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[54] **LIQUID SAMPLING**

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[51] **Int. Cl.** **G01b 1/14**

[58] **Field of Search** ..... 73/421 B; 417/118, 120, 417/137, 143–147

[56] **References Cited**

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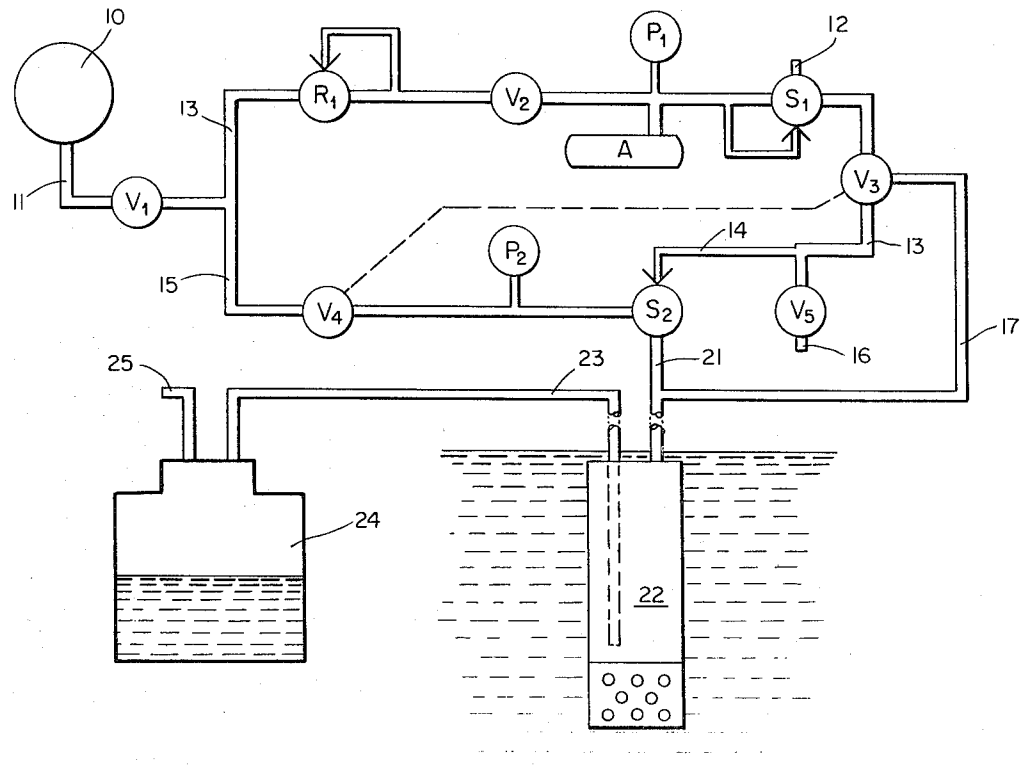
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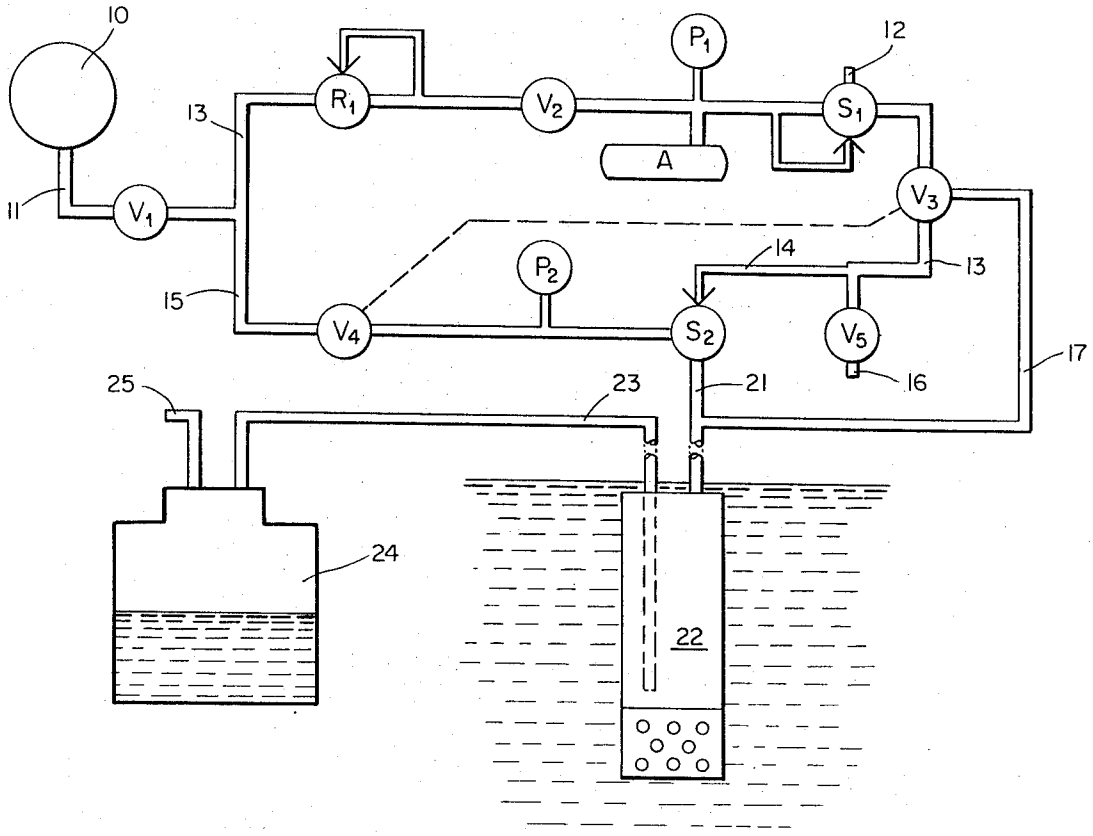
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[57] **ABSTRACT**

