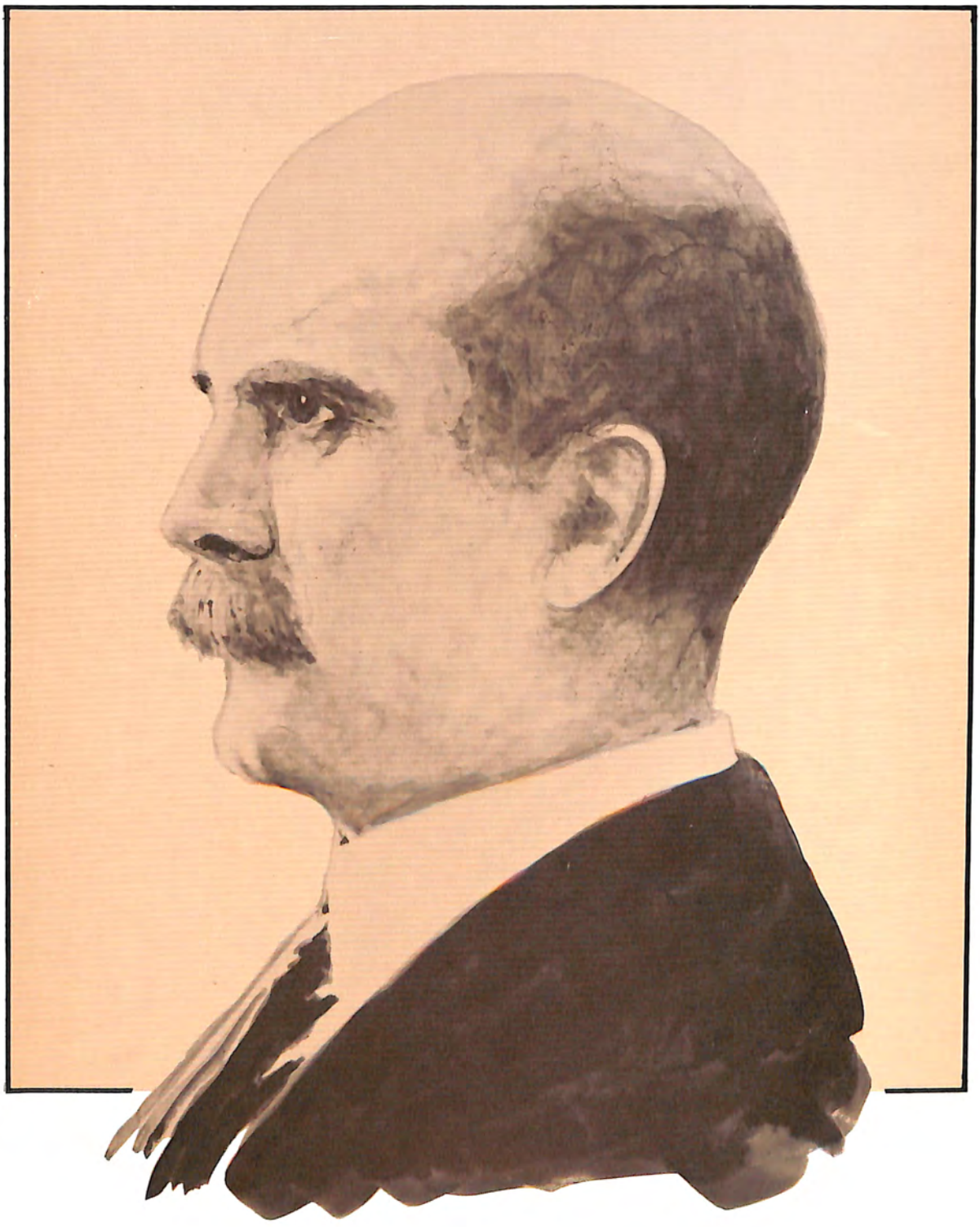
The Bragg Family
in Adelaide:

A Pictorial Celebration



By John Jenkin

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a pictorial celebration

John Jenkin

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Preface

This annotated collection of photographs is published to celebrate the arrival in Adelaide, exactly 100 years ago, of William Henry Bragg, the University of Adelaide's first Professor of Physics and second Professor of Mathematics. Bragg's predecessor, Horace Lamb, taught some Natural Philosophy but declined formal appointment in the discipline. Bragg's arrival may properly be regarded, I believe, as the formal foundation of physics at the University.

In addition to his teaching, Bragg became actively involved in almost every facet of the life of the University during the adolescent period of its growth, and he was also engaged in a very wide range of community activities beyond its walls. He gave unstintingly to his adopted homeland; he participated, encouraged and led. From 1904 through 1908 he conducted a research program whose fruits remain an enduring feature of science to the present day. Of all the scientists who have worked in Australia for an extended period, he is perhaps the most notable.

Equally, Adelaide was crucial to Bragg's own development as an individual, family man, public figure, teacher and research scientist. When he arrived in 1886 he was only 23 years old, newly graduated, inexperienced and unsophisticated. In Adelaide he grew and matured. Here he married Gwendoline Todd, and here their three children were born. Their elder son, William Lawrence Bragg, grew to manhood and received his early scientific education in Adelaide.

In 1909 Bragg and his family sailed for England to further their careers, and in 1915 he and his elder son were jointly awarded the Nobel Prize for Physics for work undertaken in England but founded in Australia. In future years, Sir William Bragg, OM, KBE, FRS was Cavendish Professor of Physics at Leeds, Quain Professor at the University of London, Director of the Royal Institution and President of the Royal Society. Sir Lawrence Bragg, CH, OBE, MC, FRS succeeded Ernest Rutherford as Langworthy Professor of Physics at Manchester and Cavendish Professor at Cambridge, and followed his father as Director of the Royal Institution. It was under Sir Lawrence's leadership that crystallography blossomed, and the structure of DNA was discovered, in the Cavendish Laboratory. In their turn, father and son occupied a special place in British science because of their ability to explain its complexities to fellow scientists, students and interested lay-people alike.

These photographs and their annotations illustrate the early portions of the Bragg story, and may perhaps not only entertain and inform but also illuminate a little of the history of science in Australia and provide one or two insights of contemporary value.

A few years ago, during scientific research at La Trobe University using the photoelectric effect to probe the electronic properties of materials, I was prompted to explore the historical development of the subject. My search led me to W.H. Bragg's experiments in Adelaide, and my own childhood and youth called me back. I am now engaged upon a detailed study of the Bragg years in this lovely city. As I pursued the subject, in Australia, America, the British Isles and elsewhere, I collected photographs whenever I could; not because I planned this book, but because they provided tangible stepping stones towards an understanding that written and printed words could not alone provide. Almost by accident I found I had a record that others, too, might enjoy; so was this book born.

Old photographs have attracted increasing interest over recent years and are now recognised as powerful tools in visualising the past. We have had the camera just long enough for its early glimpses to provide a window to the world now passed beyond experience. In addition, several photos I wished to include are faded beyond recovery; a collection such as this saves others from a similar, sad fate. I have also photographed written material, which is at present carefully stored but whose long-term preservation remains problematic.

'One picture is worth more than ten thousand words', the Chinese proverb says, but this collection certainly does not tell the whole story. Some important elements and much of the background have not found a place. At the back of the book I have given a brief bibliography of the more important works where further details may be found, but an adequately detailed account is not available.

Confusion has always surrounded W.H. and W.L. Bragg: their positions, their work and their names. W.H. was 'Will' to his wife, W.L. was 'Willie' or 'Bill' to family and friends; he used the name Lawrence only formally to distinguish himself from his father. I have adopted the neat and unambiguous procedure later adopted by the family of describing them as WHB and WLB.

A very large number of people have assisted me with my research, none of whom I can adequately thank here for their kindness and patience. In regard to this book, I am particularly grateful to those individuals and institutions who have generously allowed me to inspect and reproduce material from their treasured records; their names may be found in the notes. On a personal level I wish to acknowledge: the special support of my own family, Margaret and Ron Gibbs, Mrs Susan Woodburn (Adelaide University Archivist) and Mrs Irene McCabe (Royal Institution Archivist); the Australian Research Grants Scheme for financial assistance; staff in many areas of La Trobe University for their sympathetic help; and the University of Adelaide Foundation, which has financed the publication of this book and which is to receive the proceeds of its sale.

This volume is dedicated to WHB's grandchildren, as a brief record of their 'Australian' heritage and in appreciation of their warmth and friendly co-operation.

John Jenkin
Melbourne
January 1986

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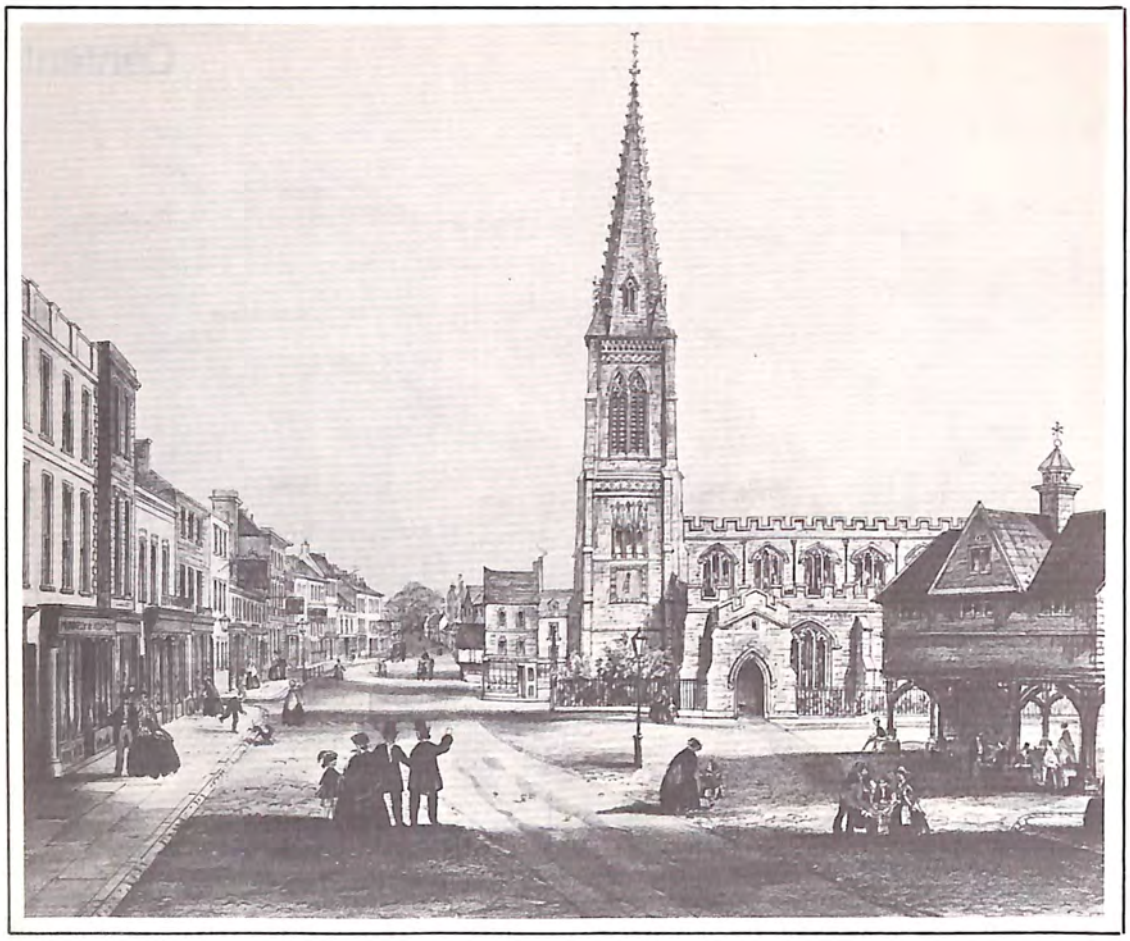


1. Market Harborough

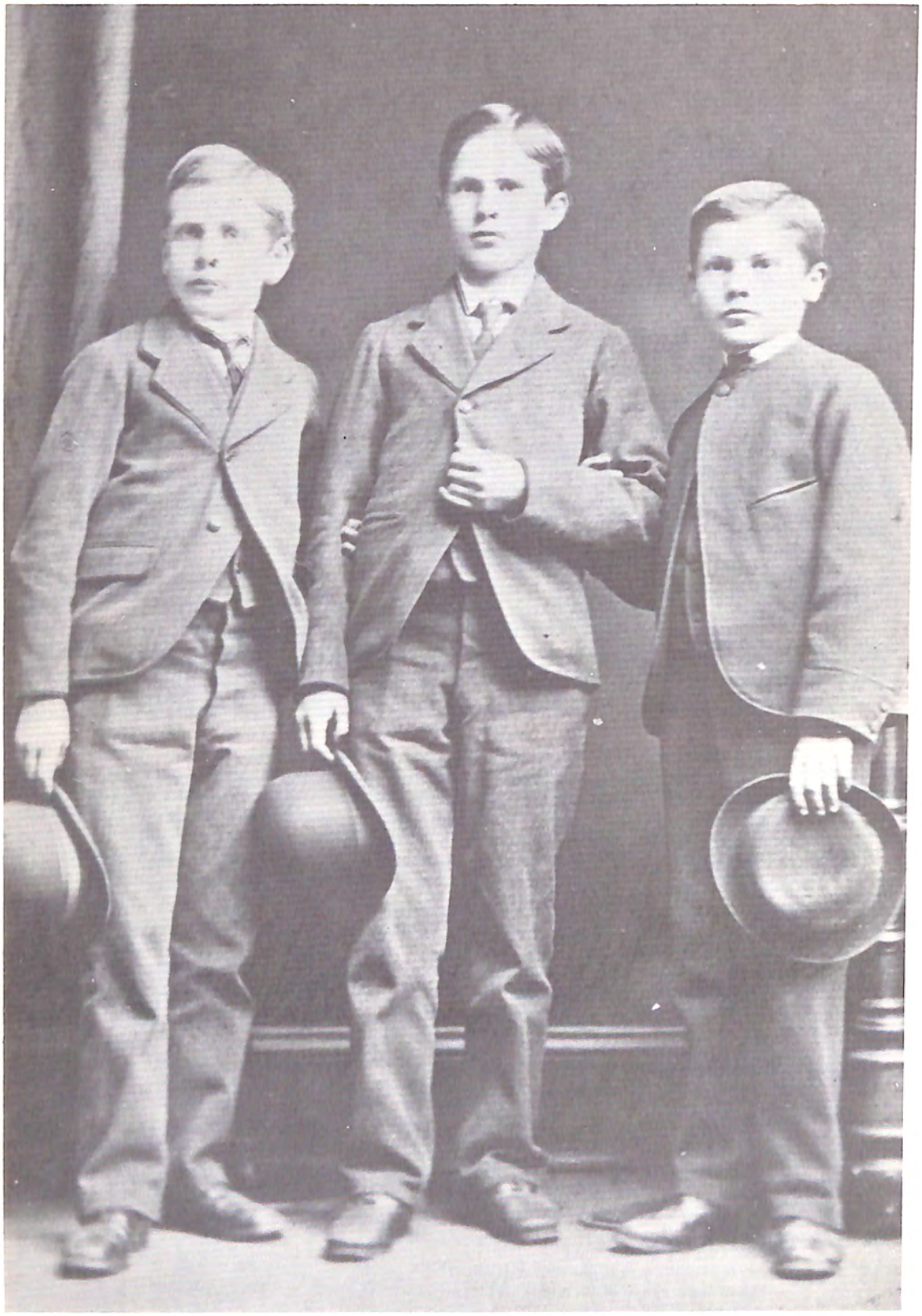
William Henry Bragg was born on 2 July 1862. His father, like his father and grandfather before him, had been a seaman, although some time before his marriage he bought a farm near Wigton in Cumberland (England) and retired from the sea. WHB's mother, née Mary Wood, was the local Vicar's daughter, and at least two of her brothers enjoyed a tertiary education. She was said to have a 'mathematical head', and taught WHB to read before he began school. Otherwise he did not remember his mother very well, for she died in 1869 when he was barely seven years old. Only a few scenes remained, which he lovingly recalled in his later autobiographical notes.

WHB was taken to live with his father's brother, Uncle William Bragg at Market Harborough in Leicestershire. Uncle William, a stern and domineering widower, owned the double shop on the corner of the Square and Adam and Eve Street. The photograph of Uncle William reveals the mellowed man of later years; the picture of the corner chemist shop is dated ca 1910. Uncle William was a chemist and druggist. His brother James looked after the adjacent grocery shop where WHB loved helping to weigh out pounds of sugar and rice, and his mother kept house in the rooms above, where WHB also lived.

Life was severe and quiet. WHB had some fun with his cousin Fanny, but otherwise there were no parties and no visits to or from other children. School offered some outlet. The old grammar school, founded in 1614 and later sadly neglected, was re-established by Uncle William and others in 1869, and the new master was an able teacher. The school building was a quaint structure raised on wooden pillars, providing a sheltered market-place beneath. It is shown in this photograph of ca 1860; it still stands next to the church in the centre of Market Harborough.

In 1873 WHB took the Junior Oxford Local Examinations at Leicester and was the youngest boy in England to get through, although he failed in Church History and Greek. An aptitude for subjects outside the old classical syllabus was already apparent.

There were just a few games of football, which WHB found a great delight. Otherwise, whatever satisfaction and contentment the young boy found in his life were discovered within himself. He was a solitary child.

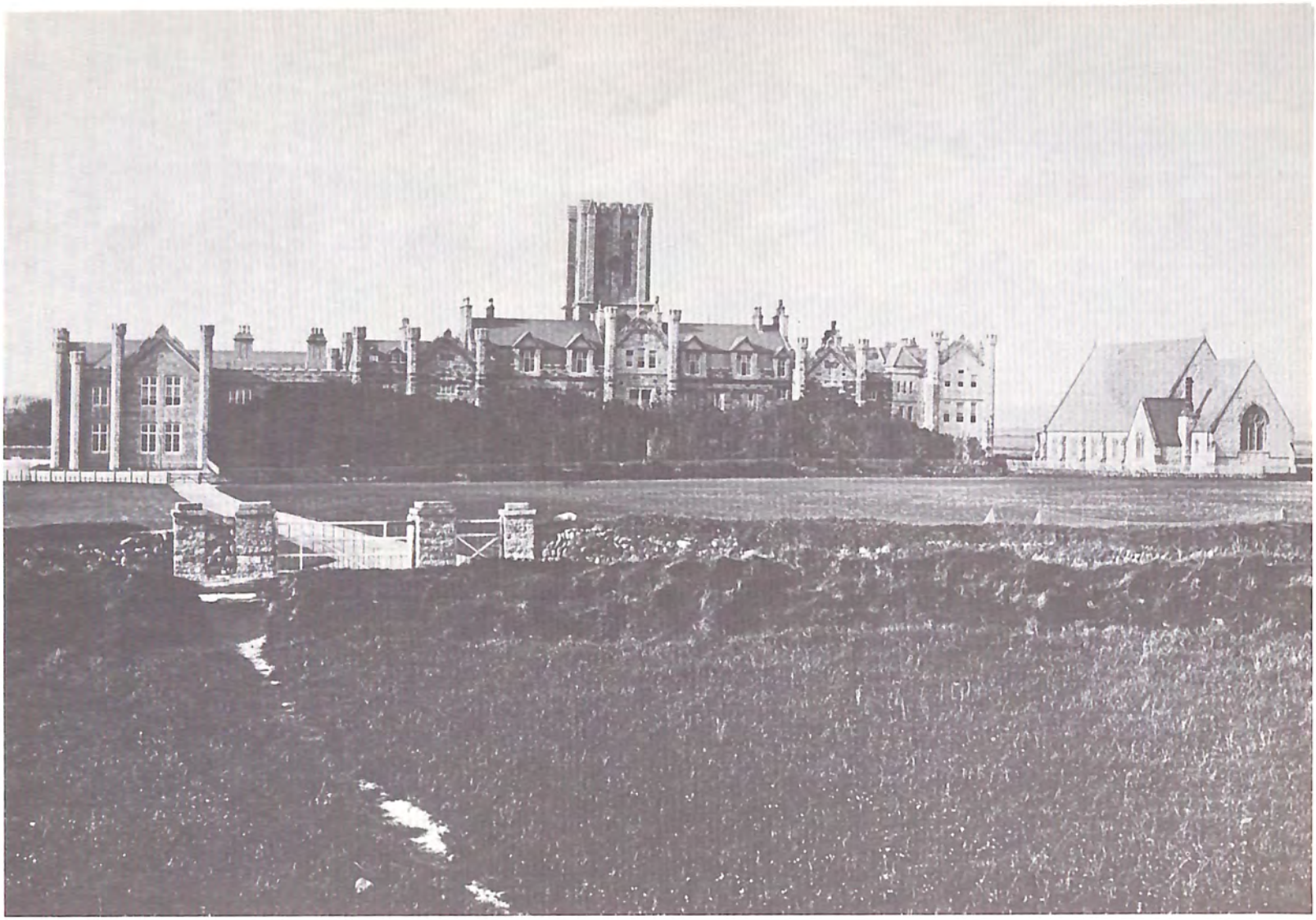


2. Family

In 1875 Robert John Bragg came to Market Harborough to demand his son, and to send him, not to Shrewsbury as Uncle William had planned, but to King William's College on the Isle of Man, where his brother-in-law was a master. Robert's three sons, William Henry, Robert John junior (Jack) and James Wood (Jimmy) Bragg, were re-united from time to time on holidays with their father. This photograph was taken on one such occasion at Carlisle in Cumberland in the late 1870s.

But WHB was not close to his father, a small and gentle man who is almost totally absent from WHB's autobiographical notes. Even his death in 1885, a few months before WHB sailed for Australia, is unrecorded.

WHB is in the centre of the photo, Jack on the left and Jimmy on the right. Jack showed even more promise as a mathematician than his elder brother. At the King William's College Prize Day in 1882 he was singled out for special mention for having obtained full marks in all the sixth-form mathematics papers, and that year he also won a scholarship to St John's College, Cambridge. His life was plagued by a constantly-recurring illness, however, and he died in January 1886 as WHB sailed for Australia. Jimmy won a scholarship to Emmanuel College, Cambridge, and graduated as a Senior Optime in the Mathematical Tripos of 1887. He took up farming in New Zealand and later worked in a successful export business between Australia and England.



3. King William's College

The grey limestone buildings of King William's College (photograph ca 1905) nestle in the gently rising ground facing the sloping sands and dark sea of Castletown Bay. The playing fields are lush and iridescent green. WHB attended from 1875 to 1881.

