



W.M. Goss

Making Waves

The Story of
Ruby Payne-Scott:
Australian Pioneer
Radio Astronomer



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The Story of Ruby Payne-Scott:
Australian Pioneer Radio Astronomer

 Springer

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Cover image: *The Great Wave, after Hokusai*, 1980, by Fiona Hall. Type C photograph, 33.0 x 25.1 cm. Courtesy of the artist and Roslyn Oxley9 Gallery, Sydney. In this work, Hall uses scraps of cloth, rotting banana peels, bits of plastic toys, a pair of children's shoes, matchsticks, perforated paper, old postcards, wire and more to reconstruct the old master print from c. 1831, *The Great Wave off Kanagawa* by Hokusai. The original print is considered by many to be a masterfully composed visual space with clear connections to the ideal mathematical proportions found in nature

Cover background image: Great Ball of Fire. This image from the Solar Dynamics Observatory of the news-making solar event on 2010 August 1 shows the C3-class solar flare (white area on upper left), a solar tsunami (wave-like structure, upper right), multiple filaments of magnetism lifting off the stellar surface, large-scale shaking of the solar corona, radio bursts, a coronal mass ejection and more. Credit: NASA/SDO/AIA

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Foreword

It is rare for a complete biography of an Australian scientist, particularly of an Australian woman scientist, to be published. It is rarer for such a book to be authored by an American.

Though scientists have written discourses on the history of their discipline, it is most unusual for a scientist to write a full-length biography of a colleague in his field. It is also uncommon for a man to write about an Australian woman scientist; most of the work on Australian women scientists has been done by other women. However, this author, a distinguished researcher in the field of radio astronomy, became so interested in the history of his discipline and in the career of the pioneer radio astronomer, Ruby Payne-Scott, that he spent some years bringing this book to fruition.

Until relatively recently, Ruby Payne-Scott had been the only woman scientist mentioned briefly in histories of Australian science or of Australian radio astronomy. This book will be an invaluable resource for anyone interested in these disciplines. Being a scientist himself, the author explains Payne-Scott's scientific work in detail; therefore, the value and importance of her contributions can, for the first time, be recognised, not only by historians but also by scientists.

After a brilliant academic career, with an M.Sc. in physics (the highest qualification then available at any Australian university), Ruby Payne-Scott worked as a science teacher, one of the few professional positions available to Australian women in the 1930s and especially in the Depression. However, the Second World War opened up opportunities for women science graduates. She was one of the first of the scientific staff members appointed to the new Radiophysics Laboratory of the Council for Scientific and Industrial Research (CSIR) from which radio astronomy developed and notably the first woman scientist in the Laboratory.

Ruby Payne-Scott was part of a pioneering group of radar scientists during the Second World War, led by J. L. Pawsey, whose scientific distinction and leadership qualities have been referred to by all writers in the field. Although it was mainly due to him that radio astronomy developed in Australia from 1944, she was one of the key people contributing to Australia's pre-eminence in the world in radio

astronomy for many decades. Pawsey valued her judgment and experience so highly that when she was absent from a meeting, he would often not make a final decision until she had been consulted. She became the overall advisor to the group on scientific issues, engineering planning and mathematics; she also made major contributions to the development of radio astronomical techniques.

By 1951, when she left the discipline, she was set to be promoted to the highest research category short of the leader and to be paid the second highest salary on the scientific staff. Her standing was confirmed later by a member of this distinguished group who himself became an important radio astronomer but who disliked Payne-Scott; nevertheless, he considered her, as the author records, to have been “one of the best physicists at Radiophysics – no, one of the best physicists in Australia”.

In telling Payne-Scott’s story, the author highlights the inferior position of women in the workforce at that time. Married women could not become permanent employees in the public service. The practice of requiring women to choose between marriage and their careers inevitably deprived Australia of unknown talent.

Payne-Scott had to suffer the indignity of keeping her marriage secret from CSIR for some 5 years. When the marriage was discovered, she fought vehemently against the injustice of this regulation but was forced to become a temporary employee, losing all her superannuation entitlements in the process. She finally resigned in 1951 when pregnant with her first child, as there was no maternity leave at that time.

