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A Lecture Demonstration Apparatus for Determining the Vapor Pressure of Water

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A LECTURE DEMONSTRATION APPARATUS FOR DETERMINING THE VAPOR PRESSURE OF WATER

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The author has devised this apparatus to show to his classes an experiment in which the vapor pressure of water is determined at temperatures from room temperature up to nearly the boiling point of water. At the right of Fig. 1 is the compact stand holding four barometric tubes. This apparatus is portable and easily carried from the storage cupboard to the lecture table. In addition to being used for this specific experiment, it is also used to demonstrate that it is air that holds up the column of mercury in a barometer. This is easily shown by means of the barometer on the left of the stand. The lower end of this barometer is immersed in mercury enclosed in an eight-ounce bottle from which the air may be removed by means of a water or vacuum pump. The second barometric tube from the left is a standard barometer. The third tube is used to show the vapor pressure of hydrated copper sulfate. It contains a small crystal of hydrated or partially dehydrated copper sulfate on the surface of the mercury. The tube on the right is the one used for this demonstration of the vapor pressure of water. It is enclosed in a water jacket except at the lower end. This tube contains a small drop of water on the surface of the mercury and the space above the mercury therefore contains saturated water vapor.

As the experiment is carried out in class a student is asked to read the level of the mercury by means of the standard meter stick mounted on the stand beside the barometer. At the same time the instructor reads the temperature of the water in the jacket surrounding the barometric tube. There is a thermometer immersed in the water at the top of the jacket. Water is pumped through this jacket by means of a circulating pump, electrically driven. The pump is immersed in water contained in an ordinary pneumatic trough and the water is pumped through rubber connecting tubes into the lower side-arm of the jacket and returned to the trough from the side-arm near the top.

The water in the trough is heated by means of three Bunsen burners. The first reading of the mercury level is taken at the temperature of the unheated water and then readings are taken as the water is heated. It has been found easier to take readings with every rise of two degrees in the temperature of the water, except near the end of the experiment, when readings may be taken at more frequent intervals. The instructor has the measurements recorded on the blackboard as they are read off, and the students copy the data into their notebooks. The pressure of the air is determined at the beginning of the experiment by means of a standard barometer and recorded in

