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FLUID VALVING SYSTEM
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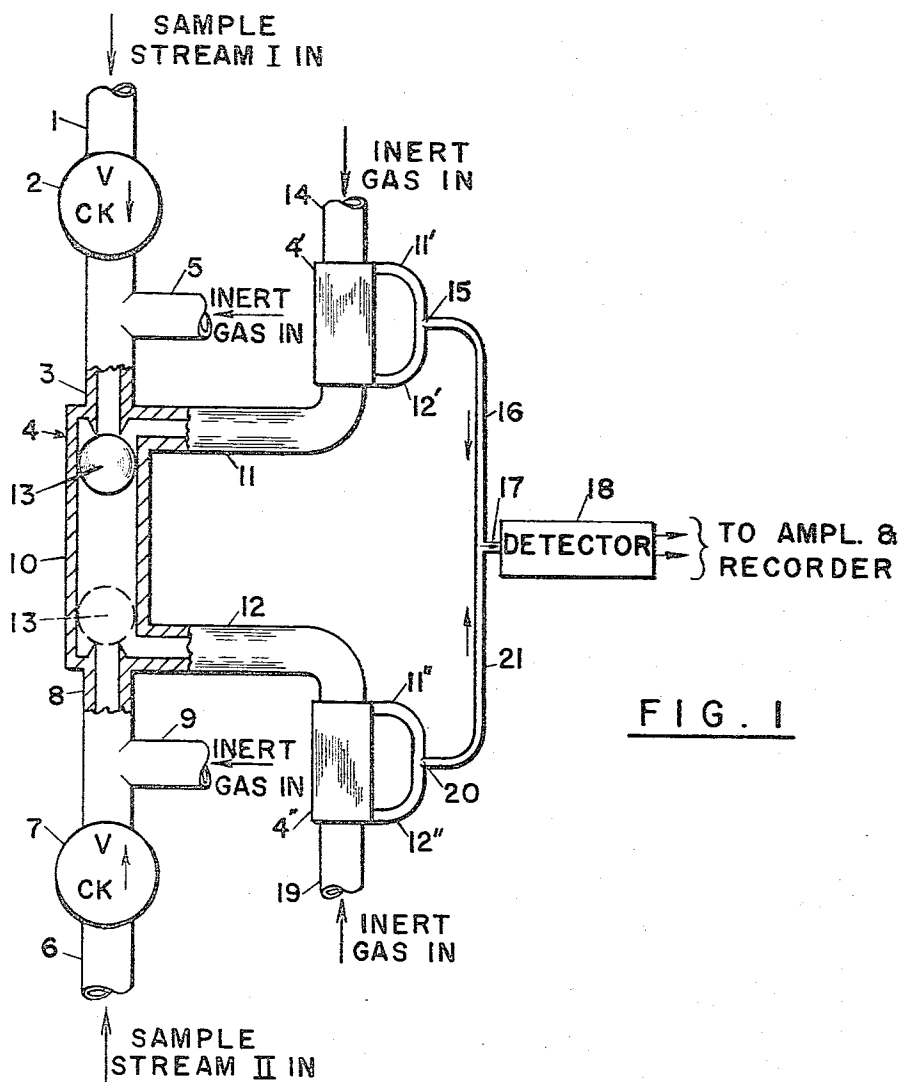


FIG. 1

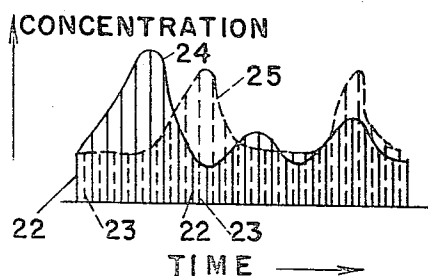


FIG. 2

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ANALYZING APPARATUS WITH PRESSURE-ACTUATED FLUID VALVING SYSTEM

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ABSTRACT OF THE DISCLOSURE

An "on-off" switching valve utilizes a ball which is moved back and forth between two seats in response to fluid pressure acting on the ball. When on one seat, the ball seals a first valve inlet off from a first valve outlet; when on the other seat, the ball seals a second valve inlet off from a second valve outlet. The first and second valve outlets may be paired, each through a separate, similar switching valve, to the single input of a detector, such as a chromatographic detector.