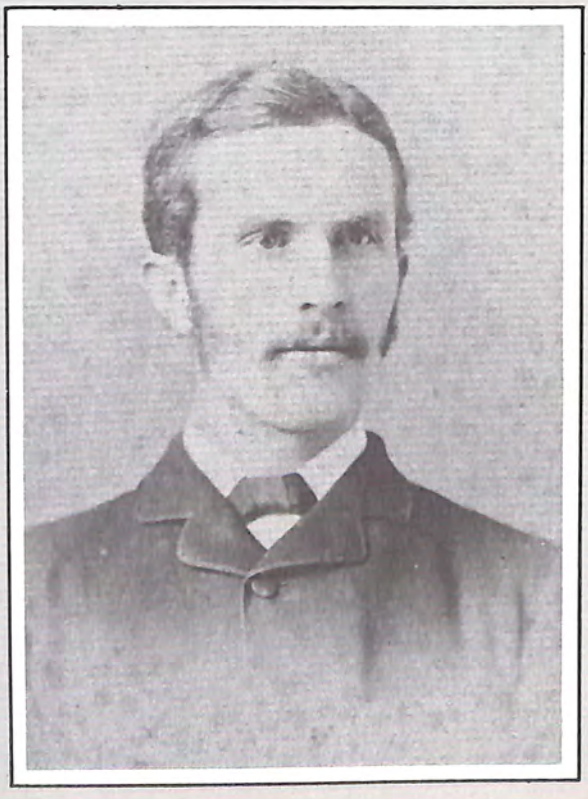
Early accounts of the College do not paint an attractive picture, although by the 1870s some improvements were being made. The physical conditions were extremely harsh, the social and psychological conditions no better. A 'religious storm' swept the school in Bragg's final year, to which he later devoted two emotion-filled pages of his brief autobiography; it clearly affected him profoundly. The difficulties were not resolved by the headmaster, nor later it seems by the established church. He survived and eventually prospered by adhering strictly to the rules of the College, by applying himself diligently to his studies, by enjoying to the full the recreational opportunities which the school increasingly provided, and by submerging almost totally the emotions he had already learnt to hide. He liked peace and was content to be alone.

His surviving school reports testify to WHB's exceptional mathematical ability and achievements. The mathematics master, Rev. D.D. Jenkins, was a good fellow, keen, and a good teacher. The ultimate goal for school and boys alike was a scholarship to one of the Oxbridge colleges, and, as a result of examinations held in the Easter week of 1880, WHB was awarded a Minor Scholarship to Trinity College, Cambridge.

Outside the classroom Bragg was a prefect in the years 1879 to 1881, and Head of the College in 1880-81. He was Secretary of the Chess Association, an active member of the Literary and Debating Society, a fair cricketer, wanting freedom and spirit in his play, and a tennis and fives player. The second photograph shows WHB (extreme left) as a member of the 1881 Sports Committee. But it was the annual theatricals with the Histrionics Society that he enjoyed most. He was Bessanio in the Merchant of Venice and Claudio in Much Ado About Nothing, and the school magazine was lyrical about his performance as Susan, the maid of all work, in the farce.

WHB returned to the College for a second sixth-form year in 1880-81, because of his youth, but his academic work stagnated. He was ready to move on.

MR. W. H. BRAGG
Trinity College, Third Wrangler



4. Trinity College, Cambridge

WHB went up to Cambridge in the long vacation of 1881 and was allocated rooms in Whewell Court. He was forced to repeat the Previous (entrance) Examination after failing Latin at his first attempt. His reserve held him back, and he did not join the Union or Boating Club, saying that he could not afford it.

When classes began WHB was accepted by Routh, who is remembered as the greatest of all the Cambridge Mathematical Tripos tutors. He won a Foundation Scholarship, and then had the right to join the Trinity Tennis Club without election and to wear the strawberry and cream blazer, which was a source of pride. The year 1884 brought examinations for Parts I and II of the Tripos, which encompassed not only basic mathematics but also such Newtonian subjects as statics, dynamics, optics, gravitation and astronomy. WHB was anxious and weary, but all this was forgotten when the results were announced: he was placed third in a strenuous and fiercely-competitive examination. He later remembered being lifted up into a new world, having a new confidence and feeling extraordinarily happy. The sketch shown here, drawn from this contemporary portrait photograph by Hills & Saunders of Cambridge, appeared in **The Graphic** of 12 July 1884, and was accompanied by similar drawings of the first and second Wranglers, the former being William Sheppard, who had been born in Sydney and educated in Brisbane.

During the autumn of 1884, WHB studied for Part III of the Tripos under the supervision of Richard Glazebrook, and after the award of First-Class honours in that examination he continued to work under Glazebrook's suggestions in the Cavendish Laboratory. Glazebrook's subjects were waves and sound, optics and the theory of light. Bragg was becoming a physicist as well as a mathematician.

Following Horace Lamb's resignation from the Elder Chair of Mathematics at the University of Adelaide, J.J. Thomson, Lamb and the Agent-General for South Australia in London were named the selection committee for the appointment of a successor, who was to carry the dual responsibility of Mathematics and Experimental Physics. Thomson was head of the Cavendish Laboratory, only a few years older than WHB and a fellow-member of Trinity College. The two men had much in common beside science, including interests in the card game whist and in sport of all kinds, particularly tennis, which they played regularly together. Thomson suggested to Bragg that he apply for the Adelaide post; it had never occurred to WHB that anyone so young and inexperienced might be eligible. He was 23 years old. The salary was £800 per annum.

The field of 23 candidates was a very strong one, but one by one they were eliminated. After an interview in London, WHB was selected. That evening at Market Harborough, in the dark of nightfall, Uncle William broke down and wept.


H.L.VOSZ

5. Adelaide and Dr Alfred Lendon

Preparations for his departure proceeded apace, and on 14 January 1886 WHB sailed from Tilbury on the RMS **Rome**, thrilled by the prospects of the great adventure that lay ahead. He was fascinated by everything he saw as the ship sailed through the Mediterranean Sea and the Suez Canal into the Indian Ocean, and he wrote long letters home recording shipboard life and his impressions of the port-cities he visited. WHB later claimed that he read a physics book on the voyage to acquaint himself with the new discipline he would be required to teach, but his old Trinity College and Adelaide colleague Sydney Talbot Smith saw this as a typically-modest exaggeration of Bragg's own perceived shortcomings.

WHB was landed by tender at Glenelg on 27 February 1886, where only 50 years before the first settlers had come ashore. He slept that night at the Pier Hotel, and next day Dr Alfred Lendon (photograph ca 1890) called for WHB and took him on his rounds in a horse-drawn Victoria. That first day was one of the most important of WHB's 23 years in Australia, the people he met symbolic of his new life.

First there was a visit to the home of the Hon. Samuel Way, the Chief Justice of South Australia and Chancellor of the University, where the two young men were refreshed with green figs. 'Montefiore' in North Adelaide was one of the city's best known houses; it had a magnificent garden and large hothouses and Way used it extensively for entertaining. It contained Way's outstanding personal library and a superb art collection. Way was also a staunch Methodist. He represented probably better than anyone else in the colony the academic and social milieu into which WHB was soon to be accepted.

Second there was Lendon himself, who became a close personal friend of WHB. Lendon lived in a house on North Terrace directly opposite the University, and he soon invited WHB to board with him there. This Bragg did for the next three years, until his marriage. It is shown in this photograph (ca 1911), with Scots Church prominent on the Pultney Street corner. Lendon later became one of Adelaide's leading medical identities and held numerous medical and academic posts. He would be best man at WHB's wedding in 1889 and the family's doctor thereafter, and WHB would be godfather to Lendon's elder son.

6. Todd family

Finally, on that first day, Lendon and Bragg trotted down Montefiore Hill, crossed the Morphett Street Bridge over the River Torrens and arrived at the neat clump of Adelaide Observatory buildings in the west parklands. They had been invited for supper at the ample two-storey home of Charles Todd, Government Astronomer, Postmaster-General and Superintendent of Telegraphs.

Charles Todd (this photograph is undated) was famous throughout the country as the architect and builder of the trans-continental Overland Telegraph Line, which linked Australia, through Darwin, with Europe. He was genial and friendly and was possessed of an over-bountiful fund of humour, which revelled in puns, spoonerisms and riddles. He was an accomplished astronomer and physical scientist, one of the very few in the colony. WHB would find pleasure in his company and conversation, and Todd delighted in the opportunities provided by a kindred spirit close at hand.

Alice Todd, his wife, immediately impressed WHB with her calm and open conversation. She too is remembered in the naming of Alice Springs. Their two sons, Charles Edward and Hedley Lawrence, were beginning medical and business careers. In later years Charlie would consult WHB on the medical use of the new X-rays, and Hedley would seek his advice on the electrification of the city.

There were also four daughters: Lizzie, Maude, Gwen (16 years old) and Lorna (8). Their inconsequential chatter delighted WHB most. It was a revelation to a young man taught to weigh every word he uttered and, until that day, almost totally deprived of female companionship and affection. They nicknamed him 'the Fressor', and he blossomed under the cheerful social atmosphere they created.

In the months ahead WHB became particularly fond of Gwendoline, and they enjoyed many happy outings together. This photograph of her was probably taken the previous year, 1885. She taught him to sketch and to paint, and introduced him to Adelaide's young society. In future years their elder son, William Lawrence, would find a particularly close friend and confidante in his Aunt Lorna.

Slate textbooks

Acoustics 1.

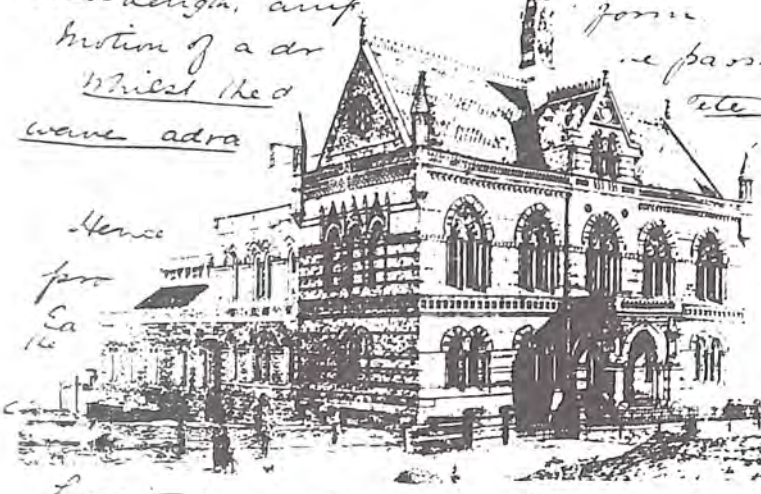
There are 3 parts to study of sound of which we take 1st 2. 1st cause of sound 2 propagation 3rd reception 4 the ear. The 3rd is physiological.

So far as we are concerned, sound is a sensation. But mechanical in fact we always connect sound with motion. some agency must produce the sensation. Explosions, beating of a drum ~~dup~~ fingerglass cannot take place without disturbing the air. So air will carry sounds. Yet air is not necessary, for sounds will travel along pipes and rods. (Waterpipes, iron railings, telephone) But something is req as the bell in receiver experiment shows. Also bell & flask There is no transference of matter in sound (for a sound made in one room can be heard in another)

Can a disturbance be propagated without a transference of matter?

By wave motion. Tube of sand. Marbles in a trough The sea. Full wave consists of crest and hollow.

Actual motion of water is not the same as actual motion of wave. Cork a ter. 1st Diagram ing. jour e passes il. Rows of men, some Wave-Length, amp motion of a dr Whilst the d wave adva



ete vibration, the

Hence versely for Sa e-length the ahead of motion that

Longitudinal vibration: Tyndall's row of boys, Rugby field gun. Diagram Condensation and rarefaction.

Here too whilst a particle makes one complete vibration, the wave advances through one wave-length.

7. Adelaide University

When WHB entered the University he found an institution still struggling to establish itself. Geoffrey Blainey's remarks about the University of Melbourne also apply to Adelaide at this time: 'the basic weakness of the university was . . . a shortage of students who wanted to study and who could afford to study. The university capped the pyramid of education, but the base of that pyramid was weak'.

This early photograph of the University is undated; the library occupied the full width of the upper floor at the front of the building, and WHB's research was later conducted in a basement room at the rear (left).

WHB was responsible for all the pure and applied mathematics and all the physics and practical physics teaching, and for much of the secondary-school public examining in these subjects as well. In 1886 he set and marked 29 major examination papers. In 1887 he recorded the details of his weekly teaching commitments as 18 hours per week for the full teaching year. In addition, there were six hours of evening teaching each week to men and women who were employed during the day and who sought to further their education at night. Adelaide had but one government secondary school at this time, the Advanced School for Girls; secondary education was otherwise the sole preserve of fee-paying private and denominational schools.

Bragg did not have a single academic colleague to assist with the work, and only one part-time laboratory assistant. During 1886 he wrote to the University Council to ask for lengths of rubber tubing for the laboratory, desks or tables upon which the students could take notes, and books for the library. At the end of the year he had returned only six of the 47 library books he had borrowed; preparation and teaching filled his days.

WHB also gave lectures to second-year music students on acoustics, a course in which he took a particular delight. He filled his lectures with analogies and demonstrations. Many years later, during the first World War, WHB was actively involved in the acoustic detection of submarines and WLB in the sound-ranging location of enemy guns in France. Reproduced here is the first page of WHB's 1886 university acoustics lecture notes, with later additions pencilled in.

In mid-1887 WHB wrote to the University Council seeking a qualified assistant. His request was granted only after he offered to provide one-third of the salary (£100) himself for the first two years. He appointed Robert Chapman after an interview in Melbourne, and thereby brought this dedicated servant to the University. Furthermore, when WHB then joined Gwen and Charlie Todd in Tasmania for a holiday and proposed to Gwen, she accepted. It had been quite a year!

TORRENS PARK THEATRE.

OCTOBER 21st, 1886.

"The best actors in the world, either for tragedy, comedy, history, pastoral, pastoral-comical, historical-pastoral, [tragical-historical, tragical-comical-historical-pastoral,] scene individable, or poem unlimited: Seneca cannot be too heavy, nor Plautus too light."—HAMLET—Act II., sc. I.

THE JACOBITE,

A Comic Drama in Two Acts, by J. R. PLANCHÉ.

CHARACTERS.

SIR RICHARD WROUGHTON, BART. ... ... PROFESSOR BRAGG
MAJOR MURRAY ... ... MR. MARRYAT
JOHN DUCK ... ... MR. A. ERNEST AYERS
LADY SOMERFORD ... ...MISS PEACOCK
WIDOW POTTLE (Landlady of the "Crooked Billet") MISS NORA HERRING
PATTY POTTLE (her daughter) ... ... MISS MARRYAT

SCENE I.—PARLOUR OF THE "CROOKED BILLET."
SCENE II.—AN APARTMENT IN AN OLD ENGLISH MANSION.

INTERVAL OF HALF-AN-HOUR.

To be followed by

GOOD FOR NOTHING,

A Comedietta in One Act, by JOHN B. BUCKSTONE.

CHARACTERS.

TOM DIBBLES (a Gardener) ... ... MR. FREDERIC AYERS
HARRY COLLIER (a Railway Fireman) ... ... MR. A. ERNEST AYERS
CHARLEY (a Carpenter) ... ... MR. FREDERIC BRAUND
YOUNG MR. SIMPSON ... ... MR. MARRYAT
NAN ... ... MISS BARR SMITH

SCENE.—A ROOM IN A COTTAGE AT WINDSOR.

Prompter—MR. C. H. T. HART.

8. Barr Smith Theatre

In October of his first year in Adelaide, WHB took the male lead in a comic drama in two acts entitled 'The Jacobite'. It was presented in the Torrens Park Theatre, a magnificently-plastered and tastefully-decorated auditorium built by Robert and Joanna Barr Smith at their massive home at Mitcham in the Adelaide foothills. With much of its interior decoration arranged by correspondence with a London architect, the theatre had a fully equipped stage, gas lighting, antique mirrors, oval windows and a glass-roofed conservatory, and seated 200 people. It has been restored to its former glory in recent years by Scotch College, which now occupies the property.

Robert Barr Smith emigrated to South Australia from Scotland in 1855, and he soon developed extensive and varied business interests, including his own pastoral holdings and the pioneering pastoral developments of Elder Smith and Co. His philanthropy became legendary, but he shrank from publicity of any kind. The University of Adelaide was not the least of his beneficiaries; he gave to general funds, specific projects and particularly the library.

Mr and Mrs Barr Smith were lavish and charming hosts, and the theatre, built partly to indulge the family's own interest in theatricals, became the venue for countless entertainments. These functions were synonymous with generosity, charm and surprise. WHB's participation in at least one is a reminder of his love of theatricals at King William's College and an indication of his immediate acceptance into the highest level of Adelaide society.

It was also a crucial pointer to WHB's future rise to scientific eminence, for seventeen years later Barr Smith would provide the money with which WHB bought his first sample of radium and thereby began his extraordinary research career. Later, in 1906, Barr Smith gave still further funds for the purchase of a machine for liquefying gases.

9. Picnics

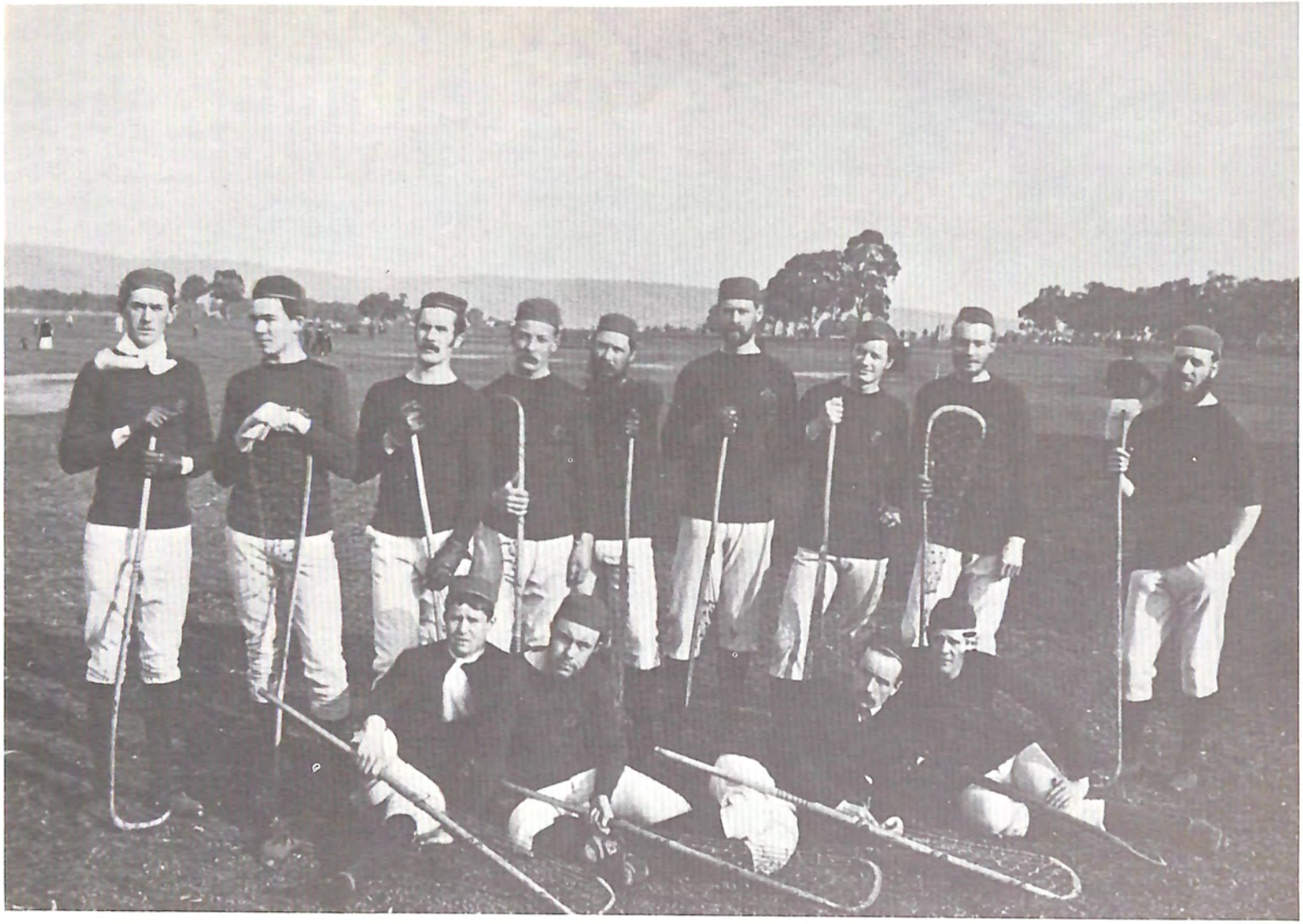
Picnics with family, friends and work-mates were a very prominent feature of life in Adelaide in earlier times. The picnic was an established English institution: a countryside escape from the industrial cities or a railway journey to a seaside resort. The colonists rapidly adapted the custom to their new surroundings.

The Adelaide beaches were very popular during the summer, but they were also crowded, raucous and broiling. By contrast, the cool, green gullies of the Mt Lofty Ranges offered seclusion and relief from the heat and openness of the Adelaide plain. The picturesque Adelaide hills became increasingly popular with family and social groups, and later for company picnics at Christmas-time and annual Sunday School outings. Each member of the group brought food and drink, to be enjoyed by everyone in common. A varied and abundant feast could be provided, and at a relatively small cost.

This picnic photograph, found amongst Bragg family photos in England, is of some interest despite the worn condition of the flimsy original. The young and smiling professor of mathematics and physics may be clearly identified by comparison with the studio protrait of 1888. Tables and chairs have been brought for the occasion, together with cutlery, crockery, glasses and a well-laundered table cloth. The formality of dress is noticeable, as too is the large hamper in the foreground, which has been packed with food.

Comparison with photographs held by the University of Adelaide suggests that some of the men in the photograph may perhaps be identified as University staff: (L to R) Edward Stirling (Physiology), Archibald Watson (Anatomy), Bragg, . . ., Edward Boulger (English and Philosophy, standing right) and William Gardner (Surgery, extreme right). The card held by the woman on the right is also intriguing, for it is a hastily-prepared menu for a sumptuous meal, written in an amusing mixture of French and English:

Montacute 9/11/87	[In the Adelaide hills, 9 November 1887]
MENU	
Pommes De Terre	[Potatoes
Saddle Du Mouton	Saddle of mutton
Salade Au Printemps	Spring salad
Jambon Au Sol[I]iciteur	Solicitor's ham
Canards Et Poulets	Ducks and chickens
Pie Au Pigeon Aux Rognons	Pigeon and kidney pie
Pate Du Bif[Teck]	Beefsteak pie
Glace . . .	Iced . . .]



