THURSDAY, SEPTEMBER 7, 1876

SCIENTIFIC WORTHIES

IX.—Sir William Thomson.

Sir William Thomson was born in Belfast in June 1824. His father, Dr. James Thomson, was a very remarkable man. The family of Thomsons had for several generations occupied a farm near Ballynahinch, in County Down, Ireland; but James Thomson, when quite a boy, endeavouring all alone to understand the principles of dialling, was led into the study of mathematics, for which it soon appeared that he possessed an extraordinary capacity. His father then permitted him to go to a small classical and mathematical school at his native place, and there he was soon promoted to be an assistant teacher. Without ceasing to labour as a teacher for his own support, he became a student in the University of Glasgow, attending there during the winter months, and teaching at Ballynahinch during the summer.

When he had nearly completed his fifth year at Glasgow, he was appointed Headmaster of the School of Arithmetic and Geography at the Royal Belfast Academical Institution, and subsequently Professor of Mathematics in that Institution. In 1832 he was appointed Professor of Mathematics in the University of Glasgow, and removed thither with his family. He was the discoverer of many improvements in algebra and in the calculus, and in particular, he was the first to apply systematically Horner's method of solving algebraic equations to the arithmetical extraction of cube roots and higher roots of numbers. He was also the author of several important educational works which have come extensively into use; and besides excelling in science, he was highly accomplished in classical and in general literature. But he is perhaps better remembered in Scotland for his success as a teacher; and those who were his pupils speak with delight of his voluntary catechetical hours, in which *vivâ voce* questions were proposed and rapidly passed from bench to bench in a class of ready and enthusiastic pupils.

There are many who remember among the readiest and the most enthusiastic, a little lad of eleven or twelve years of age who could scarcely make himself seen among his older class fellows. This was William Thomson, who at that early age had entered the University; and who even then distinguished himself greatly for originality and high mathematical ability. Having passed through Glasgow University he entered St. Peter's College, Cambridge. In 1845 he graduated as second wrangler and first Smith's Prizeman, and was immediately elected a Fellow of his college. While he was at Cambridge he was remarkable for his scholarly attainments in science and in literature. He won the Colquhoun, and was for some time president of the Cambridge University Musical Society.

After completing his undergraduate course at Cambridge he went to Paris, and spent some time working in the laboratory of Regnault, who was then engaged in some of his most important researches. After the death of Dr. Meikleham he became a candidate for the Chair of Natural Philosophy in the University of Glasgow, and was elected. Thus in 1846, at the early age of twenty-two, he was appointed to the Chair which he has filled with such distinction, and still holds.

Sir W. Thomson's earliest contributions to physical science were a defence of Fourier in answer to a charge of erroneousness which had been brought against some of the fundamental formulas of his harmonic analysis, and a paper on "The Uniform Motion of Heat in Homogeneous Solid Bodies, and its Connection with the Mathematical Theory of Electricity." These were written at the age of seventeen. They were published in 1841 and 1842 in the *Cambridge and Dublin Mathematical Journal*. The latter paper is a very remarkable one: its spirit runs through much of Sir William Thomson's subsequent work. He points out in it the analogy between the theory of the conduction of heat in solid bodies and the theory of electric and magnetic attraction; and, aiding himself with this analogy, he makes use of known theorems as to the conduction of heat in order to establish some of the most important theorems in the mathematical theory of electricity. The method was thoroughly original; and later, taken in conjunction with Faraday's admirable researches on electrostatic induction, which led to the discovery of differences in the specific inductive capacity of various substances, and to the notion of *conduction of lines of force*, it proved of the highest value in the discussion of questions in electrostatics and also in magnetism. As to the results obtained, Thomson found, a few months after, that in some of the most important he had been anticipated by M. Chasles. Later he found that Gauss had given the same general theorems shortly before Chasles independently rediscovered them; and, three years after, having heard of a paper by Green, but long inquired for it in vain, he found, on obtaining a copy of that paper, that all these theorems had been discovered and published in the most complete and general manner, with rich applications to the theory of electricity and magnetism, as early as 1828. This memoir of George Green, of Nottingham, was printed privately, dedicated to his patron the Duke of Newcastle, and it lay unread and unknown till 1845, when Thomson obtained a copy, made known what a mine of wealth it contained, and had it republished in *Crelle's Mathematical Journal*.