The War years provided some measure of equal pay for women. After the War, the old discriminatory practices returned. Payne-Scott, together with other colleagues, campaigned unsuccessfully for the recognition of the principle of equal pay.

“Women’s rights” was not the only issue about which she felt strongly and for which she argued publicly and vigorously. During the War, it was natural that the type of work which the group was engaged in was classified; but after the War, she was bitterly opposed to secret research in the CSIR. She believed that it was impossible to do good research in the atmosphere of limitations imposed by a sponsoring body, particularly when that body was the military. She wrote to CSIR: “Frightened men do not produce great research.”

The Australian Security Intelligence Organisation kept files on her that have only recently been made available to researchers. A subsequent media release by the National Archives of Australia, headed “The Secret Life of Ruby Payne-Scott”, states that she was “passionate about both the independence of scientific research and human rights. These sentiments were deemed a security risk”.

The work of pioneering Australian women scientists is gradually being recognised. CSIRO offers OCE Science Team Career Awards. One of these is the OCE Payne-Scott Career Award for researchers returning from family-related career breaks. The life and work of a feisty, brilliant woman is finally being recognised.

Preface

In the mid-twentieth century, radio astronomers revolutionised our view of the universe by observing new objects, ones that had not been previously known by optical astronomers. Even the sun is vastly different when studied by the radio astronomer, yielding clues about the outer regions of the sun that are difficult for the optical astronomer to observe. Ruby Payne-Scott was one of the first radio astronomers in Australia and the first female radio astronomer in the world. Due to her brief period of, only 6 years, employment as an astronomer, her contributions largely had been forgotten by the end of the twentieth century. In addition, she was an independent-minded, sometimes, confrontational woman, even suspected of being a communist in an era when communism was a precarious ideology for an Australian to embrace. Even so, the reader may wonder why the life of Ruby Payne-Scott is of significance to us almost 60 years after her retirement in 1951.

By studying the life and career of Ruby Payne-Scott, we gain a rare insight into the intersection between a woman, who was extremely passionate about research in the new field of radio astronomy, and societal pressures that caused her to leave the field and not realise her full potential as a research scientist. What great talent did this one Australian woman have and why was she only able to devote herself to it for about 10 years of her life? And why, for decades afterward, were her discoveries and work within radio astronomy partially erased from public knowledge?

I first heard about Ruby Payne-Scott when I was a young staff member at the Radiophysics Laboratory (RPL) in Sydney, in the decade starting in 1967. I had arrived with my wife from Berkeley, California, where I had completed a Ph.D. in radio astronomy. While using the Parkes radio telescope, John Bolton, the director, told me that I should have been there at RPL 20 years earlier, when the brightest staff scientist was a woman, Ruby Payne-Scott. He claimed she was the first person in Australia to recognise the importance of radio “confusion”. I had never before heard of this great female scientist, and I admit I was not suddenly struck by the need to find out everything I could about Ruby Payne-Scott. Bolton’s comment, however, adhered to my memory and resurfaced years later as I began hearing stories from the aging founders of the field about the early days of radio astronomy. Truly, the irony of his admiration in light of the tales of antipathy and confrontation

between Payne-Scott and Bolton, which I heard many years later, was the catalyst for piecing together her story.

Even as a child, I always enjoyed reading biographies. It is a format for understanding the history of the world that I find accessible and meaningful. There are numerous histories of optical astronomy, yet understandably few about its younger cousin, radio astronomy. Radio astronomy is a relatively young branch of science after all, as will be explained in this book; it was born from radar research performed during the Second World War. My colleague, Woody Sullivan, has in fact published a few histories of early radio astronomy, and many conversations with him over the years piqued my curiosity about the instruments and the people who engineered them in the creation of the innovative new field. I also began to feel the pull of the historian and I felt that only someone who was a radio astronomer could effectively portray the unacknowledged achievements of someone about whom I had heard so much. The more I spoke with the contemporaries of Ruby Payne-Scott, such as Harry Minnett, Don Yablsley, Chris Christiansen, Bernie Mills, John Murray and Dick McGee, the more I felt that hers was a great story and an important one that needed to be told.

