13. *Tait’s Hypothesis.—*From general considerations concern­ing minimum dissipation of energy (*Proc. R. S. Edin.,* 1867-68), Tait was led to the conclusion that “ the thermal and electric conductivities of metals varied inversely as the absolute tem­perature, and that the specific heat of electricity was directly proportional to the same.” Subsequent experiments led him to doubt this conclusion as regards conductivity, but his thermo­electric experiments (*Proc. R. S. Edin.,* December 1870) appeared to be in good agreement with it. If we adopt this hypothesis, and substitute *s=2cT,* where c is a constant, in the fundamental equation (9), we obtain at once d2*PE∣dTi=* — 2 *{c'—c"),* which is immediately integrable, and gives

*dEfft = p=2{to-t) {c,-c")* .... (10)

*Et.l' = {l-l') {c'-c")* (2⅛-(∕+t')l . . . (ιι)

where *ti* is the temperature of the neutral point at which *dE∣dt=o.* This is the equation to a parabola, and is equivalent to the empirical formula of Avenarius, with this difference, that in Tait’s formula the constants have all a simple and direct interpretation in relation to the theory. Tait’s theory and formula were subsequently assimilated by Avenarius (*Pogg. Ann.,* 149, p. 372, 1873), and are now generally attributed to Avenarius in foreign periodicals.

In accordance with this hypothesis, the curves representing the variations of thermoelectric power, *dE/dt,* with temperature are straight lines, the slope of which for any couple is equal to the difference of the constants *2(c'-c").* The diagram con­structed by Tait on this principle is fully explained and illus­trated in many text-books, and has been generally adopted as embodying in a simple form the fundamental phenomena of thermoelectricity.

14. *Experimental Verification.—*Tait’s verification of this hypo­thesis consisted in showing that the experimental curves of E.M.F. were parabolas in most cases within the limits of error of his obser­vations. He records, however, certain notable divergencies, parti­cularly in the ease of iron and nickel, and many others have since come to light from other observations. It should also be remarked that even if the curves were not parabolas, it would always be possible to draw parabolas to agree closely with the observations over a restricted range of temperature. When the question is tested more carefully, either by taking more accurate measurements of temperature, or by extending the observations over a wider range, it is found that there are systematic deviations from the parabola in the majority of cases, which cannot be explained by errors of experiment. A more accurate verification of these rela­tions, both at high and low extremes of temperature, has become possible of late years owing to the development of the theory and application of the platinum resistance thermometer. (See Ther­mometry.) The curves in fig. 2 illustrate the differences from the parabolic formula, measured in degrees of temperature, as observed by H. Μ. Tory (*B.A. Report,* 1897). The deviations for the copper-iron couple, and for the copper cast-iron couple over the range 0° to 200° C., appear to be of the order of 1° C., and were carefully verified by repeated and independent series of observations. The deviations of the platinum and platinum-rhodium 10 per cent. couple over the range 0° to 1000° C. are shown on a smaller scale, and are seen to be of a similar nature, but rather greater in pro­portion. It should be observed that these deviations are continuous, and differ in character from the abrupt changes observed by Tait in special cases. A number of similar deviations at temperatures below 0° C. were found by the writer in reducing the curves repre­senting the observations of Dewar and Fleming (*Phil. Mag.,* July 1895) to the normal scale of temperature from the platinum scale in which they are recorded. In many cases the deviations do not appear to favour any simple hypothesis as to the mode of variation of *s* with temperature, but as a rule the indication is that x is nearly constant, or even diminishes with rise of temperature. It may be interesting therefore to consider the effect of one or two other simple hypotheses with regard to the mode of variation of x with *T.*

15. *Other Assumptions.—*If we take the analogy of a perfect gas and assume x=constant, we have

*dElldTi=-s∣T, dE∕dT=s∖og .Tl>∣T . .* (12)

*Eiτ-r) = sT∖ogtTo∣T-sT"∖og.T^∣T . .* (13)

where *T* and *T'* are the temperatures of the junctions, and *T,* is the neutral temperature. These formulae are not so simple and convenient as Tait’s, though apparently founded on a more simple assumption, but they frequently represent the observations more closely. If we suppose that x is not quite constant, but increases or diminishes slightly with change of temperature according to a linear formula *s=s0+2cT* (in which xo represents the constant part of x, and c may have either sign), we obtain a more general formula which is evidently the sum of the two previous solutions and may be made to cover a greater variety of cases. Another simple and possible assumption is that made by A. Stansfield *{Phil. Mag.,* July 1898), that the value of x varies inversely as the absolute temperature. Putting *s=c∣T,* we obtain

Eιr-τo=c log .Γ∕Γ-c(Γ-Γ)∕Γo . . . (14)

which is equivalent to the form given by Stansfield, but with the neutral temperature *To* explicitly included. According to this formula, the Peltier effect is a linear function of the temperature. It may appear at first sight astonishing that it should be possible to apply so many different assumptions to the solution of one and the same problem. In many cases a formula of the last type would be quite inapplicable, as Stansfield remarks, but the differ­ence between the three is often much less than might be supposed. For instance, in the case of 10 per cent. Rh. Pt. —Pt. couple, if we calculate three formulae of the above types to satisfy the same pair of observations at 0°-445° and o°-1000° C., we shall find that the formula x=constant lies midway between that of Tait and that of Stansfield, but the difference between the formulae is of the same order as that between different observers. In this particular case the parabolic formula appears to be undoubtedly inadequate. The writer’s observations agree more nearly with the assumption x = constant, those of Stansfield with *s=c∕T.* Many other formulae have been suggested. L. F. C. Holborn and A. Day (*Berl. Akad.,* 1899) have gone back to Tait’s method at high tempera­tures, employing arcs of parabolas for limited ranges. But since the parabolic formula is certainly erroneous at low temperatures, it can hardly be trusted for extrapolation above 1000° C.

16. *Absolute Measurement of Thomson Effect.—*Another method of verifying Tait’s hypothesis, of greater difficulty but of con­siderable interest, is to measure the absolute value of the heat absorbed by the Thomson effect, and to observe whether or not it varies with the temperature. Le Roux (*Ann. Chim. Phys.,* x. p. 201, 1867) made a number of relative measurements of the effect in different metals, which agreed qualitatively with obser­vations of the thermoelectric power, and showed that the effect was proportional to the current for a given temperature gradient. Batelli has applied the same method (*Accad. Sci. Turin,* 1886) to the absolute measurement. He observed with a thermocouple the difference of temperature (about ∙01° C.) produced by the Thomson effect in twenty minutes between two mercury calorimeters, *B1* and *B2,* surrounding the central portions of a pair of rods arranged as in Le Roux’s method (see fig. 3). The value of the Thomson effect was calculated by multiplying this difference of temperature by the thermal capacity of either calorimeter, and dividing by the current, by the number of seconds in twenty minutes, and by twice the difference of temperature (about 20°) between the ends *a* and *b* of either calorimeter. The method appears to be open to the objection that the difference of temperature reached in so long an interval would be more or less independent of the thermal