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AUTOMATIC GAS METER FOR LABORATORY FERMENTERS

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SUMMARY.

A versatile, cheap and automated system is designed for the measurement of small gas flows produced in laboratory-scale fermentation processes. An automatic sampling device for programmed times is linked to the flow meter. The displacement of a liquid by the gas being measured is the principle on which both the meter and the sampling device are based. The operation of the system is controlled by a simple electronic circuit.

INTRODUCTION.

The laboratory-scale chemical or biological processes present serious difficulties in the measurement of the gas flow and in the sampling of this gas. The bibliography, "Angelidaki et al., 1992" etc., lists a number of systems for measuring small quantities of gases but these kits are not very versatile nor do they have suitable devices for programmed sampling of gas for subsequent analysis.

The system proposed in this paper is extremely cheap (less than US$ 1,000), very robust and reliable in its operation. In addition, it can handle a wide range of flow velocities and store widely different volumes of gas.

CONSTRUCTION.

The system comprises a gas flow meter and a set of flasks for taking samples (Figure.1), as well as the apparatus necessary for supply of the liquid used.

The flow meter consists of a receptacle for the gathering and measurement of the gas (1), a three-way selenoid valve for controlling the flow of the biogas (2), a solenoid valve for controlling the flow of the liquid displaced (3) and two level sensors (4). The sampling flasks each comprise a flask in which the sample accumulates (5), a three-way solenoid valve for gas-flow control (6) and a three-way, manually-operated valve for flow control of the liquid displaced (7). The system is also complemented by a raised vessel for the displacement liquid (8) ower vessel or drain outlet for this liquid (9) and an electrical control circuit for the system. All the valves used are of the "silicon tube pinching" type to make the system easy to clean.

The receptacle for accumulating the gas (1) is interchangeable and made of glass, cylindrical in shape and with two inlets, top and bottom. Each of the inlets is connected to its own selenoid valve (SIRAI); the upper valve (for tubes of 0.16cm diam, model K92921) controls the entry and exit of the gases, while the lower controls the entry and exit of the displacement liquid (0.48cm diam, model K92922). The three terminals of the level detectors (upper level, lower level and common) are conductive points and their relative position in the receptacle marks the volume measured in each cycle of the system. The sampling vessels have one level sensor and a septum (S).

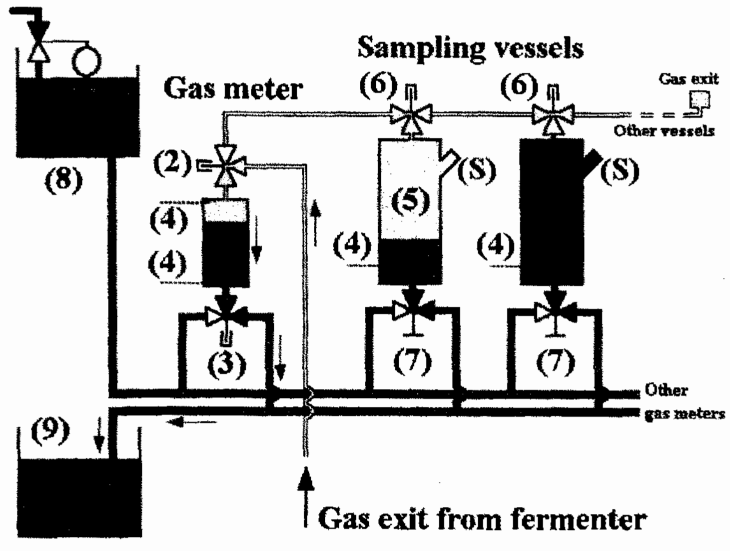


Figure 1: System diagram.

For biogas, the displacement liquid may be water or any other liquid of similar viscosity (preferably a saline solution to reduce evaporation and as an aid to the conductivity necessary for the level sensors). The raised vessel should be positioned above the flow meter and the sample collectors, to permit these to be completely filled by gravity; the drainage line for the displacement liquid should be positioned below the level of the lower valves. It is not advisable to re-circulate the displacement liquid, to avoid its contamination by the gas samples.

The control circuit effects the changes of position of the selenoid valves of the flow meter, in accordance with the signals received from the level sensors, at the same time triggering the counter of the meter system. A programmed timer opens the gas inlet selenoid valve of each of the sample collectors and closes it when the liquid falls below the level of the sensor. The programmed timing of sampling will be increasingly versatile as more sampling devices are installed.

OPERATION OF THE GAS FLOW METER.

Prior to setting the system in operation, the receptacle for the flow measurement must be selected, according to the flow of gas to be measured and the frequency with which the flow is to be estimated.

The volume of the collection receptacle should be proportional to the volume of flow measured, such that the time between each one of the cycles is greater than one minute.

In the first place, it is necessary to fill the flow meter and the sample collectors with the displacement liquid (Figure 2, position ON). Once the gas source has been connected to the flow meter, the gas will begin displacing the liquid in the meter (Figure 2, position OFF) until its level has fallen below the lower level sensor. At this moment, the control system will change the position of the selenoid valves, allowing the inflow of liquid and producing an outflow of gas from the top into the sampling system. The device proposed here offers an advantage over others in that the discharge of liquid by gravity helps the extraction of gas from the fermentation system source. In those systems where the gas produced has to displace the liquid by pressure, production of the gas could be inhibited by an excessive increase in pressure over the surface of the fermentation medium.

