CURRENT SCIENCE

Vol. VI] October 1937 [No. 4

On the Previous History of the First Law of Thermodynamics.

A critical history of Physics has appeared only sparingly in physical literature since a creative physicist requires a special incentive to devote his work to the history of physics—and even then only to the history of that part of physics in which he has been working—instead of to physics itself. Anyone other than a creative physicist, rich in ideas, cannot be thought of here as an author; he may do useful work either in the field of bibliography or biography, but he can never value the ideas critically nor can he add anything to a knowledge of their inner relationship. Therefore, works like Planck's "Principle of the Conservation of Energy" (1887), Mach's "Principles of the Theory of Heat" (1896), Dühring's "Critical History of Mechanics" (1873) have their special place in physical literature—not only for the sake of the authors, but also because they have here written history, on which should be focussed the attention of historians as much as that of physicists. On account of this rarity every new contribution made by persons of standing is very valuable for the history of physics—even more so when it belongs to a region whose history appeared to have been completely investigated. The "Thermodynamics"* by Paul S. Epstein, the well-known theoretical physicist of the California Institute of Technology at Pasadena—published this year, contains a section on the history of the First Law, by which everyone interested therein, will find himself enriched.

After the work of Rumford and of Davy during the transition from the 18th century to the 19th, almost forty years elapsed before a well-planned investigation of the mechanical nature of heat began. Besides an engineer (Séguin) there were two physicians who took up the question—Helmholtz was then a physician just as Julius Robert Mayer was. The engineer naturally took up the transformation of Heat into work and *vice versa*, but how did the interest of the physicians arise? Epstein has taken up this question and has referred to hitherto unknown historical relationships. The origin of animal heat was the greatest problem for physicians and physiologists. Since warm-blooded animals continuously give out heat to their colder surroundings their bodies can maintain their almost constant temperature only when as much heat is generated in them every moment as they give out to the surroundings. The question, therefore, turned on the cause of the constancy of temperature of warm-blooded animals. In one of his papers (1843) Joule writes: "Dr. John Davies told me that he had endeavoured from a few years past to explain that part of animal heat, which Crawford's theory had left unexplained, as due to the friction of blood against the veins and the arteries, but that he found a similar hypothesis in Haller's "Physiology" and that therefore he had not

* *Text-Book of Thermodynamics*, by Paul S. Epstein. (John Wiley & Sons, New York), 1937. Pp. xii+406.

followed the question further" (the English physician Crawford had set up the Combustion Theory of Respiration independently of Priestley). This means that Julius Robert Mayer and Helmholtz had an eminent forerunner: Albrecht von Haller who was for fifteen years (1738–53) the pride of the University of Göttingen, the founder of the Göttingischen Gelehrten Gesellschaft, and who was an anatomist, physiologist, botanist and physician. His *Elementa physiologiæ corporis humani* (1757–66) appeared very soon in French and in English and undoubtedly it has influenced several generations of physicians; in 1822 appeared another German edition, and in 1843 it quoted Dr. John Davies as an authority, as Joule writes. Haller there analyses the activity of the lungs and comes to the conclusion that animal heat is produced here and is communicated to the blood flowing through them. According to his hypothesis it is generated "by an alternate expansion and contraction, by the springing back and the compression of the lung cavity whereby the hard parts of the blood are closely pressed together during the attrition produced by the expiration and continuously rubbed against each other, just as during inspiration they move fast and are powdered." And it is no objection against this that water cannot be heated by friction; this conclusion is in fact incorrect since through violent motion water as well as milk can take up a certain amount of heat. Haller's theory of respiration therefore depends essentially upon the idea that heat can be generated by mechanical work and that at every moment, so long as the force (the life force) works—a knowledge fifteen years previous to Rumford's epoch-making experiments! The physicians and physiologists stuck to this idea in spite of Priestley's Combustion Theory of Respiration and in spite of the support given to it by the measurements of Lavoisier and Laplace (about 1781), they saw in Rumford's and Davy's work only a support for Haller's theory. Lavoisier and Laplace had found that the combustion of carbohydrates in the blood was not sufficient to explain the amount of heat developed, and had expected that the combustion of hydrogen to water would account for the remaining portion. But the announcement of a prize by the Académie des Sciences in the year 1821 first led to the taking up of the necessary investigation. The results communicated by Despretz to the Academy in 1823 (published in 1824) still left about 20 per cent. unexplained and for this he went back to Haller's theory. The work of Dulong published posthumously in 1843, first brought the final stage and put a seal upon the correctness of the Combustion Theory of Respiration. Dulong had already laid his results, which agreed with those of Despretz, before the Academy in 1822, but had not published the same because he doubted the correctness of the thermochemical data regarding the formation of carbonic acid and of water. The figures for the heat of formation of carbonic acid finally proved to be correct but the corresponding values for water were found to be much too small. It was only the improvement made possible by this that removed the error and so provided a proof for the correctness of the Combustion Theory of Respiration. But the physiologists and the physicians were for the last twenty years convinced of its sufficiency. On searching through the literature of that day Epstein came across a *Handbuch der Physiologie* in six volumes, edited by Karl Friedrich Burdach (1776–1847), Professor of Anatomy and Physiology in Königsberg. The last volume of the Handbook of date 1840 contains a history of both theories by Burdach. He first mentions Haller's theory and then the "investigation of the similarity between respiration and combustion". He shows that between 1820 and 1840 the physicians interested in the theory of respiration were carried away by the part which could not be explained by the combustion theory. Most of them sided Haller and explained the discrepancy by the friction of blood in the arteries. This idea was shared not only by the leaders of science but also by the wider circle of practical physicians, and for this, Epstein refers to two papers of dates 1830 and 1839, as examples. Above all we have here only variations of Haller's theory. Burdach himself does not sympathise with these explanations: he does not doubt that heat can be generated by work but treats it as generally known, citing Rumford and Davy for the same; but he only doubts whether all this is quantitatively correct.

