expresses the temperature at time t, if when $t=0$ the temperature is expressed by

$$v=1-\frac{1}{2}\frac{\mathrm{E}a}{k}\frac{x^2}{a^2}.$$

Taking, for instance, the copper globe of 4 centimetres diameter, we have

$$v=\left(1-\frac{1}{4000}\frac{x^2}{a^2}\right)\epsilon^{-\frac{3\mathrm{E}}{ac}t}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and we see that in the Glasgow experiments the difference of temperatures between surface and centre was just $\frac{1}{4000}$ of the excess of either above the temperature of the surrounding medium, when time enough had elapsed to allow the first term of Fourier's series to be the predominating one. *Before* that time the difference of temperatures must have been *less* than $\frac{1}{4000}$ of either, if initially the temperature was uniform from surface to centre. The Fourier analysis of the transition from the supposed initial uniform distribution to the state represented by (3) is exceedingly interesting, but unnecessary for the settlement of the present question.

VII. "Preliminary Results of an Investigation on the Electric Conductivity of Glass at different Temperatures." By John Perry, B.E., Thomson Experimental Scholar in The Natural Philosophy Laboratory at Glasgow*. Communicated by Professor Sir William Thomson, F.R.S., LL.D. Received April 8, 1875.

A quadrant electrometer now in use in the laboratory seems to retain its whole charge from day to day; a week's loss is just perceptible, and may be supplied by a few turns of the replenisher. In a guard-ring electrometer now in use the charge is almost wholly retained from week to week. These qualities are due to the exceptionally great insulation-resistance of the glass employed.

At various times experiments have been made in the laboratory at Glasgow to determine the insulation-resistance of different kinds of glass. Of the specimens hitherto examined, those of flint glass have insulated best; and it is hoped that experiments on flint glass now being proceeded with will define the most suitable glass for use in electrometers and other electrical instruments.

The method of investigation is essentially the same as that which was adopted by Sir William Thomson some years ago. B D A (fig. 1) is a

* Now Professor of Engineering in the Imperial College of Engineering, Jeddo, Japan.

hollow glass globe with a long stem. C is a brass insulator with pumice and sulphuric acid, to keep the stem free from moisture. C is supported on a stand resting on the table. A wooden clamp supports A B at A. B D is covered with tinfoil or with wet linen cloth. W is water inside the globe.

Fig. 1.

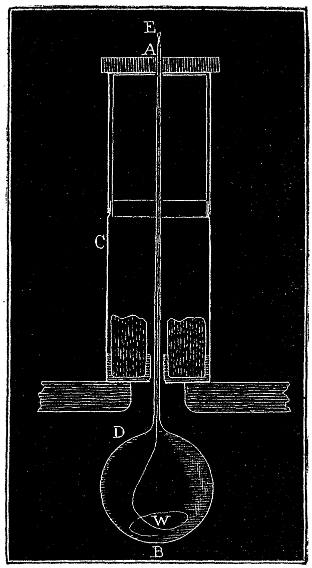
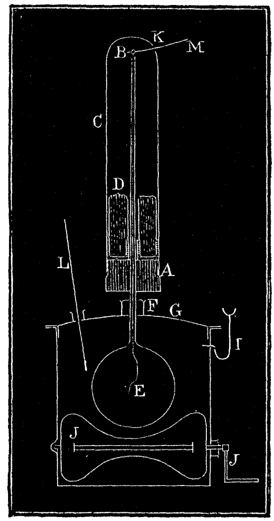


Fig. 2.



For a lecture illustration Mr. M'Farlane, on March 13th, 1874, charged a flint-glass jar, the globe of which was 13 centims. in diameter and about 0·13 centim. thick. The inside coating was put to earth by means of a wire; the outside was connected with the electrometer and then charged. The wire was then withdrawn from the inside, and the stem was sealed at E. On March 20th B D was again insulated and connected with the electrometer; the stem was broken at E, and the inside put to earth as before. The original charge was 2170. At the end of a week the charge was found to be 1952. The week's loss was 218, or 10 per cent.

The jar was again sealed on March 20th with a charge of 1875. On April 7th the charge was 1332; so that the loss in 18 days was 543, or 28 per cent. of the whole charge.

On Jan. 5th, 1875, the author gave a charge of 1465 to a flint-glass jar. On March 16th the electricity had all disappeared. Another flint-glass jar charged to 1048 on Jan. 5th, when opened on March 16th had a charge of 144, the loss in 70 days being 904, or 86 per cent.

Twenty flint-glass jars, of the shape shown in fig. 1, are now being examined. The composition of the glass of each jar is known to the manufacturer, and glass of the same composition as that of any particular jar is readily to be obtained. The diameter of the bulbs is about 9·5 centims. and their thickness about 0·25 centim. A jar is filled with water nearly to the top of the stem. A wet cloth covering all parts of the bulb and stem below the level of the insulator forms an outside coating. After being sealed, the jars are placed in running water, the temperature of which is never greater than 50° F., nor less than 46° F. The following observations have been made :—

Jar No. 4. Charged 994. Opened after 10 days. No charge remaining.

