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(12) # EUROPEAN PATENT APPLICATION

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(54) **Multiple chamber pump.**

(57) A single piston having multiple piston portions (14,15) one in each of the chambers (12,13) is connected to a single driving source. Variation in piston portion size allows variation in the ratio of liquids pumped through each chamber.

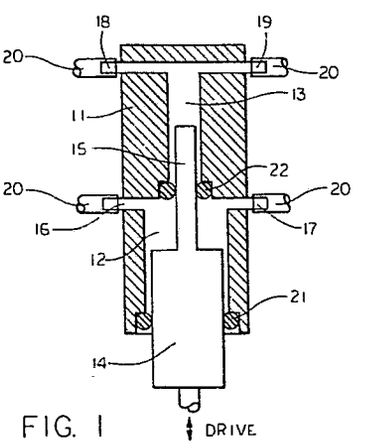

FIG. 1

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MULTIPLE CHAMBER PUMP

Background of the Invention

Field of the Invention

The invention relates to the field of fluid handling. More particularly, the invention relates to a fluid control system in a measuring and testing instrument. By way of further characterization but not by way of limitation thereto, the invention is a pump utilizing a single piston of varying diameter connected to a single driving source.

Description of the Related Art

Measuring and testing instruments involving liquid handling often require movement of two or more liquids to or from remote locations. For example, many instruments require dilution of two or more liquids in a fixed ratio. Many times it is desirable to do this dilution on a continuous basis as opposed to serially dispensing and mixing these liquids. Continuous dilutions would be useful in many chemical or biological analyzers such as continuous flow, stop flow, flame photometers, or atomic absorption photometers.

Prior instruments have used peristaltic pumps or multiple piston positive displacement pumps for continuous dilutions. While suited for their intended purpose, peristaltic type pumps can tolerate only modest back pressure without leaking. Even if different diameter tubes are used on the same roller displacement mechanism, different pressure phases are present which may alter the dilution ratio during each cycle. For large ratio dilutions, either one extremely small or large diameter flexible tube must be used. This may be disadvantageous in pump and system design.

Multiple piston pumps, while suited for their intended purpose, disadvantageously require some piston diameters to be extremely small where small volume and

high dilution ratios are used. In addition, multiple piston pumps in prior devices require mechanical coupling or a separate driving mechanism for each piston and are therefore subject to variations in driving speed, phasing, and backlash.

Summary of the Invention

The invention is a multiple chamber piston positive displacement pump. A body portion defines a plurality of chambers with each chamber effectively sealed from each adjacent chamber. A single piston with varying diameter is coupled to a single driving source. The piston diameters are sized to cooperatively displace a predetermined volume in each chamber. At least one port communicates with each chamber. These ports are valved to control the direction of fluid flow through each chamber.

In the preferred embodiment, a body portion defines a first chamber and a second chamber adjacently mounted along a single axis. Each chamber is substantially sealed from the adjacent chamber. An inlet port and outlet port communicate with each chamber. A first piston portion is connected to a driving mechanism and is movable into and out of the first chamber. A second piston portion of predetermined volume is joined to the first piston portion and is movable into and out of the first and second chambers. The difference in piston diameters controls the ratio of liquid displaced in each chamber by the associated piston portion.

Brief Description of the Drawings

Fig. 1 is a partial sectional view of a pump in accordance with the preferred embodiment of the invention; and

Fig. 2 is a perspective view of the pump.

Description of the Preferred Embodiment

Referring to Fig. 1, a housing 11 defines a first chamber 12 and a second chamber 13. A first

piston portion 14 and a second piston portion 15 are movably mounted in chambers 12 and 13 respectively. While pistons 14 and 15 may be separate units these pistons are milled from the same casting in the preferred embodiment. Piston 14 is coupled with a reciprocating drive (not shown) such that pistons 14 and 15 are mutually driven by the reciprocating drive. An inlet port 16 and an outlet port 17 communicate with first chamber 12. An inlet port 18 and an outlet port 19 communicate with second chamber 13. A seal 21 cooperates with first piston portion 14 and housing 11 to seal first chamber 12 from the outside atmosphere. A seal 22 cooperates with second piston portion 15 to substantially seal second chamber 13 from first chamber 12. Each of inlet ports 16 and 18 and each of outlet ports 17 and 19 are connected to a flexible tube 20.

Referring to Fig. 2, housing 11 is shown with inlet ports 16 and 18 and outlet ports 17 and 19 connected to flexible tube 20. First piston portion 14 is movably mounted in housing 11. A reciprocating drive (not shown) is connected to first piston portion 14.

