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SAMPLING VALVE

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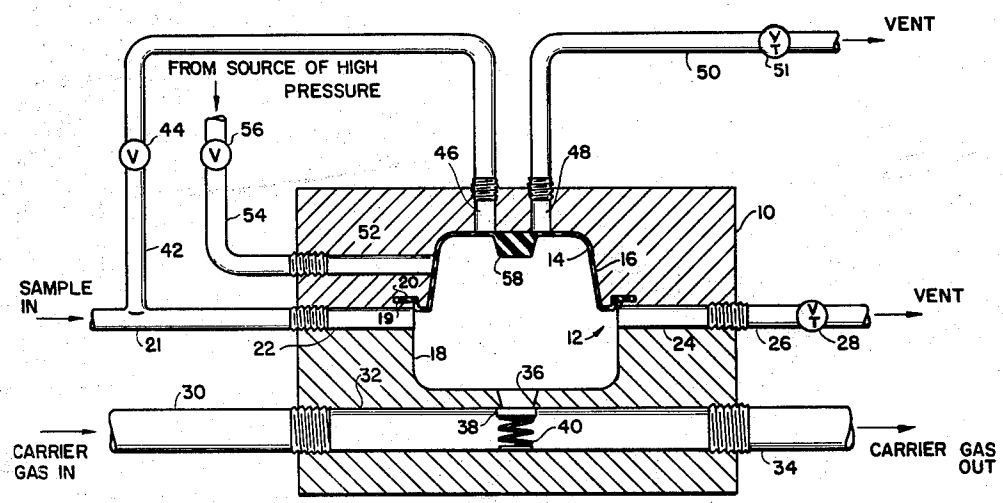


FIG. 1

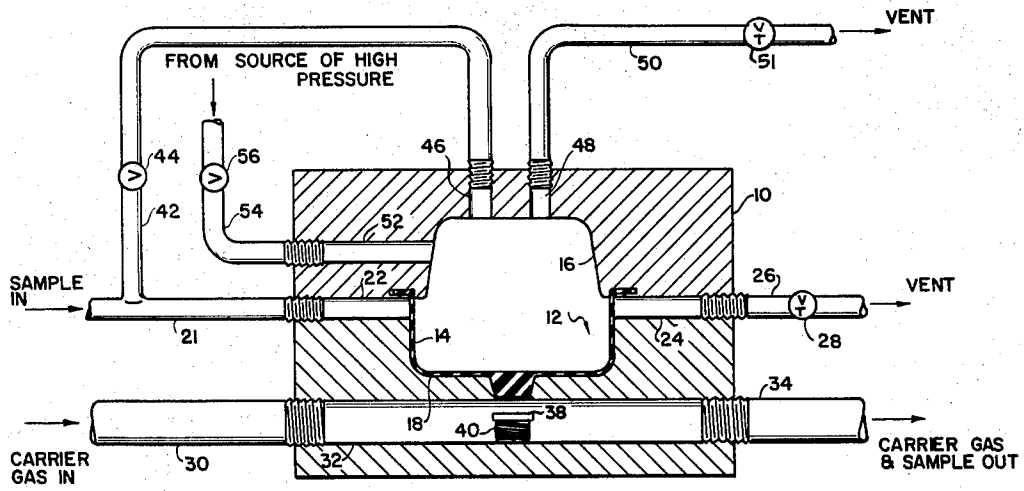


FIG. 2

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SAMPLING VALVE

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This invention relates to a sampling valve and more particularly relates to a sampling valve for injecting a precise volume of sample fluid into a carrier gas stream.

Gas chromatography has in recent years become an important technique in the analysis of gases, vapors and liquids. In such an analysis, it is often desirable to introduce the fluid sample undergoing investigation into a gas stream, which performs the function of a carrier, and passing the combined stream through a column packed with a selected adsorbent material. Since it is usually desired to perform a number of similar tests, sample injection apparatus must be provided that injects an exact amount of sample into the carrier stream each time it is operated. It is also beneficial to system operation if the sample is injected very rapidly into the carrier stream and without the creation of any "dead spaces" in the combined stream fed into the column. A number of valves have previously been proposed for performing the sample injecting operation, but all of them have utilized a sliding or rotating valve member in a valve body with consequent wear and reduced response time caused by friction. Contamination of sample problems also arise in these valves when lubricants are used to overcome the effects of friction.

According to the present invention, it has now been found that a sampling valve can be provided which uses no frictionally engaged movable parts and consequently is simpler to construct, longer wearing, and quicker acting than any heretofore known. The present invention utilizes a flexible diaphragm under the control of a high pressure source of gas for first filling a cavity of known volume with the sample fluid and then expelling the known volume of sample from the cavity and into the carrier stream.

It is therefore a primary object of the present invention to provide a sampling valve requiring no sliding surfaces for injecting a known volume of sample into a carrier gas stream.

