Feb. 27, 1962 D. H. FULLER 3,022,673

FLUID LINE TRANSFER SWITCH

Filed June 9, 1960 2 Sheets-Sheet 1

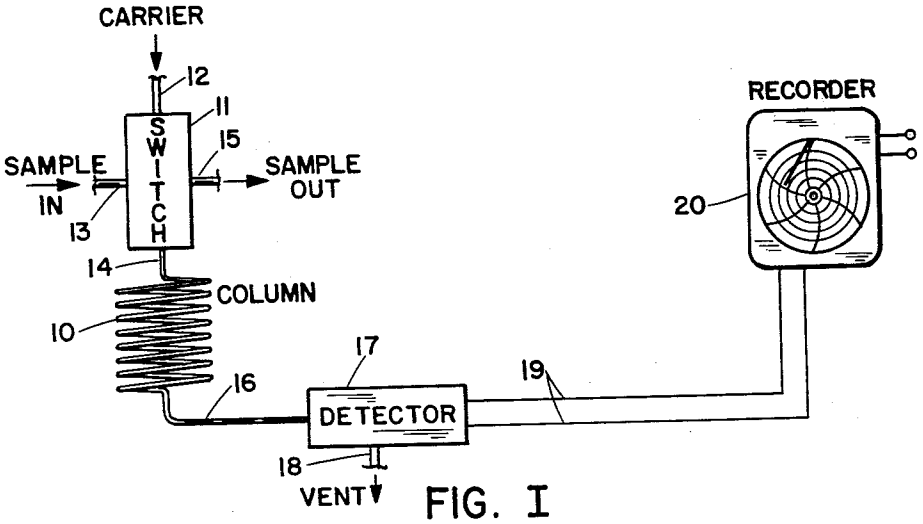


FIG. I

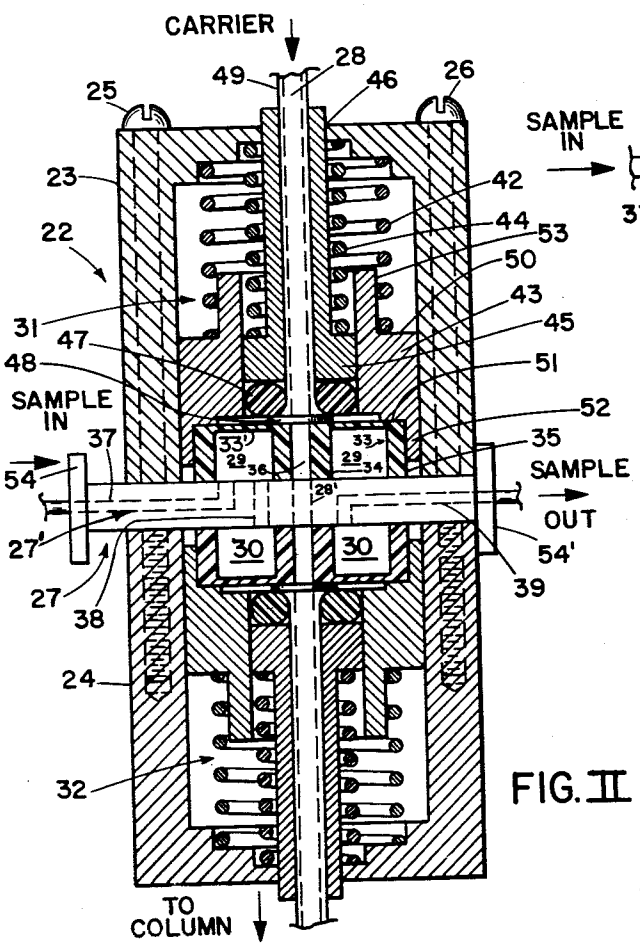


FIG. II

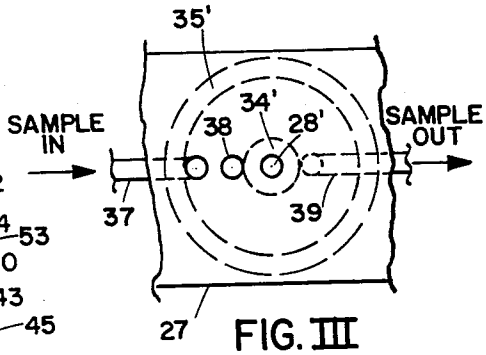


FIG. III

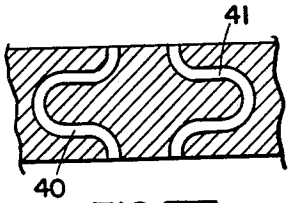


FIG. IV

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FLUID LINE TRANSFER SWITCH

