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McClure

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[54] **LIQUID SAMPLING**

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

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

[58] **Field of Search** .. 73/421 R, 421 B, 422, 423 A; 307/141, 141.8; 417/145, 146, 147; 137/113

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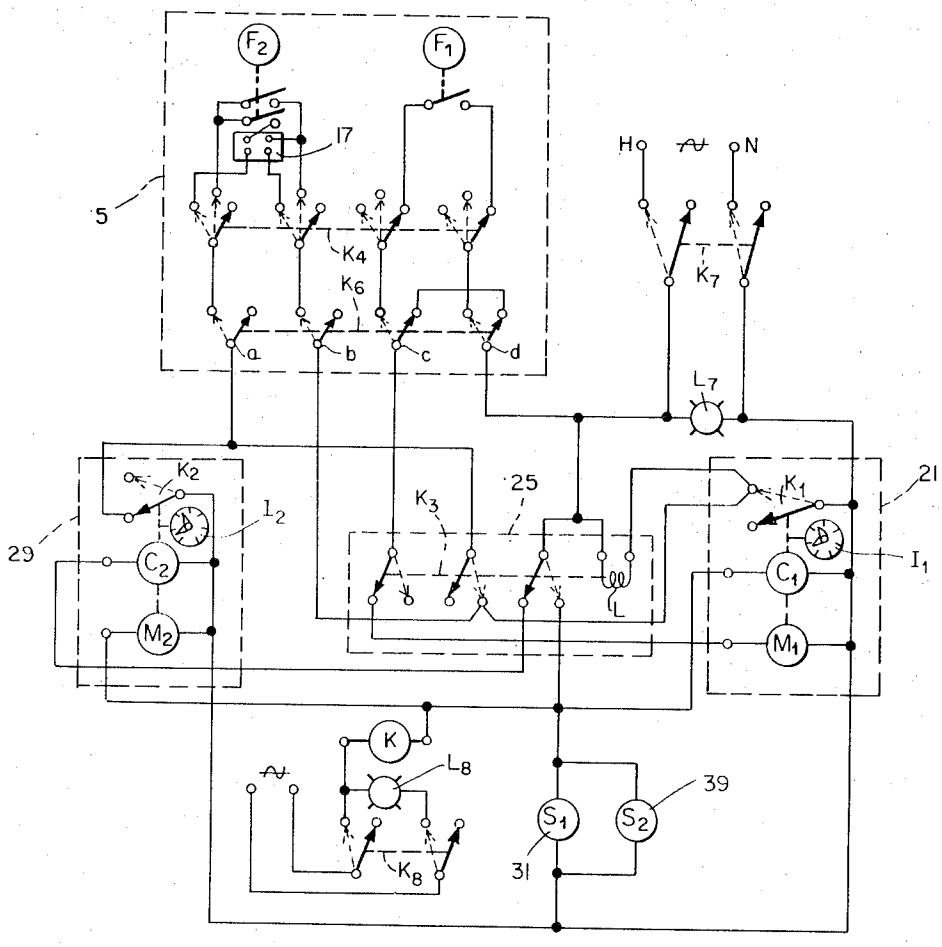
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[57] **ABSTRACT**

Electrically actuated apparatus for sampling liquid from the body thereof provides visible countdown of the time interval between successive samplings and also provides visible countdown of the duration of the time in which individual samples are being taken. The samples are propelled by fluid from an external or internal source of pressure, whichever is greater, interconnected for each sample duration period to a sample intake chamber in the body of liquid being sampled.

