United States Patent [19]

Carlyle

[11] E **Re. 29,193**

[45] Reissued **Apr. 26, 1977**

[54] **FLUID METERING DEVICE**

[75] Inventor: **Lance John Carlyle,** Cambridge, New Zealand

[73] Assignee: **Economics Laboratory, Inc.,** St. Paul, Minn.

[22] Filed: **Oct. 6, 1975**

[21] Appl. No.: **619,951**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **3,818,924**
Issued: **June 25, 1974**
Appl. No.: **294,984**
Filed: **Oct. 4, 1972**

[52] **U.S. Cl.** **137/99;** 137/101.31; 222/57; 417/375

[51] **Int. Cl.²** **G05D 11/00**

[58] **Field of Search** 137/98, 99, 99.5, 101.31, 137/88; 417/375, 393; 222/57

[56] **References Cited**

UNITED STATES PATENTS

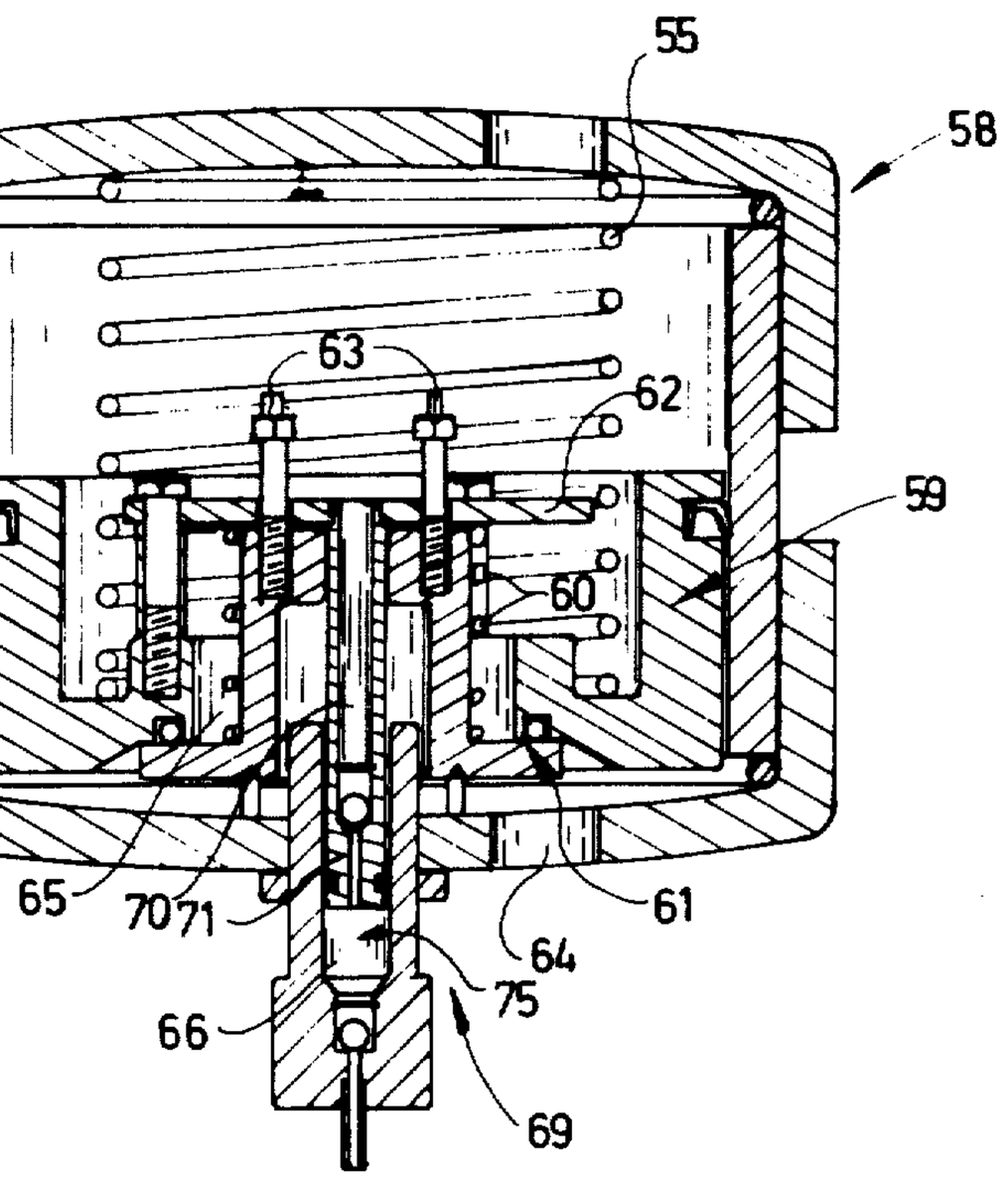
3,049,266	8/1962	Werry	137/99.5
3,205,825	9/1965	Kojabashian et al.	417/375
3,228,560	1/1966	Tacchi	417/375 X
3,489,162	1/1970	Meynell	137/111
3,604,444	9/1971	Tacchi	137/111

Primary Examiner—William R. Cline
Attorney, Agent, or Firm—Merchant, Gould, Smith, Edell, Welter & Schmidt

[57] **ABSTRACT**

A fluid metering device mixes a predetermined quantity of a first fluid with a larger quantity of second fluid supplied to the device at a higher pressure on each cycle. The pressure of the second fluid provides the force necessary to motivate a first pumping means which on movement to an 'outlet' position within a housing displaces the mixed fluids on an outlet side of the first pumping means to their destination. Movement of the first pumping means actuates a second pumping means which pumps a predetermined quantity of the first fluid into the housing on each cycle. On the maximum pumping stroke of the first pumping means being reached at the 'outlet' position, a passage is opened in the first pumping means which is then restored to an 'inlet' position, the second fluid in the housing passing through the passage during such restoration and thus being available for dispatch on the next pumping stroke. When the first pumping means reaches the 'inlet' position the passage closes and a further pumping cycle commences.

