solid; and, as in § 17 above, we see that there are fifteen independent coefficients in the quadratic function of the strain-components expressing the work required to produce an infinitesimal strain. Thus we realise the result described in § 7 above.

§ 35. Suppose now each of the four tie-struts to be not infinitely resistant against change of length, and to have a given modulus of longitudinal rigidity, which, for brevity, we shall call its stiffness. By assigning proper values to these four stiffnesses, and by supposing the tetrahedron to be freed from the two conditions making it our special tetrahedron, we have six quantities arbitrarily assignable, by which, adding these six to the former fifteen, we may give arbitrary values to each of the twenty-one coefficients in the quadratic function of the six strain-components with which we have to deal when change of bulk is allowed. Thus, in strictest Boscovichian doctrine, we provide for twenty-one independent coefficients in Green's energy-function. The dynamical details of the consideration of the equilibrium of two homogeneous assemblages with mutual attraction between them, and of the extension of §§ 9—17 to the larger problem now before us, are full of purely scientific and engineering interest, but must be reserved for what I hope is a future communication.

II. "Magnetic Qualities of Iron." By J. A. Ewing, M.A., F.R.S., Professor of Mechanism and Applied Mechanics in the University of Cambridge, and Miss Helen G. Klaassen, Lecturer in Physics, Newnham College. Received June 7, 1893.

(Abstract.)

The paper describes a series of observations of magnetic quality in various specimens of sheet iron and iron wire. A principal object was to determine the amount of energy lost in consequence of magnetic hysteresis when the iron under examination was carried through cyclic magnetising processes between assigned limits of the magnetic induction B. For this purpose observations of the relation of the induction B to the magnetic force H were made, from which curves were drawn, and the area enclosed by the curves in cyclic magnetising processes was measured. Many such cycles were gone through in the case of each of the specimens, the limits between which B was reversed being varied step by step in successive cycles, to allow the relation of the energy expended or of $\int H dI$ to B to be determined. The curves of B and H in these graded cycles are drawn in the paper, as well as curves showing the relation of $\int H dI$ to B and to H. Most of these experiments were made by the ballistic method, the specimens

being in the form of rings. The iron examined was, for the most part, thin sheet metal or wire such as is used in the construction of transformer cores. The experiments show that there are marked differences in the values of $\int HdI$ in different specimens, some nominally soft iron requiring two and even three times as much work to be spent in reversing its magnetism as is required in the best iron. They show, further, that great permeability does not necessarily imply small hysteresis losses. The order of merit in a group of samples is not the same when permeability is made the criterion of magnetic softness as it is when the smallness of $\int HdI$ is made the criterion.

In connexion with these results a formula proposed by Mr. C. P. Steinmetz ($\int HdI = cB^{1\cdot6}$)* to express the relation of the hysteresis losses to B is discussed, and it is shown that although such a formula may serve fairly well as an approximate statement of the relation within those limits of B which are important in practice, it fails when applied to the more extreme portions of the curve.

The authors go on to describe a second group of experiments, in which direct measurements were made of the heat developed in magnetic reversals. The method consisted in using two rings, alike in all respects, with divided magnetising coils. One ring had its coils coupled so that the two parts opposed each other, and the core was consequently not magnetised when a current passed. The other ring was active, and its coils (coupled inductively) were connected in series with the non-inductive coils of the inactive ring. Alternating currents were passed through both, and the active ring became heated by the effects of hysteresis and Foucault currents. To balance this a steady current was caused to flow in the core of the inactive ring, and the energy expended in the magnetic reversals of the active ring was found by measuring the energy which had to be expended in this current in order that the temperature of the two rings might continue equal. In some cases the rings used were miniature transformers, and the test was applied to see whether the energy expended in magnetic reversals remained the same when the secondary of the transformer was closed as when it was open. This question had been raised by more than one experimentalist in relation to tests of the efficiency of transformers. The authors could not detect any difference in the amount of energy consumed in the core when the "load" was taken off or put on the secondary.

In a third group of experiments the magnetic curve tracer was used to examine certain features of the curves of magnetisation. This instrument, invented by one of the authors, draws curves which exhibit the relation of the magnetisation of given samples of iron or steel to

* 'Trans. American Inst. of Electrical Engineers,' vol. 9, No. 1.

the magnetising current. Amongst other points referred to in this connexion is the time-lag in magnetisation, which is well shown by the curve-tracer, and the effects are compared of the same cycle of magnetic force gone through at various speeds. It is shown that in solid bars 1·9 cm. in diameter, especially in soft iron, remarkable evidences of time-lag are seen, even when the period of magnetic reversal is as long as 3 secs. The work spent per cycle is a maximum at a particular frequency, which in such bars is very low.

The fourth and last section of the paper relates to the molecular theory of magnetisation, and describes experiments made with groups of small pivoted magnets. It is shown that the behaviour of such groups, when exposed to the action of a variable magnetic field, presents striking points of resemblance to the behaviour of iron or steel under corresponding variations of magnetising force. Results are given which tend to confirm the theory.

The particulars of the observations are set out in about forty sheets of curves which accompany the paper.

III. "Polarisation of Platinum Electrodes in Sulphuric Acid." By JAMES B. HENDERSON, B.Sc. Communicated by LORD KELVIN, P.R.S. Received June 10, 1893.

This investigation was begun about the beginning of February, 1893, at the instigation of Lord Kelvin, and was conducted in the Physical Laboratory of Glasgow University. The object of the investigation was to obtain the difference of potential between two platinum electrodes immersed in a solution of sulphuric acid immediately after the stoppage of a current which had been electrolysing the solution, and to find how this difference varied with a variation in the intensity of the current or in the strength of the solution.

Former experiments by Buff ('Poggendorff,' vol. 130, p. 341, 1867) and Fromme ('Wiedemann,' vol. 33, p. 80, 1888) have given for the maximum polarisation with platinum wires of very small surface in the electrolysis of dilute sulphuric acid 3·5 and 4·6 volts.

Dr. Franz Richarz, in a paper "On the Polarisation of Small Electrodes in Dilute Sulphuric Acid," read before the British Association at Bath (1888), says of the above :—

"In these experiments the polarisation is calculated from measurements of the intensity of the galvanic current during the electrolysis, tacitly assuming that the resistance of the decomposition cell is independent of the intensity of the galvanic current. The correctness of the supposition has not been proved. I tried experiments by similar methods, and obtained yet greater values of the polarisation; it was calculated with a current density of 12 ampères per square