

OBITUARY NOTICES OF FELLOWS DECEASED.

WILLIAM JOHN MACQUORN RANKINE was born at Edinburgh on the 5th July, 1820. He was the son of David Rankine (a lieutenant in the Rifle Brigade, and a younger son of Macquorn Rankine, of Drumdow, of a well-known family in the county of Ayr), and of Barbara Grahame, one of the daughters of Archibald Grahame, of Dalmarnock, a banker in Glasgow. He was educated partly at Ayr Academy, partly at the High School of Glasgow, from which he went to the University of Edinburgh; but he derived much of his instruction from his father, and, like most men who have made any real mark in science, he owed the greater part of his knowledge to his own energy and industry. In 1836 he received a gold medal for an essay on the Undulatory Theory of Light, and in 1838 he gained an extra prize for his essay on Methods of Physical Investigation. Shortly after this date he entered upon the profession of Civil Engineering, as a pupil of Sir John McNeill, under whose direction he was employed from 1839 to 1841 in various schemes for waterworks and harbour-works in the north of Ireland, and on the Dublin and Drogheda Railway. At this time he invented a method of setting out curves which still bears his name. From 1844 to 1848 he was employed, under Locke and Errington, on the construction of the Clydesdale Junction Railway, and subsequently upon various schemes promoted by the Caledonian Railway. In 1845-46 he was engineer of the proposed Edinburgh and Leith waterworks, a scheme which was defeated by the rival Edinburgh Water Company. In 1852, he and the late John Thompson were joint engineers of the well-known works by which Glasgow is supplied with pure water from Loch Katrine. In November of 1855 he was appointed Regius Professor of Civil Engineering and Mechanics in the University of Glasgow: he retained this chair until his death, which occurred on the 24th December, 1872.

It is difficult to determine whether Rankine takes his highest place as an original investigator, or in respect of his great success in digesting the scientific knowledge of himself and his contemporaries into a form available for common use. His works have the very rare merit of being *thorough*, both in a scientific and in a practical sense. With great originality of treatment, and frequently of research, his text-books exhaust the useful theory of his subjects, and his results are always reduced to a form in which they can be actually used. His practice as an engineer had made him fully alive to the important difference between the crude results of theoretical reasoning from principles and the reduced formulæ adapted to the data obtainable from observation or specification. There is probably no scientific writer to be compared with him in the three aspects of the extent covered by his treatises—their scientific accuracy and exhaustiveness and their immediate adaptation to the use of practical men, who may be utterly unable to follow the reasoning by which he arrived at his formulæ. There are persons who think that the path-finder in science is of a higher and rarer order of

intelligence than the road-maker. There are those who think otherwise; who consider that the latter frequently displays the broader and more masculine intellect. However this may be, all rational men agree in awarding the highest meed of praise to those who can both find the path and make the road,—who can say to the little children of science, so far can you follow me—and to the maturer minds, from that point you may extend my paths. Of these men was Rankine.

Rankine's most important contributions to science are in the dynamical theory of heat, in the theory of the steam-engine, in that of waves in liquids, especially of sea-waves, and on the resistance and rolling of ships. He was among the earliest students in this country who were able to understand what was meant by thermodynamics. He contributed largely to the extension and settlement of the theory, and, probably to a greater extent than any other person, to its reduction to rules adapted to the practice of engineers; indeed he may be considered one of the founders of the science. In the study of waves in liquids, he and Mr. William Froude appear to have been the first persons who successfully worked out a possible theory of waves of finite displacement in the sea: all the previous researches were either incomplete in theory or limited to infinitesimal disturbance. Rankine and Froude, working independently of one another, appear to have been the first to arrive at a definite demonstration of the mechanical possibility of the trochoidal wave. They were not the first to suggest that the trochoid was the clue to the geometry of the sea-wave: Gerstner and Scott Russell had already done that; but it was Froude, in the 'Transactions of the Institution of Naval Architects,' and Rankine, in the 'Transactions of the Royal Society,' who first gave proof that it complied with all the conditions of fluid motion, except that of the absence of molecular rotation.

His study of the resistance of ships appears to have been suggested to him by an application addressed to him and to Professor (now Sir William) Thomson by his friend James Robert Napier, for advice as to the power necessary to propel vessels of any form. Professor Thomson then called attention to the defect in existing theories, with reference to the resistance of water to a ship's progress, from not taking account of the viscosity of the fluid. Professor Rankine stated that if the resistance outside a ship was the same as that inside a water-pipe, the power required to propel a certain vessel would be so and so, naming a power of about two thirds what Mr. Napier had estimated to be necessary. Alluding to this, Professor Rankine wrote, in August 1858, to the *Philosophical Magazine* (ser. 4, vol. xvi. p. 238):—"In the course of last year there were communicated to me *in confidence* the results of a great body of experiments on the engine-power required to propel steamships of various sizes and figures at various speeds. From those results I deduced a general formula for the resistance of ships having such figures as usually occur in steamers, which, on the 23rd of December,

1857, I communicated to the owner of the experimental data; and he has since applied it to practice with complete success." This circumstance no doubt led to his addressing himself to the theory of ships. With this object in view, he investigated the form and mechanical work both of sea-waves and of waves in canals, the waves which accompany ships, the loss of work consequent on the formation of divergent waves, the stream-lines or lines of motion of water flowing past a ship, the effect of the combined oscillation of a ship and a wave, the steadying effect of keel-resistance, and many other important points of the hydraulics of a ship. On nearly all these points he did important original work, although in many of them the credit must be shared between him and others who were working abreast of him—notably Sir W. Thomson and Mr. W. Froude. He also studied the question of propulsion, and placed its theory on a sound basis. This branch of knowledge owes more to Rankine than to any other writer.