10. Sport

At School WHB had taken great delight in a little football and had played first-XI cricket, albeit with little success. He was a capable sportsman, and found enjoyment in the less fiercely competitive sports such as fives, lacrosse and tennis.

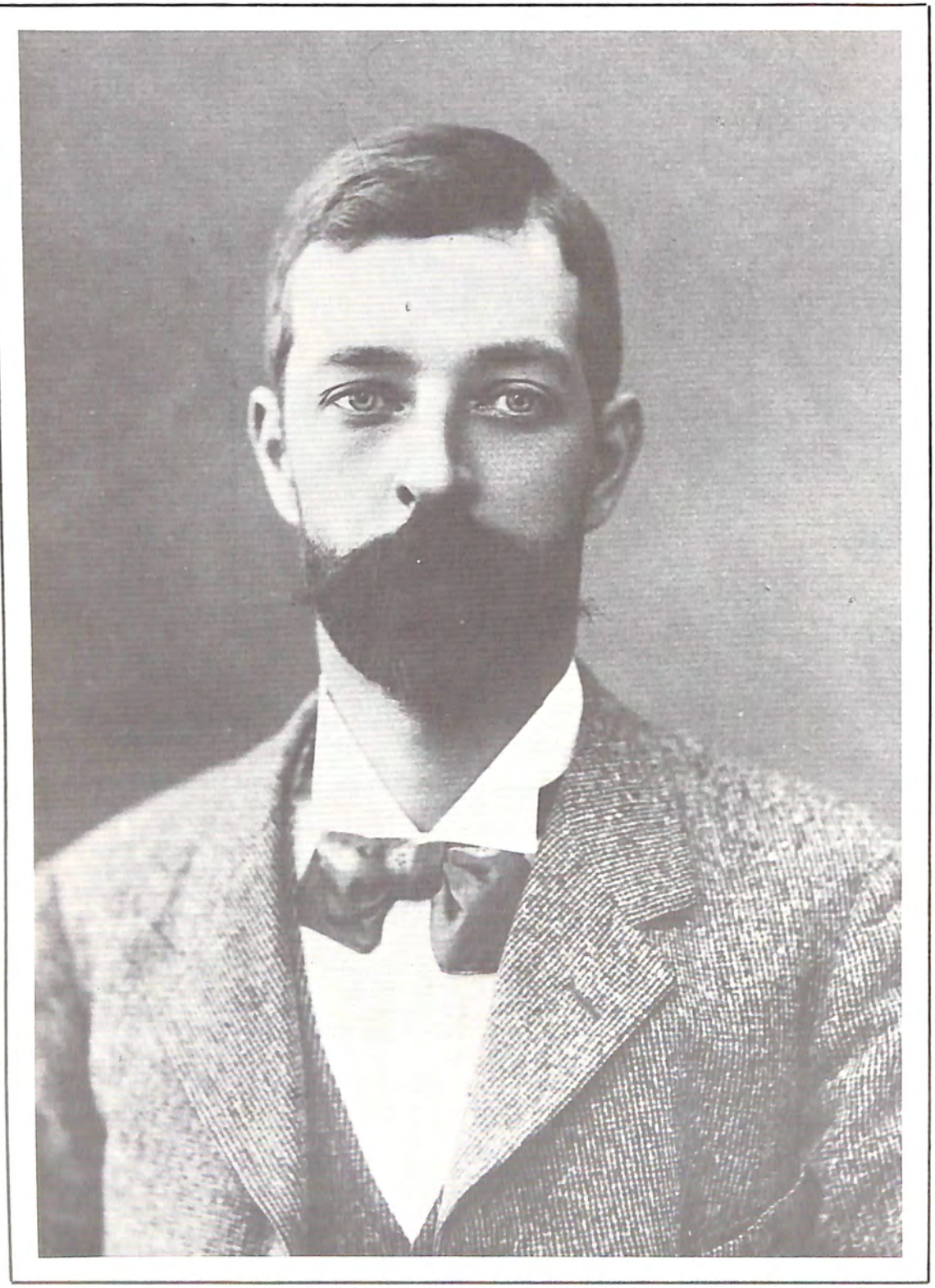
Lacrosse was introduced into South Australia in 1885, when the only two teams, Adelaide and Noarlunga, played each other twice. The following winter they played three games, and WHB rapidly established himself as the finest all-round player in the colony. This photograph of the members of the Adelaide Lacrosse Club team in their navy blue uniforms was taken on their home ground, the Old Adelaide (Victoria Park) Racecourse opposite the Grand Stand, in 1886. Its members are:
Rear (L to R): Frank Giles, R. Evans, W.H. Bragg, Alf Wilinson, S.H. Goode, S.A. Davenport, Frank Goode, Lloyd Prince, L.H. Wilkinson.
Front (L to R): William Boundey, A.H. Roberts, S. Talbot Smith, G. Codd.

Commentators saw the need for additional teams, and in the summer of 1886-87 WHB organised the establishment of a North Adelaide club, whose captain and guiding spirit he became. During the winter of 1887 the South Melbourne Club visited Adelaide, and WHB was selected in a combined South Australian team which inflicted the visitors' only defeat on a boggy Adelaide Oval.

In the 1888 season WHB declined to be captain and played less frequently; newspaper criticism of his inconsistency could not reduce his commitments elsewhere, which left little time for practice and games. In 1889 WHB helped form a University team, and in the 1890 season they won the first of several subsequent premierships. By then WHB had ceased to play, but lacrosse had become an established winter recreation.

In the summer WHB enjoyed 'social occasions punctuated by a game of tennis' on the University court and elsewhere; but in 1889-90 he was persuaded to play for the North Adelaide team in their major competitive matches, most often as a reliable doubles partner for the brilliant but erratic Baker.

With the completion of a second court, the University team joined the Lawn Tennis Association for the 1890-91 season and lost the premiership match by only three games. Allegiance and affection, rather than any burning desire to play regularly in top competition, took WHB to the University club. He played only when asked to do so, either against particularly strong opposition or during the long vacation when student players were unavailable, for by then WHB had new family commitments in addition to those at the University and elsewhere.



11. Arthur Rogers

Arthur Lionel Rogers was born in about 1860 in Devonshire, England, the son of a doctor. He attended Berkhamsted Public School, but he did not do well academically, and illness and physical disability hampered participation in other school activities. He found achievement and satisfaction in skilful and dexterous manual work. He learnt to paint and draw, and, with the Siemens company, learnt to work in metal, wood and glass. In about 1880 Rogers migrated to South Australia in the hope that the warm, dry climate would improve his health. He was bothered by severe migraine headaches, however, and walked only with difficulty and the aid of sticks for the remainder of his life.

In Adelaide Rogers joined Edwin Sawtell's optical and watchmaking business at Port Adelaide, and later in Rundle Street and North Terrace, Adelaide. Sawtell's manufactured, repaired and were agents for numerous items of equipment (nautical, electrical, photographic and surveying), as well as watches, spectacles, charts and books. They had a comprehensive workshop, and Arthur Rogers quickly rose to be its foreman instrument-maker. It may have been here, too, as we are told, that WHB apprenticed himself to a firm of instrument makers in the town, learned to work a lathe and made the apparatus for his classes.

On 19 March 1889 WHB wrote to Rogers awarding him the place in the Physical Laboratory that the University Council had approved. It was Bragg's second inspired appointment. Rogers constructed teaching and laboratory apparatus, made X-ray tubes for the early experiments in Adelaide, built radio equipment for the first successful radio transmissions in Australia, and crafted all the apparatus for WHB's alpha-particle and gamma-ray research experiments. In addition, he assisted at public lectures, built a little camera for Bobbie Bragg, helped medical practitioners with X-ray photography and resharpening their scalpels, disagreed strongly with Madsen and trained a series of apprentices.

This photograph of Rogers was taken in Ballarat at the time of his engagement, Christmas 1894, to Anita ('Tish') Sheeran.

Arthur Rogers could be a temperamental and difficult man, and his health was often poor. WHB was sympathetic and understanding, and Rogers responded with warmth, loyalty and superb workmanship. When the Braggs left Adelaide Rogers was disconsolate. He disliked WHB's successor and recorded satisfyingly in his diary for Wednesday, 19 May 1909: 'Kerr Grant blown up'.


ST LUKE'S CHURCH

12. Marriage

William Bragg and Gwendoline Todd became close friends soon after WHB arrived in Adelaide. He sent her flowers when she had whooping cough, and then a pair of gloves for a birthday. He corrected her spelling and encouraged her to read English novelists; she introduced him to the enjoyment and relaxation of social intercourse. They became engaged in January 1888, and Gwen received friendly letters of introduction and congratulation from WHB's family in England.

The progress of their relationship was not always smooth, however. As it developed, WHB became increasingly concerned at his inability to comprehend the swings of his emotions: sometimes he was elated, at other times depressed and melancholy. The year 1888 was particularly difficult. Gwen spent February/March at Pt Elliot and much of November at Pt Victor, in an attempt to improve her health, and WHB went to the August/September meeting of the Australasian Association for the Advancement of Science in Sydney. During these periods WHB missed her very greatly. His work load was very large, he was agonising over a Univesity Commemoration address and the doubts that welled up in his mind grew unchecked. He wrote to his fiancée daily, pouring out to her his troubled heart. She was concerned; but, with a maturity beyond her 18 years, she comforted, scolded, encouraged and calmed 'my dearest Will' . . . 'don't let us spoil our happy contented time by wondering whether it should not be brighter' . . 'I really must write a bit to you because you are such an awful old **stoopid**' . . . 'you musn't be always trying to love me very hard', she wrote.

WHB was firmly Church of England but had formed no religious affiliations in Adelaide; the Todds were Congregationalists. On 1 June 1889, Will and Gwen were married by the University Vice-Chancellor, Canon George Farr, at his parish church, St Luke's, in Whitmore Square, Adelaide. They honeymooned at Gumeracha, in the Adelaide hills.

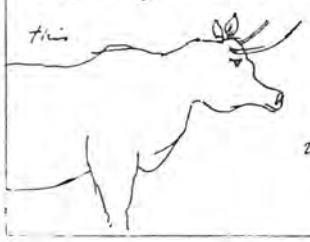
The well-known Adelaide silversmith, Henry Steiner, returned to Germany earlier the same year, but retained his North Adelaide home. Professor and Mrs Bragg rented the two-storey terrace house on the corner of Lefevre Terrace and Tynte Street, and grew to love its views over the parklands to the distant hills. Here their two sons were born: William Lawrence on 31 March 1890 and Robert Charles on 25 November 1892. WLB remembered happy times with Eric Gill, 'my great crony' and the son of H.P. Gill, Master of the School of Design and honorary Curator of the Art Gallery. Gwen had been one of his pupils, and WHB consulted him from time to time regarding artistic matters at the University.

The photographs of St. Luke's Church and the Lefevre Terrace house are modern.

and then Grandfather sucked his pipe & read the paper

And now Daddy is writing to Sonny. Soon he will have to go home in the

Daddy went to the exhibition yesterday and he saw some of mummy's pictures there & one of daddy's & then he went to see the pictures that were not good and he found me with a cow like this

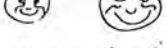


Don't you think this painter could not paint cows?

2

This is Dilly & Naomi crying & kicking & tearing full because you did not come home !!!

And this is what they will be like on Saturday



You can choose which you like for Dilly & which for Naomi.

and there's Granny wiping a hankerchief and smiling.

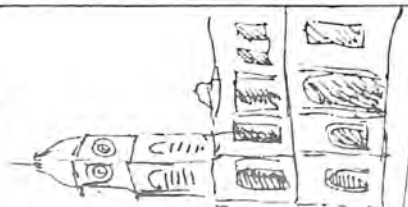
Good bye dear little boys!

From

Daddy.

3

Wednesday



Dear little boys

Where do you think I have been today? Do this :-

And there was a grand party & we had a little tea & then we had a little ride in the motor-car

hospital & saw

And there was

tasting pudding

and

and then home to tea

1

13. Little boys

Following family tradition, the Braggs and Todds enjoyed a seaside holiday each year. In the summer, Gwendoline and the two boys usually went for an extended period, while WHB would join them after examinations were marked and end-of-year ceremonies concluded. WHB reacted testily to letters from the Registrar which interrupted this precious holiday time, and he was usually absent from unscheduled University Council meetings in January.

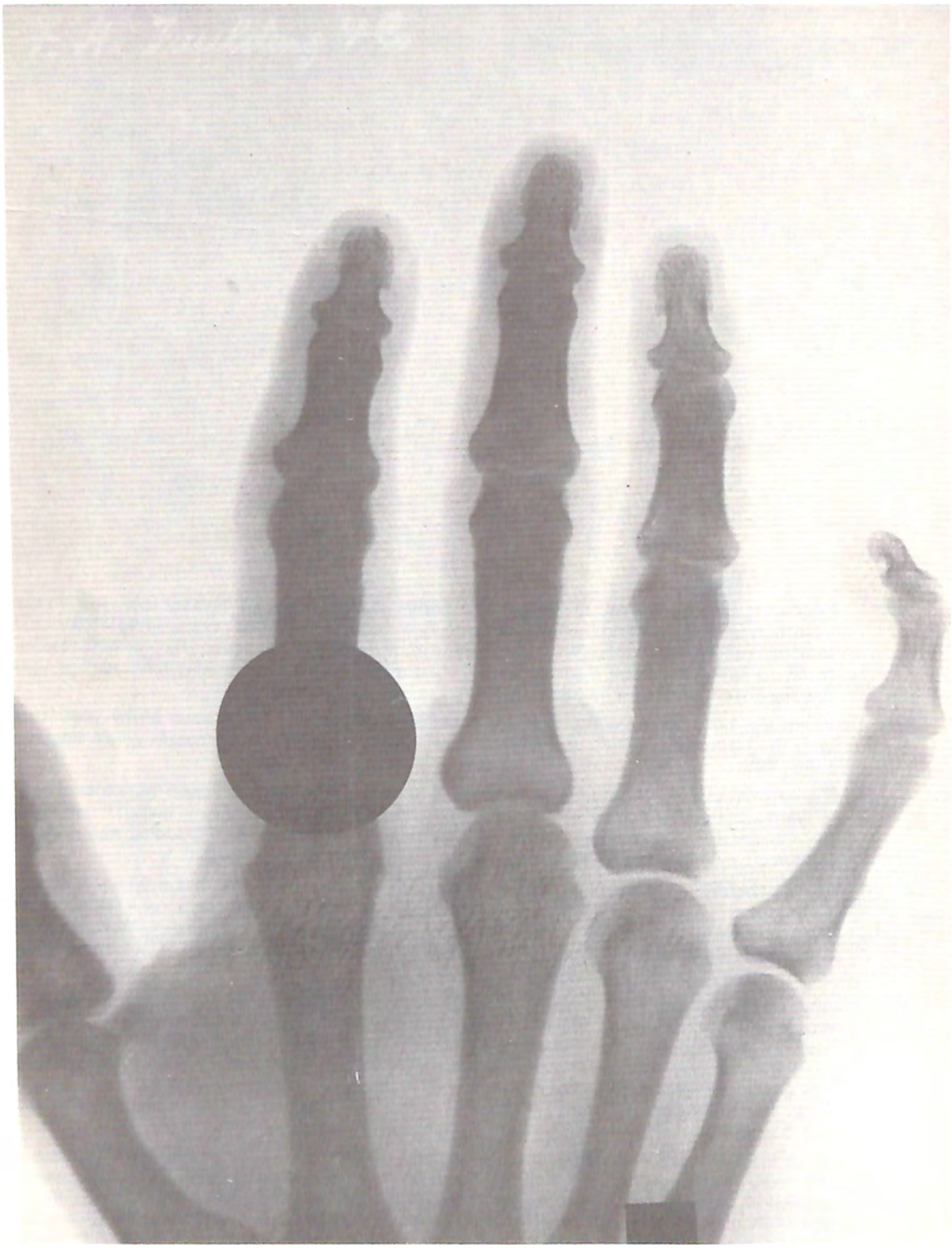
When the boys were young, holidays could also be taken at other times of the year. This charming letter was written on one such occasion; it is undated, but internal evidence suggests mid-1895.

Readers familiar with Adelaide will recognise at once the General Post Office on the corner of King William and Franklin Streets, where WHB has visited Charles Todd and been invited to dinner at the Observatory. He enjoyed a meal of beefsteak and onions, batter pudding and grapes, followed by a cup of tea. WHB's portrait of his father-in-law is unmistakable.

The day before, WHB had been to the South Australian Society of Arts exhibition, where several of Gwendoline's and one of his own paintings were displayed. They had spent many happy hours sketching and painting together, and now they were an integral part of the recently re-activated Society of Arts. WHB was shortly to become its representative on the Board of Governors of the Public Library, Museum and Art Gallery.

After writing this letter WHB would travel home to North Adelaide on the horse tram. Here he would find the cook, Tilly, and the housemaid, Naomi, for both of whom WLB had great affection. The same was not true, however, of the nursemaid, Charlotte, whom WLB later regarded as neurotic and fierce and very much the wrong person for him. She sternly repressed, for example, any game or initiative by which WLB and Eric Gill could possibly get dirty. Brother Bob, on the other hand, was little affected by Charlotte; even as a child he had considerable calm and self-confidence.

There is little evidence of WHB's early relationship with his children. This one letter is perhaps a little misleading, for I suspect that he was somewhat distant and aloof, although he later became a splendid grandfather. His own parental role-model was an extremely severe Victorian uncle, and WHB followed contemporary practice by employing a nursemaid for the children. There is no doubt that he loved his family dearly, but he very rarely expressed emotion of any kind to them, whether of joy or deep sadness. This letter, representing one such occasion, was carefully saved.



14. X-rays

X-rays were discovered late in 1895 by Wilhelm Röntgen at the University of Würzburg in Germany, and they at once provoked enormous scientific and public interest and not a little apprehension. News of the discovery reached Australia early in 1896, and by March the first experiments had been performed in Newcastle and Melbourne.

In Adelaide there were numerous press reports of the new phenomenon, and Bragg asked Rogers to make a suitable glass tube. Perhaps because of inadequate evacuation of the air in the tube, initial trials were not successful, although WHB was able to borrow a suitable high-voltage induction coil from his father-in-law's department. In May Mr S. Barbour, a manufacturing chemist employed by F.H. Faulding & Co., returned to Adelaide from Europe with one of the new tubes; but he lacked a suitable voltage source. The two groups sensibly pooled their resources, and by the early days of June successful demonstrations were being given to the Governor's family and a number of local medical practitioners, including Dr Charles Todd and Dr Alfred Lendon. WHB was already an accomplished and popular extension lecturer, and later in June he gave a public lecture and demonstration of the new X-rays in the University Library. An overflow crowd had to be turned away, and WHB repeated the lecture in a larger hall several days later.

This copy of one of the X-ray photographs taken at the time is endorsed: Taken 1st June, 1896 — Prof. Bragg's Hand — A.L. Rogers. It was claimed that the X-ray shows the injury WHB sustained to the tip of the little finger of his left hand, when it had been all but cut off by the turnip-chopping machine on the Cumberland farm of his boyhood. Modern radiographers are far less certain.

At about this time the two Bragg boys were playing in North Adelaide: WLB was riding his tricycle when Bob jumped on behind and overturned them both. They fell together on WLB's left elbow. He was taken to his father's University laboratory, where the elbow was X-rayed. WLB was frightened by the flashing sparks and the smell of ozone, and could be persuaded to submit to the exposure only after his brother had a radiograph taken. WLB's left elbow was shattered. Dr Lendon thought the arm should be allowed to set stiff, but Uncle Charlie determined to do better. Every few days WLB was put under ether and his arm flexed to form a new joint. The treatment was largely successful, although thereafter WLB's left arm was a little crooked and shortened.

In 1896 father and son surely did not guess how intimately their future scientific lives were to be bound to X-rays and to each other.

15. The Observatory

The eldest of the Todd children, Lizzie, had married an English solicitor, Charles Squires, and lived in Cambridge. She made return visits from time to time, and this photograph, taken at the Observatory house on West Terrace, Adelaide in 1897, records one such occasion. It shows, from left to right:

Back row: Elsie (Mrs Charles) Todd, Prof. William Bragg, Maude Todd, Mrs Mabel Tower (sister of Elsie), Hedley Todd, Lorna Todd (WLB's favourite maiden aunt)

Centre row: Lady (Alice) Todd, Gwendoline Bragg, Dr Charles Todd, Mrs Lizzie Squires, Jessie (Mrs Hedley) Todd, Sir Charles Todd

Front row: Willie Bragg, Frances and Yolande Tower, Bobby Bragg.

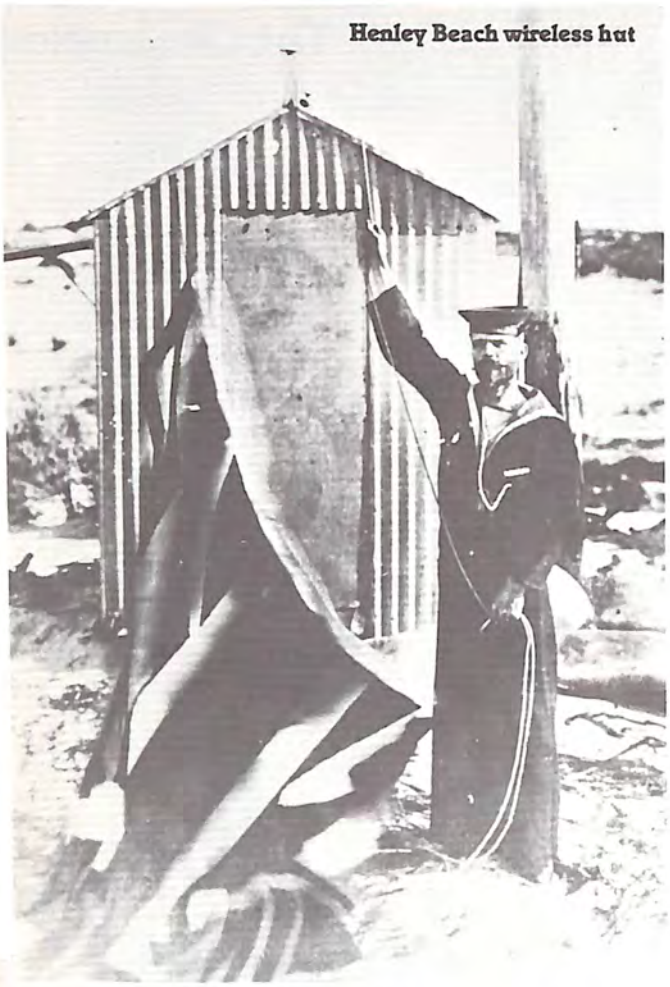
The 'best' dress of the two boys, WLB later recalled, was unusual and, influenced by their mother's artistic taste, comprised long hair done in sausage curls, a tunic with wide collar and red belt, and a broad-brimmed straw hat.

