NRAO ONLINE 26

Pawsey, Connections with Canada 1941 to 1957[1]

Epigraph

> There is no observing program here [at Toronto] and I mention Toronto only because of Williamson[2]. He is a young enthusiast, formerly of Yerkes and then Cornell, who apparently stimulated the Cornell effort … acting as a sort of promoter of such research … [H]e and [Charles] Seeger apparently prompted Burrows of Cornell to start [radio astronomy] … He has produced a very readable review of the subject in the *Journal of the Royal Astronomical Society of Canada* ["The Present Status of Microwave Astronomy", 1948, vol 42, p 9]. [3]

Introduction

In 2016, Tim Robishaw of the Dominion Radio Astrophysical Observatory in Penticton, British Columbia in Canada organised a "Workshop on the History of Canadian Radio Astronomy", with dates 25 to 26 July.

The purpose of the conference from the workshop web page:

> A major motivation for the workshop centred around the work of Richard Jarrell, the author of *The Cold Light of Dawn: A History of Canadian Astronomy*. Richard collected an extensive archive on the history of Canadian radio astronomy, including many interviews with all the original players. Richard had just begun writing a book on this topic at the time of his passing in late 2013. A group of Canadian radio astronomers hopes to finish writing this book following the outline Richard provided and using his archival material. To this end, in addition to topics of worldwide importance to the

[1] David E Hogg of NRAO has provided permission to use his mother's (Helen Sawyer Hogg -1905-1993) archive. In addition, Victor Gaizauskas of the National Research Council (Ottawa) has given permission to use his archive.

[2] See ESM_17.4 also.

[3] From NAA, C4659/4 from April 1948, Pawsey, "Solar and Cosmic Noise Research in the US and Canada", written in the US before he departed for Europe by ship on 27 March 1948. Posted to Australia from the UK in April. Comments combined from two separate sections of the report, "Personalities" and "Toronto".

history of radio astronomy, contributions were solicited on topics pertaining to the development of radio astronomy in Canada.

About 50 participants were at the conference, with half of these presenting talks. Sullivan gave a presentation on the first day: “The Beginnings of Radio Astronomy around the World”; on the second day, Goss presented “J.L. Pawsey, Father of Australian Radio Astronomy, Connection with Canada 1941-1962”.

Many outstanding presentations were given by colleagues about Canadian radio astronomy: Martha Jarrell and Elizabeth Griffin, Ken Tapping, Henry Bradford, Phil Kronberg, Tim Robishaw, Rob Roger, Ron Allen, Jasper Wall, Ellen Bouton, John MacLeod, Bob Hayward, Joe Fletcher, Wayne Canyon, Mike Kestevan, Phil Gregory, Tony Willis, Dave Routledge, Tom Landecker, Bill McCutcheon, Helen Kirk and Randall Rosenfeld.

Pawsey had major visits to Canada in 1941, 1947-1948 (with his wife Lenore), 1954 and 1957-1958 (with his wife). Pawsey’s activities during these visits are summarised in the main book in the relevant chapters (9, 17, 24, and 28).

In this NRAO ONLINE text, we summarise the Canadian visits sequentially. The outline follows the presentation given by Goss for the Penticton talk of July 2016. Of course, there is considerable overlap between this text and the book; a number of items are considered in more detail here. The detailed references can be found in the main book text; some of the references are presented in this text.

In late 1931, Pawsey met Ted Nicoll (1908-2000), a fellow 1851 Exhibition research student at the Cavendish Laboratory in Cambridge. Nicoll was from Battleford, Saskatchewan, Canada. He had graduated from the University of Saskatchewan, arriving about the same time in Cambridge as Pawsey. He completed his PhD in 1934, then taking a position at EMI in the UK and later at RCA in New Jersey in the US. Ted Nicoll was to establish a lifelong friendship with Pawsey; in 1935, Pawsey married Ted’s sister, Greta Lenore Nicoll. Through the Nicoll connection, Pawsey met a number of Canadian colleagues, a few becoming life-long friends. Descriptions of these connections and experiences are found in Chapters 6 to 8 in the main book.

