

[54] **VACUUM-OPERATED SAMPLER AND DISTRIBUTOR FOR MULTIPLE SAMPLING OPERATION**

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[22] Filed: **July 19, 1974**

[21] Appl. No.: **490,057**

[52] U.S. Cl. **73/421 B; 141/130**

[51] Int. Cl. **G01n 1/14**

[58] Field of Search **73/421 R, 421 B, 422 TC; 141/130; 137/625.11**

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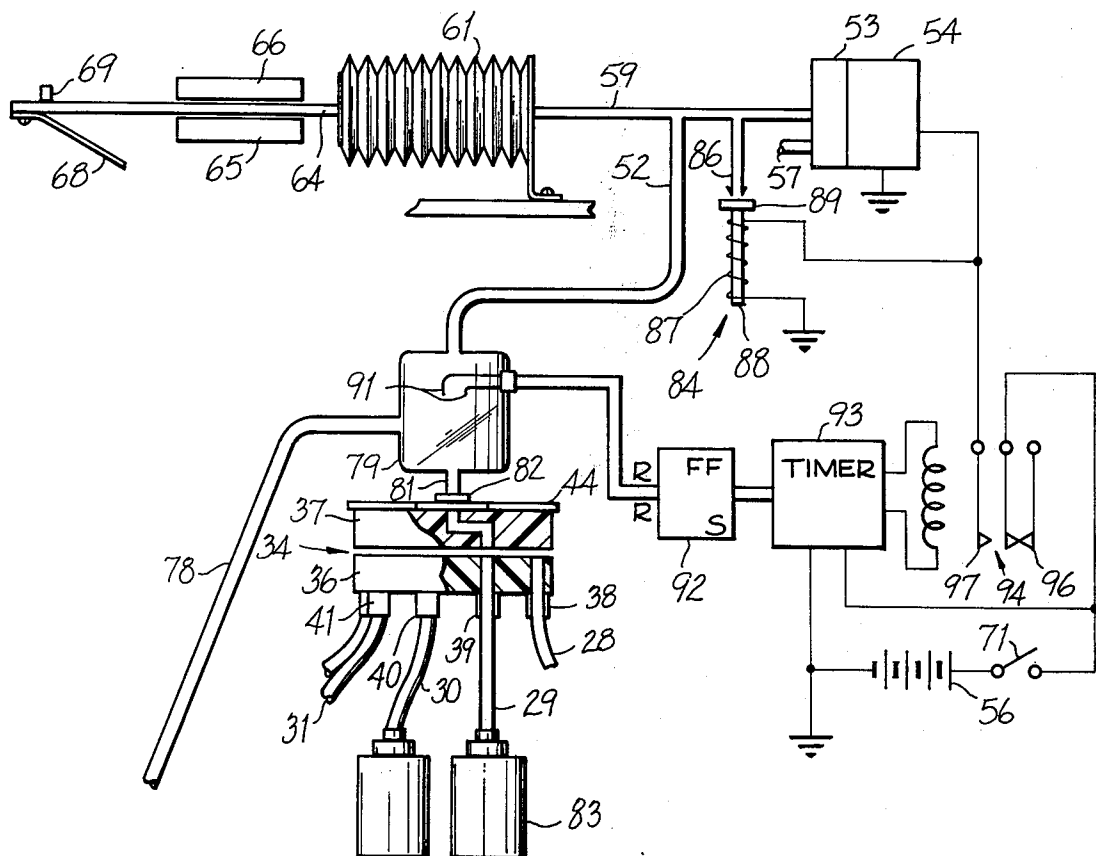
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[57] **ABSTRACT**

The sampler includes a distributor with first and second members movable relative to each other in several specific positions. In each position a transfer port in one member is aligned with a different port in the other member. Each of the latter ports is connected to a separate sample receptacle, and the transfer port is connected to the intake line of a vacuum pump. A bellows and a valve are also connected to the intake line to the pump, and the valve is actuated to open and close at certain times relative to a cycle of operation in which the pump draws into the system a sample, which may be gas or liquid depending on the construction of the sampler. When the valve is closed, the pump draws air out of the bellows causing the latter to contract and operate an advancement device to align the transfer port with the next port in the other member.