Starting in 1997, while visiting my daughter who was spending a half year at the University of Sydney, I started to collect information about her life, from both senior colleagues who had known her as well as the vast archival materials from the 1940s and 1950s in the National Archives of Australia. Of course many of these conversations occurred 45 plus years after the relevant events; frequent contradictions in recollections of the same events were often observed. The collections from the archives can be used in many cases to resolve these contradictions. In many cases these contemporary records from 1945–1955 can even be utilised to correct vague or even flawed memories.

A crucial element in efforts to recreate her life was meeting three key individuals: her children, Peter and Fiona Hall and her close friend Elizabeth Hall. I could never have predicted that, thanks to these friends, my quest for the past would become a bit of an obsession that constantly brought surprising discoveries. The more I learned, the more intriguing the mystery of her life became. In the end, this has been a joyful journey as I have unravelled the life of this remarkable scientist, woman and mother.

Ruby Payne-Scott's story is an inspiring saga of achievement and adversity. Fortunately, her successful career and life have now been recognised. A main motivation for this book was to make even more people aware of her important contributions to the field of radio astronomy and to further the quest for equality in the workplace.

This book is based on the 2009 Springer (Astronomy and Space Science Libraries series) *Under the Radar, The First Woman in Radio Astronomy: Ruby Payne-Scott* by W. M. Goss and Richard X. McGee. This volume is intended for a non-specialist reader. I do, however, hope that the astronomer reader will also enjoy this book. I have simplified the scientific text considerably; the detailed, technical appendices are not included. An additional chapter has been added at the beginning of the book to provide the reader with a basic background of both solar physics and radio telescopes.

Acknowledgements

Many colleagues and friends have contributed to this book. In the preface to *Under the Radar, The First Woman in Radio Astronomy: Ruby Payne-Scott*, I have thanked many people for their assistance in the preparation of the 2009 book. I am indebted to my late co-author of *Under the Radar*, Richard (“Dick”) X. McGee (1921–2012) for extensive collaboration since 1967.

In the writing of this book, I have been ably assisted by my daughter-in-law Pax Bobrow as a conscientious editor of *Making Waves, The Story of Ruby Payne-Scott: Australian Pioneer Radio Astronomer*. The title of this book was suggested by Alison Muir (www.textualhealing.com.au) of Sydney, who also provided the title for the 2009 book. Alison also played a major role in the 2009 book launch at the University of Sydney. Loretta Appel has remained a valuable colleague, including the identification of Ruby Payne-Scott’s image in several group photographs.

Dr. Elizabeth Hall has provided extensive assistance in updating the story of Payne-Scott’s family. Betty Hall has been a steadfast friend and advisor for many years; without her, the two books about Ruby Payne-Scott would not have been possible. Betty provided the family history in Chap. 2.

The children of Ruby Payne-Scott, Peter Hall and Fiona Hall have continued to provide advice and support. A visit with Fiona in Adelaide in 2007 was an unforgettable experience for Libby Goss and me.

Jessica Chapman and Barnaby Norris have provided amazing support in the use of the CSIRO Radio Astronomy Image Archive. Any historical studies of radio astronomy in Australia would not be possible without the use of this 16,000 plus photo collection (<https://imagearchive.atnf.csiro.au>)

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Finally I would like to thank W. Butler Burton, the chairman of the Editorial Board of the Springer *Astronomy and Space Sciences Library* series, for his initiative in the organisation of both volumes describing the life of Ruby Payne-Scott. In 2010, Butler suggested that I prepare a popular treatment of her life. Also I would like to express my gratitude to Harry Blom and Ramon Khanna of Springer for their support since 2009 in the preparation of this volume.

