large. It is possible, accordingly, that the smallness of the numbers for $l/\lambda = 0.35$ is due to the preponderant action of the nitrogen, while the constancy of the numbers for somewhat greater values of l/λ is due to the compensating action of the two gases. At any rate, the difference between the results for hydrogen and air, the fact that the numbers are almost uniformly greater in the case of air for the same value of V_0 and l/λ, is exactly what would be expected to be the result of the presence of a strongly electronegative gas.

But the main interest of the experiments lies in the question whether they can give any information as to the initial velocity of the δ rays from gases. It appears necessary to suppose that these δ rays have a finite initial velocity, and that it is of the same order of magnitude as that of the δ rays from metals. No other explanation can, I think, be given of the fact that in no case is the current through the gas saturated when $V_0 = 20$, even though the currents due to the δ rays from the electrodes and that due to the positive ions is saturated with that potential. If the constancy of the numbers in the Table over a certain range of l/λ means that within this range (1) is applicable, we should have to conclude that the δ rays from the gas are, on the average, a little faster than those from the electrodes, since the numbers in the Table are a little smaller than those calculated on the assumption that $f(V) = f'(V)$.

However, it does not appear that this method is capable of giving any very precise indications concerning the properties of these rays. They do appear to show that it is necessary to suppose that the rays have a finite initial velocity, and so provide evidence for an important proposition which was universally accepted but had never been directly proved. But this discussion has been published mainly because a brief account of the measurements had been given without any attempt at an explanation of them. It seems that they are generally in accordance with the recent addition to our knowledge of the interaction between electrons and molecules.

Summary.

The theory is considered of the conduction through an ionized gas when the pressure of the gas is so low that the free path of an electron is not small compared with the distance between the electrodes, and the number of ions made in the gas is not large compared with the number of δ rays made at the electrodes. The discussion is based mainly on the recent work of Franck and Hertz on the collisions between electrons and atoms.

The results of some measurements published previously are considered in the light of the theory. They seem in general accordance with that work. They cannot be explained quantitatively at present, but it appears that they make it necessary to believe that δ rays are emitted from ionized molecules of gases with velocities of the same order of magnitude as those from metals.

Leeds University,
August 1913.

VII. *An Experiment on Rotatory Polarization in Liquids.*

By E. Talbot Paris *and* Alfred W. Porter, *F.R.S.**

THE experiment recorded here was carried out in order to see if any evidence could be obtained of a directive action on the molecules of an optically active substance in solution by light passing through the solution. If such a directive action existed (the light tending to orientate the molecules in a certain direction relative to its direction of propagation), it would be expected that when light first passes into the liquid a small interval of time would be required for the full rotatory power to be developed. In this case, if an intermittent source of light were used, giving flashes of sufficiently short duration, the rotation of the plane of polarization would be less than that for a steady source. In the experiment described below the rotation produced in a long tube of cane-sugar solution was measured, first using a steady source of light (a mercury lamp), and afterwards an intermittent one in the form of a platinum-mercury spark.