13 Claims, 4 Drawing Figures



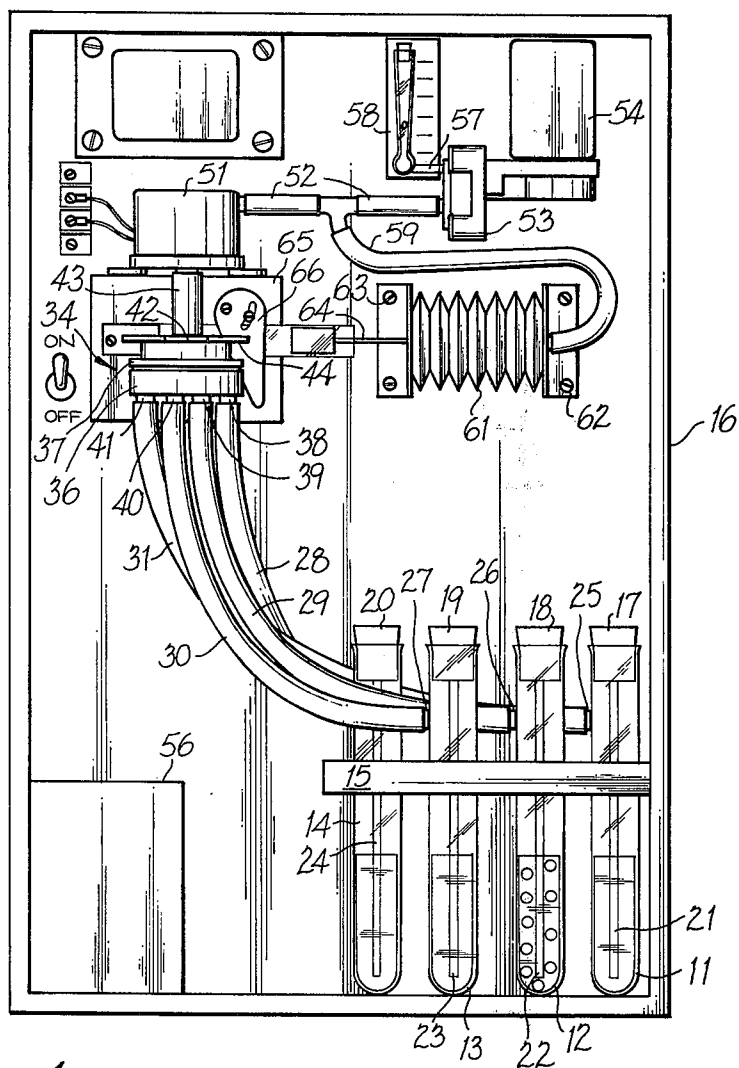
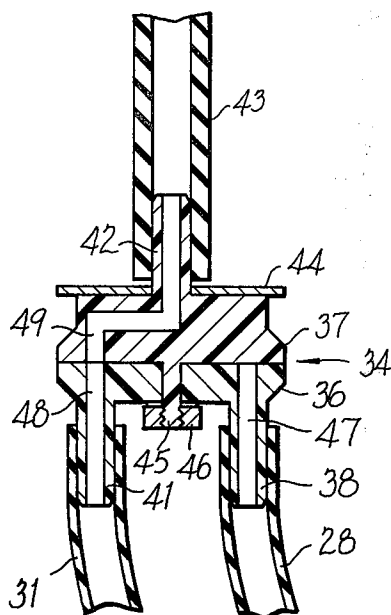
