[CONTRIBUTION FROM THE CRYOGENIC LABORATORY, BUREAU OF MINES, UNITED STATES DEPARTMENT OF COMMERCE]

HIGH VAPOR PRESSURES OF NITROGEN[1]

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The vapor pressures of nitrogen up to about one atmosphere have been measured by Wroblewski,[2] Baly,[3] Fisher and Alt,[4] Holst and Hamburger,[5] Cath[6] and von Siemens.[7] The data of von Siemens when corrected to the Leiden scale by Holst[8] agreed very well with those of Cath.

The higher vapor pressures have been measured by Olzewski[9] and Crommelin.[10] Olzewski used atmospheric nitrogen and the work was of a low accuracy. Crommelin's work was open to question for several reasons. He used boiling liquids as a cryostat without protecting the stem of the vapor-pressure bulb where it passes through the surface of the liquid. Unless the stirring is extremely vigorous, experience has shown that the bath may be considerably colder at the surface and the pressure correspondingly low. Furthermore, at the point 1.4727 atmospheres reported by Cormmelin, the temperature given is almost half a degree from the results obtained by Cath and von Siemens.

While Crommelin later states that this point is considerably less accurate than the others, the circumstance shows that there was probably some factor such as that already mentioned which disturbed the accuracy of the measurements. The measurement of the vapor pressure of nitrogen over this range, therefore, was considered to be worth while.

Apparatus and Material

The platinum-resistance thermometer and the cryostat used have already been described in reports from this Laboratory.[11,12] It was found convenient to use methane condensed from natural gas as a bath liquid for the lower temperatures. The pressures were measured with a deadweight gage of the type used by Keyes.[13]

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[2] Wroblewski, *Wied. Ann.*, **25**, 371 (1885).

[3] Baly, *Phil. Mag.*, [5] **49**, 517 (1900).

[4] Fisher and Alt, *Ann. Physik*, **9**, 1149 (1902).

[5] Holst and Hamburger, *Z. physik. Chem.*, **91**, 513 (1916).

[6] Cath, *Verslag Akad. Wetenschappen Amsterdam*, **27**, 553 (1918).

[7] von Siemens, *Ann. Physik*, **42**, 871 (1913).

[8] Holst, *Proc. Akad. Wetenschappen Amsterdam*, **18**, 839 (1916).

[9] Olzewski, *Compt. rend.*, **99**, 133 (1884).

[10] Crommelin, *Verslag Akad. Wetenschappen Amsterdam*, **23**, 991 (1914).

[11] Walters and Loomis, THIS JOURNAL, **47**, 2302 (1925).

[12] Loomis and Walters, *ibid.*, **47**, 2851 (1925).

[13] Keyes and Brownlee, *ibid.*, **40**, 25 (1918).

The nitrogen was generated from ammonium hydroxide and bromine water.[14] It was purified by standing over sodium hydroxide solution, passing through a trap cooled with liquid air, then over phosphorus and finally over phosphorus pentoxide. Three different samples were used, generated at different times. The third sample was further purified by a fractional distillation, but the vapor pressures agree very satisfactorily with the first two samples, showing that this method gives very pure nitrogen.

Table I gives the results, which are found to be fairly well represented by the equation $\log_{10} P = —302.34/T + 3.94127 - 0.000274T + 1.116 \times 10^{-6} (T - 100.5)^3$, in which the pressure is expressed in normal atmospheres. When extrapolated to low pressures this equation agrees fairly well with the data of von Siemens.

Table I

Vapor Pressures of Nitrogen

Temp., °K.	90.12	92.73	95.44	96.00	98.64	104.46
$P_{\text{obs.}}$, atm.	3.631	4.520	5.583	5.820	7.056	10.440
$P_{\text{obs.}} - P_{\text{calcd.}}$	—0.003	—0.003	0.000	—0.005	—0.006	—0.007

Temp., °K.	106.97	108.76	113.60	116.18	118.94	121.47
$P_{\text{obs.}}$, atm.	12.193	13.594	17.85	20.47	23.57	26.75
$P_{\text{obs.}} - P_{\text{calcd.}}$	—0.009	0.035	—0.05	0.00	—0.06	—0.05

Summary

The vapor pressure of nitrogen has been determined in the range from 90.12°K. (3.631 atm.) to 121.47°K. (26.75 atm.). The results are represented fairly well by the equation $\log_{10} P = —302.34/T + 3.94127 - 0.00274T + 1.116 \times 10^{-6} (T - 100.5)^3$.

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[Contribution from the Chemical Laboratory of the University of California]

THE CATALYTIC OXIDATION OF CARBON MONOXIDE
III. CATALYTIC EFFICIENCY OF MIXTURES OF DRY MANGANESE DIOXIDE AND CUPRIC OXIDE

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The mixtures of manganese dioxide and copper oxide considered in the first papers of this series[1] were prepared by kneading together measured quantities of the wet hydrated oxides. A "related series of catalysts" consisted of four mixtures and samples of the single oxides from which these mixtures had been made, all of which had been slowly dried and partially dehydrated, and were in the form of porous granules. In the dis-

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[14] Waran, *Phil. Mag.*, [6] **42**, 246 (1921).

[1] (a) Almquist and Bray, This Journal, **45**, 235 (1923) (on p. 2317, three lines from the bottom of the page, for "Catalyst 2" read "Catalyst 3"). (b) Hoskins and Bray, *ibid.*, **48**, 1454 (1926). References to the work of Frazer and his associates, and of other investigators, are given in these papers.