United States Patent

[11] 3,602,607

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[73] Assignee **Eastman Kodak Company Rochester, N.Y.**

[54] **SOLUTION METERING APPARATUS**
11 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **417/148,** 222/440, 222/432
[51] **Int. Cl.** **F04f 3/00,** G01f 11/28
[50] **Field of Search** 417/148, 101, 149; 222/158, 432, 440

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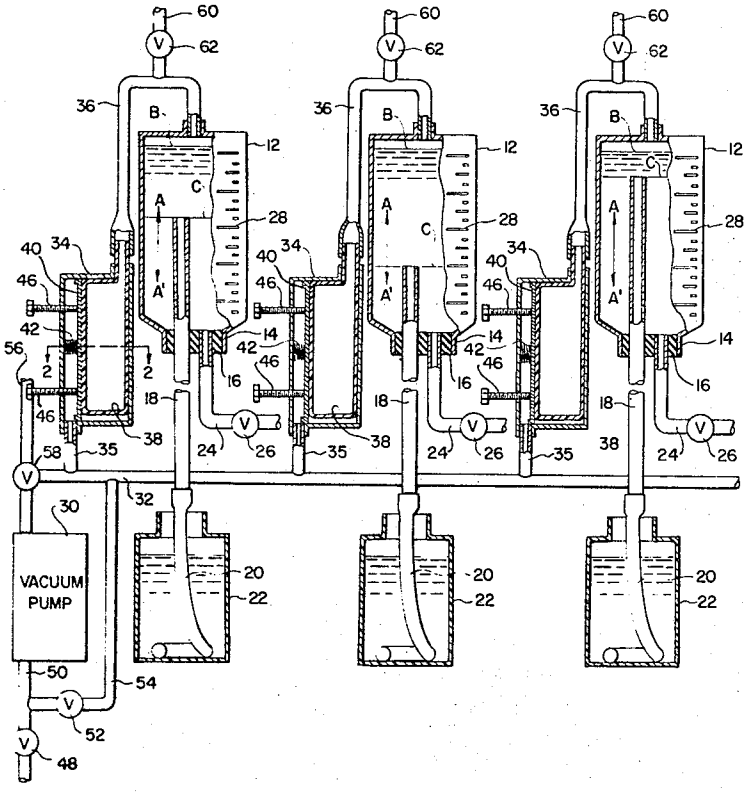
ABSTRACT: Solution metering apparatus for accurately metering and/or mixing one or more solutions in precise proportions for delivery to a solution-receiving device or process. The apparatus is provided with a source of power for filling a metering container of the apparatus with a predetermined volume of solution, and mechanism for controlling the predetermined volume.



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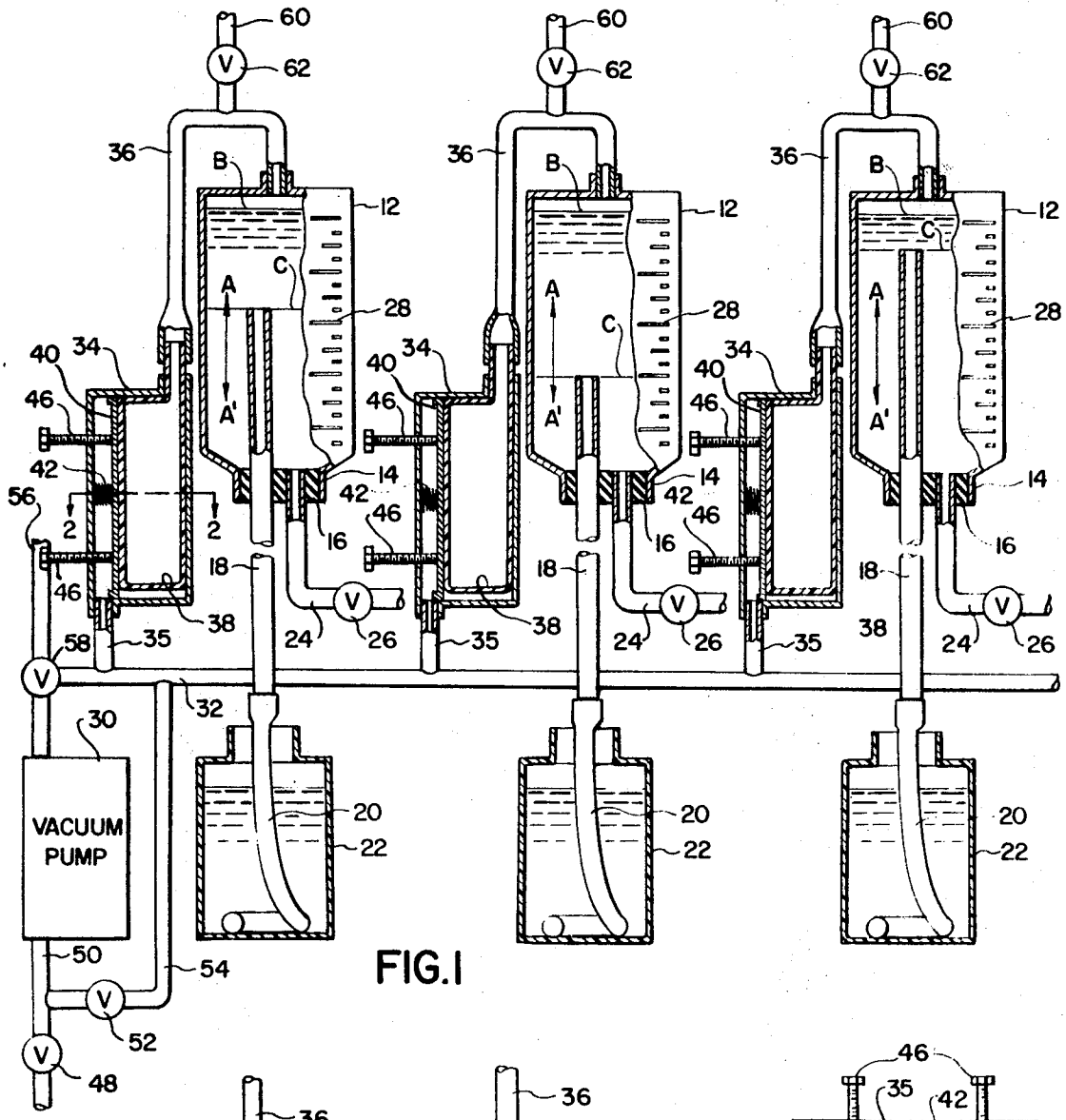

