THOMAS MURRAY MACROBERT

THOMAS MURRAY MACROBERT, who died at his home in Glasgow on 1st November, 1962, was born on 4th April, 1884 in Dreghorn, Ayrshire, the son of the Rev. Thomas MacRobert, M.A. and Isabella Edgeley Fisher. His father was for fifty-seven years minister of the Dreghorn congregation, at that time in the Evangelical Union and later in the Congregational Union. The Rev. Thomas MacRobert was prominent in the counsels of the Congregational Union and served as its President. A Liberal in politics, he was a friend of Keir Hardie, who brought his infant daughter to be baptised at Dreghorn. MacRobert's twin brother Alexander, to whom he had a striking physical resemblance, became a much-esteemed Congregational minister and succeeded his father in the charge at Dreghorn. The twin brothers attended Irvine Royal Academy, walking to and from school, a daily walk of nearly five miles.

In 1901 MacRobert entered Glasgow University. His original intention was to follow his father in the Congregational ministry; he used to say that he gave up the idea because he considered that he would have made a poor preacher. After a successful undergraduate career (not entirely devoted to study, as his prowess in a Rectorial fight shows) he graduated in 1905, Master of Arts with First Class Honours and Bachelor of Science with Special Distinction, both degrees in Mathematics and Natural Philosophy. He was appointed Euing Fellow in Mathematics, and as part of the duties of this Fellowship he helped in the class work of the Mathematics Department. In 1907 he was awarded the Ferguson Scholarship in Mathematics, open to graduates of all four Scottish universities. Anxious to widen his mathematical knowledge, he determined to go to Cambridge and sat the Scholarship examination at Trinity College, obtaining a Major Scholarship. He took the bold step of resigning his Euing Fellowship and with the most slender financial resources went up to Cambridge in October 1907. He remained a Major Scholar at Trinity during his three years at Cambridge, was a Wrangler in Part I of the Mathematical Tripos in 1908 and was placed in the First Class in Part II in 1910. MacRobert enjoyed his time at Cambridge. He spoke in the Union, supporting the policies of the Liberal Government, for which he had a great admiration; he even considered seriously making his career in politics.

In October 1910 MacRobert joined the Mathematics Department at Glasgow University as Assistant to Professor Gibson and it was here that he was to spend the whole of his teaching life. In 1913 he was appointed Lecturer and in 1927 he succeeded Professor Gibson as Professor of Mathematics, retiring from the Chair in 1954. Glasgow University conferred on him in 1917 the higher degree of D.Sc. for his work on functions of a complex variable, and in 1955, after his retirement, the honorary degree of LL.D.

When the First World War broke out, after much thought had convinced him that the cause of the Allies was a righteous one, MacRobert volunteered for service but was rejected on the ground that he had flat feet (at a time when he thought nothing of walking from Glasgow to Dreghorn, a distance of about twenty-five miles). Later he was called up for service and, after training, commissioned in the Royal Garrison Artillery. He was sent to France and immediately plunged into a most severe baptism of fire. His superior officers spoke most highly of his

https://doi.org/10.1017/S2040618500034742 Published online by Cambridge University Press

work in the Army, not merely for his outstanding physical courage but for the influence which his upright character had on his men.

During all his time on the staff at Glasgow University he was active in many causes outside the university. He was a life-long supporter of the Temperance movement, a cause for which the Congregational Union displayed great zeal, and in the early nineteen-twenties he was prominent in the No Licence campaign in the North Kelvin district of Glasgow. In this work he was the colleague of the Rev. James Barr (later the well-known Labour M.P.) for whom he had the highest admiration. About this time he was a leading supporter of, and worked hard for, Annie S. Swan, the novelist, who was Liberal candidate for the Maryhill division of Glasgow. Throughout all his life he was much in demand as a lay preacher all over Scotland and gave devoted service to his father's church at Dreghorn. For many years he was President of the church and its choirmaster and, an able organist, he travelled regularly to Dreghorn to play the organ at the Sunday services. He took a prominent part in the preparation of *Congregational Praise*, the hymn book of the Congregational Union, published in 1951.

During the Second World War MacRobert was in charge of a group of university professors and lecturers who served as voluntary intelligence officers on the staff of the District Commissioner for Civil Defence for the West of Scotland. They shared in the manning of the office through which all reports of enemy action affecting the district were passed and all rescue and other services mobilised and coordinated. He also served in the Home Guard unit charged with the duty of ensuring the safety of the War Room, the nerve centre of communications. Another arduous war-time duty was his service on the Conscientious Objectors' Tribunal, a duty which continued long after the war ended. He was well fitted for this task not only because of his integrity of character but because of his profound knowledge of the Bible, the authority on which many of the objectors based their cases. He also served on the Agricultural Wages Board for many years.