12 Claims, 5 Drawing Figures



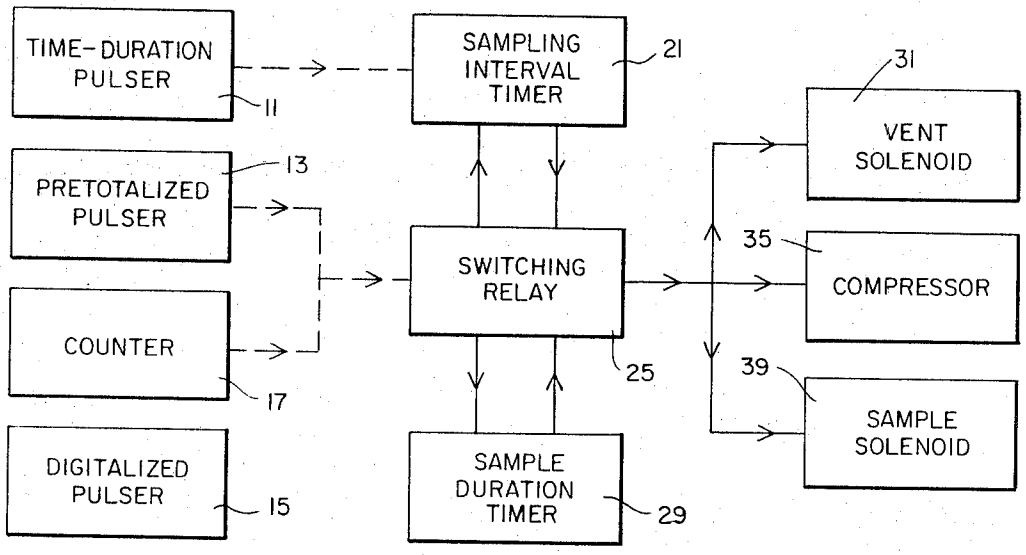


Fig. 1

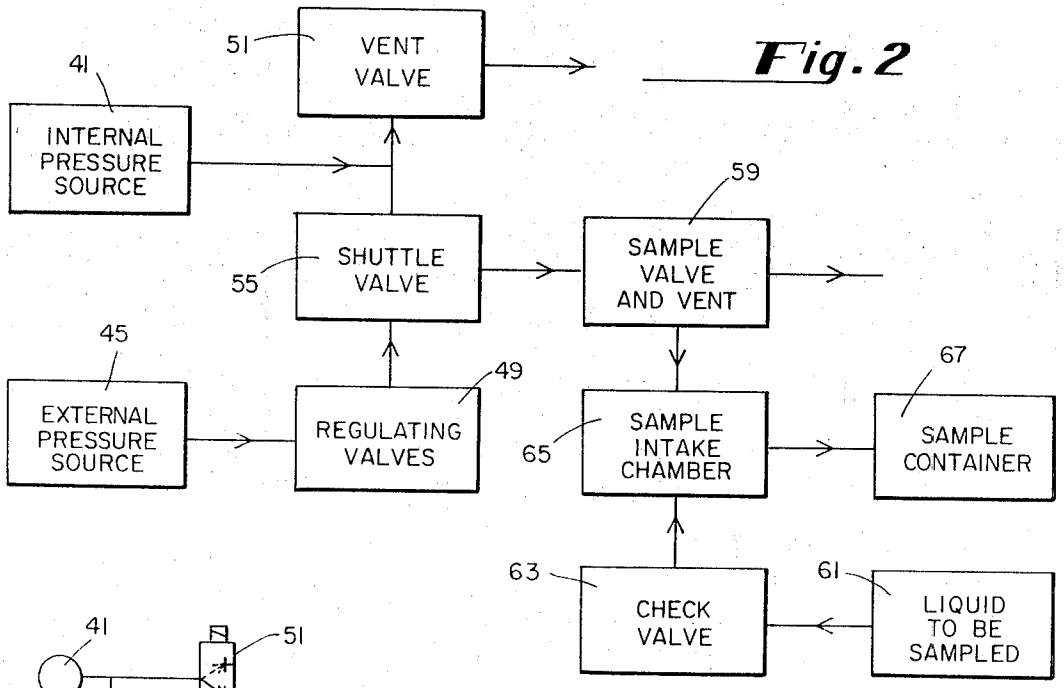


Fig. 2

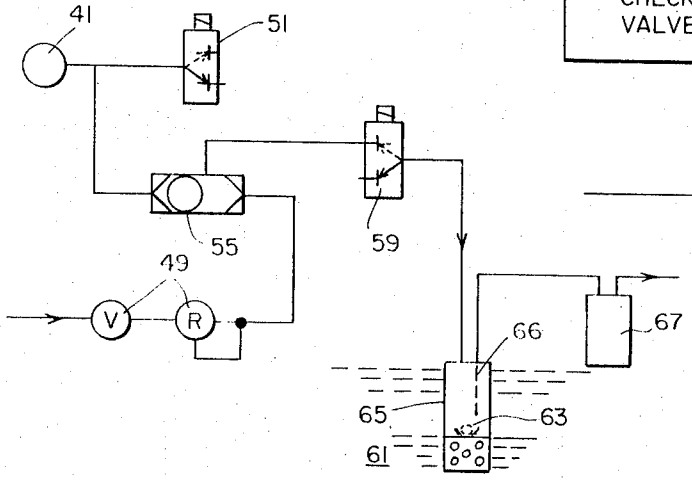


Fig. 3

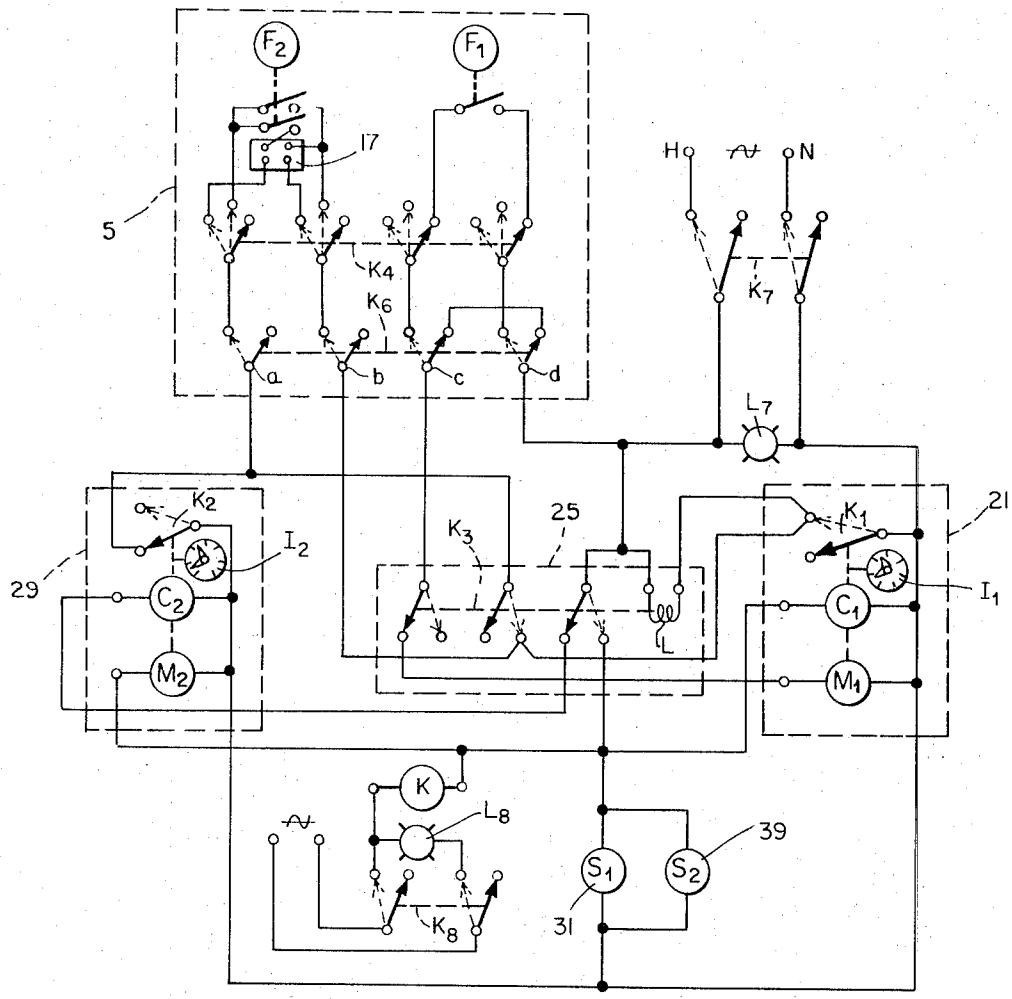

F2
F1
17
5
K4
K6
a
b
c
d
H
N
K7
L7
K2
I2
29
C2
M2
K3
25
L
K1
21
I1
C1
M1
K
L8
K8
S1
S2
39
31

Fig. 4

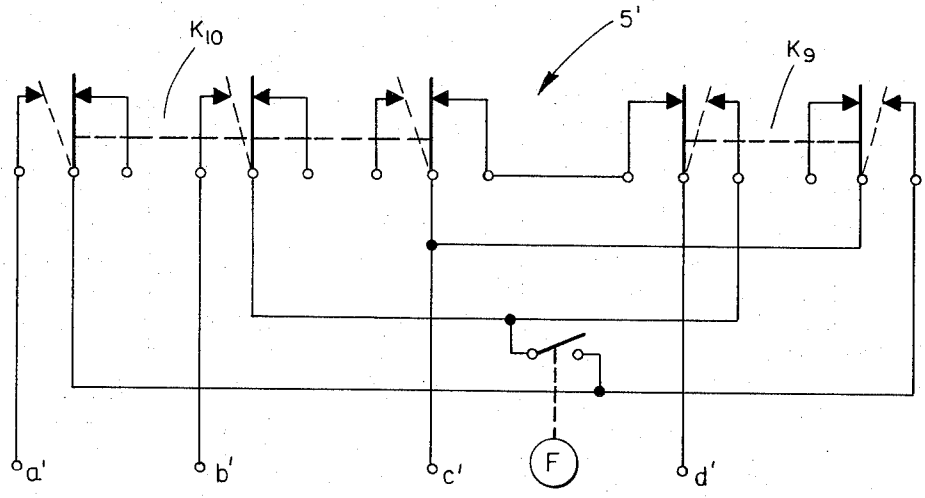

K10
5'
K9
F
a'
b'
c'
d'

Fig. 5

LIQUID SAMPLING

This invention relates to sampling of a liquid medium, as for determination of the composition thereof or of contaminants therein, and concerns especially electrically actuated apparatus for doing so by utilizing a pressurized fluid to propel the liquid samples.

As automatic sampling means and methods for sampling liquid have developed, a division into two main classes has occurred: pressure-actuated and electrically actuated. The functions performed by the