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Abbreviations and Terminology

AASW	Australian Association of Scientific Workers
ABC	Australian Broadcasting Corporation
ACTU	Australian Council of Trade Unions
ANCORS	Australian National Committee of Radio Science
ANU	Australian National University, Canberra, Australia
ANZAAS	Australian New Zealand Association for the Advancement of Science
AORG	Army Operational Research Group, the group of J. Stanley Hey in the UK during the Second World War
ASIO	Australian Security Intelligence Organisation – earlier Commonwealth Investigation Service
ATNF	Australia Telescope National Facility of CSIRO, Australia
AUI	Associated Universities, Inc. Washington, DC. USA
AWA	Amalgamated Wireless, Australasia
AWAS	Australian Women’s Army Service
BBSO	Big Bear Solar Observatory, California
Bursts	Early terminology for Type III bursts. These short timescale events were called “isolated bursts” by Pawsey and “unpolarized bursts” by Payne-Scott. See Type III bursts
CASS	CSIRO Astronomy and Space Science, Australia
CH	Chain Home; the chain of low-frequency aircraft radars in the UK, Second World War
CHL	Chain Home Low, warning radar for low-flying aircraft
CIS	Commonwealth Investigation Service, see ASIO
CME	Coronal Mass Ejections
COL	Chain Home Overseas Low – CHL used in New Zealand and Australia
CPA	Communist Party of Australia
CRC	Cancer Research Committee of the University of Sydney
CSIR	Council for Scientific and Industrial Research, 1926–1949

CSIR, OA	CSIR Officers Association
CSIRO	Commonwealth Scientific and Industrial Research Organisation, 1949-
CSIRO, OA	CSIRO Officers Association
CSO	Commonwealth Solar Observatory, Mt. Stromlo, Canberra, Australia, founded 1924. In 1957, it is transferred to the Australian National University, Mt. Stromlo Observatory – MSO
dB	Decibel, 10 times log (power ratio)
DSIR	Department of Scientific and Industrial Research, New Zealand
EAST	Eastern Australian Standard Time
Enhanced Radiation	Early terminology of Pawsey for Type I “noise storms” and associated bursts (“storm bursts”)
FASR	Frequency Agile Solar Radio Telescope
IAU	International Astronomical Union
IRE	Institute of Radio Engineers (1912–1962)
LASCO	Large Angle and Spectrometric Coronagraph - of SOHO
L band	Designation from the Second World War for the 15–30 cm range
LW/AW	Light Weight – Air Warning radar, the major achievement of RPL in the Second World War
LW/AWH	Light Weight – Air Warning-Height radar
MCA	Museum of Contemporary Art – Sydney
MHD	magneto-hydrodynamics
MSO	Mount Stromlo Observatory
nm	Nanometre (one-billionth of a metre) unit for wavelength X-ray, ultraviolet and optical radiation. For example, 500 nm is 5,000 Å (angstrom)
NRAO	National Radio Astronomy Observatory, USA
NSF	National Science Foundation, USA
NSL	National Standards Laboratory of the CSIR and the CSIRO, the Radiophysics Laboratory (RPL) shared this location from 1939 to 1968
NSW	New South Wales, Australian state
OBE	Order of the British Empire
Outbursts	Terminology invented by Allen (1947). Early term for Type II bursts. These were first discovered by Payne-Scott, Yabsley and Bolton (1947) during the giant outburst of 8 March 1947 at Dover Heights, Sydney
PC	Propagation Committee of the Radiophysics Laboratory during the last years of the Second World War until 1949, when the name was changed to the Radio Astronomy Committee
PMG	Postmaster-General’s Department (Postal, Telephone and Telegraphic Services) – Australia