The Glasgow Mathematical Association owes a great debt of gratitude to MacRobert. In a very real sense it was his Association. It was founded in 1927 (under the name of "The Euclidean Society", changed to its present title in 1930) and he was President for the first three years. The Association suspended its activities during the 1939–45 war, and when it resumed in 1945 he was again chosen to be President. In 1960 he was elected Honorary President of the Association. Under his guidance it provided (as it continues to provide) an invaluable link between school and university mathematics. It was entirely due to his initiative that the Association, with the support of the University Court of the University of Glasgow, embarked in 1951 on the publication of the *Proceedings*, and he served on the editorial committee till his death. The present standing of the *Proceedings* in the mathematical world is to a large extent a tribute to MacRobert.

MacRobert's lectures, even to the Ordinary Class, conveyed a sense of his own wide knowledge of and deep enthusiasm for the subject. They were characterised not only by clarity of exposition, but by a quiet pawky wit that responded to every accidental situation. Those, students and colleagues, who took part with him in the small tutorials with the honours classes recall not only the skill with which he selected the best methods of tackling problems in the wide range of subjects in which he was a master and the accuracy and speed with which he completed the solution, but also the pertinacity he displayed in carrying through to the end the solution of problems in subjects in which he had no great interest, even when the methods he was using were obviously not the best. Not only Glasgow students received his willing help; many mathematicians overseas, whose research followed the lines of his work, benefited greatly from his advice, and he gave them generous help, particularly in the preparation of the manuscripts of their papers for publication in British journals.

Anxious that his best students should have the greatest possible opportunity of developing their talents, he encouraged them to carry on their work, after graduating at Glasgow, in other universities, usually like himself in Cambridge. He was a shrewd judge of character and he displayed this quality to a high degree in selecting those of his former students whom he wanted to return to his staff in Glasgow. He was a wonderful colleague. He inherited a happy department and it remained a happy department under his direction. MacRobert attached great importance to the teaching of students and the high standard of teaching in his department was largely due to his own example and to his qualities of leadership. He devolved duties freely to members of his staff, trusted them completely to carry them out and gave them full credit when they carried them out well. But there was never any doubt whose was the final authority and whose the final responsibility. His staff were completely devoted to him and those who served under him remember him with great affection.

In the wider sphere of university administration, MacRobert became more and more involved as the years passed. He served on the University Court and for a number of years acted as Deputy Principal. No lover of committees, he, in his latter years as professor, had to bear the burden of serving on many such bodies. He had no patience with what he regarded as red tape and when he considered regulations to be pernicious or even only unnecessary, he had the courage simply to ignore them. His sterling qualities of character and his integrity made his advice invaluable, though sometimes unpopular, in many a difficult university problem. After his retirement he served as Dean of Faculties for several years.

In 1914 MacRobert married Violet McIlreaith and they set up their home in a flat in North Kelvinside. On his appointment to the Chair, they moved to 10, The University. Mrs MacRobert predeceased her husband by five years. They had three children, the eldest Violet, now the wife of Mr Colin Brown, J.P., and two sons, the elder, Tom, now Assistant Keeper in the Victoria and Albert Museum and the younger, Alexander, formerly in the Colonial Administrative Service in Uganda and now training as a schoolmaster. Those friends, and particularly his colleagues and their wives, who had the privilege of enjoying the warmth and generosity of the hospitality of the MacRobert home will long treasure the memory.

What leisure MacRobert had he devoted to walking, preferably hill walking. He had a great love for the countryside and for wild flowers and birds, which he knew intimately. He had no interest in games. Widely read in history and biography, he had no liking for modern fiction.

After his retirement in 1954, a committee, representative of all the many aspects of his career, was formed to mark in some tangible form the respect and affection in which he was held. The response to this appeal on the part of friends, colleagues and former students was such that they were able to present to Professor MacRobert his portrait in oils. This fine picture, conveying something of his character and personality, was painted by Mr Norman Hepple (now R.A.). It hangs in the Classroom of the Mathematics Department at Glasgow University.

Thomas MacRobert will be remembered not only for his great intellectual gifts, not only for his kindliness and courtesy, but beyond all else for his stout heart and his sterling qualities of honesty and integrity.

