

April 14, 1964

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3,128,782

SMALL VOLUME FEEDER PUMP AND PROCESS OF PROPORTIONAL FEEDING

Filed Feb. 13, 1961

3 Sheets-Sheet 1

FIG. 1

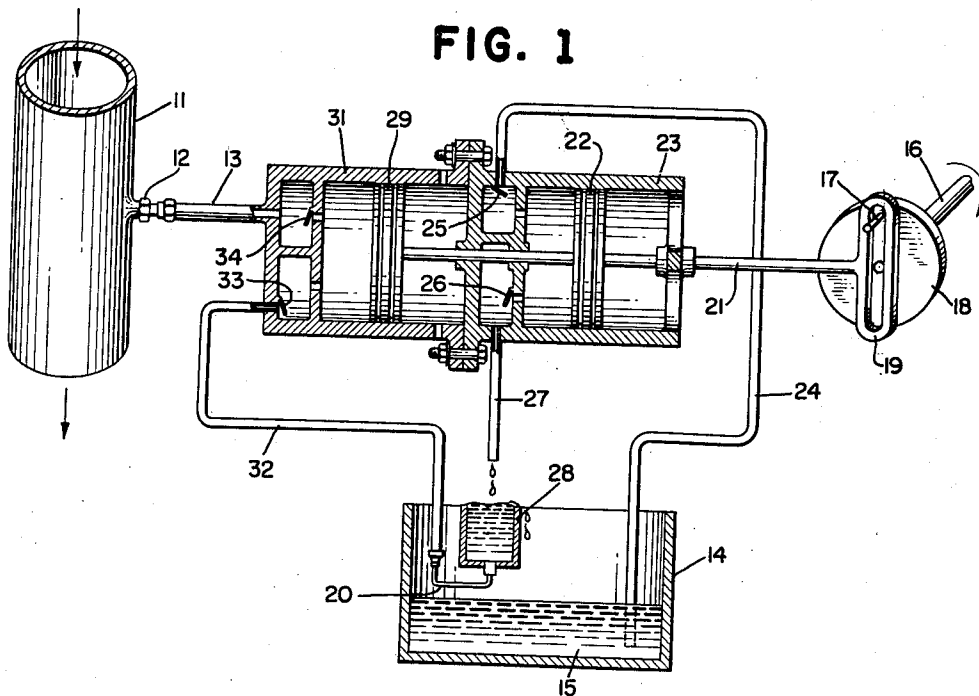


FIG. 2

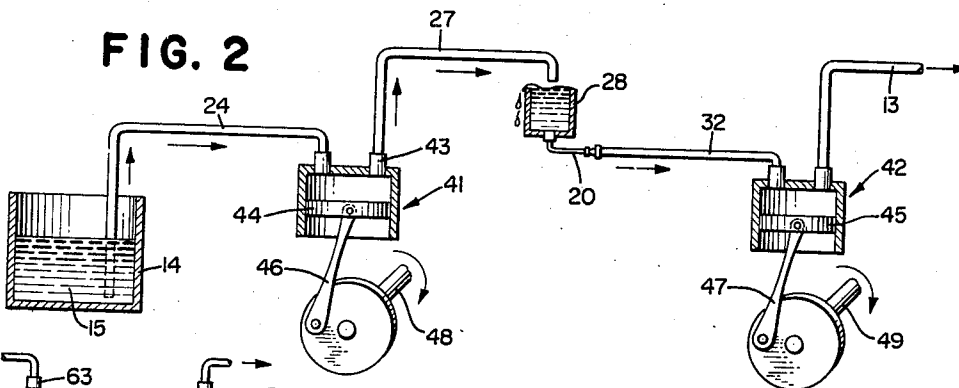


FIG. 3

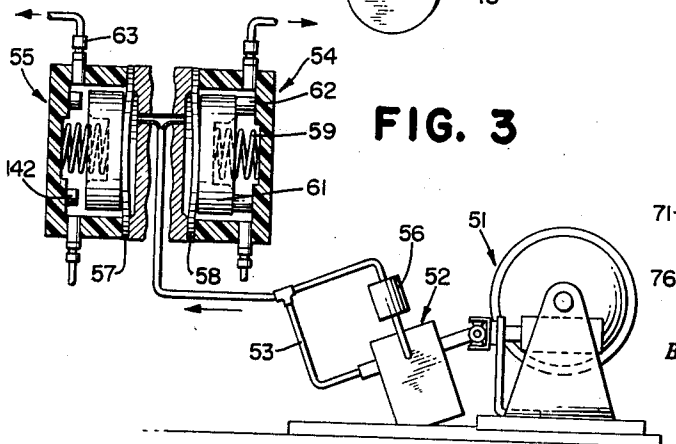
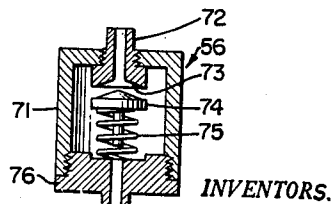