This invention relates to a fluid chopper, and more particularly to a fluid chopper or switching system for instruments such as chromatographs.

In gas chromatography, the time required for a sample to diffuse through the partitioning column, for acceptable resolution, can be as much as one hour. This means that it is desirable to reduce, in some way, the time necessary for the running of samples. It is possible to operate several columns at the same time, but in this case separate detectors are usually used for every column, and some of these detectors are very expensive. For example, a flame ionization detector, with its attendant circuitry, is quite expensive.

On the other hand, the flame ionization detector inherently has a rapid response, so that it would be possible to switch (in an alternative manner) the gas streams from two separate columns into the same ionization detector and circuitry. That is to say, two gas streams which are concomitantly present can be alternatively applied to the input of a single chromatographic detector, so that this detector can be used for two separate streams, on a time-sharing basis.

An object of this invention is to provide a fluid chopper system for instrumentation, and specifically for chromatography.

Another object is to provide a system whereby two gas streams which are concomitantly present, in separate conduits, may be alternatively switched to the input of a single detector.

A further object is to accomplish the foregoing objects in a simple yet effective manner.

The objects of this invention are accomplished, briefly, in the following manner: An automatically-operating two-position switching valve, actuated by pressure variations occurring within the valve body, has two inlets to which are fed, respectively, the two gaseous streams to be applied to the detector, and has two outlets which are coupled to the inlet of a single chromatographic detector. In one position, the switching valve interconnects the first inlet and the first outlet and closes off the second outlet; in the second position, the switching valve closes off the first outlet and interconnects the second outlet and the second inlet. Additional switching means operate to insert inert gas into the couplings between the outlets and the detector inlet, during the times when the respective outlets are closed off by the first-mentioned switching valve.

A detailed description of the invention follows, taken in conjunction with the accompanying drawing, wherein:

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FIG. 1 is a diagrammatic view, partly in section, which illustrates a fluid chopper system according to this invention; and

FIG. 2 illustrates a representative chromatogram which might be obtained using the system of FIG. 1.

Now referring to FIG. 1, a gaseous sample stream, designated I, is fed by way of a conduit 1 through a check valve 2 to one inlet 3 of a switching valve denoted generally by numeral 4. By means of a branch pipe 5 which opens into conduit 1 between check valve 2 and switching valve inlet 3, a suitable inert gas is fed into the valve inlet 3, along with the sample stream I.

Another gaseous sample stream, designated II, is fed by way of a conduit 6 through a check valve 7 to the second inlet 8 of switching valve 4. Sample streams I and II are concomitantly present in conduits 1 and 6, respectively. These streams could be developed as the result of passing the same original sample stream through two different partitioning columns, or as the result of passing different original sample streams through respective partitioning columns. In any event, the sample streams I and II are considered to be derived from respective partitioning columns, so each stream is in general present over an extended interval of time, and each stream includes a plurality of gaseous components separated in time in the respective stream.

By means of a branch pipe 9 which opens into conduit 6 between check valve 7 and switching valve inlet 8, a suitable inert gas is fed into the valve inlet 8, along with the sample stream II.

The switching valve 4 includes an elongated substantially cylindrical chamber 10, into one end of which the inlet 3 opens and into the opposite end of which the inlet 8 opens, the inlet pipes 3 and 8 extending in an approximately axial direction relative to this chamber. The diameters of the bores of inlets 3 and 8 are equal, and the inside diameter of the chamber 10 is considerably greater than the bore diameters of the inlets 3 and 8. At the upper end of chamber 10, adjacent inlet 3, an outlet pipe 11 (whose bore has the same diameter as that of inlet 3) extends outwardly from chamber 10, in a lateral or sidewise direction with respect to chamber 10. At the lower end of chamber 10, adjacent inlet 8, an outlet pipe 12 (whose bore has the same diameter as that of inlet 8) extends outwardly from chamber 10, in a lateral or sidewise direction with respect to chamber 10.

