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Author(s): Garry J. Tee
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Mathematics in the Pacific Basin

GARRY J. TEE*

INDIGENOUS PACIFIC MATHEMATICS

The development of systematic mathematics requires writing, and hence a non-literate culture cannot be expected to advance mathematics beyond the stage of numeral words and counting. The hundreds of languages of the Australian aborigines do not seem to have included any extensive numeral systems. However, the common assertions to the effect that 'Aborigines have only one, two, many'[1] derive mostly from reports by nineteenth century Christian missionaries, who commonly understood less mathematics than did the people on whom they were reporting. Of course, in recent decades almost all Aborigines have been involved with the dominant European-style culture of Australia, and even those who are not literate have mostly learned to use English-style numerals and to handle money.[2] Similar qualifications should be understood when speaking of any recent primitive culture.

In New Guinea, the many hundreds of cultures used numbers at levels ranging from those comparable to Australian Aborigines up to fairly systematic use of place-value on various bases, including[3] 60, and[4] even 24. The Polynesian peoples dominated the Pacific Ocean, from Hawaii to Easter Island and New Zealand. The Polynesian number system is purely decimal, with the numeral words formed on base ten more regularly than in the English language. In 1817 William Mariner[5] gave examples of Tongan numeral words up to 100 000 including 95 741. The French naturalist La Billardière had given a Tongan vocabulary in his book about his travels in Dumont d'Urville's first expedition, including

1 Arthur Koestler, *The Act of Creation*, Hutchinson, London, 1964, p. 622.

2 John N. Crossley, *The Emergence of Number*, Upside Down A Book Company, Steel's Creek, Australia, 1980, pp. 29–33.

3 Leopold Pospisil and Derek J. de Solla Price, 'A survival of Babylonian arithmetic in New Guinea?', *Indian Journal of the History of Science*, (1966), **1**, pp. 30–33; and 'Kapauku numeration', *Journal of the Polynesian Society*, (1977), **86**, 271–272.

4 Nancy Bowers and Punda Lepi, 'Kaugel Valley systems of reckoning', *Journal of the Polynesian Society*, (1977), **86**, (1), pp. 105–116.

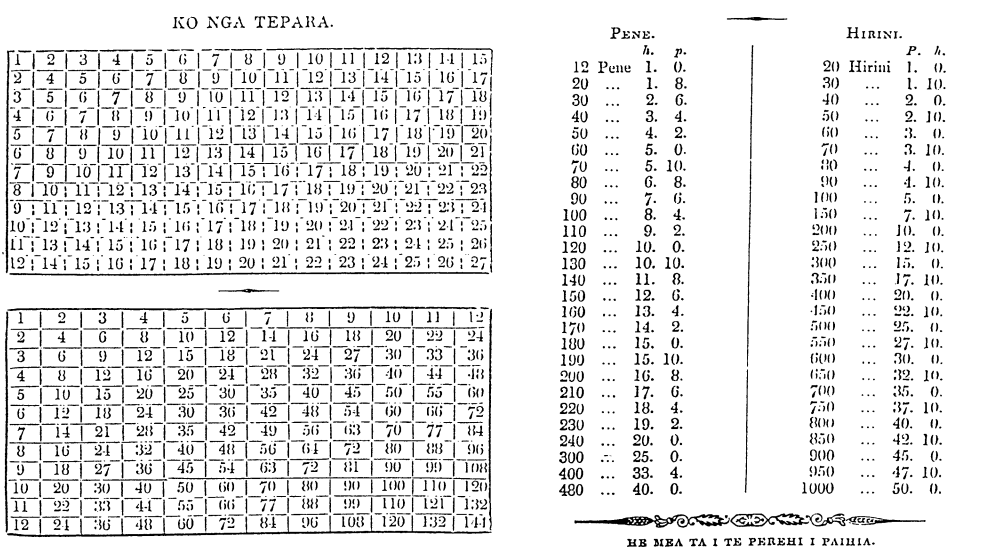
5 William Mariner, *An Account of the Natives of the Tonga Islands in the South Pacific Ocean. With an original Grammar and Vocabulary of their language. Compiled and arranged from the extensive communications of Mr. William Mariner, several years resident in those islands. By John Martin, M.D.* (2 volumes), John Murray, London, 1817, Volume 2, pp. 388–391. Dr John Martin complained pedantically (Volume 2, p. 382) that the Tongans, when speaking their own language, flagrantly ignored the rules (of Latin grammar!) for distinguishing nouns from verbs.

*Department of Computer Science, University of Auckland, Auckland, New Zealand.

An invited lecture to the Conference on Anglo-Australian Science, 1788–1988, organized by the British Society for the History of Science and the Royal Institution, London, on 7 and 8 January 1988.

words purported to mean the powers of 10, up to 10.[15] But Mariner explained tactfully (Volume 2, p. 391) that La Billardière 'instead of names of numbers, has only furnished us with names of things very remote from his speculations at that time'. In fact, the words reported for 10,[7] $10^8 \ldots 10^{14}$ were Tongan names for sundry unseemly anatomical details, and the polysyllabic word given for 10^{15} was actually an invitation to eat up the things which had been named previously!

The languages of the peoples of the Pacific were mostly reduced to writing by missionaries in the nineteenth century. The introduction of literacy was sometimes accompanied by numeracy and arithmetic, with particular emphasis upon reckoning of money. Hawaii was dominated by American missionaries, and consequently nineteenth-century Hawaiian arithmetic used dollars divided conveniently into 100 cents—but with Imperial weights and measures.[6] British missionaries dominated most of the Pacific islands and they inflicted not only the Imperial weights and measures, but also sterling currency of guineas, pounds, shillings, pence and farthings. For example, the English missionary printer William Colenso (a cousin of John William Colenso, the notorious Anglican Bishop of Natal) arrived in New Zealand in 1835, and one of the first documents printed in New Zealand was Colenso's table of addition and multiplication, with pounds, shillings



KO NGA TEPARA.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	4	5	6	7	8	9	10	11	12	13	14	15	16	17
3	5	6	7	8	9	10	11	12	13	14	15	16	17	18
4	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	8	9	10	11	12	13	14	15	16	17	18	19	20	21
7	9	10	11	12	13	14	15	16	17	18	19	20	21	22
8	10	11	12	13	14	15	16	17	18	19	20	21	22	23
9	11	12	13	14	15	16	17	18	19	20	21	22	23	24
10	12	13	14	15	16	17	18	19	20	21	22	23	24	25
11	13	14	15	16	17	18	19	20	21	22	23	24	25	26
12	14	15	16	17	18	19	20	21	22	23	24	25	26	27

