June 16, 1964 LE ROY R. HAWK ETAL 3,137,174

FLUID METERING DEVICE

Filed Nov. 9, 1962

Fig. 1

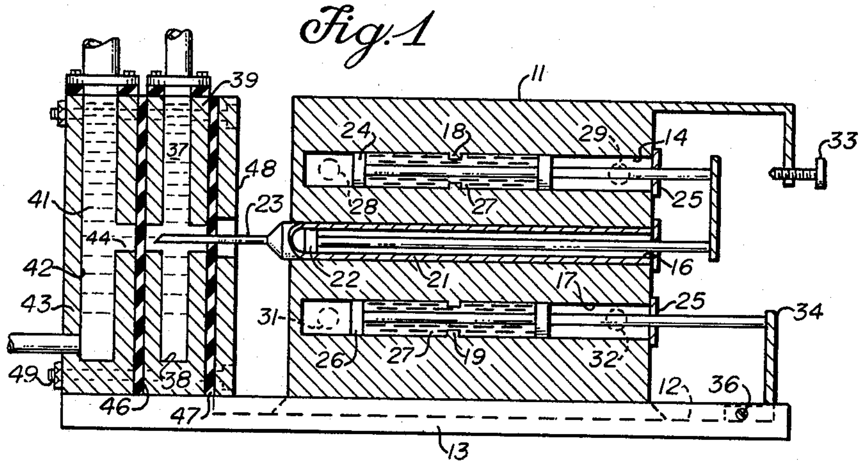
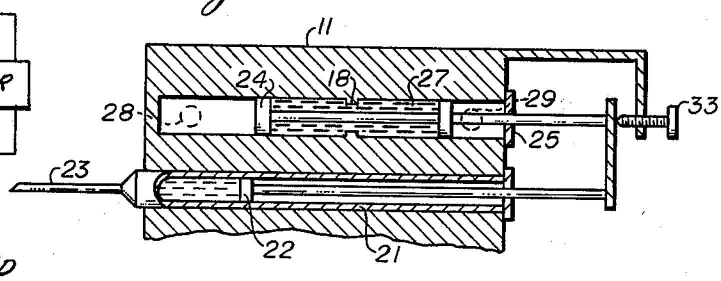


Fig. 2.



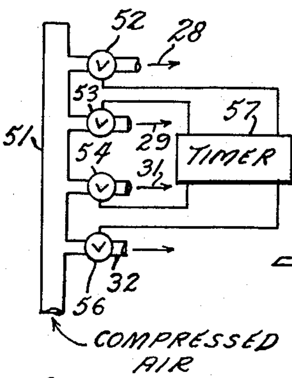
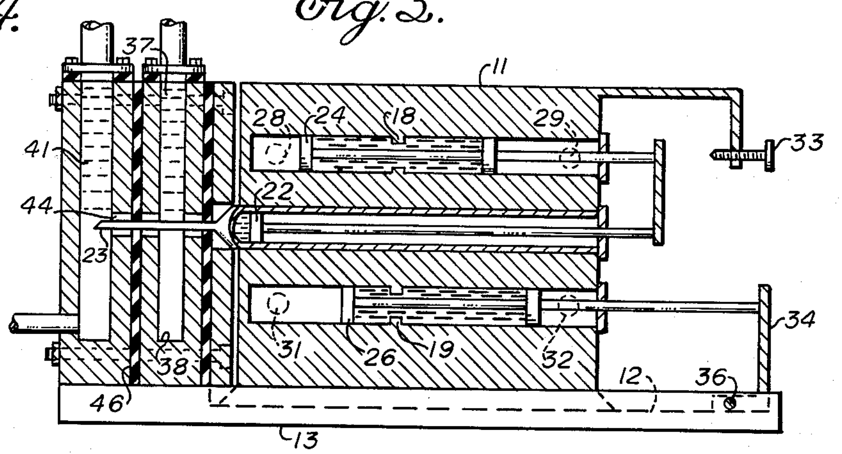


Fig. 4.

Fig. 3.



