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Precise Measurements of Dispersion in Nitrogen

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A new and much improved displacement interferometer has been built after the general plan of the one previously described to measure simultaneously refractive index and dispersion constants for a gas over a range of pressures above atmospheric. It is constructed as a single unit on a steel I-beam framework 10 feet long and 2 feet wide. The whole apparatus is supported on automobile inner tubes which very effectively eliminate vibration. The features also include a G.E. S-1 sunlamp light source, aluminum mirrors, a carefully calibrated micrometer screw of high quality and an improved temperature control.

Observations made on nitrogen at four wave-lengths, 5780A, 5461A, 4359A and 4047A, corresponding to pressure runs up to 14 atmospheres measured by a Keyes dead-weight gauge, at temperatures of 50°C, 30°C and 0°C, give readings that are linear with pressure to such a degree that the Cauchy dispersion constants can be expressed to four significant figures. The results for N.T.P. conditions are: $A_0-1=0.0002932$ and $B_0=1.637\times10^{-14}$. Since A_0-1 is the extrapolated infinite wave-length refractive index, a dielectric constant $\epsilon=1.0005864$ is thus predicted. This agrees with published determinations. The refractive index at any wave-length can be computed from these results and values so calculated are found to agree with values found by other methods, which are not suitable for direct extrapolation to infinite wave-length and which are not likely to be so accurate.

INTRODUCTION

In a previous paper[1] a method was presented for measuring the refractive index and dispersion constants for a gas over a range of pressures above atmospheric by displacement interferometry. Since that time many changes have been made in the experimental procedure which have finally resulted in the construction of an entirely new apparatus. The essential features of this new interferometer are much like those of the former one but improvements have been made in practically every important detail. Better methods have also been employed in the control and measurement of the temperature and pressure, as well as in the purification of the gas under observation. These latter changes alone have made possible a considerable extension in the range of pressures that can be used. Moreover, the manner of reducing the observations has been somewhat modified so that the results take on added significance. As a consequence of all these improvements, experimental results are obtained which are not only remarkably self-consistent and therefore precise in a relative way but also precise in an absolute sense.

[1] C. E. Bennett, Phys. Rev. **37**, 263 (1931).

THEORY

The general arrangement of the mirrors and miscellaneous optical apparatus included in the set-up of the displacement interferometer as well as the manner in which the interference pattern is established has been adequately discussed.[1] It will suffice to recall here that with this arrangement one deals with the displacements of an unsymmetrical oval dark-fringe interference pattern across a continuous spectrum in which certain wave-lengths are indicated by superposed bright or dark spectral lines, depending upon the nature of the light source used. Theory developed in the former paper[1] shows that so far as displacements of the central spot of the interference pattern are concerned,

$$\mu-1=\Delta x/e+\lambda\partial\mu/\partial\lambda, \quad (1)$$

where μ is the refractive index of any transparent substance of length e which, upon being introduced into one path of the interferometer to replace a vacuum path of the same length, produces a shift of the central fringe which requires a displacement of the movable mirror of the instrument equal to Δx to restore the fringe pattern to its original position in the spectrum.

Eq. (1) shows that the displacement is not only a function of the refractive index and path length of the substance in question but also depends upon the manner in which the refractive index changes with wave-length. By assuming a Cauchy dispersion relation

$$\mu = A + B/\lambda^2 + C/\lambda^4 + \cdots, \qquad (2)$$

from which $\partial\mu/\partial\lambda$ can be calculated, one gets by substitution in Eq. (1) the following result:

$$\Delta x/e = (A-1) + 3B/\lambda^2 + 5C/\lambda^4 + \cdots. \qquad (3)$$

Here A is of course the value of μ corresponding to infinite wave-length, a quantity which takes on physical significance as the square root of the dielectric constant of the substance.