Another very important paper written about the same time, and published in the *Cambridge and Dublin Mathematical Journal* for 1842, was on the "Linear Motion of Heat." It contained the foundation of the method of evaluating absolute geological dates from underground temperature, which he made the subject of his inaugural address on his institution to his professorship in the University, and which we believe forms a large part of the subject of his opening address to the Mathematical Section of the British Association.

The papers referred to were followed by a paper on the "Elementary Laws of Statical Electricity," which first appeared in *Liouville's Journal de Mathématiques*, in 1845, and was translated and published the same year in the *Cambridge and Dublin Mathematical Journal*. Sir W. Snow Harris had undertaken an experimental examination of the fundamental laws of electric attraction and repulsion; and his results, which received the Copley Medal of the Royal

Society, were at the time supposed to disprove the well-known laws first given by Coulomb. Thomson, however, at the age of twenty-one, undertook the examination of the results of Snow Harris, and showed that, instead of being out of harmony with the laws of Coulomb, they were, so far as they went, confirmatory of those laws. He pointed out clearly the precautions necessary in experiments on the elementary laws, and he showed that it was through a misunderstanding as to the conditions of the simple laws enunciated by Coulomb that Snow Harris was led into error. In this memoir we find also the first steps towards making Faraday's new theory of induction the basis of the mathematical theory of electricity. In subsequent papers this method of proceeding to the mathematical theory is completely worked out; and, reading together the memoirs of Faraday and of Thomson, we cannot help being struck with the way in which the notion of lines of force and lines of flow of heat fascinated the minds and guided the intuition of our two greatest investigators.

We cannot here follow Sir William Thomson in detail through his series of papers on electrostatics and on magnetism. They were collected and published in 1872, with notes and most important additions, in a volume of 600 pages. It is greatly to be desired that the same may be done for the very numerous memoirs on other physical subjects with which he has enriched the *Transactions* and *Proceedings* of a host of learned Societies.

In 1846 Mr. Thomson became editor of the *Cambridge and Dublin Mathematical Journal*, a post which he held for about seven years. Among the contributors to the journal during his editorship he could count Stokes, Cayley, De Morgan, Liouville, Salmon, Sir William Rowan Hamilton, and many other distinguished mathematicians; while from his own pen proceeded many memoirs of great importance. It was about this time, also, that he contributed to *Liouville's Journal de Mathématiques* the memoirs in which he unfolded his principle of "electric images." By means of this principle, which he in his first letter likens to Brewster's kaleidoscope, he shows how, by simple geometrical principles, to solve many problems of an apparently very complicated nature, as to the distribution of electricity on a system of conductors under the influence of a given electrified system. The veteran Liouville, concluding a note suggested by the letters of Mr. Thomson, writes of his own developments of the theory: "Mon but sera rempli, je le répète, s'ils peuvent aider à bien faire comprendre la haute importance du travail de ce jeune géomètre, et si M. Thomson lui-même veut bien y voir une preuve nouvelle de l'amitié que je lui porte et de l'estime que j'ai pour son talent."

His electrostatic researches led Thomson to the invention of very beautiful instruments for electrostatic measurement. The subject of electrostatic measurement occupied much of his attention from the very earliest, when he was obliged to call attention to the defects of the electrometers of Snow Harris. His labours in this direction have produced the quadrant electrometer, which is employed for all kinds of electric testing in telegraph construction, and for the registration of atmospheric electricity at Kew Observatory; the portable electrometer, for atmospheric electricity and for other purposes in which the extreme sensitiveness of the quadrant-electrometer is not required; and the *absolute* electrometer, which serves for reducing the scale readings of other instruments to absolute measure, and which was used by Thomson in his measurement of the electrostatic force producible by a Daniell's battery and in many other investigations. Those who have seen the collection of electrometers in the Loan Collection at South Kensington will not think it too much to say that to Sir W. Thomson is due our present system of practical electrometry.