1	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3	6	9	12	15	18	21	24	27	30	33	36
4	8	12	16	20	24	28	32	36	40	44	48
5	10	15	20	25	30	35	40	45	50	55	60
6	12	18	24	30	36	42	48	54	60	66	72
7	14	21	28	35	42	49	56	63	70	77	84
8	16	24	32	40	48	56	64	72	80	88	96
9	18	27	36	45	54	63	72	81	90	99	108
10	20	30	40	50	60	70	80	90	100	110	120
11	22	33	44	55	66	77	88	99	110	121	132
12	24	36	48	60	72	84	96	108	120	132	144

Pene.				Hirini.			
		l.	*p.*			*P.*	*h.*
12	Pene	1.	0.	20	Hirini	1.	0.
20	...	1.	8.	30	...	1.	10.
30	...	2.	6.	40	...	2.	0.
40	...	3.	4.	50	...	2.	10.
50	...	4.	2.	60	...	3.	0.
60	...	5.	0.	70	...	3.	10.
70	...	5.	10.	80	...	4.	0.
80	...	6.	8.	90	...	4.	10.
90	...	7.	6.	100	...	5.	0.
100	...	8.	4.	150	...	7.	10.
110	...	9.	2.	200	...	10.	0.
120	...	10.	0.	250	...	12.	10.
130	...	10.	10.	300	...	15.	0.
140	...	11.	8.	350	...	17.	10.
150	...	12.	6.	400	...	20.	0.
160	...	13.	4.	450	...	22.	10.
170	...	14.	2.	500	...	25.	0.
180	...	15.	0.	550	...	27.	10.
190	...	15.	10.	600	...	30.	0.
200	...	16.	8.	650	...	32.	10.
210	...	17.	6.	700	...	35.	0.
220	...	18.	4.	750	...	37.	10.
230	...	19.	2.	800	...	40.	0.
240	...	20.	0.	850	...	42.	10.
300	...	25.	0.	900	...	45.	0.
400	...	33.	4.	950	...	47.	10.
480	...	40.	0.	1000	...	50.	0.

HE MEA TA I TE PEREHI I PAIHIA.

Figure 1. Arithmetic tables, printed by William Colenso at the Mission Press at Paihia in 1835 (Alexander Turnbull Library).

6 George Leonard, *He Huinahelu oia ka Helunaau me ka Helukakau, i Huiia,* Ka na Misionari mea Pai, Honolulu, 1852, Arithmetic textbook by a Bishop of Hawaii, using dollars and cents on p. 98; Warren Colburn, *He Helunaau ke mea e Maa'i ke Kanaka,* Ellsworth, Boston, 1868. Textbook of arithmetic in Hawaiian, by a Bishop of Honolulu; James B. Thomson, *Ka Huinahelu Hou; oia hoi ka Arimatika Kulanui,* Papa Hoonaauao, Honolulu, 1870. Textbook of arithmetic, in Hawaiian, with dollars and cents used on p. 227. Copies of these three texts are held in the George Grey Collection, in Auckland Public Library.

and pence.[7] In a Rarotongan textbook[8] the student was expected to calculate a cost of £114-0-4$^2/_7$; and similarly in the Melanesian culture of Fiji, the student was expected[9] to handle sums involving £8096-17-11¾.

In the nineteenth century, a number of Europeans and Americans visiting Pacific islands recorded their surprise at being challenged by local people to solve problems in arithmetic and algebra: few of those visitors were able to match the skill of the Pacific Islanders. (An amusing version was given by Sylvia Townsend Warner in her satire *Mr. Fortune's Maggot*.[10]) In New Zealand, the missionary William Williams initially misunderstood Maori counting practice, and in the first edition of his Maori–English dictionary[11] he claimed that the Maori counted by elevens, and he gave words purported to mean 11^2 and 11^3: actually, they meant 10^2 and 10^3. That blunder was corrected in all later editions of Williams's dictionary[12]—but reports have been published in recent years claiming that the Maori used 11 as the base of their number system.[13]

INTRODUCTION OF MODERN MATHEMATICS

The British colony of New South Wales was founded on 26 January 1788, and on 30 January 1840 its boundary was extended to include New Zealand. On 24 November 1840 the boundary of New South Wales snapped back westwards across the Tasman Sea, and New Zealand became a separate colony of the British Empire. Thereafter, European culture (including mathematics) was introduced rapidly into the Pacific region. Most of the population of the Pacific live in Australasia, and modern mathematics has been cultivated primarily in Australia and New Zealand.

Frederick William Frankland (1854–1916) was a son of the eminent chemist Sir Edward Frankland from Lancaster. In 1875 he came to New Zealand to improve his health. He became the Government Actuary, and had a distinguished actuarial career in

7 (William Colenso) *Ko Nga Tepara,* He mea ta i te perehi i Paihia, 1835: single sheet with tables for addition (up to 12+15) and multiplication (up to 12×12), and tables for pounds, shillings and pence. The only known copy was acquired by the Alexander Turnbull Library in 1984.

8 Anonymous, *Koe Fika Nomiba. Ko hono tolu oe tohi. Koe falakiseni moe Tesimale.* Nae Buluji i he Kollij ko Tubou, 1871, p. 64. The George Grey Collection in Auckland Public Library has a copy of that textbook of arithmetic in Rarotongan.

9 Anonymous, *Ai Vola Ni Fika,* Printed by T.D. Hartwell, next the Wesleyan Church, Newton, 1871, p. 29. The George Grey Collection in Auckland Public Library has a copy of that textbook of arithmetic in Fijian. The author explained in the Preface that 'As this book has been prepared solely for the use of Fijians, the wants and the mental capacity of those tribes alone have been taken into consideration. . . . It has not been thought advisable to extend this work beyond Vulgar Fractions; for though natives might perhaps be found capable of understanding the more advanced rules, yet neither the national character nor the national prospects for the future give sufficient promise of such knowledge being turned to any practical use; and it is to be feared that the possession of knowledge which cannot be utilised is not only useless, but positively hurtful to savages.'

10 Sylvia Townsend Warner, *Mr. Fortune's Maggot,* Viking Press, New York, 1927.

11 William Williams, *A Dictionary of the New Zealand Language,* (1st edn), Press of the Church Missionary Society, Paihia, 1844.

12 Levi Leonard Conant, *The Number Concept: Its Origin and Development,* MacMillan, New York, 1896, pp. 122–123.

13 Peter Henrici, *Elements of Numerical Analysis,* John Wiley, New York, 1964, p. 291;
Э. И. Березкина, 'О математических методах древних (к историм систем счислений)', Ист. и Метод. Естест Наук, (1982), вып. 29, 31–40.
(È.I. Berezkina, 'On mathematical methods of the ancients (on the history of number systems)', (in Russian), *History and methodology of the Natural Sciences,* (1982), No. **29**, pp. 31–40.)

