GEORGE BALLARD MATHEWS, 1861–1922.

GEORGE BALLARD MATHEWS was born in London on February 23rd, 1861. His father, George Mathews, was the son of a Herefordshire yeoman farmer, and engaged for many years with a London business house. His mother's maiden name was Harriet Ballard, daughter of George Ballard, Secretary to the Board of Inland Revenue, and a remarkable man, from whom Mathews inherited much of his personality and intellect. From his mother he inherited his literary and musical abilities, his interest in general subjects, and his powers of calculation.

The family returned to Herefordshire in 1866, and Mathews, in 1872, entered Ludlow Grammar School, where his brilliant intellect soon asserted itself. Records of 1875 state that he was first in the top form with prizes in Mathematics, French, Drawing, Form Prize, and Parents' Prize. During the four years, 1874–78, he was captain of the school. From the Rev. W. C. Sparrow, one of the most successful Head Masters of the school, he received instruction in Hebrew as well as in Greek and Latin.

There followed a year at University College, London, of which body he afterwards became a Fellow, during which he attended Henrici's lectures on geometry and began to study Sanskrit. In 1879 St. John's College, Cambridge, offered him the senior scholarship of his year in either Mathematics or Classics. Carrying out his intention of reading for the Mathematical Tripos, he became a private pupil of Mr. W. H. Besant of St. John's. The keen competition for leading places in the Tripos of this period had brought fame to Mr. E. J. Routh as a coach. All the abler candidates went to Routh as a matter of course, for Routh had a long series of Senior Wranglers to his credit. However, Mathews' name was read out first in the list of 1883, this being the only break in a succession of about thirty consecutive seniors trained by Routh.

In 1884, Mathews was appointed to the Chair of Mathematics in the newly constituted University College of North Wales at Bangor, and in the same year was elected to a Fellowship at St. John's. His colleagues at Bangor were all of the same generation as himself, and included such men as Profs. Andrew Gray, James Dobbie, and the late Henry Jones, under the leadership of Principal Harry R. Reichel (the last three named have all since been knighted). Writing in *Nature* (June 3rd, 1922) of the

period which followed, Prof. Gray says: "[Mathews] came full of eager enthusiasm for the teaching of mathematics and for original mathematical work, and for ten years laboured hard in the hope of founding something like a school of mathematical study in North Wales. But, alas! these hopes were dashed. Perhaps he was a little impatient, and I certainly did my best to counsel him to wait, and to find out the effect of the new Welsh University on the studies of the place, but without effect. The best of the Welsh students were at that time attracted by the Neo-Hegelian philosophy, and some of them, as seems to be the way with such students, seemed not a little proud that their mental tendencies were not mathematical. To this curious type of intellectual pride Mathews referred eloquently in the posthumous paper published in *Nature* of April 22nd. In that paper, he lamented the revival of the fallacious arguments for the supremacy of the Latin-Greek classics as an educational instrument; but he in no way under-valued classical culture, only he thought that, to an Englishman, the inheritor of a copious and flexible language, and of a literature unparalleled in the past, a training in Latin and Greek was far from indispensable and might have its disadvantages."

The Bangor Chair was resigned in 1896, and shortly followed (1897) by Mathews' election into the Royal Society, on the Council of which he served for a year. He also served on the Council of our Society from 1897 to 1904. Having returned to Cambridge he was first appointed to be Mathematical Lecturer at St. John's and afterwards to be University Lecturer, and also acted for a year (1904–5) as Mathematical Secretary to the Philosophical Society. The Cambridge appointment, like the earlier one in Bangor, was resigned on account of temperament, and he returned to live in Bangor. Since 1911 he held a special Lectureship in the North Wales College, and again acted as Professor there during the two Sessions 1917–19. The honorary degree of LL.D. was conferred by Glasgow University in 1915.

While thoroughly familiar with all branches of pure mathematics, Mathews' main interests were in the theory of numbers and projective geometry. The theory of numbers, which, in its widest sense, is the theory of discrete, as opposed to continuous, magnitude, has passed through four well-defined stages of development. First there came the period of Diophantine Analysis proper, of which the greatest exponents, after Diophantos among the ancient Greeks, were Fermat and Euler. In this, the general problem is to determine all the solutions in rational numbers of a system of $m\,(<n)$ algebraic equations

$$R_i(x_1, x_2, \ldots, x_n) = 0 \quad (i = 1, 2, \ldots, m),$$

Next came the discovery of the law of quadratic reciprocity which rendered possible a discussion of quadratic arithmetical forms, so ably expounded by Gauss in the *Disquisitiones Arithmeticæ*. Such writers as Lejeune-Dirichlet, Eisenstein, and Stephen Smith added much to what Gauss had done, and a scholarly introduction to the whole theory was given by Mathews in his *Theory of Numbers* of 1892.

The third stage was marked by Dedekind's discovery of his theory of ideal numbers, which completely restore to a system of algebraic numbers certain factorisation properties of ordinary integers that appear at first to be lost. Mathews' was probably the first mind in England to realise the far-reaching effect of Dedekind's discovery, two papers by him on the subject appearing in the London Mathematical Society's *Proceedings* of 1892.