Sunday was traditionally spent with the grandparents at the Observatory, which was a wonderful place for small boys: a rambling two-storey house with deep, latticed verandahs and a balcony in front. The cluster of buildings housing the offices, telescopes and meteorological equipment was embedded in gardens and lawns of buffalo grass, with pine and almond trees overhead.

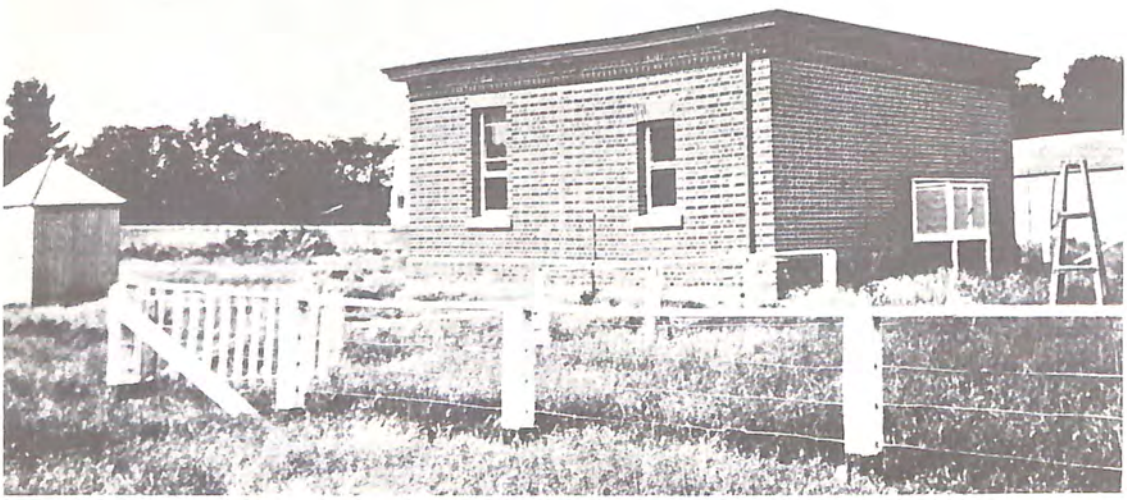
There were nesting swallows, tadpoles in the evaporation tank, and on the back verandah a huge bath made of slate slabs, where stones made islands and harbours for small boys' boats. Aborigines sometimes camped in the parklands nearby. The Observatory outbuildings — stables, storerooms and cellars — contained 'a glorious collection of junk': chaff and corn, souvenirs from the construction of the Overland Telegraph Line (including shells from the Timor Sea), boxes of old letters from which a stamp collection could be begun, insulated wire, battery elements and chemicals.

Grandmother Todd, dear, placid and vague, presided over Sunday lunch. Knowing of WLB's love of it, she always provided a custard in a stemmed glass.

Henley Beach wireless hut



Observatory seismograph house and wireless hut



16. Radio

In the years surrounding 1865, the British scientist James Clerk Maxwell developed his theory of electromagnetic radiation, and in 1887-88 the German physicist Heinrich Hertz confirmed experimentally that an oscillating electric current generates electromagnetic waves, which he detected at a spark gap several metres from the source. In England, Oliver Lodge developed an improved means of detection, the coherer, and in 1894 demonstrated how his apparatus could be used for signalling. In the same year a young Italian, Guglielmo Marconi, began to experiment with Hertzian waves. Unable to obtain backing in Italy, he moved to London, where he obtained the support of William Preece, Engineer-in-Chief of the British Post Office, and where his wireless telegraphy demonstrations soon attracted widespread interest.

In Australia, Professor Richard Threlfall repeated Hertz's work at Sydney University in 1888, but it was some years before William Bragg and Charles Todd next took up the work. During 1890-95 Bragg clarified his own understanding of electromagnetism in correspondence with Threlfall; and in August 1895 the young Ernest Rutherford visited Adelaide University on his way to Cambridge. It is reported that Rutherford had to call WHB from a darkroom where he was trying to get a Hertz oscillator to work, in order to show him his own magnetic detector. The story is plausible, for in July and early August WHB had given a course of extension lectures on 'Radiation', which had included discussion of 'electric waves, their production and detection; the coherer . . .'

In mid-1897, while the Adelaide newspapers carried reports of lectures and demonstrations by Preece and Marconi in England, Charles Todd was irritated by the rupture of an underwater communications cable linking the Althorpe Island lighthouse with the mainland at Cape Spencer. He wondered if a wireless telegraphy link might be possible, and consulted his son-in-law. In August, Rogers recorded in his diary: 'making Marconi's app[aratus]'. Some success was obtained, for on 21 September Bragg gave a lecture on 'Telegraphy without wires' to the second annual conference of the Public Teachers' Union, and a copy of Marconi's apparatus was shown in action.

WHB spent the whole of 1898 in Europe on study leave with his family. He used a letter of introduction to Preece from Todd, and he met and discussed with Marconi the latest developments.

Rogers' diary for 1899 notes Prof. Bragg's return on March 6, and his own 'working on wireless telegraphy' on March 23. April and May show similar entries, with 'splended Morse messages . . . up to 600 yards' on May 10, and 'messages sent a measured mile' on Saturday, May 13. In June, signals sent by Rogers from the Observatory wireless hut (photograph) were received clearly by WHB at Henley Beach, and in July Bragg sent a return message from the beach hut (photograph) to the Observatory mast: a distance of about 8 km.

Todd planned to experiment with transmissions over water, but in correspondence with Preece he confessed that he, like Bragg, could give little time to the project because of his regular work. Nor could he obtain from England the apparatus he needed, and he estimated that the cost of a lighthouse link would be prohibitive, because a skilled operator, properly housed, would be needed at both ends.

In May 1899 WHB gave a 'Wireless demonstration' to the Astronomical Society, and in September a course of extension lectures on 'Wireless Telegraphy' to overflow audiences. The project was abandoned early in 1900, but WHB had further widened his experience of experimental physics, and in a way that brought him progressively closer to original research.

17. Study leave

As early as 1883 Horace Lamb had sought leave of absence from the University Council to visit England and renew his acquaintance with European science, which the isolation of Adelaide had diminished. No such procedures existed, but the University finally instituted them, being the first in Australia to do so. In July 1897, WHB successfully applied to the Council for leave of absence during 1898.

Bragg was, I believe, already contemplating the possibility of beginning some research work of his own, and he pointed out that 'the science of Physics has made great strides and I feel that . . . I should study in England the advances both of the subject itself and the methods of teaching it'. In addition, the University had been discussing the training of school teachers, and there were suggestions regarding the introduction of technical education. WHB was asked to investigate these matters for both the State government and the University. He also 'would be grateful for an opportunity to see again my family in England'.

WHB and his wife left Adelaide by ship in December 1897. Gwendoline made delightful sketches and watercolours of the cities they visited, and together they kept a very full diary of their adventures. They made a trip up the Nile and spent the rest of the winter in southern Europe, arriving in England in April. WLB and his brother remained in Adelaide and travelled to Marseilles in February with Aunt Lizzie and Charlotte.

In England WHB discussed with Preece the cost of wireless equipment, and attended the Bristol meeting of the British Association, where he met several of Charles Todd's colleagues. Later he and Gwendoline visited the noted British astronomer William Huggins and his wife at Greenwich Observatory, and sought advice for Todd on spectroscopic work. Bragg spent time in Cambridge, renewing old friendships and discussing physics. He ordered a quantity of equipment for the new engineering school and the physical laboratory at Adelaide University, and discovered that there was a sizable discount for cash. This Horace Lamb provided as a loan from his Manchester University funds.

Lamb had officially left Adelaide on leave of absence, although it was understood that he would probably not return. The University now wished to make him a suitable farewell presentation, and the Council allocated £100 to WHB for the purpose. He accordingly purchased and presented to his predecessor: a large inscribed silver bowl (later donated to Adelaide University by Lamb's family), four silver candlesticks and an oak bookcase and bureau, at a total cost of £99.14.5.

While WHB was busy with all these activities Gwen and the boys stayed with the Squires in Cambridge and the Braggs at their new home, 'Catherwood House', in Market Harborough. Alice Todd died in August (1898), and Gwendoline sought the company of her eldest sister. This photograph was taken in Harborough, where the boys robbed Uncle William's rockery to build a fort in the garden, and Uncle James made toys for them.

18. East Terrace home

After the Braggs returned to Adelaide in March 1899 they lived at the Observatory for several months, something Charles Todd would have appreciated after the recent death of his wife.

WHB planned to build a new family home, and he purchased a block of land on the corner of Carrington Street and East Terrace, Adelaide. The property, like that in North Adelaide, had views over parklands to the hills, in this case across Victoria Park and its racecourse. WHB designed a two-storey house with Edwardian gables, and made a cardboard model of it when Gwendoline protested that she couldn't understand plans. Charles Todd laid the foundation stone on 9 September 1899, and named it Catherwood House after Uncle William's home in Market Harborough. With the aid of a loan from the Savings Bank of South Australia, the large brick residence rose quickly.

During the visit to Adelaide in 1901 of the Duke and Duchess of Cornwall of York, a military review took place at Victoria Park. Catherwood House was draped with red, white and blue bunting, and WHB set up a grandstand on a vacant piece of land nearby, where all their friends obtained an excellent view of the troops and the royal visitors as they passed by. Flowers decorated the house, and Gwen provided afternoon tea for 60-70 people. The house never looked better, she recorded; the hills were so blue and the grass and trees so green.

In a small plot at the back of the house WLB developed a love of gardening, which stayed with him throughout his life. A friend gave him a vine twig, which grew to cover the back of the house and was laden with huge bunches of rather tasteless grapes. Many years later the story grew up that the vine had grown from a cutting of the famous vine at Hampton Court in England, but a chance meeting in London in 1950 between WLB and Sir Henry Newland laid the myth of royal parentage to rest.

In the back yard there was also a galvanised-iron shed which the boys used as a workshop. They made endless gadgets, including an electric bell so that Charlotte could summon them to tea, and a telephone and a clock. There were several family pets: Tom the fox-terrier, a cat, parrot, canary and Tim the sparrow.

This photograph of the family on the front steps of the house may be dated ca 1902. The house was later sold to the Sandford family, and in 1959 it became the Public Schools Club. The Club has made additions at the front of the property, but the house retains a good deal of its original character. The photograph is modern.

In 1984 both the Lefevre Terrace and East Terrace houses were successfully nominated for inclusion on the Register of South Australian State Heritage Items, on the basis of their intimate association with the Bragg family.

H.M.BERESFORD
W.R.BERESFORD
J.S.BLACKBURN
T.S.P.BOWEN
W.L.BRAGG
P.D.BRIGHT
H.D.BUTLER
A.H.C.CAMPBELL
K.M.CAMPBELL

19. St Dominic's and Queen's School

As a young boy (ca 1895-97) WLB was sent to a convent school on the far side of North Adelaide. The school was almost certainly that of the Dominican Sisters, although no specific record survives. Six sisters had arrived in North Adelaide from England in 1883 to establish a convent hospital; but on arrival they found that men as well as women were to be admitted, and this was not in accord with the constitution of the English congregation. The sisters transferred their energies instead to the establishment of an advanced day school, which quickly became popular and expanded to a new property in Molesworth Street. Plans were made for a chapel for perpetual adoration, which was opened in 1893.

The sisters had enjoyed a liberal arts education, and were skilled in music, drawing and painting, and the art of illumination and needlework. They also taught modern languages and astronomy, and WLB remembered an argument with one of the nuns about how a mirror works. The school curriculum would certainly have appealed to Gwendoline Bragg, and WHB probably raised no objection.

On the family's return from England in 1899, WLB was sent to Queen's School, a private institution in North Adelaide specialising in late-primary and early-secondary education. WLB had a very long daily journey to and from the school, with lengthy walks at both ends and a considerable horse-tram journey from Adelaide city to the far side of North Adelaide. He encountered trouble with the local 'larrikins' near both school and home.

In 1891 a small private school owned by the Rev. Thomas Field and operating in the previous Christ Church school building was sold to J.H. Lindon and E.L. Heinemann, who renamed it Queen's School and soon moved it to larger premises on Barton Terrace. When Lindon's health failed in 1896 and Heinemann decided to leave the teaching profession, the school was purchased by R.G. Jacomb-Hood. WHB had known both Lindon and Heinemann well, and was impressed by Hood. WLB attended the school for two years, 1899 and 1900.

Few records survive of the school in Hood's time, but its prestige and enrolments grew steadily. WLB recalled Hood's belief in corporal punishment, some bullying from older boys, and his own misfit in the school. He was immature in some ways, being reluctant to express his desire to play lunch-time hockey, but very precocious in others, such as in Euclidean mathematics and other studies. The school provided a good grounding in English, Mathematics and modern languages, and Latin, Greek, Chemistry and Physics were also available.

When the school closed in 1949 its honour boards were deposited in the old Christ Church hall, which is now a photographic studio. The majestic World War I memorial board remains, and carries as its head the school crest and motto, taken, it is said, from Queen Victoria College on Jersey, in the Channel Islands. The name W.L. Bragg appears in the first column, but that of his brother does not.

20. Exhibition Building and Elder Conservatorium

The Jubilee Exhibition, celebrating the State's 50th anniversary and the golden jubilee of the reign of Queen Victoria, was opened in June 1887 and closed in January 1888, the longest-running spectacle in South Australian history. The Exhibition Building itself was a major addition to the imposing cluster of public buildings on North Terrace, Adelaide.

Bragg was a member of the Education and Science Sectional Committee under the chairmanship of Professor Edward Rennie; and also a member of Jury XV for Scientific Instruments, which, under Charles Todd, judged precision instruments and apparatus for physical research, chronometric apparatus, and optical and thermotic instruments. In Fine Arts, Gwendoline Todd received diplomas for a painted pot, jardinieres and carved wood bellows.

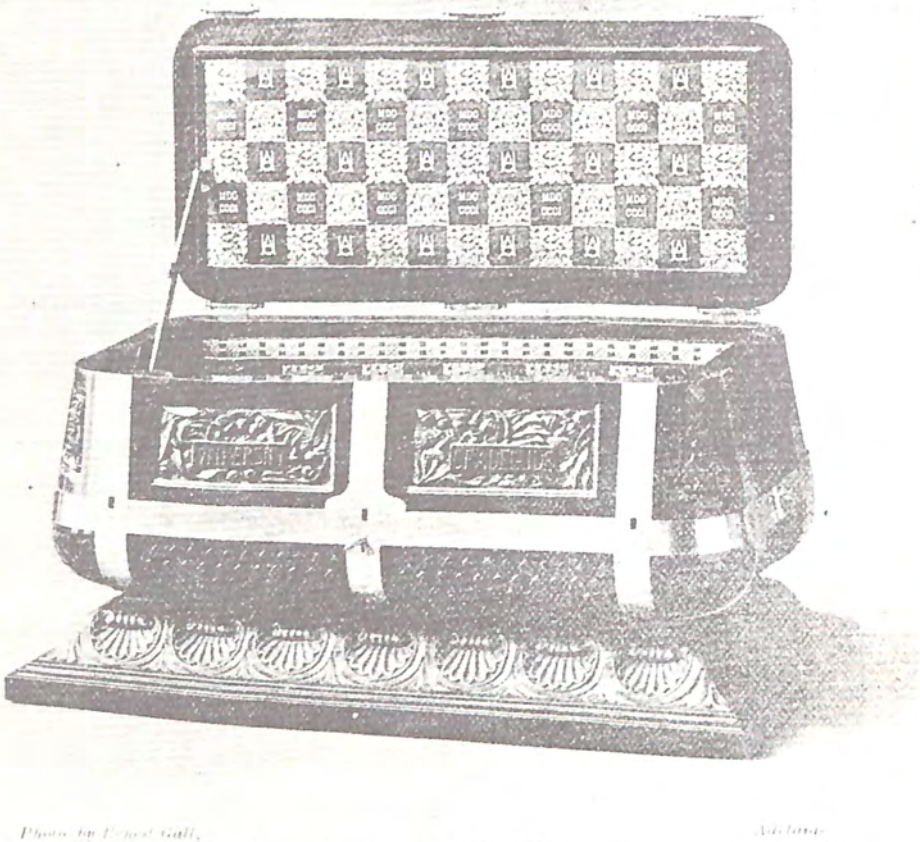
WHB was given a bronze medal for his services to the Exhibition, and his close association with the building continued later when he became involved with the School of Mines, which conducted classes there for several years.

At the University, in addition to his acoustics lectures, WHB also served on the Board of Musical Studies for more than sixteen years. He did everything possible to resolve justly the series of problems that surrounded Joshua Ives' tenure of the professorship of music, on one occasion supporting Ives in a dispute with the Vice-Chancellor. He took an active role in the planning which followed Sir Thomas Elder's 1897 bequest of £20,000 for the establishment of a School of Music, and he was a member of the small subcommittee which prepared a large report on the matter for the University Council's consideration.

WHB was also involved in discussions with the University architect, Mr Naish, regarding the Elder Conservatorium building, but he left for study leave before details were decided. Whether WHB could have contributed much to the design of the acoustic properties of the hall and its teaching rooms is uncertain, but early in 1900 he was asked to investigate the possibility of improving the impossible echoes in the class rooms. He reported that, with the assistance of Messrs Miller Anderson & Co., the rooms had been greatly improved by the use of curtains, carpet and wall hangings. Late in 1908, when asked to undertake a similar rescue operation for Elder Hall itself, he made similar recommendations.

In April 1900 the University Council approved WHB's design for the Conservatorium organ case, for which we may assume he had the advice of H.P. Gill and Mr Naish. Similarly, following WHB's experiments and suggestions, the organ was initially powered by a gas engine, and later by an electric motor after the University was connected to the electric supply. The organ was formally dedicated by the Duchess of Cornwall and York in July 1901, during University ceremonies for which WHB played the major organisational role.

This photograph shows the new Elder Conservatorium building alongside the Exhibition building, its Stirling freestone gleaming in the sunlight.



The University Casket presented to H.R.H. the Duke of Cornwall.

21. Royal visit

The Duke and Duchess of Cornwall and York, later King George V and Queen Mary, visited Australia in 1901 to open the first Federal Parliament, after which they visited Adelaide in July. The visit aroused extraordinary public interest. Following the custom begun on their trip to England, WHB and his wife recorded the events in a triplicate book, the first two copies being sent as letters to overseas relatives and the second carbon remaining as their own record. Gwendoline was feverishly excited.

Adelaide was decorated with flags, bunting, flowers and electric lighting. The Bragg family enjoyed a perfect view of the Royal couple's processional arrival from the balcony of Dr Charles Todd's home in Victoria Square. The Duchess charmed everyone, and the Duke, despite the pain of a raging toothache, endeared himself to those he met. The following day they attended a levee at Government House; Gwendoline watched as the Church of England Mothers' Union Address she had prepared was presented, and WHB was introduced along with other University staff. In the evening WHB took the boys to see the city illuminations.

The Duke and Duchess visited the University on Thursday 11 July. WHB bore the major burden of the arrangements. Apart from matters of protocol, special guests, security, tickets and seating, dress, music, photography and wet-weather arrangements, there was the prospect of student unruliness. Because of his youth, sporting prowess, personal qualities and understanding, WHB had developed a special relationship with the students. On this occasion, as on others, he negotiated with them on their unscripted contribution, and their songs became one of the highlights of the program.

The Duke laid the foundation stone of the Prince of Wales building, Professor Bensly read a Latin address of welcome, the Duke received an honorary LLD, and the Duchess opened the Conservatorium organ, which worked beautifully, much to WHB's satisfaction. Professor Bensly's address, printed on a parchment scroll, was presented to the Royal couple in a casket (photograph), the work of the School of Design and its director, Mr H.P. Gill. The body and base were of Australian blue gum, the shape and shell design suggestive of the Duke's naval associations. The body was extensively carved with University and Australian motifs, and lined with kangaroo skin embossed in gold. The whole was bound with bands and secured by hasps of Australian copper, with a single key operating a long triplicate bolt, the work of Mr A.L. Rogers. That evening the Bragg boys went to the fireworks, WHB dined with the Chancellor, and later Professor and Mrs Bragg attended a reception at Government House.

The military review on Saturday took place at Victoria Park (see photograph 18), and there was a State Concert at the Exhibition building. On Sunday, Will and Gwen attended the morning ceremonies and service at St Peter's Cathedral. It had been a memorable week.

22. School of Mines and Industries

The many Mechanics' Institute buildings scattered around the State are reminders of early elementary technical education in South Australia; but by the 1880s many people saw a need for an established centre for technical study. First, there was a drought, agricultural decline and a necessity to develop mining and industry further; second, there was no public system of secondary education and therefore a yawning gap between primary schools and the University; and third, there was a strong ideological undercurrent, seeking to open doors of opportunity for the socially disadvantaged. Following a favourable report from a Board of Enquiry, the Playford ministry established the South Australian School of Mines and Industries in 1888.

The next year students began work, and Mr John Langdon Bonython became President of the governing Council, a position he was to hold for 50 years. In 1890 the University nominated Professor Bragg to fill a vacancy left on the Council of the School by the resignation of Dr Stirling, and thereafter WHB remained a member until he left Australia early in 1909. On his departure, Sir Langdon made special mention of WHB's long service, his generous gifts of time and attention to School affairs, his valuable advice on many occasions, and the honour brought to the School by his scientific eminence.

From the beginning, School of Mines' students attended physics, electrical engineering and other classes at the University, but they were often hampered by a lack of basic knowledge. Preparatory courses were progressively introduced.

In 1899 George Brookman gave £10,000 for the construction of a building to house the School, and Bonython shrewdly built it, without permission he said later, next to the University. Around the time of its opening in February 1903, several notable figures visited the School, including (photograph) the Governor General, Lord Tennyson. WHB and Sir Langdon are on the extreme left.

Bragg believed in the value of a broad, general education for the whole community, and equally in intellectual primacy for the University. Although he responded positively to requests for some engineering courses under his supervision at the University, financial and material resources were excruciatingly short. He welcomed the role of the School of Mines in both these areas.