FIG. 4



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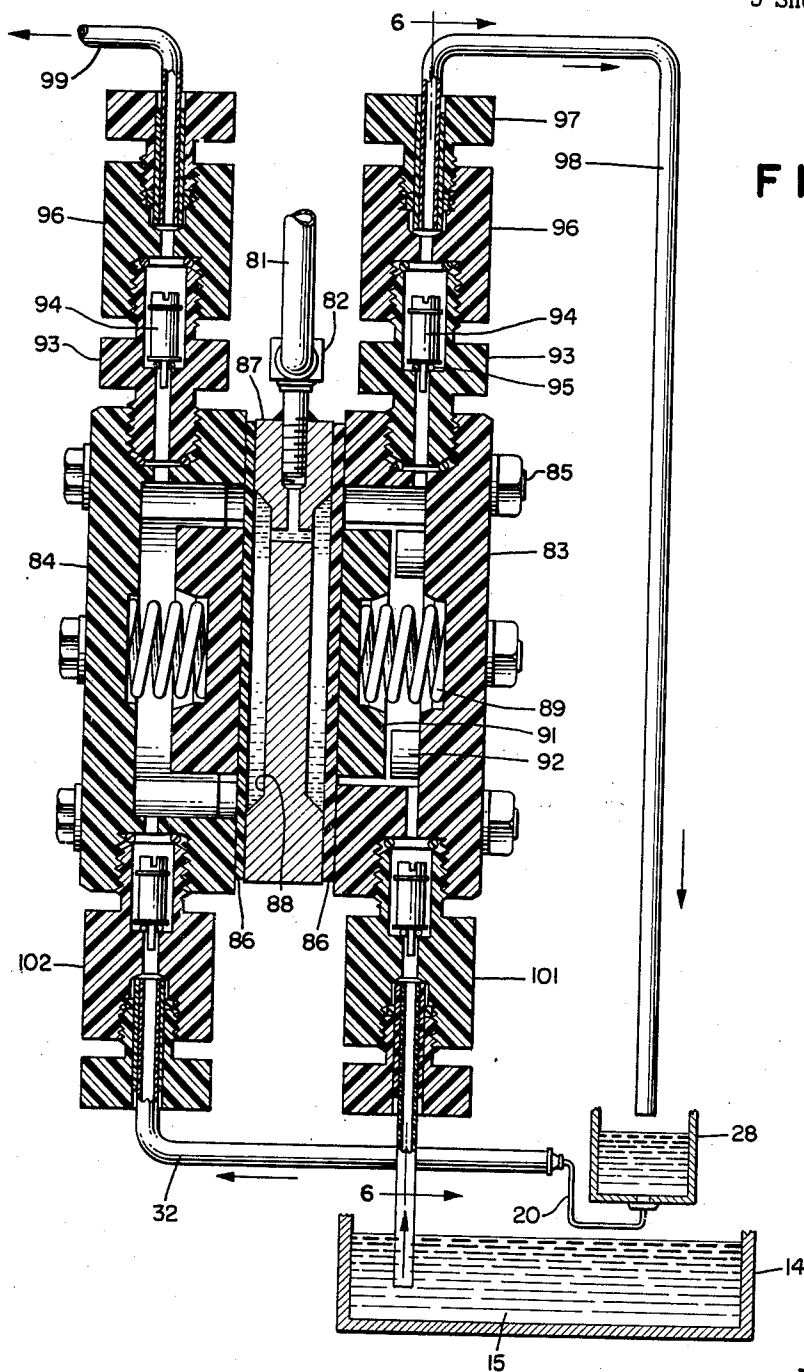