The last stage is the analytical theory, which is intimately bound up with certain transcendental functions of a complex variable. This theory had little attraction for Mathews, though his book contains an account of Riemann's classical memoir on the distribution of primes, Unfortunately Mathews wrote in 1892, four years before the proof of the prime-number theorem. Riemann had actually proved but little, beyond some formal properties of the ζ-function, and the modern analytical theory, as developed by Messrs. Hadamard, de la Vallée Poussin, Landau, Hardy and Littlewood, has diverged entirely from his original line of attack.

The tract *Algebraic Equations* on a kindred topic, written fifteen years later, contains a masterly exposition of Galois' theory, completed by Jordan and others, showing how the different types of irrationality which can be defined by an algebraic equation are associated with different types of group.

Written in collaboration with Prof. Andrew Gray and mainly concerned with physical applications, the *Treatise on Bessel Functions* (1894) is still a standard work. The *Projective Geometry* (1914), inspired by Henrici's lectures in London many years before, contains two unusual features: first, an exposition of the logical groundwork of the subject; and, secondly, an account of Staudt's theory of complex elements (whereby a real involution defines a complex point or line). Mathews also brought out a new edition (1904) of R. F. Scott's *Determinants*, and contributed articles on "Number" and "Universal Algebra" to the 1910 edition of the *Encyclopædia Britannica*.

Most of Mathews' technical papers appeared in the London Mathematical Society's *Proceedings* or in the *Messenger of Mathematics*. Some of the earliest, beginning in 1886, are connected with Fermat's Last Theorem, a question which absorbed much of his attention at intervals

during the rest of his life. Being firmly convinced of the veracity of Fermat's statement, he tried to approach the problem by such methods as might have been devised in Fermat's day. His last contribution to the subject appeared in a review published in *Nature* of January 5th, 1922.

A few of the earlier papers deal with geometrical subjects, such as twisted quartic curves, geometry on a quadric surface, and porisms. Nearly all the rest have an arithmetical bearing. Several papers discuss points connected with the Gaussian theory of quadratic forms, the subject of his book. In 1892 he wrote on quadratic forms with complex coefficients, a subject to which he returned twenty years later. In early days he corresponded freely with Cayley and Sylvester.

Among the specialised branches of the higher arithmetic Mathews was mainly interested in the complex multiplication of elliptic functions. Being an assiduous disciple of Dedekind and Klein, he fully realised the fundamental character of the absolute invariant $j(\omega)$ and of the type of irrationality involved in it. Papers written in the nineties, when Sir George Greenhill and Mr. Russell were working at the subject too, give special detailed properties of the lemniscate functions. He also showed the significance of Klein's principal moduli and calculated some new class-invariants. Returning to the subject in later years, he produced a fuller manuscript on the lemniscate functions: its publication has been delayed by the war and his subsequent illness.

Ever since the mid-eighties Mathews was a frequent contributor to *Nature* on mathematical topics. His articles and reviews, most of which appeared over the initials "G. B. M.," were always written in a careful and scholarly style; they contained his considered opinion on the book or point concerned. His keen yet kindly criticism was undoubtedly of the greatest service to the many writers whose work passed through his hands. In conversation with the present writer he once expressed the opinion that some of his best work had appeared in *Nature* reviews.

A man of simple tastes and naturally retiring by disposition, Mathews expressed sound judgment on both men and affairs. Some of his views were those of an idealist and hardly feasible in the domain of practical politics. His capacity for maturely grasping everything with which his mind came into contact made him unique in the experience of his friends. Only one or two sides of so versatile a man's brilliant intellect really appealed to most people. When he was appointed Professor of Mathematics at Bangor, at the age of twenty-three, it was manifest that he could equally well fill four or more chairs in the College. Again, to quote Prof. Gray: "Mathews had a knowledge of Latin and Greek as minute and accurate as that generally possessed by professional classical scholars.

He wrote pure and elegant Latin. I remember his amusing himself by turning into Latin prose an original philosophical dissertation which had happened to come into his hands and had arrested his attention. I remember also some Latin verses which he published anonymously, and which were much praised by a very eminent scholar. He wrote also charming English essays in the style of Charles Lamb, of whom he was a great admirer. These, I fear, are lost, but one of them, 'On a Cockloft,' was a perfect gem, a charming piece of the most natural and simple prose."

A humorous controversy in Latin Elegiacs between Profs. Arnold and Mathews, in which Mathews did not come off second best, inspired Principal Reichel's epigram, addressed, in the College Magazine, to a mathematical student who had been reading Mathews' verses:—

Versibus an numeris noster praestantior anceps
Mattius; attonito cur puer ore siles?
Qui numeros dicit vult idem dicere versus,
Testibus innumeris, o numerose puer.

In the early days at Bangor Mathews began to learn Arabic, and spent much time of later years in reading and translating Arabic poetry. His translations are full of the spirit of the original lines; it is to be hoped that some of them will be published later.

Mathews' knowledge of music, again, was fully as advanced as that of most professional musicians. His copies of Gauss and Bach were placed together on the same shelf, and he considered some of Sir Edward Elgar's compositions to be as fine as the work of Beethoven and Handel.

Undoubtedly, the strength of his numerous interests prevented him from making the most of his mathematical work. His name will be mainly remembered in connection with the higher arithmetic.

The last three years of his life were clouded by a series of operations for cancer, which finally gained the mastery. He died, unmarried, in a Liverpool nursing home on March 19th, 1922.

W. E. H. B.