OBITUARY NOTICES

EDWARD JOHN ROUTH

ONE of the most famous names in the history and the progress of mathematics in England has been transferred to the roll of record by the death of Dr. Edward John Routh on June 7th, 1907.

During the greater part of last century, nearly every able mathematical student at the University of Cambridge was prepared for his final examination by a private tutor: and among these private tutors (" coaches," to adopt the word of technical and friendly use), two names stand out, eminent beyond all others. They are Hopkins and Routh. William Hopkins was a conspicuous figure in Cambridge, teaching during the second quarter of the century: among his pupils in that period were Stokes, Cayley, Adams, Thomson, Maxwell, and Routh himself. Routh's immediate influence extended from the later fifties until 1888: and during those years, a large majority of successful students were happy in calling themselves his pupils. The University has recently decided to abolish the order of individual merit in the Mathematical Tripos, and thus, incidentally, to annihilate the significance of the title of Senior Wrangler, and of another title, as picturesque though not quite so honour-bearing. It is Routh's unique distinction to have coached twenty-four Senior Wranglers in twenty-four consecutive years : no man will ever be able to repeat the achievement.

This distinguished teacher and investigator was born in Quebec on 20th January, 1831. His father was Sir Randolph Routh, K.C.B., an old Etonian, Commissary-General in the Army, and Senior Commissariat officer at Waterloo in 1815. His boyhood was spent in London: he was educated at University College School: and later, at University College, he came under the influence of Augustus de Morgan. It may have been due to friendship with that mathematician, who was our founder, that Routh became a member of our Society at its inception in January, 1865.

He was admitted a pensioner at Peterhouse on June 1st, 1850, and com- menced residence in October. Clerk Maxwell entered at the same college in that year, but he migrated to Trinity near the close of his freshman's term. Other names belonging to the same " year " are those of the present Chancellor of the University, the Duke of Devonshire ; Mr. Aldis Wright, Mr. Henry Bradshaw, Sir Leslie Stephen, and Mr. Burbury. In these days of depleted numbers of successful candidates in the Mathematical Tripos, it is not unworthy of note that the list in " Eouth's year " (again to use our vernacular at Cambridge) contains over 140 names. Routh was Senior Wrangler in 1854, and Maxwell was second: the two dis- tinguished mathematicians were bracketed for the two Smith's Prizes (for the first time on record).

Routh soon was elected a Fellow of his college and was appointed to lecture. At the time of his degree, the Peterhouse foundation included, among other famous men, William Thomson (then Professor at Glasgow, already widely known in Europe by his original work, his name now being merged in his title of Lord Kelvin) ; Peter Guthrie Tait (cheery in spirit, strong of brain, aggressively unconventional in social superficialities, not yet gone to Belfast nor transplanted to Edinburgh); and Steele, affectionately described to me by Tait as the greatest mathematical teacher who ever lived. But the blight of illness soon fell upon Steele: during one term, Routh took his pupils : and when Steele died, the pupils remained with Routh. Thus began his connection with the private teaching of mathe- matics at Cambridge : it ceased in 1888, only upon his deliberate retirement from the work.

From that time onwards, Routh's teaching occupied the greater part of his activity though not absorbing the whole of it, for he made valuable original contributions to the science he loved and served so well. But these came slowly in the earlier years of his maturity. He examined twice for the Triposthat is, the old Tripos, in its greatest days; and, after the first occasion, he published a volume in co-operation with H. W. Watson, embodying the solutions of the questions which had been set in 1860. Already, as a young man, he had collaborated with Lord Brougham in publishing (in 1855) a volume entitled An Analytical View of Sir Isaac Newton's Principia; it can hardly be rash, on reading the book at this distance of time from its publication, to assume that the mathematics belonged to Routh and the opinions to Lord Brougham.

Other private tutorsWalton, Frost, Todhunter, Besant, Webb in later years, and now Hermanhave been successful in taking pupils at Cambridge, and have had them in ample numbers. When I came into residence in 1877 as a freshman, the reputation of Routh as a private tutor was in a class by itself; and no undergraduate, whether confident or diffident about his powers while ambitious in his prospects, dared lightly to abstain from coaching with the maker of Senior Wranglers. Thus Routh was in large practice; the largeness of his practice, and the remarkable success of his pupils in the examination lists, maintained his pre-eminent position. Occasionally (as in 1867 by Clifford, in 1870 by Greenhill, in 1875 by Burnside) a bold bid was made by some other teacher's pupil for the highest place in the Tripos : but, somehow, it did not succeed, and the Senior Wrangler still had " Mr. Routh for his private tutor."