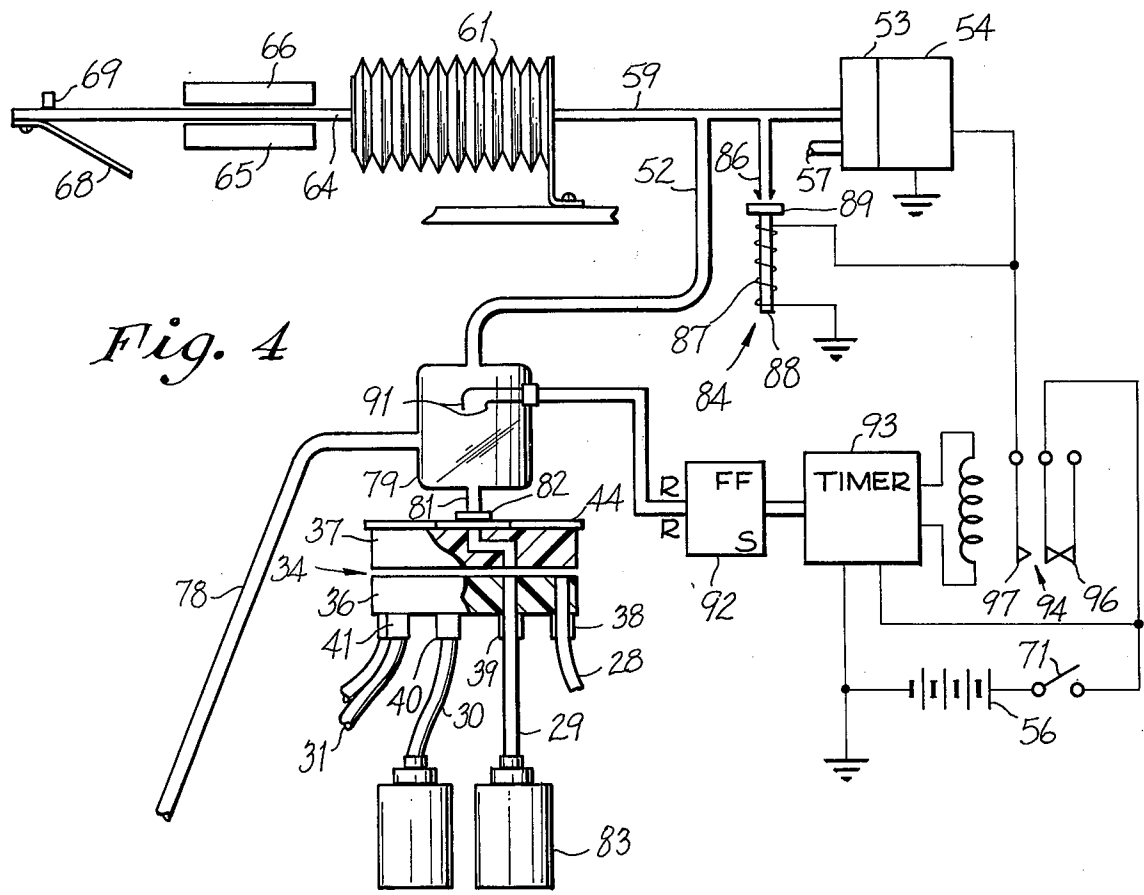
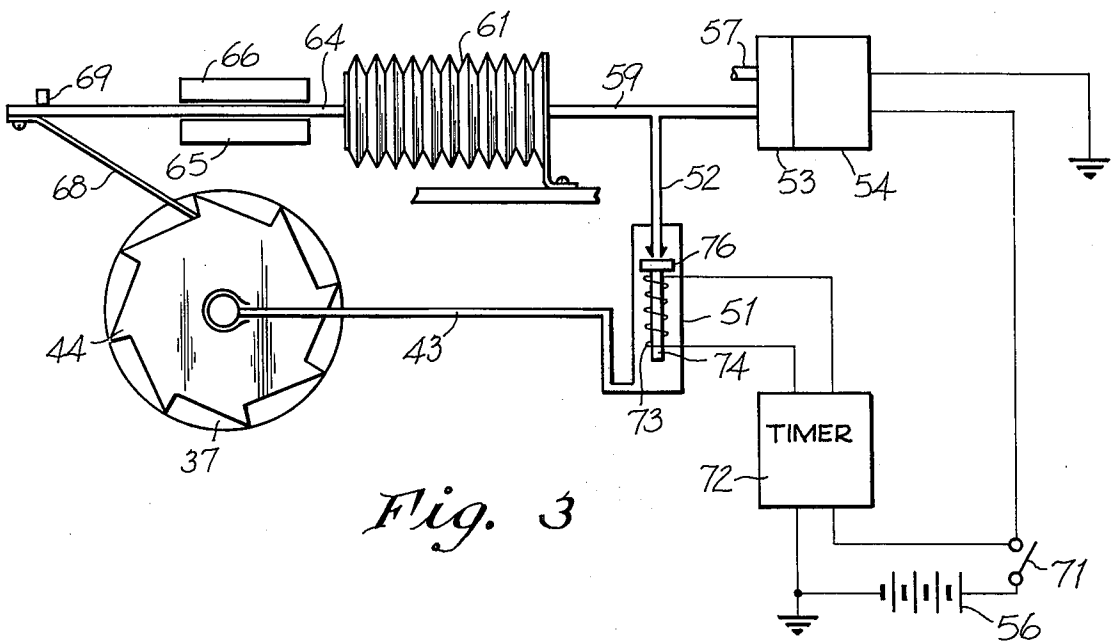