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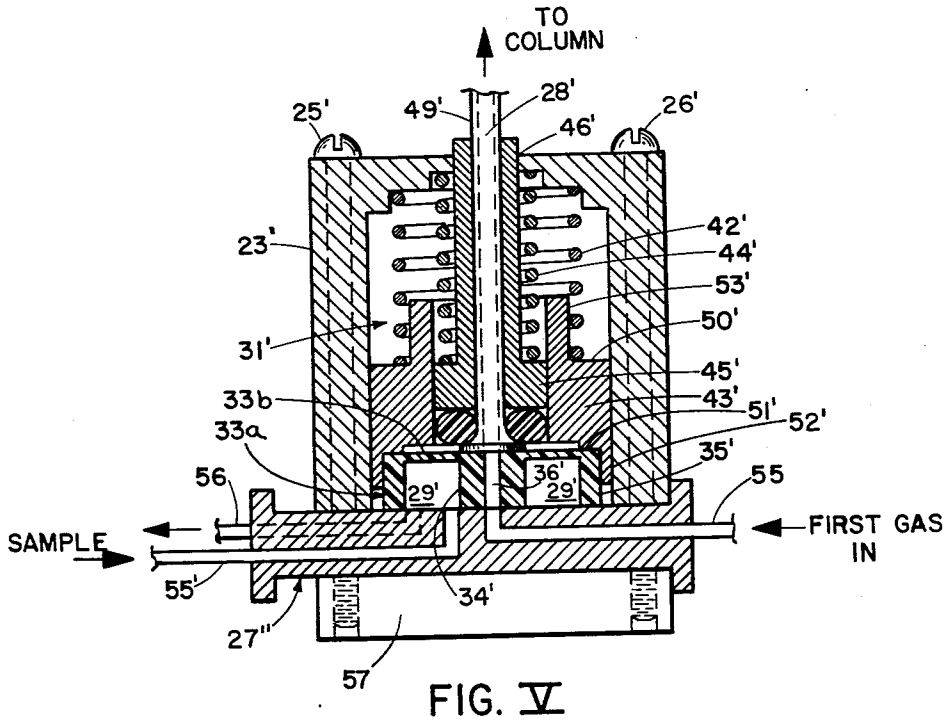


FIG. V

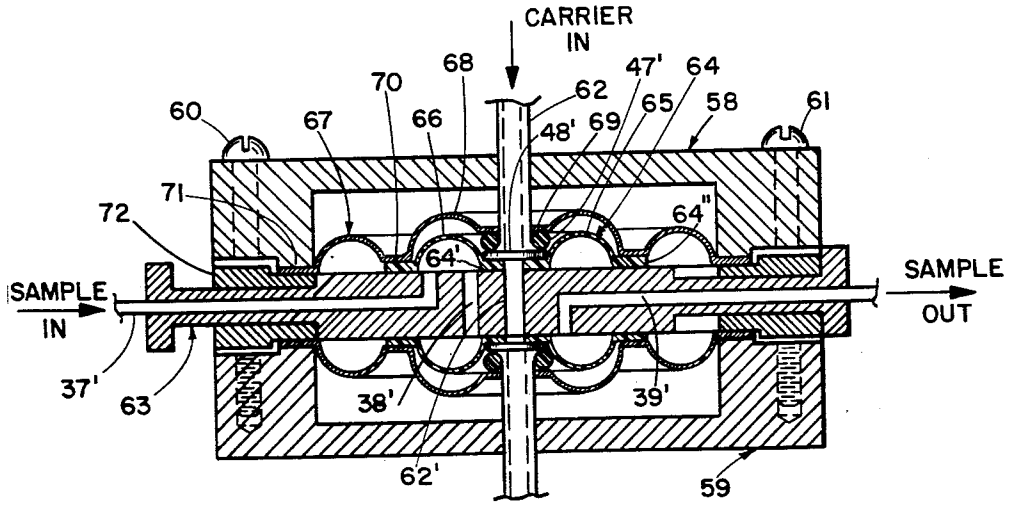


FIG. VI

TO COLUMN

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FLUID LINE TRANSFER SWITCH

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This invention relates to fluid lines and to connection switching between said lines.