PPI	Plan Position Indicator; display of azimuth and range of radar targets
RAAF	Royal Australian Air Force
Rad Lab	The Massachusetts Institute of Technology Radiation Laboratory, the centre of US radar work in the Second World War
RADAR	The new term for RDF invented in 1940. Adopted by the US Navy in 1940 and by the Allied Powers in 1943 (RA dio D etection A nd R anging)
RDF	Radio Direction Finding, the first term for “RADAR”
RPL	Radiophysics Laboratory of the CSIR and CSIRO, sometimes RP
RRB	Radio Research Board, Australia
S Band	A designation from the Second World War for the 8–15 cm range. Microwave ovens operate at S band
SBW	Sydney Bush Walkers
SDO	Solar Dynamics Observatory, satellite
SEARCH	Social Education and Research Concerning Humanity Foundation, Sydney
SGHS	Sydney Girls High School
ShD	Shore Defence Radar
SOHO	Solar and Heliospheric Observatory, satellite
SWPA	South West Pacific Area – the Second World War
TRACE	Transition Region and Coronal Explorer, far UV satellite
Type I	Most common burst events on metre wavelengths from the sun. These are short, narrow frequency band events (storm bursts) that usually occur in great numbers together with steady or slowly varying background (noise storms) with broader band continuum. Noise storms may last for hours or days. Individual bursts last for a few seconds. Type I bursts have their origin from fundamental frequency plasma emission. They were discovered by Payne-Scott and colleagues in late 1945–1946 to be associated with sunspots with high degree of circular polarization (Wild 1951). See enhanced radiation .
Type II	Bursts with slow drift from high to low frequencies. They often show fundamental and secondary harmonic frequency structures. The drift rate is in the range 0.25–1 MHz/s, lasting some minutes (Wild 1950a). Type II bursts are excited by magnetohydrodynamic shock waves in the corona, and serve as a causal agency for magnetic storms and aurorae on the earth after 1.5–3 days. During sunspot maximum, the occurrence rate is about once per 2 days. See outbursts .
Type III	Bursts of short duration (duration a few seconds) with rapid drift from high to low frequencies. These bursts may exhibit harmonics. Often they accompany the flash phase of large

	flares. They were discovered by Payne-Scott at Dover Heights in 1946. Relativistic velocities are inferred due to radiation from plasma oscillations excited by discrete bunches of fast electrons. The drift rate is in the range of 20–100 MHz/s (Wild 1950b). During sunspot maximum, the occurrence rate is about once per 20 min. See bursts .
Type IV	Bursts discovered by Boischoot and Denisse (1957), observed by Payne-Scott and Little circa 1959. They are flare-related broadband continua due to synchrotron emission. They have implied motions of about 1,000 km/s. They are also called Type IVM – “moving” in contrast to stationary component of Type IV continuum.
URSI	Union Radio Scientifique Internationale, International Union of Radio Science
VHF	Very High Frequency 30–300 MHz of 10–1 m
VLA	Jansky Very Large Array of the National Radio Astronomy Observatory
WAAAF	Women’s Auxiliary Australian Air Force
WEB	Women’s Employment Board, Australia, the Second World War and post war
WRANS	Women’s Royal Australian Naval Service
WRNS	Women’s Royal Naval Service (UK), known as the Wrens
Y Factor	Method widely used for measuring the gain and noise of a radio amplifier

Chapter 1

Introduction

Synopsis: The Life of Ruby Payne-Scott

Within this book I will explore the development of an intellectually gifted young woman during a time when women were discouraged from studying fields that were basically reserved for men. In *Irresistible Forces: Australian Women in Science* (2004), Claire Hooker has written

... [Ruby Payne-Scott] blazed her way to the peak of her profession, presaging the ambitions and successes that young women may have today... Payne-Scott from the beginning was ready for anything she might encounter in science.

I will review Ruby Payne-Scott's educational career, her work both as an engineer and astronomer, as well as a school teacher, and her passion for the Australian wilderness and bushwalking. It was this passion for the outdoors that brought her to her husband, Bill Hall, and I will also describe their wonderful family life. There are some unknown aspects of Ruby's life that I will touch on: for example, how did a middle class Australian family produce such a remarkable woman? What were the factors that influenced her career choices?

With the support of her parents, Ruby attended schools that were meant to prepare her for further education at the University of Sydney. She was an outstanding student at university and spent some years in a cancer research laboratory following her graduate degree work. Figure 1.1 is one of the earliest photographs of Payne-Scott, as a student in the 1930s. When that work dried up, she taught mathematics to secondary school children. However, with the advent of World War II when able-bodied men were rounded up all over the world by the millions as soldiers, airmen when seamen, gaping holes were left in the workforce that could be filled by able-minded women.

Ruby took advantage of this and seized a research job at the Radiophysics Laboratory (RPL) in Sydney, Australia. One can only imagine the thrill that Ruby must have felt being able to work with a group of like-minded engineers and scientists, putting all of her considerable mental faculties to work on challenging problems to perfect an aircraft warning radar system for the defence of Australia.