Mode of Operation

Referring to Fig. 1, housing 11 defines first chamber 12 and second chamber 13. First piston portion 14 and second piston portion 15 are connected to each other and to an external drive source which may be any conventional reciprocating drive. First piston portion 14 slides through seal 21 and second piston portion 15 slides through seal 22. Assuming piston portion 14 and piston portion 15 are cylindrical, the volume displaced by second piston portion 15 in second chamber 13 is the area of second piston portion 15 (πR_{15}^2) times the length of the drive stroke (L) where R_{15} is the radius of piston portion 15. The volume displaced in first chamber 12 is equal to the difference in volume displaced by first piston portion 14 and second piston

portion 15. That is, the displaced volume is equal to $\pi L(R_{14}^2 - R_{15}^2)$ where R_{14} is the radius of piston portion 14. The total volume displaced in both chambers is πLR_{14}^2. The volume displaced in chamber 12 will equal the volume displaced in chamber 13 when R_{14} equals the square root of 2 times R_{15}.

The diameters of pistons 14 and 15 can thus be varied to achieve any dilution ratio. When moderate dilution ratios are desired, it is convenient to use second chamber 13 for the sample liquid and first chamber 12 for the diluent. When the dilution ratio is large, however, the difference in diameters required are prohibitive. That is, the diameter of the second piston portion 15 must be very small in relation to that of first piston portion 14. This requires making piston portion 15 very small or piston portion 14 very large. The diameter of second piston portion 15 may be so small as to be prohibitive. In such a case, the first chamber 12 may be used for the sample and second chamber 13 may be used for the diluent. Thus, piston portion 14 is made slightly larger than piston portion 15 because a small difference in diameter between first piston portion 14 and second piston portion 15 would result in the dispensing of an extremely small sample volume.

Inlet ports 16 and 18 and outlet ports 17 and 19 are controlled by a suitable valving and logic such that sample substances and diluent substances may be picked up from different locations and combined at a continuous fixed ratio in a remote location. That is, referring to Fig. 1, assuming that the pump and tubes have been primed with the desired liquids and ports 16 and 19 are open to diluent and sample reservoirs, respectively, then downward motion of first piston portion 14 and second piston portion 15 will draw diluent substance and calibration substance substan-

tially filling first chamber 12 and second chamber 13, respectively. Any air contained in the chambers will rise to the top and be carried out through the outlet ports upon dispensing. The volumes drawn in depend upon the diameters of first piston 14 and second piston portion 15 as explained above. Preferably, sample liquid is drawn from a remote location into flexible tube 20 connected to outlet port 19 by the downward motion of piston portion 15 while calibration on other liquid is drawn into chamber 13. If inlet ports 16 and 18 are closed and outlet ports 17 and 19 are open, then upward motion of the first piston portion 14 and second piston portion 15 will dispense diluent substance and sample substance in a fixed ratio dependent on the diameters of piston portions. A fixed ratio dilution is thus accomplished. Flexible tubing 20 from outlet ports 17 and 19 could also be connected to a tee portion where calibration or other substances could be combined with diluent substance.

The disclosed invention retains the advantages of positive displacement piston pumps over peristaltic types and also avoids any variation in ratio due to speed, backlash, or errors in drive source phasing encountered with prior pumps using multiple driving sources. Because it utilizes a single drive source and piston, the pump is simpler and more economical to construct and operate.

While particular forms of the invention have been disclosed with respect to a preferred embodiment thereof, it is not to be so limited as changes and modifications may be made without departing from the scope of the invention. For example, the principle of operation may be extended to multiple chamber pumps with variations in piston portion diameters all driven by a single driving source. Another variation would be to have the diameter of piston portion 14 be less than

that of piston portion 15. In that case the displacement in first chamber 12 and second chamber 13 would be positively out of phase, that is, while one chamber would be pumping the other would be aspirating. This arrangement would allow continuous pumping. While pistons portions 14 and 15 and chambers 12 and 13 have been described as being cylindrical, it should be noted that these chambers and piston portions could be of any suitable shape.

The foregoing description, taken together with the appended claims, constitutes a disclosure which enables one skilled in the art and having the benefit of the teachings contained therein to make and use the invention. Further, the structure herein described constitutes a meritorious advance in the art which is unobvious to such skilled workers not having the benefit of these teachings.

What is claimed is:

1. An apparatus for pumping liquids in fixed ratios comprising:

a housing including a plurality of chambers, each chamber effectively sealed from each adjacent chamber;

at least one port communicating with each said chamber, said port connectible to a valving system;

a single piston including a plurality of piston portions coupled to a single driving source, each said piston portion movably mounted in a corresponding one of said plurality of chambers, each said piston portion sized to displace a predetermined volume in each said chamber; and

whereby said driving source moves said piston portions in said chambers thereby pumping liquid through each said chamber and its corresponding port.

2. Apparatus according to claim 1 wherein said housing includes:

a first chamber and a second chamber adjacently mounted therein along a single axis, said chambers including a substantially sealed portion therebetween.

3. Apparatus according to claim 2 wherein said piston includes:

a first piston portion having a predetermined cross-sectional area and connected to a driving mechanism, said first piston portion movable into and out of said first chamber; and

a second piston portion having a predetermined cross-sectional area, said second piston portion connected to said first piston portion, said second piston portion movable into and out of said first chamber and said second chamber.