FIG. 5

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FIG. 6

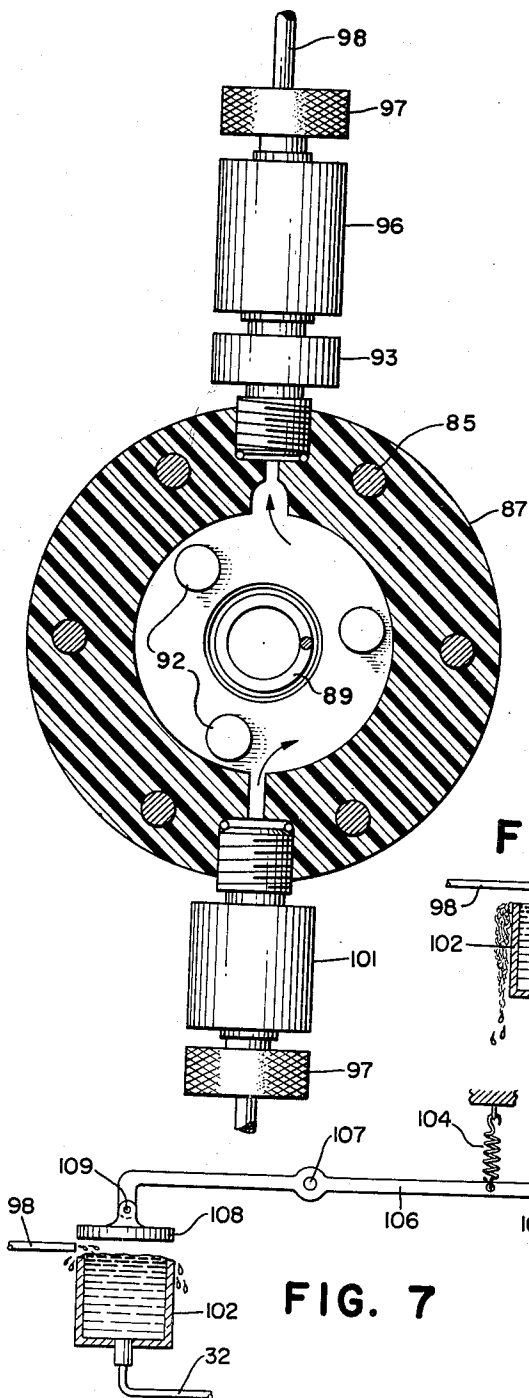


FIG. 7

FIG. 10

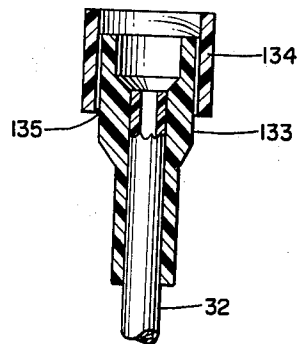


FIG. 11



FIG. 9

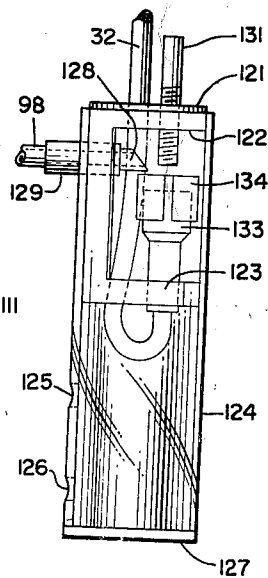
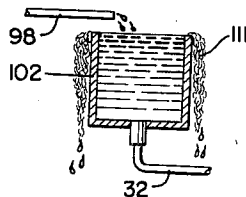


FIG. 8



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SMALL VOLUME FEEDER PUMP AND PROCESS OF PROPORTIONAL FEEDING

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Filed Feb. 13, 1961, Ser. No. 88,798
8 Claims. (Cl. 137—1)

This invention relates to chemical feeder pumps, and more particularly to an improved form of small volume metering pump having a high order of metering accuracy.

This application is a continuation-in-part of our copending application Serial No. 84,735 filed January 24, 1961 for Proportioning Pump.

Metering pumps of the ordinary kind referred to here are displacement devices, usually of small but definitely determined capacity, which are useful for injecting known quantities of reactant chemicals into a body or medium, such as water or other chemical to be treated. It is frequently the case that they are employed to inject small and accurately measured quantities of a highly concentrated reactant into a relatively large flow of medium at an average rate proportioned to the flow of the medium, and in such case they are of course termed proportioning pumps.

The reactants so handled comprise a wide variety of concentrates including as examples hypochlorous acid for purification of water, and vitamin solutions for addition to foodstuffs. Obviously, a considerable degree of precision in the amount of reactant pumped by the proportioning pump is necessary in most of these cases. For reasons later to be discussed, however, all metering pumps are inexact in some degree, and this has been accommodated in the prior art by overpumping by an amount at least sufficient to insure that the minimum required proportion of reactant is always maintained in the treated medium. This excess of pumped reactant, although wasted, is moderate in amount and harmless to the medium in most of the cases where such pumps have been employed.

