was convinced, therefore, that the action was brought about by rays emanating from the substances with which he experimented, and to these rays the name of Becquerel has been given. Here, then, was the commencement of a series of discoveries which greatly modified the views which had previously been held regarding the material constitution of the universe.

Monsieur and Madame Curie had studied under Monsieur Becquerel, and at his instigation these two brilliant investigators undertook to make a complete analysis of pitchblende, from which mineral uranium is obtained. The result, as all the world knows, was the discovery of the radium compounds. Nor were Monsieur and Madame Curie alone brought into this entrancing field of experiment. Scientists all over the world have followed, and are following in the same footsteps, each one adding more or less to the general knowledge; nor did Monsieur Becquerel relax his efforts. It was but quite recently that he gave a Friday evening's discourse on this fascinating subject before the Royal Institution.

Perhaps few scientists of his years have received so much and such widespread recognition of their achievements. Monsieur Becquerel was President of the French Academy of Science, and Perpetual Secretary for the Department of Physical Sciences, a post to which he was elected as shortly ago as 29th June last. He had received honorary degrees from the Universities of Oxford, Cambridge, Aberdeen, and Manchester. He was awarded the Rumford Medal in 1900, and then came the great Nobel prize in 1903, as already mentioned.

He received his first education at the Ecole Polytechnique and at the Ecole des Ponts et Chaussées, and was for ten years chief engineer of the Government Department of Ponts et Chaussées. He was elected a member of the Institute in 1889, and in 1895 was created Professor of Physics at the Museum of Natural History. At this institution his son Jean is now an assistant.

SIR GEORGE BARCLAY BRUCE.

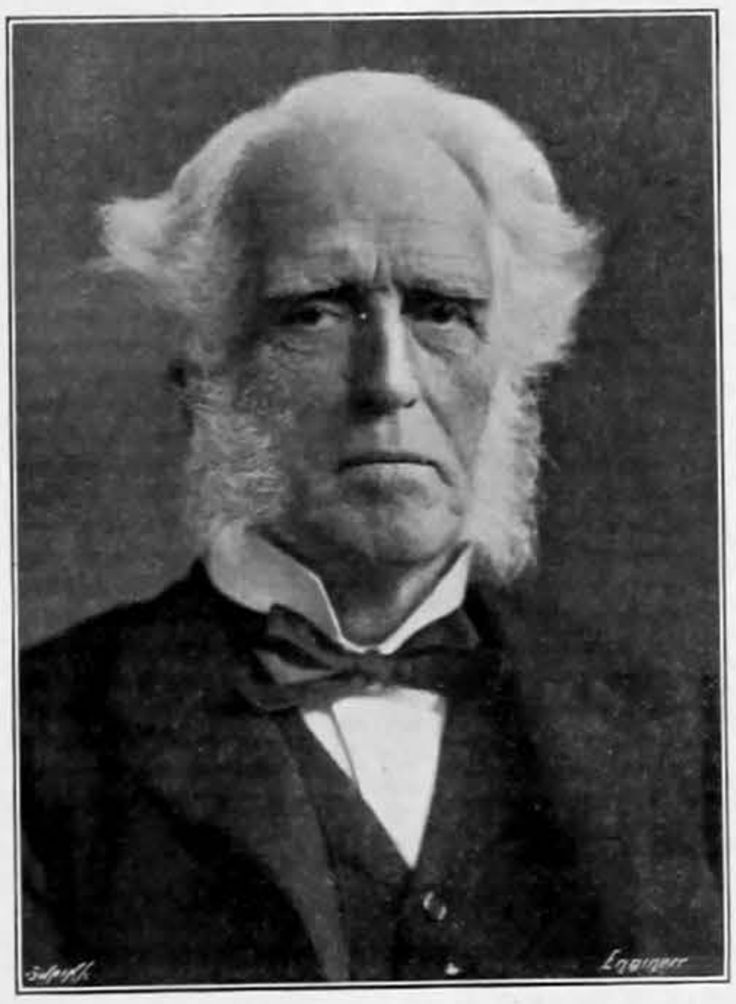
ONE of the few remaining links connecting railway engineers of the present with those great names inseparably associated with the commencement of railway construction has been severed by the death of Sir George Barclay Bruce, which took place on Tuesday evening last at his house, 64, Boundary-road, St. John's Wood. Sir George was born on October 1st, 1821, and he had therefore nearly completed his eighty-seventh year at the time of his death, which came as a termination to a long illness commencing with an attack of congestion of the lungs in February last. He was the son of Mr. John Bruce, of Newcastle-on-Tyne, a schoolmaster, at whose school he attended until he was fifteen. It is interesting to note that Sir Isaac Lowthian Bell and Robert Stephenson were also educated there. It was perhaps owing to Robert Stephenson, who was, however, seventeen years his senior, having attended the same school, that young Bruce when he left school entered the Stephensons' works, where he served a six years' apprenticeship, afterwards taking service with the firm as an engineer. This must have been about the year 1842. It will be remembered that George Stephenson, the father of Robert and the owner of the works, did not die until 1848, so that Bruce had worked under him for some twelve years, including the period of his apprenticeship. At this time the firm was engaged in the construction of the Newcastle and Darlington Railway, and in this Bruce had his share, being later on resident engineer-in-charge of the Royal Border Bridge for carrying a continuation of this line across the Tweed at Berwick. This bridge was designed by Robert Stephenson, but for the actual constructional work George Bruce was entirely responsible. The line was opened by Queen Victoria in 1850, and in 1851 Mr. Bruce read a paper on the Border Bridge before the Institution of Civil Engineers, this paper being awarded a Telford Medal.