selected power source, whether fluid pressure or electricity, include timing the interval between successive samples, timing the duration of individual samples, and valve switching between a condition of interconnection to the liquid medium to propel a sample therefrom and an alternative condition of disconnection from the liquid medium until it is time to take the next sample. Each has its disadvantages, as well as its advantages, of course.

A primary object of the present invention is electrical timing and valve switching but fluid propulsion of liquid samples.

Another object is instantaneous change-over between internal and external sources of pressurized propellant fluid.

A further object is interchangeability between use of automatic operation at the instance of electrical timing signals generated internally and, alternatively, external electrical signals, which may be proportional to flow of the liquid being sampled.

Yet another objective is visible countdown of both sampling interval (i.e., the time period between successive samples) and sample duration (i.e., the time period during which propellant fluid is being piped to the sampling locus in the liquid being sampled).

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 diagrams of a preferred apparatus embodiment, which is presented by way of example rather than limitation.

FIG. 1 is a block diagram of electrical apparatus according to the present invention;

FIG. 2 is a block diagram of pneumatic and hydraulic apparatus according to the invention;

FIG. 3 is a schematic circuit diagram of the apparatus of FIG. 2;

FIG. 4 is a schematic circuit diagram for the electrical apparatus of FIG. 1; and

FIG. 5 is a schematic diagram of alternative circuitry for part of FIGS. 1 and 4.

