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INDEX AND DISPERSION OF SOME
CERENKOV COUNTER GASES

by

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ABSTRACT

The index of refraction, n , and dispersion of several Cerenkov counter gases has been precisely measured by the interferometric method. The precision is typically four parts in $(n-1) \times 10^5$.

The gases investigated include Freon 12 (CCl_2F_2); Freon 13 (CClF_3); Freon 13B1 (CBrF_3); Freon 22 (CHClF_2); Freon 116 ($\text{CF}_3\text{-CF}_3$); Freon 218 (Perfluoropropane); Perfluorobutane (C_4H_{10}), as well as nitrogen, carbon dioxide, and dry air. Measurements of n were made at 5460 Å, 4360 Å, 4050 Å, 3650 Å and 3125 Å. For Freon 13 and carbon dioxide the measurements were carried to pressures near the critical point.

The indices of refraction and dispersions of several gases (some "Freon" compounds, nitrogen, carbon dioxide and dry air) suitable for use in Cerenkov counters have been determined. Measurements of a limited range were made earlier here¹ and elsewhere.²

The present results for the Freons are over the range from $n = 1.000$ to $n = 1.058$, which corresponds to a lower limit of $\beta = 0.9487$ at a Cerenkov angle of 5° .

The interferometer consisted of two parallel quartz plates separated by a nominal 30 mm and illuminated by a Hg^{198} bulb. Interference filters were used to isolate the desired wavelengths.

Counting was accomplished by a photomultiplier that detected variations in the fringe pattern and a scaler indicating the counts.

The procedure for counting was to evacuate the vessel to a pressure of 5μ and refill with the desired gas, allowing sufficient time for temperature stabilization. Gas was then slowly bled from the system while the

¹E. R. Hayes et al. Index of Refraction and Dispersion of Freon 13 and Other Gases as Functions of Pressure, High Energy Physics Division, Argonne National Laboratory (Sept 1963).

²W. Galbraith, G. Manning and A. G. Parham, Refractive Index Measurements in a Gas Cerenkov Counter, AERE-R 3867.

pressure was read from a "Heise" 0-1000 psia gage with a precision of $\pm 1/2^\circ$ psi at any pressure. Temperature was measured with a potentiometer, by means of a copper-constantan junction located inside the test vessel.

No comparison of the molecular refractivities as calculated from the Lorentz-Lorenz law with the summed atomic refractivities was made due to lack of precise pressure-density information near the critical points. Such a comparison was made previously¹ and found in good agreement at lower pressures.

The interferometer ^{calibration was verified} ~~was calibrated~~ by comparing the measured index of refraction of nitrogen with the values reported by Bennett.³ The results agree within the precision range of the Heise gage, as shown by Table I.

Table I

INDEX OF REFRACTION OF
NITROGEN AT 5460 Å

Pressure, psia	(n-1) x 10 ⁵	
	Measured	C. F. Bennett
20	38.3	37.3
40	77.5	76.6
100	187	188

Experimental errors resulting from the counting of whole fringes, as well as from temperature and pressure measurements, are estimated to be four parts in (n-1) x 10⁵.

The minimum purity of the gases is quoted from the Matheson Catalog as: Freon 13 - 99.0%; Freon 13B1 - 99.0%; Freon 12 - 99.0%; Freon 22 - 99.9%; CO₂ - 99.5%; N₂ - 99.7%.

A list of the measurements is given in Table II, and individual curves follow. Graphs of the indices of refraction in 11 x 17-in. size are available upon request.

³ C. F. Bennett, Dispersion and Refractive Index of Nitrogen Measured as Functions of Pressure by Displacement Interferometry, Phys. Rev., 37, 263 (1931).

Table II
LIST OF REFRACTIVE INDEX MEASUREMENTS

		Range of Measurements	Critical Pressure and Temperature
I.	Air λ - 5460 Å 3125 Å	pressure = 0-1000 psia temp = 26°C	
II.	Nitrogen λ - 5460 Å 3125 Å	pressure = 0-1000 psia temp = 24°C	
III.	Carbon Dioxide (CO ₂) λ - 5460 Å 4360 Å 4050 Å 3125 Å	pressure = 0-1000 psia temp = 30°C	1072 psia, 31°C
IV.✓	Freon 12 (CCl ₂ F ₂) λ - 5460 Å 4360 Å 4050 Å 3650 Å 3125 Å	pressure = 0-88 psia temp = 26°C	596.9 psia, 112°C
V.✓	Freon 13 (CClF ₃) λ - 5460 Å 4360 Å 4050 Å 3650 Å 3125 Å	pressure = 0-510 psia temp = 27.1°C	561 psia, 28.9°C
VI.	Freon 13B1 (CBrF ₃) M, 3.125 λ - 5460 Å 4360 Å 3650 Å 3125 Å	pressure = 0-160 psia temp = 26°C	575 psia, 67°C
VII.✓	Freon 22 (CHClF ₂) λ - 5460 Å 4360 Å	pressure = 0-140 psia temp = 26°C	716 psia, 96°C
VIII.	Freon 116 (CF ₃ -CF ₃) λ - 5460 Å 4360 Å 3650 Å 3125 Å	pressure = 0-200 psia temp = 26°C	480 psia, 24.3°C
IX.	Freon 218 (Perfluoropropane) λ - 5460 Å 4360 Å 3650 Å 3125 Å	pressure = 0-90 psia temp = 26°C	390 psia, 71.9°C
X.	Perfluorobutane (C ₄ H ₁₀) λ - 5460 Å 3650 Å 3125 Å	pressure = 0-30 psia temp = 26°C	336 psia, 113.2°C