ELECTRIC DOUBLE REFRACTION IN LIQUIDS.

By Harold E. McComb.

THE velocity of light, vibrating in different planes in di-electric media, subjected to electric strain, was first investigated by Kerr[1] in 1894. After experimenting upon a number of liquids he concluded that the velocity of the component vibration polarized perpendicular to the lines of force was changed.

Later, G. Aeckerlein,[2] following a method similar to that used by Kerr, investigated the above effect in nitro-benzol and nitro-toluol. He found that in the former the perpendicular component is accelerated and the parallel component retarded, the ratio being about 2 : 1.

In the present investigation an attempt has been made to measure accurately the effect on each component.

Apparatus.

The apparatus consisted of a Michelson interferometer mounted on a cement block. In the paths A and B were placed tubes of the liquid to be investigated. The tubes were ground so that they were practically the same length (22 cm.) and the ends covered with interferometer plates of the same optical thickness. The electrodes (made of brass) were placed within the tubes and held apart by glass plates of definite thickness. By placing the faces of the electrodes in one tube parallel to the plane of the table and in the other tube perpendicular to this plane the effect on either component could be measured without rotating the nicol. Later it was found more convenient to rotate the nicol and adjust all electrodes perpendicular to the table. The nicol N was arranged so that it could be quickly and accurately rotated 90 degrees, first transmitting light vibrating parallel to the table and then perpendicular. It was thus a simple matter to study the effect on each component in succession in the same tube. A direct-vision spectroscope was placed at S and a telescope at T. The total reflecting prism P was used to direct the light to the telescope T when adjustments were being made with sodium bands. All of the optical part of the apparatus except the light

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[1] J. G. Kerr, Phil. Mag., 37, 1894, p. 380.

[2] G. Aeckerlein, Physikalische Zeitschrift, 7, No. 17, p. 594.

sources, the spectroscope, and the telescope was enclosed in a glass case in order to eliminate sudden changes in temperature and air currents.

Electrical Apparatus.

The potentials were supplied from a storage battery (1,000 volts) in series with three 1,200-volt generators and were measured by a Weston voltmeter (V) with multipliers giving ranges (0–150), (0–300), etc., to (0–6000). The arrangement of the commutator (described later) is shown at C.

Experimental.

The apparatus was first carefully adjusted for sodium bands using the prism P and the telescope T. The prism was then removed and the Nernst light L gave a clear channeled spectrum in the spectroscope. The tubes were then interposed and brought directly in line with the beams of light A and B. This step was the most difficult in the whole operation and was almost impossible to carry out without the use of small diaphragms. After adjusting the tubes so that the two fields of view were superimposed the air path A was increased or decreased by moving the mirror M_2 until the bands appeared. By applying the electric strain it was found that the bands usually appeared more quickly than when the liquids were simply allowed to stand. By applying the potential a distinct shifting of the bands was apparent, the amount depending upon the potential used. An attempt was made to measure accurately

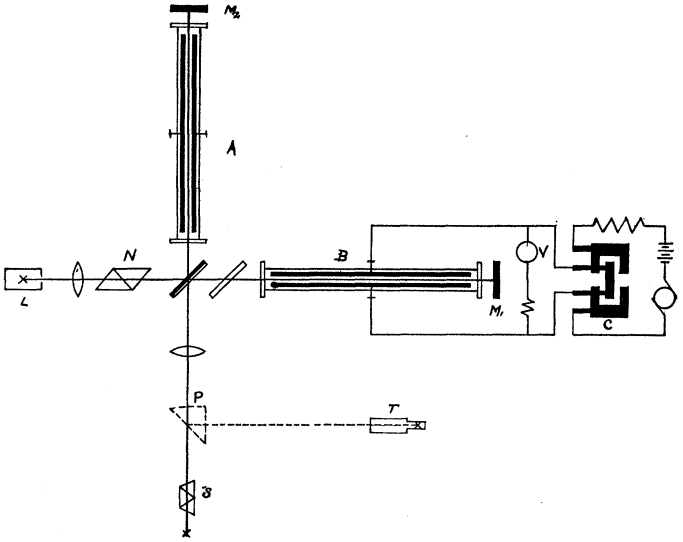

Fig. 1.

