# PERISTALTIC DILUTOR SYSTEM AND METHOD

The present application is a continuation in part of my copending application Ser. No. 308,783, filed Nov. 22, 1972, now abandoned. The present invention relates to improvements in a peristaltic dilutor system for the preparation of liquid dilutions in research and analytic laboratories, and to a method of geometrically diluting liquids.

In operations of this type, precise quantities of liquids must be distributed into test tubes, and it has been proposed, for example, to do this with a syringe. Where repeated dosing of liquid diluents are required, peristaltic pumps have been used for this purpose, such peristaltic dilutor systems comprising one or more flexible tubes whereon a power-driven rotor acts to propel liquid through the tube or tubes.

Known systems of the latter type comprise a flexible tube having an upstream end and a downstream end, a supply of diluent liquid in communication with the upstream end of the flexible tube for filling the tube with diluent liquid, and a peristaltic pump arranged between the upstream and downstream tube ends. A concavely arcuate pumping shoe is mounted for cooperation with rollers mounted on a rotor of the pump, the tube being compressed by the rollers pressing it against the shoe when the rotor rotates the rollers into engagement with the tube whereby the tube is locally occluded at successive points and the liquid filling the tube is peristaltically propelled therethrough. Dosing of the propelled liquid is obtained by a timing device which causes intermittent stoppage of the rotor rotation to enable the container of the propelled liquid to be replaced.

It has been difficult to obtain equal and regular doses of liquid with this known type of peristaltic dilutor system because the timed rotor stoppage may cause the rotor to be stopped in successive angular positions in which the state of compression of the flexible tube or tubes is not the same, which leads to considerable variations in the liquid doses. In fact, if stopping occurs when the pressure roller disengages from the tube, the resultant inflation of the flexible tube at this point causes a reverse stream of liquid which disturbs the uniformity of the dosage distributed by the apparatus.

Inaccurate metering will also result from a disparity in the number of rollers compressing the tubes during successive meterings, as well as from differences in the degree of stretching of the tubes resulting from variations in the angular position of the rollers at the successive arrests.

It is a primary object of this invention to overcome these disadvantages and to provide a peristaltic pump in a dilutor system of the described type which permits the repeated distribution of very precise doses of liquid.

It is another object of the invention to provide an improved method for geometrically diluting a liquid in a series of successive containers with a diluent liquid.

This is accomplished in accordance with the present invention with control means for intermittently entraining the peristaltic pump rotor for rotation through predetermined angular portions of a full rotation in alternate directions stopping every time in an identical predetermined angular position. Rotation in one direction for a first angular portion propels a first predetermined dose of the liquid at the downstream end of the flexible tube inwardly, and rotation in the opposite direction for a second and larger angular portion propels outwardly at the downstream tube end the first dose of liquid and a predetermined dose of the diluent liquid propelled by the pump from the upstream end of the tube. Accurate metering is assured by providing rollers distributed concentrically about the rotary shaft of the rotor and angularly spaced equidistantly thereabout whereby the propelled liquid is divided into equal doses by two of the rollers being in occluding contact with the flexible tube the rollers always being located in an identical angular configuration when in the stopping position.



The method of this invention comprises the combination of steps of peristaltically pumping accurately metered doses of the diluent liquid through a flexible tube from an upstream end of the tube in communication with a supply of the diluent liquid to a downstream end of the tube in successive communication with each of the successive containers, the downstream tube end holding a selected number of the metered doses of the diluent liquid, immersing the downstream tube end in a first one of the successive containers containing the liquid to be diluted, peristaltically pumping an accurately metered dose of the liquid from the first container, withdrawing the downstream tube end holding the accurately metered dose of the liquid to be diluted and the diluent liquid from the first container, immersing the downstream tube end in a second one of the successive containers, peristaltically pumping the metered dose of the liquid to be diluted and the selected number of metered doses of the diluent liquid into the second container, mixing the liquid to be diluted and the diluent liquid in the second container to obtain an accurately metered dose of a first diluted liquid, and continuing the cycle of withdrawing and immersing the downstream tube end, peristaltic pumping and mixing in successive ones of the containers.

The above and other objects, advantages and features of the invention will become more apparent from the following detailed description of a now preferred emodiment thereof, taken in conjunction with the accompanying drawing wherein

FIG. **1** is a side elevational view of the apparatus of this invention;

FIG. **2** is a plan view, on an enlarged scale, of the peristaltic pump in the apparatus;

FIGS. **3, 4** and **5** are respective sections along lines **3—3, 4—4** and **5—5** of FIG. **2;**

FIGS. **6** and **7** are schematic views illustrating different types of operation of the peristaltic pump;

FIG. **8** is a diagram of the electric control circuit for the operation of the pump; and

FIG. **9** schematically illustrates the geometric liquid distribution by the method of the invention.

The apparatus for the preparation of dilutions comprises peristaltic pump **P1** shown in detail in FIGS. **2** to **5.** This pump comprises a plurality of parallel flexible tubes **13** (see FIG. **2**). As shown in FIG. **1,** the downstream portion **13***b* of each tube is connected to a small tube or nozzle **77** which is mounted on a vertically movable support **76.** The upstream portion **13a** of each tube **13** is immersed in, and opens into, reservoir **84** containing a supply of dilution liquid.

The nozzles **77** associated with each of the tubes **13** of the peristaltic pump are disposed on the same support **76** for common vertical movement and are periodically immersed into respective tubes or containers **80, 81, 82, 83** which are arranged parallel to each other in series of successive containers, the containers being