19 Claims, 20 Drawing Figures



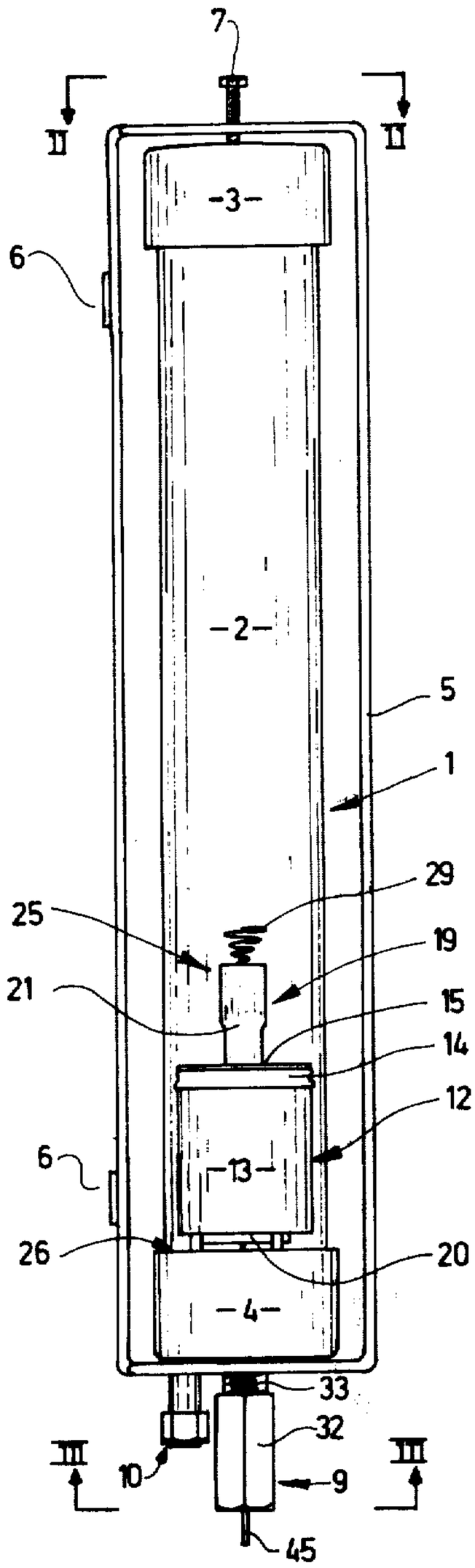


FIG 1

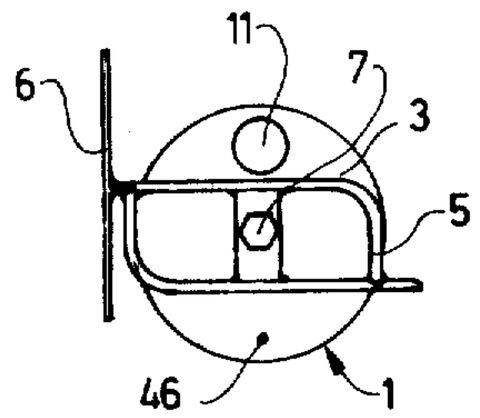


FIG 2

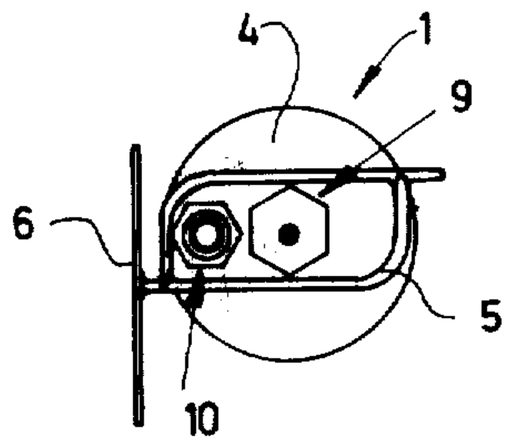


FIG 3

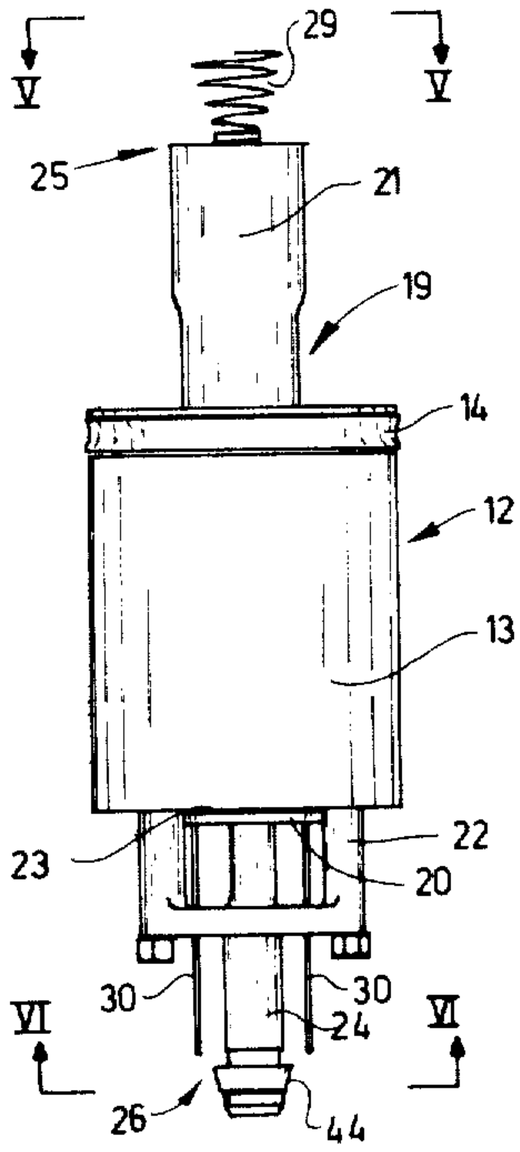


FIG 4

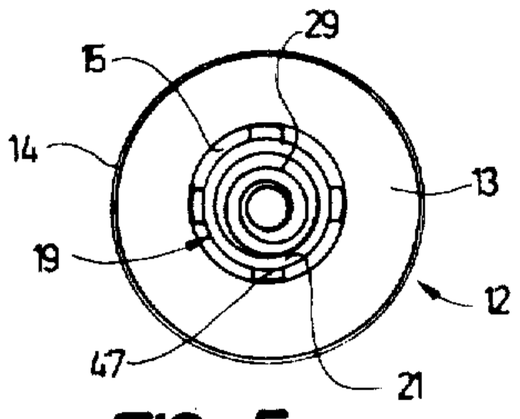


FIG 5

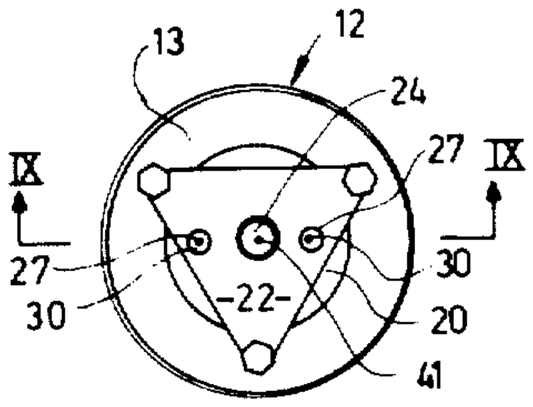


FIG 6

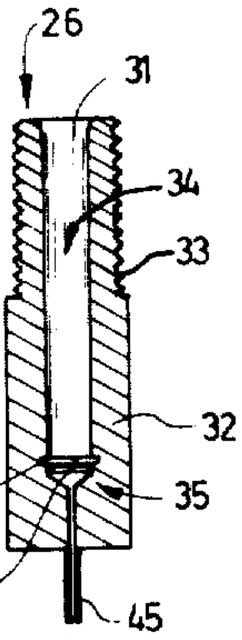


FIG 8

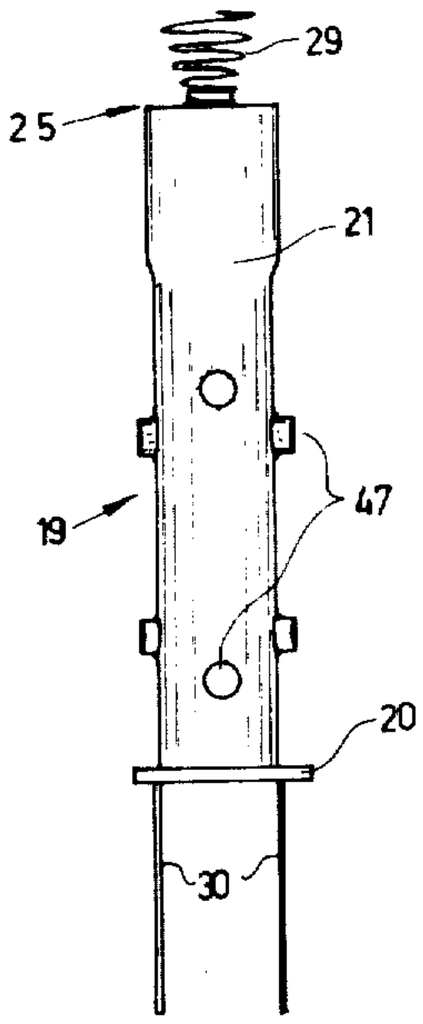


FIG 7

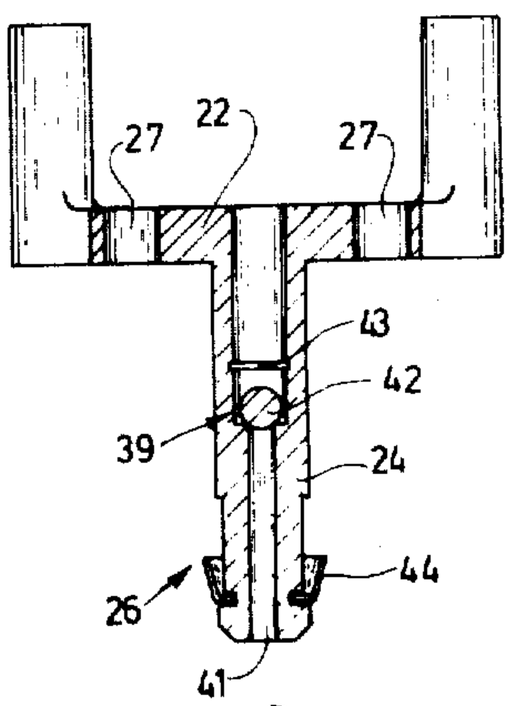


FIG 9

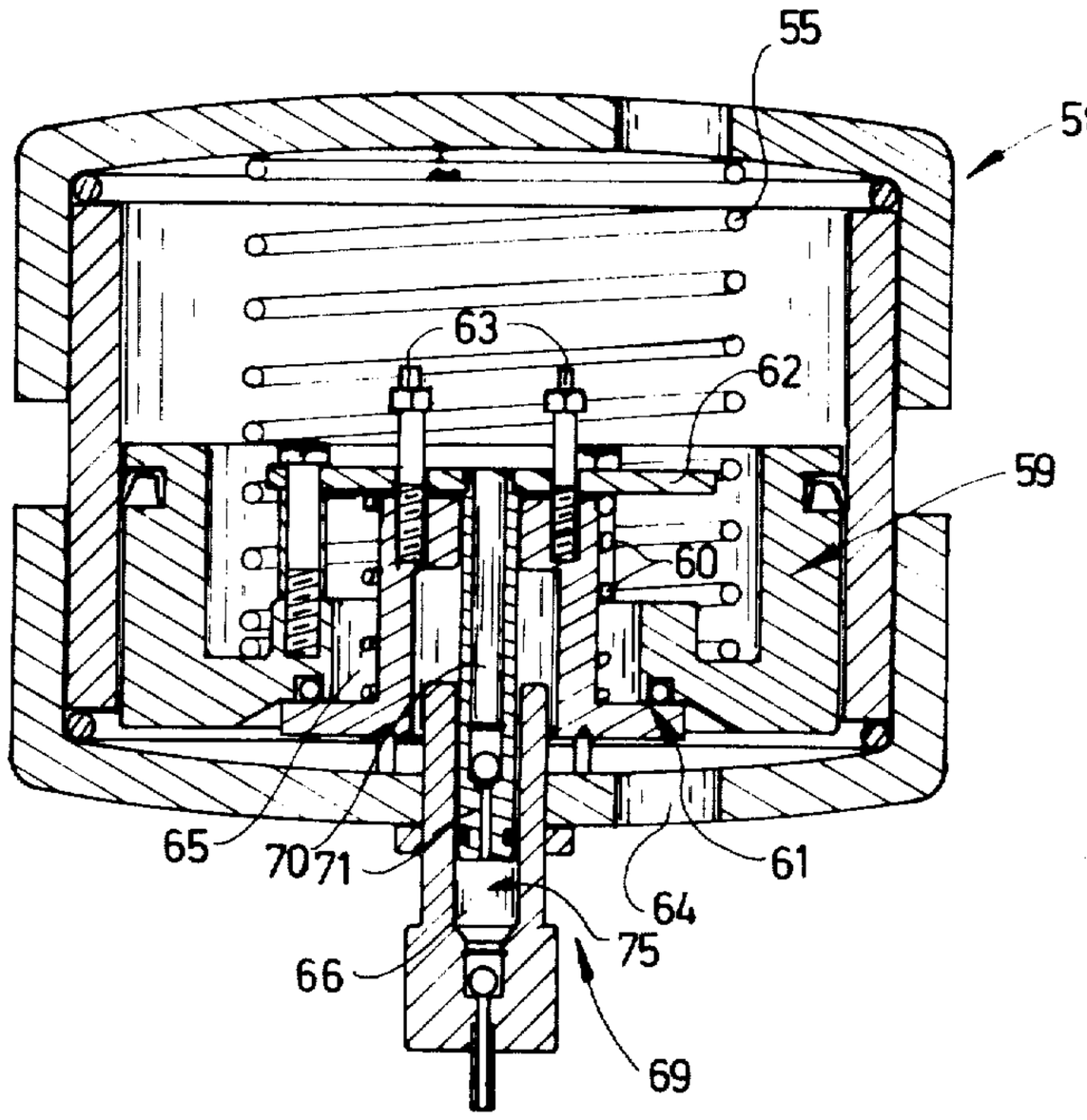


FIG 10

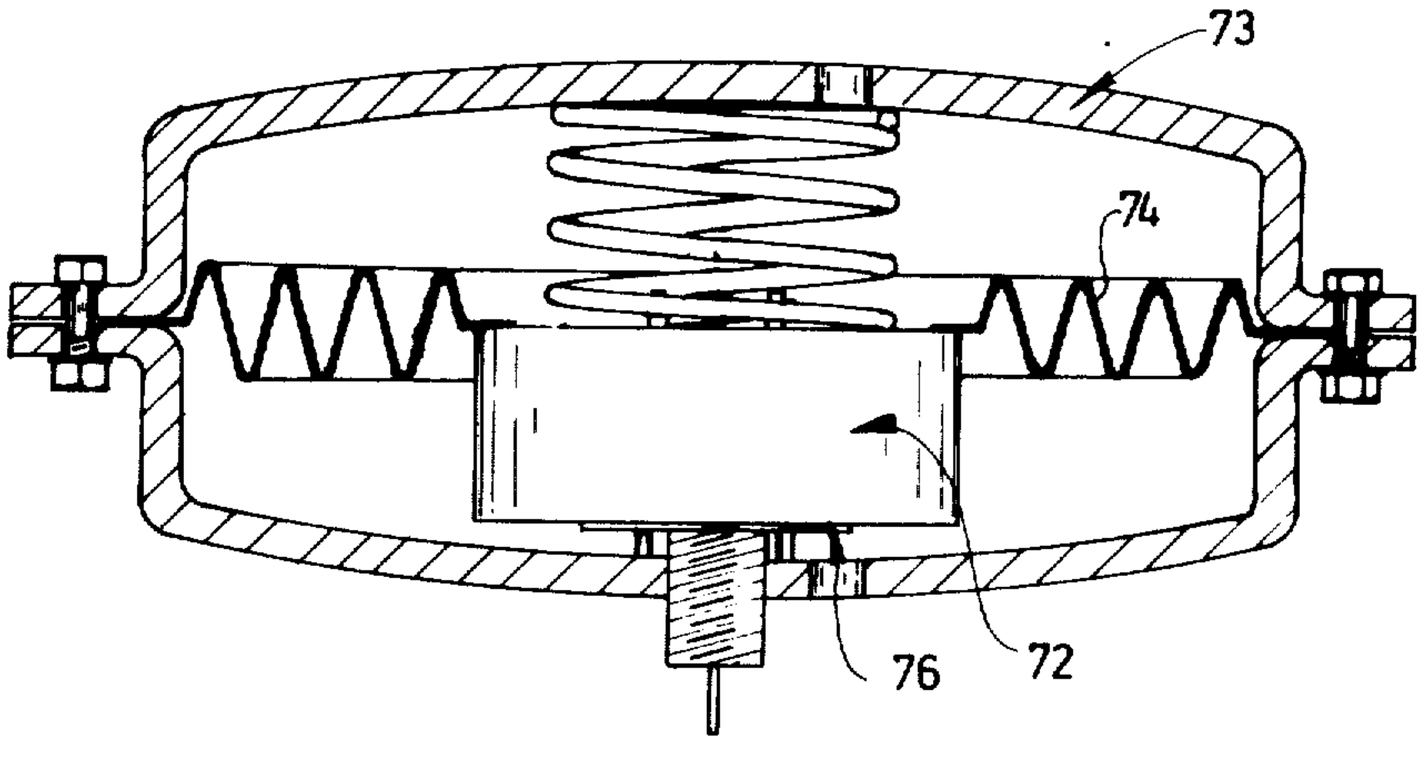


FIG 11

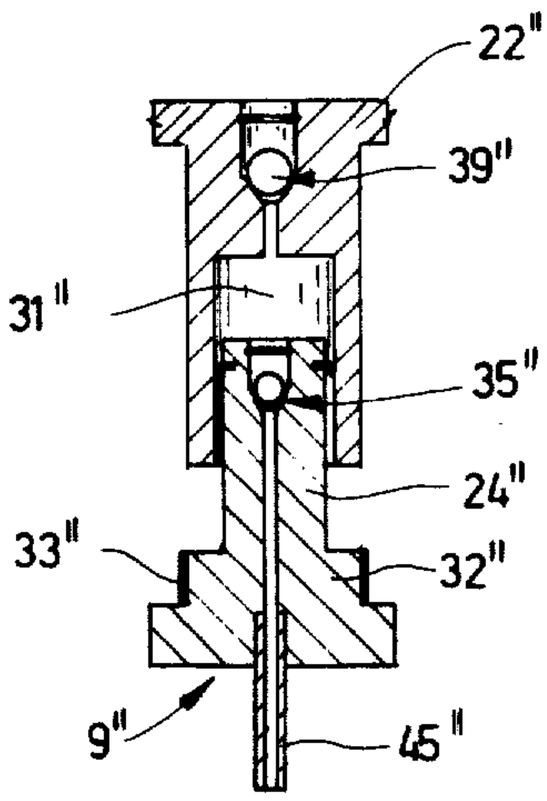


FIG 12

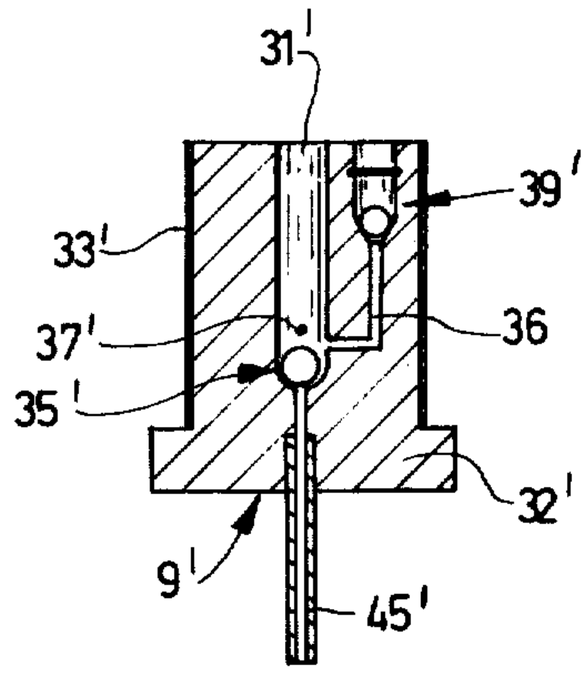


FIG 13

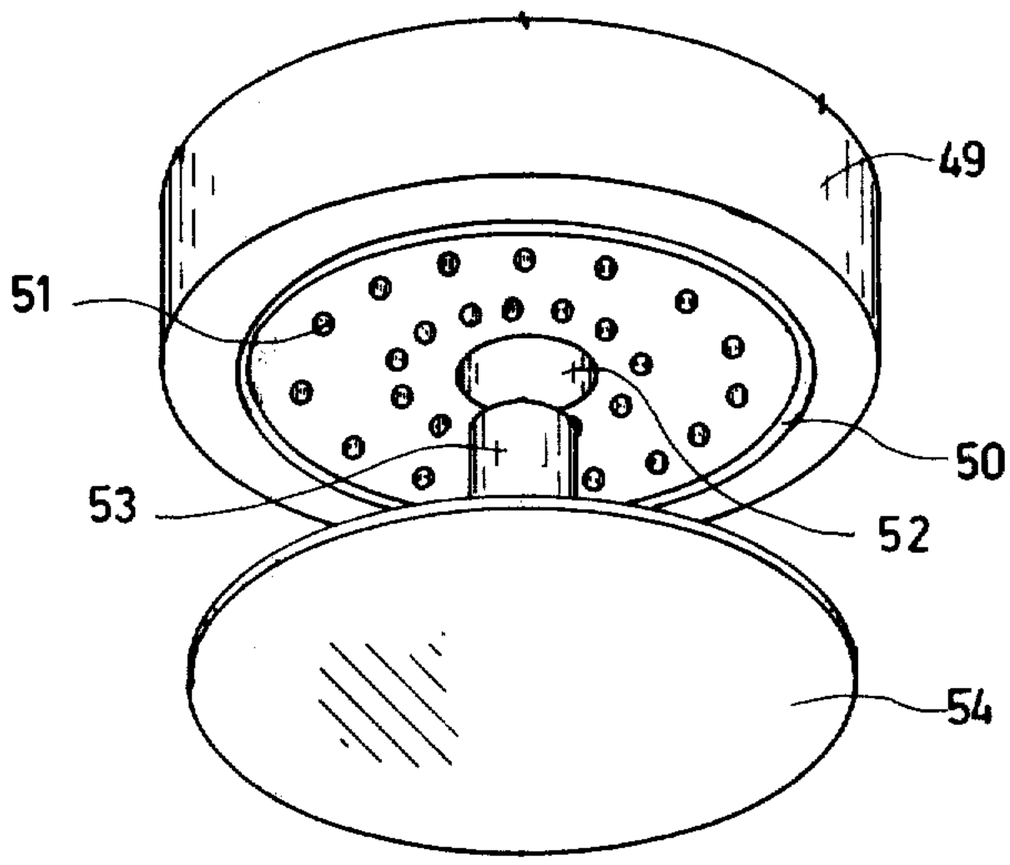


FIG 14

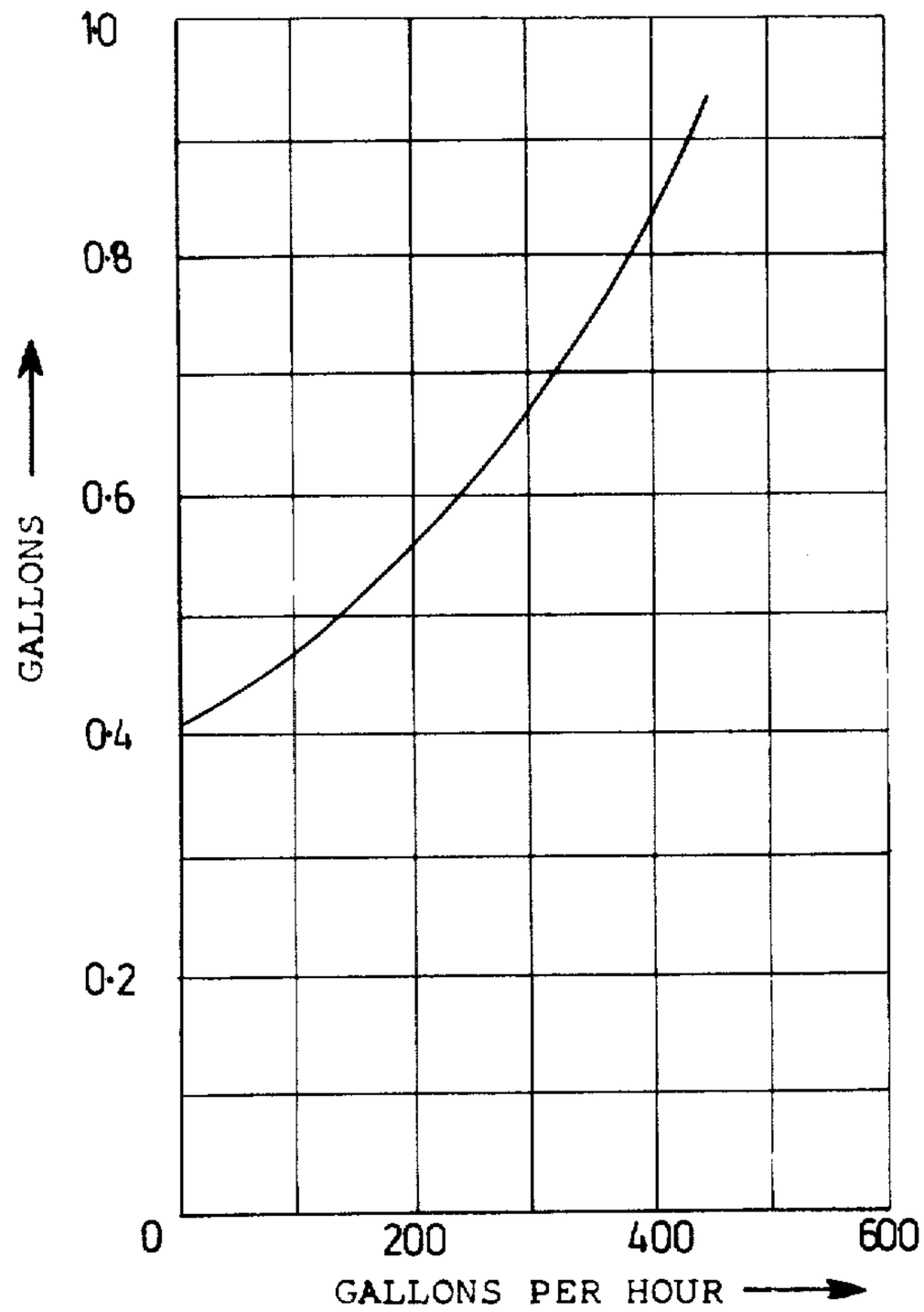

1·0
0·8
0·6
0·4
0·2
0
GALLONS
200
400
600
GALLONS PER HOUR

FIG 15

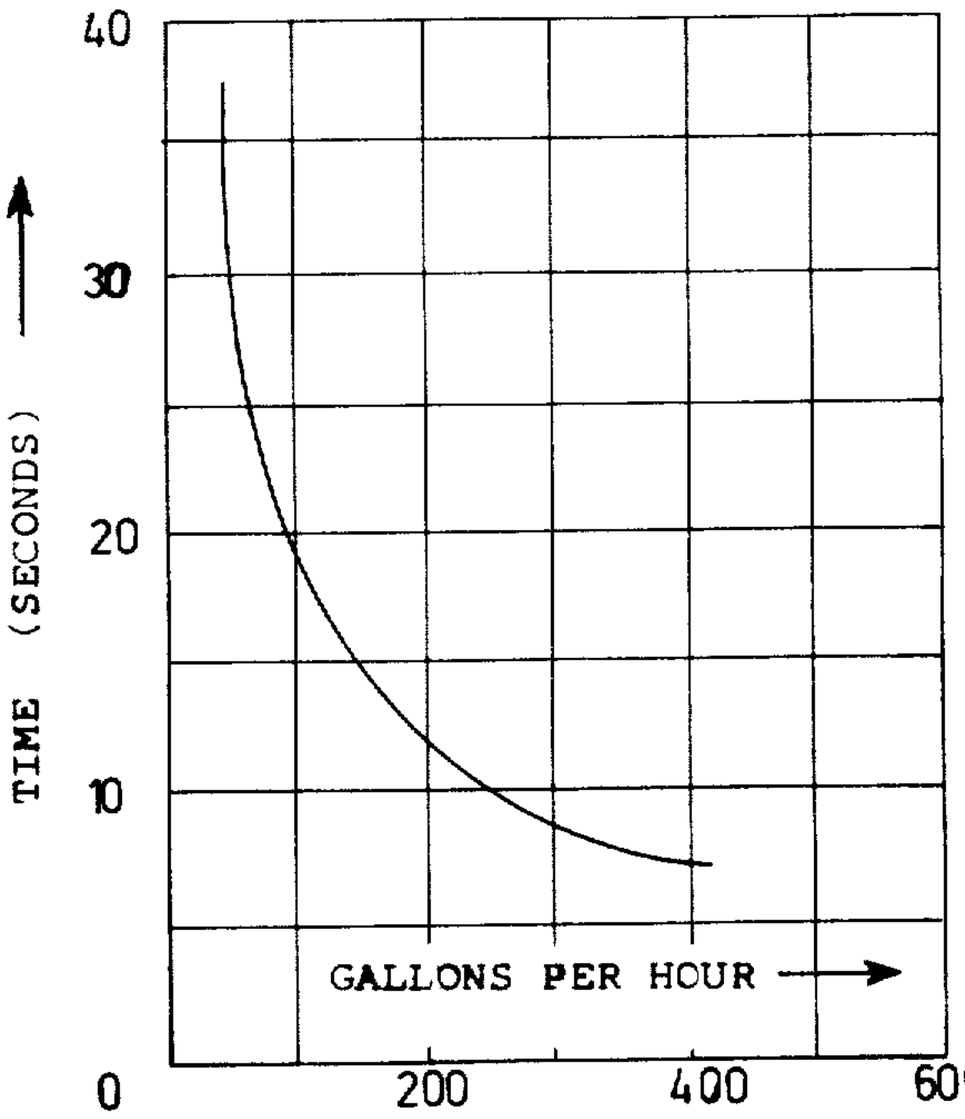

40
30
20
10
0
TIME (SECONDS)
200
400
600
GALLONS PER HOUR

FIG 16

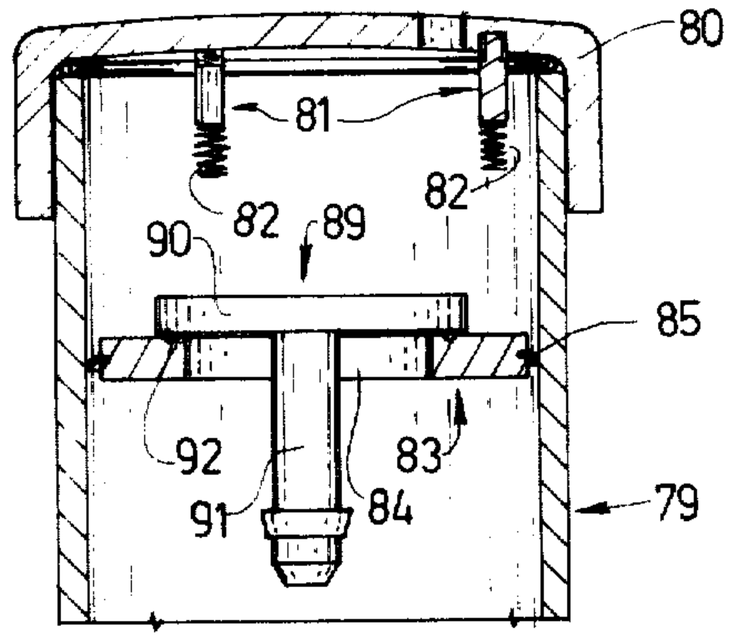


FIG 17

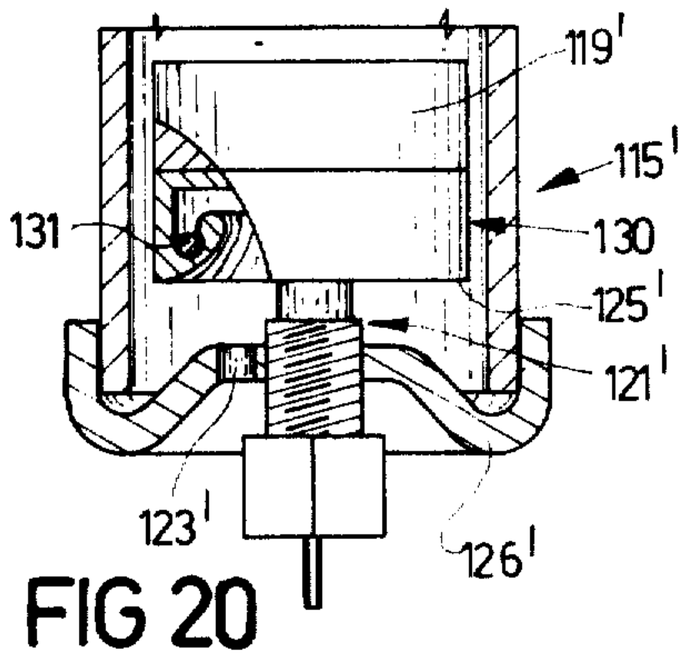


FIG 20

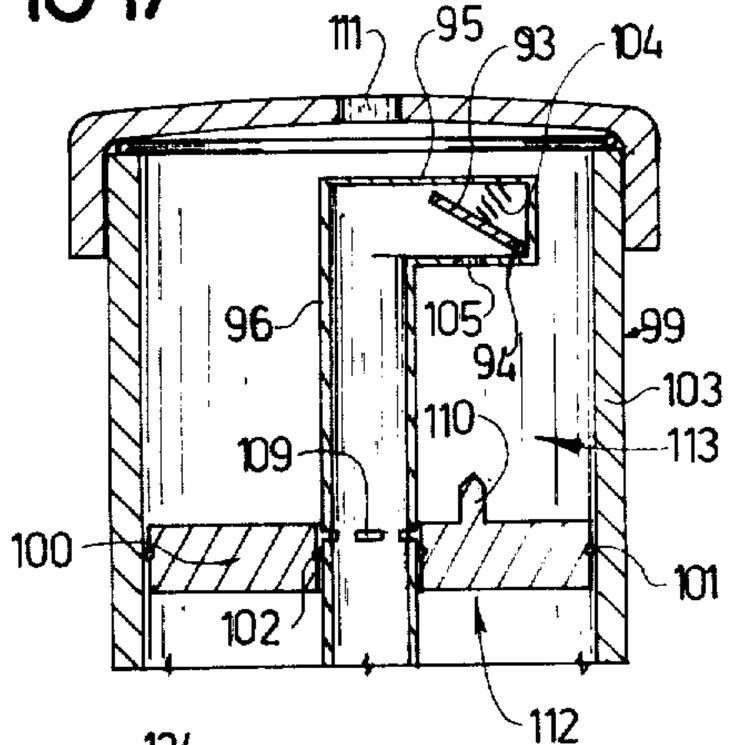


FIG 18

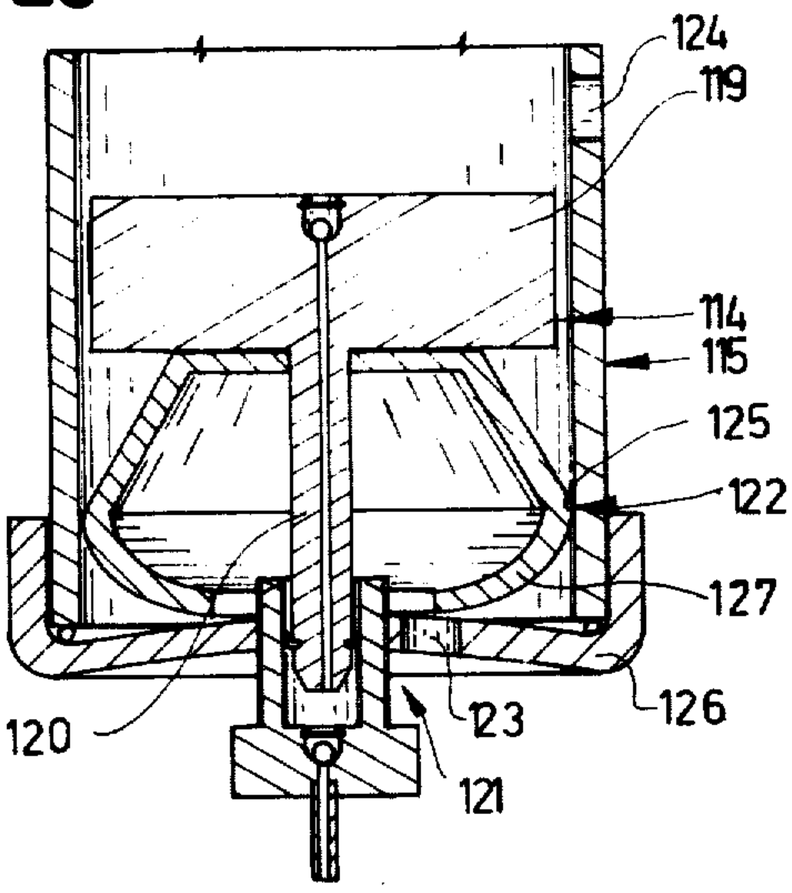


FIG 19

FLUID METERING DEVICE

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

It is frequently desired to mix fluids, particularly liquids such as water, with some chemical in metered quantities. Where the exact ratio of the two fluids to be mixed is not important and the two fluids are available at the same pressure, it is possible to mingle the two pressure streams directly through suitable valves governing the relative proportions. However, if one of the fluids must be metered accurately and is available at a lower pressure than the other, there is no satisfactory existing metering apparatus.

One particular application of this invention is to inject a bloat control chemical into the drinking water fed to cow troughs to control bloat in cows. In dry weather cows drink 12 – 22 gallons of water per day. In wet weather they drink less, but since cows are habit forming creatures, a cow which has bloat in wet weather will from past experience know that drinking water helps relieve the discomfort. It is, of course, under wet weather conditions when the farmer is least likely to inspect his stock for signs of bloat. In a preferred arrangement of this invention, the quantity of bloat control fluid injected into the water supply varies with the rate of flow of water through the device. Thus on a fine day when a large amount of water is consumed, the concentration of bloat control fluid in the water is lower than on a wet day when a lesser amount of water will be consumed. Thus a cow which will naturally drink a lesser amount of water on a wet day will still get the requisite amount of chemical needed to control any bloat condition.