The requirements of instrumentation involving gas, liquid, or combinations of these in flow, pressure, or transfer lines are increasingly high in the areas of precision and simplicity.

In chromatographic systems for example, various fluid connection transfers may be required. It is often necessary in sampling techniques to repeatably inject a precise small volume from one fluid flow into another fluid flow, as in injecting a sample volume into a carrier. The sample may be gas injected into gas or liquid, or liquid injected into gas or liquid. Also, liquid may be injected into gas for movement to a vaporization area. A further situation is involved in frontal analysis, wherein the concern in re a sample injection is the leading interface between sample and resident gas, without reference to the volume of the sample.

Connection changes of this nature may involve transfers of pressure or flow situations, as well as providing desirable interfaces or precise volume sample inserts.

There are many difficulties involved in such fluid connection transfers, such as losses by leakage, or diffusion, in or out, dead spaces, and the tendency to become undesirably complex, expensive, and bulky.

This invention provides a fluid line transfer switch which is simple, precise, compact, and suitable to modern needs of such transfers. With this invention transfer volumes as low as the order of one microliter and with extremely sharp interfaces are readily obtainable.

It is therefore an object of this invention to provide a new and improved fluid line transfer switch.

Other objects and advantages of this invention will be in part apparent and in part pointed out hereinafter, and in the accompanying drawing, in which:

FIGURE I is a schematic showing of a chromatographic system embodying a sampling switch according to the fluid line transfer switch of this invention;

FIGURE II is a vertical central section of a precise volume sampling switch such as that indicated in FIGURE I;

FIGURE III is a detail of the slider portion of the switch of FIGURE II;

FIGURE IV is a fragmentary showing of an alternate form of passages in the slider portion of FIGURE II;

FIGURE V is an illustration of a frontal analysis embodiment of the fluid line transfer switch of this invention; and

FIGURE VI is an illustration of an alternate form of precise volume sampling switch according to this invention.

As an illustration of an application of this invention, the FIGURE I chromatographic analysis system is operated with respect to a chromatographic separation column 10. In a gas analysis system for example, gas or vapor is introduced into the column 10 through a switching unit 11. The present invention embodies such a switching device as shown in the later drawings views and explained hereinafter.

The switch unit 11 has an input pipe 12 for carrier gas, an input pipe 13 for a sample gas, usually as a gas mixture, an outlet pipe 14 leading to the column 10 which is for carrier gas or carrier gas plus an injection of sample gas, according to the attitude of the switch 11.

The sample gas is exited from the switch through an outlet pipe 15, except for the measured sample volumes injected into the carrier stream. The outlet pipe 15 may be a vent or a connection to other portions of any particular system. These particular arrangements relate to the structures of FIGURES II and VI.

The column output, or effluent, is travelled through a pipe 16 to a suitable detector 17 for detecting the components of a sample gas mixture as they emerge from the column in their separated state. The detector gas is vented as at 18, and the output of the detector is applied through electrical leads 19 to a suitable recorder 20 to provide representation of the values or relative values of the various components of interest in the sample gas mixture.

In elution chromatography the usual practice is to pass a stream of carrier gas through a separation column and, as desired, manually or automatically, to inject into the carrier stream prior to its entrance into the column, a fixed volume of sample gas mixture. In order that the results be properly measurable and repeatable it is necessary for this fixed volume to be precisely and reliably establishable.

In the instance of this invention wherein a fixed volume of sample gas mixture is injected into the carrier stream, FIGURES II and VI, it is done so by actually removing a portion of the carrier pipe line and inserting in its stead a portion of the sample pipe line. Preferably these volumes are in the form of pipes with the same diameters to assure minimum disturbance of the flow and maximum efficiency in the insertion of a precise measured volume of sample gas into the carrier stream.