Almost immediately after this—so soon, in fact, that it was before the medal could be presented to him—he had set out for India, where he was to be engaged for the next five or six years on railway construction in Bengal and Madras. As chief engineer of the line he carried out the Madras Railway with its celebrated bridge over the Cauvery, near Trichinopoly. Subsequently he became consulting engineer to this line, a position which he held, we believe, at the time of his death.

His whole life was identified with railway construction, and it would take a long list to exhaust the numbers of lines with which he was more or less intimately connected, but it may be said that they spread over a wide area and included railways in South America, Germany, and Spain as well as in England and India.

Mr. Bruce was President of the Institution of Civil Engineers in 1887-88, and in the latter year he received the honour of knighthood. Coinciding as the commencement of his term of office did with the completion of the first fifty years of the reign of the late Queen Victoria, it is not wonderful that the subject chosen for the address should have been a comparison between matters engineering as they existed at that time and in 1837. The address, as those who heard it will remember, was of the greatest interest, and the pictures drawn of the disabilities under which engineering work was carried out at the earlier date were such as to occasion wonder that such magnificent results as were attained could possibly be achieved. "It is scarcely credible," runs one passage in the address, "but it is a fact that there was not a single crane in Robert Stephenson's shops in 1837. There were shearlegs in the yard, by which a boiler could be lifted on to a truck, and there were portable shearlegs in the shop, by the skilful manipulation of which, at no little risk to life and limb, wonders were done in the way of transmitting heavy loads from one part of the shop to another." . . "There were no small planing or shaping machines, which now play so important a part in every engineer's shop. There was only one slotting machine, the use of which was very restricted. Wheels were driven on to their axles by sledge hammers wielded by strong arms alone. Steam hammers were, of course, unknown, and only hand labour was available for the ordinary work of the shop and boiler yard, with the exception of the punching and shearing machines. . . ." Such were the conditions under which the young engineer commenced to work at his profession, and it must also be remembered that neither the Bessemer nor the Siemens process of steel manufacture had been invented. Truly, it is marvellous that such good work was done as was accomplished by those old-time engineers.

