Density of cathode fraction with long sparks.	Density of oxygen unsparked.	Density of cathode fraction with short sparks.
15·78	15·88	16·00
15·79	15·87	16·01
15·80	15·89	16·02
15·79	15·88	16·04
	15·88	16·06
		16·05

Mean of results of other observers = 15·887.

Density of cathode fraction from oxygen, previously for three days fractionated with short sparks, 15·75.

The experiments are still in progress.

V. "On the Question of Dielectric Hysteresis." By ALFRED W. PORTER, B.Sc., Demonstrator of Physics, University College, London, and DAVID K. MORRIS, 1851 Exhibition Scholar, University College, London. Communicated by Professor G. CAREY FOSTER, F.R.S. Received March 2, 1895.

The condenser on which the following experiments were made is the one referred to in a paper by one of us read before the Royal Society on June 1st, 1893 ('Roy. Soc. Proc.,' vol. 54, p. 7). It is a 5-microfarad condenser of tinfoil and paraffined paper, made by Messrs. Muirhead. In the paper referred to it was shown that when it is allowed to discharge itself through a coil containing induction the rate of dissipation of energy (calculated from the damping of the oscillations that occur) is greater than that due to the resistance of the outside circuit: the additional dissipation being equal to what would have taken place if about 59 ohms had been added to the circuit resistance.

The following experiments were made with the idea of ascertaining whether this additional dissipation is the result simply of viscosity in the dielectric of the condenser or to true hysteresis of the charge with respect to the potential difference between the condenser plates. A sharp distinction is not always made between the two phenomena; it cannot be too clearly borne in mind that, on the one hand, viscosity is a "time" effect—*i.e.*, it depends on the rate of change of the variables; while, on the other hand, the phenomenon of hysteresis does not in any way involve the rate at which the changes in the quantities are made.

Rapidly performed series of cycles, such as occur during an

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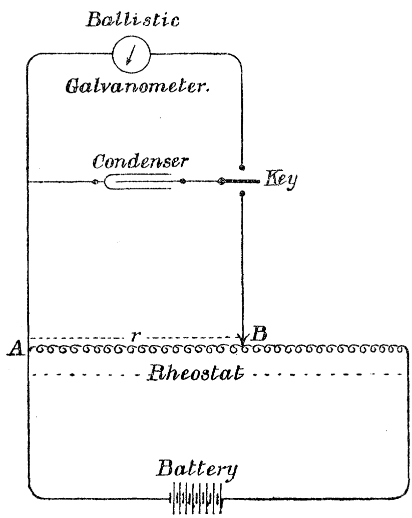
oscillatory discharge, are hence unsuited for discriminating between the two causes: to test whether true hysteresis exists it is essential to so arrange the experiment that all viscous effects shall have had time to subside before any measurement of charge is made. Hence the interesting experiments made during the last three years by Riccardo Arnò,* in which a dielectic cylinder begins to rotate when placed in a rotating electrostatic field, as well as the experiments made by P. Janet,† and by one of us using oscillatory discharges, do not serve as test experiments on this question.

The arrangement which we adopted to test for hysteresis is as follows:—

FIG. 1.



A battery (E.M.F. = 11 volts) is connected permanently in simple circuit with the ends of a rheostat of 850 ohms resistance. The condenser terminals can be put in contact by means of a two-way switch, with one end A, and an intermediate point B of the rheostat.

The position of the point B is capable of continuous adjustment, and hence also is the difference of potential between the condenser

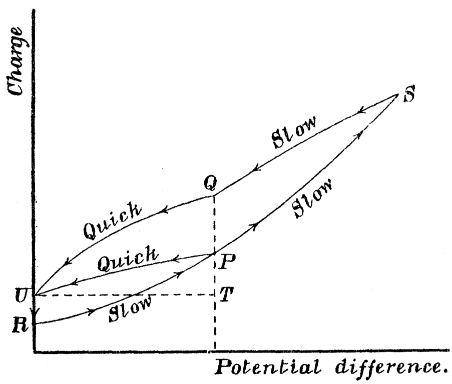
* Published in the 'Rendiconti della R. Accademia dei Lincei,' October 16, 1892, p. 284, April 30, 1893, p. 341, November 12, 1893, p. 260, March 18, 1894, p. 272, June 17, 1894, p. 585, November 18, 1894, p. 294. For translations *vide* 'The Electrician,' March 3, June 23, December 29, 1893, and January 18, 1895.

† "Sur les Oscillations Électriques de Période Moyenne," 'Journ. de Phys.,' August, 1893. For other recent literature on the subject *vide* A. Hess, "Sur les Diélectriques Hétérogènes," 'Journ. de Phys.,' April, 1893; Steinmetz, 'The Electrician,' April 8, 1892 (from the 'Electrical Engineer' of New York).

terminals. The charge that the condenser possesses at any time can be ascertained by discharging it (by means of the switch) through a ballistic galvanometer.