Successive samples are taken periodically from a body of liquid with the aid of pressurized fluid serving as both timing medium and sample propellant. Alternative high-pressure and low-pressure paths for the fluid correspond to high-lift and low-lift uses in sampling apparatus adjustable as to interval between successive samples and duration of taking of each sample, as well as convertible between levels of sample lift.

9 Claims, 1 Drawing Figure




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R_1
V_1
V_2
V_3
V_4
V_5
P_1
P_2
S_1
S_2
A

LIQUID SAMPLING

This invention relates to sampling a liquid medium such as preliminary to determination of the composition thereof or of contaminants therein, concerning especially such sampling accomplished by use of a pressurized fluid for sample propulsion.

Manual techniques for sampling a medium for analysis or related purposes are giving way to automatic sampling, often electrically operated. Devices for setting frequency of sampling include spring-driven and electrical timing devices. Electrical operation is hazardous in an explosive atmosphere, such as may be encountered in oil refineries and other industrial operations, in sewers and sewage treatment plants, and in pollution-ridden areas. Electrical power lines are not available at remote sampling sites, and batteries often are cumbersome or otherwise unsatisfactory and require frequent replacement. Spring-winding is inconvenient, and spring motors are a source of maintenance requirements.

A primary object of the present invention is provision of a system for fluid energized sampling of liquid at either high or low pressure, corresponding to either high or low lift thereof to sample collection location.

Another object is flow-regulated control of sampling interval and sample duration in such a system irrespective of which pressure level is being used for sample propulsion.

A further object is accomplishment of the foregoing objects by means of relatively simple apparatus.

Other objects of this invention, together with means and methods for attaining the various objects, will be apparent from the following description and the accompanying schematic drawing of a preferred embodiment thereof, which is presented by way of example rather than limitation.

In general, the objects of the present invention are accomplished by providing timing circuitry for attachment to a source of fluid under pressure and by providing alternative high and low pressure paths for the fluid in propelling samples from a body of liquid to be sampled. The apparatus of this invention is adjustable as to interval between successive samples and the duration of taking of each sample, by control of flow rates of the pressurized fluid, and is convertible from high to low lift of samples by selection of appropriate fluid pressure level.

The single FIGURE of the drawing is a schematic representation of the invention.