Sir George was a constant attendant at the meetings of the Institution, and until a comparatively short time ago, at any rate, he frequently took part in the discussions on papers, especially when these had to do with railway subjects, though there were occasions on which he showed clearly that there were many other departments of engineering on which his knowledge was of a first-class order. An interesting point brought out by him on one occasion was that the bogie as applied to locomotives was not of American origin, as had been alleged, since bogie engines had in the first instance been shipped to America by Stephenson, largely copied there, and re-introduced into this country. Some figures which he brought forward when discussing a paper on a tunnel between England and France by Mr. Joseph Prestwich, F.R.S., are worth mentioning. He understood, he said, that the cost was estimated at £10,000,000, but, making allowances, he would suppose it was £12,000,000. In order to make it pay 5 per cent., allowing 50 per cent. for working expenses, £1,200,000 a year gross receipts would be required, so that, assuming the line to be 28 miles long, it would have to earn £824 per mile per week. The Metropolitan, he said, running through the heart of the population of London, earned about £1099 per mile per week; the Lancashire and Yorkshire, £147; the Great Western, £65; and the London and North-Western, £105; so that the tunnel, in order to pay only 5 per cent., would have to earn



SIR GEORGE BARCLAY BRUCE

thirteen times as much as the Great Western and nearly as much as the Metropolitan. He had no doubt, he added, that a tunnel could be made, but "the idea of its being an undertaking that would pay was," he feared, "quite chimerical."

His views on technical education were pronounced; he held that the true function of a scientific education in relation to engineering and mechanical operations was the teaching of physical science and those laws of Nature that underlie the exercise of all handicrafts, and not the teaching of the handicraft itself. The latter, he considered, could be better taught, and could only be efficiently taught, in the workshop.

Sir George was one of the very few men of the present time who have seen not only the development of the railway systems of the world, but were actually alive when railways came into existence, for it was not till four years after he was born that the Stockton and Darlington line was opened. His death will be keenly felt by a wide circle of friends.

VOIDS, SHRINKAGE, AND WEIGHT OF CRUSHED STONE.

PROFESSOR IRA O. BAKER, of the State University of Illinois, author of "A Treatise on Masonry Construction," has just issued the result of a set of careful experiments made by trained observers to determine the actual proportion of voids in crushed rock. Observations were also made on the shrinkage or settlement of the crushed material in transportation, as well as on the actual weights. From these results he has prepared a set of tables for the purpose of assisting constructors in estimating what has now become a very important item on most contracts—crushed stone. It is believed that this is the first time that trustworthy results have been published on the subject.

During the past two seasons the quarry run has been carefully watched at the quarries at Chester, Joliet, and Kankakee, all of which are situated within a short distance of Chicago. The Chester stone is a rather coarsely granulated grey limestone of the lower carboniferous group. That from Joliet is a compact, fine-grained magnesium limestone of the Niagara series. The Kankakee stone is a coarse-grained argillaceous limestone of the Niagara group. The specific gravity of the stone was determined with great care in every instance, and the absorptive properties were carefully studied. In arriving at the percentage of voids the crusher product was separated into different sizes, from that passing a 3in. screen to the commercial "3in." stone. The percentage of voids was determined both by using the specific gravity method and by pouring in water, the one being used as a check on the other. Some of the vessels used in the experiments contained 27 cubic feet; others had volumes of from 2.6 cubic feet to 0.694 cubic feet. It was found that the distance of drop in filling the vessels had considerable influence on the amount of voids. The drop varied from shovelling to a fall of 20ft. in height. The 20ft. drop invariably gave a less percentage of voids than a drop of even 15ft. It was found that the voids increase with the size of the stone.

Owing to the difference found between stone as loaded and its size at its destination, wagons and cars were filled and carefully measured at fixed distances. For the sake of comparison, the experiments were made as nearly as possible under the same conditions. The state of the roads, the rate of driving, the amount of shunting, were all carefully watched. The measurements proved that for wagons about half the settlement occurs in the first 100ft., and that the settlement at half a mile is practically the same as that at a mile. With cars practically all the settlement takes place during the shunting and the first part of the journey. This part of the work, however, seems not to be very conclusive, and can only be stated in a general way.

In order to find the weight of the crushed rock at the end of the trip, the point at which the engineer usually receives it, the measurements were continued with the same care. The figures show a very considerable settlement. All conditions of weather and moisture were carefully noted, as these affect the conveyance as well as the stone. All the figures agree in a general way on these points—the weight of screenings is greater than that of coarser stone, and the weight of 3in. stone is greater than that of 2in.