The control of bloat in cows is only one possible application of this invention. It can be applied to mix oil and petrol for 2-stroke fuel, in fertiliser and weed control systems and where gases are required to be mixed, to name just a few.

SUMMARY OF THE INVENTION

The present invention consists in a fluid metering device comprising;

a. a housing with a hollow interior

b. first and second fluid inlets into said hollow interior for first and second fluids respectively

c. a fluid outlet from said hollow interior

d. first pumping means within said hollow interior and displaceable under fluid pressure between said second fluid inlet and said fluid outlet from an 'inlet' position to an 'outlet' position to cause mixed first and second fluids to be expelled through said fluid outlet

e. biasing means tending to retain or restore said first pumping means at or to said 'inlet' position in use

f. a passage communicating between said second fluid inlet and said fluid outlet

g. closure means adapted to close said passage at said 'inlet' position and also during displacement of said first pumping means, under fluid pressure, from said 'inlet' position to said 'outlet' position and to open said passage at said 'outlet' position and also during movement of said first pumping means from said 'outlet' position to said 'inlet' position and

h. second pumping means actuated on movement of said first pumping means to cause a predetermined quantity of said first fluid to enter said hollow interior through said first fluid inlet on each cycle of said first pumping means.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred forms of the present invention will be described with reference to the accompanying drawings in which:

FIG. **1** shows a side elevation of one embodiment of the invention,

FIG. **2** shows plan view II — II,

FIG. **3** shows plan view III — III,

FIG. **4** shows a side elevation of first pumping means, closure means and part of second pumping means removed from the housing,

FIG. **5** shows plan view V — V,

FIG. **6** shows plan view VI — VI,

FIG. **7** shows a side elevation of part of a closure means removed from the first pumping means,

FIG. **8** shows a central longitudinal cross section through first fluid inlet means and part of second pumping means,

