A SIMPLE METHOD FOR REFRACTIVE INDEX MEASUREMENTS FOR LIQUIDS

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A simple method for the measurement of refractive index in transparent plates using the principle of total internal reflection was recently reported. With the advent of the laser, this approach is of much practical use in any laboratory. With an interest to extend this method to liquids as well, a short-term project[2] was taken up. The details of the experimental set-up and the results of measurements on several solids, liquids and sugar solutions of various concentrations are reported in this note.

The principle of the method is based on the concept of total internal reflection of light in any medium. For observing the relevant pattern, a suitable material which acts both as a scatterer and as a screen is kept in close contact with the medium of interest. The experimental arrangements for solids and liquids are shown schematically in figures 1a and 1b respectively.

In the case of transparent solid media, a wet, thin manifold paper served as a scatterer as well as a screen and gave satisfactory results. When a laser beam is incident on the wet paper, scattered spherical wavefronts are generated in all directions and enter and travel through the medium until the condition for total internal reflection inside the slab is fulfilled. At a critical angle θ_c and at larger angles the rays are reflected[1]. This leads to the formation of a circular ring pattern consisting of (i) a perfect shadow region, corresponding to the region where the rays are transmitted through the medium, and (ii) a general bright background corresponding to the rays which are totally internally reflected.

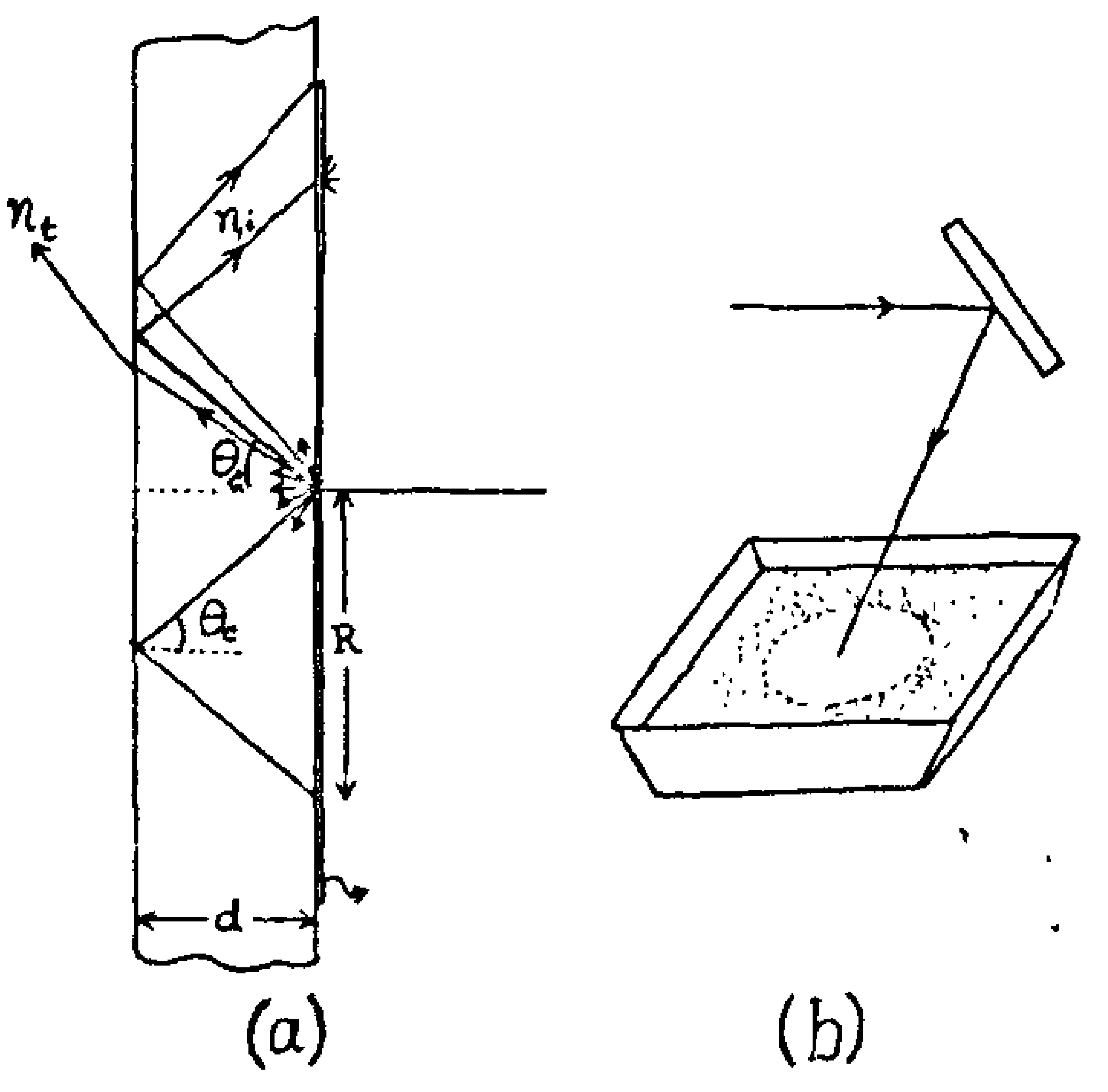

Figure 1a,b. Schematic representation of the experiment for **(a)** solids, according to Reich[1], and **(b)** liquids (present work).