In certain cases where the reactant is either expensive or dangerous in nature, and the injection of, for example, poisonous fluorine compounds into drinking water for public health purposes of dental hygiene might be mentioned as an example of such a poisonous or dangerous ingredient, it becomes very undesirable to overpump the reactant in any degree greater than is absolutely necessary to insure a complete treatment.

In all cases where substantial volumes of reactant are handled, a considerable saving could be made by reducing or eliminating the need for overpumping if a more dependably accurate metering pump were available.

There is a further problem encountered in metering pumps of the kind which handle relatively small volumes of fluid and that is the fact that because of an extremely small flow of liquid through them, such flow has little or no washing and self cleaning effect on the valves of the pump, such as would obviously occur in valved pumps operating at larger flow rates. Being often constructed of transparent plastic materials in some part, the valves of such pumps may be seen during operation of the pump under these conditions, and their motion may be quite invisible to the naked eye. It is obvious that the passageway actually open to reactant fluid around the valves more closely resembles a filter than a duct, and it acts as such, trapping even particles which are almost microscopic in size between the valve and its seat. Under such conditions, the accuracy of metering of the pump is of course destroyed, and this is also a very difficult malfunction to detect so that it may persist unnoticed for a long time. It is customary to filter the reactant both before pumping it, and upon its entry into the pumping system, and the prob-

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lem is thereby alleviated, but practical considerations usually prevent the perfection of filtering and perfect cleanliness required to entirely overcome this defect.

The inaccuracies latent in the ordinary metering pump may arise from inexact initial construction, change in dimension of parts due to prolonged stress, wear of mechanical parts due to age and use or possible corrosion of parts due to the type of chemicals and materials used for reaction with large volumes of liquid. For example, wear in the connecting rod bearing of a piston pump will cause a directly proportional change in the volume of reactant swept out by the piston at each stroke of the pump, and consequently in the pump delivery.

It is an object of the invention whereby each and every one of the above-described difficulties encountered in the use of conventional metering pumps is overcome or greatly mitigated by us through provision of a metering pump having novel principles of operation as will be herein-after described and illustrated.

It has always heretofore been regarded as an indication of serious malfunction when air bubbles are found anywhere within the circuit of a metering pump system, and in fact, it is primarily to make their detection and observation possible that such pumps and even the fluid conduits making connection to the pumps, have been constructed almost entirely of transparent plastic or like materials. As a result of this, when such a system is properly operating, there is nothing to be seen through the transparent members, since the system is completely filled with fluid, usually itself transparent. If any visible motion occurs within the fluid passageways of such a system, however, it is a clear indication of the entrainment of air bubbles, and consequent malfunction, although as above pointed out, by no means a reliable indication of all kinds of malfunction.

Another object of the instant invention is predicated upon the principle of correct metering pump operation only at those times when there does exist a substantial and continuous entrainment of air in the discharge of the metering pump.

As a result of this, correct operation of the system is indicated by a free and constant flow of numerous large air bubbles through the transparent system, which are visible from a considerable distance. A stoppage in the reactant supply conduit or system is instantly indicated by a highly visible stoppage of this regular flow of air bubbles through the system, instead of remaining completely concealed, as in former devices. Small effervescent bubbles of dissolved gas which emerge from the reactant fluid when pumping suction is applied to it, no longer pulsate in size in accordance with pump pulsations in such a way as to impair the designed accuracy of the pump, as in former devices. Inoperativeness of the pump inlet or outlet valve, the most common mode of failure in these devices, is clearly indicated by a diminution or cessation of the flow of bubbles, instead of remaining concealed, as formerly. Particles of foreign matter which cause such inoperativeness by lodging between valve and valve seat are flushed through by a generous flow of air and consequent highlift of the valves, as well as by the impact of entrained fluid particles upon them, where former devices could not lift the valve off the particle because of their minute fluid flow rate, and had substantially no washing effect on the valves for the same reason.