FIG. **9** show a cross section IX — IX through part of second pumping means,

FIG. **10** shows a cross section through a different embodiment of the invention,

FIG. **11** shows a schematic partial cross section through a still further embodiment of the invention having some resemblances to that of FIG. **10**,

FIG. **12** shows a cross section through a different embodiment of the second pumping means,

FIG. **13** shows a cross section through yet another embodiment of the second pumping means,

FIG. **14** shows a schematic perspective view of a further embodiment of first pumping means and closure means,

FIG. **15** is a graph showing a typical variation of volume of water passing through the preferred device of FIG. 1 per cycle, at different flow rates,

FIG. **16** shows a graph of cycle duration of the device of FIG. **1** at different rates,

FIG. **17** shows a further embodiment of the present invention and shows a cross section through the upper part of a housing, first pumping means and closure means, FIG. **18** shows a still further embodiment of the present invention and shows a cross section through the upper part of a housing, first pumping means and closure means,

FIG. **19** shows yet another embodiment of the present invention and shows a cross section through the lower part of a housing, first pumping means, closure means and second pumping means, and

FIG. **20** shows the last embodiment of the present invention and shows a partial cross section through the lower part of a housing, first pumping means, closure means and second pumping means.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first of all to the embodiment illustrated in FIGS. **1 – 9**, the fluid metering device comprises a housing **1** having a hollow interior. The housing is provided by means of a 3 inches internal diameter clear perspex tube **2** provided with plastic end caps **3** and **4**

clamped on the tube by means of a wire frame **5** fitted with mounting brackets **6** and clamping screw **7**. A sturdy frame is necessary to hold the end caps on to the tube **2** since there may be quite large internal forces acting against the end caps tending to blow them off the tube. End cap **4** which is arranged to be lower than end cap **3** in use, since the tube **2** must be arranged to be vertical or near vertical, is provided with first and second fluid inlets **9** and **10** through it and into the hollow interior of the housing **1**. End cap **3** is provided with a fluid outlet **11**.

