OBITUARY.

LORD ARMSTRONG was born at Shieldfield, Newcastle-on-Tyne, on the 26th November, 1810, and died on the 27th December, 1900, aged 90 years. The chief incidents in his long and illustrious life are so well known that it is difficult to invest an account of them with any novelty. His father, Alderman Armstrong, was a corn merchant in Newcastle, and his mother was a daughter of Mr. Potter, of Walbottle Hall. Alderman Armstrong prospered in his business, was a good mathematician, collected a valuable mathematical library, and contributed to the mathematical diaries of the time. He interested himself in municipal affairs, and became Mayor of Newcastle.

William George Armstrong was one of two children—an only sister, some years his senior, became the wife of the late Baron Watson of the Court of Exchequer—and he received, according to the ideas of the day, a good education, first at a private school in Newcastle, afterwards at Whickham, and subsequently at the grammar school at Bishop Auckland. He passed from school into a well-known Newcastle solicitor's office, and it was during his leisure hours that he exercised his inventive instincts in the direction of mechanical investigations and studies.

The frequently accepted idea that Lord Armstrong was a self-made man, who rose from an obscure position to greatness, is inaccurate. It is quite true that, so far as his engineering reputation is concerned, his genius carried him to an eminence which was almost unique; but, so far as mere worldly prosperity goes, he was born, as has been mentioned, in comparatively affluent circumstances, and the property which he inherited was considerable. The student of character will notice with interest that no spur of poverty was necessary to stimulate Lord Armstrong's wonderful energy. He worked, he studied, he experimented, almost up to the end of his life, because to do so was part of his nature.

His earliest and his latest researches lay in the direction of electrical science. An engineer employed at Cramlington Colliery in charge of a fixed engine, experienced a somewhat severe electric shock on approaching his hand to the lever of the safety-valve, he being in contact with a jet of steam escaping from a leak

in his boiler. The experience was so novel that it attracted considerable attention, but the experiments which Lord Armstrong made led him to give the true explanation of the phenomenon. His experiments were communicated to the Philosophical Magazine in 1842 and 1843, and in 1844 his hydro-electric machine, based upon these experiments, was exhibited to the Literary and Philosophical Society of Newcastle-on-Tyne. His larger machine, made for the London Polytechnic, was the most powerful machine then known for producing electricity of high tension. Almost immediately after the production of the hydro-electric machine, Lord Armstrong was elected a Fellow of the Royal Society. Among the signatures to his certificate may be noticed the names of Grove, Wheatstone, and Faraday. At his death in 1900, he was, with two exceptions, the Senior Fellow.

The formation of the Whittle Dene Water Company, by which to this day Newcastle is supplied with water, was due to Lord Armstrong's initiative. By his energy and ability the opposition which the scheme at first excited was overcome, and for some time he acted as Secretary of the Company, but his connection with Whittle Dene led to results little anticipated when Lord Armstrong originated the scheme. Whittle Dene Reservoir was nearly 400 feet above high-water mark, and the energy stored up in the water-pipes with this considerable head at the level of the Newcastle quays soon suggested to him the utilization of this source of power. By permission of the Newcastle Town Council, he erected, at his own expense, the first hydraulic crane, which proved at once a great success, and soon excited the attention of engineers.

One of the first to inspect the crane was the well-known Mr. Jesse Hartley, the Engineer-in-Chief of the Liverpool Docks, who was exceedingly sceptical as to the miraculous stories told about the crane, and was somewhat rough with the man in charge, who had become remarkably skilful in his manipulation of the crane. "Hydraulic Jack," as the man was facetiously called, asked Mr. Hartley what he would give him if he let the load drop and picked it up again. Some trifling reward was promised, when the load was suddenly allowed to drop at great speed, as suddenly stopped and raised again smoothly and rapidly to its starting position. Mr. Hartley declared the crane to be exactly what he wanted. He gave an order for the Liverpool Docks, the forerunner of the considerable work done by Lord Armstrong's firm for that city. The first hydraulic cranes ordered were manufactured at Messrs. Watson's works in Newcastle, and at works

elsewhere, but the demand for cranes and other hydraulic machinery increased so rapidly that in 1847 Lord Armstrong resigned the secretaryship of the Whittle Dene Water Company, and devoted his whole attention to starting the Elswick Engine Works. It is needless to say that he no longer practised as a solicitor, and indeed it was inevitable that the combination of legal work and scientific engineering could not satisfy a man whose bent was so strongly set in the direction of mechanical invention.