Metering inaccuracies due to changes in pump displacement volume brought about by age or wear are avoided, and even those due to inaccuracies in pumping chamber design, construction or calibration do not arise, since pump design is not conducted on the basis of pumping a known and constant volume of a single fluid. On the contrary, by predicating pump design upon the principle of pumping a mixture of fluid reactant and fluid air in

non-critical proportion, all need for metering accuracy in the pump chamber and its associated mechanical parts is avoided, and the design requirements for measurement accuracy transferred to the stable and inherently accurate measuring means about to be described. The only design requirement remaining on the instant pumping chamber is that it be able to pump reliably a quantity of mixed air and reactant which is greater than a specified minimum quantity, how much greater is of no consequence as it has no effect upon the result. Such a requirement is both possible and easy to fulfill, in contrast to the requirement for pumps operating on the principle of the prior art, that they pump at each stroke an exact and unvarying predetermined volume of a single fluid, which volume must however remain at all times conveniently and precisely adjustable. Obviously, this latter requirement to which prior pumps are designed can never be completely met, but only approached more or less closely, leaving some residual inaccuracy, as before noted.

Further advantages of the instant invention, as for example, in respect to an improved speed of proportioning pump operation made possible by employment of the stated principle of operation will later become apparent.

A clearer understanding of the invention may now be had by reference to the following detailed description of a specific illustrative example of a preferred embodiment thereof, taken in conjunction with the drawings, wherein:

FIG. 1 represents parts and arrangement of a metering pump system in accordance with the instant invention;

FIG. 2 represents an alternative construction of such metering pump system parts;

FIG. 3 represents a preferred construction of some of the parts for a metering pump;

FIG. 4 is a cross sectional view of a part of FIG. 3;

FIG. 5 is a cross sectional view of a preferred form of a part of FIG. 3;

FIG. 6 is a sectional view taken on line 6—6 of FIG. 5;

FIG. 7 is a view of a preferred form of a part of FIGS. 1 and 2;

FIG. 8 is a sectional view of a portion of FIG. 7;

FIG. 9 is another form of the device of FIG. 7;

FIG. 10 is another form of the device of FIG. 7; and

FIG. 11 is an alternative component of FIG. 3.

Turning now to the drawings wherein like reference numerals refer to like parts throughout, there is shown in FIG. 1, a pipe or conduit 11 wherein there is flowing a stream of fluid as indicated by the arrows in connection therewith, and to which is fastened a pipe 13 by means of a fitting 12. A container 14 contains a supply of reactant 15 for distribution into the said stream at a controlled average rate. Shaft 16 rotated at a controlled rate in the direction of the arrow by means, not shown on the drawing, drives pin 17 in disk 18 to oscillate a yoke 19, on piston rod 21. Piston 22 is thereby reciprocated in pump housing 23 causing reactant 15 to be drawn through inlet pipe 24 and valve 25, and to be discharged through valve 26 and discharge pipe 27 into cup 28 which is constructed to have a carefully controlled and invariant volume. The volume of pump housing 23 in the portion swept out by piston 22 is substantially in excess of the volume of cup 28 so that it is overfilled at every stroke, and overflows into container 14, remaining full. On the reverse stroke of piston 22 from that which fills cup 28, the piston 29 connected to rod 21 and acting in housing 31 acts to draw reagent from cup 28 through valve 33 and pipe 32 having a portion 20 of reduced diameter for reasons later explained, and when again reversed, to discharge it through valve 34 and into the pipe 13, whence it is discharged into the conduit 11. The diameter of piston 29 is such that in combination with the eccentricity of pin 17 which determines the stroke of rod 21, there is swept out at each stroke a volume substantially in excess of that of cup 28, so that the cup is entirely emptied and a considerable volume of air is taken in through the empty cup at the end of each stroke.

By these means all inaccuracies in the construction and pumping volume of the pumps are rendered immaterial to the production of an accurately metered flow of reactant. Only the rate of pump reciprocation and the volume of liquid retained by the cup 28 are significant elements determinative of measuring pump discharge flow rate. It will be observed that a necessary sequence of operations must be maintained, and that cup 28 must be filled by motion of piston 22 at a time when there is no withdrawal of reactant through the pipe 32 by the piston 29. This is accomplished by operating the said pistons from a single piston rod 21 and associated shaft 16.

Because of the small diameter of the pipe portion 20, the refilling of cup 28 with reactant is not accompanied by any flow of the reactant into the pipe until suction in the pipe 32 occurs, so that the metering accuracy of cup 28 is unimpaired.

