AN EFFICIENT BOYLE'S-LAW APPARATUS.

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NOTHING is more discouraging to teacher or student than a piece of apparatus incapable of giving consistent and approximately accurate results. For this reason the ordinary U shaped tube, used for demonstrating the truth of Boyle's law, is one of the least satisfactory things the junior laboratory student has to work with. No matter how careful his measurements, irregularities in the bore of the tube, even where all other sources of appreciable error are avoided, will lead to irregular and unsatisfactory determinations.

The importance of apparatus capable of yielding good results, however elementary the experiments, is my excuse for offering the following description of a Boyle's law device which I have recently had constructed, and which, according to tests, readily gives values that do not differ from the correct ones by more than one part in a thousand.

Referring to the figure: *V* is a tube about twelve centimeters long and one centimeter in diameter having a two-way stop-cock at each end. *D* is a long tube of about the same diameter as *V* to avoid any appreciable difference in capillary action. *D* may be sealed to *V* or connected to it in any way desired—the figure shows the method I have adopted. In the event of any leakage the short rubber tube *R* may be made tight either by wrapping or by putting it on the glass tubes with shellac varnish. However I have not found either of these precautions necessary.

The stop-cocks, of course, must be air tight. An excellent lubri-

Fig. 1.

cant for them is paraffine, with just enough vaseline added to keep it from being brittle.

The operation is as follows: Close stop-cock B and fill D to any desired height with mercury, then open B and allow a small amount of mercury to run into V , then turn B till V and T are in communication. This lets the mercury out of V but leaves the tube through B that connects V and D entirely filled. Now close A and the volume of air in V is perfectly definite and at atmospheric pressure. Next turn B till V and D are again in communication. The mercury will now rise slowly in V and be free from all air bubbles. When the mercury has come to rest close B and read the difference in mercury levels in D and V , either with a cathetometer or with a meter bar placed between D and V . Now open A and B and run the mercury out T and weigh it. Obtain similar results for as many different heights as desired.

Lastly leave V open to E say and run mercury up V and into A , close B , open V to C , then run the mercury out T and weigh. This gives the weight of the mercury necessary to fill V absolutely.

Let W = weight of mercury required to fill V ,

" w = " " " run in when A is closed,

" p = difference in heights of mercury in D and V ,

" B = height of barometer at time of experiment,

" V = volume of tube V ,

" v = " " compressed gas in V .

$$\text{Then} \quad \frac{W}{W-w} = \frac{V}{v} = \frac{B+p}{B},$$

$$\text{and} \quad B = \frac{p(W-w)}{w}.$$

Of course B may be obtained directly from a barometer, or it can be determined to within a fraction of a millimeter by the method just shown, its value substituted in the equations, and Boyle's law tested.

This is one method, and occasion to use it might arise, of obtaining a fairly satisfactory barometric reading without the use of a standard barometer. I have described the apparatus as used for pressures above one atmosphere. It can be used, however, with

equal ease and accuracy for pressures less than atmospheric, but the operations are so obvious and simple that a description of them would be superfluous, except possibly the statement that it is necessary to determine the weight of the mercury required to fill the tube in *B* that connects *V* with *T*.

If the student has time he may simply assume that, at constant temperature, the volume of a gas is some fixed function of the pressure. His values will show him what this function is, determine the height of the barometer, and in every way give him a most satisfactory demonstration of the truth of Boyle's law.

It may be not out of place to say that in filling *D* it is advisable to introduce the mercury through a small funnel or thistle tube, with its stem drawn out to a fine opening. This prevents fouling the walls of the tube, the dirt being collected on the sides of the funnel.

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