WHB was, uniquely, a member of the Councils of both the School and the University. The rivalry between them, each led by a powerful and influential man, was usually healthy but sometimes acrimonious; for example, regarding proposals to teach advanced courses at the School. On such occasions WHB was clearly the man in the middle, and the resolution of the difficulties owed much to his tact and increasing breadth of vision.

July 30
[1904]

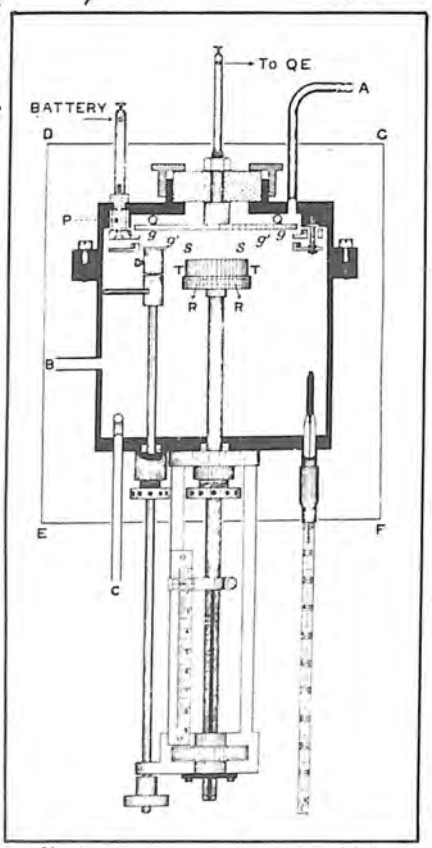
①

α ray experiments.

Depth of chamber 52mm

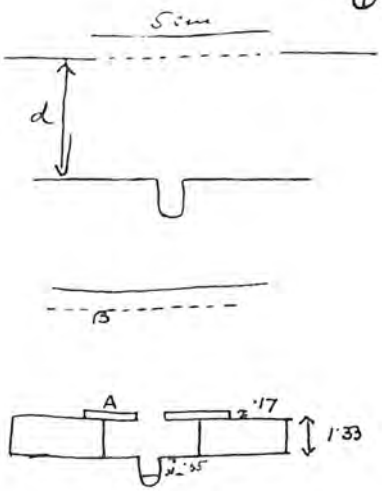
100 volts.

Distance d − 1mm		June	Zero	Leak	Leak per sec.
6·85	6·0	40	19·5	−2	·54
6·65	5·8		19·0	−3	·55
6·45	5·6			−3	·55
6·25	5·4			−10	·72
6·05	5·2		20	−21	1·00
5·85	5·0			−37·5	1·44
5·65	4·8			−56·5	1·91
5·45					2·34
5·25					2·81
5·05					3·19
4·85					3·55
4·65					3·97
					3·98
					4·00
4·45					4·32
4·25					4·69
4·05					5·20
3·85					5·96
3·65					7·07
					6·97
					6·87
3·45					7·98
3·25					9·25
3·05					10·72
2·85					11·52
2·65					13·02
2·45					14·87
2·25					16·3



3·5			16·5
4·0.	30"	10"	11·8
	40"	11"	8·32
			7·25 X
			4·50
			3·62

①



When A touches B scale reads 1·3

Then true distance gauge to Ra
= ·17 + 1·33 + ·65
= 2·15.

Hence ·85 should be added

With card over Ra:

		Leak	
40"	+27	+3	60
"	27	+6	52
40"	27	+8	48
40"	28	10"	(Repeat 45 same)
40"	28	11·5	·41
40"	28	12	·40

23. Research: Alpha-particles

WHB was contemplating independent research well before 1903, despite his later recollections to the contrary. His work on X-rays, electromagnetic theory and radio has been mentioned, and persuasive reminders of the fascinations of research were obtained during his study leave in England. All this occurred before 1900, by which time WHB was reading the major English scientific journals.

The necessary trigger came in 1903 when he was preparing the presidential address he was to give to Section A (Astronomy, Mathematics and Physics) of the AAAS meeting to be held in Dunedin (New Zealand) in January 1904. Following accepted practice, Bragg decided to review an area of widespread interest, and chose to discuss the electron and radioactivity. During his extensive preparatory literature review, WHB was captivated by some results described by Mme Curie in 1900, which implied that alpha-particles from radioactive decay all travelled about the same distance in the surrounding air, a very different behaviour to that of beta-particles. But how do the light-weight alpha-particles get past the heavier air molecules without deflection, WHB wondered; they must surely go **through** them.

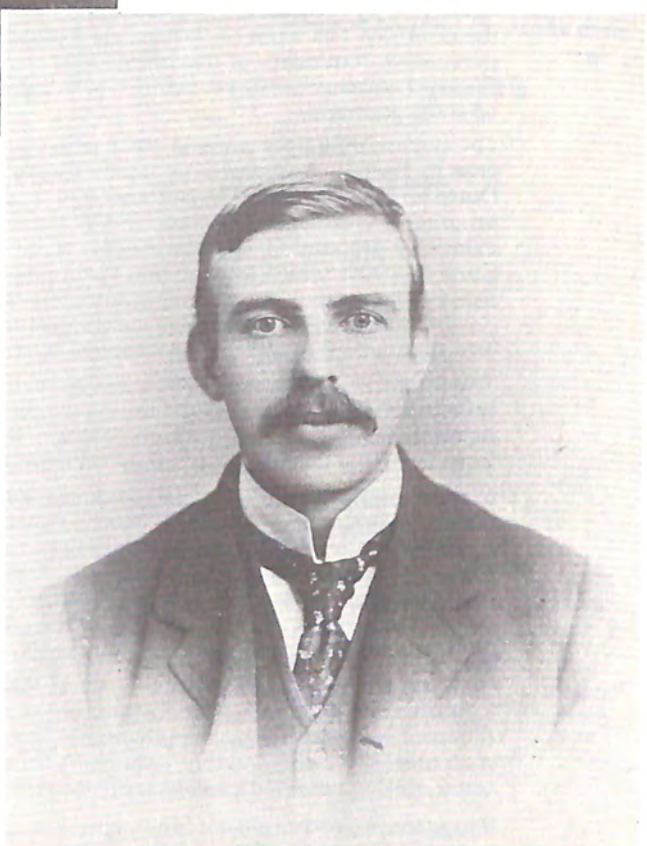
The radium bromide that WHB ordered and Robert Barr Smith paid for arrived on 14 June 1904, when WHB was able to begin testing his proposals experimentally. The initial page of his first Adelaide research notebook (opposite) is dated Saturday, 30 July 1904. Frederick Soddy arrived from Perth the following afternoon (see photograph 24).

In the months ahead, Arthur Rogers built a series of brass chambers of increasing sophistication, initially simple (sketch in notes), finally complex (drawing opposite). The apparatus consisted of a radium source (RR) and a thin ionisation chamber (ggQQ) for detecting the alpha-particles, the distance between them being variable. Different gases could be introduced through C and sampled at B, while their pressure was measured by a manometer at A and their temperature varied (oven DEFG) and read from a thermometer. Difficulties with the insulators and joints at higher temperatures required constant vigilance.

With the assistance of his first research student, Richard Kleeman, WHB was able to show: that radium emits four groups of alpha-particles, each with a characteristic 'range'; that the range in different stopping gases is approximately proportional to their density and to the square root of their atomic weight; and that alpha-particles ionise most heavily near the end of their range. The work quickly obtained international recognition and acceptance.

Bragg treasured this piece of apparatus, not least as a reminder of Rogers' great care and skill. He wrote to Rogers in 1920 saying he still had it, and that 'when I retire I shall have it silvered and keep it in a prominent position in my house'.

Frederick Soddy



Ernest Rutherford

24. Rutherford and Soddy

Ernest Rutherford was born into a humble New Zealand farming family on 30 August 1871. He was a capable student, and towards the end of his undergraduate studies at Canterbury College began to exhibit an unusual capacity for original research. In 1895 he was awarded an 1851 Exhibition Scholarship and set off for England. As we have seen (photograph 16), Rutherford called at Adelaide in August and met WHB at the University. This photograph of Rutherford was taken by Messrs Steam in Cambridge not long after he arrived there.

At Cambridge, Rutherford continued work on the detection of radio waves and also studied the conduction of electricity through gases with J.J. Thomson. In 1898 he went as Professor of Physics to McGill University in Canada, taking with him a fascination for the new field of radioactivity. Here, with the assistance of the young English physical chemist Frederick Soddy, Rutherford began his life-long studies of the nuclear structure of matter.

Soddy returned to England in 1903 to join William Ramsay's London laboratories. He was much in demand as a lecturer, and the following year accepted an invitation to give a series of extension lectures in Western Australia. This photograph of Soddy was taken the same year. After his extremely successful lecture series was completed Soddy visited Adelaide, and, although he spent only one evening with WHB, their brief discussions were of great significance. Soddy gave Bragg one important tip on handling radium, and on his return to England became WHB's agent there. Soddy speeded Bragg's papers through the publication process, arranged for his work to become known in Germany, assisted with equipment orders, encouraged and made suggestions on his work, and gave Bragg news of scientific people and events on the other side of the world.

As WHB's research results emerged he also wrote excitedly and regularly to Rutherford in Canada, and his long letters evoked reassuring and helpful replies. As expected, Rutherford's responses were particularly pertinent, and also included accounts of his own research. When WHB became too excited, Rutherford counselled less haste, so that other workers would have time to assimilate his radical hypotheses. Other scientists in Rutherford's laboratory began to use Bragg's methods, and Rutherford included references to WHB's work in his lectures, papers and books.

WHB was particularly conscious of his isolation from people and events in England and Europe, but for a time his correspondence with Soddy and Rutherford provided a bridge that enabled him to proceed quite satisfactorily. Ultimately, however, Bragg's need to talk face-to-face to scientists working in the same field became paramount, and he accepted the inevitable invitation to return to England.


DONOT
BRAGG
ABOUT
RADIUM
THIS IS NOT
SUPT
BOOKER
From Students
First Procession 1905

25. Student 'prosh'

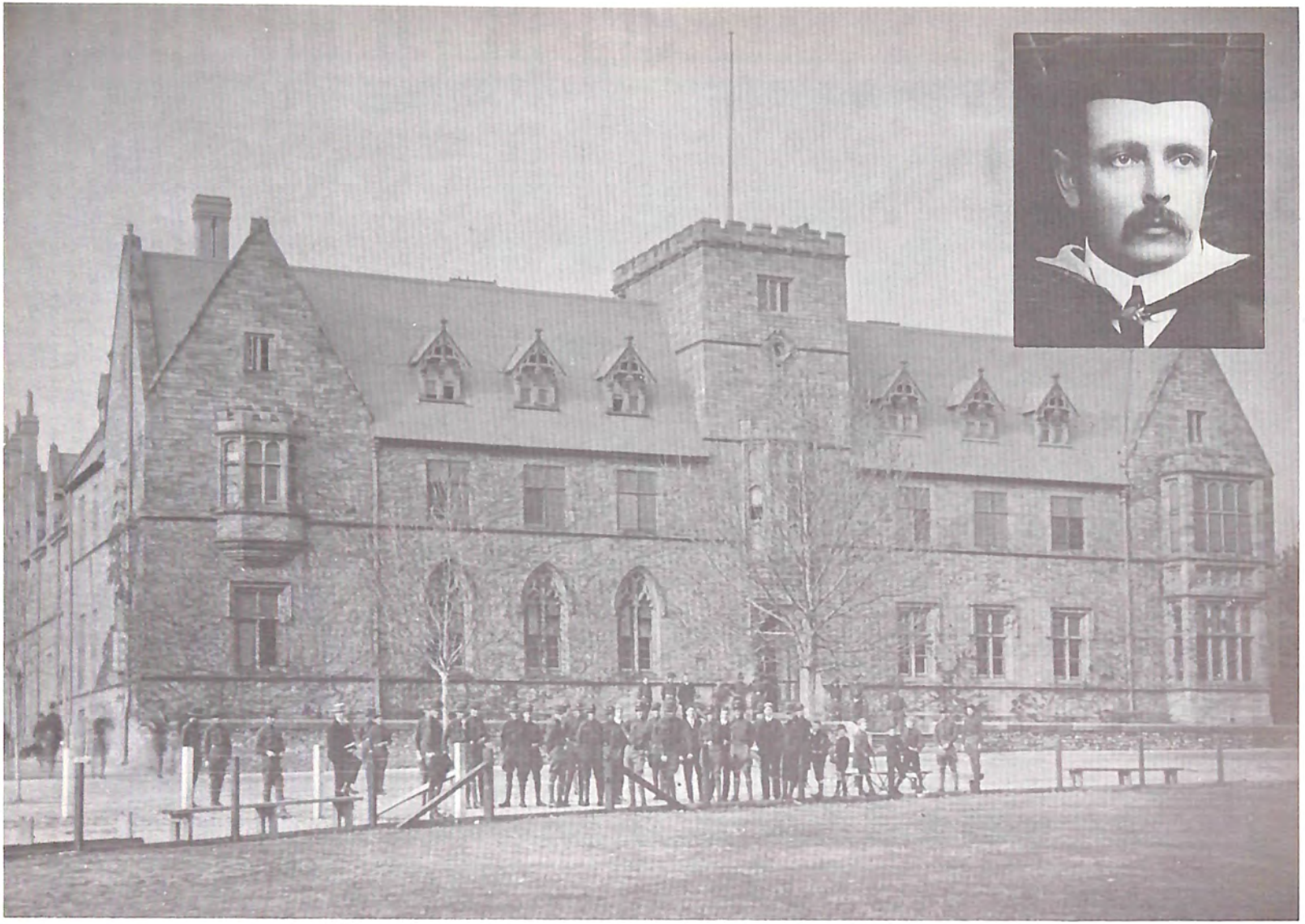
For much of the 20th century, the annual student procession, or student 'prosh', through the streets of Adelaide was one of the highlights of the academic year. Floats and groups of students carrying placards or performing burlesques drew attention to recent events in light-hearted, satirical or sometimes brutal vein, as they wound their way through the city and back to the campus. There were inevitable clashes with authority, but usually it was a relaxed interlude for students and citizens alike.

The first prosh was held in 1905. Fire Services Superintendent George Booker was an aggressive extrovert and hard drinker, one of the heaviest and most popular characters in the city. He resigned in 1907, when it was discovered that he had ordered whisky for his own consumption as 'disinfectants' on fire brigade accounts.

The jovial allusion to WHB is a straightforward reference to his research and public lectures on radioactivity and radium. Since this photograph predates Rutherford's 1909-11 discovery of the atomic nucleus and the development of nuclear energy in the 1940s, the float cannot be regarded as a precursor to later processions of a more serious nature. Nevertheless, it does raise the matter of the discovery of radioactive ores in South Australia.

Douglas Mawson was born in Yorkshire in 1882 and emigrated to Australia with his parents in 1886. In 1902 he graduated BE and BSc at Sydney University, and, with Thomas Laby (later Professor of Physics at the University of Melbourne), made preliminary examinations of a number of Australian minerals for the presence of radium. Mawson was appointed Lecturer in Mineralogy and Petrology at Adelaide University in August 1905.

At about this time S. Radcliffe began searching for radioactivity amongst the ore deposits of the Moonta and Walaroo mines; and early in 1906 A.J. Smith sent ore specimens to Adelaide from his lease in the Olary district. The Government Geologist, Henry Brown, visited the Olary area and brought back additional samples. In each case the determination of the strength of the radioactivity was undertaken by Professor Bragg at the University. Radcliff thanked WHB for the time and trouble he had expended over more than 12 months of testing, and reported some traces of radium. The Olary ores gave evidence of uranium. Mawson suggested that the location of greatest activity should be called 'Radium Hill', and asked Professor Rennie and Dr W.T. Cooke to carry out chemical tests. Thereafter Mawson took the leading role in these matters as far as the University was concerned; WHB happily went on with his research, to which he now devoted most of his time and energy.



26. St Peter's College

The Collegiate School of St Peter was established in 1847 and initially grew spasmodically, suffering in concert with the State a period of adversity from 1880 to 1893. In 1894 Rev. Henry Girdlestone, Oxford science graduate and stroke of the University eight, arrived as headmaster, and the fortunes of the College began to recover. Girdlestone was a tall, broad-shouldered man of commanding presence and friendly disposition, a firm disciplinarian with a passion for good English, thoroughness and loyalty. Under him St Peter's rose to be the premier Church of England school in the State. In 1900 Girdlestone divided the curriculum into three areas — classical, scientific and commercial — and built a chemistry laboratory and lecture room. The same year James Simpson Thomson, destined to become a legendary chemistry master, joined the staff. When in December it was decided that WLB was ready for secondary education, the grammar-school, religious and social aspects of St Peter's College were decisive.

WLB entered in 1901; this photograph of Old School House is dated ca 1910. At the age of only eleven he found himself in the fifth form, confronting a public examination at the end of his first year. He won an under-13 race at the School Sports, but thereafter competed against boys two or three years older than himself. Precocious in lessons, he found his social immaturity a great handicap.

He studied English language and literature, Latin, Greek, French, Scripture, Mathematics and Chemistry, but not German or Physics. In class, WLB and his friend Bob Chapman (R.W. Chapman's son) solved the problems that defeated the mathematics master; in chemistry J.S. Thomson (photograph 1906) inspired WLB's interest in school science. In the years 1903-5 and aged 13-15, WLB was in a sixth form: in 1904 he topped the subjects Mathematics, Chemistry and French, as well as form VIa overall, and was awarded a Christ Church Scholarship. In 1905 he passed the Higher public examination with credits in Pure and Applied Mathematics and Inorganic Chemistry and won a Farrell Open Scholarship.

Despite his later claim that he was not good at sport, WLB won the College Cup at the School Sports of 1905, with a win in the 100 yards handicap. He rowed regularly in school and public regattas, and stroked the St Peter's maiden four at the Public Schools races the same year. He took a leading part in the activities of the newly-formed Literary and Debating Society of the College. In very many ways WLB's school experiences paralleled those of his father.

Robert Bragg entered St Peter's in 1905, at form IVb and age 12. He progressed along a far more conventional path, a good but not outstanding student with a love of athletics and rowing. He represented St Peter's in Intercollegiate Athletic Sports, winning the 1907 junior 120 yards hurdles. This photograph of Bob in school cadet uniform was taken in 1907. He left St Peter's at the end of 1908, before he became a senior student.

Bob was outgoing and popular, with his mother's intuitive ease with people; WLB, gifted but often withdrawn, said he found dealing with things easier than dealing with people.

Club House, Seaton
1905

27. Royal Adelaide Golf Club

The Adelaide Golf Club was founded in June 1870, but it had lapsed by 1876. The club was re-formed in August 1892, and obtained permission to play on the north-east parklands in the area bounded by Kingston, Robe and Lefevre Terraces, directly opposite the Braggs' first home. WHB joined the club in 1893 and at once demonstrated what **The Critic** later described as 'an infinite capacity for taking pains, as during all his golfing career he has set himself to master individual shots by constant practice'.

In 1894 WHB was elected Secretary/Treasurer, was asked to superintend the preparation of the greens, and reduced his handicap from 13 to 1, the latter for the Browne Trophy competition.

Unable to prepare an adequate course in the parklands, the club amalgamated with the Glenelg Club in 1896, although even there the rules allowed 'prickly jacks' (hard, spiky grass seeds) to be removed from a ball without penalty! WHB won the August monthly medal with a net 99 (104-5), and at one stage during the year his handicap dropped to scratch, although thereafter it varied between 2 and 8. In 1900, Professor and Mrs Bragg played in the mixed-pairs handicap stroke competition at the Australian championships.

The combined club had further difficulties with their lease and the development of the course in the early years of the century. The Sandison family, which owned the land, did not favour its conversion to permanent golf links, and a search was begun for ground elsewhere. Late in 1904, land at Seaton was leased from Seaton Estates Ltd and the Adelaide Golf Club finally reached its permanent home. Not only was the sandy location suitable, but there was a good train service from the city; the line remains a famous feature of the course. At the official opening of the new links on 30 June 1906, Mrs Bragg and the other ladies wore their new uniform: a flat cloth cap, navy-blue Norfolk coat with red collar and cuffs, dark skirt and tan boots. This 1905 photograph of the Club House gives a clear picture of the undeveloped course in its earliest years.

It is clear from the surviving Committee minutes that WHB played an important role in the early development of the course; and we have WLB's recollection that: 'I used to caddy for [my father] as a boy, and I remember going around with him when he was planning a new course at Seaton . . .' WHB provided a trophy in 1905, and in 1906/7 he won the Senior Medal. By then professional advice was being sought on the architecture of the course.

WHB enjoyed golf for many years after he left Adelaide. In 1924, when discussing the joys and challenges of research, he said: 'Research is rather like playing against bogey at golf. Nature never has any weakness of which advantage may be taken; there is no hole to be won by bad play because our opponent plays worse.'

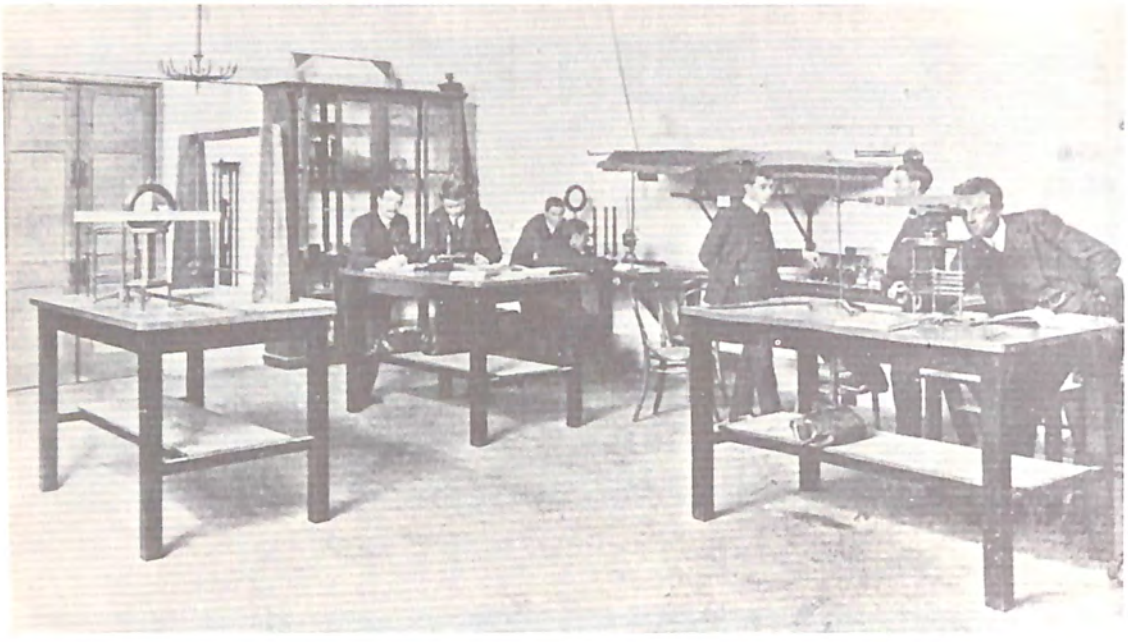
The Adelaide Golf Club became 'Royal' by the grace of King George V in 1923.