It is another object of the present invention to provide a sampling valve in which a known volume of sample is injected into a carrier gas stream by means of a flexible diaphragm under the control of a high pressure source of gas.

These and further objects and advantages of the present invention will become more apparent upon reference to the following specification and claims and appended drawings wherein:

FIG. 1 is a vertical elevation partly in section of the present invention in a first operating condition; and

FIG. 2 is a vertical elevation partly in section of the present invention in a second operating condition.

Referring now to FIG. 1, a valve body **10** of any suitable configuration is provided with an interior cavity or chamber **12**. The cavity **12** may be formed in any shape that is amenable to cooperation with a flexible diaphragm **14** located therein. The shape of the cavity should be such that the diaphragm **14** will be able to establish intimate contact with the entire surface **16** of the upper portion of the cavity when the diaphragm is in a first extreme position and to establish intimate contact with the entire surface **18** of the lower portion of the cavity when the diaphragm is in a second extreme position. In the form of the invention shown, the upper portion of the cavity is generally bell-shaped while the lower portion is generally cylindrical with rounded edges, although the upper portion could also be cylindrical or any other suitable shape.

The diaphragm **14** may be made of any suitable flexible material that will not be adversely affected by either the sample fluid to be tested or gas from a high pressure source. If desired, the diaphragm may be of the type that snaps from one position to another upon a predetermined pressure difference across it, the second position usually being the inverse of the first. In this case, the portions of the cavity on either side of the diaphragm would be symmetrical. The diaphragm can be fastened in place in any appropriate fashion. For example, the valve body may be divided into two parts, the upper part being provided with an annular recess **19**. The lip **20** of the diaphragm may be placed in this recess and securely held in place by the lower part of the valve body when the two parts are assembled.

Sample fluid from any suitable source (not shown) is introduced into the cavity **12** through a conduit **21** and a passageway or inlet port **22** in the valve body. The conduit **21** may be coupled with the passageway **22** in any well-known fashion, for example, by a threaded coupling. Sample fluid is vented from the cavity **12** through a passageway **24** in the valve body and a conduit or pipe **26** which is vented to the atmosphere through a throttle valve **28**. The throttle valve **28** serves to control the flow of sample through the conduit **26** and thus maintains the proper pressure in the cavity **12**. If desired, this throttle valve may be made adjustable to give the system more flexibility.

Carrier gas enters the valve body **10** through a conduit **30** which is preferably threadedly coupled with a passageway **32** in the valve body. The other end of the passageway **32** is coupled with a conduit **34** which leads to the column (not shown) where the sample is separated into its several components. A tapered bore **36** has one end opening into the cavity **12** and the other end opening into the passageway **32**, thus enabling the establishment of fluid communication between them. In the condition of the apparatus shown in FIG. 1, such fluid communication is prevented by a valve **38** which is maintained over the bore **36** by a biasing spring **40**. The spring **40** can be seated in the conduit **32** in any desired fashion as is well known in the art. Any other type of functionally similar valve could, of course, be substituted for the valve **38**.

The sample inlet conduit **21** has a branch conduit **42** which is coupled through a valve **44** with a passageway or inlet port **46** in the valve body. The valve **44** could, of course, be replaced by a two-way valve at the junction of the two conduits. The passageway **46** opens into the upper portion of the cavity **12** as does a passageway **48** which is coupled to a vent conduit **50**. The passageways **46** and **48** are both blocked by the action of the diaphragm **14** which is held in close contact with the surface **16** of the upper portion of cavity **12** by the sample fluid pressure built up in the cavity **12**. A third passageway or inlet port **52** also opens at one end into the upper portion of the cavity **12**. The other end of the passageway **52** is coupled to a conduit **54** which leads to a source of high pressure gas (not shown) through a valve **56**. High pressure gas from this source acts to control the movement of the diaphragm for a purpose to be explained presently. The gas may be air or any suitable gas which will not corrode the diaphragm or react with the sample fluid.

When the apparatus is in the condition shown in FIG. 1. the valves **44** and **56** are closed so that no pressure is exerted on the upper surface of the diaphragm **14** to counter-balance the pressure exerted on the lower surface of the diahpragm **14** by the sample fluid in the cavity **12**. The throttle valve **28** permits a sufficient build-up in pressure in the cavity **12** to insure that the diaphragm is in intimate contact with the surface **16** of the upper portion of the cavity but not high enough to displace the valve **38**

from the bore 36. The sample contained in the cavity 12 is thus isolated from the carrier gas stream flowing through the conduit 32.

Consider now the condition of the apparatus when the valves 44 and 56 are opened. This condition is shown in FIG. 2 in which the same elements are indicated by the same reference numerals used in FIG. 1. When the valve 56 is opened, high pressure gas appears at the inner end of the passageway 52 with the result that the diaphragm 14 is very rapidly pushed or snapped to a position in which it intimately engages the surface 18 of the lower portion of the cavity 12. The diaphragm is preferably provided with a tapered protrusion 58 that fits into the bore 36 and replaces any fluid contained therein.