His early partners at Elswick were Mr. Donkin, Mr. Addison Potter, Mr. George Cruddas, and Mr. R. Lambert, and the support they gave to, and the trust they reposed in, the genius of their partner and manager never faltered during the many difficulties which were necessarily met with in works newly started and occupied with a novel manufacture. With the single exception of Mr. Cruddas, the names of Lord Armstrong's early friends and partners have long since disappeared from the councils of the firm.

Up to 1849 the cranes erected by the Elswick firm were worked by water with a natural head, but as the demand for hydraulic cranes increased, the Elswick Works were asked to supply cranes and other hydraulic machinery for situations where sufficient pressure was not obtainable. This led Lord Armstrong to devise an apparatus, which he named an "Accumulator," consisting of a cylinder of dimensions varying with the requirements of the case, in which worked a ram carrying a load usually adjusted to give to the water pumped into the cylinder by a steam-engine, a pressure of about 700 lbs. on the square inch. This contrivance had the double advantage of allowing hydraulic machinery to be employed in any situation, and it also possessed the advantages of being almost free from those fluctuations of pressure ordinarily found in water mains, and of allowing the employment of much smaller pipes. It would be out of place here to describe the innumerable applications of hydraulic power which have resulted from Lord Armstrong's labours. Hydraulic power has been found especially useful where power is required intermittently and for comparatively short periods.

In connection with this part of Lord Armstrong's work, it may be mentioned that on the 3rd April, 1849, he was elected an Associate of the Institution, and that his eminence in regard to hydraulic machinery was referred to as a ground for his transfer to the class of Members, which took place on the 31st January, 1854, his certificate being signed, among others, by Robert Stephenson, Sir William Cubitt, Thomas Hawksley, J. M. Rendel,

Sir John Rennie, George Parker Bidder, and Sir Charles Hutton Gregory. Further in the Proceedings of the Institution there are Papers by him on "The Application of Water-Pressure as a Motive Power for Working Cranes, and other descriptions of Machinery,"[1] in 1850, "On the Concussion of Pump Valves,"[2] 1853, and "The History of the Modern Development of Water-pressure Machinery,"[3] 1877.

On the 5th November, 1854, the severely disputed battle of Inkerman was fought. The result of the day was largely influenced by the action of Colonel, now General Sir Collingwood Dickson, V.C., who, by incredible exertion, dragged two 18-pounders up a hill where their superior power and range proved of great value. The great weight and clumsiness of these pieces of ordnance induced Lord Armstrong to consider whether equally powerful and long range guns could not be made much lighter, and in December, 1854, he had an interview with the Duke of Newcastle, then Secretary of State for War, who authorised him to submit for trial certain guns, not exceeding six in number. The first gun, a 3-pounder, was tried in 1855, giving very satisfactory results, and Lord Armstrong pointed out that so far as range was concerned, he had succeeded in obtaining with 7° elevation the same range as that obtained with the smooth bore 68-pounder of the Service. This gun is still to be seen at Elswick.

But it was desired that a gun should be submitted which, so far as weight was concerned, would compare with the 9-pounder of the Service. This gun, an 18-pounder, was submitted in July, 1857, and in February, 1858, the Superintendent of Experiments reports "that the very extraordinary powers of range and precision of fire exhibited at Shoeburyness, from the breech-loading gun of Mr. Armstrong's invention, appear to afford a reasonable expectation that artillery will not only regain that influence in the field of which to a certain extent the recent introduction of rifled small arms has deprived it, but that that influence will be most materially increased." Lord Panmure, who was then Secretary of State for War, expressed himself equally strongly, and the gun was subsequently submitted to a special Committee on Rifled Cannon. This Committee, which was appointed in August, 1858, and dissolved in February, 1859, examined and reported on rifled guns submitted by seven different inventors. They reported to the War Office that these guns might be divided into two classes. The first class

[1] Minutes of Proceedings Inst. C.E., vol. ix. p. 375.
[2] *Ibid*, vol. xii. p. 450.
[3] *Ibid*, vol. l. p. 64.

