PUMPING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to pumping systems and more particularly to pumping systems that utilize a pulsating pump to draw samples from a source of liquid.

It is known to pump liquids from a liquid source through a pulsating pump, such as for example a peristaltic pump, from U.S. Pat. No. 4,415,011 to Douglas M. Grant, issued Nov. 15, 1983, and from U.S. Pat. No. 4,660,607 to Carl D. Griffith, issued Apr. 28, 1987. In such a process, the water interface in the conduit through which the liquid is being pumped is sensed to provide an indication of where the liquid is in the conduit.

Several different sensing mechanisms have been utilized in such pumps such as an optical sensing mechanism, a capacitance sensing mechanism and a electrical conductivity sensing mechanism. The information about the sensed interface is utilized together with other information to meter a fixed volume of liquid into one or more sample containers. U.S. Pat. No. 4,415,011 discloses the metering of liquid by counting cycles of the pump from the shaft of the pump.

In the prior art apparatus, the sensors are either internal or external to the conduit and utilize several different arrangements such as by sensing a change in capacitance between two electrodes outside the conduit as the liquid interface passes through or by sensing changes in the absorption of light transmitted through the conduit or changes in electrical conductivity.

These prior art pumps and sensing mechanisms have several disadvantages such as for example: (1) under some circumstances, the sensing mechanism may have difficulty in distinguishing between a continuous flow of the liquid and spurts of liquid that may be splashed through the sensing point; (2) the pump may slow due to battery drain or other unexpected effects; (3) the head of water may suddenly change, causing variations in pumping; or (4) conductivity and capacitive sensors are prone to malfunctions caused by bridges and changes in the conductivity of liquids.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a novel pumping system.

It is a further object of the invention to provide a pumping system which senses the location of liquid being pumped in a conduit by changes in force caused by the pumping.

It is a still further object of the invention to provide a pumping technique which is controlled in accordance with pulses caused by a pulsating pump.

It is a still further object of the invention to provide a pumping system which utilizes stored statistical data along with other information relating to the head of pressure and size of conduits to measure the amount of liquid being pumped.

It is a still further object of the invention to provide a novel pumping technique in which a combination of measurements of cycles of the pump and stored data is used to meter the amount of liquid being pumped.

It is a still further object of the invention to provide a novel pumping technique for metering the amount of liquid being pumped by stored statistical data relating the cycles of the pump to pressure head and flow of liquid, and other information such as that relating to conduit size and the like.

It is still another object of the invention to provide a liquid metering pump that uses detected pump cycles and stored data including conduit size, and pressure head to correlate detected pump cycles with volume of liquid pumped.

In accordance with the above and further objects of the invention, a pumping system includes: (1) a pump that creates pressure pulses as it pumps; (2) a conduit through which liquid is drawn; (3) a sample container; and (4) a sensor for sensing pulses in the conduit. The sensor is positioned at a location along the conduit where it generates a signal related to pressure or force in the conduit. In the preferred embodiment, it is a piezoelectric film which senses motion of the conduit as it attempts to expand because of force generated by the pump such as the back pressure in the liquid caused by reaction to backed inertia of moving water when a pump roller closes the conduit against further flow.

In the operation of the sensor, the sensor generates electrical signals indicating pulses caused by the pump. Signals generated at the time that the liquid reaches a predetermined point are distinguished from other pulsations to indicate the interface of the liquid. Pulses are counted and when there are interruptions in the count, a standard criteria is applied to determine if the interruption is because the initial indication of an interface of liquid was false and only caused by splashing or surging or the like or whether it was a genuine interface and the lapse in pulses was an error. Pulses are added which indicate that the liquid is indeed flowing beyond a predetermined point.

To determine when a predetermined amount of liquid has been deposited in a container, the length of conduit, inner diameter of conduit and the like are measured, and in the preferred embodiment, entered into the memory of a microprocessor. A statistical base determined over a number of runs is utilized so that when the interface of the liquid is detected, the number of counts of the pump motor before the interface reaches a predetermined location is used as an indication of the head of water pressure by statistically relating it in a look-up table.

The head of pressure is then utilized together with the known length from the interface to the sample collector to determine how many cycles of a pump are required to meter approximately the right amount of liquid into the container in the sample collector. The number of cycles is determined from a statistical base in a look-up table which is corrected for the characteristics that affect pulse counts such as drag, head of pressure, cross-sectional area of conduit, length of conduit, or the lie.

When the preset volume of liquid as determined by the number of pumping cycles has been deposited in the container, the pump reverses direction to purge the tube and prevent further liquid from being deposited into the container. This cycle may be repeated manually or automatically under the control of a microprocessor with alternate purge and filling cycles in a manner long used in the art.

With the liquid sensor, rinse cycles can be performed in which the liquid can be drawn to a more precise point than in prior art apparatus so as to better clean the conduit. With this combination, a rinse may encompass a large portion of the conduit without causing liquid to flow into a sample container. The rinse liquid can be drawn even to the highest point in the conduit down-