New Zealand, with periods in England and in the USA.[14] He was a member of the London Mathematical Society, the American Mathematical Society, the Actuarial Society of America, a Fellow of the Institute of Actuaries and a member of the American Association for the Advancement of Science, et cetera. He published numerous papers on statistics and some papers on the concepts of geometry, including a significant defence of non-Euclidean geometry.[15]

In the nineteenth century, universities were founded[16] at Sydney in 1850, Melbourne in 1853, Dunedin (University of Otago) in 1869, Christchurch (University of Canterbury) in 1873, Adelaide in 1874, Auckland in 1883, Hobart (University of Tasmania) in 1890 and Wellington (Victoria University) in 1897. (From 1870 to 1961, the New Zealand universities were colleges within the University of New Zealand.) Women were admitted to the New Zealand universities from the start, and in 1877 Kate Milligan Edger graduated at Auckland as B.A., thereby becoming the second woman to graduate anywhere in the British Empire.[17] Some Australian women came to study in New Zealand, but eventually all Australian universities accepted women as students.

From their foundation, mathematics was an important subject at each of the Australasian universities. Horace Lamb was the first Professor of Mathematics at the University of Adelaide from 1876 to 1885, during which period he wrote the first edition of his classic treatise on *Hydrodynamics*.[18] The early Australasian universities all experienced difficulties from the absence of any adequate system of secondary schools to prepare students for university study, and academic standards comparable to those of British universities entailed failing many students in examinations. There was strong local criticism of each of those universities for 'plucking' (i.e., failing) many students by their high examination standards, as in the cartoon[19] 'University Plucking Match', depicting the Professors at Adelaide University in 1879: Horace Lamb (Mathematics, right), Ralph Tate (Natural Science, middle) and John Davidson (English Literature and Philosophy, left).

Lamb was succeeded as Professor of Mathematics from 1885 to 1908 by William Henry Bragg, who began experimenting with X-rays immediately after Röntgen's discovery in 1895. His son William Lawrence Bragg was born at Adelaide in 1891. William

14 Guy H. Scholefield (ed.), *A Dictionary of New Zealand Biography,* (2 vols), Government Printer, Wellington, 1940, article on Frederick William Frankland; an obituary note on Frankland was published in the *Bulletin of the American Mathematical Society,* (1916), **23,** p. 54. I am indebted to the referee for informing me of Frederick William Frankland. (I am also grateful to the referee for the very prompt acceptance of this paper for publication.)

15 Frederick William Frankland, 'On the simplest continuous manifoldness of two dimensions and of finite extent', *Transactions of the New Zealand Institute,* (1876), **9,** pp. 272–279 (reprinted in *Proceedings of the London Mathematical Society,* (1877), **8,** pp. 57–64; and in *Nature,* (1877), **15,** pp. 515–517 and *Nature,* (1880), **22,** 170–171); 'The non-Euclidean geometry vindicated: a reply to Mr. Skey', *Transactions of the New Zealand Institute,* (1885), **18,** pp. 58–69.

16 W.J. Gardner, *Colonial Cap and Gown: Studies in the mid-Victorian Universities of Australasia,* University of Canterbury, Christchurch, 1979.

17 Grace A. Lockhart had graduated as Bachelor of Science from Mount Allison University, New Brunswick, in 1875 (Gardner[16], p. 81).

18 Horace Lamb, *A Treatise on the Mathematical Theory of the Motion of Fluids,* Cambridge University Press, Cambridge, 1879. The many later editions were entitled *Hydrodynamics*.

19 'University Plucking Match', cartoon in *Adelaide Punch,* 11 January 1879.

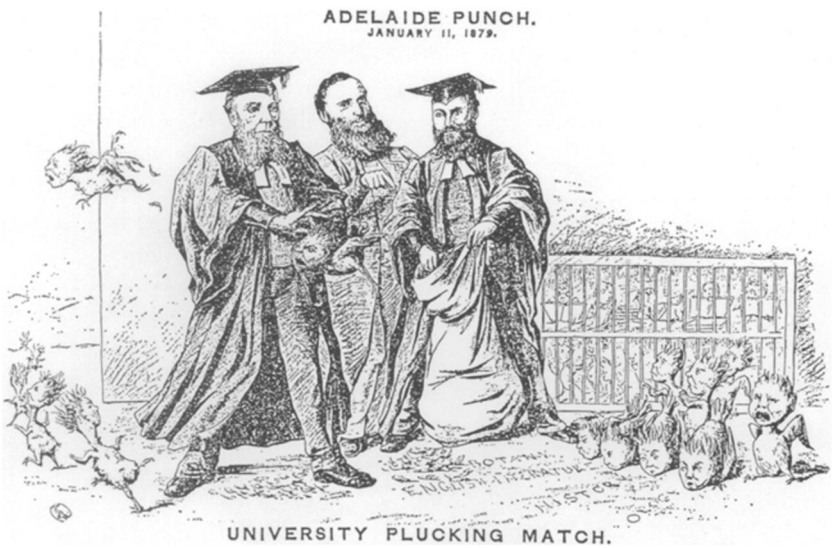


Figure 2. Students at Adelaide University are being 'plucked' by the three professors: Horace Lamb (Mathematics, right), Ralph Taye (Natural Science, middle) and John Davidson (English Literature and Philosophy, left).

Henry and William Lawrence Bragg were jointly awarded the Nobel Prize in Physics in 1915 for their research on X-rays,[20] and each of them became Director of the Royal Institution in London. Alexander McAulay (1863–1931) was the first Lecturer in Mathematics at the University of Tasmania (1893–1896) and then the first Professor of Mathematics there (1896–1929). He was a prominent advocate of quaternions,[21] and wrote significant books on quaternions and on octonions.[22] Horatio Scott Carslaw was the third Professor of Mathematics at the University of Sydney, from 1903 to 1935. He did important work on Fourier series, mathematical physics and non-Euclidean geometry.[23]

At the University of Otago, Robert John Tamish Bell (1877–1962) was Professor of Mathematics from 1920 to 1948, during which period he wrote some textbooks which have remained in print for many years.[24] At Victoria University in Wellington from 1915

20 R.B. Potts, 'Mathematics at the University of Adelaide 1874–1944', *The Australian Mathematical Society Gazette,* (1977), **4,** pp. 1–9 and 37–44; R. Radok, *A Portrait of Horace Lamb,* Mathematics Department, James Cook University, Townsville, 1980; Rod W. Home, 'The problem of intellectual isolation in scientific life: W.H. Bragg and the Australian scientific community, 1886–1909', *Historical Records of Australian Science,* (1984), **6,** pp. 19–30; Ann Moyal, A *Bright and Savage Land: Scientists in Colonial Australia,* Collins, Sydney, 1986, pp. 165–166.