included the guns of Mr. Armstrong and Mr. Whitworth. As regards the second class the Committee recommended that no further expense should be incurred with respect to them. They unanimously recommended that the Armstrong gun should be introduced into the Service both on account of its accuracy, the perfection of its workmanship, and the completeness with which the ammunition and other details had been worked out.[1] Lord Armstrong first endeavoured to use steel in the construction of his built-up guns, but the steel of that day, in large forgings, proved too unreliable for use. The first gun submitted to the British Government had a steel barrel reinforced with coiled iron hoops, a construction which for a very considerable time was that of the Service.

On the adoption of his gun, Lord Armstrong placed his inventions at the disposal of the nation, severed for a time his connection with his firm, and received the honours of knighthood and Companionship of the Bath. He was then appointed Engineer of Rifled Ordnance and Superintendent of the Royal Gun Factories, an arrangement was made with the newly-formed Elswick Ordnance Company, and the manufacture of the new rifled guns was carried on both at Woolwich and at Elswick. This arrangement was continued until the agreement with the Elswick Ordnance Company was put an end to in 1863, when, at the request of his old partners, he resigned his Government appointment and rejoined the firm.

In this year Sir William Armstrong was President of the British Association for the Advancement of Science, and as member of a Committee appointed by the Steam Collieries Association of Northumberland, having had his attention directed to the great waste of coal by steam users, he devoted a considerable portion of his Presidential Address to the duration of coal supply in this country That part of his Address attracted so much attention that a Royal Commission was appointed to investigate the subject.

It is unnecessary here to do more than allude to the Armstrong and Whitworth Committee and the artillery questions, which, at that time, so much vexed experts, but it is interesting to note that the two great rival establishments have been united for some years and bear the names of their great founders. It is more important

[1] Some idea of the precision referred to above may be gathered from an appendix attached to the Committee's report, by which it appears that, at 1,000 yards range, half of the shot fired from the smooth-bore field-gun of the Service fell in a rectangle 92 yards long by 7 yards wide, while the corresponding rectangle with the Armstrong gun was 17 yards long by 0·8 yard wide.

to note the retrograde step which at this time was taken by the British Government. The high naval and military officers of the day considered simplicity to be all-important, and there was great difficulty in introducing even the simplest mechanical contrivance. Some defects, which might easily have been remedied, were found in parts of the breech mechanism, if due and careful attention were not given when closing, and the determination was made to revert to muzzle loading. That determination placed this country at a serious disadvantage, and does not appear to have been reconsidered until, in 1878, the Elswick firm, guided by certain recent researches on explosives, submitted to the Government 6-inch and 8-inch guns, both breech and muzzle loading, with which velocities of over 2,100 feet per second were obtained. The highest velocities of the then Service muzzle loaders did not reach 1,600 feet per second, and the difference in energy due to the above velocities was equivalent to an increase of more than 60 per cent. But to obtain this increase with moderate pressures in the chamber, it was necessary to add largely to the length of the gun, and it soon became obvious that, in order to realize the highest energy and efficiency, a return to breech loading was a necessity. Lord Armstrong, whose first guns were all breech loaders, and who, although Elswick made many muzzle loaders, was throughout his career a strong advocate of breech loading, played an important part in this matter. His high authority and the results which he showed to be possible had great weight with the naval and military authorities in regard to the abandonment of the now obsolete muzzle loaders.

After the conversion of the firm into a limited company, Lord Armstrong retired more and more from active management. Questions arose from time to time into which he would enquire with all his old vigour, but unless something special was under discussion he rarely visited the works. He found in the management of his estate at Cragside, and in various scientific studies, quite sufficient occupation. So late as 1897 he gave a discourse at one of the *soirées* of the Royal Society upon his recent electrical researches. Towards the close of his life he took great interest in the reconstruction of Bamburgh Castle, and spent a considerable portion of his time in superintending the work.