With a suitable scatterer/screen, the circular line of demarcation is made very sharp so that the diameter of the ring pattern can be precisely measured. If R is the radius of the ring and d is the thickness of the slab of the solid medium, then

$$(R/2)/d = \tan\theta_c.$$

It is well known that

$$\sin\theta_c = n_t/n_i.$$

In the present experiment, $n_i > n_t = 1$ and hence from the measured R and d, θ_c could be calculated and hence the refractive index of the medium (n_i) could be determined.

This method has been conveniently extended to the case of transparent liquids using a mirror-reflected laser beam, as shown in figure 1b. A flat-bottomed, rectangular porcelain container which acts as a good scatterer and screen is used to hold liquid and gives satisfactory results. The measurement procedures were the same as in the case of solid media. It is easy to vary the thickness d by pouring more liquid into the container and it is interesting to see the subsequent enlargement of the sharp ring pattern.

The experiments were carried out using a 0.5 mW He–Ne Laser (Spectra Physics Inc., USA) on several grades of glass slabs and other materials such as perspex and Araldite. Dividers with sharp tips were employed for the measurement of ring diameter and a screw gauge was used for the thickness measurements on solid materials. The experimental data for several solids and liquids are presented in tables 1 and 2 respectively, while the variation of the refractive index of cane-sugar solution as a function of concentration is presented in table 3. The measured values reported here are in very close agreement with those reported earlier[3,4]. The actual ring pattern observed for water is shown in figure 2. The flatness of the bottom surface of the liquid container (porcelain tray) was estimated to have a precision of 0.2 μm as assessed by bandwidth measurements on the fringe pattern formed between the porcelain surface and an optical flat using a sodium vapour lamp. The probable errors in the

Table 1 *Experimental data for refractive index measurements on solids using laser light of 6328 Å*

Material	Radius of ring R (cm)	Thickness d (cm)	Measured θ_c	Measured refr. index
Glass slab I	3.030	1.75	40.88°	1.529 ± 0 007
Glass slab II	4.950	2.81	41.37°	1.513 ± 0.004
Glass plate	0.184	0.10	42.61°	1.476 ± 0.005
Perspex slab	0.925	0.51	42.20°	1.483 ± 0 008
Araldite slab	0.916	0.59	37.82°	1.628 ± 0.008

Table 2 *Experimental data for refractive index measurements on liquids*

Liquid	Radius of ring R (cm)	Depth d (cm)	Measured θ_c	Refractive index: Present work (6328 Å)	Refractive index: Reported[4] (5893 Å)
Water	2.55	1.08	47.73°	1.311 ± 0.001	1.333
Paraffin oil	1.67	0.95	41.31°	1.511 ± 0.003	–
Carbon tetrachloride	1.40	0.73	43.80°	1.443 ± 0.002	1.466
Glycerol	1.81	0.93	44.22°	1.434 ± 0.002	1.470
Carbon disulphide	0.86	0.55	38.02°	1.624 ± 0.002	1.6295
Kerosene	1.81	1 08	39 96°	1.555 ± 0 002	–
Benzene	1.72	1.02	40.14°	1.550 ± 0.004	1.501

Table 3 *Variation of refractive index of cane-sugar solution with concentration*

Measured density (g/cc)	Refr. index (present work 6328 Å)	Standard values[3]: Density (g/cc)	Standard values[3]: Concentration (%, w/v)	Standard values[3]: Refractive index (5893 Å)
1.028	1.333	1.030	8	1.345
1.062	1.350	1.064	16	1.357
1.091	1.377	1.090	22	1.367
1.113	1.385	1.113	27	1.376
1.155	1.409	1.156	36	1.392
1.185	1.434	1.187	42	1.404

refractive index measurements are appreciable since only a graduated ruler was used for liquid depth measurement (d) and dividers with sharp tips for the measurement of the diameter of the circular ring; both operations cause slight disturbances in the liquid.

When an optical measuring device such as a two-dimensional co-ordinate microscope (comparator) with better precision, viz., a least count of one micron, is used for the ring diameter measurements, the liquid is not disturbed and the probable error can be brought down. However, this requires careful alignment of the linear translation of the cross-wire of the microscope along the diameter of the ring pattern in the liquid. But when fast-evaporating liquids are to be studied, quick measurements with the microscope may be difficult.