Fig. 1.1 Photograph of Ruby Payne-Scott as a student in the 1930s, possibly while she was studying at the University of Sydney in 1929–1932, working on a B.Sc. degree in physics (Bill Hall family collection, used by permission of Peter Hall)



The RPL cohort was a cohesive and inquisitive group that respected all members based on the quality of their work. Ruby was a star performer in this group based on her experience and scientific skills. Unfortunately, during this era, women were not expected to play major roles in the workforce if they were married or having children. Were a woman worker to marry, she would lose her permanent employment status, be demoted to a temporary worker, and lose her pension. Further, when a woman became pregnant, there were no options for any paid leave and women were expected to abandon their jobs.

It was during this time that Ruby decided to get married and start a family with her bushwalking comrade, Bill Hall, but she was enjoying her work at the RPL. She was able to continue working for some time as a permanent employee by keeping her marriage secret from her highest ranked supervisors—those close to her at work certainly knew. By the end of the war, however, she was exposed to an increased scrutiny by bureaucrats, who discovered her marriage. She fought against the consequences of this discovery but was still demoted to the status of a “temporary” staff member and lost her superannuation. In 1951, when Ruby was only 39, she was forced to retire while pregnant with her first child, Peter Hall. After leaving her career in radio astronomy Ruby worked as a secondary school teacher for 9 years. Her two children grew up in a world that slowly was changed by Ruby and women like her, who championed the rights of women to combine a career and family.

The field of radio astronomy in Australia grew out of the radar research carried out during World War II at the Council for Scientific and Industrial Research (CSIR) Radiophysics Laboratory (RPL). Ruby Payne-Scott joined the new institute in 1941, as one of the founding scientific staff—she and Joan Freeman were the first female scientific staff. RPL played a key role in the War effort, producing numerous copies of the aircraft warning radars that were used so successfully in the Southwest Pacific Area by both US and Australian military personnel from 1942 to 1945 in the war against Japan. Payne-Scott made major contributions to this top secret radar research; she became the Australian expert on the theory of the detection of enemy

aircraft using the display system that had been invented in the UK, named the PPI or Plan Position Indicator. She was also an experienced radio engineer; her work with B. Y. Mills to develop experimental, high-frequency (25 cm) aircraft warning radar contributed to her success as an experimental radio astronomer starting in mid-1945.

Late in World War II, women in the civil service in the Federal government were paid wages equal to that of their male counterparts, a great contrast to the previous convention of paying women only two-thirds of the male wage. In 1949, Payne-Scott was involved in a public controversy when the CSIR began to withdraw wage parity. It was only in 1969 and 1972 that Australian women were given wage equality based on rulings of the Australian Conciliation and Arbitration Commission. In addition, she and many of her male colleagues were strong proponents of non-military research in the newly established Commonwealth Scientific and Industrial Research Organisation (CSIRO), formed in 1949. She and many others participated in writing letters to both newspapers and to internal CSIRO publications in support of this cause, thus garnering the attention of the Australian Security Intelligence Organisation.

Payne-Scott started her career in radio astronomy, testing radar equipment with Joseph L. Pawsey in 1944. Her first observation was made from the RPL building on the campus of Sydney University in March 1944, during a test of military radar equipment at 10 cm. Thus Payne-Scott became one of the first radio astronomers, as well as the first woman radio astronomer. This observation also represented the first astronomical project with Pawsey, an association that became decisive in the years 1945–1951. Pawsey was the “father” of Australian radio astronomy. His research and recruiting of new, talented radio astronomers has had an effect on the astronomical world that continues into the twenty-first century.

An explosive growth of radio astronomy occurred in Australia starting in late 1945. RPL became one of the pre-eminent radio astronomy institutes in the world under the direction of Pawsey and Edward (“Taffy”) G. Bowen. Within a few years, Australia established its international leadership in radio astronomy. Payne-Scott wrote one of the first summary papers in radio astronomy in December 1945 and participated in the first Australian publication of the budding field in early 1946, as the second author. From 1945 to 1952, the RPL radio astronomers published 62 papers in radio astronomy; Payne-Scott was a participating author in nine of these publications. During this period, radio astronomers in the rest of the world followed the Australian developments with great interest. A few Australian radio astronomers made visits to the US, Canada and Europe where the new results were shown during conferences and observatory visits.