Source **10** of pressurized fluid connects via line **11**, which conveniently contains primary on-off valve V_1, to two parallel branch lines, which may be viewed as low-pressure and high-pressure conduits, respectively.

First or low-pressure conduit **13** contains, in sequence, pressure regulator R_1, first flow-regulating valve V_2, pressure-responsive switching valve S_1, two-position outlet valve V_3, and finally second flow-regulating valve V_5, whose outlet **16** vents to the atmosphere. Accumulator tank A and low-pressure gauge P_1 are interconnected to the first conduit between the first flow-regulating valve and the pressure-responsive switching valve. The latter valve normally closes the conduit at its location but vents the downstream portion thereof via vent **12** thereof; it is responsive to the fluid pressure in the immediately upstream portion of the conduit, which interconnects directly to the accumulator tank and the pressure gauge, and opens at a predetermined pressure (simultaneously closing the vent) and recloses at a lower predetermined pressure.

Second or high-pressure conduit **15** contains secondary on-off valve V_4, which is ganged mechanically (as indicated by broken lines) for actuation simultaneously with dual-outlet valve V_3 so as to be on or open when valve V_3 is closed to the portion of second conduit **15** downstream therefrom and is open to conduit **17**, which bypasses valve V_5 and switching valve S_2 to connect directly to line **21** to sample intake chamber **22**. In the off or closed position of secondary switching valve S_2 the connection of dual-outlet valve V_3 is reversed, i.e., open to the downstream portion of conduit **13** and closed to the bypass conduit **17**. Pressure gauge P_2 is connected to the downstream portion of the second conduit, which terminates in normally closed second pressure-responsive switching valve S_2 connected to sense and be responsive to (i.e., opened at a given level of) the pressure in the portion of first conduit **13** downstream from valve V_3 and upstream from valve V_5.

As shown connected for use, the outlet of switching valve S_2 is connected via line **21** to sample intake chamber **22** submerged in the body of liquid to be sampled. From the sample intake chamber, sample line **23** (with dip tube portion shown in broken lines inside the chamber) leads to sample collection container **24**, which has vent tube **25** to the atmosphere. The sample chamber has a check valve (not shown) that enables liquid to enter the chamber, but when fluid under pressure is received via line **21** the check valve is forced shut and the liquid inside is propelled via line **23**, therefrom into collection vessel or sample container **24**, and propellant fluid is vented through vent **25** of the sample container.

Operation of the apparatus of this invention is readily understood by reference to the foregoing description and the accompanying illustration thereof.

With primary on-off valve V_1 in the on position and secondary on-off valve V_4 in the off position, fluid under pressure from source **10** flows through line **11** into branch line **13**, being the first or low-pressure conduit. Reduced to a predetermined pressure by pressure regulator R_1, the fluid flows on through the line at a rate determined by the setting of first flow-regulating valve V_2 and the pressure downstream therefrom, as indicated on low-pressure gauge P_1. The fluid collects at gradually increasing pressure, principally in accumulator tank A, until the switching pressure of normally closed first pressure-responsive switching valve S_1 is reached. Thereupon the valve switches to the open position and releases the accumulated fluid to flow downstream through bypass conduit **17** outlet of dual-outlet valve V_3 directly to sample intake chamber **22**, from which it forces the liquid contents to sample collection container **24** at the relatively low accumulated fluid pressure. Venting of fluid from vent **25** of the collection container reduces the pressure in the first conduit substantially, whereupon first switching valve S_1 recloses and vents to atmosphere the path to the sample chamber, which then takes in another sample. Pressure again builds up in the accumulator tank, and the sampling cycle repeats itself.