A fluid switching device or system for accomplishing this purpose of inserting a measured volume of sample gas, that is, an actual portion of the sample gas pipe, into the carrier stream, is illustrated in vertical central section in FIGURE II. This embodiment of this invention comprises an overall housing 22 which is a form of sleeve with closed ends and in the form of two open end opposed cups 23 and 24, with the cup 24 as a bottom upright cup and the cup 23 as a top inverted cup. These cups are secured in their assembly relationship with mounting screws 25 and 26. These cups bear against each other in solid mounting relationship for a good part of the periphery of their cylindrical arrangement but are formed with sufficient cutaway clearances to allow the insertion and easy transverse movement of a sliding member 27 mounted at the interface of the cups.

As may be seen in FIGURE II, this switching device has a carrier gas path vertically downward therethrough in continuous passage 28, in the attitude of the switch as shown in FIGURE II. A vertical passage 28' in the slider 27 is a part of this carrier gas path. In this same switch attitude, the transversely movable member 27 has passages therethrough, indicated generally at 27', which, along with associated chambers 29 and 30, provide, in the shown attitude of the switch, a sample gas mixture flow passage system in and out of the switch device. As shown, then, the carrier gas is flowing vertically downward through the switch directly to the column, and the sample gas is flowing transversely through the switch to an outlet which may be a vent or to some other portion of a desired system.

The FIGURE II switch device with its hollow portions as the insides of the cups, is provided with spring pressed assemblies, in the top cup as generally indicated at 31, and in the bottom cup generally indicated at 32, which bear upon the sliding member 27 on opposite sides thereof, top and bottom, so that the sliding member is essentially supported by these opposing spring arrangements in floating action therebetween. The spring assemblies of the top and bottom cup arrangements of FIG-

URE II are duplicates, that is, the same form of device is pressing down on the slider 27 as is pressing upward on the slider 27.

Considering the upper cup 23, the assembly 31 therewithin includes a relatively rigid and soapy plastic (polytetrafluoroethylene) inverted cup-like gas sealing member 33 which is formed with a central, downwardly extending boss 34, and a peripheral, downwardly extending annular flange 35 which encompasses the boss 34. The bottom face of the central boss 34 and the bottom face of the annular flange 35 both are flat rings resting against the sliding member 27 in gas sealing relation therewith (see FIGURE III dotted rings 34' and 35'). A vertically disposed central opening 36 is provided in the central boss 34 as a part of the carrier passage 28 downward through the overall switch device. The FIGURE II sealing member 33 is closed off at its top by a thin connector plastic wall 33' which is an annulus joining the central boss 34 and the peripheral flange 35. This arrangement establishes the annular chamber 29. This allows individual vertical movement of the central boss 34 and the peripheral flange 35.

The sample gas passage system transversely through the device, in large measure through the sliding member 27, that is the passage system 27', includes a transverse inlet passage 37 from the left, which is angled into a vertical upward portion to register as a port into the upper annular chamber 29. The transverse sample gas passage system is continued by means of a vertically disposed passage 38 extending downward through the slideable member 27 from the upper annular chamber 29 to the lower annular chamber 30, in the FIGURE II attitude of the switch. This specific length of passage 38 in the sliding member 27 is the measuring portion of the sample gas passage system. That is, gas is flowed through this passage 38, and when the shift of sample gas volume into the carrier stream is made, it is this specific fixed volume of gas in the passage 38 which is injected into the carrier stream.

In furtherance of the transverse passage system of the sample gas an exit passage 39 is provided, also in the sliding member 27, for the most part transversely extending outwardly through and therefrom, but with a port in the lower annular chamber 30 as an exit therefrom. Thus in the attitude of the switch as shown, the transverse travel of sample gas is into the passage 37, from there into the upper annular chamber 29, then downwardly through the vertically disposed measuring passage length 38 and into the lower annular chamber 30, thence around the annulus of the chamber 30, and then upwardly and transversely outwardly through the exit passage 39.

This passage arrangement is shown schematically in FIGURE III. An alternate arrangement is shown in FIGURE IV as at 40 and 41 whereby if it is desired to have a measurement passage longer than the thickness of the slider 27, that is, longer than the passage 38, such a longer passage may be formed as shown in FIGURE IV. Passages 40 and 41 compare respectively to passages 38 and 28' of FIGURES II and III.