But while thus engaged in investigations in electrostatics and magnetism, there were many other branches of science that were receiving from him advancement in a not less remarkable way. There is no part of his work of higher importance than his investigations on the Dynamical Theory of Heat. These were communicated in a series of papers to the Royal Society of Edinburgh, the first of which was given in 1849. It was a critical account of Carnot's memoir of 1824, "Réflexions sur la Puissance Motrice du Feu." Though Rumford and Davy had, in the beginning of this century, experimentally disproved the material theory of heat, their experiments and arguments were unheeded and nearly unknown; and it was only after 1843, when Joule actually determined the dynamical equivalent of heat, that the great truth that heat is a mode of motion was admitted and appreciated. Thus Carnot, although dissatisfied with it, was obliged to adopt the material theory of heat in 1824; and, regarding heat as indestructible, spoke of the letting down of the heat from a higher to a lower temperature, and looked on the production of work by the heat engine as a phenomenon analogous to that in which water, descending from a higher to a lower level, does work by means of a water-wheel. Thomson, among the first to appreciate the importance of Joule's results, set himself to alter the theory given by Carnot into agreement with the true theory; and in the series of papers referred to, placed the whole science of Thermodynamics on a thoroughly scientific basis. In 1846 he first suggested the reckoning of temperature on an absolute thermodynamic scale independent of the properties of any particular substance. Subsequently, in consequence of experimental investigations of the thermodynamic properties of air, and other gases, made in conjunction with Joule, he showed how to define a thermodynamic scale of temperature having the convenient property that air thermometers and other gas thermometers agree with it as closely as they agree with one another. This system of reckoning temperature gives great facility for the simple expression of thermodynamic principles and results.

Having here mentioned Joule and Thomson together, we cannot omit to remark that some of the most admirable researches in thermodynamics were those undertaken in conjunction by these two attached friends.

Among the many important results of Sir W. Thomson's investigations in thermodynamics, one of the most remarkable was his discovery of the principle of dissipation of energy, announced by him in 1852. During any transformation of energy of one form into energy of another form there is always a certain amount of energy rendered unavailable for further useful application. No known process in nature is exactly reversible, that is to say, there is no known process by which we can convert a given amount of energy of one form into energy of another form, and then, reversing the process, reconvert the energy of the second form thus obtained into the *original quantity* of energy of the first form. In fact, during any transformation of energy from one form into another, there is always a certain portion of the energy changed into heat in the process of conversion; and the heat thus produced becomes dissipated and diffused by radiation and conduction.

Consequently there is a tendency in nature for all the energy in the universe, of whatever kind it be, gradually to assume the form of heat, and, having done so, to become equally diffused. Now, were all the energy of the universe converted into uniformly diffused heat, it would cease to be available for producing mechanical effect, since for that purpose we must have a hot *source* and a cooler *condenser*. This gradual degradation of energy is perpetually going on; and sooner or later, unless there be some restorative power, of which we at present have no knowledge whatever, the present state of things must come to an end.

We must pass very briefly over a large number of Sir W. Thomson's contributions to science that, were our limits less circumscribed, we would gladly dwell upon. In 1855 his paper on "Electrodynamics of Qualities of Metals" was made the Bakerian Lecture for the year. This paper represents a marvellous amount of ingenuity and labour and contains, most valuable new results that, strange to say, are only now beginning to be known. In it was announced his discovery of the electric convection of heat, and a great number of most important new relations between thermal and electric properties of matter. It is interesting to remark that it was while engaged in these investigations that Thomson first called in the experimental aid of his students, and thus made a beginning of the Glasgow Physical Laboratory.

We can do no more than mention here Sir William Thomson's *proof* of electricity of contact, his calculation of the size of atoms, his memoir on the mechanical energies of the solar system, his determination of the rigidity of the earth, his researches on the tides in connection with a British Association Committee on that subject, and his recent splendid researches on vortex motion, as we have still to refer to his connection with submarine telegraphy.

