that object in view, to visit Calcutta and Rangoon for the purpose of examining the results of the Shone system there in operation. While thus engaged, it became apparent that the exertion and exposure he had undergone during the construction of the Baroda Waterworks had seriously impaired his health. He went to his native city of Bombay for rest and change; but paralysis had shown itself and he died there on the 26th of March, 1896.

Mr. Sadaswejee was a man of quiet habits and unobtrusive character, and was greatly respected by all with whom he was associated. His energy and painstaking assiduity were highly commended by those under whom he served. He was elected an Associate on the 14th of January, 1868, and was subsequently placed in the class of Associate Member.

GEORGE PARKER BIDDER, M.A., Q.C., was born on the 18th of August, 1836, in London. He was the eldest son of George Parker Bidder,[1] known from boyhood for his powers of mental calculation and who was President of the Institution in 1860 and 1861. The subject of this notice was educated first at King's College School and at the University of Edinburgh, where he gained distinction in the mathematical classes under the late Professor Kelland. Passing to Trinity College, Cambridge, he obtained a scholarship there, and in 1858 graduated as seventh wrangler. Two years afterwards he was called to the Bar at Lincoln's Inn and joined the Home Circuit, his success as a Junior being marked and rapid. He was Counsel for a large scheme originally proposed for the Forth Bridge by Sir Thomas Bouch, which was reported upon by Mr. W. H. Barlow and Dr. Pole in 1873, and his conduct of that case determined the course of his subsequent career. This lay mainly among Parliamentary Bills, arbitrations, and compensations, involving engineering, scientific or statistical evidence. Clear and lucid statement, easy exposition of intricate argument, that mastery of evidence and "first principles" which makes cross-examination so effective, were the weapons with which Mr. Bidder achieved his success. The rapid calculation of his father in the witness-box was one of the puzzles to parliamentary counsel of the last generation; the same power, in the son's hand, has proved perturbing to more than one engineering witness of later date, and he is perhaps best known for successful contest with expert evidence, alike in the box and in the convincing analysis of his subsequent

[1] Minutes of Proceedings Inst. C.E., vol. lvii. p. 294.

speech. Perhaps one of his greatest triumphs was in "The Metropolitan Board of Works *v.* The Millwall Dock Company" (1876), a case which turned on the laws of deposit and silting in rivers; better known is his masterly and effective opposition for the Mersey Docks and Harbour Board against the Manchester Ship Canal, based mainly on the theory of the formation and erosion of banks in an estuary. In the inquiry into the collapse of the Tay Bridge he successfully defended the reputation of its engineer, the case involving the closest study of every technical detail. The later Forth Bridge Bills were entrusted to him, and he was Counsel for the Metropolitan Board of Works against the Thames Conservators, a case largely depending, like that of the Millwall Dock and the Manchester Ship Canal, on the laws of flow and deposition of suspended matter, but also on elaborate arguments from chemistry and biology. He appeared for some twenty-eight years in all the Bute Dock, Midland, North-Eastern and most of the District Railway cases, and held general retainers for the Midland, North British and Brighton Railways, the Mersey Dock Board, the Marquis of Bute and the Bute Dock Companies. He was also standing counsel for more than one of the great water companies. The last case in which he appeared was one for compensation against the Great Eastern Railway Company, and his speech, on the Saturday before he died, was considered exceptionally able. He took silk in 1874 and shortly afterwards became a bencher of Lincoln's Inn, standing at the time of his death next in rotation for the annual office of Treasurer.