A ball 13, which has very nearly the same diameter as chamber 10, is positioned in this chamber for movement longitudinally of the chamber between the two ends thereof. This ball is moved between its solid-line position (at the upper end of the chamber) and its dotted-line position (at the lower end of the chamber) as a result of differential pressures acting on said ball. In its uppermost or solid-line position, ball 13 seals the inner ends of both pipes 3 and 11, and prevents any communication therebetween; when the ball is in this position, the inner ends of both pipes 8 and 12 are open, so that these pipes can then communicate with each other via the lower end of chamber 10. When the ball 13 is in its other or dotted-line position, at the lower end of chamber 10, it seals the inner ends of both pipes 8 and 12, and prevents any communication therebetween; when the ball is in this dotted-line position, the inner ends of both pipes 3 and 11 are open, so that these pipes can then communicate with each other via the upper end of chamber 10.

The principle of operation of switching valve 4 utilizes the force differential which exists across a seated ball. The ball 13, when seated (for example, when seated in its solid-line position) is exposed to one fluid pressure over a small portion of the surface of the ball (to wit, the small upper portion corresponding to the diameter of pipe 3) and another fluid pressure over a large surface of the ball

(to wit, the large lower portion corresponding to the diameter of chamber 10). The resulting force developed on the ball will determine whether the ball is maintained against the seat (at the inner end of pipe 3, for example) to thus act as a valve to close off the fluid flow through pipe 3 into pipe 11, or whether the ball is moved away from its upper seat, thus removing the valve action on pipe 3. If the ball is seated at the upper end of chamber 10, an appropriate rise in pressure in pipe 3 will move the ball off the seat and flip the ball rapidly to the opposite end of the chamber 10 where it again is seated (as indicated in dotted lines in FIG. 1), thus performing a valve function by valving "off" pipe 8 and valving "on" pipe 3. Thus, assuming that the ball 13 has just flipped to its solid-line position, pipe 3 is valved "off" and the pressure begins to increase in this pipe (since the gaseous stream is continuing to flow thereto from the respective chromatograph partitioning column and from the inert gas supply at 5). When the pressure in pipe 3 rises sufficiently to overcome the upward pressure on the ball (which latter is the result of the pressure in pipe 8, acting through the large diameter of chamber 10), the ball 13 flips rapidly to its lower or dotted-line position. This valves "off" pipe 8 and the pressure begins to increase in this latter pipe.

When the pressure in pipe 8 rises sufficiently to overcome the downward pressure on the ball (which latter is the result of the pressure in pipe 3, acting through the large diameter of chamber 10), the ball 13 flips rapidly to its upper or solid-line position. Thus, the valve acts as a two-position or flip-flop valve.

It will be seen, from the foregoing description, that the switching valve 4 operates automatically, and is pressure-actuated. Of course, when pipe 3 is valved "on" or open (i.e., when the ball 13 is in its dotted-line position), the valve inlet 3 is connected to the valve outlet 11, and gas can flow from pipe 3 into pipe 11. Similarly, when pipe 8 is valved "on" or open (i.e., when the ball 13 is in its solid-line position), the valve inlet 8 is connected to the valve outlet 12, and gas can flow from pipe 8 into pipe 12.

The other end of valve outlet pipe 11 is coupled to a moving-ball-type switching valve 4' (which is preferably exactly similar to valve 4), to provide one input thereto. Inert gas is fed to the other inlet 14 of switching valve 4'. The two outlets 11' and 12' of valve 4' are coupled together at 15 and to a pipe 16 which extends to the inlet 17 of a chromatographic detector 18 (for example, of the flame ionization type).