In 1854 Faraday, with an experimental cable, investigated the cause of the *retardation of signals* first observed in the working of the cable between Harwich and the Hague. Thomson, taking up the question published an investigation of the nature of the phenomenon, one practical result of which was that with cables similar in lateral dimensions the retardations are proportional to the *squares of the lengths*. This law is now commonly referred to as the "law of squares." About this time it was proposed to construct a cable to connect England with America; and it became obvious that the discovery of the retardation of signals raised a question whether the transatlantic cable would not prove a commercial failure. Whitehouse, experimenting with 1,125 miles of cable, found the transmission of an instantaneous signal to the farther end of the cable to occupy one second and a half. The length of a cable required to connect Ireland with Newfoundland is twice that of the experimental cable of Whitehouse; and thus, according to the law of squares, the time taken to transmit an instantaneous signal through a cable similar in lateral dimensions to that of Whitehouse, and joining those two places, would be no less than *six seconds*. In 1856 Whitehouse read a paper before the British Association, in which he described experiments by which he hoped to disprove the law of squares. Thomson replied in the *Athenæum* (Nov. 1, 1856); and subsequent experiments have established the correctness of his law.

Fortunately a true understanding of the nature of the phenomenon of retardation led Prof. Thomson to the method of overcoming the difficulties presented. The disturbance produced at the extremity of a long submarine cable by the application for an instant of electromotive force at the other end is not, as in the case of a signal through an overhead land-line, a pulse, practically infinitely short, and received only a minute fraction of a second after it was communicated. Instead of this, a long wave is observed at the farther extremity, gradually swelling in intensity, and as gradually dying away. Its duration for such a cable as we have been speaking of would be the whole six seconds, calculated from the experiments of Whitehouse. Prof. Thomson perceived that an instrument was required which should give an indication of a signal received long before the wave has acquired its maximum intensity, and in which the subsequent rising to maximum intensity should not render unreadable a fresh signal sent quickly after the previous one. This was effected by his "mirror galvanometer"; and it was by means of it that the messages transmitted through the 1858 Atlantic cable were read.

The 1858 cable, submerged under difficulties that many times threatened to be insurmountable, soon failed. Several important messages were, however, transmitted through it; and it served to *prove* the feasibility of the project which many eminent engineers up till that time regarded as chimerical. Before another attempt was made the labours of Prof. Thomson and others, to all of whom the world owes a deep debt of gratitude, had so improved the construction of the cables and the mechanical arrangements for submersion, that though many difficulties presented themselves they were all, in 1866, triumphantly overcome. It was on his return from the submersion of the 1866 cable, and the raising and the completion of the 1865 cable, that the honour of knighthood was conferred on him along with others of his distinguished fellow-workers.

Recently Sir William Thomson has invented a new and very beautiful instrument, the "siphon recorder," for recording signals on long submarine lines. It is in use at all the telegraph stations along the submarine line connecting England with India. It is also used on the French Atlantic Cable, and on the direct United States line. Sir W. Thomson, Mr. Varley, and Prof. Jenkin, combining their inventions together, have given the only system by which submarine telegraphy on long lines has been carried on up to the present time.

Sir William Thomson is an enthusiastic yachtsman and a skilful navigator. His recently-published popular lecture on Navigation proves this; and, with that bright genius which enriches all with which it comes in contact, his improvements in navigation, as we had occasion to remark a fortnight ago, in noticing his newly published "Tables for Facilitating the Use of Sumner's Method at Sea," are of very high importance. The general adoption of Sumner's Method, now made simple for the navigator, would be a reform in navigation almost amounting to a revolution, and is one most highly to be desired. Sir William Thomson has also invented a new form of mariner's compass of exquisite construction. It possesses many advantages over the best of those in general use, not excluding the Standard Admiralty Compass; but its special feature is that it permits of the *practical* application of Sir George Airy's method of correcting compasses for the permanent and temporary magnetism of iron ships. He has also invented an apparatus for deep-sea sounding by pianoforte wire. This apparatus is so simple and easily managed that he has brought up "bottom" from a depth of nearly three nautical miles, sounding from his own yacht, without aid of steam or any of the ordinary requisites for such depths. His method was much employed in taking rapid soundings during the laying of telegraph cables along the Brazilian coast to the West Indies. It has also been used with great success on the United States Submarine Survey. Recently, while on his way to Philadelphia, Sir W. Thomson himself was able to take flying soundings, reaching the bottom in 68 fathoms, from a Cunard Line steamship going at full speed.