If Δx is determined experimentally for as many wave-lengths in the spectrum as the number of arbitrary constants assumed in (2) then the same number of simultaneous equations can be set up so that values of A, B, C, etc., can be determined. Experiments show that for nitrogen gas just two constants A and B suffice to describe the dispersion to a high degree of accuracy. Therefore, under these circumstances, observations at two wave-lengths give two equations in A and B which, when solved, give

$$B = \frac{\Delta x_1 - \Delta x_2}{3e(1/\lambda_1^2 - 1/\lambda_2^2)}; \quad A - 1 = \frac{\Delta x_1/\lambda_2^2 - \Delta x_2/\lambda_1^2}{e(1/\lambda_1^2 - 1/\lambda_2^2)}. \qquad (4)$$

Once the values of A and B are known (A being μ for infinite wave-length) the value of the refractive index can be calculated for any wave-length by the relation

$$(\mu - 1) = (A - 1) + B/\lambda^2. \qquad (5)$$

It will be noted that these results (Eqs. (4) and (5)) hold only for a given value of the density of the gas, since Δx is measured by comparison with an exhausted tube in which the gas density is zero. Experimentally it is found, however, that for nitrogen, Δx increases linearly with pressure, at constant temperature to an extremely high degree. No deviation from linearity can be detected for the observed values up to the limiting pressure of 14 atmospheres thus far attained and accurately measured. This is interpreted to mean that A and B increase linearly with density as theory suggests, because the density of nitrogen is known to depart but slightly from linearity with pressure over this restricted range. Therefore, the values of A, B and also $(\mu-1)$ can be reduced to N.T.P. conditions by means of an equation of state if they are not measured under those conditions. It is hoped that, in the near future, calculations involving the use of an accurate equation of state for nitrogen will be completed, so that a direct accurate experimental determination of the validity of the Lorentz-Lorenz relation can be made. As will be pointed out, however, the results of this paper are in no way dependent upon this determination.

The fact that Δx is linear to such a high degree with pressure in the case of nitrogen indicates that for such a gas the dispersion constants can be determined with a greater accuracy than is obtainable in a single measurement of Δx, by considering the quantity $\Delta x/p$. The determination of this quantity can be based upon any number of observations of Δx over a wide range of pressures. Furthermore, the accuracy with which Δx can be measured also increases with pressure, so that with an interferometer of this type adapted for work at high pressures it is reasonable to suppose that the dispersion constants of nitrogen for N.T.P. conditions can be determined with an accuracy not attained thus far by other observers. Under these circumstances Eqs. (4) are modified to read as follows: Where the subscript zero refers to N.T.P. conditions

$$B_0 = \frac{76.0\tau}{3e273.1}\left(\frac{\Delta x_1/p - \Delta x_2/p}{1/\lambda_1^2 - 1/\lambda_2^2}\right); \quad A_0 - 1 = \frac{76.0\tau}{e273.1}\left(\frac{(1/\lambda_2^2)(\Delta x_1/p) - (1/\lambda_1^2)(\Delta x_2/p)}{1/\lambda_1^2 - 1/\lambda_2^2}\right). \qquad (6)$$

Of course, if it so happens that more than two spectral lines are available for these measurements the more appropriate procedure to obtain the highest accuracy is as follows: determine the best values of $\Delta x/p$ at each wave-length; multiply by $(\tau/273.1)(76.00/e)$ to get $\Delta x/e$; then set up as many equations like Eq. (3) as the data allow; and determine the coefficients A_0 and B_0

