand side of the vessel **10** is mounted (by mounting means not shown) in first receptacle **14**. An opening **70** is in the bottom of container **68** and allows liquid to flow out of the container **68** until the level of the liquid **72** in receptacle **14** rises above the level of opening **70**. Once the liquid has reached level **72** in receptacle **14**, the vacuum in the top of container **68** above the level **74** of the additive liquid in the container will prevent further flow of liquid through opening **70**. When the liquid level **72** in receptacle **14** drops below opening **70** in container **68** air will enter container **68** and the additive liquid within the container will accordingly flow into receptacle **14** to once again raise the liquid level **72** to the required height.

A conduit **76** connected to primary discharge **34** of pump **28** extends through opening **70** into container **68** to carry additive liquid from receptacle **14** which has been discharged from pump **28** back to container **68**. As the additive liquid flows into container **68**, the pressure in the container will increase and accordingly, the liquid in the container will flow through opening **70** into receptacle **14**. The discharge from pump **28** through conduit **76** into container **68** and the flow of the liquid from container **68** through opening **70** will rapidly reach an equilibrium point. After equilibrium is reached, the only time the level **74** of liquid in container **68** will change is when the level of liquid **72** in receptacle **14** drops low enough to allow air to enter opening **70** of container **68**. Then a quantity of the additive liquid will flow through opening **70** to raise the level **72** in receptacle **14** to reestablish the seal.

A conduit means **78** is connected to secondary discharge **36** of pump **28** to carry discharge from the pump to the other end of one way valve **66**. Check valve **66** will allow liquid from conduit **78** to flow through valve **66** to conduit **64** when the pressure of the liquid in conduit **78** is greater than the pressure of the liquid in conduit **64**. Impedance means **80** are disposed in conduit **78** to snub or dampen pressure variations which occur within conduit means **78** for purposes which will be more fully explained below.

OPERATION OF THE SYSTEM

The operation of the invention will be described as applied to an installation of the apparatus in the developing system for an electrostatic photographic copying device.

When the developing system is at rest, the developer liquid is stored in receptacle **16**, with the level of the liquid approximately indicated by the dashed line **82**. Processing bin **58** is empty because all of the liquid in the bin was returned to receptacle **16** either through return conduit **62** or by seepage back down conduit **56** through the pump **42** and into the receptacle. The level **72** of additive liquid in receptacle **14** is at its constant position, determined by the height of opening **70** in container **68** which holds additional quantities of the additive liquid.

When the developing process is started, a source of motive power (not shown) drives both drive shafts **40** and **54** respectively of pump **28** in receptacle **14** and pump **42** in receptacle **16**. Although the means for driving shafts **40** and **54** have been omitted to avoid unnecessary cluttering of the FIGURE, it should be understood that pumps **28** and **42** could be driven individually or in combination by any well-known motive power means, and, if necessary, power transmission devices. For example, a single electric motor could be connected to shafts **40** and **54**, through belt and pulley arrangements to drive both shafts simultaneously.

At the start up of the developing process, there will be adequate developing liquid in receptacle **16** and additive liquid in receptacle **14**, as mentioned above. Therefore, both pumps will immediately produce pressure in their secondary discharge outlets, and liquid in secondary discharge conduits **78** and **64** will be pressurized.

Impedance means **80** in secondary discharge conduit **78** prevents the pressure at the end of conduit **78** leading into check valve **66** from rising as rapidly as the pressure at the end of conduit **64**. Therefore, the initial pressure exerted in check valve **6** will always be from developing liquid discharged from pump **42**, which pressure will act to seat check valve **66** to prevent any leakage across the valve.

During operation of the developing process, developer liquid from receptacle **16** will be pumped through discharge conduit **56** into processing bin **58**. When the level of developer in bin **58** is above shelf **60**, the developer will return to receptacle **16** through return conduit **62**.

As the developing process operates, the developer will be used up and the level of developer in receptacle **16** will gradually fall. When the level of the developer has dropped to a sufficiently low level, as for example the level shown by dotted line **84**, the discharge pressure of pump **42** and the pressure in secondary discharge conduit **64** will start to decrease. The pressure in secondary conduit **64** will continue to decrease until it reaches a predetermined valve below the pressure in secondary discharge conduit **78** of pump **28**, at which point one-way check valve **66** will open and will allow the additive liquid in conduit **78** to enter conduit **64**. Because of its greater pressure the additive liquid will force its way downward from conduit **64** into pump housing **44** of pump **42**. The additive liquid will then be discharged from primary discharge **48** of the pump and will enter the flow system for the developing process, passing up to bin **58** and returning to receptacle **16**.

Additive liquid will continue entering the flow system through conduit **64** and pump **42** until the level of the liquid in receptacle **16** is raised enough to allow pump **42** to build up its discharge pressure and thereby close check valve **66**. The flow system will then continue to operate without any additional additive liquid until the level of liquid in receptacle **16** drops low enough to reduce the discharge pressure of pump **42** and once again open check valve **66**.