Fig. 1

Fig. 2





VACUUM-OPERATED SAMPLER AND DISTRIBUTOR FOR MULTIPLE SAMPLING OPERATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of vacuum-operated sampling devices and particularly to distribution apparatus by which samples are directed in sequence to each of a plurality of sample receptacles, the distribution apparatus being actuated in steps at controlled intervals by means operated by the vacuum pump that draws in the samples.

2. The Prior Art

Gathering samples of liquid or gas at regular intervals or in regular quantities is necessary for many analytical purposes. It has become recognized as of increasing importance in the environmental field in recent years, for measuring of both water pollution and air pollution. The locations at which the samples must be gathered are often remote from any source of electric power, and as a result, the gathering apparatus must have its own self-contained power source, usually in the form of rechargeable batteries. Sample-gathering locations remote from regular sources of electric power are also likely to be physically inaccessible, so that the apparatus must be as light as possible, consistent with the need for reliability, to permit it to be carried to such locations as easily as possible. The load placed on the batteries by the apparatus must be low to result in good battery life and to permit lightweight batteries to be used, and the weight of other components must also be considered in the light of the same requirements.

The source from which samples are to be gathered, for example a stream or the atmosphere, may change from hour to hour, and refinements in analytical technique may require that the samples be gathered accordingly. In prior patents I have described means for gathering liquid samples and even for gathering a series of samples in separate receptacles. An object of the present invention is to provide improved means for gathering a series of separate samples from a liquid source and improved means of a related nature for gathering a series of separate samples from a gaseous source, such as the atmosphere.

SUMMARY OF THE INVENTION

In the present invention, as in my prior inventions of sample-gathering apparatus, the samples are drawn from the source by creating a vacuum at the intake. The term "vacuum" is used herein with the understanding that it means a pressure low enough in comparison with the pressure of or on the source to draw the sample into the intake. The vacuum is produced by a vacuum pump, preferably driven by a battery-powered motor, and is directed to one of several sample receptacles in the apparatus.

One of the main components of the present invention is a distributor that determines which receptacle will receive the sample. The distributor comprises two main, ported members, one of which is movable to several specific positions relative to the other member. One of the members, usually the fixed one, has at least as many ports as the number of sample receptacles, and the other member has a transfer port that is brought into fluid connection with a different one of the ports in the first member as the relative movement pro-

gresses from each of the specific positions to the next.