His vigour as an old man was wonderful. Until within two or three years of his death he preserved his strength and faculties in an extraordinary way. As a young man Lord Armstrong was considered so delicate that his life was refused by several insurance offices. In later life he amused himself by calculating how much

they had lost by so refusing him. He always used to say that it was the Rothbury air which set him up, and one of the aspirations of his early manhood was to build some day a house for himself at Rothbury. His robust old age gave way in August, 1897, when an attack of illness prostrated him and left him an invalid for the few remaining years of his life. He rallied a little from time to time, but he was never able to do much more than walk about his house or drive about his grounds. Yet even when confined to his bed the clearness of his understanding was as marked as ever, and he showed no trace of any mental weakness. He survived his ninetieth birthday by a few weeks, and then, overtaken by some slight indisposition, he sank without pain and died peacefully in the last week of the nineteenth century. He was buried, on the last day of the century which owed so much to his labours, beside the remains of his wife in Rothbury churchyard. Nobody during that century had been more closely identified with the practical and material progress of mankind. The fame of Lord Armstrong as an inventor and as an adapter of natural agencies to human ends must always rank very high. For speculative questions he had no taste at all, but upon any practical problem which offered itself for solution, he would turn the whole force of his intellect, and work out his ideas with the greatest perseverance.

In private life he was charming, and was loved and revered by his intimate friends, though there was a certain reserve about his manner which sometimes rendered him rather formidable to strangers. A great benefactor to his native town, he once stood for Newcastle as a Unionist candidate with Viscount Ridley, for the House of Commons, but failed to secure a seat. Though a lucid writer and a good lecturer, he was not a speaker, and he lacked that surface *bonhomie* which aids a candidate so much. Labour troubles also had a share in his rejection. At Cragside he entertained in a princely fashion many distinguished Englishmen and foreigners. In this he was assisted by Lady Armstrong, who predeceased him by eight years.

He was raised to the Peerage in 1887, as Baron Armstrong of Cragside, and in addition to being a Companion of the Bath, held the order of Saint Maurice and Saint Lazarus of Italy, of the Dannebrog of Denmark, of Jesus Christ of Portugal, of Francis Joseph of Austria, of Charles III. of Spain, of the Rose of Brazil, of the Dragon of China, and of the Sacred Treasure of Japan.

Lord Armstrong's connection with the Institution lasted upwards of fifty-one years. The dates of his election and transfer have already been given. He served as a Member of Council from 1856

to 1865, and again from 1871 to 1881, and in December of the latter year he was elected President. His Address,[1] delivered on the 10th January, 1882, dealt mainly with the application of engineering to the operations of war. He had also held the offices of President of the Institution of Mechanical Engineers and of the North of England Institute of Mining and Mechanical Engineers. The Institution of Civil Engineers awarded him a Telford Medal in 1850, while the Society of Arts gave him the Albert Medal in 1878, and the Iron and Steel Institute the Bessemer Medal in 1891. He received the degree of LL.D. from the University of Cambridge and that of D.C.L. from Oxford and Durham.

WILLIAM GEORGE BROUNGER was born at Hackney on the 26th June, 1820, and, having been educated at Totteridge and at London University School, became a pupil of the late Sir Charles Fox (then Mr. Fox), under whom he was engaged on the construction of the London and Birmingham Railway. In 1851 he was employed by Messrs. Fox and Henderson to set out the Exhibition Building, now the Crystal Palace, with regard to which work Joseph Gwilt, in his "Encyclopædia of Architecture," wrote "the symmetry and strength of this vast building depended upon the accuracy with which the simple plan was drawn out, and much credit is due to Mr. Brounger, who superintended this portion of the work." [2]

In the early fifties he was placed in charge by Messrs. Fox and Henderson of the laying out and construction of the Zeeland Railway in Denmark, from Roskilde to Korsör, which he executed in so substantial and excellent a style as to bear favourable comparison with the best works in England.

About the year 1854, on the nomination of Sir Charles Fox, the Consulting Engineer, Mr. Brounger was appointed Engineer to the Cape Town Railway and Dock Company, and surveyed and supervised the construction of the first railway in South Africa, from Cape Town to Wellington. When that line and the branch to Wynberg were taken over by the Cape Government in 1874 he was appointed head of the Railway Department, with the title of "Railway Engineer for the Colony," and the success which has attended the Cape Government railways is in a large measure due

[1] Minutes of Proceedings Inst. C.E., vol. lxviii. p. 36.
[2] Page 1022.