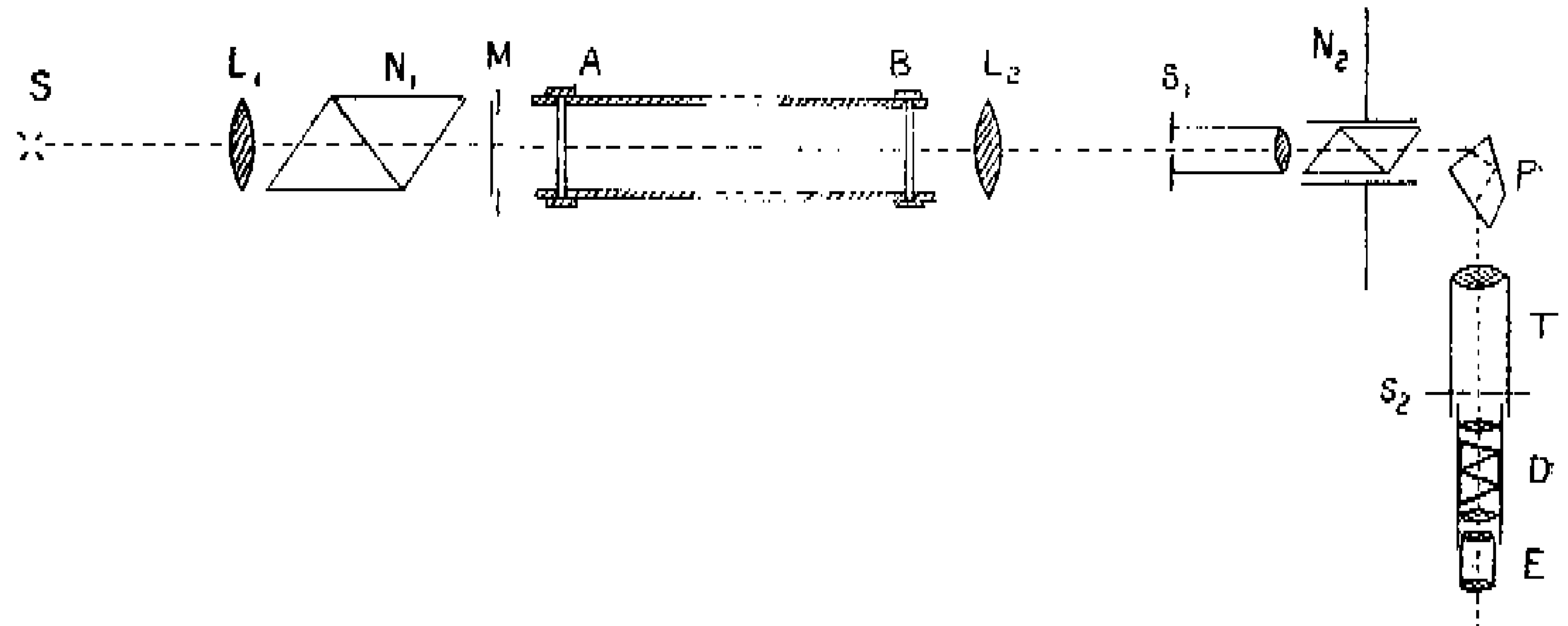
The arrangement of the apparatus is shown in fig. 1.

Light from the source S (the mercury arc or spark as the case may be) passes through the collimating lens L_1 and the polarizing nicol N_1. Sensitiveness is obtained by means of a half-wave plate of mica at M, placed across the middle of the field so as to give a "three-field" arrangement. The sensitiveness can be altered by rotating N_1. The sugar solution was contained in a long iron tube AB, fitted with plate-glass ends. To prevent the solution becoming contaminated with the iron, this tube was galvanized; the inside was painted with photographic black to avoid reflexions. The length of the solution in the tube was about 165 cm., and the rotation for the green mercury line

* Communicated by the Authors.

(λ 5461) was 534·3 degrees. To obtain a sufficiently clear solution it was necessary to mix some freshly precipitated and washed aluminium hydroxide with it and filter the liquid warm. This removes practically all suspended matter.

Fig. 1.