In the short period from 1945 to her resignation in July 1951, Payne-Scott became a driving force in early radio astronomy in Australia; she was the first scientific leader in the solar radio group, directed by Pawsey. In 1946 she discovered Type III solar radio bursts, which originated at long radio wavelengths in the solar corona. She played an important part in the discovery of Type I bursts (1946) and Type II solar radio outbursts (1947). Payne-Scott, together with Alec Little, even detected Type IVM solar radio outbursts with the Potts Hill swept-lobe



Fig. 1.2 The most commonly published photograph of Ruby Payne-Scott. This was taken at the Potts Hill Reservoir, likely in late 1948. “Chris” Christiansen is to the right with Alec Little in the middle. Payne-Scott and Little were working on observations of the sun at 97 MHz using the newly constructed swept-lobe interferometer (Chap. 10) (CSIRO Radio Astronomy Image Archive B14315)

interferometer in 1949–1951, several years before the bursts were recognised as distinct physical entities by the French group of Boischot and Denisse. The photograph we see in Fig. 1.2 of Ruby Payne-Scott, W. N. “Chris” Christiansen and Alec G. Little, taken at Potts Hill sometime between 1949 and 1951, has become well known as it is the only photo of Ruby to appear in Australian publications in recent decades.

Payne-Scott also made major contributions to the development of radio astronomy techniques. Three prominent examples were: (1) the first ever interferometric measurements in radio astronomy on Australia Day, 26 January 1946, using the sea-cliff interferometer at Dover Heights- Sydney, (2) the mathematical development of

“aperture synthesis”, the technique utilised by many of the advanced radio astronomy instruments of the modern era (e.g. the Very Large Array, the Atacama Large Millimetre Array, the Multi Element Radio Linked Interferometer, the Australia Telescope Compact Array); and (3) the swept-lobe interferometer at Potts Hill, developed by her and Little, which could make a rudimentary ciné movie (25 frames a second), showing the motions of the solar radio bursts as the emitting gas moved outwards in the corona at high velocities. In addition, there is strong evidence that she was the first person in Australia to recognise the importance of confusion in radio astronomy—the necessity to achieve high angular resolution in detecting fine details, as well as good sensitivity to recognise distinct radio sources.

In these first years of growth in radio astronomy after World War II, Payne-Scott’s auspicious career was marred by conflict with the bureaucracy of CSIR/CSIRO.

Ruby was subjected to discrimination against women, prevalent in Australian society in the 1940s and 1950s.¹ These controversies have been mentioned in a number of popular articles in the Australian press and also in books providing summaries of Australian astronomy. The latter have been correct in attributing her 1951 resignation to the birth of her first child in late 1951. The nature and the consequences of the discovery in 1950 of her “secret marriage” of 1944 have been described with considerable distortion in some popular articles and books.

The conflict with CSIR (Council for Scientific and Industrial Research) and CSIRO² occurred in the period February to May 1950, when she met in person with Ian Clunies Ross, the Chairman of the new CSIRO. Ruby Payne-Scott and William “Bill” H. Hall married in September 1944; this was known by most of her colleagues at RPL. The rule against married women at CSIRO maintaining permanent employment status was challenged head on by Payne-Scott. Clunies Ross wrote her a series of forceful letters, with equally strong replies from her side. Not surprisingly, Payne-Scott lost this battle and became a temporary employee of the CSIRO in 1950. As a consequence she had to forfeit her superannuation (pension) rights, the CSIR/CSIRO pension contributions (1946–1950), and the accrued interest on her own contributions. Ironically, some of the more productive research of her short astronomical career occurred after this demotion.

A year-long conflict with John G. Bolton was a part of Payne-Scott’s life at the RPL, after he joined the CSIR in September 1946. Bolton was demobilised from the

¹ There is a temptation to evaluate these issues with the viewpoint of the more egalitarian society of the early twenty-first century; as a number of colleagues have pointed out to Goss, the draconian treatment of Payne-Scott in the mid-twentieth century was consistent with practices in many walks of life. The characteristic that distinguished Payne Scott was her resistance to these inequalities.