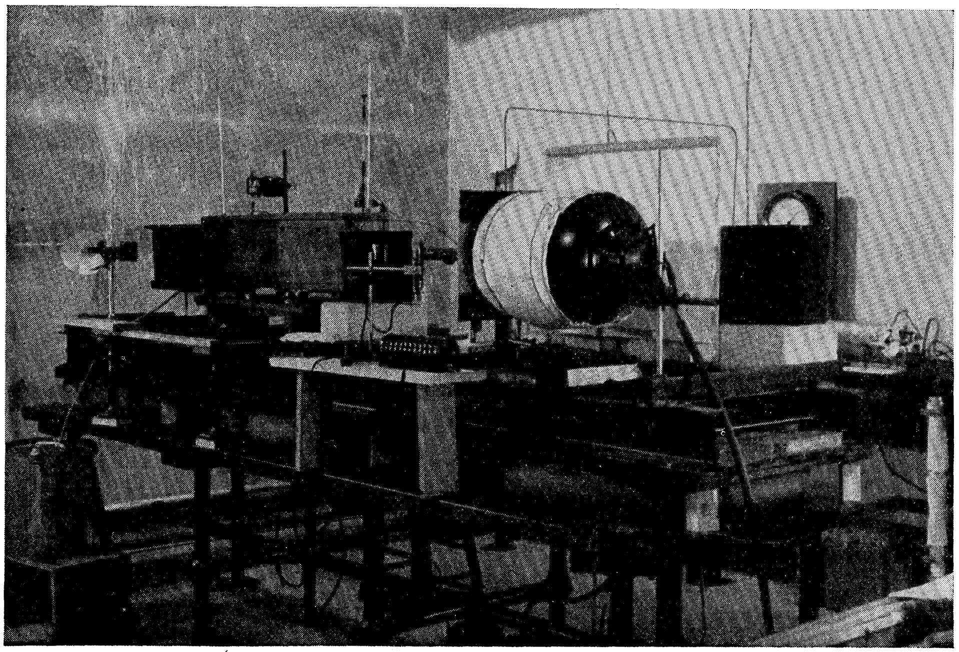

FIG. 1.

by methods of least squares. With more than two constants, however, this procedure is not feasible.

APPARATUS

In the accompanying photograph, Fig. 1, the new apparatus is shown as it is set up on a rectangular table 10 feet long and 30 inches wide with the following pieces of apparatus mounted at a fixed elevation: at the center, enclosed in a dust-proof container, a vertical semi-reflecting mirror with its face parallel to the short side of the table; at the corner of the table in the foreground the source of light; diagonally across from it, a movable vertical mirror; in the corner adjacent to the light source, a fixed vertical mirror; and diagonally across from it, adjacent to the movable mirror, a telescope with a diffraction grating mounted in front of it. The diagonal light paths, which thus lie in a plane parallel to, and at a fixed distance above the table, intersect at the surface of the semi-reflecting mirror and enclose an angle of about 20°.

The new apparatus was designed with every possible consideration given to reduce vibration to a minimum. Whereas in the former apparatus the three mirrors, separated by paths of approximately 130 cm, were mounted on independent cement piers, in the present assembly every unit was fastened to a single steel frame consisting of two I-beams 5 inches deep by 10 ft. long held parallel by cross members 2 ft. long rigidly bolted to them. This whole frame, supported on a wooden platform with a flat bottom to distribute the load uniformly, was then floated on three partially inflated automobile inner tubes uniformly spaced side by side on a specially built rigid pipe-leg table, itself resting on sponge rubber squares under each of its eight legs. The mirrors were fastened to short sturdy rods projecting out of specially constructed cement blocks approximately $11 \times 11 \times 6$ inches, constructed so as to slide in steel channel-iron frames 2 ft. long $\times 11$ inches wide laid across the I-beams at the ends and in the center, as shown. Slight accidental relative displacements of the heavy cement blocks, channels and I-beams, after the final optical adjustments were made, were prevented by applying soft wax to all regions of contact. The steel frame was loaded with slabs of soapstone and other miscellaneous heavy materials and the inner tubes pumped up until optimum anti-vibration conditions were realized. This air cushion method of mounting was found to be far superior to any of a number of other methods tried and resulted in a suspension, vibrationless to such an extent that the ever present traffic tremors, made visible by reflections in a dish of mercury placed almost anywhere in the laboratory, even on a table already mounted on sponge rubber, were completely eliminated. With this support, interference fringes formed by mirrors at the extremities of the steel frame work were observed to be stationary for periods as long as several seconds at a time, even with heavy machinery in operation on the same floor only a few doors away.