In FIG. 2 there is seen another arrangement for producing the same result, wherein separate displacement pumps 41 and 42 having valves such as 43 are provided with pistons 44 and 45 respectively, which are reciprocated by connecting rods 46 and 47 from the shafts 48 and 49. It will of course be understood that cup 28 of FIG. 2 could be located over the vessel 14, as shown in FIG. 1, for the purpose of recovering the overflow therefrom, or in the alternative, separate conduit means may be provided for this purpose in an obvious manner. As previously pointed out in connection with FIG. 1, it is imperative that the rotation of shafts 48 and 49 be timed, not only in respect to the quantity desired to be metered, but in this case also with respect to each other, so that they remain always in step in order that no flow may occur in the pipe 32 at a time when flow is occurring in pipe 27. The pistons 44 and 45 may, and in all except cases of exceedingly small rates of fluid flow, will usually be replaced by diaphragms of the conventional diaphragm type pump because of its freedom from leakage problems, and its freedom from likelihood of sticking, as hereafter described.

In FIG. 3 there is seen an adjustable speed electrically driven stroking mechanism 51 of the general type disclosed in our copending application Serial No. 84,735 for Proportioning Pump dated January 24, 1961.

It is connected to and operates an hydraulic pulsing unit 52 as described in the aforesaid application, and which provides to the output hydraulic line 53, timed hydraulic impulses which may be of an amount more than sufficient to actuate the diaphragm pumps 54 and 55. A pressure relief valve 56 is therefore connected between the output line 53 and the pulsing unit 52 to return the excess of the hydraulic pulse thereto without danger of rupturing the diaphragms 57 and 58 of the diaphragm pumps. Said diaphragms are shown in the distended position, and at the conclusion of an hydraulic pulse are returned to a relaxed position by means of springs, such as 59 operating on cheek pieces such as 61. Resilient blocks of compressible material, 141 of FIG. 11, may be used instead of springs 59 as in cases where unusually corrosive reactants are to be pumped, and may be made, for example of rubber or of synthetic rubber. There are inserted in the chamber of the pump 54 blocks such as 62 to stay the motion of cheek piece 61 and consequently the diaphragm 58. This is done so that when connected in the arrangement of FIG. 2, the supply pump 54 by reason of the lower head against which it operates, will not "hog" the hydraulic pulse by doing all of the pumping while leaving pump 55 idle. It will be remembered that each pump is designed to provide substantially more than sufficient flow on each stroke, and unless so blocked, the stroke volume of pump 54 is so much in excess of the requirements of the usual sized measuring cup that an hydraulic pulse of normal volume could be thus entirely absorbed. Similar but smaller blocks such as 141 may be inserted in the chamber of pump 55 in

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order to reduce the pump volume to an amount better adapted to the requirements of a particular type of installation when utilizing a pumping chamber of standardized design. Appropriate check valves such as 63 are provided in the customary manner when connecting the pumping unit of FIG. 3 into the system of FIG. 1 or 2, and it will be apparent that these may be of a type later to be described, which are effective to pump liquidaceous materials by which is meant fluid substances which may be other than completely dissolved materials, such as suspensions and light slurries, provided that the size of the suspended particles is small enough for them to remain in suspension during the pumping operation, and also small enough so that they will not seriously interfere with the operation of the pump valves.

FIG. 4 shows the interior details of the relief valve shown at 56 in FIG. 3. It will be seen that a housing 71 has an inlet fitting 72 affixed at one end thereof, having a conical seat 73 therein. A plunger 74 having a mating conical portion, normally is pressed into contact with the seat 73 by force of the spring 75 pressing against the outlet fitting 76. When fluid pressure in the inlet fitting exceeds a predetermined amount, spring 75 yields, permitting plunger 74 to withdraw from seat 73 and allowing fluid to discharge through the valve to relieve excess pressure and prevent bursting of the pump diaphragms.

In FIG. 5 there is shown a two-stage diaphragm metering pump of the preferred form, which is actuated by hydraulic pulsing from a unit such as 51 just mentioned, through an oil line 81 and entrance fitting 82. Chambers 83 and 84, which together with the valve chambers and valves are best made of a transparent plastic material for visibility of the flow of fluid, are fastened together by means of through bolts such as 85. Between them are located flexible diaphragms 86 of an impervious material, such as polytetrafluorethylene. A metal plate 87 provides means for securing fitting 82, and connects its channel to recesses such as 88 behind the diaphragms 86. Springs such as 89 acting on cheek pieces such as 91 distend the diaphragms in the manner heretofore described, and blocks such as 92 serve to limit the pump volume of the supply pump also as before described.