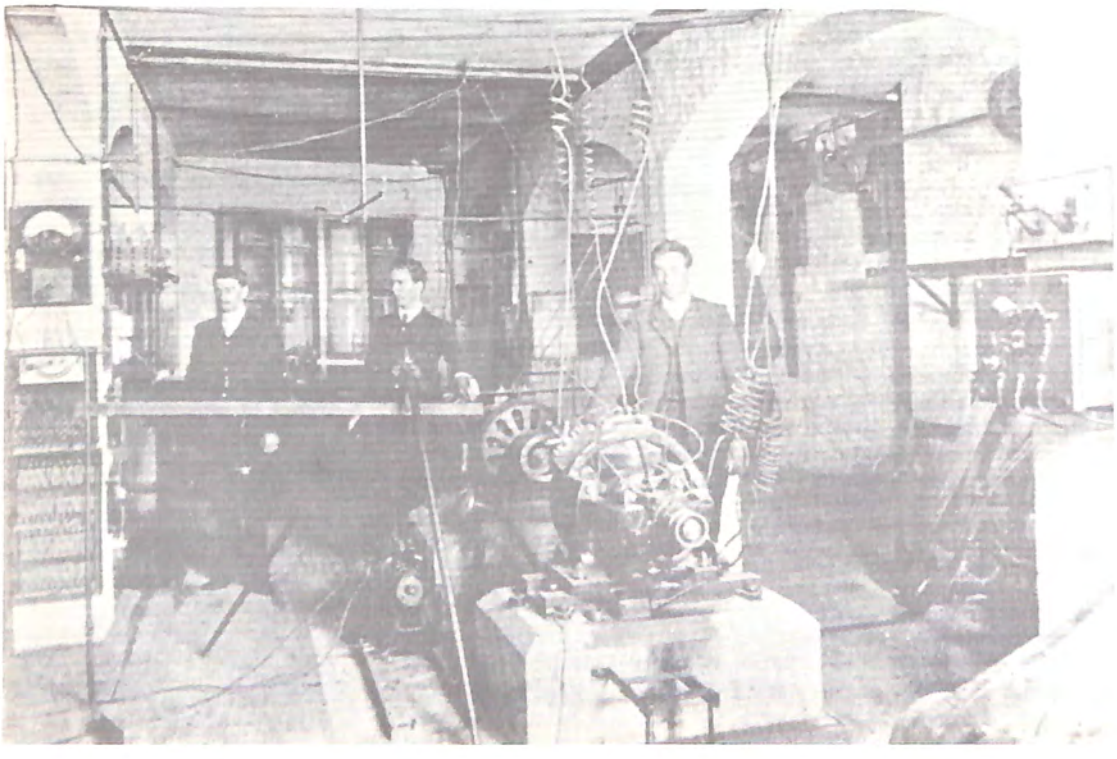
28. University staff, 1906

The Critic was a social, political, sporting and literary weekly, published in Adelaide from 1897 to 1924. C.J. Dennis was its editor in 1904, and on 11 July 1906 it published a large pictorial supplement on the University of Adelaide. Photographs 28, 29 and 30 are taken from this supplement.

The photograph of 'The Council in Session' is notable for the spartan conditions of the meeting—simple trestle tables and basic wooden chairs. WHB was a member of the Council from November 1898 until December 1908, being initially elected, and thereafter regularly re-elected, by the Senate. He participated actively in all the business that came before the University's governing body. This photograph includes: The Chancellor (Sir Samuel Way), Vice-Chancellor (William Barlow), Warden of the Senate (Frederick Chapple), Sir Charles Todd, Robert Barr Smith, Rev. James Jefferis, Professor Stirling, and four of Bragg's fellow Cambridge undergraduates from the 1880s (W.J. Isbister, S. Talbot Smith, G.J.R. Murray and J.R. Fowler). WHB is seated in the centre-front of the photograph.

The larger group is the 'Teaching Staff of the University'. Since it contains several names that appear elsewhere in these pages, as well as many that are known more widely, and because this modest group contains all of WHB's academic colleagues from the period, it seems appropriate to list them in full (L to R):
Front row: Professors Henderson, Ennis, Bragg, Rennie, Stirling and Watson, Acting-Professor Dettmann, Professor Brown and Acting-Professor Shann.
Second row: Dr Symons, Dr J.A.G. Hamilton, Mr B.D. Colvin, Mr R.W. Chapman, Dr Eitel, Mr D. Mawson, Mr W. Fuller, Mr W. Howchin, Mr W.T. Cooke, Dr A. Lendon and Dr J.C. Verco.
Third row: Dr Cavenagh-Mainwaring, Mr W. Isbister, Mr H.J. Priest, Mr W. Neill, Dr W.T. Hayward, Dr W.A. Giles, Miss E.I. Benham, Mr J.P.V. Madsen and Dr W.A. Fischer.
Back row: Mr R.J.M. Clucas, Mr P.E. Johnstone, Dr A.M. Cudmore, Dr H.S. Newland and Dr Poulton.





29. Laboratories and Electrical Engineering

The 1906 **Supplement to The Critic** contained a number of photographs of the University teaching laboratories; the two displayed here are 'A Corner of the Second-Year Physics Laboratory' and the 'Electrical Engineering Laboratory'.

Readers with some knowledge of early physics apparatus may enjoy attempting to identify some of the equipment and the experiments for which it is being used in the Physics Laboratory.*

Despite Todd's earlier suggestions, the provision of electricity in Adelaide was not seriously discussed until the 1880s. The 1887 Jubilee Exhibition provided an important impetus, and thereafter the use of electricity grew steadily. In 1890 the School of Mines reorganised the Electrical Engineering course it had begun in 1889, and asked the University for assistance. WHB was somewhat reluctant because of the shortage of staff, funds and equipment, but his suggestion of a weekly two-hour evening class was approved. It began in 1891, with Chapman as lecturer.

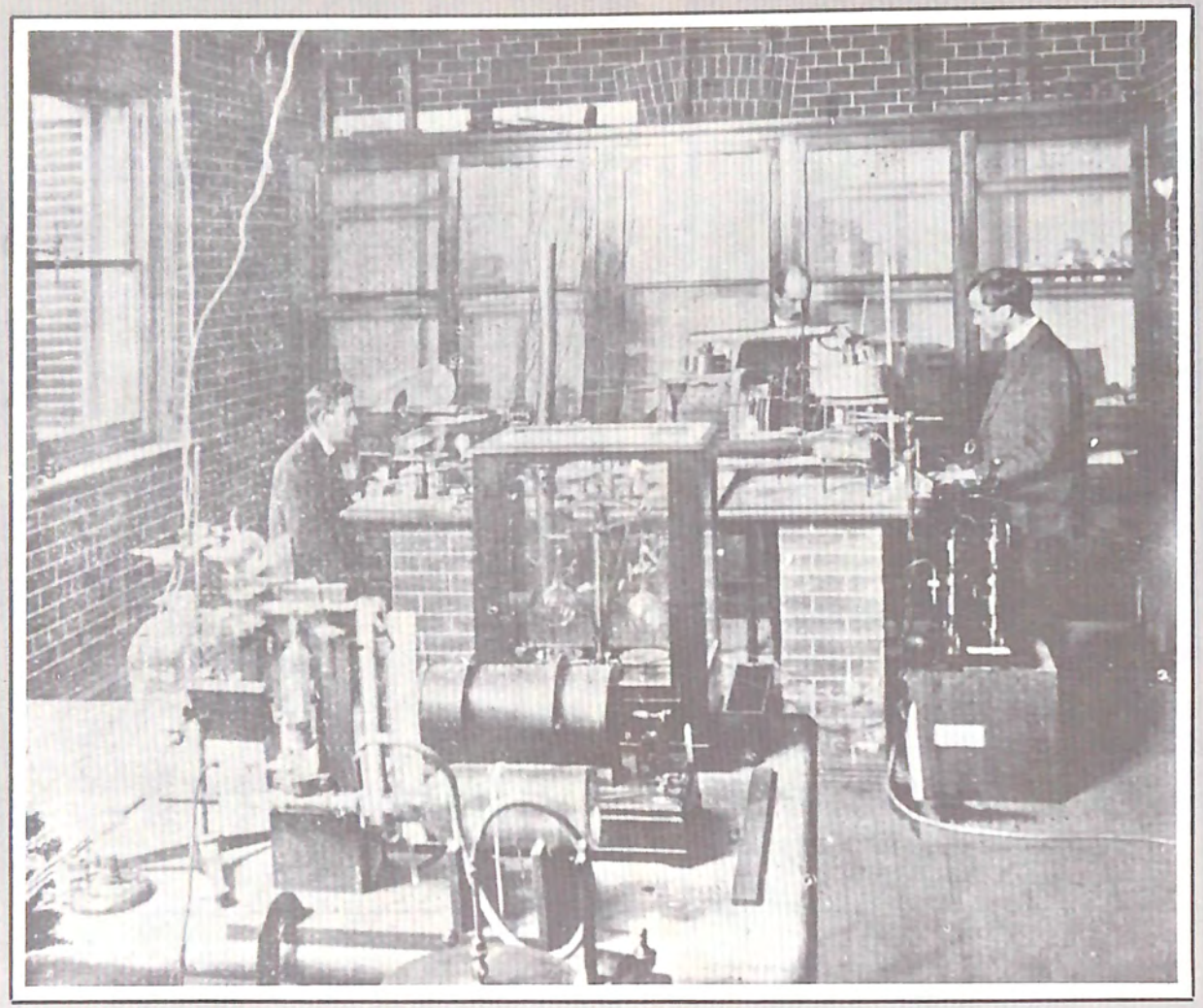
Students petitioned for the provision of an advanced course in 1894, and Bragg arranged for it to be taken by Clinton Farr, an Adelaide graduate who had been studying Electrical Engineering with Threlfall in Sydney. Chapman gave the course in 1896.

After a brilliant undergraduate career, John P.V. Madsen graduated from Sydney University BSc in 1900 and BE in 1901. He arrived in Adelaide in April 1901 to replace J.B. Allen (who was leaving for Perth) as Assistant Lecturer in Mathematics and Demonstrator in Physics. During the summer vacation of 1902/3 Madsen visited universities and electrical works in England and the USA, and in 1903 he was appointed Lecturer in Electrical Engineering. The University and School of Mines during 1902 had established several four-year courses leading to a joint School Fellowship and University Diploma in Applied Science, and the details of the Electrical Engineering course and the design of the laboratories were left entirely to Madsen. 'He alone', WHB wrote in 1904, 'is responsible for the excellence of the present arrangements'. Madsen was also in charge of all the physics practical work, provided advice for the Adelaide Electric Lighting Co., and by 1906 was also assisting Bragg with his research work.

This 1906 photograph of the Electrical Engineering Laboratory is interesting. The DC motor at bottom-right powers the shaft which provided belt-drives for all the equipment in Rogers' workshop, and the first of the DC machines in the centre has clearly had parts of its casing removed for teaching purposes. On the left is a resistive load regulator bank, and on the right a typical DC-motor starter and double-pole isolating switch.

Bragg apparently took a considerable interest in all these developments, despite the fact that he did not give any of the courses himself. With Todd's support, and that of Todd's English colleague William Preece, WHB was elected an Associate (1893) and then a full Member (1894) of The Institution of Electrical Engineers (UK), and remained a member until 1912.

* The author would appreciate notification of such details.



30. Research laboratory

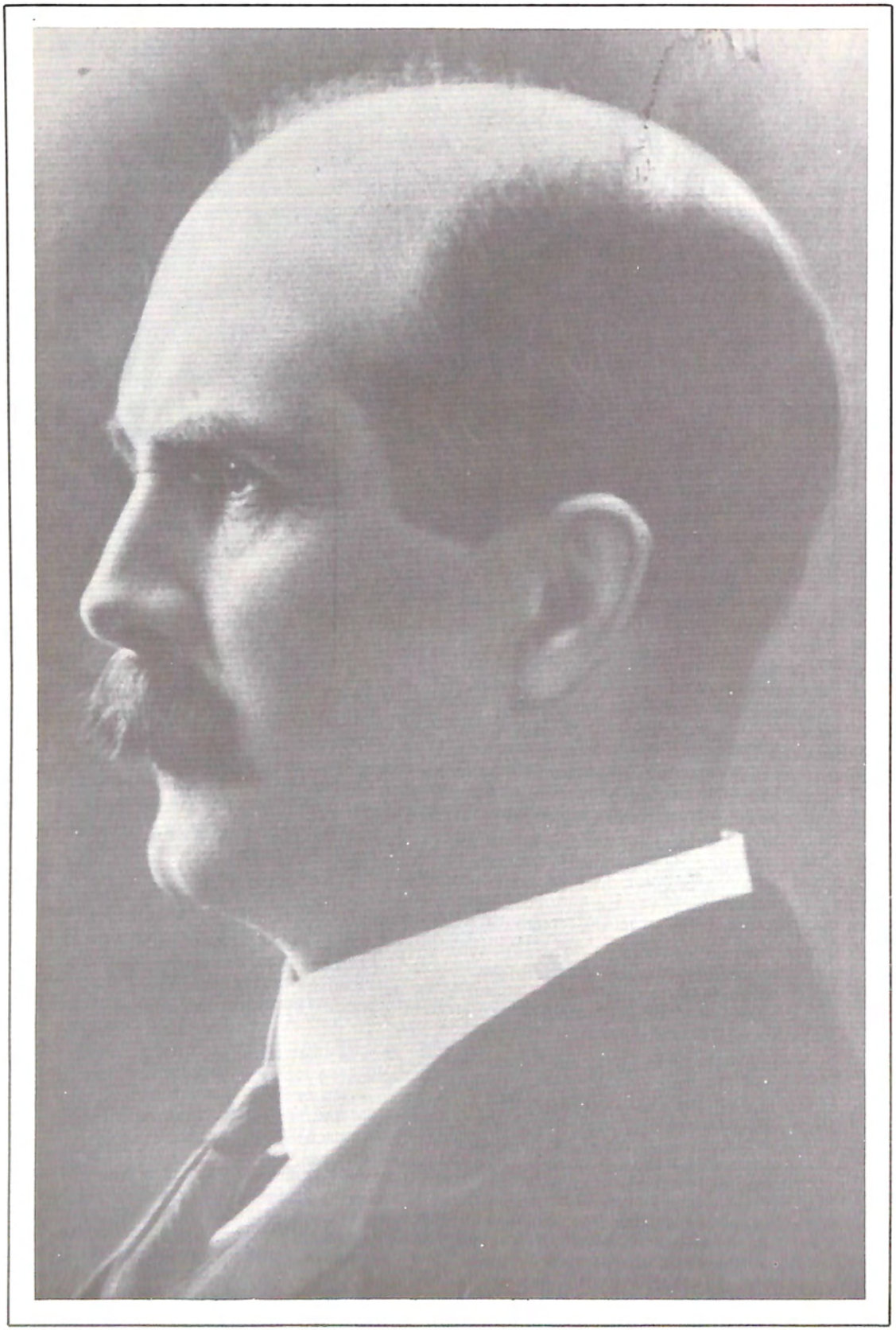
This **Supplement** photograph shows WHB in his research laboratory in the basement of the University building. The young man seated on the left is H.J. Priest, Assistant Lecturer in Mathematics and Demonstrator in Physics. I have not been able to identify the apparatus in front of him. The man standing on the right is J.P.V. Madsen.

Bragg and Madsen are facing the radium-ionisation chamber equipment with which they have begun to investigate the nature of gamma-rays (see photograph 33). The piece of apparatus standing on a wooden box at Madsen's left hand is a Geryk mechanical vacuum pump.

In the foreground are the several pieces of equipment that have been developed for the alpha-particle experiments (photograph 23). Several of these items are clearly related to the handling of gases, and the beam balance is arranged to weigh gas samples. A high-voltage induction coil lies in front of the balance, and the lid of the chamber used for these studies is visible in the immediate foreground. It is connected to a manometer to measure gas pressure.

The presence of Herbert Priest in these photographs is interesting, for his name does not appear in the Adelaide University Calendar staff list. He is a representative of the number of young Adelaide graduates whom the University allowed Bragg to employ as assistant lecturers, demonstrators and laboratory assistants; James Allen, Lawrence Birks, Isaac Boas, Geoffrey Duffield and Richard Kleeman are other examples.

In a letter to the Education Committee dated 21 November 1899, WHB had pointed out that he and Chapman and Allen were responsible for teaching in all the following areas: mathematics and physics, both undergraduate and honours courses, evening classes, mining, applied mechanics, surveying, acoustics, electrical engineering and laboratory courses in most of these subjects. In pleading for a further junior demonstrator at a nominal salary, WHB noted that: 'such an assistant is of great use in the conduct of practical classes . . .'; 'a young graduate . . . would [then] stand a better chance of employment in the schools'; 'the position would be of value to the aspiring student . . . it would give opportunities for further study and for doing original work'; 'we would have much more chance . . . of finding students fit to fulfil the conditions of the 1851 Exhibition scholarships and bursaries'; and 'again, it would add greatly to the tone of the laboratory if there were always one or more students doing original, or postgraduate work in it'. These were powerful and revealing arguments, honed no doubt during WHB's period of study leave in Europe the previous year.



31. Fellow of the Royal Society

On 5 May 1906 Horace Lamb wrote to WHB from Manchester, as follows:

> 'My dear Bragg,
> Some of your scientific friends on this side [of] the equator are of [the] opinion that the time has come when you ought to be put in nomination for the Royal Society. If you do not object . . . I will draw up the necessary certificate, and get some weighty signatures. The candidature will be warmly supported by J.J. Thomson . . .'

In July, Lamb wrote again reporting progress, and explained that 'it would be very rash to encourage anyone to look forward to being elected the first time . . . but I think you ought to be well in the running on the second occasion'. Lamb prepared three certificates of candidature, listing WHB's published papers, and Thomson added a note applauding his alpha-particle studies. The first certificate was signed in the UK by Lamb, Thomson, Forsyth, Callendar, Love, Turner, Threlfall, Preece, Strutt, C.T.R. Wilson, Lodge, Townsend and Schuster; the second certificate was sent to Australia and was signed by Ellery, Masson, Baldwin Spencer, Liversidge and Haswell; and the third was sent to Canada. It was returned with one signature: E. Rutherford. Not surprisingly, WHB was elected on the first occasion; a telegram arrived at the University of Adelaide on 2 March 1907, saying simply 'Bragg selected Royal, Lamb'.

Charles Todd had been elected in 1889, and the family happily celebrated a second time. Notes of the award appeared in the newspapers, and WHB's colleagues rejoiced and shared his satisfaction. Professor Henderson left a handwritten note on his desk — 'Hurrah, hurrah for Bragg and his University. Splendid. GCH' — and WHB received letters of congratulation from his colleagues, friends and students around the world: from J.R. Wilton in London (WHB's most able mathematics graduate), from Rev. D.D. Jenkins (his mathematics master at King William's College), and from William Sheppard (the Australian who was placed first in Bragg's Cambridge class). The School of Mines Council met on 11 March and warmly congratulated him. This undated photograph of WHB is from the School's collection.

The year 1907 was eventful for another reason. Rutherford left McGill University for Manchester in May, and was asked by McGill to assist them in finding a successor. He suggested WHB, and wrote to him at length on the matter. WHB was initially very interested, although, as he said to Rutherford, 'we have struck our roots very deep . . . I think there could hardly be a more delightful city to live in than Adelaide, nor a kindlier people'. By December, however, it had become clear that the two serious fires at McGill earlier in the year had severely wounded the University financially. WHB decided not to go. He was already considering another likely offer.

32. WLB: BA Hons

WLB completed his secondary education in 1905; but he was only 15 years old, and WHB wondered about bringing such a young boy to the University. Indeed, the University had a rule that permitted students under 16 years of age to enrol only under special circumstances. But WHB no doubt remembered his own painful final year at King William's College, when he was sent back to school because of his youth; his academic work 'stagnated' and he was subjected to a traumatic religious revival at the College. Furthermore, a number of other students had obtained permission to begin their degree studies at the age of fifteen.

WLB enrolled at the University early in 1906. He studied Physics I, Inorganic Chemistry I (BA course), and second-year Pure Mathematics, in each of which he obtained a 1st Class pass. In 1907 he obtained equally good results in Pure Maths III, Applied Maths II, Physics II and Chemistry I (theoretical and experimental). Since the major part of WLB's studies concerned mathematics and physics, much of his instruction came from his father.