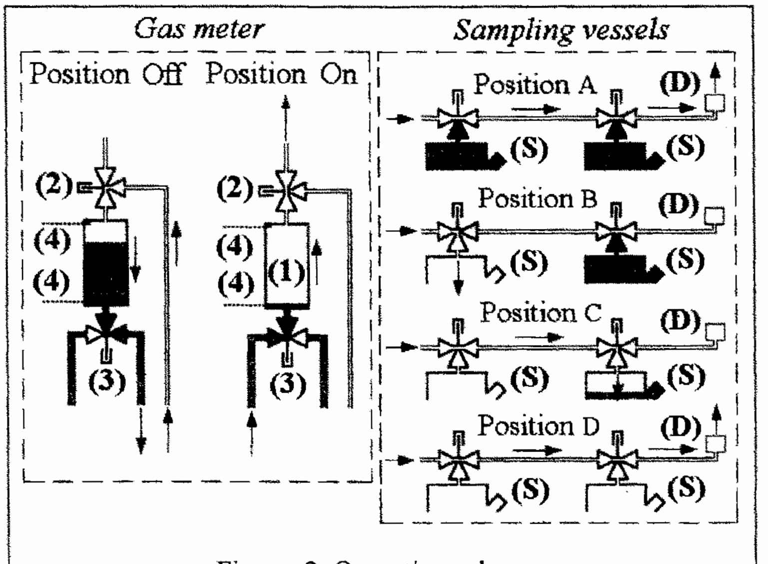


Figure 2: Operating scheme.

Once the upper level sensor is covered by the liquid, the control system registers the increase on the meter counter and changes again the position of the selenoid valves of the meter, thus repeating the process again.

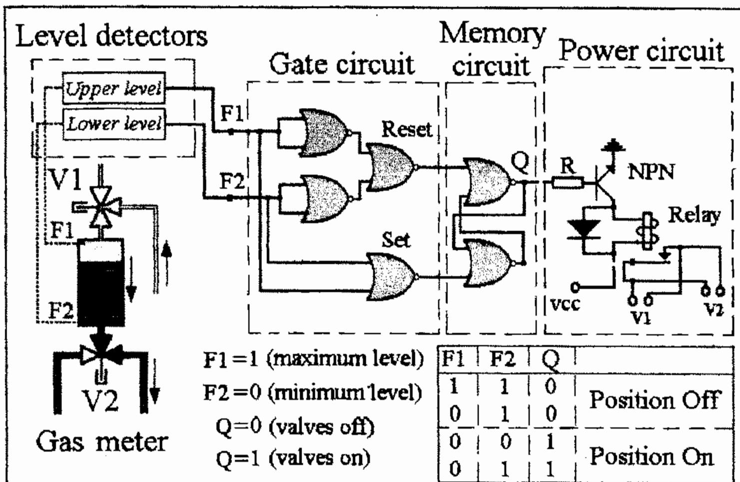
OPERATION OF THE SAMPLE COLLECTOR.

In the same way as for the flow meter, it is necessary to fill the sample receptacles with displacement liquid. This operation can be done manually, by opening the valves at the bottom of the collectors. It is also necessary to set the times at which each of the required samples are to be taken, on the control timer of each collector.

While the valves which allow the gas to pass to the collectors remain closed, the gas leaving the flow meter escapes at point (D) (Figure 2. Sample collection position A). When the set time for sampling is reached, the appropriate valve to the collector will open (Figure 2 positions B or C) and the gas will enter the appropriate receptacle. The gas will accumulate in the receptacle until the liquid level falls below the level sensor at the lower part of the vessel; at this moment, the control system will close the upper valve, returning the gas flow to point (D) (Figure 2 position D).

CONTROL SYSTEM.

The flow meter control (Figure 3) consists of the level detectors, a gate circuit, a memory circuit and a power circuit to actuate the valves. The level detection circuit used employs terminals with gold-tipped points and a logic circuit (+5v=1; 0v=0).



F1	F2	Q	
1	1	0	Position Off
0	1	0	
0	0	1	Position On
0	1	1	

Figure 3: Control circuit scheme.

The gate circuit and the memory circuit use NOR logic gates and the table of truth is shown in figure 3. The power circuit has only one outlet since the two selenoid valves operate in unison. The control system for the sampling simply comprises commercial timing devices (one for each receptacle), to which are connected the corresponding selenoid valves to open and close at the pre-set time.

CALIBRATION AND ACCURACY.

The calibration of the flow meter is simple; measurement of the volume of liquid expelled in determined cycles gives the volume of biogas given off.

The accuracy of the system is high (±1ml in each pulse). However, more accurate results can be achieved by reducing the diameter of the meters.

REFERENCES.

Angelidaki, I., Ellegaard, L. and Ahring, B.K.: (1992). Biotechnol. Bioeng. **39,** 351-353.

Beaubien, A., Jolicoeur, C., Alary, J.F.: (1988). Biotechnol. Bioeng. **32**, 105.

Erdman, M.D., Delwiche, S.R.: (1985). Biotechnol. Bioeng. **27,** 569.

Moletta, R. Albagnac, G.: (1982). Biotechnol. Lett. **4,** 319.