In general, the objects of the present invention are accomplished, in apparatus for sampling liquid from a body thereof at predetermined intervals of time and for predetermined periods of time at each sampling, by electrical means for determining the sampling interval, electrical means for determining the duration of sampling, conduit means to and from the body of liquid and adapted to receive gaseous fluid at superatmospheric pressure to propel samples of liquid from the body thereof to a collection location during sampling periods.

FIG. 1 shows in block form Switching Relay **25** interposed between Sampling Interval Timer **21** and Sample Duration Timer **29**, with oppositely directed pairs of arrows linking the relay with each of the timers. Interconnected in parallel to the relay, as indicated by arrows leading therefrom, are Vent Solenoid **31**, Compressor **35**, and Sample Solenoid **39**. Interconnectable to the sampling interval timer, as indicated by broken lines with arrow leading thereto, is Time-Duration Pulser **11**. Similarly connectable to the sample duration timer through the switching relay are Pretotalized Pulser **13** and (alternatively) Counter **17** fed by Digitalized Pulser **15**. Further details appear in a subsequent schematic circuit diagram.

FIG. 2 shows in block form Shuttle Valve **55** interposed between Internal Pressure Source **41** and External Pressure Source **45**, as indicated by arrows leading from each of the latter two components to the former. Vent Valve **51** parallels the shuttle valve downstream from the internal source, while the line from the external source contains regulating valves **49**. Interposed in series downstream of the shuttle valve are Sample Valve and Vent **59**, Sample Intake Chamber **65**, and Sample Container **67**. Upstream of the chamber are Liquid to be Sampled **61** and intervening Check Valve **63**. Further details appear in the next view.

FIG. 3 shows fluid circuitry of this invention corresponding to the block diagram in the last view, Vent Valve **51** is normally in the venting position. Shuttle Valve **55** is in whichever position corresponds to connection of the higher pressure source (internal **41** or external through valve V and regulator R (collectively identified as **49**) to sample valve (and vent) **59**, which normally is in the position of venting sample chamber **65** and thus does not pass pressurized propellant to the chamber until switched. In the normally venting position of the sample valve, liquid from body **61** thereof can enter the sample chamber through check valve **63** (shown in broken lines). In the switched position of the sample valve, the check valve seals under the pressure of incoming propellant from whichever source, whereupon the liquid contents are forced out dip tube **66** (also shown in broken lines) through the interconnecting tubing to sample container **67**, which is vented to the atmosphere.

FIG. 4 shows schematically electrical circuitry corresponding to the block diagram of FIG. **1**. Respective sampling interval and sample duration timers **21** and **29** are outlined in broken lines at the right and left. Each timer comprises a motor, a clutch, a countdown indicator, and a switch interconnected mechanically, as indicated by broken lines, such that activation of the motor moves the countdown indicator continuously toward its zero position and eventually moves the switch arm from the normal position (shown in solid) to the alternative position (shown in broken lines). The timer construction is such that upon inactivation of the motor (and concurrent declutching) the switch arm is spring-biased back to its original position, together with the countdown indicator. Switching relay **25** is outlined in broken lines and comprises actuating coil L and triple-pole double-throw switch K_3 shown normally positioned to the left and with an alternative actuated position to the right.

Outlined in broken lines at the upper left in FIG. **4** is flow-proportional (FP) adapting component, which corresponds generally to the left bank of blocks in FIG. **1**. Flowmeter F_1, with its switch shown interconnected thereto by broken lines, corresponds to time-duration pulser **11**. Flowmeter F_2 with its similar switch is adapted to function through its upper switch arm as pretotalized pulser **13**, and through its lower switch

arm as digitalized pulser **15** by reason of counter **17** having its input terminals connected in series therewith. Quadruple-pole triple-throw FP mode switch K_4 is interposed between the flowmeter switches and the counter, on the one hand, and quadruple-pole double-throw AUTOMATIC-FLOW PROPORTIONAL (AUTO-FP) switch K_6 on the other hand, all within FP adapter component **5.**