His principal published works are his 'Manual of Applied Mechanics,' a volume of about 640 pages, published in 1858; his 'Manual of the Steam-Engine and other Prime Movers,' a volume of 580 pages, published in 1859; his 'Manual of Civil Engineering,' a volume of 780 pages, published in 1862; his 'Manual of Machinery and Millwork,' a volume of 580 pages, published in 1869; and his book of 'Useful Rules and Tables,' published in 1866. Besides these, he was the corresponding editor of, and principal contributor to, the great work of 'Ship-building, Theoretical and Practical,' by Watts, Napier, Barnes, and Rankine, published in 1864-66. All these treatises have the great merits of being exhaustive, dropping out or avoiding no part of their subject, of bringing down their scientific information close upon the very date of their publication, and of having all their results reduced to a workable form. When it is added that they are terse and concise almost to a fault, and that they cover the whole of the ground from simple addition to the application of elliptic functions in pure mathematics, and from the common lever to the ellipsoids of stress and of rotation, and to the friction of gases, in applied mathematics, some idea may perhaps be formed of the immense mass of knowledge which Rankine succeeded not only in acquiring, but in reducing to a shape available in the every-day work of practical men.

As an instance of the wide generality of his interest in scientific research, may be mentioned his papers in the 'Engineer' of 1869, in which he explained the curious dynamical theory of the bicycle, or two-wheeled velocipede, which had just then come into general use. These papers are still the most complete treatise on the subject.

The joint report of Professor Rankine and Dr. Stevenson Macadam on the accident which took place in 1872 at the Tradeston Flour-Mills, by the explosive firing of air charged with flour-dust, is also a most remarkable proof of his power to handle work of a miscellaneous character.

In the 'Catalogue of Scientific Papers,' compiled under the care of the

Royal Society, Rankine is credited with eighty papers down to the year 1865. He has published a very considerable number since that date. His last, and one of his most important contributions to the Philosophical Transactions is that "On the Mathematical Theory of Streamlines," read before the Royal Society on the 10th February, 1870. This paper contains a remarkably complete investigation of the lines of motion of particles of liquid in flowing past certain solid bodies, such as ships, and of the mechanical as well as the geometrical character of the disturbance.

It is satisfactory to reflect that his labours met with full recognition during his lifetime from the scientific bodies best qualified to judge of their merits. In 1849 he was elected a Fellow of the Royal Society of Edinburgh. In 1850 he acted as Secretary to Section A of the British Association, which then met at Edinburgh. In 1845 he was elected a Member of the Philosophical Society of Glasgow, and in 1853 a Fellow of the Royal Society of London. In 1854 he was awarded the Keith Medal of the Royal Society of Edinburgh for researches in Thermodynamics. In 1855 he was appointed one of the Visitors of Edinburgh Observatory, and in the same year Regius Professor of Civil Engineering and Mechanics in the University of Glasgow. He was also President of Section G of the British Association when it met in Glasgow in 1855. In 1856 he received the honorary degree of LL.D. of Trinity College, Dublin. In 1863 he was awarded the gold medal of the Institution of Engineers in Scotland for a paper "On the Liquefaction of Steam;" and in the same year he was President of Section A of the British Association at Newcastle-on-Tyne. In 1867 he was again President of Section G at Dundee. In December 1870 he was appointed a member of the Admiralty Committee on Ships of War, which arose out of the loss of H.M.S. 'Captain,' and he contributed largely to the scientific part of the report.

His great industry and success in the field of science were never allowed to interfere with the ordinary duties owing to society, or with those sacrifices of time which all men are called upon to make for the gratification of others. Thoroughly genial in company, affectionate and beloved in his family circle, careful and yet liberal in the relations of business, amiable and even in temper, it was as great a pleasure as it was an honour to be counted among his friends. He has not unfrequently sung a song of his own writing to music of his own composing; and, what is more, the voice, the music, and the words were all worth listening to.

His illness began by a failing of the eyesight, which was at first supposed to be local, but which afterwards proved to be but a symptom of more deeply seated disease. Under treatment, he recovered from a severe attack of illness in October 1872, and up to within five days of his death no unfavourable symptoms occurred: then a change took place; he rapidly lost the power of speech, and the sensibility of the right side. He died on the 24th December, 1872.

He was never married. His only brother died while he was yet young, and he lost his father and his mother a year or two before his own death.