The connections between the distributor, the receptacles, and the pump depend on whether the apparatus is to be used to sample a gaseous source or a liquid source. In a liquid sampler according to this invention, the sample is drawn into a metering chamber and is then passed through the distributor to whichever receptacle is connected to the metering chamber by the distributor. In a gas sampler, gas is drawn directly into whichever receptacle is connected by the distributor to the pump. Each receptacle in a gas sampler contains a medium to absorb or to be acted upon by at least some of the incoming gas, as for example, a reagent in a bubbler test tube. The gas that passes through the receptacle and the distributor and the pump is, therefore, not really the sample; only the gas that remains in the receptacle is the sample to be analyzed. Even in a liquid sampler, the suction produced by the pump is only due to the displacement of air; the liquid being sampled does not reach the pump.

In either type of sampler, a closed chamber of variable volume, such as a bellows, is connected to the intake line of the pump, and a valve is also connected to the intake line so that, when the valve is closed, the chamber will be evacuated by the pump and its volume will be reduced. When the valve is open, the chamber has access to air, or gas, and can expand. One part of the closed chamber is held fixed and the other part is free to move to reduce the volume of the chamber as the pump evacuates the chamber. The movable part is connected to an actuating device, such as a pawl that engages a ratchet attached to the movable member of the distributor. As the evacuation of the closed chamber proceeds, the pawl and ratchet draw the movable member into the next operative position at which the single port in one member of the distributor connects with the next port in the other member. After the intake line is allowed to open, resilient means associated with or attached to the chamber returns the movable wall of the closed chamber to its original position as gas or air flows through the valve into the closed chamber.

The valve that is closed to move the distributor to the next position may be controlled by a timer, which can be an electronic circuit that draws very little current, and the motor that operates the pump can be turned off except during the time required to draw in the sample and the time required to cause the distributor to move to the next step. This type of operation is likely to be especially suitable for a liquid sampler, in which the pump should not continue to run longer than is necessary to fill up a receptacle and to move the distributor to the next step.

In the case of a gas sampler, the pump may run continuously so that the reagent or absorbing medium in each receptacle would be exposed to the gas inflow over a long period of time and the concentration of gas components retained in each receptacle would be an integrated value.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of a gas sampler constructed according to the invention.

FIG. 2 is a cross-sectional view of a fragment of the sampler in FIG. 1.

FIG. 3 is a schematic representation of the gas sampler according to FIG. 1.

FIG. 4 is a schematic representation of a liquid sampler constructed according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The embodiment shown in FIG. 1 is a gas sampler and is specifically arranged to sample the atmosphere in which it is located. The sample receptacles for this purpose are bubbler test tubes of which four such test tubes 11-14 are shown held in a rack 15 inside a carrying case 16. Each of the test tubes has a stopper 17-20, respectively, with an intake tube 21-24 extending through it into the test tube and terminating near the bottom of the respective test tube. Each of the bubbler test tubes also has an integral outlet tube attached near the upper end of the test tube, but only three of the outlet tubes 25-27 attached to the test tubes 11-13, respectively, appear in FIG. 1. The other one is hidden out of sight in that figure.

Each of the bubbler test tubes 11-14 contains something to absorb some of the gases and material flowing through. For example, the test tubes may contain a quantity of liquid, usually water with one or more chemical reagents in it to react with certain chemicals that might be present in the atmosphere. Each bubbler test tube may contain a different reagent or the reagents in all of them may be the same.

The outlet tubes of the test tubes 11-14 are connected by pieces of flexible tubing 28-31 to a distributor 34 that comprises first and second members 36 and 37. The first member has, in this embodiment, the same number of nipples 38-41 as there are pieces of tubing 28-31. The second member 37 has a single central nipple 42 that extends into another piece of tubing 43 to form a slip joint. The purpose of this slip joint is to permit the member 37 to rotate relative to the member 36 while the latter is held stationary by a bracket (not shown). A ratchet wheel 44 is attached to the member 37 to rotate the latter in a manner to be described hereinafter.