FIG.1

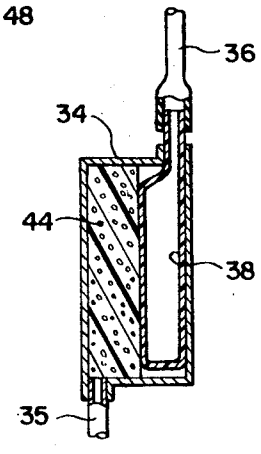

FIG.3

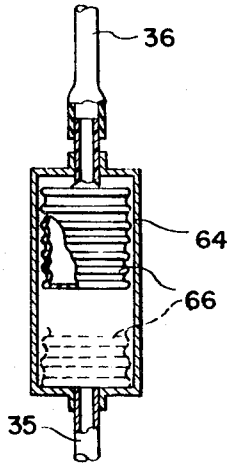

FIG.4

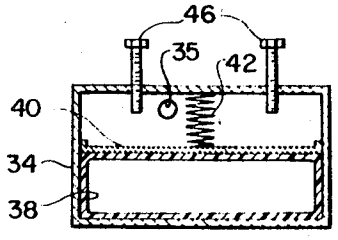

FIG.2

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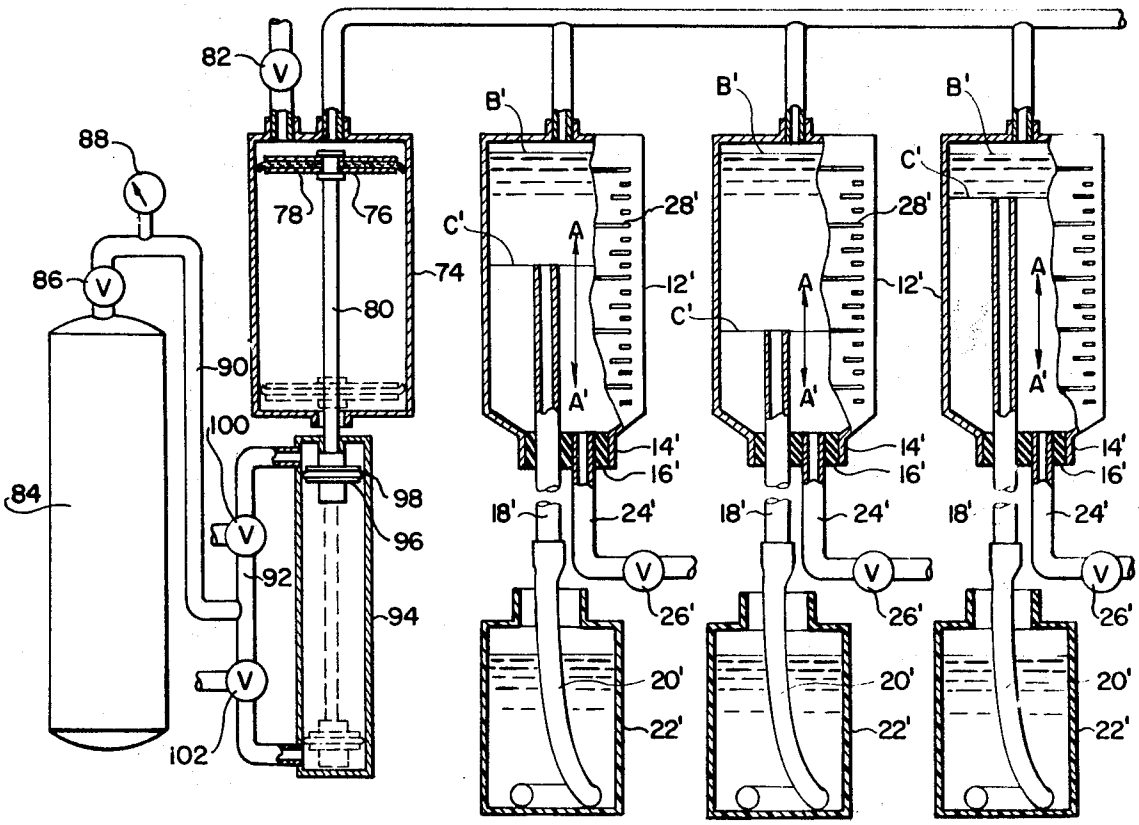