At all times while the developing process is in operation, pump **28** is continuously operating to pressurize the liquid in conduit **78** and to recirculate the additive liquid in receptacle **14** and container **68** and thereby prevent settling of the ingredients in the liquid.

It should be mentioned that the location of the pump with respect to the level of the liquid in the receptacle is not a critical factor in the operation of the invention. The invention will function properly as long as the inlets of the pumps are disposed at the desired locations within the receptacles and the pump suction is great enough to draw the liquid from the inlet to the pump casing.

It should also be mentioned that the height of the liquid in receptacle **16** at which additive liquid will be drawn into the liquid flow system can be easily adjusted by adjusting the height of inlet **46** of pump **42**. This can have an important effect on the operation of the flow system since the quantity of working liquid which must circulate for adequate function of the flow system will be determined by the minimum level of working liquid in receptacle **16** necessary to prevent additive liquid from entering the flow system.

It should also be pointed out that it is easy to adjust the sensitivity of the apparatus to a decrease in the quantity of working liquid in the flow system. For example, by altering the shape of sump **20** in receptacle **16**, to make the sump even narrower than is shown, a small decrease in the quantity of liquid in the liquid flow system will produce a large drop in the level of liquid in the sump and, therefore, increase the sensitivity of the system.

It should also be pointed out that although it is desirable for the output of both pumps in the system to be matched at equal pressure, the system can be made to function with differences of pressure between the pumps. For example, if the discharge pressure of pump **42** in receptacle **16** were greater than the discharge pressure of pump **28** in receptacle **14**, the system would still operate but it would require a greater drop in the discharge pressure of pump **42** before additive liquid was introduced into the liquid flow system. Additionally, the operation of check valve **66** could be adjusted to compensate for any differences in the discharge pressures of the pumps.

As mentioned above, the additive liquid for the liquid flow system is continuously agitated both in the container **68** and in the receptacle **14**, by the constant recycling of the additive liquid through the container. This assures that the components of the additive liquid will not settle during the periods between maintenance of the system, or replacement of the replenisher containers.

Although the impedance means **80** is shown as being a flow restriction within conduit **78**, there are many other impedance means well known in the art which would function equally well. For example, the impedance could be provided solely by the frictional coefficient of the material forming conduit **78**. That frictional coefficient would exert a force against the flow of liquid through the conduit which could be adjusted by altering the length of the conduit. Similarly, clamping devices or other constricting means could be used to provide the necessary impedance means.

It should be mentioned that the impedance means insures the seating of check valve **66** so that there is no possibility of the liquid in the liquid flow system seeping through to the additive liquid. In several types of processing systems it is necessary for the additive liquid to be added to the working liquid to avoid contaminating the additive liquid. This is particularly true in such applications as electrostatic photographic copying devices, where contamination of the replenisher liquid by the developer liquid will cause flocculation of the toner particles in the replenisher.

It will be understood that various changes in the detail, materials and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention may be made by those skilled in the art within the principal and scope of the invention as expressed in the appended claims.

I claim:

1. Apparatus for adding a liquid to a liquid flow system comprising:

a source of liquid to be added to said liquid flow system;

first conduit means communicating at one end with said source of liquid to be added;

first pressure means operatively associated with said first conduit means to apply pressure to the liquid in said first conduit means;

second conduit means operatively connected at one end with said liquid flow system;

second pressure means operatively associated with said second conduit means to apply pressure to the liquid in said second conduit means;

said second pressure means responsive to the level of liquid in said liquid flow system, to lower the pressure in said second conduit means in response to a decrease in the level of the liquid in said liquid flow system; and

means communicating said first conduit means with said second conduit means so that liquid to be added to said liquid flow system will flow from said first conduit means to said second conduit means, when the pressure in said second conduit means falls below the pressure in said first conduit means.

2. The combination claimed in claim **2** wherein said means communicating said first conduit means with said second conduit means include check valve means which allow liquid to flow only from said first conduit means to said second conduit means.

3. The combination claimed in claim **2** wherein said source of liquid to be added to said liquid flow system further comprises means to continuously agitate said liquid to be added.

4. The combination claimed in claim **3** wherein said first pressure means include a first pump means comprising:

a pump casing;

outlet means in said pump casing;

inlet means in said pump casing; and

said first conduit means is connected to said outlet means of said first pump casing to receive discharge from said first pump means.

5. The combination claimed in claim **4** wherein:

said source of liquid to be added comprises first receptacle means for liquid to be added; and

said inlet means in said second first pump casing is disposed in said first receptacle means.

6. The combination claimed in claim **5** wherein said outlet means of said first pump means discharge into said source of additive liquid to continuously agitate said additive liquid.

7. The combination claimed in claim 6 wherein:
said outlet means of said first pump means comprise primary outlet means and secondary outlet means; and
said first conduit means are connected to said secondary outlet means of said first pump means.

8. The combination claimed in claim 6 wherein said means to continuously agitate said additive liquid include:
a container of additive liquid disposed in said first receptacle means, said container having an opening in the bottom thereof to allow additive liquid to pass into said first receptacle means; and
fourth conduit means extending through said opening in the bottom of said closed container and connected to said outlet means of said first pump means so that liquid from said first pump means will be discharged into said closed container means to agitate the additive liquid contained therein.

