

24.
The two
laws of
thermo-
dynamics.

quainted with Carnot's ideas and with Joule's work, increasingly felt the necessity of reconciling both views in one consistent view. So did Clausius independently at Zürich. The result was the doctrine of the "conservation of energy,"—not of heat, as Carnot had it,—and the embodiment of the two correct ideas contained independently in Carnot's and Joule's work in the two well-known laws of thermo-dynamics¹—viz., the conservation, equivalence, and convertibility of energy, as

formation or destruction of heat as an equivalent for the destruction or formation of other agencies, such as mechanical work" ('Math. and Phys. Papers' vol. i. p. 161, note). The acceptance of the doctrine of the convertibility of heat and mechanical work—implying the conservation of energy in place of the conservation of heat, as Carnot had it—seems to have taken place in Lord Kelvin's mind immediately after his paper referred to above in consequence of a paper by Rankine "On the Mechanical Action of Heat" (Roy. Soc. Edinburgh, Feb. 1850), as is shown by his letter to Joule, dated October 1850 (*loc. cit.*, vol. i. p. 170). He there refers also to a memoir by Clausius in Poggen-dorf's 'Annalen' of April and May of the same year as adopting "Joule's axiom instead of Carnot's" (*ibid.*, p. 173).

¹ The reconciliation of Joule's dynamical theory of heat with Carnot's doctrine, and the necessary modification of the latter, is contained in Lord Kelvin's classical memoir, "On the Dynamical Theory of Heat," in the 'Trans. of the Roy. Soc. of Edinburgh,' March 1851 ('Math. and Phys. Papers,' vol. i. p. 173 *sqq.*) In the introduction, Davy, Mayer, Joule, and notably Liebig, are mentioned as earlier supporters of the doctrine

of the convertibility of heat into mechanical effect, Rankine and Clausius as the latest contributors (p. 176). The first and celebrated enunciation of the second law by Thomson is given at the very beginning (p. 179), and in the sequel the denial of it is shown to mean the possibility of a perpetual motion. A little farther on Thomson refers to Clausius in the words: "The merit of first establishing the proposition upon correct principles is entirely due to Clausius, who published his demonstration of it in the month of May last year" (1850). It has on the other side been admitted by Clausius ('Die mechanische Wärmetheorie,' 2te Aufl., 1876, vol. i. p. 358) that Thomson's independent development of the second law, though published later, is conducted from a more general point of view, whereas his own treatment was purely mathematical and confined to special cases. The most general and philosophical expression of the new principle was given by Thomson in his celebrated communication to the Royal Society of Edinburgh, April 19, 1852, "On a Universal Tendency in Nature to the Dissipation of Mechanical Energy" (reprinted in 'Math. and Phys. Papers,' vol. i. p. 511).