First pumping means **12** are slidable within the hollow interior and separate the first and second fluid inlets **9** and **10** from the fluid outlet **11** since the first pumping means which largely comprises a brass cylinder **13** is in sealing engagement with the internal walls of the housing **1** by means of a resilient sealing ring **14**. The weight of the first pumping means **12** provides biasing means tending to retain or restore the pumping means at or to an 'inlet' position which is the lowermost position it can assume within the housing **1**. For the weight to provide a biasing means it is necessary that the average density of the first pumping means exceed that of the fluid or mixed fluids which are to pass through the device; otherwise the pumping means would float and alternative biasing means would be needed. The first pumping means **12** also has a passage **15** which communicates between the first and second fluid inlets **9** and **10** and the fluid outlet **11**. However, the passage is adapted to be closed at the 'inlet' position and also during displacement of the first pumping means **12** under the pressure of the second fluid (that entering via the second fluid inlet **10**) when it travels up the tube **2** to an 'outlet' position which is defined as being the position when the passage is first opened. Closure means **19** are adapted to close the passage **15** at the 'inlet' position and also during displacement of the first pumping means **12** from the 'inlet' position to the 'outlet' position and are adapted to open the passage at the 'outlet' position and also during movement of the first pumping means from the 'outlet' position to the 'inlet' position. The forces causing such movements will be described later.

In the preferred embodiment, the closure means is provided with a closure member **20** in the form of a disc of brass surmounted by a heavy brass stem **21**. The closure member **20** is displaceable relative to the first pumping means **12** and in order to limit the displacement, stop means are provided by the diameter of the closure member disc **20** being larger than the diameter of passage **15** and by means of a cage **22** bolted onto the bottom of the cylinder **13**. A circular neoprene sealing ring **23**, embedded in a groove in the cylinder **13**, is provided between the closure member **20** and the cylinder **13** so that the passage **15** may be effectively sealed.