Since the methods for testing for hysteresis consist in putting the thing tested through cyclic series of states, it is essential that any change of state involved in the measuring operations should itself form part of a cycle. This was accomplished by making the cycles in the manner indicated in Fig. 2, which has been drawn as it might appear if considerable hysteresis were present.

FIG. 2.



Commencing at the point R in the cycle (*i.e.* with no difference of potential between the terminals), the potential difference is gradually increased until the point P on the curve is reached; the condenser is then discharged; the portion of the curve PU is traced during the "instantaneous" discharge, and the galvanometer indicates the loss of charge PT, which includes whatever viscous flow takes place during the time of throw of needle ($2\frac{1}{2}$ seconds). While the galvanometer is still in connection with the condenser a further viscous flow takes place, until, if the cyclic state has been set up, the starting point R is arrived at. Before allowing the switch to again connect the condenser to B (Fig. 1) the rheostat is unwound so as to bring B back to A; there is then no potential difference between B and A, and the condenser receives no charge when the switch completes connection. After this connection has been made the potential difference is again gradually increased, but to a higher value than before—to S (say); it is gradually diminished till it has the same value as at P; we thus arrive at a point Q; the condenser is then discharged through the galvanometer; the throw of the needle measures the loss of charge QT, which includes the same

viscous effect as before; the point U is reached during the throw of needle: after which, a further viscous flow takes place, until (if the cyclic state be set up) the point R is returned to once more.

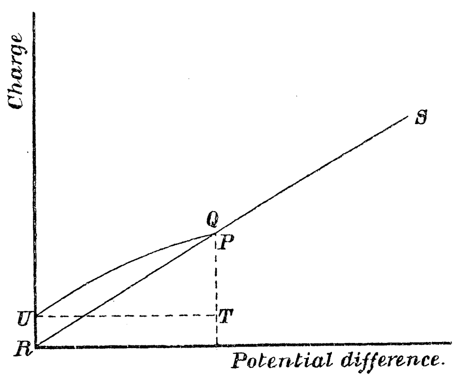
The contact B is moved back to A while the condenser is still detached from it; and this series of operations is then many times repeated.

If the dissipation of energy in the condenser is due to hysteresis, then, as in the magnetic analogue, we know that the cyclic curve will embrace an area, and the point Q will not coincide with the point P; and the converse of this is also true if time has been given for viscous effects to subside.

If, on the other hand, experiment shows no difference in the charge when at Q from what it is at P, there can be no hysteresis, unless of an amount so small as to elude this method of detecting it.

The following figure (Fig. 3) shows the kind of curve that will be traced if hysteresis be absent.

FIG. 3.



The experimental results are given in Table I.

The point P was so chosen that the charge was then almost exactly half of the maximum charge. The duration of a cycle of operations was never less than five minutes. The galvanometer throws were read by a telescope and scale, and are expressed in centimetres. As both galvanometer mirror and telescope are of fine quality there is no difficulty in detecting a tenth of a millimetre on the scale.

It will be observed that the throws fall off gradually throughout the experiment in consequence of gradual failure of the battery power; but as this affects both series to the same extent it has no influence on the ratios. Individual values of the ratio Throw at Q/Throw at P differ amongst themselves by small amounts, being below unity in 11 cases, above in 12, and equal to unity in one case.

Table I.

Discharge at P.		Value of $q-p$.	Discharge at Q.	
Time of discharge.	Galvanometer throw (p).		Time of discharge.	Galvanometer throw (q).
hrs. m.			hrs. m.	
11 27	52·61	−0·11	11 33	52·50
11 37	52·72	+0·06	11 44	52·78
11 48	52·77	−0·01	11 52	52·76
11 56	52·71	−0·01	12 4	52·70
12 6	52·63	+0·02	12 10	52·65
12 12	52·61	+0·03	12 17	52·64
12 21	52·53	+0·06	12 25	52·59
12 28	52·45	+0·06	12 32	52·51
12 36	52·49	+0·05	12 44	52·54
12 46	52·53	−0·03	12 50	52·50
12 53	52·48	−0·03	12 58	52·45
12 60	52·43	−0·02	1 4	52·41
2 39	52·04	+0·02	2 45	52·06
2 54	52·00	−0·02	2 58	51·98
3 4	51·98	−0·03	3 11	51·95
3 14	51·95	−0·06	3 18	51·89
3 21	51·92	+0·04	3 25	51·96
3 27	51·83	−0·05	3 31	51·78
4 32	51·70	−0·07	4 36	51·63
4 39	51·55	+0·04	4 42	51·59
4 44	51·56	+0·02	4 48	51·58
4 55	51·55	+0·02	5 00	51·57
5 4	51·53	+0·03	5 8	51·56
5 11	51·53	+0·00	5 16	51·53

	At P.	At Q.
Mean of first 12 throws	52·580	52·586
Mean of second 12 throws	51·762	51·757
Mean of all 24 throws........	52·1710	52·1715