R. P. GILLESPIE

Professor MacRobert's publications span almost half a century, his first paper having appeared in 1916, while the last one was in the press at the time of his death. All in all, he wrote three books, revised or prepared for publication three works by other authors and published some seventy research papers and notes. The list of his publications shows one unusual feature. The very second item in chronological order (preceded only by a two-page note in 1916) is a substantial book which went through five editions (the fifth edition appearing in the last year of its author's life) and numerous reprintings and is still in use, 45 years after its first appearance.

The book in question is *Functions of a complex variable*. The theoretical part of this book is on a comparatively modest level, mirroring presumably the level current in undergraduate instruction before the First World War; one is conscious of the book preceding by a decade and a half or so the more advanced texts by Titchmarsh and Copson. This part of the book changed little in subsequent editions. The main strength of the work lies in the presentation of special functions, such as the gamma function, functions of the hypergeometric type, and elliptic functions. This is the part of analysis that occupied the most important place in MacRobert's research. Here he was an acknowledged master and not only improved the presentation in each edition but also added new results obtained by himself, his associates and others. Results of the research which he carried out in the course of a long and diligent life appear in the appendices and the "miscellaneous examples ". In this respect Appendix V and the third group of miscellaneous examples are especially noteworthy in that they contain an excellent presentation of the E-function.

Since the first publication of *Functions of a complex variable* a large number of text-books on complex variable theory and on special functions have appeared, among them some distinguished and famous works. The very fact that through almost half a century MacRobert's book has maintained a place of its own beside the later books testifies to its quality.

His next book appeared ten years later, in 1927. Its title *Spherical harmonics* does not describe its contents adequately and the subtitle " An elementary treatise on harmonic functions with applications " indicates what the book was originally intended to be rather than what it actually became. Apparently MacRobert set out to write an elementary presentation of Legendre functions (without using analytic function theory) with applications to potential theory. The plan grew under his hands, and he wound up with a book on the solution of the classical boundary value problems of mathematical physics by Fourier series, Legendre functions and Bessel functions. This book too has proved sufficiently popular to merit a second edition in 1947.

Approximately another ten years later (in 1937 and 1938) appeared the third, and the last, of MacRobert's books, *Trigonometry* (in four parts) written in collaboration with W. Arthur (then Lecturer in MacRobert's department). The scope of this work is much wider than is

https://doi.org/10.1017/S2040618500034742 Published online by Cambridge University Press

indicated by the titles of its four parts. In particular, the third part, entitled *Advanced trigonometry*, is really a text-book on infinite series and products, including topics such as double series and uniform convergence. Like all MacRobert's books, it contains a remarkably rich collection of examples.

Besides writing original works, MacRobert found time to revise or see through publication books by others. He collaborated with Gray on the second edition of Gray and Mathews's *Bessel functions*, which was published in 1922. The appearance in the same year of Watson's monumental work on the same subject caused this revised edition to have somewhat less impact than it might have had in different circumstances; but the book (which up to that time was the most important book on its subject) has merit, and is still widely used especially by applied mathematicians. In 1926 appeared the revised edition of Bromwich's *Infinite series.* The revision of this important work embodies considerable improvements, both of a mathematical nature and in a more systematic presentation, and this revised edition proved of great and lasting influence in its field. Finally, he prepared for publication *Advanced calculus* by his predecessor in the Glasgow Chair, G. A. Gibson.

It has already been indicated that MacRobert's publication record shows a trend opposite to that of many other mathematicians. All of his books were written in the first half of his career, while both the number and importance of his research papers increased during the second half. He continued his research activities after his retirement from the Glasgow Chair and was producing interesting papers up to the time of his death.

The turning point in his research activities is, beyond any manner of doubt, the discovery of the E-function in the middle thirties. Up to that point MacRobert had no clearly delineated field of research but applied his analytical skill to a variety of problems connected with special functions, especially functions related to hypergeometric functions, and related topics. Most of the special functions in question can be expressed in terms of the generalized hypergeometric series ${}_pF_q$, where

$$\frac{\Gamma(a_1)\dots\Gamma(a_p)}{\Gamma(c_1)\dots\Gamma(c_q)}\,{}_pF_q\left(a_1,\dots,a_p;\,c_1,\dots,c_q;\,-\frac{1}{z}\right)=\sum_{n=0}^{\infty}\frac{\Gamma(a_1+n)\dots\Gamma(a_p+n)}{n!\,\Gamma(c_1+n)\dots\Gamma(c_q+n)}\left(-\frac{1}{z}\right)^n. \quad (1)$$

