Apparatus for Illustrating Boyle's Law.

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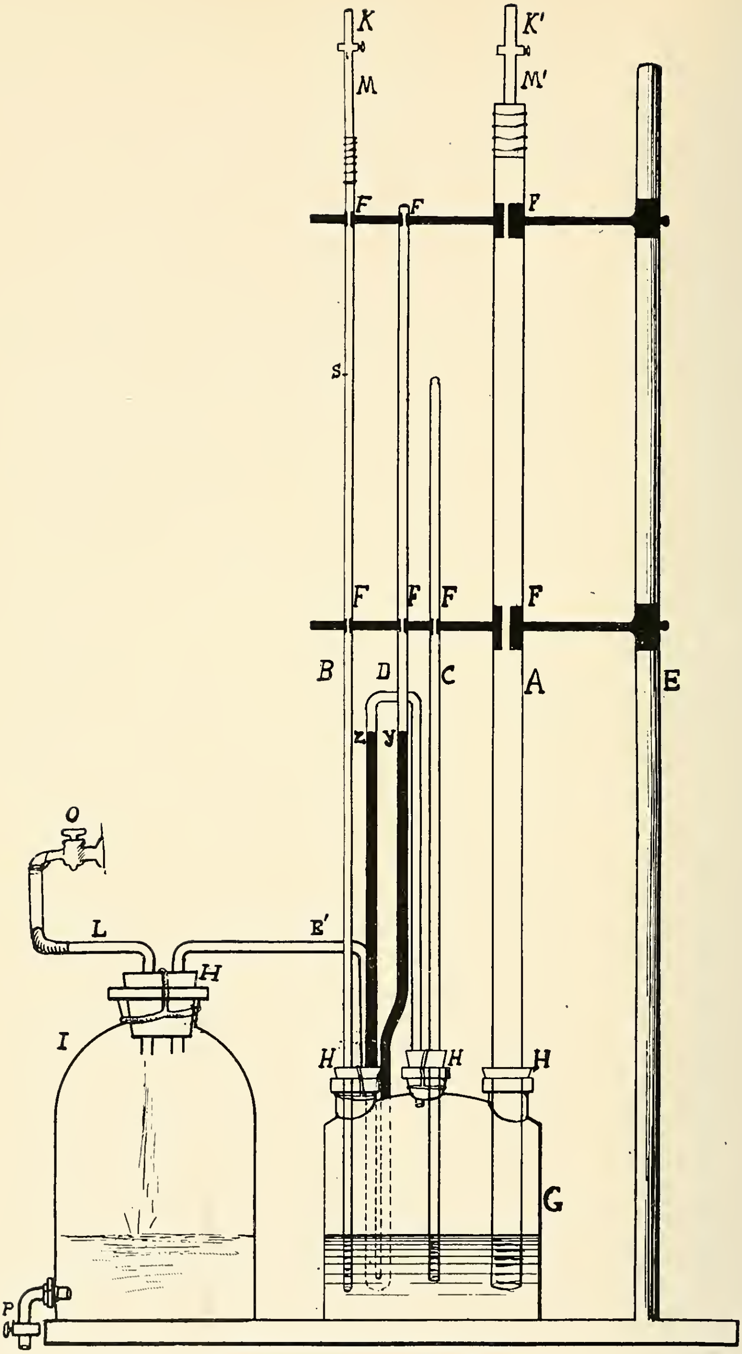
The apparatus shown in Figure 1 illustrates not only Boyle's or Mariotte's Law, but also a combination of attendant phenomena which I shall describe presently: Figure 1 is about one-fourth the true size of the apparatus. It consists of an ordinary iron ring-stand E, by means of which the various glass tubes A, B, C, and D, are held in the proper position by means of clamps at F. At the base is situated a Woulfe bottle G, with which A, B, C, D, and E′ communicate. The bottle G is about one-third filled with a concentrated aqueous solution of eosin. This solution is readily visible and on account of its intense red color is also seen at a considerable distance in the transparent glass tubes A, B, and C. Such an eosin solution has the additional advantage of being rather permanent in color, for in two years the solution I had used did not change perceptibly, and only a slight reddish brown precipitate was visible. It is also quite resistant in the presence of HCl, and even by the use of strong HCl a heavy precipitate results which is almost as red for a time as the original solution. The glass tubes A, B, and C extend below the surface of the eosin solution, while D merely projects through the rubber cork H. The connection of all the glass tubes A, B, C, D, E′, and L are made air-tight by means of the rubber corks H, and the latter are held firmly in place by copper wires to prevent their being blown out of the pressure generated in I and G. By means of the glass tube E′ the large glass bottle I is connected with G, and another glass tube connects I with the water-tap, air-pump or other contrivance for generating pressure. If the apparatus is connected as shown in the figure to water mains carrying a high pressure, and if then we open the valve O, the water will be forced into I. This will of course cause compression of the air in I, as well as pressure in proportion to the amount of water allowed to enter. Since G is connected with I by E′, the same pressure will be generated in G as in I. As A, B, and C project below the surface of the eosin solution, and if the valves K and K′ are closed and the water continues to enter I, in a few seconds the volume of air in the tube C, which is sealed at the top, will be compressed one-half its former volume by the eosin solution rising one-half the inside



Apparatus for Determining Boyle's Law.

length of the tube when the pressure in G equals one atmosphere. This illustrates Boyle's Law by showing that the volume of gas in C varied inversely as the pressure brought to bear upon it. The same principle would be shown in A and B under similar circumstances if K and K′ of the tubes M M′, which are fastened to A and B by means of rubber tubing held by copper fire and sealing-wax, remained closed.

Again, when the air in A, B, and C is compressed one-half its volume by a pressure of one atmosphere, this will be shown by the manometer which the tube D forms. This tube has each of its two arms filled to a height of forty centimeters with mercury. The total height of the two columns is therefore equivalent to more than an atmosphere. When the pressure in G is zero, then the two columns of mercury X and Y are equal in height. When, however, the pressure in G is equal to one atmosphere, then the column X will sink and column Y will rise till the difference of their heights is 76 cm. Since, in estimating accurately the height of a mercury column both pressure and temperature must be considered, this may be done by the usual formula.

When it is desired to again reduce the pressure in G to zero and allow the water in I to escape, this may be done by closing O, opening P, and either K or K′, or both. Unless I is interposed between O and G, water could not for obvious reasons be used. Air could, of course, be forced directly into G.

The apparatus can also be used to show that the height to which a liquid will rise in a tube is independent of its diameter. If we open O then, as mentioned above, the pressure developed in I and G will cause the eosin solution to rise with ease in A and B if K and K′ are left open. When the eosin solution has risen to S, or to any other height in B, whose internal diameter is three millimeters, then if we notice A, disregarding the small effect of capillarity in B, the column of liquid will stand at exactly the same height in A, whose internal diameter is one cm., as in B.

If, finally, both A and B are rapidly filled with the eosin solution by quickly and strongly generating pressure in G, then it will be seen by carefully timed observations that the liquid in A will rise to an equilibrium of the pressure in G somewhat more quickly than the same equilibrium will be attained by the liquid in B, due to the greater friction produced by the smaller tube B. For the same reason if the pressure is rapidly reduced to zero by opening P, the eosin solution in B will require a slightly longer time to fall from a polnt, as S, and reach the level of the liquid in G, than would be required by the same height of a column in A.

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