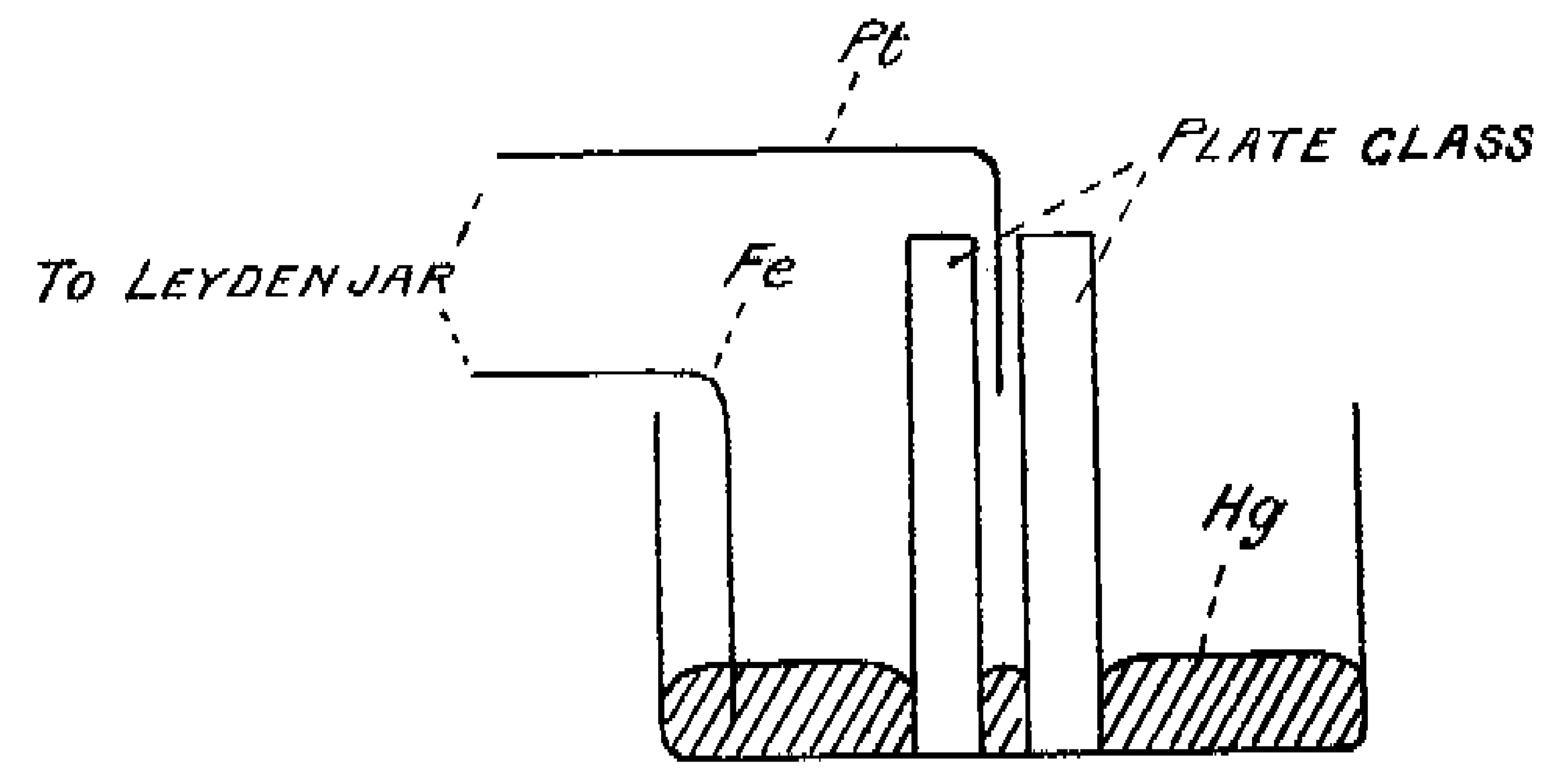
The lens L_2 forms a reduced image of the half-wave plate, M, on the slit s_1. The remainder of the apparatus, comprising the analysing nicol N_2, the constant-deviation prism P, and the telescope T, was adapted from a spectrophotometer. The graduated circle attached to N_2 was fitted with a vernier attachment reading to minutes. Light of the required wave-length is sorted out by rotating the prism P and adjusting the slit s_2. The telescope is focussed on the slit s_1 so that a sharp image of the half-wave plate is seen.

All measurements were made with the green mercury line (λ 5461). Further purification of the light after its passage through P was found necessary, and so the direct-vision spectroscope D was inserted between the eyepiece E and the rest of the telescope. With the light from the arc there was some diffuse light from the yellow mercury lines present, and with the spark, in addition to the diffuse yellow light, some green light on each side of the mercury line, but less intense. This green light was not diffuse but formed a definite image of the half-wave plate.

The spark was produced by the discharge of a large leyden-jar connected with an induction-coil, and passed between a platinum wire and a layer of mercury at the bottom of a glass vessel, contact with the mercury being made with a piece of iron wire soldered on to the end of the lead from the leyden-jar. Considerable inconvenience in taking the readings was caused by the irregular movements of the spark, a small change in its position causing the image formed by the lens L_2 to move off the slit s_1. To keep the spark as much as possible in one position the platinum wire was placed between two pieces of plate-glass standing about

2 mm. apart in the mercury (see fig. 2). The spark gap was about 1 cm.

Fig. 2.