This series converges for each z if $p \leqq q$, it converges for $|z|>1$ if $p=q+1$, and (unless it terminates) it diverges for each z when $p>q+1$. Nevertheless, cases have been known for a long time in which such a divergent series represents certain functions of the hypergeometric type asymptotically as $z\to\infty$. Presumably in an attempt to construct proofs by induction (on p and q) of certain results involving (convergent) generalized hypergeometric series, MacRobert discovered a multiple integral which possesses (1), with $p>q+1$, as its asymptotic expansion. Defining $E(a_1,\dots,a_p;\;c_1,\dots,c_q;\;z)$ by (1) when $p\leqq q+1$ and by his multiple integral when $p \geqq q+1$, he found that the two definitions are equivalent when both hold (i.e., when $p=q+1$ and $|z|>1$), and that (1) when divergent provides the asymptotic expansion of E in a certain sector. Moreover, a great many identities involving the E-function hold irrespective of the relative size of p and q, and many known formulae involving functions of the hypergeometric type can be expressed elegantly in terms of E.

These discoveries convinced MacRobert that in the E-function he had found an appropriate extension of generalized hypergeometric functions, and from 1938 onwards we find

https://doi.org/10.1017/S2040618500034742 Published online by Cambridge University Press

him devoting most of his research efforts to the investigation of this function. In the course of the years he built up an impressive body of results, including, in particular, a formidable number of integrals with E-functions. These results not only serve to unify and express conveniently known facts involving special functions of the hypergeometric type but also lead to many new formulae. A considerable number of research workers are now engaged in research in this field: some of them are MacRobert's pupils, while others learned about the subject from his publications. It may be mentioned that another extension of generalized hypergeometric functions was developed, also in the middle thirties, by Dr. (now Professor) C. S. Meijer of Groningen (The Netherlands) whose G-function is more complicated, but also more inclusive, than MacRobert's E-function. Each of these two generalizations has its own devotees, and the two schools appear to develop their theories independently of each other, often taking little notice of each other's work.

A. ERDÉLYI

PUBLICATIONS

BOOKS

Functions of a complex variable, Macmillan. 1st edn 1917, 1925; 2nd edn 1933, 1938; 3rd edn 1945, 1950; 4th edn 1954; 5th edn 1962.

Spherical harmonics: an elementary treatise on harmonic functions with applications, Methuen. 1st edn 1927; 2nd edn 1947.

(with W. Arthur) *Trigonometry*, Methuen: Part I, *Intermediate trigonometry*, 1937, 1942, 1945, 1947, 1950 (5 edns); Part II, *Higher trigonometry*, 1937, 1943, 1947, 1950; Part III, *Advanced trigonometry*, 1938, 1950; Part IV, *Spherical trigonometry*, 1938, 1946, 1950.

OTHER WORKS

A. Gray and G. B. Mathews, *A treatise on Bessel functions and their applications to physics*, Macmillan. Second edn prepared by A. Gray and T. M. MacRobert, 1922.

T. J. l'A Bromwich, *An introduction to the theory of infinite series*, Macmillan. Second revised edn prepared by T. M. MacRobert, 1926, 1931, 1942, 1947, 1949.

George A. Gibson, *Advanced calculus*, Macmillan, 1931, 1944, 1948. Prepared for publication by T. M. MacRobert.

Mathematics (and Astronomy). An account of mathematics and astronomy in the University of Glasgow published in *Fortuna Domus*, a series of lectures delivered in the University of Glasgow in the academic year 1950–51 to commemorate the Fifth Centenary of the Foundation, Glasgow, 1952, pp. 59–73.

PAPERS

1. A method of obtaining examples on the multiplication of determinants, *Edinburgh Math. Notes* **20** (1916), 230–231.

2. Relations between the integrals of the hypergeometric equation, *Proc. Edinburgh Math. Soc.* (1) **37** (1919), 2–6.

3. The modified Bessel function $K_n(z)$, *Proc. Edinburgh Math. Soc.* (1) **38** (1920), 3–12.

4. Asymptotic expressions for the Bessel functions and the Fourier-Bessel expansions, *Proc. Edinburgh Math. Soc.* (1) **39** (1921), 1–8.

5. The asymptotic expansion of the confluent hypergeometric function, and a Fourier-Bessel expansion, *Proc. Roy. Soc. Edinburgh* **42** (1922), 89–96.