In some cases, it may be desired that no protrusion be provided on the lower surface of the diaphragm. In this event, the bore 36 may be made very shallow so that the diaphragm can conform to the shape of the bore, leaving no appreciable volume in which sample fluid can remain after the diaphragm has moved downwardly. The speed of movement of the diaphragm is, of course, dependent on the difference in pressure between the high pressure source and the sample fluid present in the cavity 12 and the characteristics of the material of which it is made. As the diaphragm is pushed downwardly it immediately rolls over and seals closed the inner openings of the passageways 22 and 24 thus preventing the admission of any further fluid into the portion of the cavity 12 below the diaphragm 14 and the exit of any fluid previously contained in this space.

The opening of the valve 44 causes the sample fluid to flow through the conduit 42 rather than the conduit 21 which is now blocked and into the upper part of the cavity 12 through the passageway 46 thus adding to the pressure exerted on the upper surface of the diaphragm 14 and enabling a continuous flow of sample fluid. The sample fluid and the high pressure gas can be vented through the passageway 48 and conduit 50 which if desired may be provided with a throttle valve 51 to insure the proper build-up of pressure in the portion of the cavity 12 above the diaphragm.

The rapid downward motion of the diaphragm 14 causes a build-up in pressure in the portion of the cavity below the diaphragm 14. This pressure soon reaches a value high enough to overcome the biasing force exerted by the spring 40 on the valve 38. The valve 38 thus is pushed downwardly away from the bore 36 enabling the sample fluid to be exhausted from the portion of the cavity 12 below the diaphragm 14 and into the carrier gas stream flowing in the passageway 32 whereupon it is carried to the column for analysis.

When the sample fluid previously present below the diaphragm 14 in the cavity 12 is completely exhausted into the carrier gas stream, the valves 44 and 56 are closed. The pressure exerted on the upper surface of the diaphragm 14 quickly diminishes due to the venting action of the passageway 48 and conduit 50 with the result that the pressure exerted on the lower surface of the diaphragm 14 by the sample fluid flowing into the passageway 22 causes the diaphragm 14 to move upwardly into the position shown in FIG. 1. It can readily be seen that this operation can be performed very quickly and may be easily automatically programmed by suitable control of the valves 44 and 56.

It will be apparent from the foregoing that the present invention provides a fluid-sampling valve of simple and sturdy construction that can quickly and accurately inject a precise volume of sample fluid into a carrier gas stream. The valve utilizes a flexible diaphragm rather than relatively slidable parts and thus is free from the effects of friction or the contaminating effects of lubricants used to overcome friction.

The invention may be embodied in other specific forms not departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

We claim:

1. Apparatus for introducing a sample fluid into a flowing stream of a carrier gas comprising, in combination; a first valve, said valve comprising a valve body with interior walls defining a cavity therein, a flexible diaphragm located in said cavity and fixedly attached to the walls thereof, a first inlet port to said cavity on one side of said diaphragm, second and third inlet ports to said cavity on the other side of said diaphragm, a first venting port from said cavity on said first side of said diaphragm, a second venting port from said cavity on said other side of said diaphragm, a passageway extending through said body, normally blocked fluid conducting means having one end opening into said passageway and the other end opening into said cavity on said one side of said diaphragm, said diaphragm when in a first position blocking said second and third inlet ports and said second venting port and when in a second position blocking said first inlet port and said first venting port; a first conduit for supplying sample fluid to said first inlet port when said diaphragm is in said first position; a second conduit for supplying sample fluid to said second inlet port when said diaphragm is in said second position; a source of high pressure gas; a third conduit for supplying said high pressure gas to said third inlet port; a second valve located in said third conduit for controlling the supply of said high pressure gas to said third inlet port; a fourth conduit for supplying a stream of carrier gas to said passageway; said diaphragm being in said first position when said second valve prevents high pressure gas from being supplied to said third inlet port; said diaphragm being moved to said second position when said second valve prevents high pressure gas to be supplied to said third inlet port; movement of said diaphragm from said first position to said second position causing the unblocking of said fluid conducting means whereby the sample fluid present in said cavity on said one side of said diaphragm is exhausted into said passageway; and a third valve in said second conduit for controlling the supply of sample fluid through said second conduit when said diaphragm is in said second position and for selectively interrupting flow of sample fluid through said second conduit thereby to permit movement of said diaphragm from said second position back to said first position when said flow of high pressure gas is interrupted through said third conduit.

2. The apparatus of claim 1 wherein a fifth conduit is coupled to said second venting port and a fourth valve is provided for controlling the flow of fluid through said fifth conduit.

3. The apparatus of claim 1 wherein said fluid conducting means is normally blocked by a spring biased valve.

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