To determine approximately the duration of the spark, photographs were taken of tinned iron wires threaded radially near the rim of a rotating wooden disk, the disk itself being painted black. The disk was driven by a small motor to which was attached a revolution-counter. The following times were observed during which the disk made 500 revolutions :—15·0, 15·4, 14·8, 15·4, and 14·8 secs., giving a mean of 15·1 secs., or 2000 revns. per minute very nearly. The middle points of the wires, each about a centimetre long, were 19 cm. from the centre of the disk. A camera was focussed on the wires so as to give a magnification of 2, and the disk having been set rotating, photographs were taken by the light from the spark. The velocity of the wires being 3980 centimetres per second, a blur of width x cm. on the photograph will be produced by a spark of duration t secs. where

$$x = 2 \times 3980\,t.$$

If the duration of the spark were 3×10^{-6} sec. the blur in the photographs would be ·24 mm. A number of photographs were taken of the moving wires and compared with photographs taken under similar conditions but with the wires at rest. No blur, however, could be detected; therefore the duration of the spark probably does not exceed 3 millionths of a second.

Owing to the intermittent nature of the light from the spark, it was not possible to use the most sensitive arrangement of the apparatus. A half-shade angle of about 12° to 20° was necessary. The reading for the arc was first taken and then the spark substituted for the arc and a fresh observation made. The temperature of the solution was indicated by two thermometers passing through side-tubes—one at each end of the tube containing the solution. The temperature of the solution in all the experiments was about 18° C. It must be pointed out that large readings mean *small* rotation. The position of the *polarizer* is different for each set of readings, so that there is no relation between the numbers in different sets. This of course does not interfere with a comparison of the arc and spark readings.

Set.	Circle-reading for arc-light.	Circle-reading for spark-light.	Set.	Circle-reading for arc-light.	Circle-reading for spark-light.
I.	96° 59′	96° 56′	II.	97° 33′	97° 26′
	54	53		27	15
	56	97 0		25	23
	57	4		30	32
	57	2		33	36
		96 57			29
		97 1			23
		96 57			
		48			
III.	100° 32′	100° 24′	IV.	97° 22′	97° 36′
	30	42		25	9
	34	21		25	32
	33	23		27	26
	35	34		27	23
	30	21		25	20
	34	42		27	53
	33	47		26	15
	31	46		25	30
	33	47		25	29
				27	36
					38

If all the observations are included in the estimate of the means, the values are as follows:—

	Arc.		*Spark.*	
Set I.	96°	56′·6	96°	57′·5
II.	97	29·6	97	26·3
III.	100	32·5	100	34·7
IV.	97	25·5	97	28·9
Grand means ...	98	36·05	98	36·8

The total rotation is about 500°; hence the grand means differ by less than 1 minute in 500°, or less than 1 part in 30,000. It is noteworthy, however, that in three out of the four sets the rotation is less for the spark than for the arc. In the exceptional set (II, spark) occurs one very low reading—too low to be due to ordinary experimental errors. If this reading were excluded there is a difference in the grand means of about one part in 13,000—the rotation in the case of the spark being the less. Since this is within the possible error of the experiment, the final result may be stated by saying that so far as these experiments go there is no certain indication of a directive action of light upon the molecules of the sugar in solution.

University College,
London.

VIII. *On the Viscosity of Calcium Chloride Solutions.* By FREDERICK SIMEON, *B.Sc., Physics Research Scholar, University of London, University College* *.

WHILE the present work was in progress, an account of work on the same subject was read before the Physical Society of London by Mr. Tucker †. However, so much of the present work had been done, and the apparatus in use differed in so many respects from that used by Mr. Tucker, that it seemed well to proceed until a comparison of results could be made.

The apparatus employed was identical in principle with that used by Thorpe and Rodger ‡. It consisted of a horizontal capillary tube, about 30 cm. long and 0·4 mm. in diam., connected to two vertical tubes about 18 cm. long and 1 sq. cm. cross-section. A fixed quantity of the liquid whose viscosity was to be determined was forced through the capillary tube under constant pressure from one upright tube to the other, and the time of passage carefully observed. The apparatus was immersed in a large bath of water at constant temperature until the lines on the upright tubes which determined the volume of liquid transmitted were just visible above the edge of the bath.

At least six, and usually eight to twelve readings of the time of passage, which did not vary by more than about 0·2 per cent., were made for each solution.

The coefficient of viscosity is calculated from the ratio of this time to the corresponding time for pure water, assuming the values for water found by Thorpe and Rodger. The times of passage in opposite directions differ by a very small amount due to slight asymmetry in the apparatus; but, in practice, the times in opposite directions were kept separate, and thus two values for the ratio of viscosities were found which agreed very closely.

* Communicated by Prof. A. W. Porter, F.R.S.
† Proc. Phys. Soc. vol. xxv. p. 111.
‡ Phil. Trans. 1894, A. p. 1.