As a source of light a General Electric S-1 Sunlamp was used.[2] This lamp is ideally suited for this sort of work by virtue of the fact that it gives a continuous spectrum on which the ordinary mercury spectrum, in the visible region, is superposed as bright lines. Furthermore, it requires no attention whatever. In its use an image of one of the tungsten electrodes is formed on the slit of the interferometer.

Other improvements in the optical system included the use of aluminum mirrors[3] which extended the spectral range so as to include the mercury 4047A line. These mirrors also have the valuable property of not tarnishing readily. The intensity of the continuous spectrum was also improved by the use of a diffraction grating specially ruled so as to throw most of the light into the first order spectrum on one side only of the normal beam.[4]

To measure the displacements of the fringes, the movable mirror was mounted on the carriage of a small laboratory Michelson interferometer, the screw of which was carefully calibrated in advance by interferometric methods over several millimeters of its length. This screw was found to be more uniform than the one formerly used. No variation in pitch exceeding one part in four hundred was observed in any whole turn. The actual pitch was found to be 1.040 percent greater than 0.5 mm.

In addition to the optical aspects of this problem, considerable attention was also given to the purity of the gas used, as well as to the constancy and precise measurement of pressures and temperatures. The nitrogen used in this work was commercial water pumped nitrogen which was passed under pressure through a 30-inch steel tower of silica gel to remove traces of water vapor and through a furnace consisting of a steel tube one inch in diameter and 12 inches long, packed tightly with crumpled 100-mesh copper screening maintained at a temperature of about 600°C to remove possible traces of oxygen.

The temperature of the gas was regulated by a mercury-switch thermostat to variations of less than 0.01°C measured by two calibrated mercury thermometers, one at each end of the bath of paraffin oil, which completely surrounded the experimental tube except for the glass windows at the ends. The bath, described before except for minor improvements, is 100 cm long with a square cross section 20 cm to a side.

Pressures were measured to one millimeter of mercury over the whole range from vacuum to nearly 11,000 mm (approx. 14 atmos.) by a Keyes type dead-weight piston gauge.[5] Variations in pressure from the measured value never exceeded a few millimeters in any run and in some cases were less than one millimeter throughout a set of readings made at a given pressure over a period of 15 to 30 minutes.

The same gas refraction tube was used in these experiments as before, the only difference being a slight modification in the method of fastening on the glass windows. The film of De Khotinsky cement used in the former packing, which was described in some detail, was replaced by a cement consisting of litharge and glycerine to facilitate the use of higher temperatures than were formerly possible. Also, a very thin gasket of lead foil was used to replace the one of dental

[2] The author is grateful to the General Electric Company for the sunlamp unit placed at his disposal for this work.

[3] These mirrors were made by Dr. J. C. Wulff by evaporation of aluminum on glass.

[4] The replica grating used was loaned by Dr. H. M. O'Bryan.

[5] This pressure gauge was kindly loaned by Dr. F. G. Keyes, Director of the Laboratory of Physical Chemistry, to whom the author is also greatly indebted for the opportunities offered to discuss with him high pressure technique and matters pertaining to the purification of gases.

rubber formerly used. The tube is made of $\frac{1}{8}$-inch steel and is 100.30 cm long by 2.5 cm in diameter. The windows are $\frac{1}{4}$ inch thick.

Steel tubing was used throughout to connect the various parts of the apparatus and steel stopcocks of improved design replaced those used in the former set-up. These specially constructed stopcocks were necessary to insure against leakage in the packings, because in some cases they are used as open rather than as closed valves.

Results

Observations were made in a manner similar to that previously described[1] at four wave-lengths, namely: 5780, 5461, 4359, 4047A. Pressure runs were made corresponding to constant temperatures of 50, 30 and 0°C. The 0°C observations were obtained with a constant temperature bath of cracked ice and water. Readings of the micrometer screw in centimeters corresponding to absolute pressures and wave-lengths at the various temperatures are given in Table I.