FIG.6

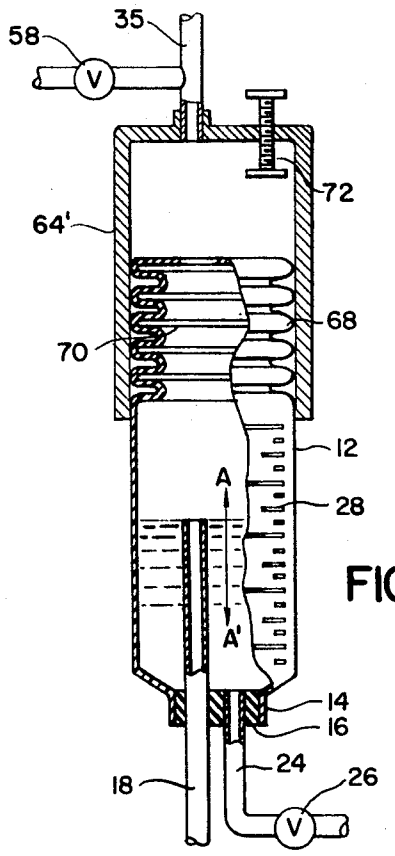

FIG.5

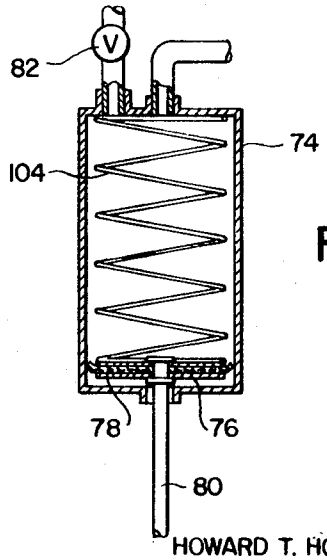

FIG.7

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FIG.8

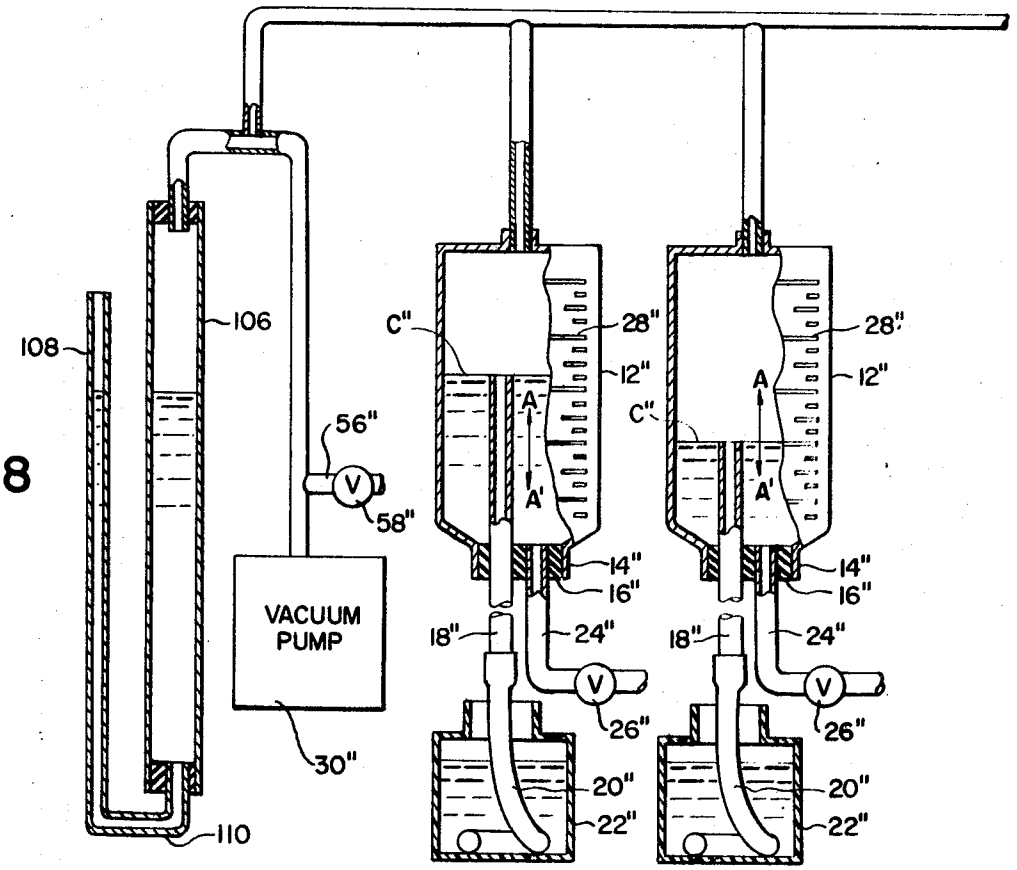
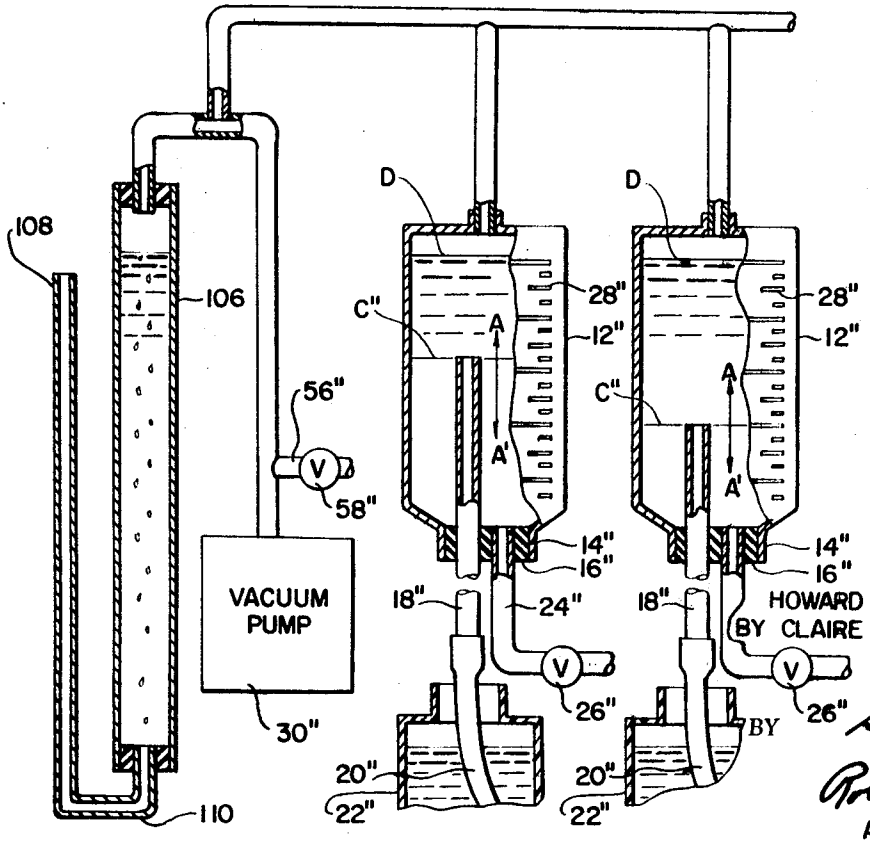