21 Michael J. Crowe, *A History of Vector Analysis,* University of Notre Dame Press, Notre Dame, 1967, Ch. 6.

22 Alexander McAulay, *Utility of Quaternions in Physics,* MacMillan, London, 1893, and *Octonions: a Development of Clifford's Biquaternions,* Cambridge University Press, Cambridge, 1898.

23 Harold Oliver Lancaster, 'The departments of mathematics in the University of Sydney', *The Australian Mathematical Society Gazette,* (1986), **13,** pp. 29–38.

24 Robert John Tamish Bell, *An Elementary Treatise on Co-ordinate Geometry of Three Dimensions,* Bell, London, 1910 (3rd edn 1950).

Figure 3. Professor Emeritus Henry George Forder. Drawn by P. Brown, 1957 (University of Auckland).

to 1934, Professor Duncan M'Laren Young Sommerville (1879–1934) wrote texts on non-Euclidean geometry and multi-dimensional geometry which have remained in print until now.[25] Hentry George Forder (1889–1981) was Professor of Mathematics at Auckland University from 1934 to 1955. He was a leading modern geometer, whose books on

25 Duncan M'Laren Young Sommerville, *Bibliography of non-Euclidean Geometry*, (1st edn) University of St. Andrews Press, 1911 (2nd edn, Chelsea, New York, 1970); *The Elements of non-Euclidean Geometry*, Bell, London, 1914 (Dover edn, New York, 1958); *Analytical Conics*, Bell, London, 1924 (3rd edn 1933); *An Introduction to the Geometry of N Dimensions*, Methuen, London, 1925 (Dover edn, New York, 1958); *Analytical Geometry of Three Dimensions*, Cambridge University Press, Cambridge, 1934.

geometry[26] have been translated into Rumanian and Turkish. His large monograph on Grassmannian analysis *The Calculus of Extension* gained him the Hector Medal of the Royal Society of New Zealand.[27]

Almost all Professors of Mathematics (as with most other subjects) continued to come to Australasia from Great Britain, until refugees from Nazi Germany began to arrive in Australia, including Kurt Mahler.[28] The University of Adelaide gained Hans Schwerdtfeger in 1940, followed by George and Esther Szekeres in 1948.[29] In the 1930s, Hanna Neumann (1914–1971) and her husband Bernhard escaped from Germany to Great Britain. In 1963 Bernhard Neumann founded the research Department of Mathematics at the Australian National University, and Hanna Neumann was appointed as Reader and then as Professor of Pure Mathematics in that department.[30]

LOCAL MATHEMATICIANS

Richard Cockburn MacLaurin (1870–1920), a descendant of the eminent Scottish mathematician Colin MacLaurin (1698–1746), was born in Scotland but educated in New Zealand. He studied at Auckland University College, graduating M.A. (First Class Honours in Mathematics and Mathematical Physics) in 1891. At Cambridge University he was awarded the Smith's Prize in Mathematics in 1897 and the Yorke Prize in Law. In 1903 he was appointed as the foundation Professor of Mathematics at Victoria University College of Wellington, and in 1908 he became Professor of Mathematical Physics at Columbia University. In 1910 he became President of the Massachusetts Institute of Technology, which was then a technical college of only local significance. By the time

26 Henry George Forder, *The Foundations of Euclidean Geometry,* Cambridge University Press, Cambridge, 1927 (reprinted by Dover, New York, 1958; Rumanian translation *Fundamentele geometriei euclidiene,* Editura Ştiinţifică, Bucureşti, 1970); *A School Geometry,* Cambridge University Press, Cambridge, 1930 (2nd edn 1938); *Higher Course Geometry,* Cambridge University Press, Cambridge, 1931 (reprinted 1949 and 1955); *The Calculus of Extension,* Cambridge University Press, Cambridge, 1941 (reprinted by Chelsea Press, New York, 1960); *Geometry,* Hutchinson, London and Longmans Green, New York, 1950 (2nd edn, Hutchinson, London, 1960 and Harper, New York, 1962; Turkish translation *Geometri,* Millî Eğitim Basimeví, Istanbul, 1968).

27 John Charles Butcher (ed.), *A Spectrum of Mathematics: Essays Presented to H.G. Forder,* Auckland University Press and Oxford University Press, Auckland, 1971.

28 John H. Loxton, 'Celebration of the 80th birthday of Kurt Mahler FRS, FAA', *The Australian Mathematical Society Gazette,* (1984), **11,** pp. 1–2. In the month following the delivery of this lecture at the Royal Institution, Kurt Mahler died at the Australian National University, on 25 February 1988: cf. Bernhard H. Neumann and Alf van der Poorten, 'Kurt Mahler 1903–1988', *The Australian Mathematical Society Gazette,* (1988), **15,** pp. 25–27. The Australian National University has set up a Mahler Memorial Fund, whose aims will include the promotion of the theory of numbers among senior high school students and undergraduates.

29 R.B. Potts, 'Mathematics at the University of Adelaide 1944–1958', *The Australian Mathematical Society Gazette,* (1985), **12,** pp. 25–30.

30 Michael F. Newman, 'Hanna Neumann (1914–1971)', In: Louise S. Grinstein and Paul J. Campbell (eds), *Women of Mathematics: A Biobibliographic Sourcebook,* Greenwood Press, New York, 1987, pp. 156–160; The *Selected Papers of Bernhard and Hanna Neumann* (6 vols), with commentaries by Bernhard Neumann, have been published in May 1988 by the Charles Babbage Research Centre (University of Manitoba), as a contribution to the Australian Bicentennial celebrations.

that MacLaurin died in 1920, he had built M.I.T. into a world-class technological university.[31]

Earnest[32] Rutherford (1871–1937) was born at Brightwater, near Nelson, and he studied at Canterbury University College from 1889 to 1894. He was taught mathematics by Professor C. H. H. Cook (Professor of Mathematics from 1874 to 1908), who was described[33] as 'a sound and orthodox mathematician, and a good teacher'. Rutherford was taught physics by Professor A. W. Bickerton, a flamboyant and unorthodox physicist who developed a theory of collisions between stars. Rutherford became the supreme experimental physicist (surpassed only by Faraday), whose bluff and hearty manner indicated scant regard for theorists. But when he needed mathematics in order to interpret his experimental results then he demonstrated considerable mathematical skill, as in his treatment of systems of linear ordinary differential equations for radioactive decay.[34] His discovery of the nuclear structure of atoms by statistical analysis of α-particle scattering (in which he appears to have been influenced by Bickerton's theory of stellar collisions) required mathematical expertise of an uncommon order.[35]

Charles Ernest Weatherburn (1884–1974) graduated from the University of Sydney with First Class Honours in Mathematics. He was Professor of Mathematics at Canterbury University College (1924–1929), then at the University of Western Australia. He wrote major books[36] in vector analysis and on differential geometry, and[37] 'in 1947 his textbook was one of the earliest to give a correct but elementary mathematical presentation of mathematical statistics'.