INVENTORS
LEROY R. HAWK
VIRGIL E. SCRIBNER
BY
Roland A. Anderson
ATTORNEY

United States Patent Office

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FLUID METERING DEVICE

Le Roy R. Hawk, Hayward, and Virgil E. Scribner, Pleasanton, Calif., assignors to the United States of America as represented by the United States Atomic Energy Commission

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1 Claim. (Cl. 73—423)

This invention relates to fluid metering devices and, in particular, to a device for periodically injecting predetermined volumes of fluid into a process stream.

It is often necessary to accurately meter small volumes of a fluid into a process stream. This situation arises in the monitoring of radioactive effluent streams, in gas chromatography, and in certain phases of the pharmaceutical industry, e.g., controlled dilution of concentrated stock solutions.

The present invention provides a pneumatically-actuated fluid metering device for accurately injecting small volumes of a fluid into a process stream. Briefly, the invention comprises two adjacent fluid chambers separated by a self-sealing septum. The fluid to be injected is contained within one of the chambers, and the process stream flows through the other. A pneumatically-actuated hypodermic syringe reciprocates between the two chambers through the septum, thereby transferring measured volumes of the injection fluid into the process stream.

The invention will be described with reference to the accompanying drawing, of which;

FIGURE 1 is a cross sectional view of the metering device at the start of the operating cycle,

FIGURE 2 is a partial view showing the hypodermic syringe in the filled condition,

FIGURE 3 is a cross-sectional view showing the syringe discharging into the process stream,

FIGURE 4 is a schematic diagram of means to operate the metering device in a predetermined motion cycle.

Referring now to FIGURE 1, there is shown an injection block **11** which slides in a groove **12** formed in a base **13**. Upper, middle, and lower cylindrical bores **14**, **16**, and **17**, respectively, are formed into block **11**. Upper bore **14** and lower bore **17** are constricted at their midpoints to form respective constrictions **18** and **19**. A hypodermic syringe **21**, having a piston **22** and a needle **23**, is disposed within middle bore **16** so that one end of piston **22** projects beyond block **11**, and needle **23** projects beyond the opposite side of the block. Double-headed pistons **24** and **26** are disposed within bores **14** and **17** respectively, and the piston shafts project beyond block **11** through airtight shaft seals **25** fixed thereto. Pistons **24** and **26** are disposed so that their shafts pass through constrictions **18** and **19** respectively. The space between the heads of pistons **24** and **26** is filled with a high-viscosity oil **27**. Piston **24** is actuated by compressed air admitted into bore **14** via ports **28** and **29**. Similarly, injection block **11** is actuated by compressed air admitted into bore **17** via ports **31** and **32**. The admission of air into ports **28**, **29**, **31** and **32** can be controlled by various cyclic control means, e.g., solenoid valves in conjunction with a rotating electrical switch. FIGURE 4 is a schematic diagram of apparatus for operating the metering device in a predetermined motion cycle. Compressed air is admitted to a manifold **51** which, in turn, communicates with solenoid valves **52**, **53**, **54**, and **56**. The outlets of the solenoid valves are respectively connected to ports **28**, **29**, **31**, and **32**. An electrical timing mechanism **57** is connected to the electrical inputs of the solenoid valves so as to actuate the valves in a predetermined cycle. The electrical timer may comprise a rotating electrical switch, or other equivalent devices. Alternately, the admission of air into the ports can be controlled manually. Pistons **22** and **24** are linked together at one end so as to move as a single unit. The stroke of piston **24** (hence, piston **22** as well) is adjusted by means of a limiting screw **33**. The shaft of piston **26** is fixed relative to base **13** by means of a link **34** and a lock screw **36**. As will be described later, the position of piston **26** relative to base **13** determines the stroke of block **11**.

A fluid **37** to be injected is contained within a well **38** bored into a first flow block **39**. A process stream **41** flows through a channel **42** formed in a second flow block **43**. Well **38** and channel **42** are connected by a transverse channel **44**, but the process stream and the injection fluid are prevented from mixing by a self-sealing septum **46** disposed between flow blocks **39** and **43**. Transverse channel **44** is sealed off at one end by a self-sealing partition **47**. The two flow blocks are fixed to base **13**, and the entire block assembly is held together and made liquid-tight by a pressure plate **48** which is forced against the block assembly by peripherally-spaced bolts **49**. The pressure plate has a central cutout portion so that needle **23** can pass therethrough.