Observations were also made to determine coefficients by which to deduce the weight per unit of volume of crushed stone when the weight of a unit of solid stone or the specific gravity is known. After studying this question for all the different sizes, a mean was taken for each size. From this it was found that the coefficient by which to multiply the weight of a cubic foot of limestone to obtain the weight of a cubic yard of the crushed stone is for ¼in. screenings 15.5, for 2in. to ½in. 14.6, and for 3in. to 2in. 15.2. The mean of all these is 15.1. It will be noticed that the coefficient is largest for the finest stone and smallest for the intermediate size. This seems to prove that the weight of screenings is greater than that of coarser stone, while the weight of the intermediate size is less than that of either extreme size.

Size of stone.	Per cent. of voids.		Per cent. of settlement.		Weight, lb. per cubic yard.			
	By pouring water.	By specific gravity.	½ mile or more, wagon.	75 miles or more, cars.	Wagons.		Cars.	
¾in. scr. C..	40.9	46.8	12.7	—	—	—	—	—
,, K..	39.6	46.1	10.0	—	2430	2697	—	—
½in. scr. J	42.2	47.1	9.1	8.4	2303	2533	2659	2905
¾in. scr. C..	43.0	45.6	11.8	10.6	2442	2797	2546	2850
,, J	—	—	—	9.7	—	—	2652	2882
1¼in. to ¾in. K.. ..	45.7	44.7	8.6	—	2325	2546	—	—
2in. to ½in. J	47.9	46.2	6.6	7.4	2315	2480	2386	2592
2in. to ¾in. C	46.6	46.6	9.2	—	2344	2582	—	—
2in. to ¾in. J	—	—	—	9.5	—	—	2296	2516
2½in. to ¾in. K.. ..	44.3	42.9	—	5.4	—	—	2260	2390
2½in. to 1¼in. K ..	46.2	43.4	—	—	—	—	—	—
3in. to 2in. C	46.1	45.1	8.2	7.0	2367	2569	2348	2545
,, J	47.5	46.1	—	7.8	—	—	2361	2553

The above table has been compiled from the summary of the various results given by Professor Baker. In the table C stands for Chester, J for Joliet, and K indicates the stone from the Kankakee quarry.

RECENTLY Captain A. P. H. Desborough reported to the Home-office on a fatal explosion of gelignite which occurred at the factory of Messrs. Curtis and Harvey, Roslin, in March last. It appears that the fatality happened when a 50 lb. box of gelignite was being placed in a cart. Some of the cartridges had shown signs of exudation, and, as the explosive was congealed at the time of the accident, the exuded nitro-glycerine would be frozen. The inspector says that, "should one of the projecting wire stitches [the wire stitching of the cardboard packages containing the explosives, which had not properly been clinched down] have come in contact with a congealed film of nitro glycerine, sufficient heat might be generated to cause an explosion." The Home-office's chemical advisers, even in the light of the accident, reported that the sample examined by them showed "exudation decidedly more than is desirable, though hardly dangerous, not increased by freezing and thawing."

THE INCORPORATED INSTITUTION OF AUTOMOBILE ENGINEERS.—The following is a provisional programme of this Institution for the session 1908-9:—On October 14th, presidential address, entitled "Some Problems of the Motor Car," will be given by Mr. Dugald Clerk; on November 11th, a paper entitled "A Complete Test of a Modern Petrol Engine"—Power, Thermal and Mechanical Efficiency, Exhaust Products at Various Powers and Speeds—will be read by Mr. Bertram Hopkinson; and on December 9th, a paper entitled "How the Weight of the Motor Car is made up" will be read by Mr. Mervyn O'Gorman. The following papers and discussions have been arranged for the general meetings of the Institution in 1909:—Mr. F. H. Royce, "Causes of Wear in Motor Machinery;" Mr. G. H. Baillie, "Carburettor Experiments;" Mr. Horatio Ballantyne, "The Chemistry of Petrol;" Mr. Bertram Blount, "On Specifying the Quality of Petrol;" Mr. F. R. S. Bircham, "The Use of Small Internal Combustion Engines for Marine Work;" Mr. L. A. Legros, "Transmission;" Mr. E. H. Cozens-Hardy, "Motor Cabs," and a discussion on "Valve Setting," introduced by Max R. Lawrence, M.I. Mech. E. Dr. W. Watson, of the Royal College of Science, South Kensington, has promised to give a paper on "Petrol Engine Experiments."