With secondary on-off valve V_4 in the alternative or on position, however, the action is the same only until the accumulated pressure opens the first switching valve. Now dual-outlet valve V_3 is closed to the bypass line and open to the downstream portion of first con-

duit **13**, through which the fluid then proceeds to and through second flow-regulating valve V_5 to the atmosphere at a rate controlled by the setting thereof. The surge of fluid into the downstream part of the first conduit located between the dual-outlet valve and the second flow-regulating valve is sensed via sensing line **14** to normally closed second pressure-responsive switching valve S_2, which itself is located at the terminus of second or high-pressure conduit **15**. The resultant opening of the latter switching valve permits fluid to flow through the latter conduit at such high pressure, indicated on second pressure gauge P_2, into line **21** to propel the contents of sample intake chamber **22** to the collection container. When second flow-regulating valve V_5 has reduced the pressure accumulated in the first conduit to the reclosing pressure of first switching valve S_1, the reclosing thereof and the consequent venting of the downstream portion of the first conduit through S_1 vent **12** drops the pressure sensed by second switching valve S_2, which also recloses, whereupon the high-pressure sampling cycle repeats itself.

Thus, in both low-pressure and high-pressure operation, first flow-regulating valve V_2 mainly determines the interval between successive samples and second flow-regulating valve V_5 determines the duration of the time over which each sample is taken, which usually is much shorter than the period between successive samples. The pressure in the low-pressure line is conveniently reduced by the first pressure regulator to about one atmosphere, and the low-pressure switching valve set to open at about 16 psi and to reclose at about 14 psi, for example. The high-pressure switching valve may open at not so high a pressure (e.g., 15 psi) and reclose at a somewhat lower pressure (e.g., 5 or 10 psi). Alternatively, the respective switching valves could be set so that the band through which the low-pressure valve operates is broader than that through the high-pressure valve operates (e.g., first valve to open at 25 psi and reclose at 10 psi, high-pressure valve to open at 20 psi and reclose at 15 psi) but this is not preferred because of the excessive venting of fluid by the timing circuitry and perhaps unduly short resulting sample duration.

The source of fluid under superatmospheric pressure may be located internal or external to the apparatus. The fluid source may comprise a reservoir of suitable fluid, such as nitrogen, helium, or other gaseous medium that is inert relative to the body of liquid and preferably also to any chemical tests to be performed upon the samples propelled thereby from the body of liquid. If air is not objectionable as a propellant, the source may be a tank of compressed air or a line from an air compressor wherever located. The lift available at low-pressure operation is about 30 feet of water (at about one atmosphere switching pressure of S_1); the lift at high-pressure operation is determined by the source pressure, which may be hundreds of pounds per square inch. By adjusting the setting of pressure regulator for the source (usually part of the source apparatus) the operator of this apparatus can adapt it readily to different lift requirements. Thus, for a 100-ft. deep well the source pressure (of perhaps 250 psi) may be dropped to about 50 psi.

Conventional materials of construction inert to the liquid being sampled are suitable for the various valves and other components. The flow-regulating valves, in addition to controlling the flow of fluid therethrough, may comprise visual indicators of flow rate, as by means of one or more balls or similar floats in a tapered tube as illustrated (e.g., FIG. 2) and described in U.S. Pat. No. 2,720,109. The pressure-responsive switching valves may be of the W-spring type shown (e.g., FIG. 5) and described in that patent or may be of the ball-controlled type shown (e.g., FIGS. 2*a*, 2*b*, 3*a*, 3*b*) and described in U.S. Pat. No. 3,751,983 or other suitable construction. The sample chamber conveniently is constructed as shown (FIGS. 6 and 5, respectively) and described in each of those patents.

Although only a single embodiment of this invention has been described and illustrated here, modifications may be made therein, as by adding, combining, or subdividing parts or steps, or by substituting equivalents, while retaining distinctive advantages and benefits of the present invention, which itself is defined in the following claims.

The claimed invention:

1. In liquid-sampling apparatus operable from a source of propellant fluid under pressure to collect samples of liquid from a body thereof, the improvement comprising a first conduit and a second conduit for connection in parallel to the source of pressurized fluid, and a pressure regulator in the first conduit to reduce the pressure therein below that in the second conduit; in sequence in the first conduit downstream from the regulator, a flow-regulating valve, an accumulator tank, a first pressure-responsive switching valve, and a two-position outlet valve; the switching valve being interconnected to sense the pressure of fluid accumulated immediately upstream therefrom, being normally closed below a given accumulated pressure and venting the conduit downstream therefrom, and being adapted to open and stop venting at a given higher accumulated pressure; and, in sequence in the second conduit, an on-off valve ganged to the two-position outlet valve in the first conduit, and a second pressure-responsive switching valve interconnected to sense the pressure between the two-position outlet valve and the second flow-regulating valve, the latter valve being normally closed to the body of liquid and adapted to open at a given pressure and to reclose at a given lower pressure therebetween; the ganging of the on-off valve in the second conduit with the two-position outlet valve in the first conduit being such that the latter valve in the closed or off position of the on-off valve is open downstream to the body of liquid to be sampled, and in the open or on position of the on-off valve is open instead to a second flow-regulating valve to the atmosphere.

