ART. XL.—*Note on the vapor-tension of Sulphuric Acid, with the description of an accurate Cathetometer Microscope*; by CHAS. A. PERKINS, Ph.D., Associate in Physics, Bryn Mawr College.

IN the physical laboratory it is frequently necessary to measure small differences in the height of two objects, such as two columns of liquid, etc., and especially to measure changes of height; and several forms of apparatus have been designed for this work. The cathetometer is accurate for this purpose only when provided with two telescopes and when the objects to be measured are in the same vertical line, and then is not readily used if the points are less than about 10^{cm} apart. Desiring to make some measurements of this nature, I made use of the following apparatus: A microscope of rather long focus is mounted upon a rigid vertical brass column and is carried by a vertical micrometer screw, reading to $\frac{1}{200}$ ^{mm}. Immediately in front of the object glass and covering one-half of it, is placed a small total reflecting prism, so adjusted that when the microscope is focussed upon one object, the prism throws into the field the image of an object vertically above or below the second, but on a level with the first. If the objects to be measured are situated upon the same level, they will thus be superimposed; if not at the same level, they will come successively to the center of the field, by moving the micrometer through the necessary distance. With this apparatus, measurements may be made in which the probable error of a single setting is considerably less than $\frac{1}{200}$ ^{mm} and in which the motion is a simple vertical one as if the two objects were in the same vertical line. The principal difficulty encountered is to bring both objects into focus at the center of the field. For this it is desirable to have one of the objects movable and to perform the adjustment by moving this object, but it is quite possible to make the adjustment when the objects are connected, as the two legs of a U-tube.

I have made use of this apparatus to measure the vapor tension of sulphuric acid. This liquid has some properties fitting it to be used in pressure gauges, either by itself or in connection with mercury.* I desired to use it for this purpose in a place where its vapor tension if appreciable would be injurious.

The only experiment, so far as I know, upon the vapor tension, was made under the direction of Sir Wm. Thomson,

* Callendar, On the practical measurement of Temperature. Phil. Trans., vol. clxxviii, p. 161; and Bottomley, On a practical Air Thermometer with constant volume, Phil. Mag., ser. V, vol. xxvi, p. 149.

and consisted in proving that the tension does not change much between 20° and 100° C.: the column of acid, by which the change of tension was measured, being 3^{mm} in diameter and terminated at one end by a vacuum and at the other by a bulb of gas which was kept as nearly as possible at the same temperature while the acid at the vacuum end of the tube was heated.*

My own plan originally was to take a U-tube, half filled with mercury, and after drying and exhausting the air from both legs, to observe the depression of mercury in one leg, when a drop of acid was introduced. In every case an elevation was observed, due to moisture leaking in through the cocks, or remaining on the glass and evaporating as exhaustion advanced; a form was therefore adopted which was free from

cocks and in which the mercury could be boiled to drive off all moisture. It consists of two barometers. One is an ordinary cistern barometer (I), the other is an inverted U-tube with mercury in both legs. One end (*b*) dips into the same vessel as the tube I, the other (*a*) is recurved to prevent the admission of air, but allowing the acid to be introduced by a curved pipette or medicine dropper. The height of the column (*b*) in U is compared with that in I, before and after admitting acid into U through *a*. The internal diameter of the tubes is about 0.8^{cm} . In filling the U-tube, it is exhausted by a Sprengel pump and heated strongly. When cool, a

little mercury is introduced and boiled and this operation is repeated till the tube is full. Unless this precaution is taken, the acid in rising through the tube, carries up air, which causes a depression of the mercury.

The acid was purchased of Queen & Co. as pure concentrated acid, but not absolutely anhydrous.

In making the measurements from three to five readings were made of the position of the meniscus in U and the same number for I: then acid was introduced into the other leg of U and the readings were repeated in the same order. The mercury column is illuminated from behind and a ring of black paper, sliding on the tube, is adjusted as near as possible to the top of the meniscus, allowing only a thread of light to pass over the top of the column. Unless this is done, reflections will make the top of the column uncertain. Where it is possible, the method of using the image of a black point and

* Encyc. Brit., 9th ed., Article "Heat."

its reflection, as done at Breteuil, leaves nothing to be desired ; but I could not work with large enough tubes, and errors of setting were not my principal errors.

Measured in this way, my three best measurements gave for the vapor tension :

Difference of U and I in 200ths ^{mm} .		Difference in ^{mm} .
Before admitting acid.	After.	
31	33	+·01
9	11	+·01
—12	—13	—·005

This result is considered to be purely negative, as errors due to the change of the height of the barometer during the experiment and those introduced by irregularities in the capillarity of the mercury (in spite of shaking the tube) would be sufficient to account for the measured tension. A larger tube would have avoided some of the trouble, but would have increased very much the labor of manipulation.

In several other experiments, attention was carefully fixed upon the top of the mercury column in the tube *b* just as the acid rose through the other tube (*a*), in order to observe any instantaneous movement of the column. The movement, if any, was very slight—certainly not in excess of the above measurements. I therefore conclude that the tension is not greater than about ·01^{mm}.