FIG.9



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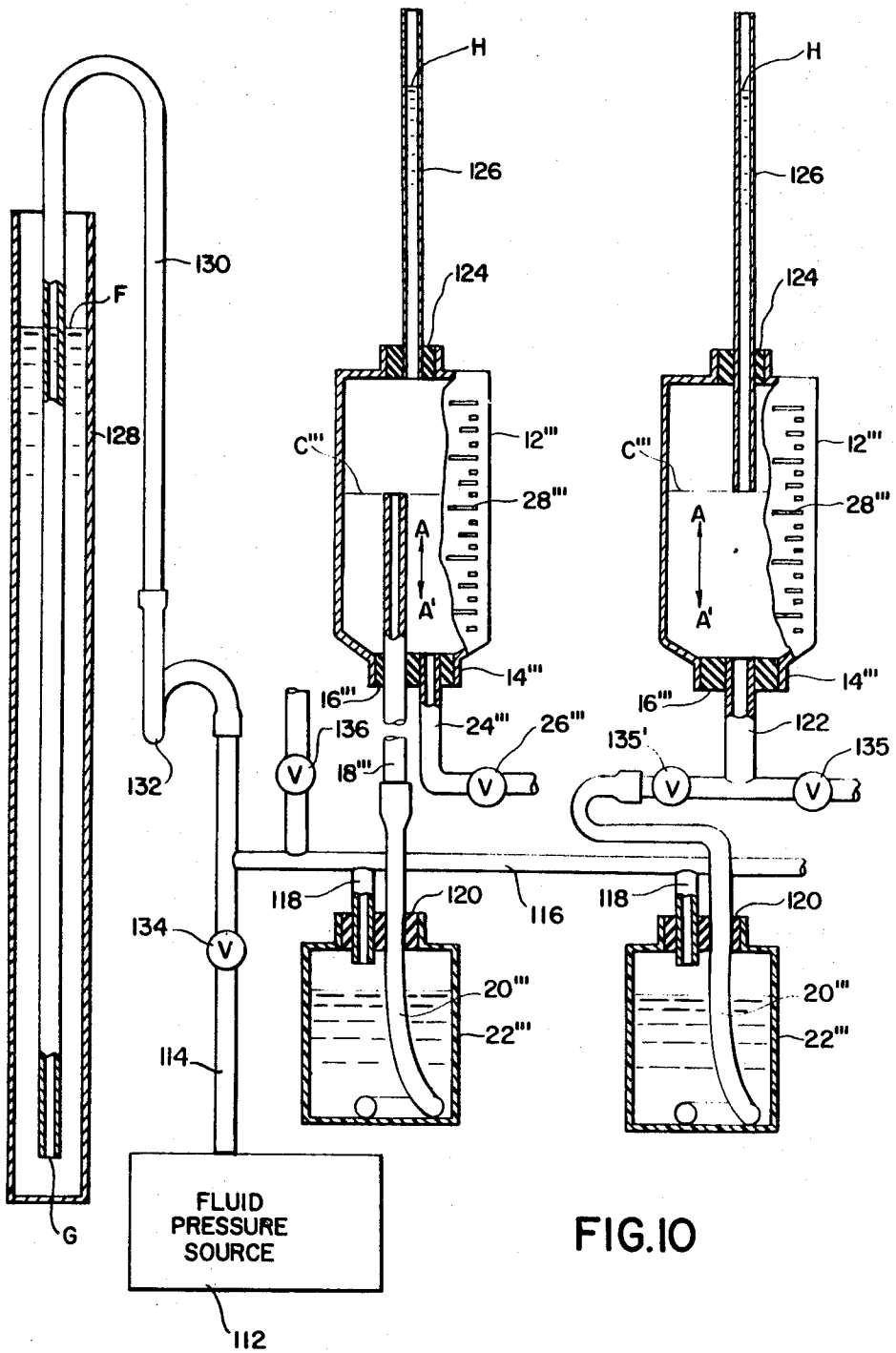

FIG.10

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SOLUTION METERING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates generally to metering devices, and more specifically to an improved power-operated, solution metering apparatus.

