and Joule. If this last law, which practically amounts to a definition of *heat* as a dynamical quantity, coupled with a statement of the principle of conservation of energy, is to be admitted among the laws of motion, why should the second law of thermodynamics be excluded? In chapter vii. the author discusses the possible causes of loss of energy in the universe, but he might with considerable advantage introduce something about the degradation of available energy. This principle has an important bearing on the question of the infinity of the universe and the infinity of time. A finite universe cannot have existed for an infinite time past, radiating its energy into infinite space, but as soon as the principle of degradation of available energy is assumed, a similar difficulty as to infinity of time is found in dealing with an infinite universe, all of whose energy ultimately tends to be dissipated in the form of heat, and all of whose parts tend to a common temperature.

There is thus ample room for M. de Freycinet to write a further essay on the irreversible phenomena of Nature. There is another interesting field of study which he now mentions only in a footnote on p. 43, namely the existence of imaginary quantity and the remarkable fact that the generalisation of the laws of ordinary algebra requires the introduction of only one imaginary symbol. But, as the author points out, in the present state of science it is impossible for one man to survey our knowledge of more than a limited portion of natural phenomena. M. de Freycinet has given his readers much to think about in the domains of infinitesimal analysis and rational mechanics, and, moreover, this is written in a style which makes the book easy to read.

The Thermal Measurement of Energy. Lectures delivered at the Philosophical Hall, Leeds, by E. H. Griffiths, M.A., F.R.S. Pp. viii+133. (Cambridge: University Press, 1901.)

THIS little book consists of an account of four lectures, delivered to teachers by the author, at the request of the Technical Instruction Committee of the West Riding County Council. The author remarks that "The reflection that hundreds of such teachers should have been willing to sacrifice their Saturday afternoons to the study of certain physical measurements which did not even possess the charm of novelty may somewhat lighten the gloomy prospect sketched for us by those who hold pessimistic views as to the future of Intermediate Scientific Education in this country."

In attempting to render interesting a discussion of the thermal measurement of energy, Mr. Griffiths undertook a difficult task, which he has discharged admirably. There is no trace of the "popular lecturer" pure and simple; in his treatment of the subject success is due, not to an adroit avoidance of difficulties, but to the straightforward and conscientious attention given to every point of importance. In the first lecture, a number of well-chosen experiments are used to illustrate the conversion of work into heat. The second lecture is occupied with a consideration of the first and second laws of thermodynamics; incidentally the student is made acquainted with some of the difficulties attending thermometric determinations. In the third lecture an account is given of the principal methods which have been employed to determine the mechanical equivalent of heat. In this connection students will welcome the description of Reynolds and Moorby's determination, which has not as yet been dealt with in the text-books; it is to be regretted that more space could not be devoted to this valuable piece of work. A good account is given of Mr. Griffiths' own experimental test of the validity of the system of electrical units. Lecture iii. closes with a description of the recent experimental work of Callendar and Barnes on the variation in the specific heat of water.

The fourth lecture possesses very great interest. After remarking that text-books frequently give the specific heats of the metals to four of five decimal places, it is pointed out that these results necessarily depend for their accuracy on the values assumed for the specific heat of water at various temperatures. Generally speaking, authors content themselves with referring to Regnault's results, without, however, consulting Regnault's original papers. It appears that *only two* experiments were performed by Regnault for temperatures below 107°, and these were undertaken merely to test the working of the apparatus used, and Regnault himself attached no importance to them. As a matter of fact, Regnault performed a series of determinations of the changes in the specific heat of water *over the range* 107° *to* 190° C. After discussing the results, he stated what the nature of the variation between 0° and 100° would be if deduced by extrapolation from the experimental curve obtained at he higher range. Later investigations have proved these conclusions to be at fault, so that much otherwise unimpeachable experimental work relating to specific heats requires revision, and in many cases the data necessary for this purpose are not given by the authors.

It is finally recommended that the specific heat of water between 17° and 18° C. shall be defined as of unit value; this also amounts to defining the mean specific heat of water between 0° and 100° as of unit value. In that case the most probable value of the mechanical equivalent of heat is equal to $41{\cdot}84 \times 10^6$. E. E.

Instruments et Méthodes de Mesures Electriques Industrielles. By H. Armagnat. Pp. iii+614. (Paris: C. Naud.)

FEW, perhaps, realise how much electrical engineering owes its rapid development to the ease and precision with which the measurements it needs can be made. Yet it is this which renders it so amenable to mathematical and scientific treatment, and it is very largely owing to the fact that it can be so treated that it has progressed so rapidly. The manufacture of instruments has in many instances led rather than followed the development of the engineering side of the electrical industry. The practical engineer finds ready to his hand instruments for almost every conceivable purpose he may require, and it cannot be questioned that it is of the highest importance that he should properly understand their construction and limitations. M. Armagnat's book should therefore prove exceedingly useful to such men as a work of reference in which they can find a full discussion of the principles underlying the construction of the tools they use. As the author points out in his preface, beginners, and those also who habitually use instruments, are too often ignorant of their powers and of the proper way of treating them. Many mistakes, often of a serious nature, would be avoided if this state of affairs were remedied.

M. Armagnat describes both the instruments which are only to be found in electrical laboratories and those which are in daily and extended commercial use. It is the part of the book dealing with the commercial instruments which will commend itself more particularly to the practical engineer. The author has wisely confined himself to describing typical instruments of each class, and has refrained from giving descriptions of the numerous different examples of the type. Perhaps, however, an improvement would be introduced if instruments of different makes were compared, as this would serve as a useful guide to those who are in doubt as to what to purchase most suitable for their particular requirements. Valuable information is given as to the best methods of installing delicate instruments, of securing good illumination, freedom from vibration and outside disturbance, and of carrying out observations and measurements. The chapters devoted to these subjects add very greatly to the usefulness of the book, especially from the point of