II. "Residual Charge of the Leyden Jar.—II. Dielectric Properties of various Glasses." By J. Hopkinson, M.A., D.Sc. Communicated by Prof. Sir William Thomson, F.R.S. Received November 30, 1876.

(Abstract.)

I. The two following propositions are included under the law that the effects of simultaneous electromotive forces are superposable.

(*a*) If two jars be made of the same glass but of different thicknesses, if they be charged to the same potential for equal times, discharged for equal times, and then insulated, the residual charge will after equal times have the same potential in each.

(*b*) Residual charge is proportional to exciting charge.

These propositions are verified experimentally within the limits of errors of observation.

II. Electric displacement through a dielectric may be supposed to depend not only on the electromotive force at the instant, but also in part on the electromotive forces at all previous times. If we assume that the effect of the electromotive force at any previous time decreases according to some law as the time elapsed increases, and that these effects are superposable, we may write

$$y_t = x_t + \int_0^\infty x_{t-\omega} \psi(\omega)\, d\omega,$$

where x_t is the electromotive force at time t, and y_t is the surface integral of electric displacement divided by the instantaneous capacity of the jar.

If $\psi(\omega)$ is determined for all values of ω, the properties of the glass as regards conduction and residual charge are completely expressed.

$\psi(\infty)$ is equal to the reciprocal of the specific resistance of the material multiplied by 4π and divided by the specific inductive capacity. During insulation y_t is constant; hence

$$x_t = \text{A} - \int_0^\infty x_{t-\omega} \psi(\omega)\, d\omega.$$

This is the fundamental equation of the following experiments.

Two methods of finding values of $\psi(\omega)$ present themselves.

1st. Let x_t be constant $=$ X for a time T; insulate for time t.

$$x_t = \text{A} - \int_0^{t+\text{T}} x_{t-\omega} \psi(\omega)\, d\omega;$$

$$\frac{dx_t}{dt} = -\text{X}\,\psi(t+\text{T}) - \int_0^\infty \frac{dx_{t-\omega}}{dt} \psi\, \omega d\omega;$$

if t be small,

$$\frac{dx_t}{dt} = -\text{X}\psi(\text{T}),$$

and the value of $\frac{dx_t}{dt}$ may be observed with more or less accuracy.

2nd. Let x_t be constant $=$ X for a very long time T previous to time $t=0$; discharge and at time t insulate and observe $\frac{dx_t}{dt}$.

$$x_t = \text{A} - \text{X}\int_t^{\text{T}+t}\psi(\omega)d\omega\,;$$

$$\frac{dx_t}{dt} = \text{X}\left\{\psi(t) - \text{B}\right\}.$$

There are also methods of verification; for example:—Charge during time T′, reverse the charge for time T″ and discharge; then after time t insulate and observe $\frac{dx_t}{dt}$; we shall find

$$\frac{dx_t}{dt} = \text{X}\left\{\psi(t) - 2\psi(\text{T}'' + t) + \psi(\text{T}'' + \text{T}' + t)\right\}.$$

III. Experiments were tried on ten glasses. The verifications were perhaps as close as could be expected, considering that no attempt was made to observe at a constant temperature. The glasses were:—

No. 1. A soda-lime glass containing much soda.
No. 2. A soda-lime glass coloured deep blue with oxide of cobalt.
No. 3. Window-glass.
No. 4. Optical hard crown.
No. 5. Soft crown.
No. 6. A very light flint glass.
No. 7. Light flint.
No. 8. Dense flint.
No. 9. Extra-dense flint.
No. 10. Opal glass.

Glasses 1, 2, and 3 agree in possessing high conductivity and also large values of $\psi t - \text{B}$; whilst 7, 8, 9, 10 have a high resistance (thousands of times as great as 1, 2, or 3) and small residual charge.

IV. Electrolytic conduction may occur through the soda-lime glasses at the ordinary temperature of the air.

Summary.—The experiments appear to verify the fundamental hypothesis, viz. that the effects on a dielectric of past and present electromotive forces are superposable. Ohm's law asserts the principle of superposition in bodies in which conduction is not complicated by residual charge. Conduction and residual charge may be treated as parts of the same phenomenon, an after effect as regards electric displacement, of electromotive force. The experiments appear to show that the principle of Ohm's law is true of the whole phenomenon of conduction through glass.