6. The asymptotic expansions of the spherical harmonics, *Proc. Edinburgh Math. Soc.* (1) **41** (1923), 82–93.

7. On an asymptotic expansion of the hypergeometric function, *Proc. Edinburgh Math. Soc.* (1) **42** (1924), 84–92.

8. A proof of the addition theorem for the Legendre functions, *Proc. Edinburgh Math. Soc.* (1) **42** (1924), 93–94.

https://doi.org/10.1017/S2040618500034742 Published online by Cambridge University Press

9. The addition theorem for the Legendre functions of the second kind, *Proc. Roy. Soc. Edinburgh* **46** (1926), 30–35.

10. On some Legendre function formulae, *Proc. Edinburgh Math. Soc.* (2) **2** (1930), 20–25.

11. On an integral due to Ramanujan, and some ideas suggested by it, *Proc. Edinburgh Math. Soc.* (2) **2** (1930), 26–32.

12. George Alexander Gibson, M.A., LL.D. Obituary Notice, *Proc. Roy. Soc. Edinburgh* **50** (1931), 325–327.

13. Fourier integrals, *Proc. Roy. Soc. Edinburgh* **51** (1931), 116–126.

14. The Mehler-Dirichlet integral and some other Legendre function formulae, *Phil. Mag.* (7) **14** (1932), 632–656.

15. Proofs of some formulae for the hypergeometric function, *Phil. Mag.* (7) **16** (1933), 440–449.

16. Some integrals, with respect to their degrees, of associated Legendre functions, *Proc. Roy. Soc. Edinburgh* **54** (1934), 135–144.

17. On some trigonometric series, *Phil. Mag.* (7) **19** (1935), 1142–1146.

18. Some series and integrals involving the associated Legendre functions, regarded as functions of their degrees, *Proc. Roy. Soc. Edinburgh* **55** (1935), 85–90.

19. Derivation of Legendre function formulae from Bessel function formulae, *Phil. Mag.* (7) **21** (1936), 697–703.

20. Gaspard Monge: The discoverer of descriptive geometry, *J. Glasgow Math. Assoc.* **1** (1936), 10–17.

21. Some formulae for the associated Legendre functions of the second kind; with corresponding formulae for the Bessel functions, *Proc. Roy. Soc. Edinburgh* **57** (1937), 19–25.

22. Some series and integrals for the associated Legendre functions of the first kind, regarded as functions of their orders, *Phil. Mag.* (7) **24** (1937), 223–227.

23. Induction proofs of the relations between certain asymptotic expansions and corresponding generalized hypergeometric series, *Proc. Roy. Soc. Edinburgh* **58** (1938), 1–13.

24. A proof by induction of the analytical continuations of certain generalized hypergeometric functions, *Phil. Mag.* (7) **25** (1938), 848–851.

25. Proofs of some formulae for the generalized hypergeometric functions and certain related functions, *Phil. Mag.* (7) **26** (1938), 82–93.

26. Solution in multiple series of a type of generalized hypergeometric equation, *Proc. Roy. Soc. Edinburgh* **59** (1939), 49–54.

27. Expressions for generalized hypergeometric functions in multiple series, *Proc. Roy. Soc. Edinburgh* **59** (1939), 141–144.

28. On Dixon's formula for well-poised series, *Phil. Mag.* (7) **27** (1939), 579–581.

29. Some formulae for the associated Legendre functions of the first kind, *Phil. Mag.* (7) **27** (1939), 703–705.

30. Formulae for generalized hypergeometric functions as particular cases of more general formulae, *Phil. Mag.* (7) **28** (1939), 488–492.

31. Some integrals involving Legendre and Bessel functions, *Quart. J. Math.* (*Oxford Ser.*) **11** (1940), 95–100.

32. Some formulae for the *E*-function, *Phil. Mag.* (7) **31** (1941), 254–260.

33. Some integrals involving *E*-functions and confluent hypergeometric functions, *Quart. J. Math.* (*Oxford Ser.*) **13** (1942), 65–68.

34. Associated Legendre functions of the first kind when the sum of the degree and the order is a positive integer, *Quart. J. Math.* (*Oxford Ser.*) **14** (1943), 1–4.

35. Proofs of some formulae for the hypergeometric function and the *E*-function, *Phil. Mag.* (7) **34** (1943), 422–426.