„ No. 9. Charged 2085. Opened after 7 days 6 hours. The charge remaining was 276.

„ No. 19. Charged 1933. Opened after 10 days. The charge remaining was 868.

The arrangement shown in fig. 2 was employed to determine the relation between temperature and electric conductivity in a flint-glass jar. The jar was filled to the height A, at ordinary temperature, with sulphuric acid. A is a cork supporting the glass insulator C, with the lead trough D containing pumice moistened with sulphuric acid. A piece of platinum wire hangs into the sulphuric acid and terminates in a loop at B, so that the inside coating of the jar is insulated. A stiff wire, M K, soldered to the electrode of the guard-ring electrometer, passes through a small hole at K without touching the glass insulator. Contact between B and this wire may be made or unmade by a small motion of the apparatus. E is surrounded by water. L is a thermometer, J a stirrer. I supplies water when necessary. G is connected with the outside of the electrometer.

To test the cleanness of the glass stem from A to B, a charge was given to the jar by the wire K M. After a certain time no further diminution of charge was observable during ten minutes, and the electrometer-wire was removed, the hole K being closed. The charge was given on Friday. On Monday it was found that less than 20 per cent. had been lost, a proof that the stem was clean, and that the insulation-resistance of the sides of the bulb was very considerable.

The first results obtained by the author are given here in preference to those which have since been obtained. They exhibit the joint effects of polarization and true conductivity, and are instructive when examined along with the table of approximately true conductivity given below. The jar was charged by an electrophorus; when polarization had sensibly ceased, a lamp was placed under the vessel.

The change of temperature between successive readings was pretty regular, except when water was poured in. When hot water was poured in the stirrer was kept in rapid motion.

The rapidities of loss are obtained by dividing the Napierian logarithm of the quotient of two charges or readings by the interval in minutes between the two observations. Thus it is roughly assumed that the capacity of the jar is the same at all temperatures.

Time.	Temp. F.	Reading.	Rapidity of loss.	
h m	°			
1 20 P.M.	56½	1184		
25	63	1184	0	
30	69	1184	....	Poured in hot water after reading.
35	78	1170	....	" " "
40	94	1154		
45	98	1149	0·0023	
50	103	1132		
55	107	1126		
2 0	110	1086	0·0037	
5	116	1080		
10	120	1053		
15	124	1036		
20	128	1011		
25	131	982		
30	134	950	0·0055	
35	138	924		
40	140	894		
45	143	861		
50	144	828	0·0099	
55	146	781	....	Poured in hot water after reading.
3 0	147½	740	....	Lamp taken away after reading.
5	147½	712		
10	150	690		
15	151	658		
				Charged again.
45½	181·5	1330		
47½	184·2	1137		
50	193·5	936		
52½	201·7	707	0·0120	
55	206·7	495		
56	205·5	443		
57	208	375	0·2776	
58	211·5	319		
				Charged again.
4 5	206	953		
6	206·5	614		
6½	211	518	0·2128	
7½	207	446		
				Charged again.
10½	205·5	1070		
12½	205·5	764		
13½	205	648		
14½	203·5	550		
15½	195	482	0·1982	
16½	192	442		
17½	190·5	422		
				Charged again.
22½	185·5	978		
23½	184·5	905		
24½	184	837		
25½	171	755	0·0391	
26½	170·2	726		
29	159·7	678	....	Poured in cold water after reading.
30	159	662		

The polarization which occurs after charging is very marked. Some of the later tables of results seem to indicate an increased polarization due to increase of temperature. Thus, when at any low temperature the conductivity calculated from successive intervals is nearly constant, if the temperature is rapidly raised and then kept constant, the conductivity at the new temperature diminishes for a short time as if the jar had just been charged.

[In such a jar the charge is approximately represented by

$$\frac{\mathrm{IAV}}{4\pi a},$$

where I is the specific inductive capacity of the glass, V the reading of the electrometer, and a the thickness of the glass. But if k is the specific conductivity of the glass, the rate of conduction through it is

$$k\mathrm{A}\frac{\mathrm{V}}{a},$$

and the quantity conducted through, divided by the charge, is equal to

$$\frac{4\pi k}{\mathrm{I}}.$$

Hence

$$\frac{k}{\mathrm{I}}=\frac{1}{4\pi}\cdot\frac{\text{difference of Napierian logarithms}}{\text{difference of times}}.$$

Thus the rapidity of loss given above multiplied by the specific inductive capacity, and divided by 4π, represents the specific conductivity of the glass.

To determine the following Table of conductivities as measured by rapidity of loss, the jar was kept long enough at each temperature for the polarization to become insensible.