2. Liquid-sampling apparatus according to claim **1**, wherein the second switching valve is adapted to open at a pressure below the pressure at which the first switching valve is adapted to open.

3. Liquid-sampling apparatus according to claim **2**, wherein the second switching valve is adapted to close at a pressure below the pressure at which the first switching valve is adapted to close.

4. In liquid-sampling apparatus operable from a source of propellant fluid under pressure to collect samples of liquid from a body thereof, the improvement comprising a first or low-pressure conduit and a second or high-pressure conduit for connection in parallel to the source of pressurized fluid; in sequence in the first conduit, a flow-regulating valve, a first pressure-responsive switching valve, and a two-position outlet valve; the switching valve being interconnected

to sense the pressure of fluid immediately upstream therefrom, being normally closed below a given accumulated pressure and being adapted to open at a given higher accumulated pressure; in sequence in the second conduit, an on-off valve ganged to the two-position outlet valve in the first conduit, and a second pressure-responsive switching valve normally closed to the body of liquid and interconnected to sense the pressure between the two-position outlet valve and the second flow-regulating valve, and adapted to open at a given pressure and to reclose at a given lower pressure therebetween; the ganging of the on-off valve in the second conduit with the two-position outlet valve in the first conduit being such that the the latter valve is open downstream to the body of liquid to be sampled, and in the open or on position of the on-off valve is open instead to a second flow-regulating valve to the atmosphere.

5. Liquid-sampling equipment according to claim **4**, including an accumulator tank connected to the first conduit between the flow-regulating valve and the first switching valve.

6. Liquid-sampling equipment according to claim **4**, wherein the first switching valve is adapted to vent the conduit downstream therefrom in its closed position only.

7. Liquid-sampling apparatus operable from a source of propellant fluid under pressure to collect samples of liquid from a body thereof and convertible between low-pressure and high-pressure propulsion of samples, comprising a low-pressure conduit and a high-pressure conduit for connection in parallel to the source of pressurized fluid, with a pressure regulator in the first conduit to reduce the pressure therein below that in the second conduit; in sequence in the low-pressure conduit downstream from the regulator, means for accumulating fluid temporarily, for timing intervals between successive samplings, and for releasing the accumulated fluid during each sampling; the means for releasing the accumulated pressure being adapted to do so to propel samples from the body of liquid during low-pressure operation; in the high-pressure conduit, means for releasing fluid from the propellant source to propel samples from the body of liquid during high-pressure operation; and means in both conduits for switching the respective pressure-releasing means alternatively to propel such samples, the switching means being adapted to divert the accumulated low pressure to the atmosphere during high-pressure propulsion of samples.

8. Liquid-sampling apparatus according to claim **7**, wherein the low-pressure conduit contains, in sequence following the pressure regulator, a flow-regulating valve, an accumulator tank, a first pressure-responsive switching valve, and a two-position outlet valve; the switching valve bveing interconnected to sense the pressure of fluid accumulated immediately upstream therefrom, being normally closed below a given accumulated pressure and venting the conduit downstream therefrom, and being adapted to open and stop venting at a given higher accumulated pressure, the latter valve being normally open downstream to the body of liquid being sampled, to propel samples therefrom and otherwise open to the atmosphere through a second flow-regulating valve.

9. Liquid-sampling apparatus according to claim **7**, wherein the high-pressure conduit contains, in sequence, a normally closed on-off valve, and a pressure-responsive switching valve also normally closed to the body of liquid being sampled and adapted to open by pressure in the first conduit during each sampling.

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