THE DIELECTRIC CONSTANT OF COMMERCIAL NITROGEN AT HIGH PRESSURES

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Abstract

The dielectric constant of commercial nitrogen, 99 percent pure, was measured at pressures up to 167 atmospheres by the same electrometric method previously employed by the writer in the determination of K for air. $(K-1)$ was again found to vary directly with the pressure, at the rate of 556×10^{-6} per atmosphere at 16.5°C, with the exception of an apparent slight deviation from linearity in the sense of a smaller rate of increase of K with P at pressures above 150 atmospheres. The greatest departure from linearity was only of the order of the probable error, however, and is not considered to be definitely established.

THE values of the dielectric constant of nitrogen herein presented were obtained from data secured during an investigation of the residual ionization in the gas at high pressures. The method of measurement was precisely the same as that described in detail in a paper[1] dealing with the dielectric constant of air at high pressures.

It was mentioned in the report[2] of the residual ionization measurements that the nitrogen was only slightly more than 99 percent pure. An impurity of only 0.2 percent of argon and oxygen had been claimed by the company manufacturing the nitrogen. Local analysis of the gas actually used showed 0.72 ± 0.02 percent oxygen, however, with no carbon dioxide or water vapor, no test for argon being made. Subsequent analysis of some of the unused nitrogen by the commercial concern showed the greater impurity.

Because the temperature varied between 15.35°C and 17.5°C during the measurements, the observed pressures were reduced to corresponding pressures at 16.5°C rather than 18°C as in the case of the air measurements, and these reduced pressures are shown plotted against the resistance ratios in Fig. 1.

In the case of air the resistance ratio and hence the dielectric constant was found to vary linearly with the pressure over the entire range of the observations. In the case of nitrogen the linear relation is again observed at all pressures below 150 atmospheres. At higher pressures, however, there is an apparent slight deviation from the linear relation in the direction to be expected on the basis of the departure from Boyle's law in that region. According to the experimental curve the dielectric constant of the commercial nitrogen is 1.000556+ at 1 atmosphere and 16.5°C, increasing at the rate of 556×10^{-6} per atmosphere up to 150 atmospheres, above which the pressure-rate of increase is slightly less. The experimental curve gives the value of $K=1.0920$ at 167 atmospheres, whereas if the straight line were continued the value 1.0929 would be obtained.

[1] J. W. Broxon, Phys. Rev. **37**, 1338 (1931).
[2] J. W. Broxon, Phys. Rev. **38**, 1704 (1931).

In view of the discussion of the accuracy of the measurements included in the earlier paper it would seem that the deviation observed in the present instance, amounting to about one percent of $(K-1)$ at 167 atmospheres, may extend only to the neighborhood of the limit of the experimental accuracy. Consequently, there is some doubt relative to the reality of the curvature at the high pressure end of the curve. It is regretted that an entirely independent series of observations extending to higher pressures was not immediately feasible.[3] However, the readings are well distributed over the range of the observations and the linear relation between dielectric constant and pressure in the region below 150 atmospheres is clearly designated.

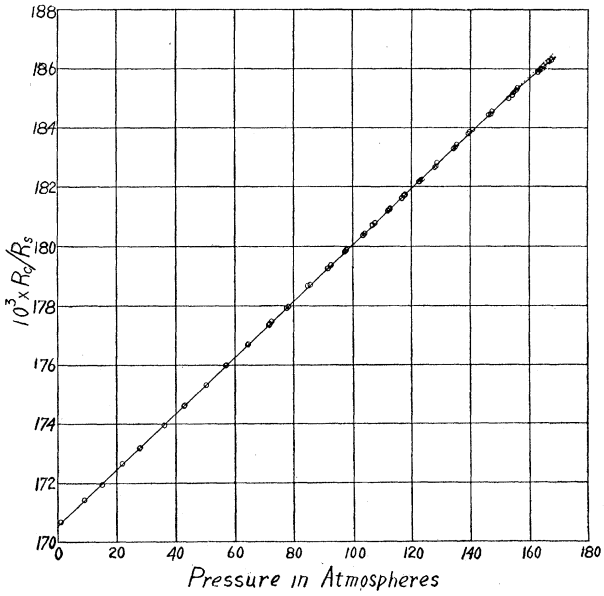

Fig. 1. Resistance ratio for nitrogen.

The relation of these observations to those of other investigators is about the same as in the case of air. Tangl[4] found the Clausius-Mossotti relation to hold for nitrogen at pressures up to 100 atmospheres, while Bodareu[5] arrived at a similar conclusion for the region between 87 and 226 atmospheres. At N.T.P., Tangl found $K=1.000581$ while Bodareu's value, obtained by extrapolation, was 1.000587. If the constancy of $(K-1)/P$ and of P/T is assumed for the region between 0°C and 16.5°C, the corresponding value yielded by the present investigation is 1.000590 for the commercial nitrogen used.

[3] Further work on the dielectric constants of gases at high pressures, including the application of high frequency methods, is in progress.

[4] K. Tangl, Ann. d. Physik **26,** 59 (1908).

[5] E. Bodareu, Accad. Lincei, Atti **22,** 480 (1913). Only an abstract of this paper was available.