HENRY WILLIAM WATSON. 1827–1903.

Henry William Watson was the son of Thomas Watson, Esquire, of the Royal Navy. He was born in 1827, and received his early education at King's College, London. In 1846 he entered at Trinity College, Cambridge, and devoted his attention principally to mathematics, in Hopkin's Classes, but not to the entire exclusion of other studies. In 1850 he took his degree as Second Wrangler and Smith's prizeman, and in 1851 was elected a Fellow of Trinity. He held the office of Assistant Tutor of his College for two years, 1851–1853. He then went to reside in London with some not very decided intention of studying law, and was a pupil in the chambers of Mr. Christie, the conveyancer. Legal studies seem to have had little fascination for him, and he returned to mathematics, accepting, in 1854, the post of Second Master in the City of London School, and subsequently that of Mathematical Lecturer at King's College, London. In 1856 he married Miss E. Rowe, of Cambridge, and in 1857 became Mathematical Master at Harrow, then under Dr. Vaughan. He was ordained Deacon in 1856, and received Priest's orders in 1858.

In 1865 he accepted the living of Berkeswell, in the gift of the father of one of his Harrow pupils. At Berkeswell he had more leisure to study on his own account, and from this time, so long as his health lasted, he took a keen interest in applied mathematics, contributing occasionally to scientific periodicals, and being the author, alone or in partnership, of the works mentioned in the sequel. He was always a ready and sympathetic helper in other men's work, and there are many who would gladly acknowledge their obligations to him.

In 1860 and 1861, while still at Harrow, he acted as Moderator, and then Examiner, in the Cambridge Mathematical Tripos. He was again an additional Examiner in 1877.

He was elected a Fellow of this Society in 1881, and in 1883 the University of Cambridge conferred on him the degree of Doctor of Science. The University also appointed him, in 1879, their representative Governor of King Edward the Sixth School, Birmingham. He was one of the Founders of the Birmingham Philosophical Society, and its President for two years.

During the whole of his active life, after leaving Harrow, he gave up much, perhaps too much, of his time to examination work, acting for the Civil Service Commissioners, and occasionally for the University of London, and for some years, ending in 1896, he held the office of Mathematical Examiner to that University.

He published in 1871 a text-book on Geometry (Longman's Series) designed mainly for the use of schools.

In 1876 he published a treatise on the Kinetic Theory of Gases (Clarendon Press), which reached a second edition in 1893. The foundations of this Theory had been laid by Maxwell in his articles on the collision of elastic spheres, "Philosophical Magazine, 1860." Beginning a new subject, Maxwell naturally adopted the simplest hypotheses. For his molecules he chose, in 1860, as a limiting case, smooth perfectly elastic spheres, supposed to rebound on collisions with each other without loss of kinetic energy. Subsequently, in 1868, he started the hypothesis that molecules were centres of force repelling one another according to the inverse fifth power of the distance, no one objecting at that time to instantaneous action at a distance. Also for the sake of simplicity he assumed, as a limiting case, the motions of his molecules to be mutually independent, the chance of any one having its velocities within assigned limits being wholly independent of the positions and velocities of all the others. Nature might have made matter continuous and not molecular. But if molecules existed, they could not, so it is assumed, have mutually related motions.

On these assumptions the distribution of velocities among the molecules was found to be, according to the $e^{-h\Sigma mu^2}$ law, generally known as Maxwell's law, and it led to the doctrine of equipartition of energy.

In the meantime the subject had been treated in Germany with elaboration, but on nearly the same assumptions, by O. E. Meyer, and by Ludwig Boltzmann in a great series of papers beginning in 1867 in the Vienna Sitzungsberichte.

Boltzmann accepted Maxwell's second assumption of independence, and deduced therefrom, in addition to Maxwell's results, the H or entropy theorem, according to which Maxwell's law is not only a sufficient, but a necessary, condition for steady motion. He also gave us the law of space distribution known as the $e^{-2h\chi}$ law, which states that the chance of any group of molecules being in a configuration in which the potential of all the mutual and other forces acting on them is χ, varies as $e^{-2h\chi}$. Such was the state of the theory in 1876.