Pre-WWII trip to Canada and the US, July to October 1941[4]

[4] References: NAA C3823 E13/1 (Liaison with Canada- Mr Pawsey General), A8520 PH/Paw/1B Part 1- Correspondence 1940-1954 and Evans, W. F. (1970). "History of the radiophysics advisory board 1939-1945." Melbourne (Australia): CSIRO, 233 p.

Sir John Madsen's role was decisive on the organisation of Pawsey's visit to Canada and the US from July to October 1941. Sir John, the Chair of the Radio Research Board, was visiting from Sydney to the US, Canada and later UK starting late April 1941; he was to consult with Allied colleagues concerning new developments in radar technology. He sent a cable to Rivett (CEO of the CSIR) on 11 June 1941 from Ottawa: "Strongly recommend Pawsey proceed immediately to Ottawa by air via Los Angeles and New York for two months, probably including work at Boston. Canadian authority secured. Arrange to meet Munro [Scientific Liaison] New York".[5]

Evans (1970, *History of the Radiophysics Advisory Board*, CSIRO, p. 54) continued:

> Munro was transferred from London to North America[6] at this stage [April 1941] and Madsen helped to establish him in new quarters in Washington. Madsen also visited Canada before leaving for Europe, and cleared the channels for Pawsey to spend some months with the Canadian National Research Council [Ottawa] and the Massachusetts Institute of Technology [Radiation Laboratory, Boston] studying microwave techniques. Both the Canadians and the Americans had by that time already adapted microwaves into RDF [radio direction finding, later radar] applications of their own devising and Madsen arranged for samples of these new sets to be made available to Australia.[7]

Within a few days, the project was underway in Sydney. The RAB [Radiophysics Advisory Board] had a meeting on 18 June 1941 (12th meeting), at Victoria Barracks in Melbourne. Fred White was the chair, the Australian Military Chiefs were there as well as S.H. Witt, stepping in for D. McVey from the PMG.

Item No. 3 was "Proposed Visit of Dr Pawsey to Canada":[8]

> It was reported that a cable had been recently received from Sir John Madsen in the USA pointing out that new RDF techniques urgently necessitated a special officer gaining personal experience and taking back equipment. Sir John recommended further that Dr

[5] NAA C3823 E13/1

[6] Munro transferred from the London Australian High Commission as Scientific Liaison Officer to Washington and Ottawa, sharing the liaison position between the US and Canada.

[7] The Tizard Mission had brought a number of UK radar secrets to Canada (where Tizard met C.J. McKenzie- head of the NRC on 16 August 1940) and the US in September 1940. In the UK, the Battle of Britain continued until the end of October 1940. The members of the Mission were Tizard, Bowen, Cockcroft, Wallace, Faulkner, Pearce and Woodword-Nutt. Zimmerman's, *Top Secret Exchange*, 1996, has provided a masterful account of this decisive event of World War II. The Radiation Laboratory of the National Defence Research Committee grew out of the efforts of the Tizard Committee. A sample magnetron from the UK was shown to the Canadians and the Americans.

[8] Australian Academy of Science, archive.

> Pawsey should proceed immediately to Ottawa by air from Los Angeles and New York for a period of two months and probably carry out some work at Boston [Rad Lab]. He indicated that Canadian authority had been secured, and that Dr Pawsey should arrange to meet Mr Munro at New York. This suggestion was approved.

Joe Pawsey had only a few weeks to prepare.

Pawsey's North American adventure began in July 1941. After flying to Auckland on a Qantas flight on 3 July, he left by Pan American Clipper flying boat on 10 July, a week later[9]. During the wait in NZ, he visited New Zealand RDF colleagues in Wellington. After leaving Auckland, the trip to Hawaii lasted three days with a flying time of about 40 hours (distance about 7,000 km, a flight to the north and slightly to the east). After a wait of two days in Honolulu, he arrived in Los Angeles on 15 July (visa stamped in the port at San Pedro, near Long Beach). He then went to the NRC in Ottawa for some weeks, followed by the Radiation Laboratory in Boston. The exact times are not at all clear, but it is likely he was in Ottawa for 3 to 4 weeks and in Boston for 6 to 7 weeks during July, August and September 1941. Pawsey had a large amount of excess baggage with plans for Shore Defence (ShD) auxiliary equipment. Few details of Pawsey's visits to North America have survived.