Apparatus for metering and/or mixing one or more solutions are particularly applicable to devices and chemical processes that require accurate measurement and delivery of a solution or solutions in precise quantity or proportions. In many of such applications, the metering and/or mixing of a solution or solutions in precise quantity or porportions is provided by precision manufactured pumps designed to maintain a stable pump rate for a given life. In those situations where corrosive solutions are handled, the parts of such pumps that are in direct contact with the solution must be constructed of a material that will not be chemically attached by the solution, or prone to rust or corrode. Naturally, precision pumps of this type are relatively expensive. Also, the performance of such pumps, particularly when designed for a precise flow rate, are subject to variables such as drive speed, wear which affects parts clearances, and changes in supply and output pressures. Applicant's power-operated, solution metering apparatus is believed to obviate many of the disadvantages of such prior known metering apparatus.

SUMMARY OF THE INVENTION

This invention includes within its scope a power-operated, solution metering apparatus for accurately metering and/or mixing one or more solutions. Metering apparatus of this type are useful for replenishing processing solutions in a photographic processing device, and are further useful in any chemical process utilizing mixtures of liquids or solutions. The solution metering mechanism of this invention is operated by a suitable source of motive power, and the volume of solution introduced into a metering container of the apparatus is controlled by volume limiting means coupled to the container such as a volume limiting chamber comprising a hollow flexible member, a suction cylinder, a bellows, a manometer type device, or a pressure regulating device.

One of the objects of the present invention is to provide power operated, solution metering apparatus for devices, chemical processes and the like for metering and/or mixing one or more solutions.

Another object of the invention is to provide a power-operated, solution metering apparatus having volume limiting means for controlling the volume of solution introduced into a metering container of the apparatus.

Objects and advantages other than those set forth above will be apparent from the following description when read in connection with the accompanying drawings:

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a schematic view partially in section showing a preferred embodiment of the solution metering apparatus of this invention with a volume limiting chamber as the volume limiting means;

FIG. **2** is a section view of the volume limiting chamber taken along line **2—2** of FIG. **1**;

FIG. **3** is a segmental view in section of a volume limiting chamber of the type shown in FIG. **2** showing a modification of the resilient pressure pad;

FIG. **4** is a segmental view partially in section showing another embodiment of the volume limiting chamber of FIG. **2**;

FIG. **5** is a segmental view partially in section showing still another embodiment of the volume limiting means of the invention;

FIG. **6** is a schematic view similar to FIG. **1** showing another embodiment of the solution metering apparatus of this invention with a suction cylinder as the volume limiting means;

FIG. **7** is a segmental view of an alternate construction of the power cylinder for operating the suction cylinder of FIG. **6**;

FIG. **8** is a view similar to FIG. **6** showing another embodiment of the solution metering apparatus in its normal position and incorporating a manometer type volume limiting means;

FIG. **9** is a view of the apparatus of FIG. **8** showing the metering apparatus and volume limiting means in a volume limiting position; and

FIG. **10** is a view similar to FIG. **8** showing another embodiment of the solution metering apparatus in its normal position and incorporating a pressure regulating, volume limiting means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, a preferred embodiment of the power-operated, solution metering apparatus of this invention is shown in FIG. **1** as comprising one or more metering containers **12** preferably constructed of a rigid, transparent material such as glass or plastic. Each of the containers **12** has a throat **14** at the lower end thereof provided with an opening for receiving a rubber seal **16**. Any well-known means, not shown, such as a nut in engagement with threads on the periphery of throat **14**, may be provided for holding seal **16** in the opening in sealing engagement therewith. The seal **16** has an opening through which one end of a supply tube **18** is inserted, and slidably adjustable in the direction of the arrows AA'. A flexible supply hose **20** has one end connected to tube **18**, and the opposite end thereof insertable in a supply tank **22** of solution. An output tube **24** has one end partially inserted into an opening in seal **16**, and is provided with a suitable valve **26** for controlling solution flow from container **12** to any suitable solution-receiving device, not shown, such as a photographic processing device or the like. Each container **12** is provided with a volumetric index **28** on the outer surface thereof for indicating the volume of solution in the container at any selected index mark. To meter a precise volume of solution, the operator must adjust metering tube **18** with the upper end thereof in alignment with a selected index mark on container **12**. Solution is introduced into metering container **12** from supply tank **22** until the solution level in the metering container reaches a level designated B which is above the uppermost index mark on metering container **12**. The excess solution in the metering container is allowed to drain back through supply tube **18** into supply tank **22**, and such action will continue until the solution level in metering container **12** is at a level C equal to the top of tube **18**, and represents a precise volume of solution. Upon opening of valve **26**, the precise volume of solution in container is fed by gravity to a receiving means such as a processing device or the like, not shown.