In order to describe the distributor 34 more clearly, reference will be made to FIG. 2, which shows the distributor in the form of discs held in contact with each other by any suitable means. One example of such holding means is a threaded axial stud 45 that extends from the member 37 through the center of the member 36. A nut 46 on the stud provides enough surface-to-surface pressure between the members 36 and 37 to prevent gas from leaking into the system at that location. Any two of the nipples 38 and 41, which are diametrically opposite each other, are shown extending from the member 36. The ends of the corresponding two flexible tubings 28 and 31 are shown fitted in a gas-tight manner onto these nipples. The nipples 38 and 41 have ports 47 and 48, respectively, at the upper surface of the member 36, and because the member 36 is fixed, the ports 47 and 48 are referred to as fixed ports.

The member 37 has a single port 49 at the same radial distance from the common axis of the members 36 and 37 as the ports 47 and 48. The single port 49 leads to the axial nipple 42 that extends into the tubing 43 and is therefore called a transfer port. The ratchet wheel 44 is shown fitted to the upper part of the member 37 around the nipple 42, although it could be placed elsewhere on the member 37 or even molded integrally with the member 37.

The upper end of the tubing 43 is shown in FIG. 1 as being connected to a solenoid valve 51. A piece of tub-

ing 52 connects the outlet port of the valve 51 to an exhaust pump 53 operated by an electric motor 54 which, in this embodiment is powered by a battery 56. The pump 53 has an outlet pipe 57 connected to a pressure gauge 58.

A branch tubing 59 joined to the tubing 52 by a T-junction couples the tubing 52 to a fixed end of a bellows 61 supported by a bracket 62. The bellows 61 is shown expanded so that its closed left end rests against a bracket 63, but this end of the bellows is not attached to the bracket 63 and is free to move toward the bracket 62 as the bellows collapses when air is pumped out of it. A connecting rod 64 is attached to the movable end of the bellows to be moved back and forth as the bellows contracts and expands. A fixed guide 65 has a slot in it to constrain the motion of the connecting rod 64 to simple reciprocating motion, and a stop 66 on the guide limits the movement of the connecting rod 64 so that it cannot move too far toward the bracket 62.

The operation of the apparatus shown in FIGS. 1 and 2 will be described in conjunction with FIG. 3. The latter figure shows the electrical components and the air channels of the system in schematic representation. As may be seen, the connecting rod 64 has a spring pawl 68 that engages the teeth on the ratchet wheel 44. It also has a projection 69 that engages the stop 66.

When the apparatus is put into operation, a switch 71 is closed, applying power to a timer 72 and to the pump motor 54. The timer 72 produces, essentially, repetitive pulses of electric current. During a time interval t_1 , which may be made as long as desired by adjusting the timer 72, no current reaches the solenoid valve 51. However, the motor 54 operates continuously and causes the vacuum pump to draw air through the intake tube 21, the bubbler test tube 12, the tubing 28, the aligned fixed port 47 and transfer port 49, the slip joint tubing 43, the valve 51, and the tubing 52. As this air passes through the liquid and the test tube 11, the reagent or reagents in the test tube react with chemicals in the air (if such chemicals are, in fact, present) to produce a visible reaction product or, at least, to absorb some of the air that bubbles through the liquid.

When the end of the time t_1 arrives, the timer 72 applies a pulse of current to the solenoid valve 51 and, specifically, to the coil 73 therein. This coil produces a magnetic field that operates an armature 74, causing the armature to rise and block off the end of the tubing 52. In order to be sure that tubing is completely blocked off, the upper end of the armature 74 may have a gasket 76 attached to it. The running of the motor 54 and the vacuum pump 53 is not affected by the current pulse that energizes the solenoid valve 51. However, the pump can now no longer draw air through the bubbler test tubes and so it pulls air out of the bellows 61, causing the bellows to collapse and move the connecting rod 64 and the pawl 68 toward the fixed bracket 62. As the pawl 68 moves, it forces the ratchet wheel 44 to rotate so that the transfer port 49 becomes aligned with the next fixed port in the member 36. Although only two fixed ports 47 and 48 are shown in FIG. 2, and only four are indicated in FIG. 1, a more typical number is eight, and thus the ratchet wheel 44 as shown in FIG. 3 has eight teeth. However, it could have any number of teeth depending on the physical limitation of size.

