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# ON THE DETERMINATION

OF THE

# VARIATION OF THE THERMAL CONDUCTIVITY

OF

# METALS WITH TEMPERATURE,

BY MEANS OF THE

# PERMANENT CURVE OF TEMPERATURE ALONG A UNIFORM THIN ROD HEATED AT ONE END.

(SECOND PAPER.)

BY

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# *On the Determination of the Variation of the Thermal Conductivity of Metals with Temperature, by means of the permanent Curve of Temperature along a uniform thin Rod heated at one end.* (*Second Paper**.)

*To the Editors of the Philosophical Magazine and Journal.*

GENTLEMEN,

I WROTE to you last May stating that I had made an oversight in the beginning of the paper on Thermal Conductivity which you published in the March and April Numbers of the Philosophical Magazine, and promising to go through the calculation again and make the necessary correction as soon as I conveniently could.

The slip consisted in setting out with the ordinary equation to the curve of permanent temperature down a rod

$$\frac{d^2\theta}{dx^2}=\frac{\mathrm{H}p}{kq},$$

which is true when $k$ is constant, and working with it as if it were equally valid when $k$ is assumed to be variable. The oversight was inexcusable, because in § 2 of the paper referred to I indicated, for the sake of completeness, the ordinary way in which this fundamental equation is obtained, and I thoughtlessly wrote the gain of heat per second by an element of the rod at a distance $x$ from the origin as

$$kqd\frac{d\theta}{dx}$$

as usual, instead of what it obviously becomes when $k$ is not considered constant,

$$dkq\frac{d\theta}{dx};$$

and this slip it is which necessitates my troubling you with the following further communication on the subject, and requires an apology from me both to you and to your readers.

The term containing $\frac{dk}{d\theta}$ which I omitted is but a small one, however, and does not make very much difference to the result: hence the sections 16–20, though superseded by the present communication, are not exactly incorrect, but are first approximations; and the curve A spoken of in § 21, and drawn in Plate X., does represent the character of the curve of temperature down a long iron rod *in vacuo*, with one end

* Read before the Physical Society, as a correction of the first paper.

300° hotter than the other. But no calculation of the variation coefficient of conductivity is likely to be possible by means of equations from which the term $\frac{dk}{d\theta}$ had been omitted.

I am, Gentlemen,
Your obedient Servant,
OLIVER J. LODGE.

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30. With the exception of the correction now indicated in equations (1) and (3), the first fifteen sections of the paper are quite unaffected by the slip, and may remain as they stand, except that I have now a little more to say on the subject of §§ 5–9.

Professor Tait has been kind enough to send me a copy of his researches on "Thermal and Electric Conductivity," read before the Royal Society of Edinburgh in March and June 1878; and I find that he has given up his enticing speculation as to the inverse variation of thermometric conductivity with absolute temperature—and in fact that he believes iron to be possibly exceptional in the inverse connexion of conductivity and temperature, all other metals which he has subjected to experimental observation showing a slight *increase* of conductivity as the temperature rises. Prof. Tait's results are thus in opposition to the results of Prof. Ångström for copper; but since Prof. Ångström, in the interpretation of his very ingenious method of experiment, used the ordinary Fourier equations, formed on the supposition that $k$ is constant, and that rate of cooling is proportional to excess of temperature, Prof. Tait does not consider his observations competent to decide a point as to the variability of $k$. Without venturing an opinion of my own on the subject, it is evident that this opposition is an additional reason for attacking the important question of the law of the variation of thermal conductivity with temperature.

Prof. Tait finds that a linear function of the temperature, $k=a+bt$, will express the value of the thermal conductivity according to his experimental results, at least in their present preliminary stage; and we saw in § 8 that Prof. Forbes's results for iron could be expressed nearly as

$$k=\cdot207(1-\cdot00144\,t);$$

hence instead of the law of variation of *thermometric* conductivity,

$$\frac{k}{c\rho}=\frac{A}{b+t},$$