Valve chambers 93 contain outlet valves 94 in communication with their respective pump chambers and have O ring seals, such as shown at 95, to prevent leakage. Fittings 96 accommodate each outlet valve to a compression nut 97 for the supply pump outlet line 98 and discharge pump outlet line 99, respectively. Identical inlet valves are contained in the housings 101 and 102, and are similarly connected to their respective inlet lines which are preferably made of transparent plastic material. The arrangement of inlet and outlet valve chambers 101 and 93 respectively on the plate 87 may be seen more clearly in FIG. 6 which is a section taken on the line 6-6 of FIG. 5.

The vessel 14 and cup 28 of FIG. 5 are diagrammatic in respect to this figure, and represent an arrangement found to be subject to improvement in certain instances of practical application. When the volume of reactant is relatively small, the size of cup 28 is such that the effect of meniscus on the surface introduces undesirable variability in its operating volume.

A means of overcoming this error is shown in FIG. 7 wherein a cup 102 is filled by the supply pump outlet tube 98 during the positive pressure period of the hydraulic pump driving pulse. During this period, bellows 103 which is connected to the hydraulic line 53 of FIG. 3 by means of its tube 53' is distended against the force of the fixed ended spring 104. Being pivoted at 105 to the lever 106 which is fulcrumed at 107 the remote end of the lever is thus raised carrying with it the cover 108 pivoted thereto at 109. As the pressure of the hydraulic pulse decreases, spring 104 causes the cover to lower onto cup 102, leveling the surface of the liquid which is then

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withdrawn through tube 32 as the hydraulic pressure further decreases. Another method of accomplishing this result is seen in FIG. 8 wherein the cup 102 is surrounded by woven wicking 111. In this case the capillarity of the wicking is sufficient to draw down the meniscus of the liquid in cup 102 without further mechanical arrangements. However, a drawback of this device is that the wicking may become contaminated if the reactant is not of suitable composition, and for that reason the device of FIG. 9 is preferred.

A cylindrical retainer 121 having a deep notch 122 and a cut-away portion 123 is retained in a cylindrical tube 124 having a bottom plug 127 and drain holes 125 and 126 for return of reactant to a storage vessel by gravity. Inserted in retainer 121 is a nozzle 128 retained in a sleeve 129 and communicating with supply pump discharge pipe 98. Discharging horizontally, the stream of reactant from nozzle 128 impinges on screw 131 and is deflected downwardly into the cup 133 which is exteriorly prismatic in shape surrounded by shield 134, which is slotted so that it may resiliently grip the cup 133 while at the same time remaining easy to adjust manually in the vertical direction. A suction tube 32' leads to the second stage pump inlet as previously described, and makes connection to the cup 133 in the manner seen more clearly in FIG. 10, the entire assembly conveniently being made of transparent plastic material for reasons before set forth.

In FIG. 10, which is a vertical cross sectional view of a portion of FIG. 9, it is seen that the tip of tube 32' is relatively small in internal diameter, and this is found to be desirable in order to prevent the flow of liquid downwardly out of the cup 133 while it is being filled. The interstice 135 occurring between sleeve 134 and cup 133 is the result of fitting a cylindrical sleeve over a cup of polygonal cross section and is an essential portion of the invention. It may also be produced by filing or machining flats on the exterior surface of a cylindrical cup or by broaching internal longitudinal recesses in the sleeve. In any event, the depth of the interstice in its minor dimensions should be such as to provide sufficient capillarity to discharge the meniscus formed in the cup to the desired degree in the interval normally occurring between filling of the cup and withdrawal of its contents by the second stage pump. Four or five hundredths of an inch on a three-eighths inch diameter cup is satisfactory for aqueous reactants in contact with acrylic materials, and is not critical, since the adjustability of the height of sleeve 134 will allow some variation of the constant volume measured by the resultant assembly. This is because the effect of sleeve 134 is to immediately regulate the liquid meniscus to a constant shape and height at the top of cup 133, which is therefore adjustable in the region where cup and sleeve levels approach, within the small range necessary to calibrate the entire equipment for measuring a precise volume of liquid at each pump stroke.

Because of the unusually small volume of reactant thus accurately pumped at each pump stroke, it is obvious that more frequent pump strokes may be employed by the instant arrangement, and this is very advantageous, as it results in a much more uniform and better distributed flow of final mixture in the conduit 11 of FIG. 1, which is desirable for all purposes, and sufficiently essential in some applications to require separate mixing equipment. This is usually in the form of a mixing tank, and in appropriate circumstances, the superior mixing thus provided by this feature of the instant invention can be adequate to overcome the need for installing this expensive extra equipment.