36. Expansions in terms of associated Legendre functions, *Phil. Mag.* (7) **35** (1944), 670–680.

37. Some applications of contour integration, *Phil. Mag.* (7) **38** (1947), 45–51.

38. On an identity involving *E*-functions, *Phil. Mag.* (7) **39** (1948), 466–471.

39. On Neumann's formula for the Legendre functions, *Proc. Glasgow Math. Assoc.* **1** (1951), 10–12.

40. An expansion in terms of associated Legendre functions, *Proc. Glasgow Math. Assoc.* **1** (1951), 13–15.

41. Inequalities for a class of terminating generalized hypergeometric functions, *Proc. Glasgow Math. Assoc.* **1** (1951), 32–37.

42. Generalizations of some hypergeometric function transformations, *Proc. Glasgow Math. Assoc.* **1** (1951), 38–41.

43. An integral involving an *E*-function and an associated Legendre function of the first kind, *Proc. Glasgow Math. Assoc.* **1** (1953), 111–114.

44. Integral of an *E*-function expressed as a sum of two *E*-functions, *Proc. Glasgow Math. Assoc.* **1** (1953), 118.

45. Integers the sum of whose squares is the square of an integer, *J. Glasgow Math. Assoc.* **1** (1953), 112–113.

46. An indefinite integral involving a product of two modified Bessel functions of the second kind, *Proc. Glasgow Math. Assoc.* **1** (1953), 187–189.

47. Some integrals involving *E*-functions, *Proc. Glasgow Math. Assoc.* **1** (1953), 190–191.

48. Integrals involving a modified Bessel function of the second kind and an *E*-function, *Proc. Glasgow Math. Assoc.* **2** (1954), 93–96.

49. Integrals involving *E*-functions and associated Legendre functions, *Proc. Glasgow Math. Assoc.* **2** (1955), 127–128.

50. Integrals involving products of modified Bessel functions of the second kind, *Proc. Glasgow Math. Assoc.* **2** (1955), 129–131.

51. Some Bessel function integrals, *Proc. Glasgow Math. Assoc.* **2** (1956), 183–184.

52. On recurrence formulae, *Proc. Glasgow Math. Assoc.* **2** (1956), 36–37.

53, Integrals allied to Airy's integrals, *Proc. Glasgow Math. Assoc.* **3** (1957), 91–93.

54. Integrals involving hypergeometric functions and *E*-functions, *Proc. Glasgow Math. Assoc.* **3** (1958), 196–198.

55. Integrals involving *E*-functions, *Math. Z.* **69** (1958), 234–236.

56. Infinite series of *E*-functions, *Proc. Glasgow Math. Assoc.* **3** (1958), 26–28.

57. Integrals of products of *E*-functions, *Math. Ann.* **137** (1959), 412–416.

58. Infinite series of *E*-functions, *Math. Z.* **51** (1959), 143–145.

59. Integration of *E*-functions with respect to their parameters, *Proc. Glasgow Math. Assoc.* **4** (1959), 84–87.

60. The multiplication formula for the gamma function and *E*-function series, *Math. Ann.* **139** (1959), 133–139.

61. Multiplication formulae for the *E*-functions regarded as functions of their parameters, *Pacific J. Math.* **9** (1959), 759–761.

62. Applications of the multiplication formula for the gamma function to *E*-function series, *Proc. Glasgow Math. Assoc.* **4** (1960), 114–118.

63. Recurrence formulae for the *E*-functions, *Math. Z.* **73** (1960), 254–255.

64. Expression for an *E*-function as a finite series of *E*-functions, *Math. Ann.* **140** (1960), 414–416.

65. Evaluation of an *E*-function when two of the upper parameters differ by an integer, *Proc. Glasgow Math. Assoc.* **5** (1961), 30–34.

66. Transformations of series of *E*-functions, *Pacific J. Math.* **11** (1961), 309–311.

67. Fourier series for *E*-functions, *Math. Z.* **75** (1961), 79–82.

68. Beta-function formulae and integrals involving *E*-functions, *Math. Ann.* **142** (1961), 450–452.

69. Integrals involving Gegenbauer functions and *E*-functions, *Math. Ann.* **144** (1961), 299–301.

70. Barnes integrals as a sum of *E*-functions, *Math. Ann.* **147** (1962), 240–243.

71. Integrals involving *E*-functions, *Proc. Glasgow Math. Assoc.* **6** (1963), 31–33.

72. Evaluation of an *E*-function when three of its upper parameters differ by integral values, *Pacific J. Math.* **11** (1963), 999–1002.