Note that in the FIGURE II attitude of the switch the central boss passage 36 in the sealing member 33 is aligned with, is of the same diameter, and forms a continuous carrier downward passage with, the previously mentioned vertically transverse carrier passage section 28' in the central portion of the slider 27. Thus the boss 34 is a sleeve which encompasses the carrier passage in the slider 27. Note also that the annular flange 35 of the sealing member 33, again in the attitude as shown in FIGURE II, encompasses not only the boss 34 but the sample gas measuring vertical passage 38, and the sample gas inlet and outlet passage port areas.

Transverse movement of the slider 27 is made to register the slider sample measurement passage 38 with the carrier passage 28, while the sample gas flow continues as before except that it now travels between chambers 29 and 30 through the passage 28' in its new location, removed from the carrier flow line 28. Note that thereafter the reverse movement of the slider 27 uses the passage 28' as a sample gas measurement volume, and transfers this sample volume into registry with the carrier flow in the carrier flow line 28.

A feature of importance in this device with respect to the sealing unit 33 especially when this sealing unit is made of relatively rigid plastic such as tetrafluoroethylene resin in order to get suitable sealing under high temperature, and pressure and sliding surface transfer arrangements, is the thin flexible bottom 33' of the sealing cup 33. This flexible connector forms the top of the annular chamber 29. Thus with this thin and flexible connector 33', the sealing of the central boss 34 against the slideable member 27 is essentially independent with respect to the sealing of the peripheral flange 35 against the slideable member and the connector 33' forms the top wall of the annular chamber 29. Thus downward, sealing pressures may be applied to the peripheral flange 35 essentially independently of pressures which are applied to the central boss 34 in so far as is necessary to get the necessary sealing arrangements.

Such pressures are applied in the case of the structure shown in FIGURE II by a pair of springs. One is a relatively large diameter spring 42 which has its upper end based on the inner wall of the top of the overall housing cup 23 and its lower end based on a pressure sleeve member 43 which engages, in a ring fashion, the top of the peripheral flange sealing portion 35 to press it downward against the slideable member 27. The other portion of the resilient arrangement is a smaller diameter spring 44 which at the top rests against the inner wall of the top of the inverted cup outer housing 23 and at the bottom rests against a pressure sleeve block 45 which presses down the central boss 34 of the sealing unit 33 against the slideable member 27. Thus the seal of different portions of a multiple contacting device are independently pressure biased downwardly to assure a suitable sealing arrangement in all portions of the device.

The overall housing inverted cup 23 has an opening 46 in its upper end which contains the pressure sleeve 45 extending down into the cup and upwardly outward thereof for a short distance, with this sleeve pressing down against an O-ring 47 which in turn presses upon a bottom outflaring flange 48 of a carrier gas passage pipe 49 which extends upward through the pressure block sleeve 45 and the cup top opening 46 to form part of the input pipe for the carrier gas passage 28. In turn, the flared flange 48 is pressed down against the top of the central boss 34 of the sealing unit 33, to accomplish the independent pressure sealing arrangements about the carrier passage opening 28' in the sliding member 27. The pressure sleeve 43, which is used to apply resilient pressure to the peripheral flange 35 of the resilient unit 33 is formed with an upper shoulder 50 to receive the lower end of the large spring 42 and a lower shoulder 51 to engage the top of the peripheral flange 35 of the sealing member 33. Further, the pressure sleeve 43 has a downwardly extending peripheral ring flange 52 at the bottom thereof. This annular flange seats the pressure sleeve 43 in the upper cup housing 23 in a piston-like fashion for vertical movement, and at the same time peripherally encloses the sealing unit 33 so that the sealing unit as a whole is confined and not permitted lateral movement. The upper portion of the pressure sleeve 43 is provided with an upwardly extending inner ring flange 53 which provides a sleeve support around which the spring 42 is based and also provides a confining arrangement for the smaller diameter spring 44.

The various parts described in connection with the upper portion of FIGURE II are mirrored in the lower portion of FIGURE II and thus it will be seen that independent seating is provided in different portions of each

sealing member about different portions of passageways in the transversely slideable member 27.