The readings in Set III at 30° were made several months after all the others for purposes of checking the constancy of the apparatus over a period of time. As a result of many hours of continuous operation, the sunlamp bulb had become blackened and the mirrors had become slightly tarnished so that it was impracticable to attempt accurate observations on the 4047A line. In Table I the readings of the micrometer screw are recorded rather than values of Δx as was the former procedure, because instead of actually calculating the values of $\Delta x/p$ it is more accurate to calculate what corresponds to the same thing, namely, the slope of the readings themselves *vs.* pressure. In the former work the values of Δx were computed by subtracting the readings at zero pressure from the readings at the various pressures which, of course, gives a greater weight to all the readings corresponding to zero pressure (vacuum) than to the others, thereby increasing the probable error.

The above micrometer readings were first plotted against pressure on a very large scale and showed not the slightest departure from linearity. They were then analyzed by the standard method of averaging by splitting the data into groups and solving the linear equations so obtained. Table II gives the values of $\Delta x/p$ so obtained, with the corresponding values reduced to 0°C by multiplying the former by $\tau/273.1$ (τ = absolute temperature). These values have been corrected for micrometer screw error.

TABLE I. *Micrometer readings* vs. *pressure.*

Temp. °C	Pressure (cm Hg)	Wave-length 5780A	5461A	4359A	4047A
30° (I)	0.00	0.5995	0.6680	1.0530	1.2260
	356.04	3.1855	3.2630	3.7230	3.9445
	497.49	4.2120	4.2930	4.7825	5.0100
	626.23	5.1515	5.2345	5.7525	5.9885
	803.64	6.4365	6.5260	7.0850	7.3250
(II)	0.00	0.6235	0.6925	1.0700	1.2460
	331.22	3.0350	3.1155	3.5600	3.7710
	566.56	4.7325	4.8175	5.3160	5.5510
	800.59	6.4170	6.5175	7.0750	7.3280
	1075.36	8.4160	8.5250	9.1385	9.4140
(III)	0.00	0.5145	0.5830	0.9660	
	309.80	2.7650	2.8475	3.2920	
	566.60	4.6220	4.7135	5.2230	
50°	0.00	0.6210	0.6875	1.0660	1.2400
	309.75	2.7335	2.8140	3.2585	3.4500
	582.91	4.5860	4.6780	5.1810	5.4120
	1022.20	7.5775	7.6880	8.2835	8.5600
0°	0.00	0.6160	0.6830	1.0615	1.2290
	321.09	3.1860	3.2655	3.7270	3.9405
	437.68	4.1225	4.2050	4.6935	4.9215
	549.42	5.0250	5.1155	5.6265	5.8740
	662.69	5.9430	6.0385	6.5740	6.8300
	791.48	6.9825	7.0830	7.6565	7.9160
	1000.57	8.6570	8.7745	9.3960	9.6935

TABLE II. *Values of* $\Delta x/p$ *(cm/cm Hg).*

Temp.	5780A	5461A	4359A	4047A
	Results obtained by analysis of data			
30°C (I)	.00036695	.00036820	.00037911	.00038333
(II)	.00036532	.00036728	.00037868	.00038330
(III)	.00036604	.00036807	.00037943	
50°C	.00034342	.00034325?	.00035633	.00036186
0°C	.00040661	.00041006	.00042194	.00042725
	Preceding values reduced to 0°C			
30°C (I)	.00040731	.00040870	.00042081	.00042550
(II)	.00040550	.00040768	.00042033	.00042546
(III)	.00040630	.00040856	.00042117	
50°C	.00040627	.00040606?	.00042154	.00042808
0°C	.00040661	.00041006	.00042194	.00042725
Mean	.00040640	.00040875	.00042116	.00042657
Pr. error mean	±.00000020	±.00000040	±.00000022	±.00000050

It will be observed that the values of $\Delta x/p$ reduced to 0°C as given in Table II are very nearly constant for each wave-length. The probable error of the mean in each case is less than one part in a thousand on the average. The greatest deviation is observed for the values at wave-length 4047A. This is due to the relatively poor visibility in this region. As was pointed out before, only the use of aluminum mirrors made these observations possible at all. On the other hand, the probable error here is only five parts in four thousand.