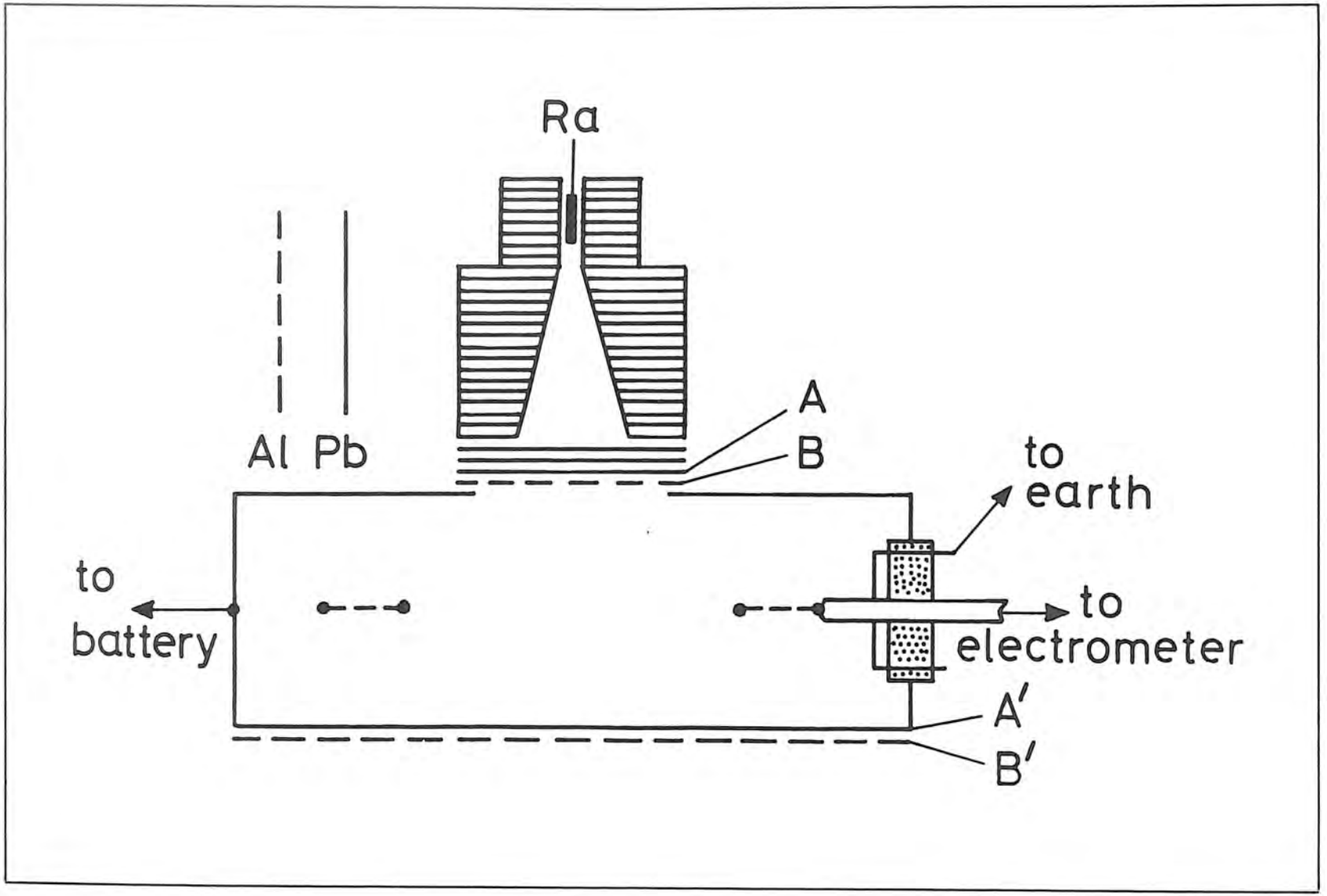
We know little about WLB's undergraduate life, but many years later he recalled these days with some sadness, albeit with a narrow focus:

> 'Although I was fifteen when I entered Adelaide University I think my emotional age was about twelve or less, and my fellow students were mature young men and women. Such a disparity has a cumulative effect. Anyone handicapped in this way is debarred from taking part in those normal activities of his age group, and the very fact that he cannot enter into their plans, schemes, differences of opinion, exercise of authority and so forth means that he loses the earlier experience which would teach him how to take his place later in life in the world of affairs. He loses touch with what is going on round about him, and he thinks of the people who guide the course of events as "they", not as "we". He develops a defence mechanism to hide his inexperience from those he meets, and this again makes him shy of asking the questions, the answers to which would keep him in touch. He is like a hermit-crab, with a formidable array of whiskers and claws in front, but with a soft white tail which it has to conceal in a protecting shell.'

WLB was too young to feel at home, and his relationship with his peers was not helped by the use of his father's University office for study purposes, which WHB encouraged. This photograph was taken in 1906, when WLB was a first-year student.

In 1908 WLB undertook the honours mathematics course and graduated BA with first-class honours. His father's influence is surely evident, for, like him, WLB did not concentrate on physics until the later years of his subsequent studies at Cambridge.

The difficulties WLB faced must not be overstated, but the tension of living in his father's shadow was a cross that WLB carried with filial piety for many, many years. Its most notable example is the confusion that survives even to the present day regarding the initial interpretation of X-ray diffraction and the origin of 'Bragg's Law'. These were WLB's discoveries; WHB, perhaps understandably but nevertheless sadly, often got the credit, despite his own efforts to direct the kudos where it belonged.


Ra
Al
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to
earth
to
battery
to
electrometer
A′
B′

33. Research: Gamma-rays

Beta-particles (electrons) and gamma-rays are also liberated in radioactive decay, and during his research with alpha-particles WHB was conscious of the vigorous discussions taking place regarding the nature of X-rays and gamma-rays. While visible and ultraviolet light could be refracted and undergo interference and diffraction, X-rays could not be demonstrated to do so, and this set them apart from electromagnetic radiation. The prevailing view was the ether-pulse theory, which saw X-rays as a stream of electromagnetic wave pulses. Bragg noted that the bulk of the ionisation induced by various rays consisted of the displacement of electrons from the atoms of the material they traversed; but how, he wondered, could an expanding wave pulse later give sufficient energy to an electron to eject it from its parent atom.

When X-rays were first investigated, WHB pointed out, and again when gamma-rays were discovered, it was suggested that they might consist of material particles. Bragg reactivated this suggestion, and gave it new persuasiveness and prominence. He proposed that a gamma-ray was a neutral pair, a positive and negative particle combined, which would have great penetrating power, be uninfluenced by magnetic and electric fields and which would ultimately suffer a violent encounter, from which its negative component would emerge as a secondary electron.

Bragg invited Madsen to assist him in investigating these radical ideas, and he was able to use the experimental techniques he had perfected earlier. If gamma-rays were ether pulses, then theory predicted that the liberated electrons would be given off equally in all directions. If they were neutral pairs, however, the electrons would fly off predominantly in the forward direction. He set up the apparatus shown opposite (redrawn from two of his papers, and visible in photograph 30), in which the forward yield from A and/or B could be compared with the backward yield from A' and/or B'. The results of interchanging A and B, or A' and B', could also be studied.

Interpretation of the experiments is complex, but WHB was justifiably convinced that his 'neutral-pair hypothesis' offered explanations which the ether-pulse theory could not provide. Through a series of letters to the English journal **Nature**, Bragg and the English physicist Barkla conducted a vigorous but inconclusive debate, Barkla insisting on a wave theory and WHB on a particle picture. WHB continued to pursue the question after he left Adelaide, but it was many years before others found what he sought: 'a scheme of greater comprehensiveness, under which the light wave and the corpuscular X-ray may appear as the extreme presentments of some general effect'. In the meantime, WHB was an eloquent advocate of the particle nature of X-rays and gamma-rays, although, unable to read German, he was largely unaware of the vital contributions being made to this question by Einstein and other German scientists.

THE STEWARDS, JUDGES, AND OFFICIALS.

Top Row: L. A. Jessop, C. Hayward, A. Scott, G. J. R. Murray, W. A. Magarey, Dr. Stokes, Dr. Hornabrook, W. Henderson, D. M. Steele.
Bottom Row: J. S. K. Mackennan, C. L. Jessop, Prof. Bragg, Dr. Barlow, Hon. G. Brookman, C. M. Muirhead, W. Fuller, C. Doudy, C. Kellett.

34. University Union and Sports Association

In the early years of the University, the handful of full-time students were content with a small, unfurnished Students' Room, but by 1889 this was quite inadequate. Angry students damaged the room and the University Council closed it. The Medical Students' Society was formed and met with other students to discuss grievances, while the Lacrosse Club joined the existing Boats and Tennis clubs. In her idiosyncratic history of the Union, Margaret Finnis sees these events as the catalyst for the forthcoming foundations of the Adelaide University Union and Sports Association. It is as the guiding spirit of the Lacrosse Club that WHB therefore enters the Union story.

Two years later the Council re-opened the Students' Room and there was further talk of a Student Union; but it was 1895 before senior members of the University proposed a more broadly-based association of graduates, staff and undergraduate students. Canon Slaney Poole formally moved the formation of the Union at a meeting held on 25 April, and the Vice-Chancellor, J.A. Hartley, occupied the chair. WHB is not mentioned, and offered his apologies for the adjourned meeting. Nevertheless, after the necessary formalities had been discussed at length, and the role of Chancellor Way as Patron or President had been left unresolved, it was the selection of Professor Bragg as a Vice-President that allowed the new Union Committee to move forward.

First priority was given to the provision of their own student and Union accommodation, and the report WHB soon presented on a building scheme was adopted and referred back to the Committee for implementation. Donations were sought, and on 24 April 1896 Bragg and Hartley wrote to the Council seeking permission to erect a modest structure designed by the University architect on the site of the old asphalt tennis court behind the main building. They had enough money to erect the central hall, but the side rooms, verandah and other embellishments would have to await further funds. Council approved the request, and the Governor laid the foundation stone on 5 August 1896; WHB insisted that students deliver the major speeches. The tiny building rose steadily, destined to become much used and much loved. WHB superintended its furnishing. The Sports Association was formed the same year.

No record of the donors survives; surely WHB was among them. Furthermore, he provided additional funds as a loan: the Secretary reported for 1897/8 that it had been possible to reduce substantially the Union Committee's debt to Professor Bragg. WHB was away on leave-of-absence during 1898 and thereafter played no major role in Union or Sports Association affairs. However, as this photograph taken at the 1906 University Athletic Sports shows, he remained a sympathetic supporter.


Australasian Association for the Advancement of Science
Adelaide Meeting 1907

35. Australasian Association for the Advancement of Science

During the summer vacation of 1887/8, WHB visited Melbourne and Sydney; young and monied, he was keen to explore his new homeland. When he got to Sydney he was welcomed by Richard Threlfall, whom he had known in Cambridge, and heard details of a preliminary meeting held two months earlier to consider the formation of the AAAS.

The first full meeting of the AAAS was held in Sydney in August-September 1888, and WHB attended as a member of its Council, having been nominated by the Royal Society of South Australia. The Association (later ANZAAS) modelled itself closely on the British Association; there were already 700 members and more than 100 papers were offered. As part of a long letter to Gwendoline Todd, WHB recorded the following impressions:

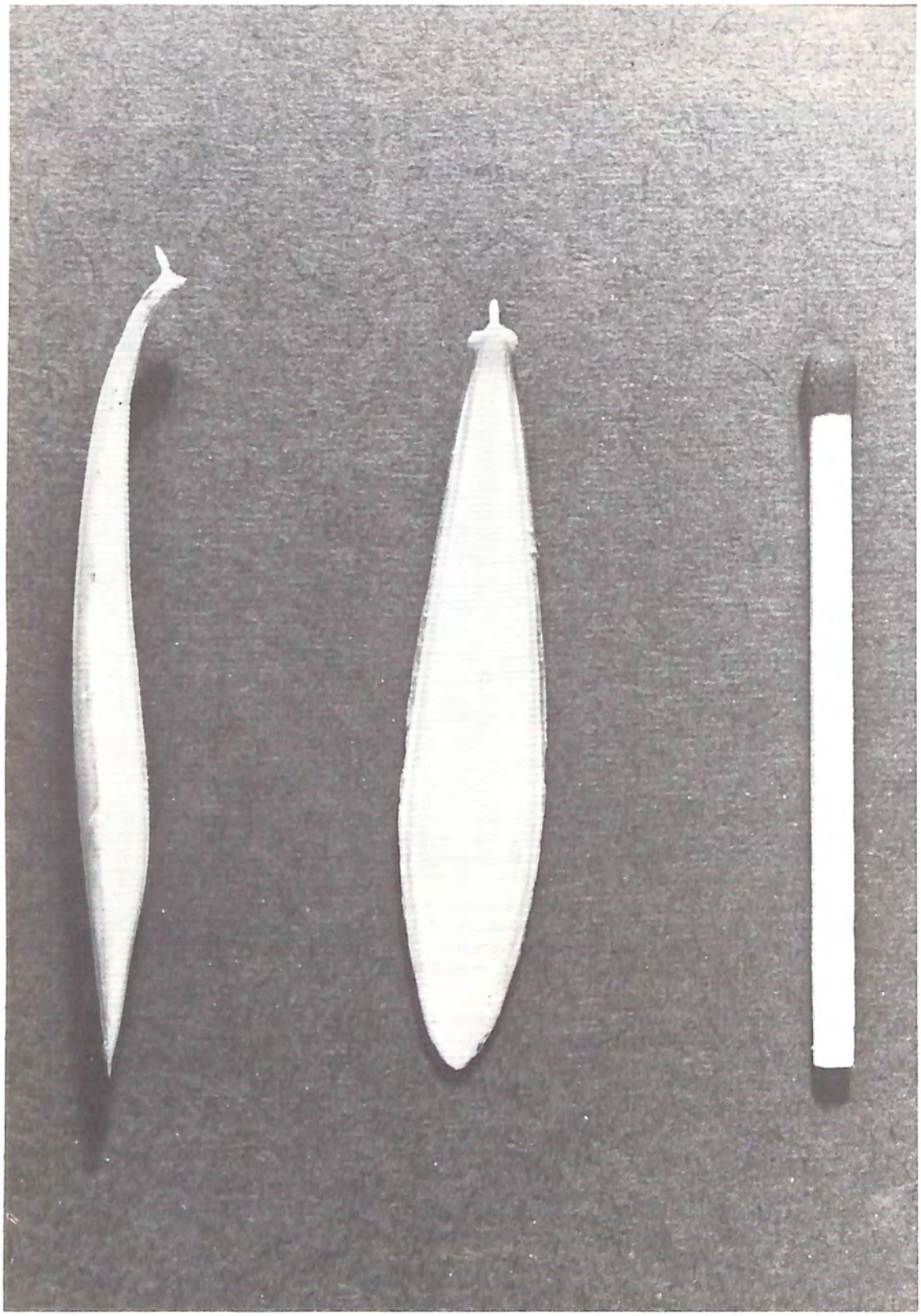
> '. . . afterwards a few of us went to Threlfall's new laboratory. Oh, Gwen, it is a fine place: mine looks so small to it. You know my workshop with my one little lathe? Well, he has a room full of all sorts of machinery, driven by a gas engine . . . Then the lecture room and laboratories and so on . . . I admire the knowledge and genius of the man who can plan such a place . . . and get it built. Well, I must just learn as much as I can, and I think I can get a lot of assistance. I think this Association is going to do us a lot of good, especially such as, like me, are willing to work, but don't quite know where to begin. Contact with other and more experienced workers will start us off on the right track.' . . . 'I find it such a great advantage to me to meet these men and for a time to live in the atmosphere they create.'

There can be fewer more dramatic statements of the value of scientific conferences, and it throws into sharp relief the particular advantage of AAAS meetings for the locally and internationally isolated Australian scientists, and particularly for WHB, young and energetic but very inexperienced. These meetings were an essential ingredient in his professional and personal development.

Electricity and magnetism was the focus of WHB's early contributions to AAAS meetings: at Christchurch in 1891, Hobart 1892 (Section A Presidential Address), Adelaide 1893 (for which he and Rennie were the General Secretaries), Brisbane 1895 and Sydney 1898 (by WHB's colleague, C.C. Farr). The 1904 Section A Presidential Address WHB gave at Dunedin, as we have seen (photograph 23), marked the commencement of his research career.

The January 1907 meeting was held in Adelaide; Madsen helped with secretarial tasks and WHB was Treasurer. He and Kleeman reported their latest research results. This photograph was taken at the Government House Garden Party. WHB is clearly visible in the foregound, but I have searched in vain for his wife. She almost certainly excused herself, as she had done for the January 1890 Melbourne meeting, and for the same reason: WLB was born on 31 March 1890, their daughter Gwendolen Mary Bragg on 26 February 1907.

WHB took his two sons to the 1909 Brisbane meeting shortly before the family left Australia, and there he gave the major Presidential address. Entitled 'The Lessons of Radioactivity', it is a large and insightful paper. Its disarming style makes delightful reading.



Sepia braggi

The Bragg family usually spent their holidays at the seaside: Pt Willunga, Pt Elliott, Semaphore, Brighton, Normanville, Aldinga and Grange. The boys loved the crashing breakers of the southern ocean and the whisper of the waves travelling along the beaches of St Vincent Gulf.

WLB collected shells. Sometimes, alone or with his brother or a friend, he took the train to Glenelg to search for additions to his collection. In the summer of 1906/7 Willie Bragg found a cuttlefish bone that he had not seen before: small, slender and elegantly curved. He took it to Dr Verco, who had the finest collection of shells in the city and was always helpful to a young enthusiast. Verco verified its novelty and proposed the name **Sepia gondola** because of its shape, but as WLB's face fell Verco quickly suggested **Sepia braggi**. When Verco described it to the Royal Society of South Australia in August he noted: 'The type was found at Glenelg by Master Bragg, and we have pleasure in naming it after him, and at the same time complimenting his father, one of our most honoured Fellows, who has just been distinguished by the Fellowship of the Royal Society of London.'

Only in recent years have animal specimens been collected and detailed studies of southern Australian cephalopoda been undertaken. This photograph shows two views of a **Sepia braggi** cuttlebone, with a match to indicate size.

The careers of WHB and WLB had much in common: brilliant school and undergraduate records, specialising in mathematics; membership of Trinity College, Cambridge; Professorships of Physics; Fellowships of the Royal Society; joint Nobel Prizes; Directorships of the Royal Institution and a life-long devotion to X-ray crystallography. But their surviving contemporaries have described the two men to me in very different terms. They had very different personalities, I was told. Yet I am struck by how much they had in common, even at a personal level. WHB, for example, saw himself as a solitary child: 'I liked peace, and was content to be alone.' In describing WLB, his sister Gwendolen Caroe wrote: 'He took to solitary pursuits, such as shell collecting . . .' At school both felt out of place. As adults, neither felt totally relaxed in the company of other people, and both hid from the outside world the deep emotions they felt within. Although letters were easier, they found it difficult to talk frankly and openly to each other, each seeing, I believe, as he looked at the other, a mirror image of himself. For WLB this must have been particularly disconcerting. As he wrote in 1949 when recalling his early shell collecting in South Australia: 'it is even possible that biology rather than physics might have been my trend had there not been such a strong family tradition'.

37. Farewell

William Stroud, Cavendish Professor of Physics in the University of Leeds, was considering resignation in order to enter a business partnership. Hearing the news, Frederick Soddy wrote to his colleague Arthur Smithells at Leeds on 24 January 1907, pointing out that the claims of Professor Bragg of Adelaide University should not be overlooked in the case of any vacancy.

Leeds, like Manchester (which had appointed Rutherford) was determined to build a reputation for the quality of its research, and agreed to provide a retirement allowance and at least £1,000 for equipment in order to secure WHB's acceptance. J.J. Thomson, Larmor, Schuster and Rutherford testified to his qualities as a research scientist and teacher. Stroud agreed to stay on until WHB could arrive early in 1909.

Bragg agonised over the offer. He loved Adelaide, and industrial Leeds was far less attractive. On the other hand, he would be near Rutherford and close to Cambridge where he hoped his boys would study; he would have less teaching, more research students, greater facilities and constant opportunities to meet other research men; and the country north of Leeds offered a delightful retreat from the grimy city. Still WHB was uncertain. In April 1908 he wrote to the Adelaide University Council tendering his resignation, but at the same time suggesting that the Council grant him ten months leave-of-absence and an opportunity to return if Leeds proved undesirable. The Council realised that, after 22 years, WHB was moving on; the Chancellor, indeed, had privately urged him to accept such an offer.

Many letters of congratulation flowed in, particularly from England, where old friends and fellow physicists welcomed this significant addition to their ranks. Equally, Australasian scientists were sad to see him go. Farr wrote to Rutherford from New Zealand: 'He is one of the finest fellows I know. He is as unassuming as he is brilliant . . . We are sorry to lose him from our hemisphere, for lately he, more than any other man, has helped to shift the centre of gravity of scientific research a little to the south.'

This photograph was taken at a farewell picnic in the Adelaide hills, given to WHB by his closest University colleagues and mentioned by Arthur Rogers in his diary for 3 November 1908: 'Picnic to Prof. Bragg leaves University about 1 o'clock. A great success. Given by Dr R[ennie]; most enjoyable.' Those shown are (L to R):

Front row: Eardley, Higgins, Jethro Brown, Chapman, Rennie.
Second row: Rogers, (hidden), Darnley Naylor, Henderson, W. Mitchell, Bragg, Stirling, Adams.
Back row: Priest, Madsen, Fuller, Benson, Hodge, W.T. Cooke.

Adelaide gave the Braggs a rousing send-off, with parties, tributes and gifts, but family farewells are unrecorded; Sir Charles Todd must have felt very sad. The family sailed on the new **Waratah**: Will and Gwen, Willie and Bob, and Gwendy, just able to walk. Their Australian odyssey was over.

Physics Research Students; June 1913.

W.D. Rudge. R.W. James. W.A. Jenkins. J.K. Robertson.

W.L. Bragg. V.J. Pavlov. S. Kalandgk. F.W. Aston. H.A. McTaggart. H. Smith. F. Kerschbaum. A. Norman Shaw.

R.D. Kleeman. A.M. Hughes. R. Whiddington. C.T.R. Wilson. Prof. Sir J.J. Thomson. F. Horton. R.T. Beatty. A.E. Oxley. G. Stead.

38. Cambridge

WLB entered Trinity College for the Long Vacation term of 1909. He completed the first year of the Mathematical Tripos with a First-Class pass and, on the basis of a brilliant essay, was awarded a College Senior Mathematics Scholarship. WHB strongly urged his son to change to physics, and WLB therefore took Part II of the Natural Science Tripos, graduating with a First in June 1912. C.T.R. Wilson lectured on optics and ran the Part II practical class. The delivery of his lectures was appalling, WLB remembered, but the content was marvellous, and he was excellent in the laboratory. J.J. Thomson gave them 'stimulating fireworks'.

In addition to his studies, WLB developed a close relationship with a small but varied group of friends, and he revelled in the opportunities and activities they provided. He became particularly close to Cecil Hopkinson, who introduced him to adventure and hardship, spiced with danger. They went skiing, shooting, sailing and climbing, and WLB talked to Cecil about art, new ideas and quaint and bizzare points of view.

WLB began research work in the Cavendish Laboratory in 1912. He remembered it as a sad place at the time, with too few ideas for too many students, too little money and inadequate equipment. JJ set him to work on an experiment with crude, self-made apparatus. The results were meaningless. Later in the year Robert Bragg came up from Oundle School to read Engineering at Trinity College, and in about June WHB became aware of a paper by Friedrich, Knipping and Laue and began to discuss its meaning with WLB before the end of summer holidays took him back to Cambridge. A new day was dawning.

In this 1913 photograph of the Cavendish physics research students there is WLB, J.J. Thomson, C.T.R. Wilson, and one other person WLB would have recognised immediately: Richard Kleeman.