For ready reference the four leads from the FP component are identified by reference to K_6 switch arm contact or pivot points, from left to right, as *a, b, c, d.* The lead from contact *a* connects to the normally closed contact of sample duration timer switch K_2 and to the middle of switch K_3 and switching relay **25.** The lead from contact *b* interconnects to the normally open contact of the same arm of switch K_3 and to the normally open contact of sampling interval timer switch K_1. The lead from contact *c* connects to one side of main power switch K_7, through which it is connectable to high side H of the supply power line. The neutral or N side of the power line is connectable through the other side of that switch to the switch arm of sampling interval timer switch K_1, as well as to one side of motor M_1 and clutch C_1 thereof and of motor M_2 and clutch C_2 of the sample duration timer, also vent solenoid S_1 and sample solenoid S_2. The H power lead reaches the opposite side of the solenoids and of clutch C_1 and motor M_2, also one side of compressor K via the normally open contact of the right arm of the switching relay, whose coil is connected between that lead and the normally open contact if switch K_1. The other side of the compressor is connectable to the N power lead via one side of switch K_8. Pilot lamps L_7 and L_8 across respective power switches K_7 and K_8 indicate their ON position.

Operation of the apparatus of this invention, which is readily understood by reference to the foregoing description and the diagrams, will be described first by reference to the action with switch K_6 in its right or AUTOMATIC (AUTO) position, which excludes any further consideration of the FP adapter component.

Sampling interval timer motor M_1 is supplied with power through the N lead from one side of switch K_7 (which is closed to apply main power) and through the H lead from the other side of that switch, through the jumper across the two rightmost normally closed contacts of AUTO-FP switch K_6, through the normally closed leftmost contact of switching relay switch K_3. After a time interval determined by internal setting of conventional gear reductions (not shown) to a predetermined time-equivalent value, M_1 closes its normally open switch K_1 through normally connected clutch C_1, whereupon electric power is supplied across coil L of switching relay **25** and the three arms of switch K_3 are thrown from their normal left positions to their actuated right positions. Throwing of the left arm removes the power from motor M_1, which stops; throwing of the middle arm applies power to the FP adapter component (which will be discussed separately); and throwing of the right arm of switch K_3 removes power from sample duration timer clutch C_2, which was being held declutched thereby, and applies it to motor M_2 of that timer (which begins to run) and to sampling duration timer clutch C_1, which is declutched thereby—permitting switch K_1 to be released to its normally open position. Nothwithstanding the opening of switch K_1, the switching relay is retained in its actuated position by alternative N lead path closed thereby through the middle arm of relay switch K_3 and the normally closed arm of sample duration timer switch K_2.

Application of power to solenoid S_1 when switching relay **25** is actuated closes normally open vent valve **51** (FIG. **3**), as well as actuating compressor K of internal pressure source **41** (if switch K_8 is thrown) to supply air under superatmospheric pressure to shuttle valve **55.** Simultaneous actuation of solenoid S_2 closes sample valve vent and interconnects whichever pressure source has the higher pressure, from the shuttle valve, to the interior of sample chamber **65,** thereby closing intake check valve **63** and forcing the liquid contents of the chamber through dip tube **66** and the interconnecting tubing into sample container **67,** any excess air or externally supplied propellant being vented therefrom.

When sample duration timer motor M_2 has run for the desired period (predetermined similarly to that for M_1) it opens switch K_2, thereby interrupting power to the switching relay, which returns to its original position, removing power from motor M_2 and from compressor K and solenoids S_1 and S_2 but applying power (through the right arm of switch K_3) to clutch C_2, deswitching it and permitting the arm of switch K_2 to return to its normally closed position. Sampling interval timer **21** is reactivated by the release of the switching relay, and the timer recycles. Thus in the AUTO mode, the respective timers (**21** and **29**) operate alternately so long as the apparatus has power applied thereto, whether the power switch for compressor K is thrown or not, as is optional when an external pressure source is being used.