The other end of valve outlet pipe 12 is coupled to a moving-ball-type switching valve 4'' (which is preferably also similar to valve 4), to provide one input thereto. Inert gas is fed to the other inlet 19 of switching valve 4''. The two outlets 11'' and 12'' of valve 4'' are coupled together at 20 and to a pipe 21 which extends to detector inlet 17. Thus, pipes 16 and 21 are both connected, essentially in parallel, to the detector inlet, and the gaseous feed or input to the chromatographic detector 18 comprises the gases flowing in the two pipes 16 and 21.

The output of detector 18 is fed to a suitable amplifier and recorder, as indicated in FIG. 1. It will thus be seen that, according to this invention, only one detector, amplifier, and recorder are utilized, for both of the sample streams I and II. The flame ionization type of detector inherently has a fast response time, so it is well adapted to have separate respective inputs switched thereto, in an alternative manner (i.e., on a basis of time-sharing). The recorder which is coupled to the output of detector 18 should have a fast response time (e.g., 0.1 second for full-scale deflection), so that it can follow the switching, which might take place at a rate of ten cycles per second. It is pointed out here that FIG. 2 illustrates a typical record (chromatogram), such as might be produced by the recorder which is coupled to the output of detector 18.

The operation of the system of this invention will now be explained. Assume first that ball 13 of switching valve

4 is in its solid-line position. Under these conditions, the flow of sample stream I is cut off from pipe 11, as previously described. Thus, there is no pressure in pipe 11 at this time, which means that the ball in valve 4' is forced to its lower position by the pressure of the inert gas supplied at 14 to this latter valve; in this ball position, the inner end of pipe 12' is sealed off. Inert gas then flows from pipe 14 through the upper end of the chamber in valve 4' to pipe 11', and thence by way of pipe 16 to the detector input 17. At this same time, sample stream II flows from pipe 8 into pipe 12. This flow provides a pressure on the ball in valve 4'' which is sufficient to overcome the pressure exerted on this latter ball by the inert gas at 19, so the ball in valve 4'' is forced to its lower position, sealing off the inner end of pipe 19 and opening the right-hand end of pipe 12. Sample stream II then flows from pipe 12 through the upper end of the chamber in valve 4'' to pipe 11'', and thence by way of pipe 21 to the detector input 17. This results in the production of a bar such as 22 on the record of FIG. 2, the height of which bar is proportional to the output of detector 18, and thus to the concentration of gas in sample stream II, at that particular time.

As previously described, when ball 13 is in its solid-line position, the pressure begins to rise in pipe 3. After a short time, then, ball 13 flips rapidly to its dotted-line position. Under these conditions, the flow of sample stream II is cut off from pipe 12, as previously described. There then being no pressure in pipe 12, the ball in valve 4' is forced to its upper position by the pressure of the inert gas supplied at 14 to this latter valve; in this ball position, the inner end of pipe 11' is sealed off. Inert gas then flows from pipe 19 through the lower end of the chamber in valve 4' to pipe 12', and thence by way of pipe 21 to the detector input 17. At this same time, sample stream I flows from pipe 3 into pipe 11. This flow provides a pressure on the ball in valve 4'' which is sufficient to overcome the pressure exerted on this latter ball by the inert gas at 14, so the ball in valve 4'' is forced to its upper position, sealing off the inner end of pipe 14 and opening the right-hand end of pipe 11. Sample stream I then flows from pipe 11 through the lower end of the chamber in valve 4'' to pipe 12'', and thence by way of pipe 16 to the detector input 17. This results in the production of a bar such as 23 on the record of FIG. 2, the height of which bar is proportional to the output of detector 18, and thus to the concentration of gas in sample stream I, at that particular time. Actually, the bar 23 will appear as a solid line on the record; it is shown as a dotted line in FIG. 2 merely for convenience in illustration.