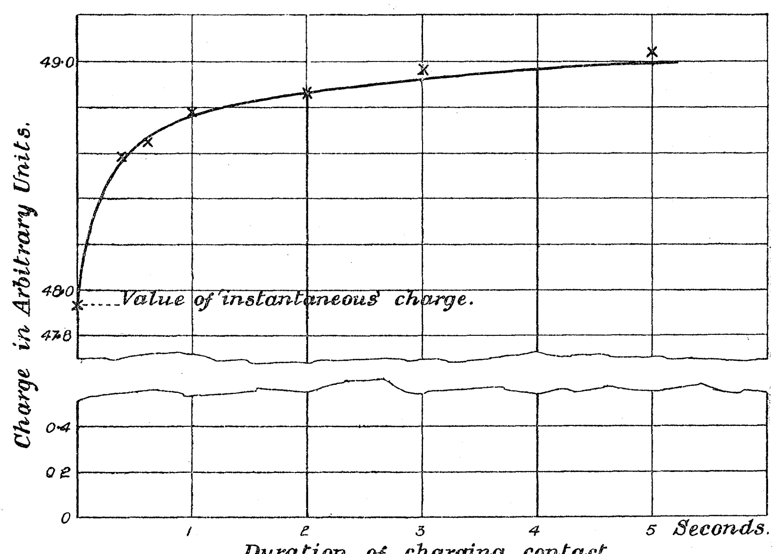
The ratio derived from the first twelve values is $1+\frac{1}{8760}$, that derived from the second twelve values is $1-\frac{1}{10350}$. The best values of the ratio derived from all 24 values approximates still more closely to unity.

Hence the position of the point Q in the diagram is indistinguishable from the position of the point P; and we may conclude that when time has been given for viscous effects to subside the charge of the condenser is the same for a given value of the potential difference, whether that value has been arrived at from higher or from lower values than itself.

Since, until further experiments be made, this conclusion can only be taken as applying to the condenser when under the conditions of this experiment, it is necessary to form an idea as to the highest value of the electromotive intensity which was produced in the dielectric. Only a very rough estimate of its value can be made without dismounting the condenser. If we assume that the thickness of the paraffined paper is about ·01 cm., then with 11 volts potential difference between the plates, the electromotive intensity equals 1,100 volts per cm., or about 3·7 electrostatic units. If we take the dielectric constant of paraffined paper as 2, the corresponding electrostatic induction is 7·4 electrostatic units. It may be mentioned that in the experiments of Signor Arnò the induction ranged from ·03 to 14·58 electrostatic units.

In order to give an idea of the viscous effects which come into play in the same condenser, we have ascertained the variation of the charge which it takes up on the application of an unvaried E.M.F. to its terminals for different intervals of time. The results are plotted in Fig. 4. The time constant of the rise of charge, calculated from the capacity of the condenser and the resistance of the circuit through

FIG. 4.—Relation between Charge of Condenser and the Duration of Application of Charging Electromotive Force.



which it was charged, was less than $\frac{1}{20000}$ of a second: hence in 7 times $\frac{1}{20000}$ of a second the charge would have risen to within $\frac{1}{10}$ per

cent. of its final value if dissipation of energy had taken place only in the outside circuit.

Thus, while the condenser here experimented upon exhibits marked viscous effects, yet we can detect no hysteresis.

The foregoing experiments were conducted in the Physical Laboratory of University College, London, and our thanks are due in many respects to Professor G. Carey Foster in connection with them.

VI. "On the Changes in Movement and Sensation produced by Hemisection of the Spinal Cord in the Cat." By CHARLES DEVEREUX MARSHALL, F.R.C.S. Communicated by Professor V. HORSLEY, F.R.S. Received January 31, 1895.

(Abstract).

The present research was undertaken in order to determine more exactly the nature and origin of epileptiform convulsions and the paths in the spinal cord by which both afferent and efferent impulses are transmitted.

The method employed was as follows :—

Hemisection of the spinal cord was performed in the lower dorsa region on the right side, the animals being anæsthetized with ether and strict antiseptic precautions being observed.

The animals were kept alive for different periods of time after the operation, and the effects produced on the voluntary movements, sensibility, and the reflexes were carefully noted.

After death the spinal cords were at once removed, and after hardening and staining, by Marchi's method, both the lesion and the tracts of degeneration were investigated by microscopic examination. There were 16 experiments performed.

The following results are briefly what were obtained.

(*a.*) *Motion.*—After hemisection of the cord there is immediate paralysis of the limb below, and on the same side as the section, this remains for a time, and then gradual recovery takes place to a greater or less extent; sometimes the recovery is so complete that it is with difficulty that one can determine which was the paralyzed limb. At other times more or less permanent weakness is left so as to cause a limp when walking, foot-drop is not infrequently seen and the animal does not appear to appreciate correctly the position that the leg occupies.

(*b.*) *The Reflexes* are, as a rule, greatly exaggerated below and on the same side as the lesion, and sometimes continue so for a long period; in many cases they get less as time goes on; occasionally they are not so well marked as on the opposite or uninjured side.