The fact that $\Delta x/p$ shows no detectable temperature variation other than that associated with density from 0°C to 50°C is interpreted to mean that these results, over this limited temperature range, are in accord with the accepted view that the refractive index of nitrogen does not vary with temperature except through its dependence on density. This latter view is based upon the fact that no successful attempt to measure such a coefficient has ever been reported.

On the basis of these data, the values of A_0 and B_0 were determined by the alternative method suggested in the preceding theoretical discussion, whereby least square calculations were carried out on four equations patterned after Eq. (3). These results are tabulated in Table III, where values of $\Delta x/e$ have been calculated from the computed A_0 and B_0, for purposes of comparison with the observed values of the same quantity.

TABLF III. *Cauchy dispersion constants A and B for nitrogen (0°C, 76.0 cm Hg).*

λ	$\frac{\Delta x}{p}$	$\frac{3}{\lambda^2}\times 10^{-8}$	$\frac{\Delta x}{e}$ (obs.)	$\frac{\Delta x}{e}$ (calc.)
5780A	0.00040640	8.9799	0.00030793	0.00030792
5461	.00040875	10.0596	.00030971	.00030969
4359	.00042116	15.7887	.00031911	.00031907
4047	.00042657	18.3174	.00032321	.00032321
	$(A_0-1)=0.00029322$		$B_0=1.637\times 10^{-14}$	

The accuracy with which A_0-1 and B_0 are here determined can be appreciated by noting that the average deviation between the last two columns of Table III is only two parts in thirty thousand. This high relative accuracy led the writer to check the numerical calculations by carrying out the detailed computations indicated by Eq. (6), considering all six possible ways of combining the four sets of data taken two at a time. In only one case did the resulting value of A_0-1 differ from that given above by more than one part in three thousand. A check to one part in sixteen hundred was also obtained in this manner for B_0. Of course, the least square values are considered the more accurate.

TABLE IV. *Cauchy dispersion constants for nitrogen (0°C, 76.0 cm Hg).* (Three-constant formula.)

Wave-length range	B_0 $\times 10^{-14}$	C_0 $\times 10^{-24}$	A_0-1
5780A–5461A–4359A	1.672	−0.21	0.0002929 (5780A)
5461 –4359 –4047	1.705	− .44	.0002929 (5461A)
5780 –5461 –4047	1.677	− .25	.0002929 (4359A)
5780 –4359 –4047	1.700	− .38	.0002929 (4047A)
Mean	1.689	− .32	.0002929

Sufficiency of Two Cauchy Constants

All the foregoing calculations have been based on the assumption that the refractive index of nitrogen can be adequately expressed by Eq. (2) limited to the λ^2 term. In the former paper[1] the author cited his graphical analysis of the work of Meggers and Peters on air[6] to justify this procedure. The high precision obtained with the new apparatus, however, has warranted the carrying out of calculations on the basis of a three-constant formula to check this point. The simple least square method used in the two-constant case is not applicable here, so that only an extension of the other method is feasible. This calls for a consideration of the four possible ways of combining the four sets of data taken three at a time. The equations for determining B_0, C_0 and (A_0-1) corresponding to Eq. (6) become considerably more involved, as follows:

[6] Meggers and Peters, Bull. 372, Bureau of Standards, 1918.