In the embodiment of the invention shown in FIG. **1**, the motive power responsible for introducing solution from supply tank **22** into metering container **12** comprises any suitable vacuum pump **30** connected to a manifold conduit **32** which is blocked (not shown) at the right end thereof when looking at FIG. **1**. A volume limiting means for each container for limiting the volume of solution introduced therein comprises a chamber **34** having a tube **35** at one end connected to manifold conduit **32**, and its opposite end connected by a conduit **36** to the upper end of container **12**. The chamber **34** comprises a housing for receiving a bag **38** preferably constructed of a flexible material such as impregnated cloth, neoprene, plastic, or the like. A resilient means, such as a pressure pad **40** biased by a spring **42** as seen in FIGS. **1** and **2**, or a foam rubber mat **44** as seen in FIG. **3**, is provided for returning bag **38** to its original deflated condition. The pad **40** is slidably movable within housing **34**, and adjustable stops **46** are provided for limiting movement of pad **40** in one direction. It is also possible to use a flexible material such as rubber which will stretch and recover its original shape, thus obviating the need for any additional resilient pressure means. Also, the resilient pressure means may be unnecessary if, following

the suction cycle during which solution is introduced into metering container **12**, valve **48** in pump output tube **50** is closed, and valve **52** in tube **54** is opened so that pump **30** produces an output pressure forcing evacuation of the flexible bag **38**. A vent tube **56** is connected to manifold conduit **32** at a point intermediate pump **30** and the first container **12**, and is provided with suitable vent valve **58** located at the junction of vent tube **56** and manifold conduit **32**. Vent valve **58** is of the two-way kind which is operable to close vent tube **56** to the atmosphere while opening vent tube **56** to manifold conduit **32** or, alternatively, to open vent tube **56** to the atmosphere while closing vent tube **56** to manifold conduit **32**. Furthermore, a vent tube **60** is connected to each conduit **36** at a point intermediate container **12** and chamber **34**, and is provided with a vent valve **62**.

When vacuum pump **30** is operated during a normal suction cycle for introducing solution into metering container **12**, vacuum is applied to control chamber **34** causing bag **38** to inflate resulting in a reduction in pressure within metering container **12** to a value below the pressure in supply tank **22**, in this instance below atmospheric pressure. Accordingly, atmospheric pressure operating on the solution in supply tank **22** forces solution therefrom into container **12**. The chamber **34** is provided with a volume preselected so that when bag **38** inflates and fills the chamber, the metering container **12** is filled with solution to a level B which is above the level of the maximum metered volume indicated, but below the level which would result in solution being forced into bag **38**. By adjusting the position of stops **46** for pressure pad **40**, the level of the volume of solution introduced into container **12** may be varied.

In the operation of the vacuum-operated, solution metering apparatus of FIG. **1**, the operator initially adjusts the setting of tube **18** with the top thereof in alignment with the desired volume of solution to be metered, the valve **58** is operated so that vent tube **56** is closed to the atmosphere and opened to manifold conduit **32**, valve **48** is opened, the valves **26**, **52**, and **62** are closed and vacuum pump **30** is energized for operation through a suction cycle. The vacuum created in chamber **34** during the suction cycle causes bag **38** to expand resulting in a lowering of the pressure within container **12** and solution being forced into metering container **12** to a predetermined level above the metered volume desired. Opening of vent valve **62** allows solution in container **12** to drain back through tube **18** to a level equal to the top of the tube, which is the adjusted volume setting. The valve **26** is opened to deliver the metered volume of solution to any suitable solution receiving means.

FIG. **4** disclosed a modification of the volume limiting chamber of FIGS. **1** and **2** in which a housing **64** is provided with an expandable bellows **66** mounted therein and expandable as shown in broken lines. The bellows **66** may be constructed of a stretchable rubber having a normal closed position to which it inherently returns.

Another modification of the volume limiting chamber is disclosed in FIG. **5**. In this modification, a bellows **68** is provided secured by any suitable means to the upper end of container **12**. A spring **70** in the bellows **68** urges the bellows into a normally closed position as seen in FIG. **5**. During operation, the spring force increases as bellows **68** expands, such force increasing until it is equal to the vacuum force. At such time, solution flow into container **12** is terminated. It is also possible to provide an adjustable stop **72** for limiting the expansion of the bellows **68** to a predetermined amount representing a finite volume of solution introduced into container **12**.

In the modification of the invention disclosed in FIG. **6**, parts similar to the parts disclosed in FIGS. **1** and **2** will be denoted by the same numerals primed. In this modification, the volume limiting means comprises a suction cylinder **74** of fixed displacement within which a piston **76** and sealing ring **78** affixed to one end of a piston rod **80** are reciprocally movable. When a vent valve **82** connected to the upper end of cylinder **74** is closed and piston **76** moved downwardly through a section stroke from its normally inoperative position shown in full lines in FIG. **6** to its dotted position, the pressure in cylinder **74** is decreased to a value below the atmospheric pressure acting on the solution in supply tank **22'**. Accordingly, solution is forced from the supply tank into metering container **12'** to a predetermined level B'. When valve **82** is opened, the solution in metering container **12'** will flow under the influence of gravity through tube **18'** back into supply tank **22'** until the solution level reaches the level of tube **18'**, designated by C'. The solution remaining in metering container **12'** represents a precise volume of solution determined by the initial setting of tube **18'**. Upon opening valve **26'**, the metered solution is fed by gravity to a receiving means such as a processing device or the like.

Any suitable power means may be provided for moving piston **76** and piston rod **80** through its suction stroke and than back to its normal inoperative position. In FIG. **6**, the power means comprises a compressed air or gas cylinder **84** of known type having a valve **86** for controlling the release of the gas, and a gauge **88** for measuring the pressure of the released gas. The gas is fed from cylinder **84** through a tube **90** to a manifold **92**, the ends of which are connected to opposite ends of a power cylinder **94**. The piston rod **80** extends through openings in the bottom and top of cylinders **74**, **94** respectively, and a piston **96** and sealing ring **98** are mounted on the end thereof. Valves **100**, **102** are provided in each of the arms of manifold **92**. With valves **82**, **102** closed and valve **100** opened, manually opening valve **86** introduces gas into the upper end of cylinder **94** for driving the pistons **76**, **96** and piston rod **80** downwardly to provide a suction stroke for the apparatus. By closing valve **100**, and opening valves **82**, **102** gas pressure introduced into the lower end of cylinder **94** will return the pistons **76**, **96** and piston rod **80** to this normal inoperative position as seen in FIG. **6**.