According to Epstein's studies, medicine played a much more important part in the history of the principle of the conservation of energy than has been generally assumed till to-day. It begins in the middle of the 18th century and continues uninterrupted till the middle of the 19th. The physiologists were for half a century the keepers of the idea of the identity of heat and work. Julius Robert Mayer and Helmholtz transplanted it into physics to which it naturally belongs. There lay a further interval between the approximate knowledge of the physicians about the generation of heat by work and the formulation of their equivalence. Julius Robert Mayer lost the credit of the discovery because he could not give any strict proof for the correctness of his ideas, and that in an age which through the failure of Schelling's Natural Philosophy was set quite against all speculations without clinching proofs. Helmholtz was of greater consequence, but Joule's work had, in the meanwhile, built for the principle of the conservation of energy a basis resting on experience.

ARNOLD BERLINER.

Professor The Right Honourable Lord Rutherford of Nelson, O.M., D.Sc., LL.D., Ph.D., F.R.S.

THE news of the sad demise of Lord Rutherford, Cavindish Professor of Experimental Physics and Director, Cavendish Laboratory, since 1919, President elect of the Jubilee Session of the Indian Science Congress, Calcutta, 1938, reached us as we were going to the press. It is with feelings of deep sorrow that we record the obituary of this eminent investigator whose contributions to the scientific thought during the past four decades have been both varied and remarkable, and formed an outstanding feature of the present era. Ernest Rutherford, first Baron of Nelson, KT., O.M., F.R.S., Nobel Prizeman, was born at Nelson, New Zealand, on 30th August 1871. He was educated at Nelson College, and Canterbury College of the New Zealand University. He then proceeded to the United Kingdom for higher studies and passed the M.A. Degree Examination of the Cambridge University with 1st class honours in Mathematics and Physics in 1893. His record has been all through, one of untarnished brilliance. He was awarded the 1851 Exhibition Scholarship in 1894. He entered the King's College and prosecuted research at the Cavendish Laboratory. His brilliant researches have brought him "crowded" recognition. Several Universities of Europe and America vied with each other in conferring on him their highest academic distinctions. He was awarded the Rumford Medal (1905), Copley Medal (1924), Albert Medal (1928), Faraday Medal (1930), and he received the Bressa Prize from the Turin Academy of Sciences in 1908. He was President of the Royal Society 1925–30; President, British Association for the Advancement of Science, 1923, Macdonald Professor of Physics, McGill University, Montreal, 1898–1907, Langworthy Professor and Director, Physical Laboratory, University of Manchester, 1907–19 and Fellow of the Trinity College since 1919. He is the author of numerous technical contributions on the Conduction of Electricity through Gases and Radioactivity which adorn the pages of the *Transactions of the Royal Society*, *Philosophical Magazine* and other scientific Journals. Among his other publications mention should be made of: Radioactivity (1904), Radioactive Transformations (1906), Radioactive substances and their Radiations (1912) and Radiations from Radioactive substances (1930).