Operation FP adapter component **5** is readily understood as a variant of the operation just described. With switch K_6 thrown to the left of FP position, flowmeters F_1 and F_2 are interconnectable to the body of the apparatus through setting of FP MODE switch K_4. The mode switch is shown in the rightmost or TIME DURATION (TD) position, in which the switch of flowmeter F is connected in circuit between power lead H from main power switch K_7 through the AUTO-FP switch to sampling interval timer motor M_1 through normally closed leftmost contact of switch K_3. Accordingly, closing of the F_1 switch actuates motor M_1, which runs so long as the switch is closed, thereby totalizing successive closure periods of that flowmeter switch up until an entire sampling interval is completed, whereupon the switching relay is actuated as before to effect sample recovery.

In the other positions of the FP MODE switch flowmeter F_2 is interconnected either directly through the middle position thereof, or indirectly through digital pulse counter **17** in the leftmost position. In the midposition, whenever flowmeter F_2 closes its upper switch, a so-called "pre-totalized" pulse is applied through a power circuit completed to coil L of switching relay **25** through normally closed switch K_2 of the sample duration timer, thereby actuating the relay independently of the sampling interval timer and effecting a cycle of sample recovery. In the left position of the FP MODE switch, flowmeter F_2 supplies a digital pulse every time its lower switch closes to connect counter **17** in a series with the power source in like manner, and when the counter has tallied a preset number of such pulses it closes the power circuit to coil L and effects sample recovery as already described. It will be understood that

the switching action of the respective flowmeters is an indication of the flow of a given volume of liquid past the sample chamber in the body to be sampled, so that sampling is proportioned to such volume, thereby rendering a composite of a succession of samples more nearly representative of the liquid that has flowed by than if sampling had proceeded automatically at regular intervals.

FIG. 5 shows a simplified alternative construction of FP adapter component, designated as 5', in which flowmeter F may deliver either pretotalized or time-duration pulses (i.e., contact closures) with the same effect as just described. A three-position switch is shown in its central or AUTOMATIC position. The four leads at the bottom of the view have contacts designated *a'*, *b'*, *c'*, and *d'*, which correspond to and can be substituted for respective contacts *a*, *b*, *c*, and *d* of component 5 in FIG. 4. Double-pole switch component K_9 at the right, when thrown to the right, puts the apparatus in a TD FP mode of operation (as in the rightmost position of switch K_4 on component 5), whereas triple-pole switch component K_{10} at the left, when thrown to the left, puts the apparatus in a PT FP mode (as in the midposition of switch K_4). It will be understood that movement of respective switch components K_9 and K_{10} of this three-position switch do not affect one another. A prime advantage of this alternative arrangement is that only a single pair of contacts is required to accommodate FP signals of either TD or PT type. This modification can be adapted to use with a digitalized pulse flowmeter by incorporating the counter in the flowmeter circuit.

Both sampling interval and sample duration timers are conveniently furnished with conventional dial and moving pointer indicators (I_1 and I_2) for visual countdown of the time period remaining in the sampling interval or sample duration period, as the case may be. Pilot lights (not shown) parallelling the respective motors also facilitate observation of the timer actuated at any given moment. The timers, which have similar synchronous motors, may have similar or different gear reductions for the same or different timing ranges. In normal practice, it is convenient to have a range from a minute or so to about a day or so for the sampling interval timer, depending upon desired sampling frequency; and a range from a few seconds to about a minute for the sample duration timer, depending upon sample head or lift and upon length and diameter of sample lines. Such timers are readily available commercially, as are all the other parts of the described apparatus.

This apparatus and the methods of automatic and flow-proportional sampling disclosed here represent a highly versatile and effective advance in the art of liquid sampling, whose convenience and effectiveness will be best appreciated and understood by those undertaking to practice it. Although a principal embodiment and at least one modification have been described and illustrated, the invention is not to be deemed limited thereto. Additional modifications may be made therein, as by addition, combination, or subdivision of parts and steps, which retaining advantages and benefits of the invention, which itself is defined in the following claims.