Kleeman was born in the Barossa Valley in 1875, and left school to learn the coopering trade. He studied mathematics and physics in his own time and corresponded with WHB. With WHB's support, he entered Adelaide University in 1901, and in 1904 graduated BSc with first-class honours in physics. On the basis of his work with WHB on the alpha-rays of radium, Kleeman was awarded an 1851 Exhibition Scholarship for study at the Cavendish Laboratory. Here, working largely alone, he published five good papers, earned a BA (by research) degree, had his scholarship unusually extended for a third year, won a college prize and was awarded an Adelaide DSc. From 1909-11 Kleeman held the Mackinnon Studentship of the Royal Society, which allowed him to continue his work in Cambridge, and, for a few months, to work with WHB at Leeds. By 1913 he was married and looking for a permanent position, which he later found in the USA.

39. X-rays and crystals

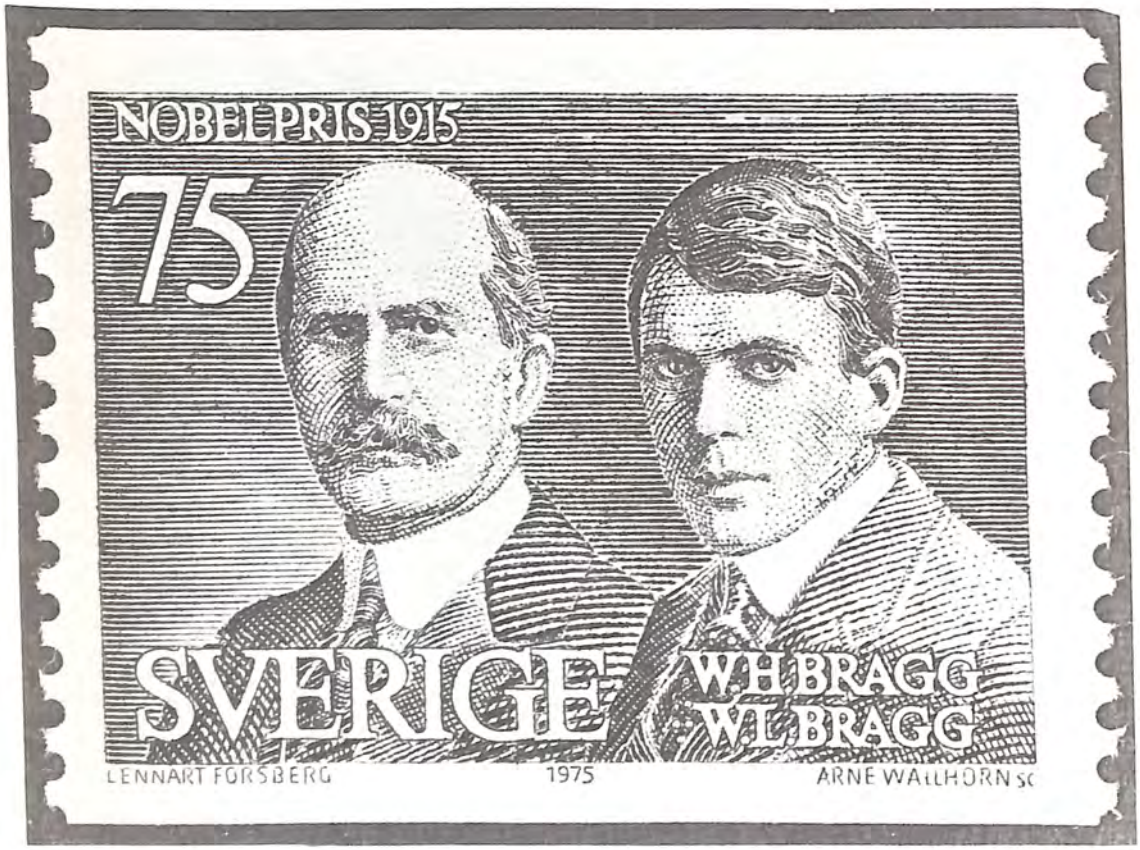
Gwendoline Bragg was horrified by the grime of Leeds but quickly recovered in the company of new friends and on holidays in the countryside. WHB took much longer to settle down. He found it difficult to build up a new laboratory, and continuation of his Adelaide work became unproductive. Then von Laue's group suggested that X-rays could be diffracted.

Diffraction was a wave phenomenon, apparently contradicting WHB's neutral-pair model, and he tried to explain the German result as the channelling of X-ray particles down the avenues between the crystal atoms. WLB, still on holiday, tried unsuccessfully to confirm this suggestion in his father's laboratory.

Back in Cambridge, WLB became convinced that diffraction was the correct explanation. He put together Thomson's pulse theory of X-rays, Wilson's optics and some knowledge of crystal structure he had gleaned from a science student group, and suddenly visualised the effect as one of reflection from atomic layers. Furthermore, if the structure of zincblende was face-centred rather than simple cubic, WLB could fully explain the German results. A crystal chemist suggested an attack on the structure of the alkali halides; and following Wilson's suggestion, WLB was able to confirm specular reflection of X-rays from the surface layers of mica.

In Leeds, WHB seized the essence of the reflection explanation and realised that an optical spectrometer could be easily adapted for the new purpose. This photograph shows WHB with an early form of the apparatus. X-rays from a hidden tube impinge on a crystal (left of centre) and are reflected into an ionisation chamber (centre), which replaced the photographic plate of the German experiment. WHB was a master of the delicate manipulations required for all these components. He excitedly determined the X-ray spectra of a range of source elements, thereby anticipating the work of Moseley and Darwin, and also determined the structure of diamond. Father and son agreed to combine their work, whether together in vacations or separately during term time; new results tumbled out every week.

In a way that seems characteristic of the family, however, great achievement and elation were mixed with sadness. WLB, jealous of his very first scientific discoveries, was overlooked. WHB's spectrometer results were far more spectacular than WLB's analysis of the German photos, and WHB was invited to tour England, Europe and America giving lectures about the work, while WLB remained at home. WHB was very careful to give his son full credit for his contributions, but for WLB this was inadequate. He felt he deserved the recognition of his peers. And then the first World War broke out.


NOBELPRIS 1915
75
SVERIGE
W.H. BRAGG
W.L. BRAGG
LENNART FORSBERG
1975
ARNE WALLHORN SC

40. Nobel Prize

At the outbreak of the War, Willie and Bob were in a territorial unit called King Edward's Horse, a mounted infantry unit composed of men from the Dominions. WLB applied for a commission, was assigned to the Leicestershire Royal Horse Artillery and spent a year training in Norfolk. Bob also applied for a commission and joined the 58th Brigade of the Royal Field Artillery.

In June 1915, Bob sailed with his unit to Alexandria, where mixed bathing in the warm water was 'just like out in Australia'. In August, WLB was withdrawn from the horse artillery and sent to France to superintend the development of a new French technique for determining the position of enemy guns by recording the time of arrival of their sound along the front. With the help of other physicists, WLB developed 'sound ranging' into a practical and accurate technique. The Germans were outwitted; the Americans came to copy.

WHB was in Canada and America on a lecture tour, but he curtailed his visit and hurried back when Gwendoline's anxiety called him home. On 3 May 1915, the Trustees of Columbia University awarded to WHB and WLB the Barnard Gold Medal, given every five years for meritorious service to science, for their work on X-rays and crystals. In June, WHB accepted an invitation to go to University College, London, and resigned reluctantly from the University of Leeds.

In August, Harry Moseley, 'the most promising of all the English physicists of his generation', was killed at Gallipoli; and then September brought the news they feared most. Bob was sitting in a Gallipoli dugout when a shell came through the sand bags, severed his left leg and damaged the other beyond repair. He died some hours later. WLB's other great friend, Cecil Hopkinson, was also killed.

When, on 14 November 1915, WHB received a telegram from Sweden notifying him of the joint award of the 1915 Nobel Prize for Physics, he had no remaining strength with which to celebrate. He buried the happiness deep within, alongside the agony of Bob's death, and went on with his war work. The Australian days of sunshine and innocence were gone forever.

Gwendoline never fully recovered. Her gaiety went, her daughter recalled; from then on her cheerfulness was a fire lit for others, at which she warmed her own hands.

WLB seems to have remained largely untouched by the hell around him. He enjoyed the challenge of his scientific work and its successful outcome. He remains the youngest person ever to win a Nobel Prize, and he savoured the attention it brought. Perhaps, like others, he realised that the only way to survive was to concentrate on the job at hand and ignore the rest. Surely the madness would soon be over and he could resume his research as before.

Notes

Major references

The following are the principal works in regard to the subject matter of this book.

a. **W.H. and W.L. Bragg**

G.M. Caroe, **William Henry Bragg 1862-1942: Man and Scientist** (Cambridge University Press, 1978).

E.N.daC.Andrade, 'William Henry Bragg 1862-1942', **Obit. Notices Fellows Roy. Soc., 4** (1942-44) 276-300.

Sir David Phillips, 'William Lawrence Bragg 1890-1971', **Biog. Memoirs Fellows Roy. Soc., 25** (1979) 75-143.

Sir Lawrence Bragg and Mrs G.M. Caroe, 'Sir William Bragg, F.R.S.', **Notes & Records Roy. Soc. Lond., 17** (1962) 169-182.

P. Forman, in C.C. Gillispie (ed.), **Dictionary of Scientific Biography** (Scribner's Sons, New York, 1970) vol. II, pp. 397-400.

S.G. Tomlin, in B. Naim and G. Serle (eds), **Australian Dictionary of Biography** (Melbourne University Press, 1979) vol. 7, pp. 387-389.

S.G. Tomlin, **Aust. Physicist, 12** (1975) 165-168; **ibid., 13** (1976) 76-80, 97-99; **ibid., 14** (1977) 55-60.

Sir Kerr Grant, **The Life and Work of Sir William Bragg** (University of Queensland Press, 1952).

P.P. Ewald (ed.), **Fifty Years of X-ray Diffraction** (International Union of Crystallography, Utrecht, 1962).

At their deaths (WHB, 1942; WLB, 1971) there were numerous obituary notices in the popular press and scientific literature.

The professional and some personal papers of W.H. and W.L. Bragg are lodged in the Archives of the Royal Institution, London. The University of Adelaide has retained the great majority of its papers, including inward and outward correspondence and committee papers, now lodged in the University's Archives. Other family papers are in the care of Lady Adrian, Pembroke College, and Dr S.L. Bragg, Cambridge. I have also benefitted from a helpful conversation with Lady Bragg.

b. **South Australia**

The centenary history of the University is useful if not extensive: W.G.K. Duncan and R.A. Leonard, **The University of Adelaide 1874-1974** (Rigby, Adelaide, 1973).

M.M. Finnis, **The Lower Level** (A.U. Union, Adelaide, 1975) is a discursive history of the Adelaide University Union.

D. Pike, **Paradise of Dissent** (Melbourne University Press, 1967) remains the authoritative history of the early years of South Australia; a shorter and more general work is R.M. Gibbs, **A History of South Australia** (Southern Heritage, Adelaide, 1984).

The following notes give some specific references to particular topics and provide the names of people and institutions who have supplied photographs. Items from the list of major references above, however, are not repeated.

1. **Market Harborough**
   Ref: J.C. Davies and M.C. Brown, **Yesterday's Town: Victorian Harborough** (Barracuda, Buckingham, 1981).
   Photos: Michael Brown; Leicestershire Museums, Art Galleries & Records Services (Sam Mullins, Keeper, The Harborough Museum).

2. **Family**
   Photo: Lady Adrian.

3. **King William's College**
   Refs: College Archives, including **King William's College Register** (Maclehose, Glasgow, various editions), and the College magazine, **The Barrovian.**
   Photos: King William's College (Dr P.K. Bregazzi, Principal).

4. **Trinity College, Cambridge**
   Refs: Cambridge University Library (e.g. **Cambridge University Reporter**, Rutherford papers etc.); Trinity College Library (e.g. **Admissions Book, 1850-**, etc).
   Photos: King William's College Archives; **The Graphic**, 12 July 1884, p. 29.

5. **Adelaide and Dr Alfred Lendon**
   Ref: J.G. Jenkin, 'The Appointment of W.H. Bragg, F.R.S., to the University of Adelaide', **Notes & Records Roy. Soc. Lond., 40**(1) (1985).
   Photos: South Australian Archives (North Terrace); Mrs E. Wells (Dr Lendon).

6. **Todd family**
   Photos: Mrs E. Wells (Gwendoline Todd); The South Australian Institute of Technology (Charles Todd).

7. **Adelaide University**
   Refs: G. Blainey, **A Centenary History of the University of Melbourne** (Melbourne University Press, 1957) p. 24; J.G. Jenkin, **op. cit.** (note 5).
   Photos: Barr Smith Library (University); Royal Institution Archives (lecture notes, 31A/1).

8. **Barr Smith Theatre**
   Ref: J. Brown and B. Mullins, **Town Life in Pioneer South Australia** (Rigby, Adelaide, 1980), pp. 174-186; Scotch College **(Magazine 1981,** and Mr K. Preiss).
   Photo: South Australian Collection, State Library of S.A.

9. **Picnics**
   Ref: E. Warburton, 'Picnics in the Hills', **J. Hist. Soc. Sth. Aust., 6**(1979) 46-54.
   Photos: Mr A.D.R. Caroe (picnic); Mrs E. Wells (W.H. Bragg). I am grateful to Dr J. Liesegang for deciphering the menu lettering.

10. **Sport**
    Refs: J.G. Jenkin, 'William Bragg and Lacrosse in Adelaide', **Aust. Physicist, 17** (1980) 75-78; J.G. Jenkin, 'William Bragg in Adelaide: Tennis too!', **Aust. Physicist, 18** (1981) 69-70, 131.
    Photo: South Australian Archives.

11. **Arthur Rogers**
    Ref: Personal diaries of A.L. Rogers, in the care of Miss E.C. Rogers.
    Photo: Miss E.C. Rogers

12. **Marriage**
    Ref: Royal Institution Archives, Bragg papers (37A(1)).
    Photos: Mr R.M. Gibbs.

13. **Little boys**
    Photo: Royal Institution Archives, Bragg papers (28A/1).

14. **X-rays**
    Ref: Adelaide newspaper reports; H. Hamersley, 'Radiation Science and Australian Medicine 1896-1914', **Hist. Records Aust. Sci., 5** (1982) 41-63.
    Photo: Flinders Medical Centre (Mr G. Tidswell).

15. **The Observatory**
    Photo: South Australian Archives.

16. **Radio**
    Refs: J.F. Ross, **A History of Radio in South Australia** (author, Adelaide, 1978) ch. 1; Royal Institution Archives, Bragg papers (Thelfall correspondence, 6C); A.S. Eve, **Rutherford** (Cambridge University Press, 1939) p. 13; Telecommunications Museum, Adelaide (Mr M. Gooley).
    Photos: G.F. Dodwell, 'Brief Account of the Adelaide Observatory', in **Intelligence Bulletin** (SA Government, Adelaide, 1910) Fig. 6; South Australian Archives (the sailor in front of the radio hut at Henley Beach is Chief Petty Officer Signalman F.V. Woodman).

17. **Study leave**
    Photo: Dr S.L. Bragg.

18. **East Terrace home**
    Ref: Regarding the royal visit, see J.G. Jenkin, 'The 1901 Royal Visit to Adelaide: An Account by William and Gwendoline Bragg', **J. Hist. Soc. Sth. Aust.,** (1986) forthcoming.
    Photos: Dr S.L. Bragg (family); Mr R.M. Gibbs (house).

19. **St Dominic's and Queen's School**
    Refs: D. O'Sullivan, **Dominican Sisters of North Adelaide: Their History and Spirituality 1883-1983** (St Dominic's, North Adelaide, 1983); Mr D.O. Haslam (regarding Queen's).
    Photos: author.

20. **Exhibition Building and Elder Conservatorium**
Refs: Adelaide Jubilee International Exhibition, **Reports and Lists of Awards** (A.J.I.E. Exec. Ctee, Adelaide, 1889); C. McKeough and N. Etherington, 'Jubilee 50', **J. Hist. Soc. Sth. Aust., 12** (1984) 3-21.
Photo: South Australian Archives.

21. **Royal visit**
Ref: See note 18.
Photo: **The Critic**, 27 July 1901, p. 2.

22. **School of Mines and Industries**
Refs: S.A. School of Mines and Industries, **Annual Reports**; D. Green, **An Age of Technology 1889-1964** (S.A.I.T., Adelaide, 1964).
Photo: South Australian Institute of Technology (Mrs H. Pearce).

23. **Research: Alpha-particles**
Ref: For Bragg's own retrospective account of this research, see W.H. Bragg, **Studies in Radioactivity** (Macmillan, London, 1912).
Photo: **Ibid.**, p. 14 (from **Philosophical Magazine, 13** (1907) plate IX); Royal Institution Archives, Bragg papers (research note-books, box 12).

24. **Rutherford and Soddy**
Refs: There is a considerable literature on Ernest Rutherford: the recent D. Wilson, **Rutherford: Simple Genius** (Hodder & Stoughton, London, 1983) has a bibliography of the major works; for Soddy and his visit to Australia, see J.G. Jenkin, 'Frederick Soddy's 1904 Visit to Australia and the Subsequent Soddy-Bragg Correspondence', **Hist. Records Aust. Sci., 6**(1) (1985) and references therein.
Photos: Dr J.A. Campbell (Rutherford); British Journal of Radiology (Soddy).

25. **Student 'prosh'**
Refs: M. Page, **Muscle and Pluck Forever: The South Australian Fire Services 1840-1982** (S.A. Metro. Fire Service, Adelaide, 1983); B. O'Neil, **In Search of Mineral Wealth** (S.A. Dept. Mines & Energy, Adelaide, 1982).
Photo: Dr E.H. Medlin.

26. **St Peter's College**
Refs: A.G. Price, **The Collegiate School of St Peter 1847-1947** (S.P.S.C., Adelaide, 1947); St Peter's College Archives (Messrs S. Owen and R.W. Fisher).
Photos: St Peter's College Archives.

27. **Royal Adelaide Golf Club**
Ref: R.A.G.C. Archives (Mr B. Scott); Corporation of the City of Adelaide Archives (Mr P. Crush); G.M. Caroe, **William Henry Bragg (op. cit.)** p. 131.
Photo: Royal Adelaide Golf Club.

28. **University staff, 1906**
Photos: **Supplement to The Critic**, 11 July 1906.

29. **Laboratories and Electrical Engineering**
Refs: Sir Frederick White, 'J.P.V. Madsen', **Records Aust. Acad. Sci., 2** (1970) 51-65; R.W. Home, 'W.H. Bragg and J.P.V. Madsen: Collaboration and Correspondence, 1905-1911,' **Hist. Records Aust. Sci., 5** (1981) 1-29.
Photos: See note 28.

30. **Research laboratory**
Ref: University of Adelaide Archives (docket 936/99, WHB to Education Committee, 21 November 1899).
Photo: See note 28.

31. **Fellow of the Royal Society**
Refs: Royal Institution Archives, Bragg papers (4A/2,3); Library of the Royal Society, London (Mr N.H. Robinson); Cambridge University Library, Rutherford correspondence (Add MS 7653).
Photo: South Australian Institute of Technology.

32. **WLB: BA Hons**
Refs: University of Adelaide Archives; WLB unpublished autobiographical notes.
Photo: Royal Institution Archives.

33. **Research: Gamma-rays**
Refs: R.H. Stuewer, 'William Bragg's Corpuscular Theory of X-rays and γ-rays', **Brit. J. Hist. Sci., 5** (1971) 258-281; B.R. Wheaton, **The Tiger and the Shark: Empirical roots of wave-particle dualism** (Cambridge University Press, 1983).
Photo: J.G. Jenkin, 'Was the "First" Angle-resolved Photoemission Experiment done at Adelaide University in 1908?', **J. Electron Spectrosc., 15** (1979) 307-322, fig. 4.

34. **University Union and Sports Association**
Ref: M.M. Finnis, **The Lower Level** (A.U. Union, Adelaide, 1975).
Photo: **The Adelaide Observer,** 25 August 1906, p. 28.

35. **AAAS**
Refs: **AAAS Reports** for relevant meetings; Royal Institution Archives, Bragg papers (37A(1), letter of 28-30 August 1888).
Photo: Barr Smith Library, University of Adelaide.

36. **Sepia braggi**
Refs: J.C. Verco, 'Notes on South Australian Marine Mollusca, with Descriptions of New Species — Part VI,' **Trans. Roy. Soc. Sth. Aust., 31** (1907) 213-214; Royal Institution Archives, Bragg papers (50A, letter WLB to W.I.B. Beveridge, 28 September 1949).
Photo: Mr G.J. Newton, (specimen supplied by Dr C.C. Lu, National Museum of Victoria).

37. **Farewell**
Ref: Cambridge University Library, Rutherford correspondence (Add MS 7653).
Photo: Barr Smith Library.

38. **Cambridge**
Refs: See note 4; for Kleeman see **Record of the Science Research Scholars of The Royal Commission for the Exhibition of 1851, 1891-1960** (Commissioners, London, 1961) p.35.
Photo: Cavendish Laboratory, Cambridge.

39. **X-rays and crystals**
Refs: There is a very considerable literature on the early days of X-ray crystallography, P.P. Ewald (ed.), **Fifty Years of X-ray Diffraction** (Intl. Union of Crystallography: Utrecht, 1962) offers a very good introduction; W.L. Bragg wrote several accounts, the most extensive being W.L. Bragg, **The Development of X-ray Analysis** (Bell & Sons, London, 1975).
Photo: Science Museum, London (578/77).

40. **Nobel Prize**
Refs: Sir Lawrence Bragg, **et al., Artillery Survey in the First World War** (Field Survey Association, London, 1971); J.L. Heilbron, **H.G.J. Moseley** (University of California Press, Berkeley, 1974) p. 123.
Photo: Mr G.J. Newton (stamp, Sweden, 1915).

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John Jenkin was born in Adelaide and educated at Prince Alfred College, the University of Adelaide and the Australian National University. After periods of post-doctoral research in England and America, he returned to Australia in 1968 to teach physics at La Trobe University, Melbourne, an occupation he still enjoys. Dr Jenkin's major research interests have progressively changed in recent years from physics to the history of science.

This photograph was taken in 1984 in front of the old Market Harborough Grammar School, Leicestershire, England, where W.H. Bragg received his early education during the years 1869 to 1875; Dr Jenkin (right) is talking to Market Harborough historian Mr Chris Davies (photograph courtesy Mr Sal Lo Galbo and the **Harborough Mail**).

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