in expanding by freezing is made to do work, it overcomes pressure; it has to freeze under pressure. The temperature of water freezing under pressure must be lower than that of water freezing under ordinary conditions.[1] Knowing the mechanical duty of a degree of temperature and the work of the expansion of ice, he could calculate how much the freezing-point of water must be lowered by pressure. In 1850 his brother William Thomson verified this theoretical prediction by actual experiment.[2] It is well known how Helmholtz in 1865 made use of this theoretically predicted and practically verified phenomenon in his celebrated glacier theory.[3] Both James and William Thomson, when they drew the conclusions from Carnot's theory, still adhered to the doctrine of the entire conservation of heat.[4] But William Thomson, who was equally ac-

freezing; and therefore it seemed to follow that if a quantity of it were merely enclosed in a vessel with a movable piston and frozen, the motion of the piston consequent on the expansion being resisted by pressure, mechanical work would be given out without any corresponding expenditure; or, in other words, a perpetual source of mechanical work, commonly called a perpetual motion, would be possible. . . . To avoid the absurdity of supposing that mechanical work could be got out of nothing, it occurred to me that it is necessary further to conclude that the freezing-point becomes lower as the pressure to which the water is subjected is increased."

[1] "The mechanical pressure promotes—as is generally the case with the alternate action of different forces in nature—such a change, viz., melting of ice, as is favourable to the effect of its own action" (Helmholtz, 'Vorträge und Reden,' vol. i. p. 217).

[2] 'Proceedings of the Roy. Soc. of Edinburgh,' January 1850, reprinted in 'Math. and Phys. Papers,' vol. i. p. 165.

[3] Helmholtz, *loc. cit.*, p. 215 *sqq.*, where also the phenomenon discovered and called "regelation of ice," by Faraday, is similarly explained.

[4] It is important to notice this, as the formula with which we are now familiar, that the mechanical work gained meant consumption of heat, was not available at that time. This is significantly pointed out by Helm ('Energetik,' p. 69). The reasoning was accordingly more difficult and refined. James Thomson, however, had at the time some misgivings on the then prevalent view, and in a footnote he refers to the "possibility of the absolute