No doubt can be felt that, at the epoch of his greatest influence, most of the ablest of the undergraduates went to him for their private teaching. Success certainly led to increased numbers: but it was incessant and diligent care which made Routh's teaching supremely effective. It is true that, after a time, the examiners in the Tripos were mostly old pupils of his, and so his dominance might easily be

inferred as obvious : yet such an explanation is hardly even a fragment of the truth. Wherein, then, consisted the genius of his teaching ?

It belonged to his time; also to the tradition which, silently trans- mitted to him, was maintained and strengthened. It was superbly direct for the purpose in view : and it was strong in the measured completeness with which he covered the whole ground for the Tripos. Independence on the part of a student was not encouraged; for independence would rarely, if ever, be justified by the event. Foreign books were seldom mentioned: Routh himself had summarised from them all that could be deemed useful for the examination. Above all, he was a born teacher. Regularity and steady diligence were two demands which he always made from his pupils. As a result, any one who worked carefully could feel confident that he had had the best preparation for the Tripos which was possible, and that he had been trained so as to make the most of his powers in the examination.

The method was simple in operation. His pupils went to him three times a week, for an hour on each occasion. They were arranged in classes of six to ten, selected at first mainly by their own statements of mathematical knowledge brought from school, and sifted later by their attainments and progress. Each hour's work was substantially of the nature of a lecture. A few minutes at the beginning of the hour were devoted to the inspection of written exercises, a process at which Routh was wonderfully quick. The remainder of the hour was occupied with a skilful exposition of the subject under consideration, sometimes summarised in such a way as almost to compel remembrance. The intrinsic interest of the teaching was not of uniform quality ; he was at his best in subjects so diverse as solid geometry and physical optics ; he seemed below his best in a subject like rigid dynamics, perhaps because (as some of us used to imagine) all he had to say on it was contained in the book which he had written.

In addition to the direct teaching, he set to all his pupils a weekly paper of a dozen problems, taken mainly from past examinations. The conditions of answering this paper were made to alternate in successive weeks. In one week, a student could devote unlimited time to the questions : in the other, he was expected to limit himself to three hours so as to feign some similarity to the pressure of the Senate House. The pupils' answers were deposited in Routh's rooms in Peterhouse on the Friday or the Saturday of any week : they were returned on the succeed- ing Monday, when he placed in an outer room a carefully written set of solutions. To add a stimulus of competition, every pupil's answers had been marked ; and there was a list containing names and marks, so that the men even of different years were almost encouraged to regard the weekly problem-paper as a field for rivalry and comparison. Finally, at some period before the crucial examination, there began the process of revision, in the form of bookwork papers. The answers to each such paper had to be brought two days after the paper was set, and they were

examined critically in class. The pupils were brought up to the mark, so far as the teacher was concerned, partly by good humour, partly by occasional warnings that were kindly in phrase and in spirit, and always under a genial sense of his easy mastery over the whole range of subjects included in the examination.

It is obvious that the process, if not supplemented by other means, would imply a uniformity of treatment which would not be found advan- tageous by the eager members of even an average class. The necessary supplement was provided by Routh in the form of " manuscripts," which really were of the character of small pamphlets dealing with special por- tions of subjects not taught in his classes. Pupils were expected to copy these manuscripts, in default of English text-books ; but diligence in taking copies was far from universal. Little or no account was paid to work done in college lectures: and attendance at a course of any Uni- versity professor's lectures, save only in the case of Stokes, was almost a rare exception. Routh prepared his men thoroughly for the examination : its needs dictated and limited alike the range and the spirit of the work done with him. Out of much knowledge and experience he realised, almost as by instinct, the wants, the needs, the possibilities, of examiners and examinees. Simply and effectively, he dominated the Mathematical Tripos, almost during the whole period (1855 to 1888) of his coaching activity. In that time, he had more than six hundred pupils. On twenty- seven different occasions, he prepared the Senior Wrangler : and in my own year a class of six men, who had been taught together since their freshmen's term, occupied the first six places in the Tripos.

Exacting as was this work throughout the year (for he taught through the long vacation residence, as well as during the usual three terms), it was far from exhausting his mathematical activities. Quite early he had produced a text-book on rigid dynamics, of which no fewer than seven editions have appeared. The book, in its first form, was of modest size and occupied a single volume : but the contents were gradually increased. The seventh edition occupies a couple of closely packed volumes and is an encyclopaedia of the subject, representing much original work on the part of the author as well as the results obtained by a vast number of writers. This treatise was translated into German on the initiative of Prof. Klein, of Gottingen, who contributed an introductory preface in warm commenda- tion of its importance.