9. The combination claimed in claim 7 further comprising impedance means disposed in said first conduit means to dampen any rapid increase in pressure in said first conduit means.

10. The combination claimed in claim 3 wherein said second pressure means include a second pump means comprising:
a pump casing;
outlet means in said pump casing;
inlet means in said pump casing; and
said second conduit means is connected to said outlet means of said pump casing to receive discharge from said second pump means.

11. The combination claimed in claim 10 wherein:
said liquid flow system includes second receptacle means for liquid in said liquid flow system; and
said inlet means in said second pump casing is disposed in said second receptacle means so that the discharge pressure of said second pump means will decrease when the level of liquid in said second receptacle means falls below a predetermined point.

12. The combination claimed in claim 11 wherein:
said second receptacle means include second sump means; and
said inlet means of said second pump means is disposed in said second sump means.

13. The combination claimed in claim 11 wherein:
said outlet means in said second pump means comprise primary outlet means and secondary outlet means; and
said second conduit means are connected to said secondary outlet means of said second pump means.

14. The combination claimed in claim 13 further comprising:
a processing bin;
third conduit means communicating said primary outlet means of said second pump means to said processing bin; and
means to return liquid from said processing bin to said second receptacle means.

15. Apparatus for adding a liquid to a liquid flow system comprising:
first receptacle means containing additive liquid;
first pump means having discharge means and having inlet means disposed in said first receptacle means;
first conduit means communicating with said discharge means of said first pump means;
second receptacle means containing liquid in said flow system;
second pump means having discharge means and having inlet means in communication with said second receptacle means;
means to drive said first and second pump means;
second conduit means connected with said discharge of said second pump means; and
check valve means connecting said first conduit means and said second conduit means to allow flow of additive liquid from said first conduit means to said second conduit means when the pressure in said first conduit means is greater than the pressure in said second conduit means.

16. The combination claimed in claim 15 further comprising fourth conduit means communicating with said discharge means of said first pump means to direct discharge from said first pump means to said additive liquid in said first receptacle means to continually agitate the additive liquid.

17. The combination claimed in claim 16 further comprising:
a plurality of discharge openings in said discharge means of said second pump means;
third conduit means connected to one of said discharge openings in said second pump means to circulate discharge from said second pump means to said liquid flow system; and
means connecting first conduit means and said fourth conduit means to separate discharge openings in said first pump means.

18. The combination claimed in claim 17 further comprising impedance means operatively associated with said first conduit means to prevent rapid build up of pressure in said first conduit means to insure proper seating of said check valve means connecting said first and second conduit means.

19. The combination claimed in claim 17 further comprising sump means in the bottom of said second receptacle means; and wherein said inlet means of said second pump means is disposed in said second receptacle sump means so that the discharge pressure from said second pump means will decrease when the level of liquid in said second receptacle sump means drops to a predetermined point in said second receptacle sump means.

20. The combination claimed in claim 19 further comprising:
container means for additive liquid, said container means having an opening in the lower part thereof disposed in said first receptacle means above the level of said inlet means of said first pump means in said first receptacle means; and
said fourth conduit means extend through said opening in said container means to direct discharge from said first pump means into said container means to agitate the additive liquid therein.

21. Apparatus for adding a liquid to a liquid flow system comprising:
first receptacle means containing additive liquid;
a closed container of additive liquid disposed in said first receptacle means;
said closed container having an opening in the bottom thereof to allow additive liquid to flow into said first receptacle means when the level of liquid in said first receptacle means drops below the level of said opening so that a constant level of additive liquid will be maintained in said first receptacle means;
first pump means having a plurality of discharge outlets and having an inlet disposed in said first receptacle means below the level of said additive liquid in said first receptacle means;
fourth conduit means connected to one of said discharge outlets in said first pump means and extending through said opening in said container to direct discharge from said first pump means to said closed container to agitate the additive liquid in said closed container and in said first receptacle;
second receptacle means adapted to hold liquid from said liquid flow system;
second pump means having a plurality of discharge outlets and having an inlet disposed in said second receptacle;
third conduit means connected to one of said discharge outlets in said second pump means to carry discharge from said second pump means into said liquid flow system;
means to drive said first and second pump means;
first conduit means connected to one of said discharge outlets in said first pump means to carry additive liquid discharged from said first pump means;
second conduit means connected to one of said discharge outlets in said second pump means to carry liquid from

said liquid flow system discharged from said second pump means;

check valve means connecting said first conduit means with said second conduit means to allow flow of additive liquid from said first conduit means through said second conduit means into said second pump means and then into said liquid flow system, when the pressure of the liquid in said second conduit means drops a predetermined value below the pressure of the liquid in said first conduit means; and

impedance means in said first conduit means to insure a more rapid buildup of pressure in said second conduit than in said first conduit to seat said check valve means when said first and second pump means are started simultaneously.