An Apparatus for Aerating Culture Solutions.

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A number of experiments on various phases of plant physiology, in each of which it was necessary to secure a constant stream of air continuing for several days, has led to the construction of a very efficient piece of apparatus for that purpose. The apparatus used by Prof. D. M. Mottier several years ago for aerating artificial cultures of algæ was modified by F. L. Pickett and used in a series of experiments on desiccation; and the writer has made some further changes in the construction of the apparatus shown in the figure and described below. This is now being used very successfully in the aeration of culture solutions.

The princple employed is that of the Sprengel mercury pump (water being used as a liquid in this case) by which bubbles of air are entangled in a stream of liquid which flows into a closed vessel. The only thing that remains to be done is to separate the air and the liquid, which are under slight pressure, and convey them from the reservoir by separate tubes.

The first problem is that of getting a stream of water that will flow uniformly. An attachment to a water pipe is usually sufficient for this. If this is not satisfactory, however, a siphon may be arranged to give a uniform flow. D, in the figure, is an ordinary battery jar provided with a siphon, B, which has an adjustable stopcock. A, which taps a water pipe and has an adjustable stopcock, supplies the jar with water a little faster than it is taken out by the siphon, B. Another siphon, C, removes the excess and keeps the water always at the same level, determined by its outer end, thus assuring an even flow, which should be just fast enough to cause the water to fall as a succession of drops.

The funnel, E, made by fitting a stopper into the end of a short piece of glass tubing about 1 cm. in diameter, has the end of the slender tube, F, extending 2 or 3 mm. above the cork. By means of this arrangement the water dropping into the funnel is caused to descend through the tube as a series of drops separated by spaces filled with air. Thus, if no escape is allowed, the reservoir, K, is filled with water and air under a pressure

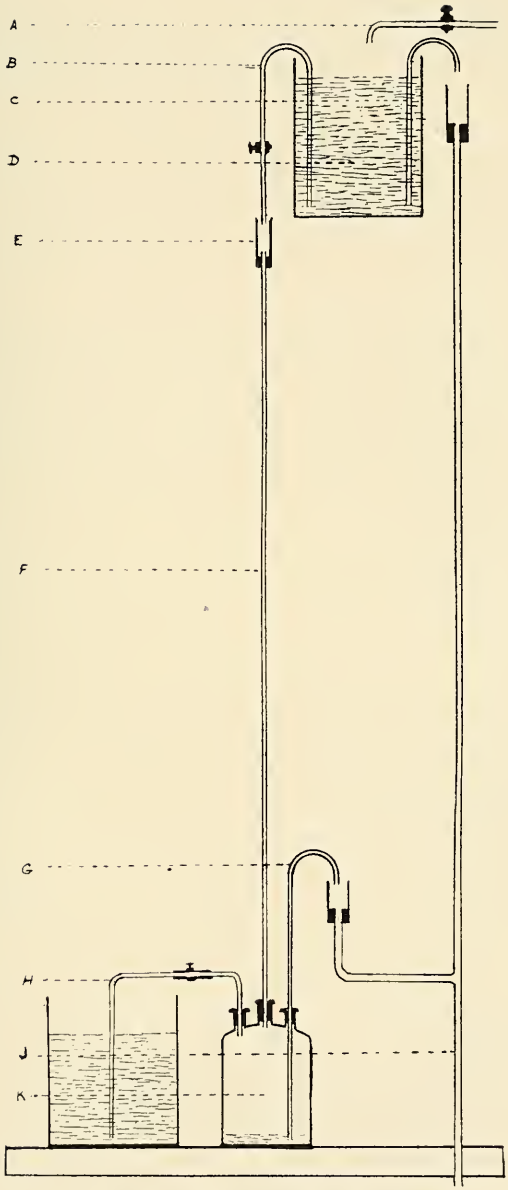
equal to that of the aggregate length of all the water drops in E at any one time. But the air escapes through H, under control of a pinchcock, and the water is forced out through G. The waste water escapes through J.

The flow of air through H must be so regulated that water is forced out through G just a little faster than it enters from F. This provides for an occasional release of surplus pressure by the escape of air through G and prevents the filling of K with water, as will be the case if the air is allowed to escape too fast through H. The only irregularity of flow is at the time of the release of pressure through G; but the air stream is seldom interrupted for more than a few seconds, and by careful adjustment the frequency of these interruptions may be reduced to a minimum. Perfect adjustment would entirely eliminate these irregularities by allowing the water to escape through G just as fast as it enters through F; but, perfection being impossible, it is better to have the interruption occur as an escape of air through G than of water through H.

Theoretically the pressure of the air issuing from H, and consequently the depth to which a solution can be aerated, is determined by the vertical distance from the level of the water in K to the outlet of G. In practice, however, the apparatus falls somewhat short of this, due to friction of the air through H and the capillarity of the liquid to be aerated. The density of the culture solution is, of course, a determining factor also.

The efficiency of the apparatus depends largely upon the nature of the tube F. If it is of too small bore, the friction is too great; and if it is too large, the water has a tendency merely to run down the inside surface and fails to carry any air with it. A very satisfactory size of tube is one having an internal diameter of 2 to 4 mm. If a larger quantity of air is needed at H, the pressure to remain the same, it is better to use two tubes for F than to try to increase the capacity by substituting one larger tube. If the pressure is to be increased and the amount of air to be delivered in a given time is to remain the same, G must be lengthened, and this may necessitate the lengthening of F also, for F will carry air only so long as the aggregate length of its water column is greater than that in G. In adjusting the apparatus, glass or metal stopcocks have been found more satisfactory where the flow of water is to be regulated, while pinchcocks on pieces of rubber tubing have been found best for regulating the stream of air.

When well adjusted and in good working condition the apparatus is economical. Tests on the one now in use have shown that it can be made



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to deliver 50. c. c. of air per minute at a depth of 15 cm. in a ½ per cent. Knops solution at the expense of 50 c. c. of water. At this rate less than 20 gallons of water per day would be used with the apparatus running continually.

The apparatus as now in use is designed for the aeration of water cultures, but its wide range of adjustment and its economy will permit its being used for many other purposes. Various devices may be attached at H for changes of temperature, humidity, or chemical nature of the air, provided that allowance be made for the increased pressure that may be necessary.

Where it is desired that the stream of air be carefully guarded from outside contamination, this apparatus is clearly the superior of any by means of which the air is drawn through tubes by an aspirator at the end, for it is a decided advantage in such cases to have the pressure, which determines the direction of any possible leakage, outward rather than inward.

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