$$B_0=\frac{76.0\tau}{3e273.1}\left\{\frac{\left(\frac{\Delta x_2}{p}-\frac{\Delta x_1}{p}\right)\left(\frac{1}{\lambda_3^4}-\frac{1}{\lambda_1^4}\right)-\left(\frac{\Delta x_3}{p}-\frac{\Delta x_1}{p}\right)\left(\frac{1}{\lambda_2^4}-\frac{1}{\lambda_1^4}\right)}{\left(\frac{1}{\lambda_2^2}-\frac{1}{\lambda_1^2}\right)\left(\frac{1}{\lambda_3^4}-\frac{1}{\lambda_1^4}\right)-\left(\frac{1}{\lambda_3^2}-\frac{1}{\lambda_1^2}\right)\left(\frac{1}{\lambda_2^4}-\frac{1}{\lambda_1^4}\right)}\right\},$$

$$C_0=\frac{76.0\tau}{5e273.1}\left\{\frac{\left(\frac{\Delta x_3}{p}-\frac{\Delta x_1}{p}\right)\left(\frac{1}{\lambda_2^2}-\frac{1}{\lambda_1^2}\right)-\left(\frac{\Delta x_2}{p}-\frac{\Delta x_1}{p}\right)\left(\frac{1}{\lambda_3^2}-\frac{1}{\lambda_1^2}\right)}{\left(\frac{1}{\lambda_2^2}-\frac{1}{\lambda_1^2}\right)\left(\frac{1}{\lambda_3^4}-\frac{1}{\lambda_1^4}\right)-\left(\frac{1}{\lambda_3^2}-\frac{1}{\lambda_1^2}\right)\left(\frac{1}{\lambda_2^4}-\frac{1}{\lambda_1^4}\right)}\right\}. \tag{7}$$

(A_0-1) is then obtained by Eq. (3) for the value of $\Delta x/p$ at each wave-length, by using the mean values of B_0 and C_0 thus obtained. The results of these calculations are given in Table IV.

It must be pointed out that this procedure is a very severe test of the data, and the consistency of the (A_0-1) values is very remarkable. The spread of the B_0 and the C_0 values can be easily attributed to the relative inaccuracy of the 4047A data previously pointed out. A three-constant calculation would require data at six wave-lengths for the same accuracy as a two-constant calculation gives from data at four wave-lengths. Furthermore, the C_0 values in Table IV, although reasonably consistent, are relatively extremely small (0.32×10^{-24}). Besides, the value obtained for (A_0-1) by these less accurate calculations differs from the two constant value by only one part in one thousand, which is, after all, just about the accuracy of the absolute value of this quantity as based on the figures of Table II. These considerations, therefore, indicate that no necessity exists for considering the C_0 constant in the Cauchy formula, even though dispersion data are customarily so expressed in the literature even when based upon data known to be less accurate than the above.

Comparison of Results with Other Published Values

The conclusion drawn from this work is that for nitrogen A_0-1 is 0.0002932 to better than one-tenth of one percent and that B_0 is 1.64 to better than one part in one hundred and fifty, certainly. It is of some interest to compare these results with other published values. A value for the dielectric constant of nitrogen has recently been published[7] giving $\epsilon=1.000589$ with a probable error of three figures in the last place. The above value of A_0-1 gives $\epsilon-1=0.0005864$ to one-fifth of one percent.

As for published values of $\mu-1$, the results obtained by other methods are usually not extrapolated to infinite wave-length (this not being generally possible from determinations at isolated wave-lengths) but expressed for specific wave-lengths. Displacement interferometry, however, yielding the B constant as well as the A constant, provides the means of directly calculating $\mu-1$ for any wave-length by Eq. (5). Cheney[8] reported values of μ_0-1 for nitrogen at wave-lengths 6678A, 6143A and 5852A, of 0.0002969, 0.0002977 and 0.0002985, respectively. The above values of A_0-1 and B_0 give 0.0002971, 0.0002975, and 0.0002980, respectively, which are in close agreement. In the opinion of the writer, however, the values of refractive index given in this paper are more accurate than previously published values for the reasons already presented. Furthermore, since it is generally believed that nitrogen possesses no absorption bands in the infrared, the extrapolated A_0-1 value predicts a value for the dielectric constant probably more accurate than has previously been determined.

Summary

An improved displacement interferometer has been built which has definitely established the fact that methods of displacement interferometry are suitable for precise absolute as well as relative determinations of dispersion in gases.