In order that the closure means opens the passage when required, it is necessary in this embodiment for the closure member **20** to have a ratio of thrust surface (which is basically the area contained within the diameter of the sealing ring **23**) presented to the second fluid inlet **10** at the 'inlet' position to the biasing force (which in this case is weight) tending in use to retain or restore the closure member to the 'inlet' position which exceeds the same ratio of the pumping means **12** (where the thrust surface is the internal area of the housing tube **2** minus the thrust area of closure member **20**). The weight of the closure means **19** is the total

weight of the cylinder **13**, the cage **22** and the associated plunger **24** of second pumping means **26**, the operation of which will be described later on. This requirement is necessary so that under a given second fluid pressure, when the first pumping means and closure means are at the 'inlet' position with the passage closed, the closure means **19** is more floatable than the first pumping means **12**, i.e., it experiences a greater resultant up-thrust and thus tends to carry the first pumping means up the tube so that the seal is maintained until the 'outlet' position is reached.

In order to open the passage at the 'outlet' position, engagement means **25** are provided adapted to restrain or stop the movement of the closure member **20** as the first pumping means **12** approaches or attains the 'outlet' position. In the embodiment shown, the engagement means **25** are provided by the stem **21** surmounted by spiral spring **29** which at the 'outlet' position bears against the end cap **3**.

To describe the operation of the parts of the device so far described, assume that a cycle commences with the first pumping means and closure means at the 'inlet' position with the space in the tube **2** above these filled with fluid. The fluid referred to as the "second" fluid is introduced under a suitably high pressure through the second fluid inlet **10**. The first pumping means **12** and closure means **19** form a slidable barrier across the interior of the tube **2** and are therefore acted upon by the fluid pressure and caused to rise displacing as they do so fluid through the fluid outlet **11** if the outlet pressure is sufficiently lower than the second fluid pressure. Eventually the spring **29** meets the cap **3** and is compressed on further upward movement of the stem **21** until either the stem strikes the cap **3**, or the force developed within the spring, if it is sufficiently stiff, is such as to provide a greater downward force on the closure member **20** than the up-thrust it experiences because of the pressure differential on the inlet side. When either happens, the passage is opened. Immediately the pressure differential disappears and the spring **29** recoils providing an initial acceleration to the closure member **20** displacing it relative to the first pumping means **12** which will continue moving upwards a little from the point of opening until its kinetic energy is dissipated so that the passage is opened very quickly and cleanly. Immediately the closure means **19** begins to sink and the closure member **20** would usually come to rest on the bottom of the cage **22** and the combination of first pumping means and closure means would descend down the tube to the 'inlet' position. There the legs **30** extending below the closure member disc **20** and through holes **27** in the cage hold the closure member at a suitable height so that it supports the weight of the first pumping means **12** at the 'inlet' position. However, immediately the first pumping means **12** descends on the closure member disc **20** to close the passage, the cycle recommences.

Since the device will often be operated with outlets fitted with shut-off valves such as ballcocks on troughs, it should be appreciated that the cycling of the first pumping means will stop when the outlet back pressure builds up to such an extent that there is an insufficient force on the inlet side of the first pumping means to move it against the force provided by the combined weights of closure means and first pumping means and the fluid pressure on the outlet side. This means that occasionally on movement from the 'inlet' position to the 'outlet' position such a balance between the forces

is encountered and the first piston means and closure means simply remain stationary with the passage closed until such time as the outlet back pressure is reduced when the cycle can continue.

The second pumping means **26** provided by the plunger **24** extending from the bottom of the cage **22** and the barrel **31** provided centrally within a hexagonal plug **32** threaded at **33**. The plug forms part of the first fluid inlet means **9** and is able to be screwed into the end cap **4**. The combination of plunger **24** and barrel **31** serve to define a chamber **34** interposed in the first fluid inlet and as will be described, the volume of this chamber is caused to fluctuate by a predetermined amount on cycling of the first pumping means so that a predetermined quantity of the "first" fluid to be admitted into the hollow interior through the first fluid inlet **9** is pumped in by the second pumping means once per cycle. To facilitate this pumping action, first and second one way valve means **35** and **39** are provided. The first one way valve means **35** is preferably in the form of a flap valve with a circular neoprene disc **40** being held in the barrel **31** by means of a circlip or pin **37**. The second one way valve means **39** is provided in a bore **41** through plunger **24** and may comprise a flap valve substantially the same as the first one way valve means **35** or alternatively, and as shown, may comprise a phosphor bronze ball **42** held in place by pin or circlip **43**.

The arrangement of plunger and barrel is such that at the inlet position, the plunger extends into the barrel **31** a certain amount. When the pumping cycle commences from the 'inlet' position, the plunger **24** rises with the cage **22** and cylinder **13**. A resilient seal **44** ensures that there is a suction created below the plunger in the barrel which causes the first one way means **35** to open (the second one way valve means **39** being shut) and draws the first fluid, usually from an open container attached by means of a flexible tube to the nipples **45**, into the chamber **34**.

In the embodiment shown, a point is eventually reached where the plunger **24** leaves the barrel **31** and at that juncture the first one way valve means **35** shuts. There may be some mixing of the first fluid contained within the barrel with the second fluid in the housing but the degree of mixing is unimportant for on the descent of the first pumping means, the plunger **24** enters the barrel and the second one way valve means **39** opens to relieve the pressure which would otherwise be created (since the first one way valve means **35** is shut). Any first fluid remaining in the barrel is expelled through the bore **41** of the plunger and thus into the hollow interior where it mixes with the second fluid. In order to ensure turbulent flow and good fluid mixing, lugs **47** are provided on stem **21**.

It is possible to adapt the seal **44** to form a one way valve in the manner of the normal tyre pump so that the bore **41** may be dispensed with. Also it is possible, as is shown in FIG. **13** where like parts have been given like references where possible, for the second one way valve means **39'** to be provided in the plug **32'** communicating with the chamber **34'** via a passage **36** a little above the first one way valve means **35'**. The reverse form of arrangement where the plunger **24''** is provided as part of the first fluid inlet **9''** and the barrel is provided depending from the cage **22''** is shown in FIG. **12**, where again like parts have been given the same references.

In the preferred embodiment described so far, the cylinder **13** is not constrained against rotation in the tube **2** and therefore the plunger **24** is provided concentric with the axis of the cylinder so that it will always mate with the barrel **31**, which is provided centrally in the end cap **4**, when the cylinder **13** descends. In order to regulate the volume fluctuation of the chamber **34**, regulator means comprising the threads **33** and mating threads in the end cap **4** are provided so that the relative position of the chamber along the direction of movement of the first pumping means **12** may be varied, i.e. the depth of entry of the plunger **24** into the barrel **31** is adjustable.

In order to give a better appreciation of the workings of the preferred embodiment illustrated in FIGS. **1 – 9**, a few dimensions will be given. The overall length of the tube **2**, which has an internal diameter of 3 inches, is 25½ inches. The weight in air of the cylinder **13** with cage **22** and plunger **24** is 6 lbs. The weight of the closure means **19** is 2 lbs. Most of those parts are constructed of solid brass. The diameter of the circular seal **23** is 1.875 inches so that the ratio of up-thrust area of the closure means **19** when at the 'inlet' position to weight is approximately twice that of the first pumping means. This ensures that the passage **15** is properly closed when the combination moves from the 'inlet' to the 'outlet' position. At high draw-off rates through the fluid outlet **11**, the cycle time is fairly short, as shown in FIG. **16**. This means that the first pumping means **12** is moving with a relatively high velocity when the closure means is restrained from further movement by contact with the end cap **3** and under these conditions the resilient spring **29** is not really necessary since the first pumping means has a relatively large amount of kinetic energy when the passage is opened and it moves an appreciable distance further up the tube **2** before this is wholly converted to potential energy and the velocity falls to zero. By that time, if not before, the closure means **19** has probably descended to rest on the cage **22**. At low draw-off rates, however, the velocity of the first pumping means at the outlet position may be fairly slow so that there is only a short lag after the passage is opened before the cylinder **13** begins to descend. Under those circumstances the initial impetus provided to the closure means **19** via the spring **29** is useful to ensure that the passage is opened quickly and completely at the 'outlet' position; otherwise there is a possibility if certain other undesirable characteristics are present that the passage may not open cleanly and in fact the passage can even shut after a short descent of the first pumping means, if certain criteria are not met and a cycle can then commence without the necessary influx of first fluid.

There are various other ways in which it can be ensured that the closure means **19** descends to the 'inlet' position before the first pumping means **12**. FIG. **14** shows one method useful where the fluid is relatively viscous. There, instead of one large central passage **15**, the cylinder **49** with embedded circular sealing ring **50** is provided with a large number of small passages or tubules **51** as well as a central passage **52** of a diameter just sufficient to loosely receive a small diameter engagement means stem **53** fastened to a closure member disc **54** of a diameter slightly larger than that of the sealing ring **50**. The closure means in such a case suffers far less fluid frictional retardation when descending than does the cylinder **49** where the relatively small diameter passages **51** and **52** impede the rate of flow of

fluid through it and thus slow its descent. It is also possible to arrange that the mechanical friction of the resilient sealing ring **14** surrounding the cylinder **13** is quite high, which again retards the rate of descent of the first pumping means. Also, since the first pumping means and the closure means are at the 'outlet' position and on descent suspended in a fluid, then the forces acting on the first pumping means and the closure means, ignoring mechanical friction forces, are in each case its weight acting downwards, the Archimedes up-thrust acting upwards and the viscous resistance acting upwards. Where the first pumping means and the closure means are each made of an identical material, the Archimedes up-thrust equal to the weight of fluid displaced will in each case bear the same proportion to the total weight of the first pumping means or the closure means respectively. However, by varying the relative densities, such as by including air voids or making them of dissimilar materials, the resultant downward forces acting on each can be made unequal, thus resulting in different accelerations, thus keeping the passage open during the descent with a suitable choice of parameters.