Watson's task was to a great extent that of summing up the work of his predecessors. Like Boltzmann before, and Tait after him, he accepted without discussion the limiting case assumption of independence. It was not until nearly twenty years later, in the discussion of the H theorem and FitzGerald's objection, that the true nature of the assumption was pointed out. And then, and not till then, it was that Boltzmann announced that he would have to make "eine besondere Annahme."

Watson, however, discusses the possible forms of the molecule, and was the first to introduce the most general conception of it as a system defined by n, generalised co-ordinates and corresponding momenta. In the discussion of the relation of the Theory of Gases to Thermodynamics, as then known, he made considerable advance on Boltzmann's work. Maxwell's hypothesis of the inverse fifth power he did not give *in extenso*, probably not considering it a sufficiently good working hypothesis. It is noteworthy that he refused to accept, though he did not deny, the extension of the $e^{-2h\chi}$ law to intermolecular forces, which is distinctly asserted by Boltzmann.

He had the advantage, while preparing this work, of correspondence with Maxwell on many of the points arising.

In 1877, this time in partnership with Mr. S. H. Burbury, he contributed the article "Molecule" to the "Encyclopædia Britannica," ninth edition. In this article the same theory of gases is explained in outline as in Watson's own book, but the article contains likewise some account of the Diffusion and Viscosity of Gases as deduced from the Kinetic Theory, and a somewhat more extended discussion of the ratio between the two specific heats, and the problems thereout arising.

In 1879, again with Mr. S. H. Burbury as colleague, he published a treatise on the Application of Generalised Co-ordinates to the Dynamics of a Material System (Clarendon Press). It was a work on abstract dynamics. It contained a new definition, fundamental to the theory, of the generalised component of momentum. Also a discussion of the abstract theorems of Bertrand, Gauss, and Thomson, relating to impulsive motion from rest, the two latter theorems being presented in a new form. The theory of kinetic foci, and of least action in the strict sense, given in this work was also in great measure new.

Watson then, again in partnership with S. H. Burbury, published a treatise on the Mathematical Theory of Electricity and Magnetism, of which the first volume "Electrostatics" appeared in 1885, the second, "Magnetism and Electrodynamics," in 1889. As stated in the Preface, this treatise was intended rather as a commentary on Maxwell's great work than as an original investigation. Maxwell cared little for mathematics, except as interpreting experiment, or suggesting lines of investigation. His mathematics, for this reason, presented many difficulties to the student, and were even, in some cases, accused of being inaccurate. Watson and his colleague endeavoured to clear up these difficulties, and in some cases, though but seldom, departed considerably from Maxwell's method. The work was completed before the great extension was given to electrical science by Hertz, Röntgen and other recent investigators. For this reason it did not anticipate the great importance since given to the theory of electrons.

The science of electricity, like chemistry, has undergone and is undergoing very rapid changes, the complete knowledge of to-day being no more than a stepping stone to the results attained to-morrow.

In scientific matters Watson had on the whole a Conservative bias, requiring much deliberation before adopting new methods or lines of investigation. By contrast he was in his political opinions a strong Liberal, of the school perhaps of Sir W. Harcourt rather than of any other modern statesman. His Liberalism was, however, more theoretical than practical, and did not induce him to take any active part in the Parliamentary elections for his division. It did not, in fact, consist in any very strong approval of Liberal measures popular for the time being; still less did it stand in the following of any particular politician. It was a mental state to which he had himself attained, and to which it was desirable that other men should attain, and find rest.

As might have been expected, he was never an extremist in his theological opinions. Extreme opinions did not readily grow in the climate of Cambridge in the middle of the last century. He was the friend of all his parishioners, and knew how to sympathise with opinions that were not his, and with studies and interests that he did not share. So far as his influence extended he was of all things a peacemaker.

S. H. B