[7] H. L. Andrews, Physics **1**, 366 (1931).

[8] E. W. Cheney, Phys. Rev. **29**, 292 (1927).

For a gas like nitrogen for which the displacements are linear with pressure to a high degree, the dispersion constants have been determined with extremely high accuracy. It is also shown that two Cauchy constants are quite sufficient to express the dispersion to one part in a thousand for nitrogen up to pressures of 14 atmospheres, at least. Furthermore, within this pressure range and within a temperature range of 0° to 50°C the Lorentz-Lorenz relation $[(\mu^2-1)/(\mu^2+2)](1/\rho)$ is shown to be probably constant, where ρ is the density. It must be pointed out, however, that the accuracy with which this relation is shown to hold is not necessarily the accuracy claimed for A_0-1 in the preceding work, because in this paper the results are based on the experimentally observed linearity of the displacements as functions of pressure, not density. Calculations involving accurate knowledge of p.v.t. data are under way at present to ascertain the precise validity of the Lorentz-Lorenz relation within this density range.

The value of A_0-1 given by this work is 0.0002932 to better than one-tenth of one percent. This value is in accord with other published results determined at atmospheric pressure but is in all probability more accurate than these by virtue of the fact that it is obtained by averaging a great many observations over a range of pressures. The result is also consistent with dielectric constant measurements of others.

In conclusion it seems proper to emphasize by restating that displacement interferometry yields not only refractive index values but gives simultaneously the manner in which they vary with wave-length. It is the lack of the latter information, of course, that has made previous isolated determinations of refractive index at particular wave-lengths less useful than they might otherwise have been in molecular refraction considerations.

The results of this paper have been critically reviewed by Professor A. deF. Palmer, of Brown University, with whom the writer has had the pleasure of discussing the work from time to time throughout its progress.

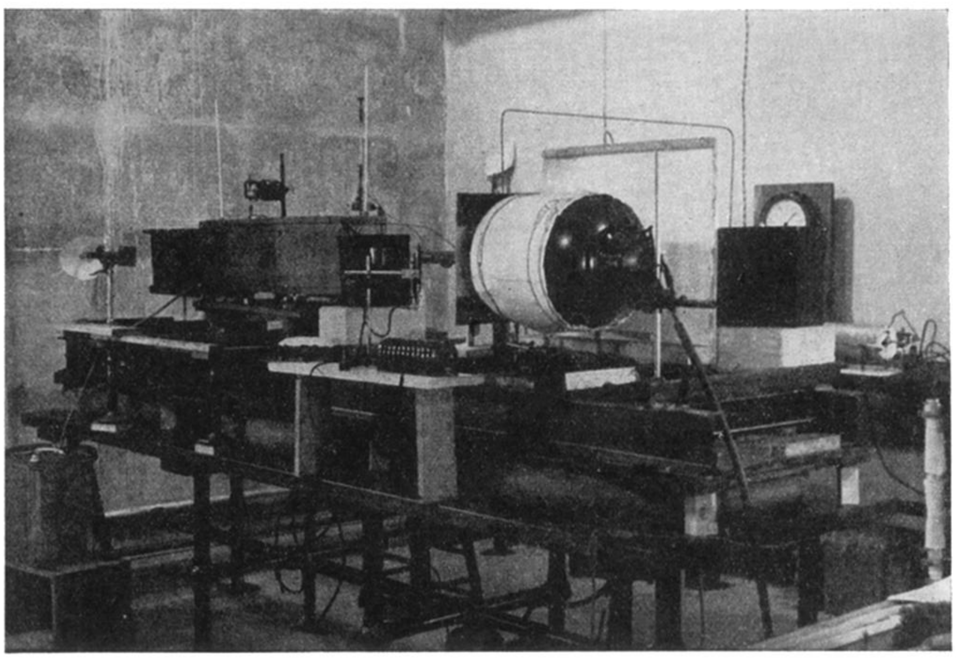

Fig. 1.