



Philosophical Magazine Series 5

ISSN: 1941-5982 (Print) 1941-5990 (Online) Journal homepage: <http://www.tandfonline.com/loi/tphm16>

LV. On a test for telegraph lines

Oliver Heaviside

To cite this article: Oliver Heaviside (1878) LV. On a test for telegraph lines , Philosophical Magazine Series 5, 6:39, 436-438, DOI: [10.1080/14786447808639537](https://doi.org/10.1080/14786447808639537)

To link to this article: <http://dx.doi.org/10.1080/14786447808639537>



Published online: 13 May 2009.



Submit your article to this journal [↗](#)



Article views: 5



View related articles [↗](#)

one has been able to discover the true and most active cause of those currents, as well as of the electrical phenomena of the atmosphere in general. In fact there are good grounds for asserting that none of the explanations given, up to the present, of these phenomena will bear the examination of scientific criticism. If, till now, no one has seen in these phenomena the results of the unipolar induction of the earth, it is, without any doubt, because an idea has been formed of the nature of that induction which did not permit its application to this object.

There still remain many things that are obscure in the phenomena of the aurora borealis and atmospheric electricity. Of these it will be sufficient to indicate the secular periods in the frequency of auroræ boreales. The relation of these periods with the solar spots gives positive evidence of the cooperation of extratellurian forces. The preceding statement has no claim to be presented as a complete theory of atmospheric electricity and auroræ boreales. My intention has been simply to show that the unipolar induction of the earth plays a most important and significant part in the explanation of those phenomena, and that it ought not to be neglected by those physicists who hereafter apply themselves to this matter.

LV. On a Test for Telegraph Lines.

By OLIVER HEAVISIDE*.

THE true conduction and insulation resistances of a uniform line may be found from the potential and current at the ends, when a constant electromotive force acts at one end. Suppose at one end A of the line there is a battery of electromotive force E , and a galvanometer, the two together of resistance R_1 ; also at the other end B of the line a galvanometer of resistance R_2 , the circuit being completed through the earth. If the potential at distance x from A, where $x=0$, is v , the current at the same point γ , the conduction and insulation resistance k and i respectively per unit of length, then

$$\frac{d^2v}{dx^2} = h^2v,$$

where

$$h^2 = \frac{k}{i};$$

and

$$\gamma = -\frac{1}{k} \frac{dv}{dx};$$

* Communicated by the Author.

whence

$$\left. \begin{aligned} v &= a\epsilon^{hx} + b\epsilon^{-hx}, \\ \gamma &= -\frac{1}{\sqrt{ki}}(a\epsilon^{hx} - b\epsilon^{-hx}), \end{aligned} \right\} \quad \dots \quad (1)$$

where a and b are undetermined constants.

If now the potential and current at A are v_1 and γ_1 , and the same at B are v_2 and γ_2 , then it may easily be shown from equations (1) that

$$ki = \frac{v_1^2 - v_2^2}{\gamma_1^2 - \gamma_2^2} \quad \dots \quad (2)$$

Since the length of the line does not appear in (2), the relation therein expressed applies to any two points of the line. The reason is that the product of the conduction and insulation resistances is the same for any length, the one varying directly and the other inversely as the length. Now the insulation of land-lines is in this country very variable, while the real conduction resistance (*i. e.* its resistance if it were perfectly insulated) is nearly constant. It follows that (2) may be used for determining i , considering k as constant. In (2),

$$\left. \begin{aligned} v_1 &= E - R_1\gamma_1, \\ v_2 &= R_2\gamma_2. \end{aligned} \right\} \quad \dots \quad (3)$$

R_1 and R_2 being interposed resistances are, of course, known; so that three quantities have to be observed, viz. E , γ_1 , and γ_2 ; or equivalent information must be obtained. To make the test in its simplest form, let the resistances R_1 and R_2 be small compared with the line resistance. Also, let equally sensitive tangent-galvanometers be used, and let n_1 and n_2 be the deflections corresponding to γ_1 and γ_2 , and n_3 the deflection E gives through 1000 ohms. Then (2) becomes

$$ki = \frac{n_3^2}{n_1^2 - n_2^2} \times 10^6, \quad \dots \quad (4)$$

where k and i are both in ohms; or if k is in ohms and i in megohms, the 10^6 must be cancelled.

If R_1 and R_2 are taken into account, then instead of (4) we have

$$ki = \frac{(10^3 n_3 - R_1 n_1)^2 - (R_2 n_2)^2}{n_1^2 - n_2^2};$$

and if the galvanometers are not equally sensitive, the deflection n_2 must be multiplied by the ratio of the sensitiveness of the galvanometer at B to that at A.

Using formula (4), the test can be easily made, though it is

obvious that the line must be long enough to make an appreciable difference between the sent and received currents.

We may also determine k and i separately from the same data. If l is the length of the line, then

$$\left. \begin{aligned} kl &= \sqrt{ki} \log \frac{v_1 + \gamma_1 \sqrt{ki}}{v_2 + \gamma_2 \sqrt{ki}}, \\ \frac{i}{l} &= \sqrt{ki} \div \log \frac{v_1 + \gamma_1 \sqrt{ki}}{v_2 + \gamma_2 \sqrt{ki}}. \end{aligned} \right\} \dots \dots (5)$$

It is to be observed that these formulæ give the true conduction and insulation resistances. The measured resistances, or those deduced from observations with the bridge, differential galvanometer, &c., at the battery-end alone, are very different from the true, when the line is long and badly insulated. The measured is always less than the true conduction resistance, and the measured always greater than the true insulation resistance; while the measured conduction resistance can never be greater than \sqrt{ki} , and the measured insulation resistance never less.

LVI. *On Electrical Discharges in Insulators.* By Dr. W. C. RÖNTGEN, *Professor of Physics in the University of Strassburg*.*.

IN the following communication are contained the results of an experimental investigation begun long since, but often interrupted, on the disruptive discharge of electricity through insulators; for I had set myself the task to discover whether in such a discharge there exists any expressible relation between the physical constitution of the insulator, the difference of potential required for a discharge, and the quantity of electricity discharged. The investigation extended to solid, liquid, and gaseous bodies; but up to the present time I have only succeeded with the latter in finding such a relation.

The solid bodies, mostly crystals, were placed, in the form of thin plates, between two rounded-off brass points, one of which was led away to earth, the other connected with a source of electricity, mostly a Holtz machine. By slow rotation of the machine the potential was raised until a spark passed through the thin plate. An electrometer specially constructed for the present case permitted the course of the potential to be

* Translated from a separate impression, communicated by the Author, from the *Nachrichten der Kön. Gesellschaft zu Göttingen*, 1878.