In the application of the preferred embodiment of FIGS. **1 – 9** to bloat control, typical flow rates may be 5–500 gallons per hour and typical water inlet pressures may be 2–175 pounds per square inch. Throughout this specification "gallons" means Imperial or United Kingdom gallons. The first fluid is simply located in a vessel open to atmospheric pressure and is sucked into the first fluid inlet through a 3/16 inch internal diameter plastic tube. With the dimensions of the preferred embodiment mentioned, when one cycle of the first pumping means causes the volume of bloat control fluid contained in a 3 inches length of the 3/16 inch plastic tube to be displaced into the hollow interior of the housing then this corresponds to a desired 15 ounces of bloat control fluid per 100 gallons of water when the flow rate is 100 gallons per hour. The hexagonal plug **32** is screwed in or out to achieve this. If the flow rate is only 50 gallons per hour, 25 ounces of bloat control fluid are injected per 100 gallons of water but at rates higher than 100 gallons per hour, a lesser amount than 15 ounces per 100 gallons is injected. This is because at higher flow rates a greater amount of water will pass through the passage on descent of the first pumping means during the relatively fixed time it takes to descend in water. This is because on the descent part of the cycle, the device presents an open valve between second fluid inlet and outlet. The effect is shown in FIG. **15.** Thus while the volume of second fluid is variable per cycle, the volume of first fluid remains constant and thus the concentration rate alters with draw-off rate.

The weight of the first pumping means and closure means is such that with second inlet pressures within the above range, no difficulty is caused by jetting of the water through the second fluid inlet. The jetting forces are insufficient to prevent a seal being made on descent of the first pumping member on to the closure means. To avoid back syphoning through the fluid outlet **11** in the event of a possible malfunction, a one way valve **46** (FIG. **2**) admits air into the housing in the event of the pressure within the housing dropping below atmospheric.

An alternative embodiment of the invention is shown in FIG. **10.** There, instead of relying on gravity to provide the biasing acceleration on the masses and thus a

force tending to retain or restore the first pumping means at or to the 'inlet' position, a spiral compression spring **55** is utilised. The spiral compression spring **55** acts between the housing (indicated generally as **58**) and the first pumping means **59.** A weaker compression spring **60** acts between the closure means **61** and a bridge **62** forming part of the first pumping means **59.** Resilient blocks **63** of rubber or other elastic material surmount the bridge **62** for the same purpose as the spiral compression spring **29** of FIG. **1.** The arrangement is such that at the 'inlet' position, as illustrated, second fluid entering the second fluid inlet **64** is met with a situation where the closure member **61** is more floatable (against spring pressure) than the first pumping means **59** so that the passage **65** is closed until the 'outlet' position is reached. Then on opening of the passage and equalisation of the fluid pressure around the closure member **61** the initial displacement of the closure member **61** from the first pumping means **59** given by recoil of the elastic blocks **63** is maintained or increased by means of the spring **60** as the first pumping means descends until the closure means, which includes (but is not limited to) the compression spring **60,** closure member **61** and resilient block **63,** seats on the bottom of the housing when spring **55** causes the first pumping means to continue moving until the passage is closed. It will be apparent that the biasing force need not be provided by a spiral spring but could be provided by any resilient material. Furthermore it would be possible to make an embodiment utilising elastic materials placed in tension and by means of suitable valving to construct an embodiment of this invention where the biasing means is provided by fluid pressure.

The second pumping means **69** (FIG. **10**) is virtually identical to that described with reference to FIGS. **8** and **9** except that it may be noted that the bore **70** of the plunger **71** communicates on the outlet side of the first pumping means **59,** not the inlet side. This illustrates that the position of the first fluid inlet is not of vital importance to this invention since adequate mixing will probably occur in most circumstances regardless of whether it is situated on the inlet or outlet side of the first pumping means. It should also be noted that although the plunger **71** probably would leave the barrel **66** in the embodiment illustrated in FIG. **10,** this is by no means necessary. In fact the chamber **75** could be provided by some flexible diaphragm, diaphragm pair or concertina like arrangement provided with the first and second one way valve means which would be equivalent to the form of second pumping means illustrated. There are, however, many other types of second pumping means which could be used in this invention and they need not be situated on the inlet side, nor need they be provided with one way valves since an arrangement of simple shut-off valves could be used to achieve a similar pumping effect.

A further embodiment illustrated in FIG. **11** has resemblances, as far as the first pumping means **72** and closure means **76** are concerned, to FIG. **10.** However, the first pumping means **72** instead of being slidable within the housing **73,** incorporates a flexible diaphragm **74** secured to the housing around its circumference. The use of a diaphragm obviates the possibility of leaks between the first pumping means and the housing which may be very desirable in certain applications where considerable metering accuracy is necessary. Also the short length of travel which is possessed by the

embodiment illustrated in both FIGS. **10** and **11** tend to limit the variation in volume of second fluid passing through the device at different draw-off rates which may be desirable in certain applications.

Although in the embodiments described above the closure member has been unattached to the first pumping means, it will be evident that the closure member could comprise a flap hinged to the first pumping means and such a device would function in an obviously equivalent manner. Also, although in the embodiment described above the closure means has been more "floatable" than the first pumping means, it is not essential that that should be so. In FIG. **17**, the housing **79** has an end cap **80** including three downwardly depending engagement means **81** (only two of which are shown) equipped with spiral compression springs **82.** The first pumping means **83** in this embodiment comprises a cylindrical piston with a central passage **84** through it and an outer sealing ring **85.** It is surmounted by the closure means **89** which comprises a closure member **90** in the form of a disc having a downwardly dependent plunger **91** forming part of second pumping means. A resilient sealing ring **92** is contained in a groove in the first pumping means **83.** The arrangement is such that the thrust area of the closure means **89** presented to the second fluid inlet (not shown), being that area contained within the diameter of the sealing ring **92,** to the biasing means (which in this case is its weight) tending to retain or restore the closure means at or to the 'inlet' position is less than that of the first pumping means **83** so that the first pumping means is relatively more floatable and on movement from the 'inlet' position to the 'outlet' position tends to carry the closure means **89** upwardly so that the passage **84** is closed. At the 'outlet' position it is not the closure means **89** which is restrained from further movement but the first pumping means by means of the engagement means **81.**

The embodiment of FIG. **17** has the disadvantage that mechanical friction forces at the seal **85** could, in certain circumstances such as where grit might enter through the second fluid, slow down the rate of descent of the first pumping means so that the closure means **89** caught up to it and closed the passage **84** before the plunger **91** had fully re-entered its barrel. For this reason the diaphragm and spring equivalent may be preferred over the sliding piston type illustrated.

It will also be apparent from the above description that where the second pumping means are provided by a plunger and barrel or some equivalent instead of regulating the position of the barrel **31** of FIG. **8** or the plunger **24''** of FIG. **12** with respect to the housing, it would be possible to regulate the position of the plunger **24** of FIG. **9** or barrel **31''** of FIG. **12** at the inlet position with respect to the housing. Incidentally, the reason why the second pumping means preferably forms part of the first pumping means (where that is less "floatable" than the closure means) is that if it were part of the closure means, there would be a danger that the descent of the closure means would be slowed up on re-entry of the plunger into the barrel and that a seal would be made closing the passage before the plunger had fully entered the barrel. This would mean that a cycle would commence in such circumstances with a lesser amount of first fluid being pumped into the housing.

It will also be apparent that the engagement means, although it has been described primarily as a stem extending up through the passage from the closure member, could equally well comprise a stem or similar protruding from the inside of the housing, such as FIG. **17** illustrates.

In the embodiment shown in FIG. **18,** the closure member **93** is a flap pivotted at **94** within the hollow head region **95** above a tube **96.** These parts are situated within a housing **99** within which there is a piston **100** comprising part of first pumping means and by means of seals **101** and **102** making sealing engagement with the cylindrical wall **103** of the housing and with the tube **96.** The closure member **93** is by means of gravity or the pressure of a light spring **104,** or both, caused to cover a port **105** in the head. There are also one or more ports **109** near the base of the tube **96.** On the upper surface of the piston **100** there is a striker pin **110** forming part of engagement means. The fluid outlet is indicated at **111.**

The operation of this device is as follows. Assume a cycle commences with the piston **100** approximately in the position shown and with the closure member **93** shut against the port **105.** The pressure of the second fluid on the inlet side **112** of the piston **100** causes it to rise up the housing. If the port **109** is not already uncovered, it becomes uncovered so that the pressure on the inlet side also exists within the tube **96** and the head **95.** Seeing there must be a lesser pressure on the outlet side **113** of the piston **100** for it to move, the closure member **93** will remain shut. However, eventually the piston **100** comes to a position where the striker pin **110** displaces the closure member **90** from the port **105.** The thrust area of the piston is chosen to be large enough to achieve this. At that point the second fluid is able to flow through the tube **96** and out through the port **105** on its journey to the outlet **111** and the piston **100** sinks seeing that the pressure around it is equalised. Eventually it will restrict the flow of fluid through the port **109** so that the flow which previously held the closure member **93** open against the force of its weight and the pressure of spring **104** is insufficient to hold the closure member open and the port **105** is sealed. Immediately the second fluid pressure causes the piston **100** to rise once more, thus commencing another cycle. As will be appreciated, second pumping means of some form are actuated by cycling of the piston **100** to meter in the desired amount of first fluid. The notable difference of this embodiment is that the closure means does not cycle with the first pumping means. Also the tube **96** can be C shaped so that the passage through it passes around and not through the piston **100.**

In FIG. **19** an embodiment is shown which uses a still different approach. There the first pumping means **114** is not in continuous sealing engagement with the housing **115** but comprises a piston **119** which is loosely fitting within the housing, having depending from it a plunger **120** forming part of second pumping means **121.** The piston **119** is in sealing engagement with the housing **115** only via a reslient rubber somewhat cone shaped device **122** secured to the under surface of the piston. A second fluid inlet is shown at **123** and the fluid outlet at **124.** The 'inlet' position is as illustrated.

