DETERMINATION OF THE VAPOR PRESSURE OF MERCURY BY MEANS OF THE KNUDSEN PRESSURE GAUGE

PROF. C. F. HILL, UNIVERSITY OF ILLINOIS

While engaged in experimental work in the spring of 1920, the question arose as to the pressure of saturated mercury vapor. Upon looking in the tables for the values at temperatures ranging from 0° to 20°C., it was noticed that there is little or no agreement between different observers. Data for but three direct methods was found listed at the above temperatures. An accurate knowledge of the vapor pressure of mercury is important in vacuum work since mercury is almost always involved in the vacuum in some way, either in gauges or pumps. Due to this fact, and to the lack of agreement of former observers, and also to the small amount of data really taken before, it was decided to try to devise a more dependable method. To this end a Knudsen pressure gauge was used. This instrument is independent of the gas used and gives accurate readings on pressures of the order of those of mercury vapor at ordinary working temperatures. The calibration of the instrument was accomplished by connecting the apparatus as shown in the Fig. 1. All vapors were removed from the Knudsen gauge side and kept out by

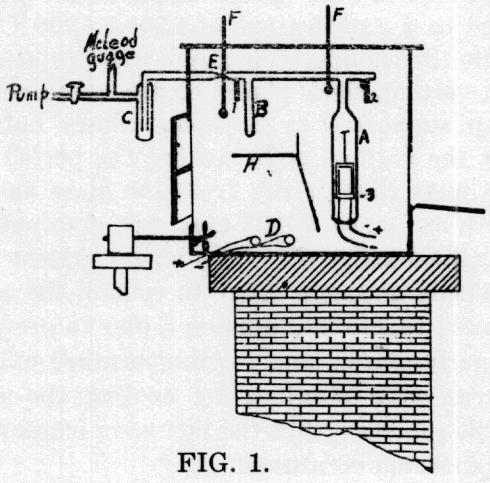

FIG. 1.

means of a liquid air trap. The pressure was then varied in the apparatus and simultaneous readings were taken on a standard McLeod gauge and the Knudsen gauge. A calibration curve was drawn on a large scale from the data thus obtained. This is made possible since the deflection at zero pressure is zero, and the origin thus became an accurate point of the curve. Mercury vapor of course still existed in the McLeod gauge; this, however, had no effect since this instrument does not read small vapor pressures. The Knudsen gauge consists of a platinum strip rigidly mounted within the bulb of the gauge and it is heated by means of an electric current. A light vane is freely suspended in front of the platinum strip. The bombardment of the molecules thrown off from the hot foil causes the vane to turn. The instrument may be used for pressures where the mean free path of the molecules is greater than the distance between the vane and foil. Since this condition obtains only when the vacuum is high, it follows that the Knudsen gauge is therefore adapted for the measurement of exceedingly high vacua only. It has been used in measuring pressures as low as 10-8 mm. of mercury.

Having calibrated the gauge the mercury sample was introduced into the container, B, and purified by repeated distillations in the vacuum. Later on one sample was also treated with nitric acid before being used. The tube was then heated to a temperature of 250° to 300°C for several hours, while the sample of mercury was protected by warm water in a vacuum flask placed on the container. A Langmuir pump supported by a Gaede rotary outfit kept the vacuum at the highest point during the period of heating. All vapors were thus driven from the glass and a residual air pressure as low as .00002 mm. was obtained. The tube was then sealed off at E. The whole system was rigidly fastened within a box in order to control the temperature, and the box in turn was placed on a pier to prevent jarring. A fan properly placed kept the temperature uniform. Low temperatures were obtained by cooling the room, while heating coils placed within the box were employed in maintaining higher temperatures.

After allowing the system to reach a constant temperature for a time, the deflection of the gauge was taken and the total pressure read from the calibration curves. The mercury vapor was then driven into the sample container and held there by liquid air, after which the residual gas pressure was measured as above. The difference of the two readings gave the vapor pressure of mercury at that temperature. Four separate sets of readings were taken, using nineteen temperatures ranging between—7° and 34.9°C. All of the values are within about 6% of a mean curve, which is estimated as the accuracy that is attainable by this method. (See Fig. 2.)

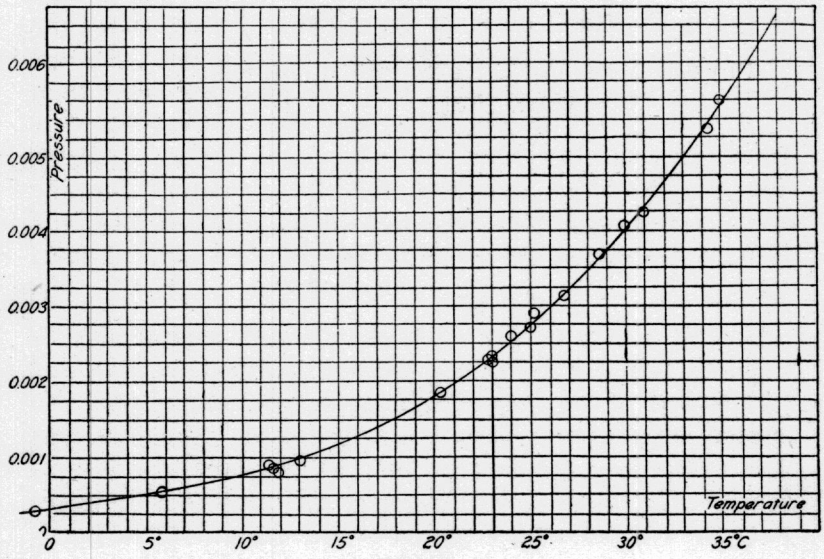

FIG 2.

The data obtained agrees fairly well with that of Morley, van der Plaatz, and with the extrapolated values from higher temperatures by Ramsey and Young. The percent variation in the actual readings is much less in the present method. Measurements by Knudsen, in 1909, give results only 1/3 to 1/2 of those of the three methods mentioned above. His method, however, would be expected to give values too low, and it is not probable that either of the above methods would be in error as much as Knudsen's results indicate. A detailed study of all of the methods seems

to indicate that the value of the vapor pressure of mercury over a range in temperature from 0° to 40°C is near that of the results given by Morley, van der Plaatz, and by the present method, and from the standpoint of accuracy of observations, the present values obtained by the present method should be the more accurate.

The mean values of mercury vapor pressure as read from the mean curve at 10° intervals are:

0°	.00035 mm.
10°	.000775
20°	.00182
30°	.00407
40°	.008

Physics Laboratory, University of Illinois
April, 1921.