² The transition from the CSIR to the CSIRO (Commonwealth Scientific and Industrial Research Organisation) occurred in the period March to May 1949 with the passing of the Science and Industry Research Act 1949 by the Australian Parliament. The change from “Council” to “Commonwealth” was chosen to emphasise the national character of the new organisation and the word “Organisation” was used to highlight the changed character of the administration by the new CSIRO Executive of five members, including three scientists (Schedvin 1987).

British Navy in late 1945, having served as a radar officer on the Royal Navy aircraft carrier *Unicorn* for about a year in the East Indies and the Pacific. During the time of Pawsey's overseas trip, September 1946 to October 1947, the conflict reached a boiling point. Sharing the Dover Heights site by the two strong-willed scientists produced continual conflict and Payne-Scott was "exiled" to the Hornsby field station.³

An important gain for Payne-Scott's career at RPL was her interaction and the support of two prominent women colleagues during World War II: Joan Freeman Jelley and K. Rachel Makinson. Joan Freeman's autobiography (*A Passion for Physics*, 1991) preserves a number of famous anecdotes about Payne-Scott and others (see Additional Note, No. 1, end of this chapter).

Payne-Scott had been known as a "left winger" at the RPL in the 1940s. The Australian Security and Intelligence Organisation (ASIO) maintained a large dossier on her and suspected that she was a member of the Communist Party of Australia (CPA). ASIO had no proof of this affiliation at the time of a 1950 report. In 1999, however, Goss discovered that she had been a member of the CPA, possibly breaking with the Party later in the 1950s. Rachel Makinson has told Goss that Ruby was often referred to as "Red Ruby", even by her closest friends.

One of Payne-Scott's great loves was bushwalking. She met her husband through the Sydney Bush Walkers in 1941. They remained enthusiastic bush walker for many years. A typical picture of her during the period is shown in Fig. 1.3, a trip to the Blue Mountains west of Sydney.

In July 1951, Payne-Scott resigned from the RPL, with an advance notice of only 2 days. She was pregnant; her son Peter G. Hall—future Professor of Mathematics at the University of Melbourne and Fellow of the Royal Society of London—was born on 20 November 1951. There was no maternity leave at CSIRO. A daughter, the famous Australian artist Fiona Hall, was born 2 years later.

After the birth of her children, Ruby chose to remain at home in Oatley (a suburb of Sydney) to care for the two young children. After the children were about 10 and 12 years old, she became a mathematics and science teacher at Danebank Anglican School for Girls in nearby Hurstville; she was in this position from 1963 to 1974. It is likely that Ruby developed Alzheimer's disease at an early age, with signs of deterioration of her mental facilities in her last years at Danebank. She died in Sydney on 25 May 1981, a few days before her 69th birthday. Bill Hall died 21 July 1999.

³ Melrose and Minnett (1998) have quoted one colleague at RPL who suggested that there was "a triangle of antagonism between John Bolton, Ruby Payne-Scott and Jack Piddington" [another prominent scientist at RPL] in the late 1940s. Minnett, himself, acknowledged these antipathies and described them as "creative tensions between very different personalities". RPL was blessed with some strong personalities!



Fig. 1.3 Bushwalking, a passion of Ruby Payne-Scott. Here she is probably in the Blue Mountains in the 1940s. Many photos of Payne-Scott show her eating or drinking at the time of the photographic session. Her daughter Fiona suggested that her mother likely thought that posing for photos was a waste of time; thus she could be more efficient when combining posing while eating or drinking! (Bill Hall family collection, used by permission of Peter Hall)

The Legacy of Ruby Payne-Scott

Ruby’s legacy has two major components. First, she was a crusader for the rights of women in the scientific workplace in Australia. Other women had experienced discrimination; Payne-Scott complained loudly about the treatment. She helped pave the way for future generations. Secondly, Payne-Scott was one of the first three pioneers in the new field of radio astronomy, which burst into prominence at RPL in Sydney in 1944–1945. Within a few years, Australia and the United Kingdom became the leaders in this revolutionary new form of astronomy. Pawsey and Payne-Scott provided the key leadership for the rapid growth in solar physics that solar radio astronomy created in the first decade after World War II. After she