At the end of the time t_2 , the timer 72 interrupts the current flowing to the coil 73 and allows the armature

74 to move away from the end of the tubing 52. This allows air to flow through the next bubbler test tube in sequence and through the distributor 34, the tubing 43, the valve 51, and into the bellows 61. The bellows is resilient so that it is normally in an expanded state, and thus it moves the connecting rod 64 and the pawl 68 to the left toward the position shown in FIGS. 1 and 3. This is the end of one complete cycle, and the apparatus is ready to begin the next cycle.

FIG. 4 is a schematic representation of a similar pumping mechanism to the in FIGS. 1-3 but is arranged so that it takes in liquid samples, such as from a stream or sewer or other liquid source, and deposits the samples one at a time in a plurality of sample containers. The apparatus may be constructed in a case similar to the case 16 in FIG. 1 and with the layout arranged similarly to that in FIG. 1 but with certain differences due to the difference in gaseous and liquid samples.

The apparatus in FIG. 4 has only a single intake pipe 78 that leads into a metering chamber 79. The metering chamber has an outlet tube 81 that connects with a slip joint 82 similar to that in FIG. 1. Below the slip joint 82 is the ratchet wheel 44 and the distributor 34 with the upper member 37 and the lower member 36. The latter has the same nozzle 38-41 and lengths of flexible tubing 28-31 as in the embodiment in FIG. 1. However, each length of flexible tubing leads to a sample container similar to the example 83 shown in the drawing.

At the upper end of the metering chamber 79 above the level in which the intake pipe 78 enters the sidewall of the chamber is a connection to the tubing 52 similar to that in FIG. 1. This tubing is connected to the vacuum pump 53 and, by way of the branch tubing 59 to the bellows 61 in the same manner as in FIG. 1. However, instead of having a solenoid valve connected in series with the tubing 52, the embodiment in FIG. 3 has a solenoid valve 84 connected to a side tube 86. The valve 84 includes a coil 87 and an armature 88 with a gasket 89 therein to close off the end of the tube 86 when the valve 84 is actuated.

The metering chamber 79 also has a pair of electrodes 91 connected to the reset terminal of a flip-flop 92. The flip-flop 92 has a set terminal connected to the output of a timer 93, and the output terminal of the flip-flop 92 is connected to the coil of a relay 94. Power is supplied to the circuit from the battery 56 through the main power switch 71 which is connected to the timer 93 and to one of the contacts 96 of the relay 94. This contact is normally open with respect to another contact 97 that is connected to the coil 87 of the solenoid valve 84 and to the motor 54.

The operation of the system shown in FIG. 4 begins with the closure of the switch 71 that causes the timer 93 to set the flip-flop 92, thereby energizing the relay 94 and closing the contacts 96 and 97. This starts the motor 54 and the pump 53 and also closes the solenoid valve 84. As the pump 53 runs, it draws liquid through the intake tubing 78 into the metering chamber and at the same time collapses the bellows 61, pulling the pawl 68 to the right and rotating the ratchet wheel 44 and the member 37 from one alignment position between the transfer port 49 and one of the fixed ports to the next alignment position. When the bellows 61 collapses to the point that the projection 69 strikes the stop 66, the bellows will not contract any further even though the motor 54 and the pump 53 may continue to run.