Leslie John Comrie

Leslie John Comrie (1893–1950) was born at Pukekohe and in 1916 he graduated from Auckland University College as M.A. (Honours in Chemistry). From 1925 until his death

31 Donald A. Nield, 'University mathematics in Auckland: a historical essay', *Mathematical Chronicle,* (1983), **12,** pp. 1–33.

32 Rutherford's first name is often given as Ernest, but his name is spelt Earnest Rutherford on his birth certificate. cf. M.E. Hoare and L.G. Bell (eds), *In Search of New Zealand's Scientific Heritage* (1984), Bulletin 21, The Royal Society of New Zealand, p. 119.

33 E.S. Eve, *Rutherford,* Cambridge University Press, Cambridge, 1939.

34 Earnest Rutherford, 'The succession of changes in radioactive bodies', *Phil. Trans. Roy. Soc; Series A,* (1904), **204,** pp. 169–219. (The Bakerian Lecture for 1904. Reprinted in *The Collected Papers of Lord Rutherford* (ed. James Chadwick), George Allen and Unwin, London, Vol. 1, 1962, pp. 671–722).

35 Earnest Rutherford, 'The scattering of α and β particles by matter and the structure of the atom', *Phil. Mag;* Series 6, (1911), **21,** pp. 669–688. (Reprinted in *The Collected Papers of Lord Rutherford*[34], vol. 2, 1963, pp. 238–254.)

36 Charles Ernest Weatherburn, *Elementary Vector Analysis with Applications to Geometry and Physics,* Bell, London, 1921 (revised edition 1956); *Advanced Vector Analysis with Applications to Mathematics and Physics,* Bell, London, 1924 (and 1957); *Differential Geometry of Three Dimensions,* Cambridge University Press, Cambridge, 1927; *An Introduction to Riemannian Geometry and the Tensor Calculus,* Cambridge University Press, Cambridge, 1938 (and 1942); *A First Course in Mathematical Statistics,* Cambridge University Press, 1946 (and 1947).

37 cf. Lancaster.[23]

Figure 4. L. J. Comrie (1932) (Royal Society).

in 1950 he was the undisputed world leader in scientific computing.[38] He did not invent new computing machinery (taking heed of Babbage's difficulties), but he devised ways to exploit commercially available calculating machinery for scientific computation. In 1926 he became Deputy Director of the Nautical Almanac Office at Greenwich, and in 1930 he became its Director. He invented the first computing laboratory, producing the Nautical Almanac by punched-card machinery designed for accounting work.

38 Garry John Tee, 'Two New Zealand mathematicians', In: John N. Crossley (ed.), *History of Mathematics: Proceedings of the First Australian Conference*, Department of Mathematics, Monash University, Clayton, Victoria, Australia, 1981, pp. 180–199. (L.J. Comrie and A.C. Aitken).

In 1930 he discovered that a National Accounting Machine could be creatively perverted to purposes never intended by its makers, and misused as a Babbage Difference Engine. Thereafter he applied Babbage's ideas, using such machines to print mathematical tables of quite unprecedented accuracy; and conversely he used them to detect an enormous number of errors in existing tables.[39] In 1938 he founded the Scientific Computing Service Ltd in London, as the first computing agency. Through that company he had immense influence on the development of scientific computing, and many scientists were inspired by him to create computing laboratories in Europe and the U.S.A. During World War II, Comrie's company performed very valuable computations for the British and American governments, including computing the locations of transmitters of radio beams guiding German bombers over Great Britain. In 1946 he reviewed the first book about the Harvard Mark I, one of the earliest computers, and his review[40] started the current fame of Charles Babbage. Indeed, Comrie's title 'Babbage's dream comes true' has become proverbial in computing.[41]

Comrie had ruined his health by overworking on military computing during World War II. In March 1950 he was belatedly elected as F.R.S., but on 11 December 1950 he died at the age of fifty-seven. He is much admired for his work on scientific computation, and his fame continues to grow.[42] Scientific Computing Service Ltd continues to operate in London, and proclaims proudly on its letterhead that it was 'founded in 1938 by Dr L. J. Comrie'. He is frequently referred to as the great *British* pioneer of computing.

Alexander Craig Aitken

Many mathematicians refer to Alexander Craig Aitken as a great Scottish mathematician; but he was born at Dunedin in 1895. On holiday at his grandparents' dairy farm on Otago Peninsula in 1904, he discovered the now-famous breeding colony of the Royal Albatross. His Calvinist grandparents punished him for telling such an unlikely tale—but later one of his uncles was appointed as a Ranger to protect the colony. After two years at the University of Otago he enlisted in the Army and was severely wounded at the Battle of the Somme. He completed his studies at the University of Otago, and graduated M.A. in 1919 (First Class Honours in Latin and French, Second Class Honours in Mathematics). He taught at Otago Boys' High School until 1923, when Professor R. J. T. Bell persuaded him to study at the University of Edinburgh, where he spent the rest of his life. E. T. Whittaker assigned him the problem of smoothing of data, which had practical importance in actuarial work. Aitken's thesis was of such merit that he was awarded the degree of D.Sc., rather than a Ph.D.

39 Leslie John Comrie, *Modern Babbage Machines,* The Office Machinery Users' Association, London, 1933.

40 Leslie John Comrie, 'Babbage's dream comes true', *Nature,* (1946 October 26), **158,** pp. 567–569.

41 Maurice V. Wilkes, 'How Babbage's dream came true', *Nature,* (1975 October 16), **257,** pp. 541–544.

42 Brian Randell (ed.), *The Origins of Digital Computers: Selected Papers* (3rd edn), Springer-Verlag, Berlin, 1982. (Randell's annotated Bibliography describes *c.* 850 publications, of which twenty-two are publications by Comrie—more than for any other author (pp. 450–452).)

Figure 5. Alexander Craig Aitken in 1927 (Victoria University, Wellington).