It is of more than personal interest to compare Mr. Bidder's special gifts with those of his father. In a letter published in the *Spectator* of 28th December, 1878, he says of the latter:—

"In my opinion he had an immense power of realising the actual number. . . . He was aided, I think, by two things—first, a powerful memory of a peculiar cast, in which figures seemed to stereotype themselves without an effort; and secondly, by an almost inconceivable rapidity of operation. I speak with some confidence as to the former of these faculties, as I possess it to a considerable extent myself (though not to compare with my father). Professor Elliot says he (my father) saw mental pictures of figures and geometrical diagrams. I always do. If I perform a sum mentally, it always proceeds in a visible form in my mind; indeed, I can conceive no other way possible of doing mental arithmetic. The second faculty, that of rapid operation, was no doubt congenital, but developed by incessant practice, and by the confidence thereby acquired. . . . With my father, as with myself, the mental handling of numbers and playing with figures afforded a positive pleasure and a constant occupation of leisure moments. . . . It is also worthy of record that my father had an enormous store of facts, formulas, and constants relating to all manner of geometrical questions and physical subjects, which were always available for the ready solution of problems, either in pure mathematics, or in the application of mathematics to mechanics, hydraulics, &c. In my opinion, this is a kind of knowledge which is not half appreciated. I have found continually immense advantage in having formulas and constants ready to hand. . . . I myself can perform pretty extensive arithmetical operations mentally, but I cannot pretend to approach even distantly to the rapidity and accuracy with which my father worked. I have occasionally multiplied fifteen figures by fifteen in my head, but it takes me a long time, and I am liable to occasional errors. Last week, after speaking to Professor Elliot, I tried the following sum, to see if I could still do it:—

$$378,201,969,513,825 \times 199,631,057,265,413.$$

And I got in my head the answer:—

$$75,576,299,427,512,145,197,597,834,725,$$

in which I think, if you take the trouble to work it out, you will find four figures out of the twenty-nine are wrong."

The final statement at first sight seems to contradict the claim for great inferiority to his father in arithmetical gifts. But the method of calculation explained to the Institution by Mr. Bidder in 1856[1] was not followed by the son when the number of significant figures was large. For such cases he employed a method which, although inapplicable without powers of numerical conception and realisation, yet enormously increased their scope and effect. Briefly, the two numbers to be multiplied and the answer as obtained, were recorded by a simple *memoria technica* ("Gray's") as letters of the alphabet or diphthongs, and the answer was obtained from right to left, as in ordinary paper arithmetic.[2]

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[1] Minutes of Proceedings Inst. C.E., vol. xv. p. 251.

[2] Thus, treating for example two small numbers by the method which would be employed for larger ones, multiplication would be effected as below [for comparison the numbers chosen are those multiplied at length by the elder Mr. Bidder in the discourse referred to]. In the memory system employed there are ten vowel sounds and ten consonants, one of each class for each numeral:—

397×173, recorded as "toup" × "boit."

(1) $3 \times 7 = 21$; 1 and carry 2; 1 recorded as "b";

last figure of answer recorded as "b."

(2) Carried 2;

$3 \times 9 = 27$, and $2 = 29$;
$7 \times 7 = 49$, and $29 = 78$; 8 and carry 7; 8 recorded as "ei";

last two figures of answer recorded as "eib."

(3) Carried 7;

$3 \times 3 = 9$, and $7 = 16$;
$7 \times 9 = 63$, and $16 = 79$;
$1 \times 7 = 7$, and $79 = 86$; 6 and carry 8; 6 recorded as "s";

last three figures of answer recorded as "seib."

Mr. Bidder often remarked that the method pursued by those of very great numerical gifts, such as his father, necessitated a far more severe mental operation, since there had always to be carried in the mind a perpetually fluctuating number of the order of magnitude of the final answer,[1] whereas multiplying as on paper every figure obtained is final. He was wont to lay down the rule that to facilitate mental calculation, every operation, where possible, should take the form of division. Mr. Bidder, the elder, said:—"Division is, in mental, as in ordinary arithmetic, much more difficult than multiplication."[2] If followed out, these two statements will be found to well illustrate the essential difference between the two methods.

Multiplying billions by billions accurately to the twenty-ninth place has no value except as a form of mental athletics. Such athletics, however, produced in the Queen's Counsel, as formerly to a greater degree in the engineer, a knowledge of numbers of the highest practical importance, causing the ordinary calculations occurring in daily life to present themselves instantaneously in forms of almost spontaneous solution. In addition to this, the

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(4) Carried 8;

$7 \times 3 = 21$, and $8 = 29$;
$1 \times 9 = 9$, and $29 = 38$; and carry 3; 8 recorded as "ci";

last four figures of answer recorded as "eiseib."