In operation the second fluid causes the first pumping means **114** to rise in the housing until the outlet **124** is uncovered. The second pumping means **121** is actuated as usual. When the outlet **124** is uncovered, the natural resilience of the cone device **122** causes the outer circumference **125** to contract. This leaves a passage around the first pumping means through which the

second fluid may flow as the first pumping means descends. When the cone strikes the end cap **126**, however, it is spread outwardly by the weight of the piston **119** so that the circumference **125** re-establishes sealing contact with the housing **115**. The cycle then commences once more.

In a similar construction the portions **127** of the coned device **122** can be omitted and the base end cap **126** can be pronouncedly coned upwardly to assist in the spreading and sealing operation when the device **122** decends on the end cap. Such a device is shown in FIG. **20** where the same references are used where possible. The sealing means **130** is in the form of a skirt formed with an inner groove to receive a loop tension spring **131** so that in its normal position the circumference **125'** does not make sealing contact with the housing **115'**. However, when the first pumping means reaches the 'inlet' position on descent the pronounced cone shape of end cap **126'** assists spreading of the seating means **130** to form a seal against the housing **115'** which is retained by the pressure of the second fluid on ascent of the first pumping means.

In FIGS. **19** and **20** it will be appreciated that biasing means other than weight could be used, e.g., a compression spring and that the passage communicating between the second fluid inlet and the fluid outlet passes around the first pumping means.

What I claim is:

1. A fluid metering device comprising;

a. a housing with a hollow interior

b. first and second fluid inlets into said hollow interior for first and second fluids respectively

c. a fluid outlet from said hollow interior

d. first pumping means within said hollow interior and displaceable under fluid pressure between said second fluid inlet and said fluid outlet from an 'inlet' position to an 'outlet' position to pump mixed first and second fluids through said fluid outlet

e. biasing means tending to retain or restore said first pumping means at or to said 'inlet' position in use

f. a passage communicating between said second fluid inlet and said fluid outlet

g. closure means adapted to close said passage at said 'inlet' position and also during displacement of said first pumping means, under fluid pressure, from said 'inlet' position to said 'outlet' position and to open said passage at said 'outlet' position and also during movement of said first pumping means from said 'outlet' position to said 'inlet' position and

h. second pumping means actuated on movement of said first pumping means to cause a predetermined quantity of said first fluid to enter said hollow interior through said first fluid inlet on each cycle of said first pumping means.

2. A fluid metering device as claimed in claim **1** wherein said closure means comprises a closure member within said hollow interior and said closure member moves with but is displaceable relative to said first pumping means; and stop means coacting between said closure member and said first pumping means and adapted to limit such relative displacement so that said passage is closed on maximum relative displacement in one direction and opened on displacement in the reverse direction.

3. A fluid metering device as claimed in claim **2** wherein engagement means are provided to alter the relative speed of said closure member and said first pumping means at said 'outlet' position.

4. A fluid metering device as claimed in claim **3** wherein said closure member has a ratio of thrust surface presented to said second fluid inlet at said 'inlet' position to biasing force tending in use to retain or restore said closure member at or to said 'inlet' position which exceeds that of said first pumping means.

5. A fluid metering device as claimed in claim **4** wherein said engagement means is elastic so that on the point of opening of said passage and equalisation of the fluid pressure on said closure member and said first pumping means, the recoil causes a sudden speed difference to be imparted between said closure member and said first pumping means.

6. A fluid metering device as claimed in claim **5** wherein said second pumping means includes a chamber interposed in said first fluid inlet and first and second one way valve means, said chamber communicating in use with a supply of first fluid via said first one way valve means and with said hollow interior via said second one way valve means, the volume of said chamber being adapted to fluctuate by a predetermined amount on cycling of said first pumping means so that said predetermined quantity of said first fluid is pumped into said hollow interior.

7. A fluid metering device as claimed in claim **5** wherein said second pumping means includes regulator means adapted to regulate or adjust the volume fluctuation of said chamber so that the volume ratio of first to second fluids to be mixed can be altered.

8. A fluid metering device as claimed in claim **7** wherein said chamber is defined by a barrel and a plunger movable within said barrel in the line of movement of said first pumping means.

9. A fluid metering device as claimed in claim **8** wherein said biasing means comprise resilient spring means.

10. A fluid metering device as claimed in claim **9** wherein said first pumping means includes a resilient diaphragm, the perimeter of which is sealingly engaged with said housing.

11. A fluid metering device as claimed in claim **8** wherein said first pumping means comprises a piston, the perimeter of which is in sealing engagement with said housing.

12. A fluid metering device comprising;

a. a housing with a hollow interior

b. first and second fluid inlets into said hollow interior for first and second fluids respectively

c. a fluid outlet from said hollow interior

d. first pumping means within said hollow interior comprising a piston in continuous sealing engagement with said housing and displaceable under fluid pressure between said second fluid inlet and said fluid outlet from an 'inlet' position to an 'outlet' position to cause mixed first and second fluids to be expelled through said fluid outlet

e. biasing means tending to retain or restore said first pumping means at or to said 'inlet' position in use

f. a passage through said piston communicating between said second fluid inlet and said fluid outlet

g. closure means adapted to close said passage at said 'inlet' position and also during displacement of said first pumping means under fluid pressure from said 'inlet' position to said 'outlet' position and to open said passage at said 'outlet' position and also during movement of said first pumping means from said

'outlet' position to said 'inlet' position comprising a closure member within said hollow interior adapted to open and close said passage, said closure member moving with, but being displaceable relative to, said piston, stop means coacting between said closure member and said piston and adapted to limit such relative displacement so that said passage is closed on maximum relative displacement in one direction and opened on displacement in the reverse direction, engagement means adapted to alter the relative speed of said closure member and said piston at said 'outlet' position, said closure member having a ratio of thrust surface presented to said second fluid inlet at said 'inlet' position to biasing force tending in use to retain or restore said closure member at or to said 'inlet' position which exceeds that of said first pumping means and

h. second pumping means actuated on movement of said first pumping means to cause a predetermined quantity of said first fluid to enter said hollow interior through said first fluid inlet on each cycle of said first pumping means, said second pumping means including a chamber interposed in said first fluid inlet and first and second one way valve means, said chamber communicating in use with a supply of first fluid via said first one way valve means and with said hollow interior via said second one way valve means, the volume of said chamber being adapted to fluctuate by a predetermined amount on cycling of said piston so that said predetermined quantity of said first fluid is pumped into said hollow interior.

13. A fluid metering device as claimed in claim **12** wherein said closure member has a ratio of thrust surface presented to said second fluid inlet at said 'inlet' position to weight which exceeds that of said piston and said 'inlet' position is adapted to be lower than said 'outlet' position in use so that said piston travels in a substantially vertical direction and the density of said piston is adapted to exceed that of said second fluid.

14. A fluid metering device as claimed in claim **13** wherein said engagement means are elastic so that at the point of opening of said passage and equalisation of the fluid pressure acting on said closure member, the unbalanced recoil force of said engagement means provides an initial acceleration to said closure member, displacing it relative to said piston to open said passage quickly.

15. A fluid metering device as claimed in claim **14** wherein said chamber is defined by a barrel and a plunger movable within said barrel in the line of movement of said first pumping means.

16. A fluid metering device comprising;

a. a housing with a hollow interior

b. first and second fluid inlets into said hollow interior for first and second fluids respectively

c. a fluid outlet from said hollow interior

d. first pumping means within said hollow interior slidable under fluid pressure between said second fluid inlet and said fluid outlet from an 'inlet' position to an 'outlet' position to cause mixed first and second fluids to be expelled through said fluid outlet

e. biasing means tending to retain or restore said first pumping means at or to said 'inlet' position in use

f. a passage between said first pumping means and said housing communicating between said second fluid inlet and said fluid outlet

g. closure means adapted to close said passage at said 'inlet' position and also during displacement of said

first pumping means under fluid pressure from said 'inlet' position to said 'outlet' position and to open said passage at said 'outlet' position and also during movement of said first pumping means from said 'outlet' position to said 'inlet' position, said closure means comprising a resilient skirt on the inlet side of said first pumping means adapted to open said passage except when the circumference is forced into contact with said housing and a difference in fluid pressure is applied between its sides with a higher fluid pressure on the second fluid inlet side, said fluid outlet being positioned so that said skirt uncovers said fluid outlet at said 'outlet' position, thereby equalising the pressure and opening said passage and

h. second pumping means actuated on movement of said first pumping means to cause a predetermined quantity of said first fluid to enter said hollow interior through said first fluid inlet on each cycle of said first pumping means.

17. A fluid metering device as claimed in claim **16** wherein said biasing means coacts with an inwardly coned or curved portion of said housing to spread the circumference of said skirt into sealing contact with said housing at said 'inlet' position.

18. A fluid metering device having a housing with a hollow interior and inlet and outlet openings respectively into and out of said hollow interior, first pumping means within said hollow interior and displaceable under fluid pressure between said inlet and outlet openings from an 'inlet' position to an 'outlet' position to pump fluid through said fluid outlet opening, biasing means tending to retain or restore said first pumping means to said 'inlet' position in use, and said first pumping means defining a passage communicating between said fluid inlet and outlet openings; characterized by: closure means adapted to close said passage at said 'inlet' position to said 'outlet' position and to open said passage at said 'outlet' position and also during movement of said first pumping means from said 'outlet' position to said 'inlet' position; and second pumping means actuated on movement of said first pumping means to meter a predetermined quantity of other fluid into said first mentioned fluid on each cycle of said first pumping means.

19. A fluid metering device comprising:

a. a housing with a hollow interior;

b. said housing having inlet and outlet openings respectively into and out of said hollow interior;

c. first pumping means within said hollow interior and displaceable under fluid pressure between said inlet and outlet openings from an 'inlet' position to an 'outlet' position to pump fluid through said fluid outlet opening;

d. biasing means tending to retain or restore said first pumping means at or to said 'inlet' position in use;

e. said first pumping means defining a passage communicating between said inlet and outlet openings;

f. closure means adapted to close said passage at said 'inlet' position and also during displacement of said first pumping means, under fluid pressure, from said 'inlet' position to said 'outlet' position and to open said passage at said 'outlet' position and also during movement of said first pumping means from said 'outlet' position to said 'inlet' position;

g. and at least one second pumping means actuated on momevment of said first pumping means to meter a predetermined quantity of other fluid into said first mentioned fluid on each cycle of said first pumping means.

* * * * *