The treatise on "Natural Philosophy" written by Prof. Thomson, in conjunction with Prof. Tait, brings before us another branch of activity in which he has shown himself as eminent as in research.

Sir William Thomson is a Fellow of the Royal Society of London and of the Royal Society of Edinburgh. He has received the Royal Medal of the former and the Keith Medal of the latter. He is also an honorary member of several foreign societies. The Universities of Dublin, of Cambridge, and of Edinburgh have each conferred upon him the honorary degree of LL.D., and that of Oxford the honorary degree of D.C.L. On his marriage in 1852 he gave up his Fellowship at St. Peter's College, Cambridge; but in 1871 his college again elected him to a Fellowship, which he now holds.

Sir William Thomson's brother, Dr. James Thomson, is Professor of Civil Engineering in the University of Glasgow. He is well known as the discoverer of the lowering of the freezing-point of water by pressure; and is the author of many other important physical researches.

The following opinion of Sir William Thomson's merit as a worker in science has been sent us by Prof. Helmholtz:—"His peculiar merit, according to my own opinion, consists in his method of treating problems of mathematical physics. He has striven with great consistency to purify the mathematical theory from hypothetical assumptions which were not a pure expression of the facts. In this way he has done very much to destroy the old unnatural separation between experimental and mathematical physics, and to reduce the latter to a precise and pure expression of the laws of phenomena. He is an eminent mathematician, but the gift to translate real facts into mathematical equations, and *vice versâ*, is by far more rare than that to find the solution of a given mathematical problem, and in this direction Sir William Thomson is most eminent and original. His electrical instruments and methods of observation, by which he has rendered amongst other things electrostatical phenomena as precisely measureable as magnetic or galvanic forces, give the most striking illustration how much can be gained for practical purposes by a clear insight into theoretical questions; and the series of his papers on thermodynamics and the experimental confirmations of several most surprising theoretical conclusions deduced from Carnot's axiom, point in the same direction."

British science may be congratulated on the fact that in Sir William Thomson the most brilliant genius of the investigator is associated with the most lovable qualities of the man. His single-minded enthusiasm for the promotion of knowledge, his wealth of kindliness for younger men and fellow-workers, and his splendid modesty are among the qualities for which those who know him best admire him most.

METEOROLOGICAL RESEARCH

IN previous articles the necessity of dividing into two groups the subjects usually called meteorological has been strongly insisted on. The one of these may be termed climatic meteorology, and is intimately connected with physiology and those sciences which have reference to life. The other may be called physical meteorology, and recent researches have shown that this is intimately connected with other branches of physical inquiry, forming in its wider aspect a sort of meeting ground between molar and molecular physics—a region, in fact, where we find the largest bodies of the universe influencing the smallest.

It is a fortunate thing that we have no longer any need to enlarge upon the practical importance of the latter branch, since this is now recognised even by those who are furthest from considering science worthy of investigation for its own sake; while our present Government, who have shown themselves so willing to further the interests of abstract science, are, we believe, no less anxious to encourage amongst us a truly scientific meteorology. I think, therefore, that the present moment is an opportune one for discussing our subject from the point of view of pure science.

Nor is a feeling of national pride out of place even here. England is the greatest maritime nation on record, and her interests are represented in every quarter of the globe. If her offspring, America, is content to bestow a yearly subsidy of 50,000*l*. on meteorology, it is surely not too much to expect that the subject should receive the most liberal and enlightened treatment from the mother country.

One of the reasons why it is necessary to call attention to meteorology is because the science, being young, is in a very different position from that occupied by her sister sciences, chemistry and physics, so that we cannot be said to have a school of meteorologists at present existing. It would be an object of national importance to encourage the formation of such a school.

Again, while a want of clearness exists generally and everywhere regarding the scope of meteorology, there is also a large amount of widespread ignorance. When a leg of mutton dropped from Nadar's balloon into