The invention claimed is:

1. In apparatus for sampling liquid from a body thereof at predetermined intervals of time between and for predetermined periods of time at successive samplings, including conduit means to and from the body of liquid and adapted to receive gaseous fluid at superatmospheric pressure to propel samples of liquid from the body thereof to a collecting location during the sampling periods, the improvement comprising a pair of like electrical timing means, one for determining the interval between successive samplings and one for determining the duration of each sampling period, and including an indicator of the time remaining in any current sampling interval and the time remaining in any current sampling period; means for switching the respective timer means alternately off and on, each one being switched on when the other has counted down to zero time remaining, for an automatic mode of operation; switch means for inactivating such automatic switching and interconnecting the apparatus for operation in accordance with signals supplied from an external source, the first timing means including electrical means for totalizing time-duration signals and the second timing means including electrical means for determining the duration of sampling periods; and switch means interposed between the electrical means and the external signal source together with electrical interconnectors therebetween such that in one position of the switch means the external signal source is connected to the totalizing electrical means and in another position of the switch means the external signal source is connected to the electrical means for determining the duration of sampling periods.

2. Liquid sampling apparatus according to claim 1, including switching valve means, actuated by the electrical means, for alternately permitting and precluding such flow of propellant.

3. Liquid sampling apparatus according to claim 1, including relay means, actuated by the electrical means, for switching the respective electrical means alternately on and off.

4. Liquid sampling apparatus according to claim 1, including an internal source of gaseous fluid at superatmospheric pressure and an inlet for gaseous fluid at superatmospheric pressure from an external source thereof, both connected to the conduit means, and shuttle valve means for interconnecting the external inlet to the conduit means when the external gaseous fluid pressure exceeds a given value and for otherwise connecting the internal pressure source to the conduit means.

5. Liquid sampling apparatus according to claim 1, wherein the electrical means for determining the sampling interval and the electrical means for determining the sample duration are identical.

6. Liquid sampling apparatus according to claim 1, wherein the electrical means for determining the sampling interval and the electrical means for determining the sample duration have respective indicator means associated therewith for displaying the time thereof remaining at any given instant.

7. Liquid sampling apparatus according to claim 6, wherein the respective indicator means are identical and include respective actuation indicators.

8. In apparatus for sampling liquid from a body thereof, in accordance with contact closure signals supplied from an external source, including means in contact with the liquid and adapted to propel a sample from the body thereof to a collection location during sampling periods and including electrical means for totalizing time-duration signals from such source and

electrical means for determining the duration of such sampling periods, the improvement comprising switch means having a plurality of positions and interposed between the electrical means and the external signal source, with electrical interconnectors therebetween such that in one position of the switch means the external signal source is connected to energize the totalizing electrical means rather than the means for determining sample duration, and in another position of the switch means, the external signal source is connected to energize the electrical means for determining duration of sampling periods rather than the totalizing electrical means.

9. Liquid sampling apparatus according to claim **8**, wherein the sample is propelled by gaseous fluid at superatmospheric pressure, and including valve means actuated by the electrical means alternately to interconnect such fluid for sample propulsion and to disconnect such fluid during the interval between successive periods of sample propulsion.

10. Liquid sampling apparatus according to claim **8**, including a contact closure at the external signal source end of the electrical interconnectors.

11. Liquid sampling apparatus according to claim **8**, wherein a two-wire electrical interconnection to the external signal source is adapted to accommodate both time-duration and momentary signals therefrom, the former in one position of the switch means and the latter in the other position of the switch means.

12. Liquid sampling apparatus according to claim **8**, including switch means for inactivating the apparatus relative to the external source of signals and enabling it to operate automatically and including means for switching the respective electrical means alternately off and on, each being adapted to be so switched on when the other has counted down to zero time remaining.

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