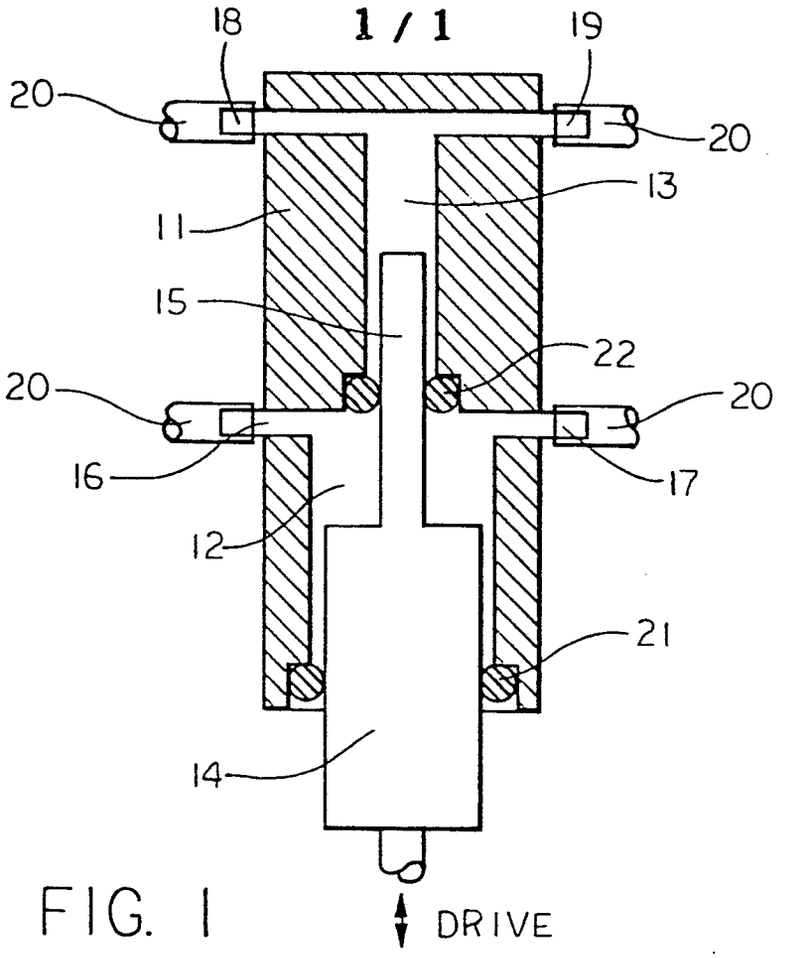
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FIG. 1

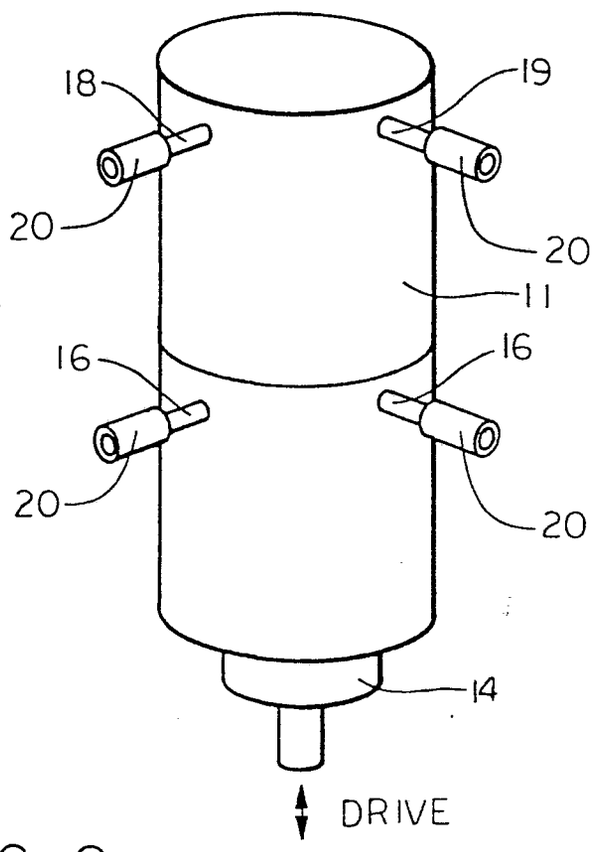
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FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 30 1477

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	US - A - 2 365 234 (WINEMAN) * Page 2, column 1, lines 2-23; figure 2 *	1-3
X	US - A - 2 522 783 (GOLDEN) * Column 2, line 43 - column 3, line 8; figure 2 *	1-3
X	US - A - 3 330 217 (BAUR) * Column 3, lines 9-57; figures 1,3 *	1-3
X	US - A - 3 091 186 (HOFMEISTER) * Column 2, line 57 - column 4, line 7 *	1-3

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
F 04 B 5/00

TECHNICAL FIELDS SEARCHED (Int. Cl.³)
F 04 B

CATEGORY OF CITED DOCUMENTS
X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons
&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	02-06-1981	BAATH

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