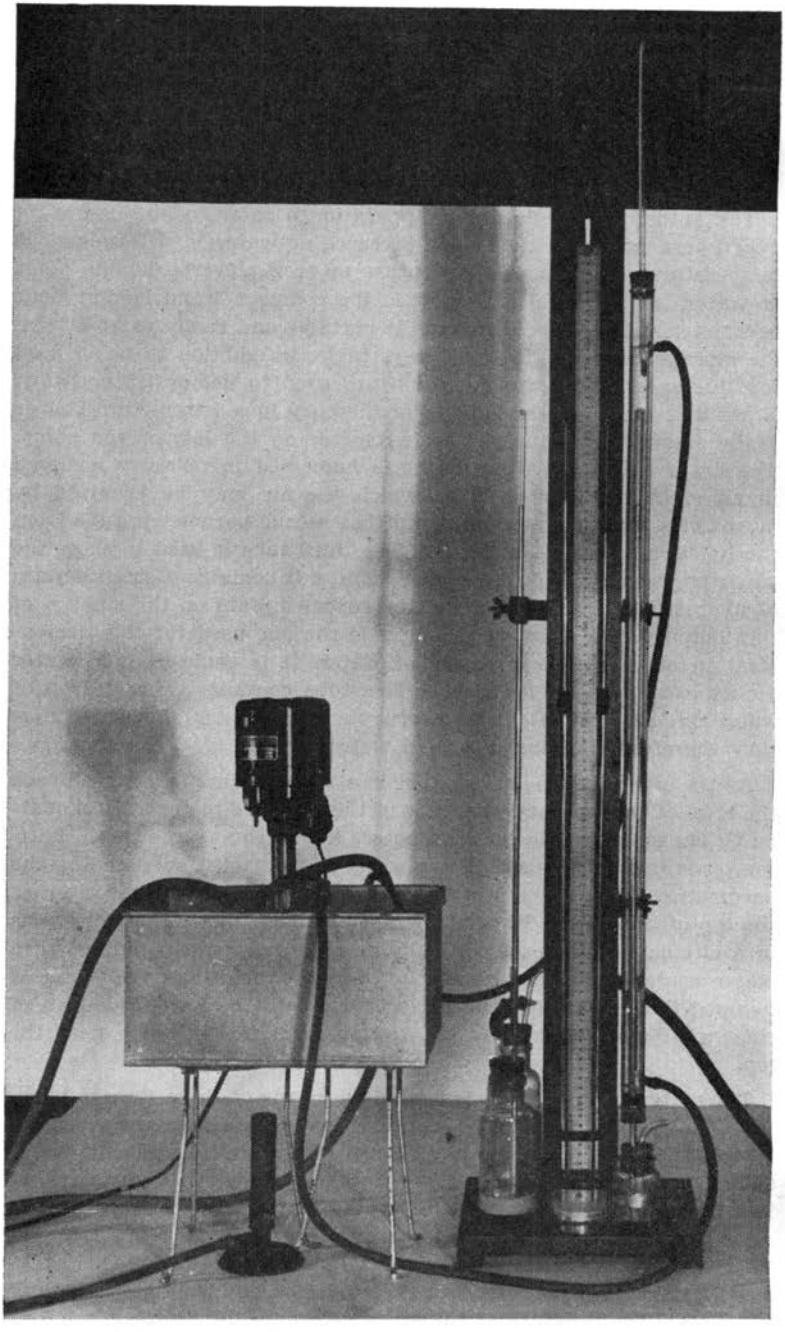

Fig. 1. The pump used by us is a moderate priced pump obtained from Arthur LaPine & Co. of Chicago, Ill. We have found it very satisfactory and useful for many other purposes. Until this pump became available recently, we used a Ford water pump obtained from a used-parts man and for a motor a second-hand washing machine motor. This was a very cumbersome piece of apparatus compared with this small lightweight pump and motor.

millimeters of mercury on the board. The vapor pressure of the water at the different temperatures is then obtained by subtracting the reading of the mercury level from the reading of the standard barometer.

The pressure of the saturated water vapor increases with rise of the temperature; hence, as the temperature of the water circulating in the jacket rises, the level of the mercury falls. This is clearly seen by the students. The data in Fig 2 was collected in a class demonstration. Figure 2 shows the vapor pressure curve for water plotted from the data shown on page 262.

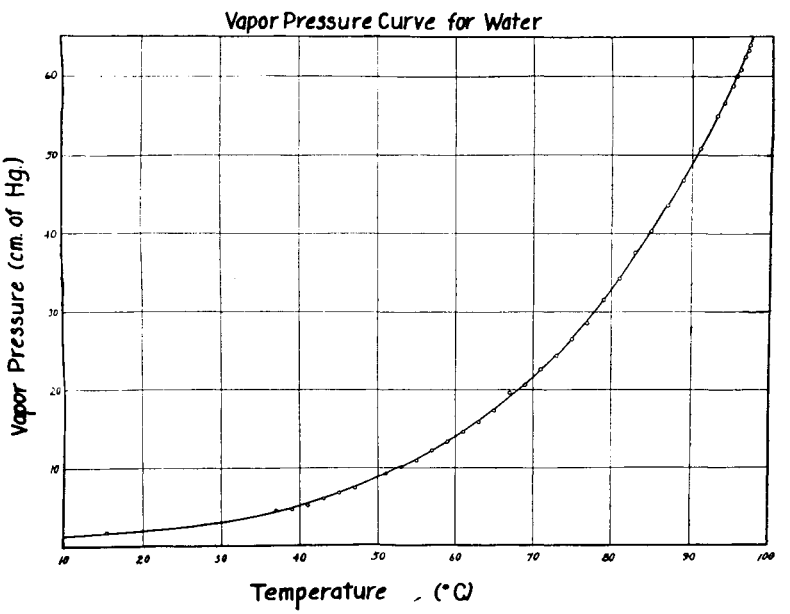

Figure 2.

The students are asked to present a written report of this experiment at the next class meeting. They are expected to make a sketch of the apparatus used, label each part of the apparatus and explain the use of each part. They are also asked to use the data collected to make a vapor pressure curve for water as in Fig. 2 and to submit this curve and the data from which it was obtained as a part of the written report.

It should be stated that it is not possible to carry the experiment above 97.1 degrees because above this temperature the mercury falls below the water jacket. Three Bunsen burners are used to heat the water so that the experiment can be completed in forty minutes or less. This allows time at the beginning of the hour for a discussion of the experiment, method of collecting data, etc. It is admitted that there are inaccuracies in the results because of the higher level of

the mercury in the well at the end of the experiment than at the beginning, and because of the mercury itself being heated to different temperatures. However, it is believed that, since the results when plotted approximate closely the vapor pressure curve for water, the experiment is worthwhile. The students see the level of the mercury fall as the temperature rises; they observe the collecting of the data. Finally, by themselves plotting the data, they learn how the vapor pressure curve for water may be obtained.

Temperature (Degrees Centigrade)	Vapor Pressure (in mm. of Hg.)
20.5	18.8
37	45
39	47
41	51
43	61
45	68
47	75
49	82
51	92
53	100
55	109
57	121
59	133
61	146
63	159
65	173
67	198
69	207
71	226
73	244
75	265
77	287
79	317
81	343
83	376
85	403
87	436
89	468
91	509
93	550
94	567
95	588
95.5	600
96	609
96.5	625
97	634
97.1	639

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