When ball 13 is in its dotted-line position, the pressure begins to rise in pipe 8. After a short time, ball 13 flip back to its solid-line position, causing the balls in valves 4' and 4'' to flip back to their "original" positions, and the above-described process repeats.

It may therefore be seen that sample streams I and II are applied alternately to the input of the single detector 18, to produce a two-trace record of the type illustrated in FIG. 2. Actually, of course, the record will consist of two separate series of bar graphs which represent the respective concentrations of the gases in sample streams I and II. The envelopes 24 and 25 will not actually appear on the record; these are shown in FIG. 2 merely for illustrative purposes.

The various pressures of inert gas supplied to the system at 5, 9, 14, and 19 must be adjusted or set to values such as to operate the switching valves in the manner previously described, which is the manner desired for proper operation of the system.

The invention claimed is:

1. In apparatus for analyzing gaseous streams, analyzer having an inlet; a two-position switching valve having a body to which are coupled first and second inlet conduits and first and second outlet conduits; means providing separate gaseous streams for said first and second

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inlet conduits, respectively; means in said valve body, and automatically actuated by pressure variations occurring therein, for isolating said first inlet conduit from said first outlet conduit in one position of said valve and for isolating said second inlet conduit from said second outlet conduit in the other position of said valve; means coupling said first outlet conduit to the inlet of said analyzer, and means coupling said second outlet conduit to the inlet of said analyzer.

2. Apparatus as set forth in claim 1, wherein the second-mentioned means comprises a ball movable back and forth between two positions, in one of which it isolates said first inlet conduit from said first outlet conduit and in the other of which it isolates said second inlet conduit from said second outlet conduit.

3. Apparatus as claimed in claim 1, wherein said means coupling said first outlet conduit to the analyzer inlet includes a two-position valve which in one position thereof connects said first outlet conduit directly to the analyzer inlet, and which in its other position connects an inert gas supply to the analyzer inlet.

4. Apparatus in accordance with claim 3, wherein the last-mentioned two-position valve is automatically actuated by pressure variations occurring within the body thereof.

5. Apparatus as claimed in claim 1, wherein said means coupling said second outlet conduit to the analyzer inlet includes a two-position valve which in one position thereof connects said second outlet conduit directly to the analyzer inlet, and which in its other position connects an inert gas supply to the analyzer inlet.

6. Apparatus in accordance with claim 5, wherein the last-mentioned two-position valve is automatically actuated by pressure variations occurring within the body thereof.

7. In analyzing apparatus, an analyzer having an inlet; a two-position valve having first and second inlets and first and second outlets, said first inlet being coupled to said first outlet in one position of said valve and said second inlet being coupled to said second outlet in the other position of said valve; a first conduit coupled to

said first inlet, a second conduit coupled to said second inlet, means coupling said first outlet to the inlet of said analyzer, said means including a two-position valve which in one position thereof connects said first outlet directly to the analyzer inlet, and which in its other position connects an inert gas supply to the analyzer inlet; and means coupling said second outlet to the analyzer inlet.

8. Apparatus in accordance with claim 7, wherein the last-mentioned two-position valve is automatically actuated by pressure variations occurring within the body thereof.

9. In analyzing apparatus, an analyzer having an inlet; a two-position valve having first and second inlets and first and second outlets, said first inlet being coupled to said first outlet in one position of said valve and said second inlet being coupled to said second outlet in the other position of said valve; a first conduit coupled to said first inlet, a second conduit coupled to said second inlet, means coupling said first outlet to the inlet of said analyzer, and means coupling said second outlet to the analyzer inlet, said last-mentioned means including a two-position valve which in one position thereof connects said second outlet directly to the analyzer inlet, and which in its other position connects an inert gas supply to the analyzer inlet.

10. Apparatus in accordance with claim 9, wherein the last-mentioned two-position valve is automatically actuated by pressure variations occurring within the body thereof.

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