the shift produced by the application and quick removal of a definite potential. For this purpose the spectroscope was fitted with an eyepiece having movable and stationary cross-hairs. This method might have proved satisfactory had the field of view remained stationary but owing to the heating effect the whole field of view continually shifted. Nevertheless measurements were made until a potential was applied which gave a shift of *one band*. Up to this point the shift was quite large and measurable but for exactly *one band shift* the field of view apparently remained stationary. This might have been predicted because an instant shift of exactly one band could not be detected by the eye. A device was then made for rapidly and uniformly making and breaking the circuit. It consisted of a large commutator highly insulated which could be rotated at speeds varying from a few R.P.M. up to several hundred. It was found that a speed of about 200 R.P.M. was most satisfactory, there being one make and one break for each revolution. The field of view in the spectroscope was diaphragmed down so that different colors could be investigated. To obtain the retardation, then, for any wave-length it was only necessary to observe the potential required to produce a shift of one or more bands. Shifts up to three bands were thus measured with considerable accuracy. The results with nitro benzol are given in the tables which follow. In the first table the first column gives the wave-length; the second column, the potential difference (electrostatic) required to give an acceleration of one wave-length on the perpendicular component; the third column, the values of "$B_\perp$" (perpendicular component) computed from Kerr's law,

$$B = \frac{\delta a^2}{V^2 l},$$

in which δ is the retardation or acceleration, a the distance between the electrodes, l their length, and V the potential. The fourth column gives the potential difference required to give a retardation of one wave-length on the parallel component; the fifth column, the value of $B_\parallel$ (parallel component); and the last column the ratio $B_\perp$ to $B_\parallel$.

The second table gives the same for δ = two wave-lengths retardation and acceleration.

With nitro-benzol, *the component vibrating parallel to the lines of force is retarded amd the perpendicular component is accelerated, the ratio being 0.53.*

Several other liquids were investigated but none gave as satisfactory results as were obtained with nitro-benzol. In most cases the effects were too small to be measured accurately and distortions in the field of

Nitro Benzol.

(One Wave-length Retardation.)

March 20, 1914. Temperature 20° C.

Wave-length μμ.	Potential Difference Electrostatic.	$B_\perp$	Potential Difference Electrostatic.	$B_\parallel$	Ratio $B_\perp/B_\parallel$
660	8.24	$87.\times 10^{-7}$	5.96	$167.\times 10^{-7}$	.52
620	7.88	95.	5.85	173.	.55
580	7.57	103.	5.39	204.	.51
540	7.15	116.	5.22	218.	.53
660	8.17	89.	5.95	167.	.53
				Mean......	.53

Nitro Benzol.

(Two Wave-lengths Retardation.)

Wave-length μμ.	Potential Difference Electrostatic.	$B_\perp$	Potential Difference Electrostatic.	$B_\parallel$	Ratio $B_\perp/B_\parallel$
660	11.58	$88.\times 10^{-7}$	8.46	$166.\times 10^{-7}$	.53
620	11.21	94.	8.10	181.	.52
580	10.83	101.	7.81	194.	.52
540	10.17	115.	7.28	224.	.51
660	11.60	88.	8.48	165.	.53
				Mean......	.53

Note.—Length of electrodes, 20 cm. (effective path 40 cm.). Distance between electrodes, .154 cm.

view caused considerable trouble. Carbon bi-sulphide and chloroform could be easily investigated with longer tubes or higher potentials but the effect is too small on either to give one band shift with the apparatus described here. The following qualitative measurements were made:

With Carbon Bi-sulphide.—Potentials were supplied from a static machine and measured approximately by means of a spark gap. By allowing the condensers to charge and discharge rapidly the effect was similar to that obtained with the commutator. Using this method no effect was observed upon the component vibrating perpendicular to the lines of force up to a 4 mm. spark gap potential. The other component, that is, the component vibrating parallel to the lines of force, is retarded and apparently is the only component affected.

With Chloroform.—Both components are accelerated, the component vibrating parallel to the lines of force is the larger.

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