In an alternate construction of the suction cylinder **74** shown in FIG. **7**, a spring **104** may be provided interposed between piston **76** and cylinder **74** which is tensioned during the return of pistons **76**, **96** and piston rod **80** to this normal inoperative position. When the pistons are released by venting cylinder or releasing any suitable latch means, not shown, for the pistons or piston rod, the spring **104** urges the piston **76** through a suction stroke of fixed volume. Although the spring **104** is shown interposed between piston **76** and cylinder **74**, a spring may be interposed between piston **96** and cylinder **94** or between both pistons **76**, **96** and cylinders **74**, **94** respectively.

In the embodiment of the invention shown in FIGS. **8** and **9**, parts similar to parts disclosed in FIGS. **1–4** will be denoted by the same numerals double-primed. In this embodiment of the invention, the motive power means comprises any suitable vacuum pump **30''**. The volume limiting means is shown as a manometer-type device comprising a cylinder **106** partially filled with a liquid, and a tube **108** parallel to cylinder **106** having one end connected by a bent section **110** to the bottom of cylinder **106** and its opposite end open. In this embodiment of the invention, operation of the vacuum pump **30''** causes pressure in metering container **12''** to decrease below the atmospheric pressure in supply tank **22''**. The increased pressure in supply tank **22''** forces solution therefrom into the metering container **12''**. During such action, the pressure in the upper end of cylinder **106** is also decreased below atmospheric, and atmospheric pressure acting on the liquid in tube **108** forces the liquid from tube **108** into cylinder **106**. When all of the liquid in tube **108** is forced into cylinder **106** as best seen in FIG. **9**, an air bypass is formed in which air bubbles through the liquid in cylinder **106** into the upper end of the cylinder in an attempt to equalize the pressure differential. As a result of this bypass, further solution flow into metering container **12''** from supply tank **22''** is stopped. At that point, the solution level in container **12''** will be at some level such as D (FIG. **9**) above the maximum metered volume indicated. This condition will persist as long as vacuum pump **30''** continues to operate. Upon turning off the vacuum pump, solution in con-

tainer 12'' will drain back through tube 18'' until the solution reaches level C'' equal to the top of the tube which is the precise volume of solution that is to be metered. The liquid in cylinder 106 returns into tube 108 where it seeks the same level in both as shown in FIG. 8. Opening valve 26'' delivers the metered volume of solution to a suitable solution receiving means.

In the embodiment of the invention shown in FIG. 10, parts similar to parts disclosed in FIGS. 1–4 will be denoted by the same numerals tripled-primed. In this embodiment of the invention, the motive power means comprises any suitable fluid pressure source 112 such as a container of compressed air or the like shown schematically in block diagram form. The fluid pressure source 112 is connected by a tube 114 and a tube 118 of manifold 116 to the inside of supply tank 22''' through a seal 120 to subject the solution therein to a positive pressure. The metering container 12''' on the right when looking at FIG. 10 is provided with a supply hose 20''' connected by a tube 122 to the bottom thereof, and the container 12''' on the left is provided with the normal supply tube 18''' which is slidably adjustable within container 12''' for controlling the quantity of solution to be metered as described in connection with previous embodiments. The upper end of each of the metering containers 12''' is provided with a seal 124 for slidably supporting a tube 126 open at each end and vertically adjustable within the container for, among other things, controlling the quantity of solution to be metered in those situations where an adjustable supply tube 18''' is not provided for the metering container. Since the volume of solution in tube 126 is extremely small in comparison to the metered quantity, the error in metering volume is negligible. As solution enters a metering container 12''' and reaches the lower open end of tube 126, the container is no longer vented and solution rises in tube 126 to a pint where the pressure of the supported column of solution in the tube equals the air or gas pressure supplied to supply tank 22''', whereupon further solution flow to container 12''' is discontinued.

The solution volume limiting means for this embodiment comprises the aforementioned vertically adjustable tube 126 in combination with a pressure regulating means for regulating the fluid pressure supplied to supply tank 22''', and hence the height of the solution column in tube 126. The pressure regulating means comprises a vertical column of liquid in an open ended cylinder 128. A curved tube 130 has one end insertable within cylinder 128 and its opposite end connected by a flexible hose 132 to tube 114 and fluid pressure source 112 to permit vertical adjustment of tube 130 within cylinder 128 for regulating the fluid pressure supplied to tank 22''' in a manner to be explained hereinafter.

In the operation of this embodiment of the invention when a valve 134 in tube 114 is opened, fluid pressure forces solution from supply tanks 22''' into metering containers 12''', and simultaneously forces liquid out of tube 130 into cylinder 128, the liquid level within tube 130 and cylinder 128 initially being at the same level as seen in FIG. 10. As the pressure builds up, the level of liquid in tube 128 continues to move downwardly until all of the liquid has traveled from tube 130 into cylinder 128. At this pressure, determined by the selected height between the initial level of the solution in cylinder 128 designated F and the open end of tube 130 designated G, air will pass from the end of tube 130 into cylinder 128 and provide a bypass preventing further pressure build up. During this action, the solution in metering containers 12''' enters tube 126 and rises therein to a predetermined level designated H. At this level, the pressure of the column of solution in tube 126 is equal to the regulated air pressure supplied to tank 22''', preventing any further solution flow into containers 12'''. This level may be adjusted to any desired level by raising or lowering tube 130 in cylinder 128, thereby changing the distance between the initial level F of the solution in cylinder 128 and the end G of the tube 130, and hence the value of air pressure supplied to tank 22'''.