The motor continues to run until sufficient liquid has been drawn through the intake tubing 78 to cause the liquid in the metering chamber 79 to rise to the level of the electrodes 91 and create a conductive path between these electrodes. These electrodes are connected to a reset circuit within the flip-flop 92 and the establishment of the conductive path between the electrodes causes the flip-flop to reset, thereby removing current from the relay 94 and allowing the contacts 96 and 97 to spring apart. This causes the motor 54 to stop running and simultaneously de-energizes the solenoid valve 84. Air then enters the system through the tube 86 and allows the bellows 61 to re-expand. At the same time, the air entering the system allows the liquid in the metering chamber 79 to flow through the tubing 81 at the bottom of the chamber and through the slip joint 82 and the distributor 34 to the sample container 83.

The timer 93 continues to operate, and after a predetermined length of time, which may be set to any desired value, it again supplies a signal to set the flip-flop 92 and supply current to the relay 94 to close the contacts 96 and 97 and start the motor 54 for the next cycle.

The invention has been described in terms of specific embodiments, but it will be understood by those skilled in the art that the apparatus can be arranged in different ways to achieve the objects of the invention without departing from the true scope of the invention as defined by the following claims.

What is claimed is:

1. Sampling apparatus comprising:

A. a plurality of sample receptacles;

B. a distributor comprising:

1. a first member comprising a plurality of connectors, each connected to a corresponding one of said receptacles,

2. a second member comprising a transfer port;

C. a vacuum pump and system to draw fluid samples into said apparatus;

D. a closed chamber connected to said pump to be evacuated thereby and comprising a movable portion and means to connect said movable portion to one of said members of said distributor to move said one of said members to align said transfer port with each of said connectors sequentially to cause said samples to enter each of said receptacles sequentially; and

E. a valve connected to said chamber to control the evacuation of said chamber.

2. The sampling apparatus of claim 1 in which said valve comprises:

A. a vent to allow air to enter said chamber; and

B. closure means to close said vent in order to draw one of said samples into said apparatus and to move said one of said members to align said transfer port with the next one of said connectors in sequence.

3. The sampling apparatus of claim 2 in which said vacuum system comprises a metering chamber connected to said pump to receive said fluid samples, said distributor being connected between said metering chamber and said receptacles to direct each of said samples from said metering chamber to a successive one of said receptacles.

4. The sampling apparatus of claim 3 in which said connectors of said first member are arranged in a circle and said second member is rotatable relative to said

first member and said transfer port moves in a circle divided into arcuate segments to bring said transfer port into alignment with each of said connectors in turn.

5. The sampling apparatus of claim 4 in which said means to move said one of said members comprises a ratchet wheel connected to said second member to rotate therewith and a pawl connected to said movable portion to move therewith and engaging said ratchet wheel to rotate it a step at a time.

6. The sampling apparatus of claim 1 in which said closed chamber is a bellows and said movable portion is a wall at one end of said bellows.

7. The sampling apparatus of claim 1 in which each of said sample receptacles comprises a sample intake port and an exhaust port connected to a respective one of said connectors, whereby each of said receptacles is exhausted in turn to draw in a sample through its intake port.

8. The sampling apparatus of claim 7 in which each of said receptacles contains material to retain a gaseous sample.

9. The sampling apparatus of claim 7 in which said first member of said distributor is fixedly positioned

and said second member rotates relative to said first member.

10. The sampling apparatus of claim 9 in which said valve is connected in air flow series between said distributor and said pump and comprises closure means, said closed chamber being connected between said pump and said valve to force said pump to evacuate said chamber only when said valve closes.

11. The sampling apparatus of claim 10 in which said advancement means comprises:

A. a ratchet gear fixedly connected to said second member to rotate therewith; and

B. a pawl connected to said movable portion of said chamber and engaging said ratchet gear to rotate said ratchet gear.

12. The sampling apparatus of claim 1 in which said valve is a solenoid valve.

13. The sampling apparatus of claim 12 comprising a timer connected to said solenoid valve to energize said solenoid valve at predetermined spaced time intervals.

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