Aitken's mathematical work was devoted mainly to numerical analysis,[43] statistics and linear algebra. He founded the Oliver and Boyd series of textbooks and wrote the first two volumes[44] himself: both *Determinants and Matrices* and *Statistical Mathematics* are recognized as classic textbooks. In numerical analysis he devised many algorithms which exploited the capabilities of the calculating machines then available, and which have proved to be fundamental to much later work in numerical analysis. He gained wide fame as the greatest mental calculator for whom detailed and reliable records exist.[45]

43 Alexander Craig Aitken, 'On Bernoulli's numerical solution of algebraic equations', *Proc. Roy. Soc. Edinb;* (1925), **46,** pp. 289–305; 'On interpolation by iteration of proportional parts, without the use of differences', *Proc. Edinb. Math. Soc;* (1931), **3,** pp.56–76, and many other papers.

44 Alexander Craig Aitken, *Determinants and Matrices,* Oliver and Boyd, Edinburgh, 1939; and *Statistical Mathematics,* Oliver and Boyd, Edinburgh, 1939. (Both texts have been reprinted in many editions.)

45 Steven B. Smith, *The Great Mental Calculators,* Columbia University Press, New York, 1983, Ch. 31.

Aitken's experiences in World War I had shattered his body and overwhelmed him with horror. After forty-seven years he exorcised those ghosts which haunted him by publishing his memoir[46] *Gallipoli to the Somme: Recollections of a New Zealand Infantryman*, which was acclaimed as a classic account of death and life in the trenches. In recognition of his achievement in writing that memoir, the Royal Society of Literature elected him as a Fellow.

Several students from New Zealand studied with Aitken at Edinburgh. When Whittaker retired in 1946, Aitken was appointed as Professor of Mathematics at the University of Edinburgh, without any move on his part. Aitken retired in 1965, and in 1967 he died[47] at the age of seventy-two.

Keith Edward Bullen

Keith Edward Bullen (1906–1976) was born at Auckland, and he graduated from Auckland University College in 1930 as M.A. (First Class Honours in Mathematics) and B.Sc. (in Physics). He was a Lecturer in Mathematics at Auckland University College (1934–1940), then at the University of Melbourne. At the University of Sydney from 1945 until 1971 he was Professor, first of Mathematics and then of Applied Mathematics.[48] He became a major authority on seismology, analysing the internal structure of the Earth (and other planets) from seismic data.[49]

HISTORY OF MATHEMATICS

Some noteworthy research into the history of mathematics has been done in Australasia. The First Australian Conference on the History of Mathematics,[50] held at Monash University in 1980, was attended by seventy-two mathematicians, most of whom were actively conducting research into the History of Mathematics. Jock Hoe, born at Wanganui, became a Senior Lecturer in Mathematics at Victoria University of Wellington, and established his reputation as the leading researcher into ancient Chinese mathematics.[51] He is now lecturing in mathematics at Jiaotong University in Shanghai.[52] William Francis Hawkins graduted from the University of Auckland in 1982 (at the age of seventy-six) for his thesis[53] on John Napier. Hawkins shews[54] that John Napier, in addition to inventing

46 Alexander Craig Aitken, *Gallipoli to the Somme: Recollections of a New Zealand Infantryman*, Oxford University Press, Oxford, 1963.

47 cf. Tee.[38]

48 cf. Nield.[31]

49 cf. Lancaster.[23]

50 The *Proceedings* (ed. John N. Crossley[38]) publish thirteen papers from that conference.

51 John (*sic!* for Jock) Hoe, *Les systèmes d'équations polynômes dans le Sìyuán yùjiàn (1303)*, Mémoires de l'Institut des Hautes Ètudes Chinoises, (1977), tome **6**, Paris; and Jock Hoe, 'Zhu Shijie and his Jade Mirror of the Four Unknowns', In: Crossley,[38] pp. 103–134.

52 Garry John Tee, 'Mathematical science in New Zealand', *Gaṇita Bhāratī*, (1987), **9**, pp. 1–9.

53 William Francis Hawkins, *The Mathematical Work of John Napier (1550–1617)*, Ph.D. thesis, University of Auckland, 1982 (to be published by University Microfilms International). (Abstract published in *Bulletin of the Australian Mathematical Society*, (1982), **26**, pp. 455–468.)

54 William Francis Hawkins, 'The first calculating machine (John Napier, 1617)', *The New Zealand Mathematical Society Newsletter*, (December 1979), No. **16**, Supplement, pp. 1–23. (Reprint in *Annals of the History of Computing*, (1988), **10**, 37–51).

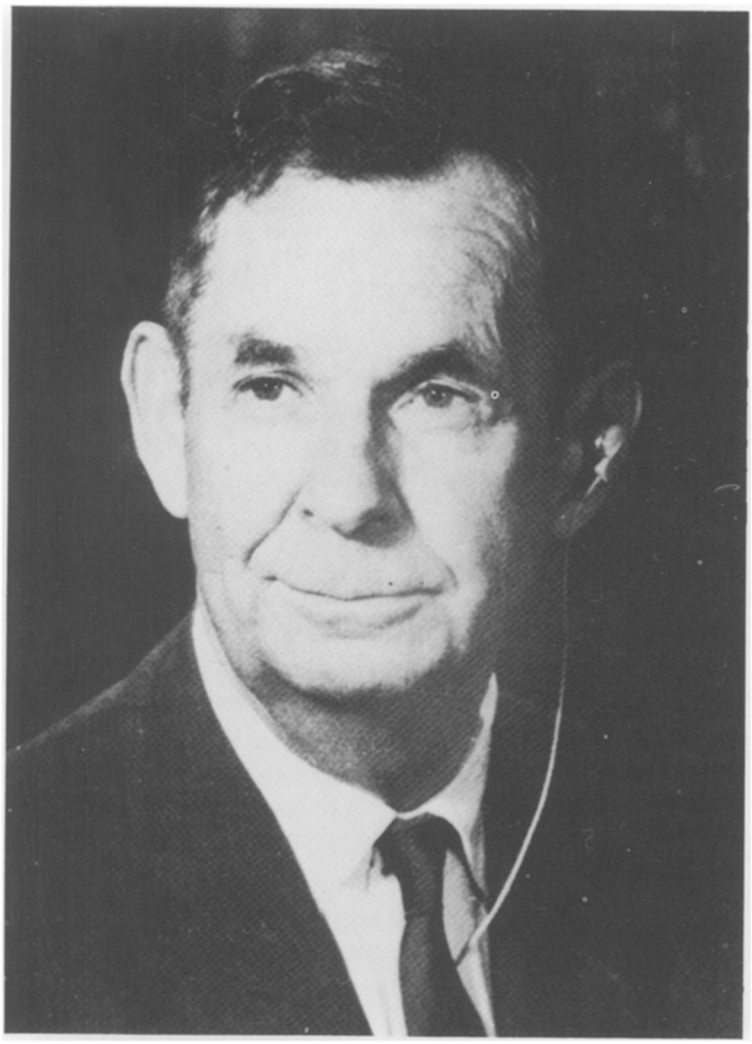


Figure 6. Keith Edward Bullen, FAA, FRS (1906–1976) (University of Sydney).

logarithms, also published in 1617 his invention of binary arithmetic (as far as square root extraction) and a complete specification for his multiplier the Promptuary, which has a strong claim to be regarded as the first calculating machine.