The above experimental approach is found to be simple for quick refractive index measurements for solids as well as liquids. It is suitable for translucent materials such as Araldite as well. The highly symmetrical nature of laser light and the non-requirement of critical angular adjustments of the incidence of the laser beam on the medium are additional advantages of the technique. When liquid containers with diameter markings on the bottom surface and depth markings on the side walls are used, this method will be further simplified and

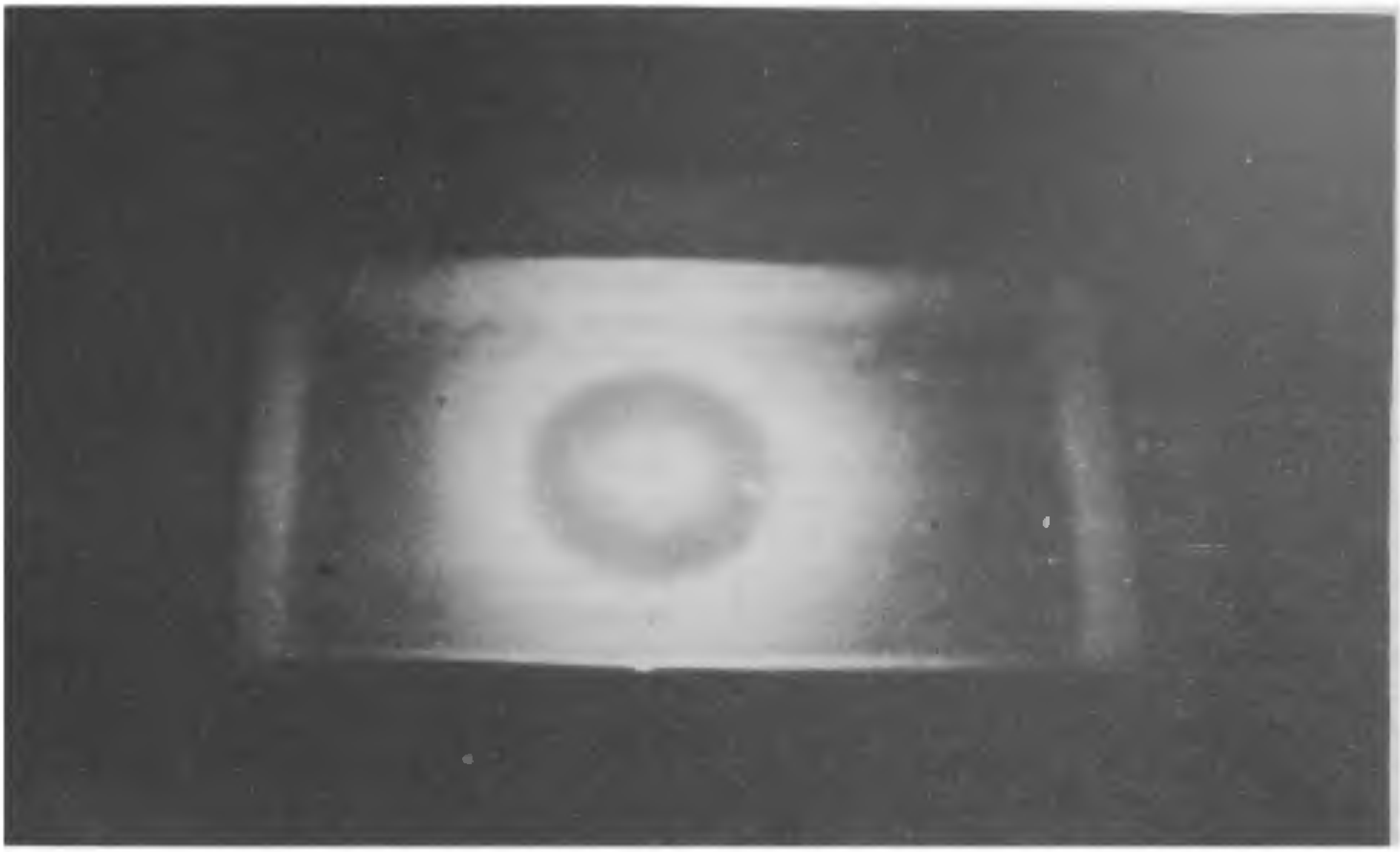

Figure 2. Photograph of circular ring pattern observed for water.

useful for volatile and acid media. The method is very practical for several quantitative studies such as variation of refractive index with temperature, refractive indices of liquid mixtures and solutions of different concentrations, opalescence properties, and so on.

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PMR SPECTRAL EVIDENCE FOR STERIC ENHANCEMENT OF RESONANCE

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AFTER the discovery of steric enhancement of resonance[1], several studies[2–13] have afforded additional evidence for it. The present study, which deals with the PMR spectra of 2- and 2,6-disubstituted 4-nitroanisoles, and 2- and 2,6-disubstituted 4-carbomethoxyanisoles, provides further evidence for steric enhancement of resonance.

There is resonance interaction of the CH_3O- and $-NO_2$ groups in 4-nitroanisole. A substituent like a methyl group or a halogen atom in the 2-position (**I**) enhances the resonance by a steric effect.

The substituent X prevents the free rotation of the methoxy group and so the CH_3 of the methoxyl will be oriented away from X. Such a situation will increase the chances of the methoxyl attaining the plane of the benzene ring and consequently the resonance interaction of CH_3O- with $-NO_2$ also