The Effect of Pressure on the Index of Refraction of Paraffin Oil and Glycerine

By THOS. C. POULTER, CARTER RITCHEY AND CARL A. BENZ
Physics Department, Iowa Wesleyan College

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A refractometer for measuring the index of refraction of liquids under very high pressure is described. The values obtained for glycerine and a paraffin oil together with the constants for the Lorenz-Lorentz relation are tabulated.

PROCEDURE AND RESULTS

THERE have been relatively few studies made on the change of the refractive index with pressure and those at pressures seldom, if ever, greater than 200 atmospheres.

By making use of a liquid prism which could be subjected to high pressure, the authors have constructed a refractometer for studying the effect of very great pressure upon the index of refraction of different materials.

The windows are mounted directly in contact with the hard steel disk R in the figure and in such a position that the liquid in the apparatus forms a 30° prism.

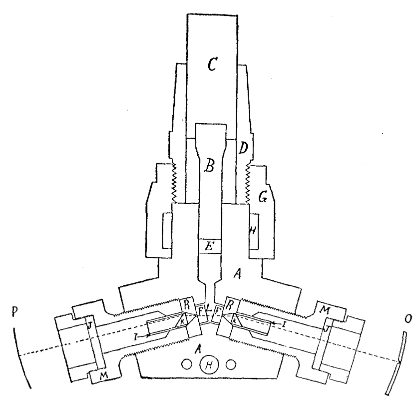

Fig. 1.

In measuring the index of refraction for different materials a much smaller opening is made in the window support than had been used in the ordinary type of pressure cylinder. This serves as a slit system to run the light through parallel to the base of the prism.

This window support is held firmly against the shoulder of the pressure cylinder by the steel plug M which screws down tightly against it. On the outer end of this plug is a safety window J, held in place by another steel plug. Because of the large shift in the light beam this safety window must be larger than the triple safety window usually used so that the light beam can be easily followed.

Since the position of the prism L formed by the liquid in the pressure cylinder would bend the light up, it is necessary to place two small correction prisms K in the cylinder to direct the beam of light from the light source O, through the liquid prism L and out onto the screen P. These two correction prisms are mounted in brass tubes which enable one to adjust their positions readily.

The space between the pressure windows and the small correction prisms is filled with a liquid of nearly the same index of refraction as the glass, so as to correct for the lens effect of the pressure windows.[1] Knowing the angle of the prism L, the pressure that is developed, and by measuring the angle of minimum deviation, it is possible to study the effect of pressure on the index of refraction of different liquids.

The liquids used were a paraffin oil, merasol, a product of the Standard Oil Company and glycerine. This oil is used for transmitting pressures in various other experiments and for this reason it was desirable that we know the effect of pressure upon its index of refraction.

The expression $n=(\sin \frac{1}{2}(R+D))/(\sin \frac{1}{2}R)$ gives the index of refraction n when the prism angle R and the angle of minimum deviation D of a transmitted beam is known. By measuring the change in deviation of the transmitted yellow light, the change in n was determined with each increase of pressure. The densities for the oil were measured by the piston travel in a cylinder designed for such measurements, while that for the glycerine was taken from data obtained by P. W. Bridgman.[2]

Tables I and II give the values for the refractive index n and density e at the pressures designated, together with the constant K for the Lorenz-Lorentz relation:

$$\frac{n^2-1}{n^2+2}\cdot\frac{1}{d}=K$$

TABLE I. *Refractive index and density of paraffin oil.*

pressure (atm.)	density (gm/cc)	n	K
1.	0.8706	1.4749	0.324
2697.	0.954	1.5340	0.325
5394.	1.006	1.5659	0.324
8091.	1.031	1.5895	0.326
10789.	1.052	1.6008	0.324
13585.	1.069	1.6039	0.324

TABLE II. *Refractive index and density of glycerine.*

pressure (atm.)	density (gm/cc)	n	K
1.	0.987	1.4722	0.282
1803.	1.025	1.4858	0.279
3703.	1.054	1.4962	0.278
4510.	1.078	1.5103	0.279
7212.	1.100	1.5210	0.279

From these values of K it can be seen that the value for the Lorenz-Lorentz relation is constant within the limits of experimental error up as far as measurements were made.

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[1] Thos. C. Poulter and Carl A. Benz, Phys. Rev. **40**, 872 (1932).

[2] P. W. Bridgman, Proc. Amer. Acad. Arts and Sci. **67**, 1–27 (1932).