Any liquid may be used in the pressure regulating means, and a liquid having a low evaporation rate such as transformer oil or the like is preferred. Also, any suitable commercial pressure limiting valve could be substituted for cylinder 128 and tube 130 of the pressure regulating means. A valve 134 can be turned off and exit valve 135 opened to permit the solution within the metering container 12''' on the right as seen in FIG. 10 to flow to a processing device or the like. The solution within the left container 12''' that is above the level of metering tube 18''' is returned to supply tank upon opening of a vent valve 136. The solution remaining in metering container 12''' represents the precise volume of solution which may be fed by gravity to a receiving means, such as a processing device or the like, upon opening of exit valve 26'''.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. In a solution metering apparatus, the combination comprising:
- a solution supply tank;
- a solution metering container;
- means for interconnecting said solution supply tank and said solution metering container for hydraulic communication therebetween so that said solution metering container can receive solution from said solution supply tank;
- vacuum source means cooperable with said solution metering container for drawing solution from said solution supply tank into said solution metering container;
- means cooperable with said vacuum source means for limiting, to a predetermined volume, solution drawn into said solution metering container from said solution supply tank by said vacuum source means; and
- conduit means for interconnecting said solution metering container, said vacuum source means and said solution limiting means so that a vacuum can be effected therebetween.

2. The combination as recited in claim 1, wherein said solution limiting means includes:
- a chamber having a predetermined volume, said chamber being connected to said vacuum source means for pneumatic communication therewith; and
- an expandable hollow member located in said chamber, said expandable member being connected to said solution metering container for pneumatic communication therewith and being movable between deflated and inflated positions,
- whereby said vacuum source means is adapted to move said expandable member from said deflated position to said inflated position for drawing solution from said solution supply tank into said solution metering container.

3. The combination as recited in claim 2, wherein said solution limiting means further includes:
- resilient pressure means disposed in said chamber and in contact with said expandable member for urging said expandable member for movement from said inflated position to said deflated position.

4. The combination as recited in claim 3, wherein said solution limiting means further includes:
- adjustable means for selectively restricting expansion of said expandable member from said deflated position for varying the volume of solution drawn into said solution metering container from said solution supply tank by said vacuum source means.

5. The combination as recited in claim 2, wherein said expandable member is a bellows, said bellows being integrally connected to said solution metering container and having resilient means in contact therewith for urging said bellows for movement from said inflated position to said deflated position.

6. The combination as recited in claim 1, wherein said solution limiting means includes:

pressure responsive means, said pressure responsive means having a first portion connected to said vacuum source means and said solution metering container for pneumatic communication respectively therewith and having a second portion exposed to ambient pressure,

whereby a pressure differential can be established between said first and second portions of said pressure responsive means.

7. The combination as recited in claim **1**, wherein said solution limiting means includes:

a closed, vertically disposed first vessel partially filled with a liquid, said first vessel having a first cross-sectional area and having upper and lower portions, said upper portion of said first vessel being connected to said vacuum source means and said solution metering container for pneumatic communication respectively therewith;

a vertically disposed second vessel having a second cross-sectional area smaller than said first cross-sectional area of said first vessel and having upper and lower portions, said upper portion of said second vessel being open to expose the interior of said second vessel to ambient pressure; and

means for interconnecting said lower portion of said first vessel and said lower portion of said second vessel for hydraulic communication between said first and second vessels.

8. In a solution metering apparatus, the combination comprising:

a solution supply tank;

a solution metering container;

means for interconnecting said solution supply tank and said solution metering container for hydraulic communication therebetween;

vacuum source means cooperable with said solution metering container for drawing solution from said solution supply tank into said solution metering container;

conduit means for interconnecting said vacuum source means and said solution metering container so that a vacuum can be effected therebetween; and

means interposed in said conduit means between said vacuum source means and said solution metering container for limiting, to a predetermined volume, solution drawn into said solution metering container by said vacuum source means.

9. The combination as recited in claim **8**, wherein said solution limiting means includes:

a chamber having a predetermined volume, said chamber being connected to said vacuum source means for pneumatic communication therewith; and

an expandable hollow member confined in said chamber, said expandable member being connected to said solution metering container for pneumatic communication therewith and being movable between deflated and inflated positions,

whereby said vacuum source means is adapted to move said expandable member from said deflated position to said inflated position for drawing a predetermined volume of solution from said solution supply tank into said solution metering container.

10. The combination as recited in claim **8**, further comprising:

means connected to said solution metering container for reducing, to a selected volume, a predetermined volume of solution drawn into said solution metering container by said vacuum source means; and

means connected to said solution metering container for delivering a selected volume of solution from said solution metering container.

11. The combination as recited in claim **10**, wherein said solution reducing means includes:

means for supporting said solution metering container above said solution supply tank;

means for mounting said solution supply tank and solution metering container interconnecting means for movement within said solution metering container between a plurality of discrete elevational levels; and

means for venting the interior of said solution metering container to ambient pressure.