(5) Carried 3;

$1 \times 3 = 3$, and $3 = 6$; 6 recorded as "s."

Answer recorded as "seiseib" = 68,681.

It will be seen that at any moment there are held in the memory three articulate nonsense words, and at the most two comparatively small numbers; the nonsense words are never changed during the process except by prefixing fresh letters to that representing the answer. The word is recorded on the memory as a visible, an audible and a speakable imagination; the memory being also guided by its relationship to significant words, precisely as in the recollection of a proper name read for the first time. Its letters are thus stereotyped in a block, in which they can be examined singly at will. Thus, while not refuting "the necessity of keeping only one result before the mind at a time," pointed out in the discourse of Mr. Bidder, sen., the operator is enabled to retain the three principal numbers without acute consciousness of them, while actively employed on a subsidiary operation of comparatively small difficulty.

It would seem that the method should be practically used only within the limits of certain freedom from error, since error is as likely to cccur among the left-hand as among the right-hand digits of the answer.

[1] Minutes of Proceedings Inst. C.E., vol. xv. p. 260.

[2] *Ibid*, vol. xv. p. 264.

actual material of such athletics was mainly those "facts, formulas and constants" above referred to, which were thus not only perpetually receiving additions, but perpetually becoming more and more familiar and ready to the mind.[1] In 1890 he added some explanations and remarks to a Paper contributed to the Proceedings of the Institution by Dr. W. Pole, describing the mode of calculating logarithms mentally adopted by his father.[2] Mr. Bidder hated to feel dependent on works of reference for any constants or formulas, and it was one of his greatest powers, perpetually utilised, that he could almost always remember data and devise a method to form a rough and rapid estimate of any calculable quantity. In cross-examination especially, this power furnished a valuable weapon, for the figure given by an expert presented rapidly to his mind its long train of consequent figures, branching all over the case in his charge and crossing or coinciding as might be with the lines traced by evidence from other sources already obtained or obtainable.

He was very fond of mechanics as a diversion and used to amuse himself by designing little suspension-bridges for his trout-stream; two of which—one, with the tension-members beneath the roadway, of light and graceful design—were erected from his drawings and are in use. In the "Monthly Notices of the Royal Astronomical Society"[3] will be found the account of a new form of position micrometer, devised by him for the telescope and always used by him in double-star measurements. He invented an ingenious modification for increasing the delicacy of the chemical balance, and used to spend hours in filing brass and in polishing agates; for in the workshop, as with calculations, he hated to be compelled to use a ready-made article. But perhaps his most favourite intellectual recreation, besides the construction of easy formulas for mental calculation, was the study of ciphers.

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[1] As a simple instance may be quoted a method, the invention of which pleased him much many years ago, for calculating rapidly the squares of numbers under 100:—

$$N^2 = (N - 25)\,100 + [25 - (N - 25)]^2$$
$$\text{Ex.—}49^2 = (24)\,100 + [25 - 24]^2$$
$$= 2{,}400 + 1 = 2{,}401;$$

everyone, of course, knowing the squares of numbers up to 25. Formulas for vital statistics, for compound interest problems, for the formation of a calendar of the sun's altitude, were the frequent subjects of his recreation; and it may be said that there was no series of facts with which he was familiar for which he had not devised, and generally remembered, some ready-reckoning process.

[2] Minutes of Proceedings Inst. C.E., vol. ciii. p. 250.

[3] Vol. xxxiv. p. 394.

He early published an article[1] on their general principles and from the latest advertisement in *The Times* to seventeenth-century State Papers, he was to the end of his life never tired of pitting his ingenuity against that of the man who believed concealment insoluble and rarely succeeded in preserving it.