It is of course clear that the proportion of reactant provided by the metering pump is determined not only by the adjustment of the volume of the cup 133, but also by the speed of pumping, and this is rendered adjustable by conventional means associated with the prime mover of

the hydraulic pulsing means, as described in the reference aforementioned.

Although this invention has been described in terms of a specific illustrative example of the preferred form thereof it is obvious that to those skilled in the art there will occur modifications and alternatives which do not depart, however, from the essential spirit of the invention. It is, therefore, intended that the invention be limited only by the appended claims.

What is claimed is:

1. In a system for providing a metered flow of liquid, metering means comprising an open measuring vessel, means to overflow the vessel with liquid, means to lower the meniscus of the liquid in the overflowed vessel to a constant predetermined level, and means to remove the liquid from said vessel wherein said means to lower the meniscus of the liquid comprises a cover mounted for movement into a predetermined position below the top of said meniscus of the liquid in the open measuring vessel, and said cover being mounted for downward swinging onto said measuring vessel, and means to swing said cover downward and means to raise said cover.

2. In a system for providing a metered flow of liquid, metering means comprising an open measuring vessel, means to overflow the vessel with liquid, means to lower the meniscus of the liquid in the overflowed vessel to a constant, predetermined level, and means to remove the liquid from said vessel wherein said means to lower the meniscus comprises a body of capillary material disposed adjacent to the lip of said measuring vessel to withdraw the meniscus of said liquid by capillarity.

3. In a pumping system, a measuring vessel, means for periodically filling the same to overflowing with liquid, a pumping device for periodically withdrawing said liquid along with some air from said vessel; means for timing the filling and withdrawing periods so that they do not coincide, and means for varying the volume of the measuring vessel.

4. A pumping system comprising supply pump means having a reciprocating pumping movement, means in connection therewith for limiting said movement to a predetermined amount, discharge pump means comprising a displacement pump, said displacement pump having a definite and certain displacement volume and a repetitive reciprocating pumping cycle wherein said displacement volume is pumped by said displacement pump at each said cycle, open cup fluid measuring means located for filling by said supply pump means at each said pumping movement thereof, and connected for emptying by said discharge pump means, said displacement volume of said discharge means always exceeding the volume of said open cup fluid measuring means, fluid overflow means comprising cup fluid level control means located in prox-

imity to said open cup fluid measuring means effective to provide cup filling to a constant predetermined volume, and hydraulic means interconnecting the said supply pump means and the said discharge pump means for applying hydraulic pumping pulses thereto for producing substantially simultaneous reciprocating pulses thereto for producing pumping strokes in each said pump.

5. The invention of claim 4 wherein said overflow means comprises wall means surrounding said open cup fluid measuring means at cup lip level and spaced therefrom by a radial distance of capillary dimensions, whereby liquid standing above the lip of the cup is drawn into the capillary space until a constant predetermined height of liquid is reached in the cup to provide a constant volume of liquid therein at each filling of the cup.

6. The process of proportioning one liquid containing an entrained gas with another liquid flowing under desired pressure and having a particular rate of flow, which comprises supplying a flow of said one liquid at a flow rate which is arbitrarily large, repetitively intercepting and measuring out discrete and predetermined-volume portions of liquid from said flow of said one liquid at a uniform rate of repetition, injecting each said measured-out portion of said one liquid together with an arbitrary amount of entrained gas into said other liquid, and adjusting the said repetition rate of said interception, measuring, and injection to provide a predetermined concentration of said one liquid in said other liquid at the said particular rate of flow of the said other liquid.

7. Metering pump means for metering liquids comprising in combination, a measuring vessel, supply pump means operable for providing a periodic supply of fluid into said measuring vessel, said period of operation being adjustable as to repetition rate thereof and a fluid discharge means connected to said measuring vessel for the periodic emptying thereof at periods having a repetition rate equal to that of said supply pump means, the said discharge means having a discharge capacity exceeding that needed to empty said measuring vessel at each emptying period.

8. In a system for providing a metered flow of a liquid, means comprising an open vessel, means periodically to overflow said vessel with liquid, means to lower the meniscus of the liquid in said filled open vessel to a constant predetermined level, and means to thereafter remove the liquid from said vessel, said means to lower the meniscus comprises capillary means mounted for periodic movement into position on the said open vessel.

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