COMPARATIVE STUDIES ON RESPIRATION.

XIII. An Apparatus for Measuring the Production of Minute Quantities of Carbon Dioxide by Organisms.

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(Received for publication, June 28, 1920.)

Osterhout¹ has described an apparatus by means of which the production of small quantities of carbon dioxide by organisms may be measured at short intervals. In this apparatus air is caused to circulate through a tube containing the organisms and then into a tube containing an indicator, the color changes of which are compared with buffer solutions containing the same amount of indicator.

The purpose of the present article is to describe a modified apparatus devised by the writer.

The whole apparatus, with the exception of a short piece of rubber tubing, is made of glass. In order to prevent leakage the joints and glass stop-cocks are ground with special care.

Fig. 1 shows a sectional view of a portion of the apparatus. The tube O contains the organisms and the tube I contains an indicator. These tubes are connected to the apparatus by ground joints. When the stop-cock S is opened, and the stop-cocks S₁ and S₂ are closed, the air is allowed to pass from the tube O containing the organisms to the tube I containing the indicator. When S is closed and S₁ and S₂ are opened, the air passes from O to I through N which contains lumps of sodium hydroxide for the absorption of carbon dioxide. The ground joint J allows the apparatus to be disconnected.¹ The dotted

¹ Osterhout, W. J. V., J. Gen. Physiol., 1918–19, i, 17.
² A single three-way stop-cock may be used in place of S, S₁ and S₂ in order to avoid dead spaces.
³ The indicator tube and the inlet tube within it are made of Pyrex glass.
⁴ It may be desirable to make the entire apparatus of Pyrex glass in which case the ground joint J may be transferred to the right of S. This facilitates the substitution of tubes of various sizes in place of O.
lines at X and Y indicate two glass tubes running off at right angles and connecting (at the points marked X₁ and Y₁ in Fig. 1, B) with another tube, composed partly of glass and partly of rubber. The central portion of this tube (R, Fig. 1, B) consists of a piece of rubber tubing 2 mm. in thickness and 7 mm. in diameter (inside) which is joined to glass tubes at W and Z. The ends of the glass tubes are about 1 inch apart. In order to avoid leakage, the rubber tubing is compressed at intervals, forcing air through the valves V and V₁ and so maintaining a circulation throughout the apparatus.

Experiments are in progress with a view to replacing the rubber by other materials.

Fig. 1. (A) Apparatus for measuring the production of CO₂. Organisms are placed in the tube O and the CO₂ is carried over into the tube I which contains an indicator. The tube N contains NaOH for absorbing CO₂ when this becomes necessary.

(B) The rubber tube R is compressed at intervals, forcing air through the valves V and V₁ and so maintaining a circulation throughout the apparatus.
slipped over the glass for about 1 inch and cemented to the glass by soft de Khotinsky cement. V and V1 show the position of the valves, which allow the air to pass in one direction only (from Z to W). The valves are made of thin rubber sheeting attached to perforated rubber stoppers.

In order to produce a circulation of air the piece of rubber tubing is alternately compressed and released by means of the device shown in Fig. 2. The motor operates a cam the turning of which causes the two horizontal arms alternately to separate and to approach each other (they are held together by a vertical spring at the right of the cam5). Two projections at the ends of these arms are adjusted so as to compress the rubber tubing to the proper degree. The arms are made so that the height and the angle can be adjusted. The writer prefers a speed of 120 compressions per minute (the speed of the motor is reduced by gears).

5 A worm may be substituted for the cam if noiseless operation is desired.
The glass portion of the apparatus is rigidly fastened to the wooden frame by two screws. The wooden frame, however, is not fastened to the table but is allowed to move freely to compensate for the slight motion produced by the compression of the rubber tube; without this freedom of motion the connecting glass tubes might be broken.

When a constant temperature must be maintained it may be desirable to immerse the apparatus in water. The motor must then be adjusted so that the arms which compress the rubber tubing occupy a vertical position. The water should be contained in a suitable glass vessel so arranged that the changes in the color of the indicator may be readily observed. The buffer solutions must also be immersed and should be placed beside the tube which contains the indicator.