Quite remarkable quantities of historical mathematical material have been found in Australia and New Zealand.[55] The two elder sons of Charles Babbage (1791–1871), the inventor of the computer, emigrated to South Australia in 1849 and 1851. His eldest grandson moved in 1880 to a farm near Wanganui in New Zealand; and there are now very many relics of Charles Babbage in New Zealand and Australia, some with his descendants and some presented by them to museums and libraries. The Babbage family in

55 cf. Tee.[52]

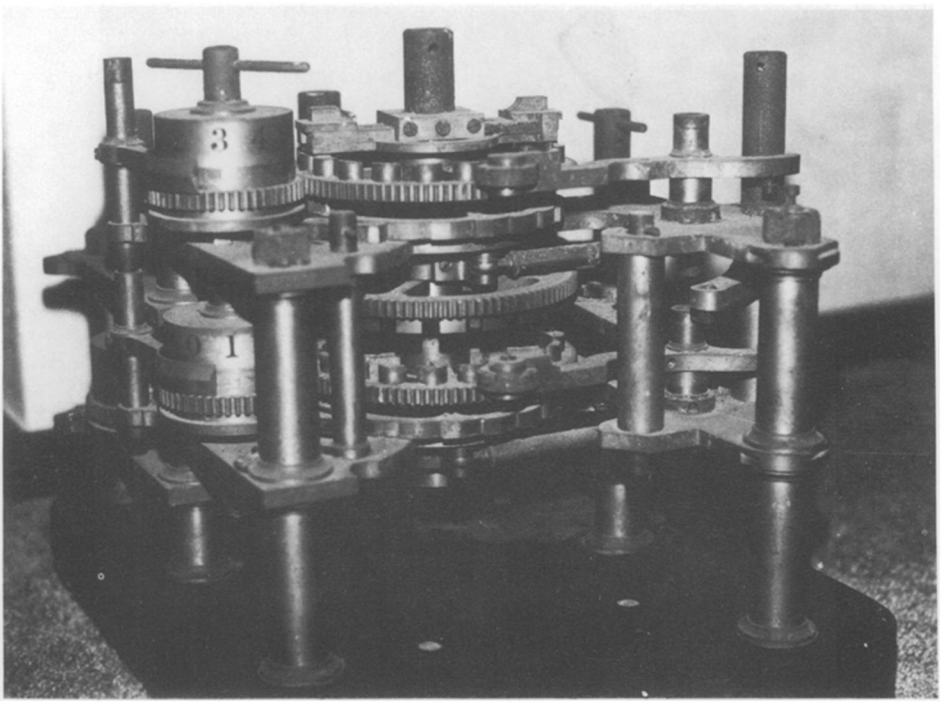


Figure 7. Charles Babbage's Difference Engine—the fragment in Auckland. One of the six fragments assembled by H. P. Babbage in 1879 (Mrs Jean Babbage).

Auckland have a fragment of Babbage's Difference Engine—one of six fragments assembled in 1879 by Babbage's youngest son, from parts made before 1834. They have Benjamin Herschel Babbage's superb drawing of the 1833 fragment of the Difference Engine (that fragment in the Science Museum in London), and the first gold medal of the Royal Astronomical Society, which was awarded to Babbage on 13 February 1824 for his invention of the Difference Engine.[56] They have many letters to Babbage, including two written by his young disciple Augusta Ada (1815–1852), the daughter of Byron; and the Babbage families in Sydney have many other relics. Other collections include letters written to his friends Sir George Grey (1812–1898, Governor and Premier of New Zealand), the astronomer John Herschel, the discoverer of dinosaurs Dr Gideon Algernon Mantell,[57] and letters from Henry Monson (gaoler in Dunedin).

William Rowan Hamilton (1805–1865) was appointed as Professor of Astronomy at Trinity College Dublin and Royal Astronomer of Ireland in 1827, when he was still an

56 Several publications date the award to 13 July 1823—but the medal is inscribed with the date 1824, and the presentation was made by Henry Thomas Colebrooke, who was elected as President of the Society in February 1824.

57 Garry John Tee, 'The heritage of Charles Babbage in Australasia', *Annals of the History of Computing,* (1983), **5**, pp. 45–59 (reprinted in *The World—Te Reo,* (August 1983), pp. 5–19); 'Charles Babbage (1791–1871) and his New Zealand connections', In: M.E. Hoare and L.G. Bell (eds),[32] pp. 81–90 (reprinted in *The New Zealand Mathematics Magazine,* (January 1986), **22**, pp. 112–123).

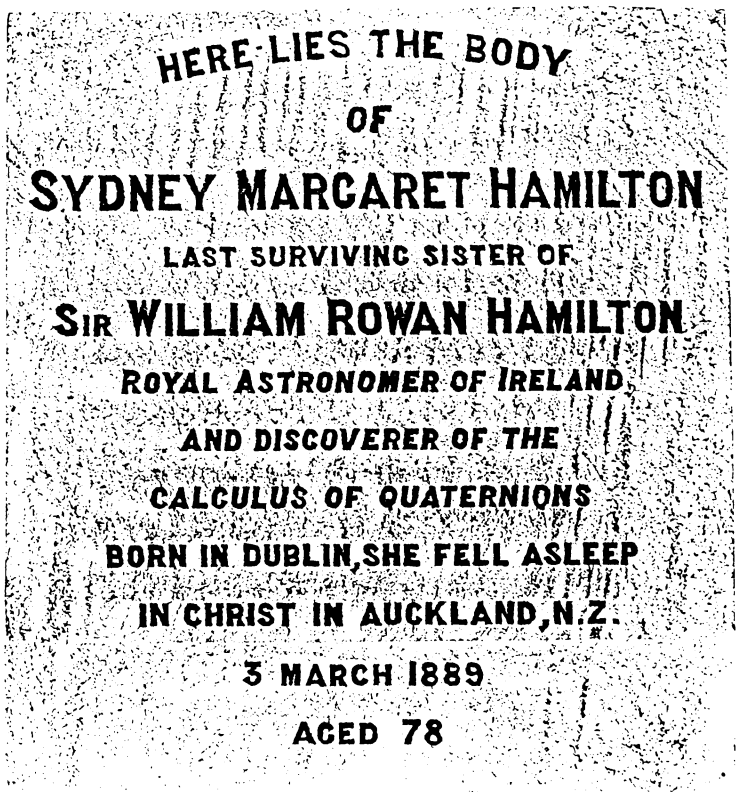


Figure 8. Tombstone in Rosebank Road cemetery, Auckland (From Segedin[59]).