Thus, in furtherance of the FIGURE II discussion, it will be seen that in the attitude of the switch as shown in FIGURE II, the only gas going to the column is carrier gas. However, the slideable member 27 may be moved from left to right manually or automatically as desired and with suitable flexible portions (not shown) on the input and output pipe leads as well as in the carrier in and out leads, such movement of the slideable member 27 first disengages the carrier passage portion 28' in the slideable member 27 from the carrier passage and moves it to the right and into connection arrangement with both the upper annular chamber 29 and the lower annular chamber 30, and meanwhile the sample gas measuring vertical passage 38 becomes aligned with the carrier passage 28, in place of the passage 28' just removed. A stop 54 is provided on the slideable member 27 to butt against the side wall of the overall assembly 22 in order to terminate the left to right transverse movement of the slideable member 27 and to properly locate sample gas passage 38 in alignment with the carrier gas passage 28. A similar stop 54' is provided for right to left movement. After such movements, it will be seen that the carrier gas passage continues the same, that is vertically downward through the column, and the carrier gas then takes with it a measured volume of sample gas. Meanwhile, the sample gas flow continues through the inward passage 37 to the upper annular chamber 29 and around through that chamber and then downward through the removed portion 28' of the carrier passage in the slideable member 27, to the lower annular chamber 30, and then upward and laterally outward through the exit passage 39. Thus the lateral movement of the slideable member 27 places a volume of sample gas in the carrier stream and then continues to flow through a transverse passage arrangement through the overall switch unit while the carrier proceeds to convey the measured volume of sample gas to the column.

Referring now to FIGURE V, this structure illustrates an embodiment of this invention in which a switch arrangement is used in frontal analysis of chromatography. In this arrangement a first stream is established, and by a switching action, an interface between the first stream and a sample stream is provided by essentially cutting off the first pipe line and connecting in the sample pipe line. Thus the interface is between a leading portion of first gas and a following portion of sample gas, with no particular consideration for the volume of the sample gas, since in frontal analysis it is the interface separation action through the chromatographic column which is measured.

It may be noted in FIGURE V that the device is essentially one half of the structure of FIGURE II in so far as the overall structure is concerned, that is the cup arrangement, the sealing arrangements, the transversely sliding member, and the spring arrangements for separately biasing different portions of the sealing member against the sliding transverse member 27. The differences arise in the passages arranged in the sliding member 27. For example the first gas inlet is indicated at 55, and in the attitude of the switch as shown in FIGURE V the first flow is continuous through the inlet 55 and upward through the passage 28'. Meanwhile the sample flow is from the left through an inlet 55' in the sliding member 27', then upward to the annular chamber 29' and then outward through an exit passage 56.

Since the greater part of the structure of FIGURE IV is a duplicate of the upper half of the FIGURE II structure various duplicated parts are indicated with primed numbers relative to those shown in FIGURE II on the same parts. The FIGURE II sealing unit and connector 33 and 33' are represented in FIGURE V as 33*a* and 33*b* respectively.

The FIGURE V structure has a base member 57 to which the upper portion generally indicated at 23' is secured by bolts 25' and 26'. This assembly is the same as that of FIGURE II in that the upper portion 23' and the base portion 57 are solidly secured by the bolts and yet a clearance is provided for movement of the transversely movable slide member 27' with the passageways therein.

Thus in the switch attitude shown in FIGURE V the first gas is flowing through the device to the column and the sample is simply flowing in and out of the switch. When the switch is adjusted to its sample providing attitude, that is when the member 27' is moved to the right as in the drawings, then the sample passage 55' replaces the first gas passage 55 as the input to passage 28' leading to the column, and the first gas travels around the annular chamber 29' and exits through passage 56.

Accordingly, the device as shown in FIGURE V is suitable for frontal analysis wherein the volume of the sample is relatively immaterial and the initial interface between the sample and the first gas is the area of separation and measurement.