For the purpose of illustrating the operation of the invention, FIGURE 1 shows the apparatus at the start of the injection cycle. The syringe is empty, and the tip of needle **23** is immersed in the injection fluid **37**. To start the cycle, compressed air is admitted to port **28**, and port **29** is opened to the atmosphere. The admitted air forces piston **24** to the right and, since piston **24** is linked to piston **22**, also forces piston **22** to the right which causes the syringe to fill with injection fluid **37**. The stroke of piston **24**, and hence the injection volume, is determined by the position of limiting screw **33**. Constriction **18** operates in conjunction with viscous oil **27** as a frictional damper to prevent piston **24** from moving too rapidly under the compressed air pressure. FIGURE 2 shows the syringe in the filled condition with piston **24** in contact with screw **33**.

In the next phase of the injection cycle, compressed air is admitted to port **31**, and port **32** is opened to the atmosphere. The admitted air exerts force to the right on piston **26**, and to the left on the closed end of bore **17**. Since piston **26** is fixed relative to base **13** by link **34** and lock screw **36**, the resultant force is directed to the left. Therefore, block **11** slides in groove **13** towards the left. Constriction **19** operates in conjunction with viscous oil **27** as a frictional damper to prevent block **11** from moving too rapidly under the compressed air pressure. The movement of the block pushes needle **23** through septum **46**, and the tip of the needle is immersed in process stream **41**. Compressed air is admitted to port **29**, port **28** is opened to the atmosphere and, as a result, piston **22** is pushed home, thereby discharging the loaded syringe into the process stream. FIGURE 3 shows the apparatus at this stage in the injection cycle. The cycle is completed by admitting compressed air to port **32** and opening port **31** to the atmosphere. The resultant force directed to the right causes block **11** to slide towards the right in groove **13**. Needle **23** is pulled back through septum **46**, and the relative positions of the components are restored to those shown in FIGURE 1.

The invention has been described in terms of injecting a fluid of constant composition into a process stream. However, the apparatus can be modified to inject a fluid of changing composition simply by extending well **38** all the way through flow block **39**, and providing the resulting channel with input and output fittings. In this form the invention would be suitable for use as a sample injector in continuous gas chromatography; the stream to be analyzed would flow through the channel formed from well **38**, and the chromatographic carrier gas would flow through channel **42**.

Septa 46 and 47 must be fabricated of a self-sealing material, otherwise the continuous penetration by needle 23 would result in leakage between the injection fluid and the process stream. Several synthetic elastomers have excellent self-sealing properties. In particular, "Silastic" rubber (a silicone rubber) has been tested as a septum material, and has exhibited no detectable leakage after several hundred cycles of operation.

Various modifications may be made in the invention without departing from the principle thereof, and the scope of the invention is intended to be limited only by the following claim.

What is claimed is:

A fluid metering device comprising,

(*a*) a grooved base,

(*b*) an injection block slideably mounted on said grooved base, said injection block having first, second, and third cylindrical bores formed therein,

(*c*) a hypodermic syringe disposed within said second cylindrical bore, said syringe comprising a barrel, piston, and needle,

(*d*) first and second double-action pistons disposed respectively within said first and third cylindrical bores,

said first double-action piston being linked to said syringe piston, and said second double-action piston being adjustably locked to said base,

(*e*) valve and control means for operating said double-action pistons in a predetermined motion cycle,

(*f*) first and second flow blocks fixed to said grooved base, said first and second flow blocks having first and second fluid chambers formed therein and a channel communicating between said first and second fluid chambers, said channel being oriented so that its longitudinal axis is collinear with the longitudinal axis of said syringe needle,

(*g*) a first self-sealing elastomeric septum terminating one end of said communicating channel,

(*h*) and a second self-sealing elastomeric septum disposed between said first and second fluidchambers and intersecting said communicating channel so as to prevent fluids in said first and second chambers from mixing.

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