undergraduate. He trained three of his many sisters to operate Dunsink Observatory for him, whilst he worked at mathematics—he became one of the outstanding mathematicians of the nineteenth century. His third sister Sydney Margaret Hamilton (1811–1889) did most of the observational work, administered the observatory and performed extensive computations to reduce the data to publishable form.. She lived in Nicaragua from 1863 to 1874, and in 1875 she sailed from Dublin to Auckland, to earn her living at the age of sixty-four as Matron of the Auckland Lunatic Asylum. To her surprise, New Zealand's elder statesman Sir George Grey was eager to meet her, as sister of the great mathematician.[58] In 1875 Grey, at the age of sixty-three, was studying P. G. Tait's *Treatise on Quaternions*. Grey attended her funeral in 1889, and his magnificent gifts to the Auckland Public Library include many papers which Sydney had presented to him. Those include some manuscripts of William Rowan Hamilton and copies of many of his

58 Thomas L. Hankins, *Sir William Rowan Hamilton*, The Johns Hopkins University Press, Baltimore and London, 1980, p. 321.

publications inscribed to Sydney.[59] Amongst those are bound editions of two of Hamilton's major works,[60] both of which are earlier than any editions listed in the standard biographies and bibliographies of Hamilton.

Mathematical Associations

The Australasian Association for the Advancement of Science (now the Australian and New Zealand Association for the Advancement of Science) was founded in 1888, in emulation of the B.A.A.S. For many decades the A.N.Z.A.A.S. Congresses provided the only occasion for mathematicians to get together in Australasia, with Sir Robert Ball (Lowndean Professor of Geometry at Oxford) contributing mathematical papers at two Congresses in Brisbane (1895 and 1909).[61] However, the A.N.Z.A.A.S. Congresses did not provide ideal occasions for mathematicians to communicate their ideas.[62]

Accordingly, the Australian Mathematical Society was founded[63] in August 1956 and the New Zealand Mathematical Society was founded in May 1974. Those national societies have organized a series of Australasian Mathematical Congresses, held at Canterbury University in 1978, the University of Sydney in 1981 and the University of New South Wales in 1985.

Some mathematicians have, in recent years, been elected as Fellows of the Royal Society of London, Fellows of the Royal Society of New Zealand or Fellows of the Australian Academy of Science. The eminent Hungarian mathematician Paul Erdös has made several visits to Australasia, and in 1985 he was elected to Corresponding Membership of the Australian Academy of Science.[64]

Kernels

Several other living Australians and New Zealanders are now eminent mathematicians. Of those, I shall discuss only Professor Roy Patrick Kerr, Head of the Department of

59 cf. Tee.[52] The tombstone on Sydney Margaret Hamilton's grave, in Rosebank Road cemetery in Auckland, tells more about her brother than about herself: cf. Marin G. Segedin, 'Sir William Rowan Hamilton', *The New Zealand Mathematics Magazine,* (1967–1968), **5,** pp. 128–131. Hamilton's biographer, Archdeacon Robert Perceval Graves, had arranged for that tombstone to be placed on Sydney's grave (letter from Graves to Sir George Grey, 14 July 1892, Grey Collection, Auckland Public Library, GL-26(2)).

60 *Theory of Conjugate Functions, or Algebraic Couples; with a Preliminary and Elementary Essay on Algebra as the Science of Pure Time,* printed by Philip Dixon Hardy, Dublin 1835; and *Researches Respecting Quaternions, First Series,* read 13 November, 1843, printed by M.H. Gill, Dublin, 1847.

61 Garry John Tee, 'Mathematics and ANZAAS', *The New Zealand Mathematical Society Newsletter,* (1986), No. **37,** p. 34.

62 'At an ANZAAS Meeting in Adelaide, Schwerdtfeger gave a talk on "The Pfaffian invariant of a skew-symmetric matrix". The audience consisted of his wife, his two honours students (Wall and Potts), Mrs. Marta Sved, and one unknown, a non-mathematical newspaper reporter, who was intrigued by the mystery of the title of the talk. As one can imagine, the subsequent newspaper article was strange-reading publicity for mathematics at Adelaide!' [Potts,[29] p. 28].

63 A.L. Blakers, 'The Australian Mathematical Society: foundation and early years', *The Australian Mathematical Society Gazette,* (1976), **3,** pp. 33–52 and 65–86.

64 Marta Sved, 'Paul Erdös—portrait of our new Academician', *The Australian Mathematical Society Gazette,* (1987), **14,** pp. 59–62.

Mathematics at the University of Canterbury. In July 1963 he published a note[65] in which he constructed an exact solution of Einstein's field equations, representing a black hole with rotation. Such rotating black holes are now known commonly as 'kernels', in honour of Professor Kerr.[66] Much effort has been devoted by astrophysicists to searching for kernels: in particular, there is growing evidence for a massive kernel at the centre of our galaxy.

The astrophysicist Subrahmanyan Chandrasekhar (awarded the Nobel Prize in Physics) has told[67] that 'in my entire scientific life, extending over forty-five years, the most shattering experience has been the realisation that an exact solution of Einstein's equations of general relativity, discovered by the New Zealand mathematician, Roy Kerr, provides the *absolutely exact representation* of untold numbers of massive black holes that populate the universe. This "shuddering before the beautiful", this incredible fact that a discovery motivated by a search after the beautiful in mathematics should find its exact replica in Nature, persuades me to say that beauty is that to which the human mind responds at its deepest and most profound'.

In November 1984, the President of the Royal Society of London awarded the Hughes Medal to Professor Roy Kerr, for his discovery of rotating black holes.

65 Roy Patrick Kerr, 'Gravitational field of a spinning mass as an example of algebraically special metrics', *Physical Review Letters,* (1963 September 1), **11**, pp. 237–238.

66 Charles Sheffield, 'Killing vector', In: *Vectors,* Ace Books, New York, 1979.

67 Subrahmanyan Chandrasekhar, *Shakespeare, Newton and Beethoven, or, Patterns of Creativity,* The Norma and Edward Ryerson Lecture at the University of Chicago for 1975.