The alternate structure of FIGURE VI is an arrangement for accomplishing the advantages of this invention by using a spring diaphragm arrangement instead of coil spring arrangements as in FIGURE II. The device has opposed cup like housings 58 and 59 mounted and held together by bolts 60 and 61 with a main carrier flow passage vertically centrally downward therethrough as at 62 and transverse sample passage arrangements in a transversely slideable member 63 which is comparable to the slideable member 27 in FIGURE II, with a carrier passage 62' therethrough comparable to passage 28' in FIGURE II. This FIGURE VI switch operates in the same fashion as does the FIGURE II device, that is, it transfers a fixed reproducible volume from one flow line into another flow line, and the passage arrangements and chambers are the same in FIGURE VI as in FIGURE II, except for the annular dome configuration of the chambers. The sealing member of FIGURE VI is indicated at 64 and is in the form of a plastic diaphragm with a central seal at 64' and a peripheral seal at 64''. The thin portions of the flexible diaphragm joining the two seats to form the chambers and provide independent action are indicated at 65 and 66. The spring arrangements taking the place of the two coil springs in the FIGURE II structure are joined in the form of a single flexible metal diaphragm 67 having an annular thin wall portion 68 which joins the seating portions of the spring as at 69 and 70 with a sufficiently strong spring arrangement and yet flexible so as to allow the different seating portions to be seated essentially independently within the operating range of the device. An O-ring 47' and a seating flange 48' are provided in the FIGURE VI device, comparable to the like elements 47 and 48 in FIGURE II.

The spring flexure diaphragm 67 has a peripheral edge portion 71 which is clamped to the upper portion of the device by a ring member 72. As in the FIGURE II structure the sliding member 63 is provided with sufficient clearance to be able to slide readily transversely through the device and to be essentially held in resilient floating support between the upper and lower spring combinations as shown. The lower portion of the FIGURE VI structure is duplicated in its diaphragm sealing and spring arrangement with respect to the upper portion of the device.

The FIGURE V construction lends itself to displacement chromatography as well as to the frontal analysis technique previously described herein.

This invention provides as a substantial advantage, means in which all passageways may be formed of polytetrafluoroethylene in order to provide a system which does not absorb, adsorb, diffuse in or out, or change with relatively high temperatures, so that fluids used

therein are unaffected by the nature of the passageway material.

This invention therefore provides a new and improved fluid line transfer switch.

As many embodiments may be made of the above invention, and as changes may be made in the embodiments set forth above, without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative only and not in a limiting sense.

I claim:

1. A fluid switch assembly for transferring fluid from one flow line into another flow line, comprising a member containing separate passages, one of said passages forming a part of one of said flow lines and another of said passages forming a part of the other of said flow lines, one situation of said switch assembly having one plastic sealing member encompassing one end of said one of said passages to connect said one of said passages into its respective flow line, another plastic sealing member encompassing said one sealing member and one end of said other of said passages to connect said other of said passages into its respective flow line outside of said one sealing member, a flexible joiner between said sealing members whereby a chamber is formed by a surface of said movable member and said flexible joiner as one pair of opposite walls and said sealing members as another pair of opposite walls, means for effectively independently resiliently biasing said sealing members against said passage containing member, and an exit passage from said chamber, said passage member and said sealing members being relatively movable so as to be positionable, from the situation described above, by transverse movement between said sealing members and said passage member, to a situation wherein said one of said passages is registered with said other of said flow lines and the other of said passages is registered with said chamber and said exit passage therefrom.

2. A fluid sampling switch assembly for transferring a precise volume of fluid as a unit from one fluid flow in one flow line into another fluid flow in another flow line comprising a movable member containing separate passages, one of said passages forming a part of one of said flow lines and another of said passages forming a part of the other of said flow lines, one situation of said switch assembly having one plastic sealing member encompassing one end of said one of said passages into its respective flow line, another plastic sealing member encompassing said one sealing member and one end of said other of said passages to connect said other of said passages into its respective flow line outside of said one sealing member, a flexible joinder between said sealing members whereby a chamber is formed by a surface of said movable member and said flexible joinder as one pair of opposite walls and said sealing members as another pair of opposite walls, means for effectively independently resiliently biasing said sealing members against said movable passage containing member, and an exit passage from said chamber, said movable member and said sealing members being relatively positionable, from the situation described above, by transverse movement between said sealing members and said member, to a situation wherein said one of said passages is registered with said other of said flow lines and the other of said passages is registered with said chamber and said exit passage therefrom.

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