Temp. F.	58°	86°	148°	166°	188°	202°	210°
Rapidity of loss	0·000	0·004	0·021	0·025	0·051	0·075	0·084
Rapidity as corrected by a freehand curve	0·000	0·004	0·018	0·029	0·051	0·073	0·090
Rapidity as given by the formula	0·000	0·003	0·018	0·029	0·051	0·072	0·091

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The free curve drawn to correct the observed conductivities was found to approximate very closely to the logarithmic curve

$$\mathrm{C}=c\,a^{t},$$

where C is the conductivity at the temperature $166+t$, c is the conductivity given by the free curve for 166° F., and a is 1·027.

Messrs. Bright and Clark found that the conductivity of gutta percha followed a similar law.

The author hopes to obtain some definite results with regard to polarization, and to determine for flint glass the law of temperature and absolute specific resistance.

Fig. 1.

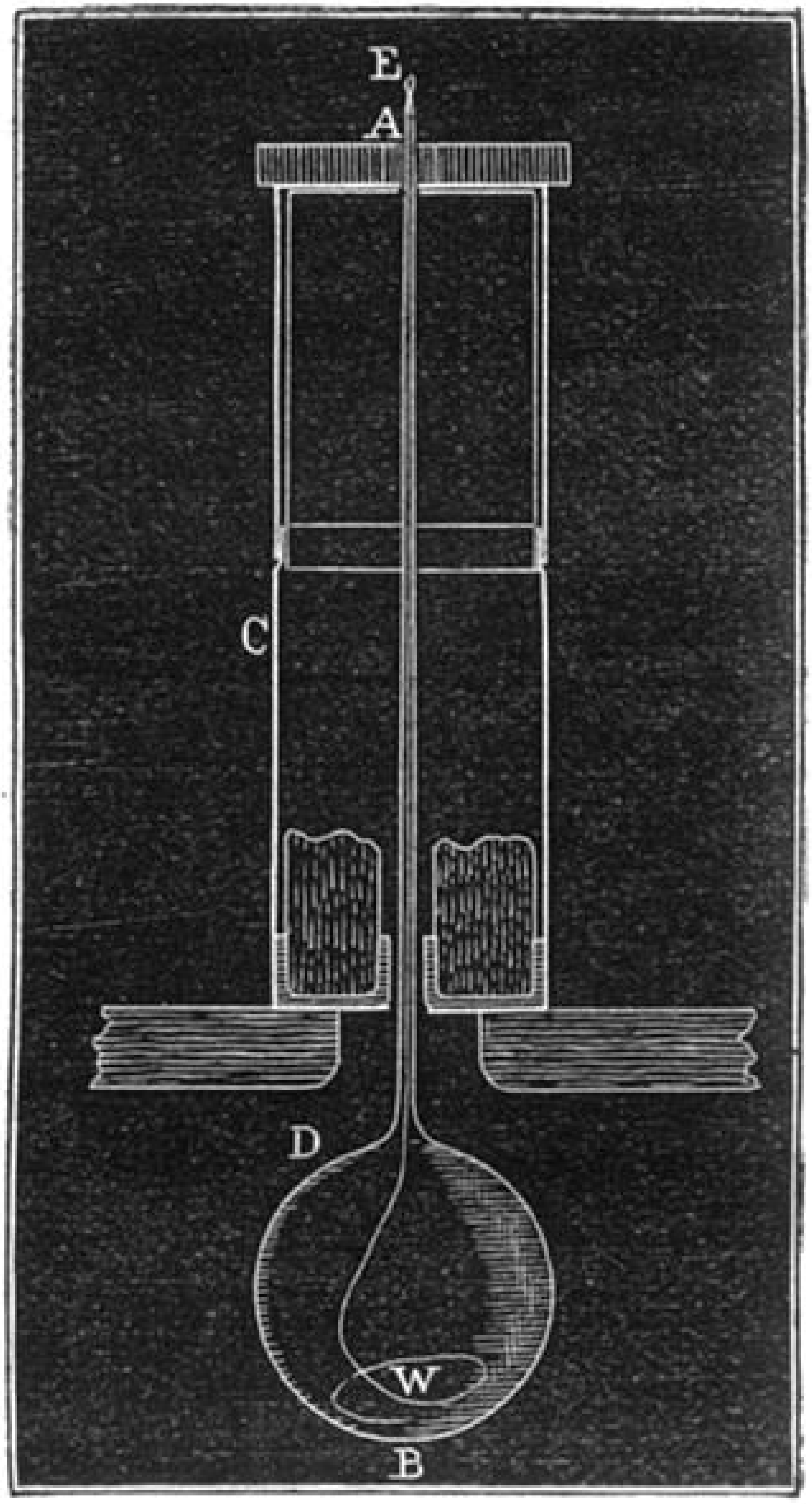

Fig. 2.