Mr. Bidder took a prominent part (as Chairman of the Cannock Chase Colliery Company) in the great coal strike of 1893, and was a member of the body of coal-owners which, under Lord Rosebery's presidency, met the representatives of the colliers. He published at this time a valuable article on the economics of a coal-mine,[2] pointing out the importance of quantity in coal-mining, as opposed to price, on account of the heavy fixed expenses which are unaffected by diminution of output. His mastery over figures was greatly valued by his colleagues of the Cannock Chase Colliery Company, of the Danish Gas Company (of which he was Chairman) and of the Rock Life Assurance Company. He was on the County Council and Commission of the Peace for Surrey, and was a considerable benefactor to Mitcham, where he resided, especially in the continuous protection of Mitcham Common, for which he ultimately obtained an Act fairly assuring its future. Among other instances in which he helped to preserve the property of the community may be mentioned his successful defence of the right-of-way along a beautiful path near Dartmouth to Compass Cove. He was a pioneer of the Charity Organization Society, and took great interest in all that tended to increase the liberty and well-being of the less wealthy classes. While he lived in London he served as almoner at Stepney, working there through a severe cholera epidemic.

Mr. Bidder was a keen fisherman and golf-player, and in 1867 was fourth for the Queen's Prize at Wimbledon. In physique he was robust, capable alike of great concentration and of prolonged exertion. In character he was always courageous, never spared himself, and gave freely of time, money or labour for the public good or in private kindness; he was much loved by very many friends. Stern conscientiousness and strong combativeness were the qualities most known in his public relations. Those intimate with him will remember as vividly a boyish lightness of spirit, a fresh versatility of culture and a sincere reverent piety.

Mr. Bidder was elected an Associate on the 3rd of December, 1861. A few months previously he had contributed to the

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[1] *Macmillan's Magazine*, February, 1871.

[2] *Nineteenth Century*, vol. xxxv.

Institution a Paper entitled "The National Defences,"[1] for which he was awarded a Telford Medal and a Manby Premium. He was also an Associate of the Surveyors' Institution and a Fellow of the Royal Astronomical Society. He married in 1860 Anna, daughter of Mr. J. R. McClean,[2] M.P., F.R.S., President of the Institution in 1864–65. He died at Queen Anne's Mansions, Westminster, in the full tide of ability and success, on the 1st of February, 1896, quite unexpectedly, from the effects of a street accident in Manchester three weeks previously. It was characteristic that the day after he had been run over, rather than necessitate the inconvenience to so many people of coming together again at a future date, he conducted cross-examinations for six hours, though suffering acutely.

MAJOR-GENERAL SIR JAMES BROWNE, R.E., K.C.S.I., C.B., who died at Quetta, Baluchistan, on the 13th of June, 1896, was the son of Mr. Robert Browne, of Falkirk, N.B. He was born on the 16th of September, 1839, and, was educated abroad and at the Military College, Addiscombe, obtaining a commission in the Bengal Engineers in 1857. In 1860 he served with the expedition against the Mahsud Waziris on the North-West frontier of India, being present at the storming of the Burera Pass and at the capture of Kaneegurum and Mukeen. For this he was mentioned in despatches and received a medal with clasp. He then acted for a time as Assistant Engineer on the construction of the road between Lahore and Peshawar. In 1863 he served in the Umbeyla campaign and greatly distinguished himself, being three times mentioned in despatches and receiving the brevet of Major. It was during the period from 1860 to 1864 that he laid the foundation of that colloquial knowledge of Pushtu and Persian which proved so useful in his subsequent career.

In 1864 Major Browne took a short furlough to England, when he married Alice, the daughter of Mr. C. Pierson. On his return he was sent to open out and construct roads in the hill district of Kangra in the Punjab. His work there added greatly to his reputation, some of his bridges especially being distinguished by their great span and boldness of design. In 1869 he again took furlough, part of which he spent in studying the best examples of iron bridge construction in England, America, and Holland.

[1] Minutes of Proceedings Inst. C.E., vol. xx. p. 391.
[2] *Ibid*, vol. xxxviii. p. 287.