When he retired from private teaching, he remained a lecturer at Peter- house and at Pembroke College. In the comparative leisure which then became his, he compiled a two-volume work on analytical statics, which now is in its second edition ; and, later, he published a single volume on the dynamics of a particle. The most original work written by Routh -- a work which secures for him an honoured place among the most dis- tinguished writers on theoretical dynamics -- was his essay, A Treatise on the Stability of a Given State of Motion, particularly

Steady Motion, to which the Adams prize in the University of Cambridge was awarded in 1877. In that essay, he introduced the modified Lagrangian function which, as Professor Larmor says, [Nature, 27th June, 1907, p. 202.]made a fundamental advance in the principles of the dynamical interpretation of nature. Over thirty mathematical papers have been published under Routh's own name. O f these, perhaps the most important, and the most novel in its time, was a brief paper published in the seventh volume of the Quarterly Journal in 1866. There, Routh develops some properties of the curvature of twisted curves, by using the kinematical relations of a set of moving axes in three dimensions: readers of Darboux's Theorie generale des surfaces (of which the first volume appeared in 1887) are familiar with the frequent applications of a moving trihedron in that great treatise. It may be added that twelve of Routh's papers appeared in our own Proceedings.

In 1864 he married Hilda, the eldest daughter of Sir G. B. Airy, and a god-daughter of Dr. Whewell: she survives him, together with a daughter and three sons. As already stated, he was a member of this Society from its earliest days: and he was elected a Fellow of the Royal Society in 1872. Before graduating at Cambridge, he had proceeded to the degree of M.A. in London University, winning the gold medal for mathematics in 1853 : and at the time of his death, he was a Fellow of that University. When the new degree of Doctor of Science was instituted at Cambridge, he was induced to apply for it together with Besant: they were admitted to the degree on 31st May, 1883, being the first two recipients. The honorary degree of Doctor of Science was conferred upon him by the University of Dublin, and that of Doctor of Laws by the University of Glasgow. His fellowship at Peterhouse had been vacated by his marriage in 1864 ; in 1883, he was elected an honorary fellow of his old college, and for many years, he has been the senior among the small and select body of honorary fellows of that ancient foundation.

The conclusion of his full activity as a private teacher was marked by an act of his old pupils in token of their gratitude. At their request, his portrait was painted by Herkomer; and it was presented to Mrs. Routh, by Mr. Justice Stirling on their behalf, at a gathering held in the combi- nation room at Peterhouse. Those who were present are not likely to forget the remarkable collection of distinguished men there assembled, or the appreciation then expressed for him and for his teaching, or the un- affected simplicity of his speech in his reply of thanks. A copy of the picture hangs in the dining hall of Peterhouse.

He served for one term of office, from 1888 to 1892, on the Council of the Senate of the University: but the business did not seem to interest him keenly. "What did interest him, among matters academic, was the Mathematical Tripos. Broadly conservative by spirit, alike in imperial politics and in academic politics, he was

willing to make small changes in the examination from time to time, especially if their tendency appeared to foster the study of applied mathematics. He was a member of the Syndicate which recommended the changes first effected in 1882, when the examination was divided : he signed the report which maintained (though without enthusiasm) the order of merit in one portion of the examination and replaced it by a classified order in the other portion. Seven years ago, an attempt was made, on the recommendation of the Special Board for Mathematics, to abolish the order of merit in that portion of the examination where it had been retained: the attempt failed. During the past academic year, a similar attempt succeeded. On both occasions, Routh was the leader of the opposition, taking an active part in the struggle.

His natural constitution must have been strong, to enable him to endure the severe and prolonged labour of teaching so many pupils: in the middle period of his work, he had over a hundred in the Michaelmas Term. His regularity was a marvel; his days in term seemed to have a stable precision in their round, and the time on any afternoon could almost have been told by the different stages of his walk along the Trumpington Road. Latterly, his strength began to give way: and in recent months, his health failed so completely that his death, when it came, was not unexpected. The attendance at the funeral service, in Great St. Mary's Church on the 10th of June, gave silent and significant testimony to the esteem in which the great teacher was held by his old pupils in particular and by the University at large.

July 5th, 1907.   A. R. FORSYTH.