Two artifacts from the trip were found in the Pawsey family archive: the Visa Application Photo of the 33-year old J.L. Pawsey (Fig 1) and the whimsical equator crossing certificate from Pan-American (Fig 2), his fifth crossing of the equator, on 12 July 1941. The time was 15:35 GMT (local time would have been 5 or 6 am in the Pacific). The weather was cloudy and the Clipper was flying at 2000 feet elevation with a speed of 135 knots.

In addition, Pawsey visited the Naval Research Laboratory in Washington. Albert Hoyt Taylor, the prominent radar pioneer of US radar from the 1930s.[10] In his memoires, *Radio Reminiscences: A Half Century,* Taylor (1948) wrote about the Australian visitors (he had trouble with correct spelling of these Australian names[11]):

---

[9] On 4 July 1941, he sent a telegram to his family at 21 Derby Street, "Watsons Bay" [actually Vaucluse). "Arrived safely going Wellington tonight. Expect depart Thursday (10 July) address Pan American. Hope you happy. Joe Pawsey" He had a massive amount of excess baggage. Madsen had asked him to bring to Canada ShD plans for plotters, masts, results of shooting tests, etc; these were to be used by the Canadian Military.

[10] In December 1934, Taylor and R.M. Page constructed a working prototype radar. The famous CXAM naval 200 MHz radar was developed by his group in 1937.

[11] Numerous other visitors came to NRL as reported by Taylor. He mentions the "wiry young Welshman ... one of the keenest and most alert men attached to the British Mission", clearly E.G. Bowen, and Professor Cockcroft and Professor Oliphant "who gave us valuable information on the design of new tubes, particularly the design of very high-power magnetrons". These names were all spelled correctly.

> Mr. C.H. Monroe [sic, George H. Munro] and Dr. J. W. Tawsey [sic, J.L. Pawsey] of the Australian Legation were frequent visitors, requesting frequent information concerning our CXAM [200 MHz, Naval radar] equipment. Subsequently, their coastal defence service long range warning radars incorporated many of the features of our CXAM design, and were built to use American tubes [valves].

Pawsey also visited Bell Labs in New Jersey, meeting Harald Friis, George Southworth and Karl Jansky. At the Rad Lab he met Lee DuBridge (Director) and I.I. Rabi (associate Director); we do not know if he met E.G. Bowen (then "Eddie" Bowen, changing his nick name when he moved to Australia at the end of 1943, early 1944) who was working at the Rad Lab as a representative of the British Mission. These contacts were to play an important role in Pawsey's future; Bowen was to become a colleague in 1944. He was Chief of the Division of Radiophysics from 1946 to 1971.[12]

From the Battleford, Saskatchewan, newspaper from Thursday 2 October 1941, "Town and District" news of recent events, we read of a short personal visit to Pawsey's in-laws in Battleford just on his way home (27 and 28 September):

> The district had an interesting visitor from Australia in the person of Dr J. L. Pawsey, who is visiting the North American continent from the first time on important duties for the Australian Government in connection with the Industrial and Scientific Research Bureau. Dr Pawsey married Miss Lenore Nicholl, a former student of the Saskatchewan University and the Battleford Collegiate Institute and came by plane on Sunday [28 September] to visit his wife's parents, Mr and Mrs John Nicoll, leaving again the following afternoon. The urgency of his work makes traveling by air necessary. And his trip to Ottawa was delayed by the recent storm, when a train journey was made from Ottawa to Toronto. He has been touring the Eastern States [in the US] for three months, having had his headquarters at the Australian legation [Washington]. Most of his journeys have been made on the Clipper plane of the Pan-American Airways, and he left Monday for San Francisco before going back to Australia. He worked in London, England, prior to war, when he married Miss Nicoll, and on the outbreak of war was offered the Government post in Australia.

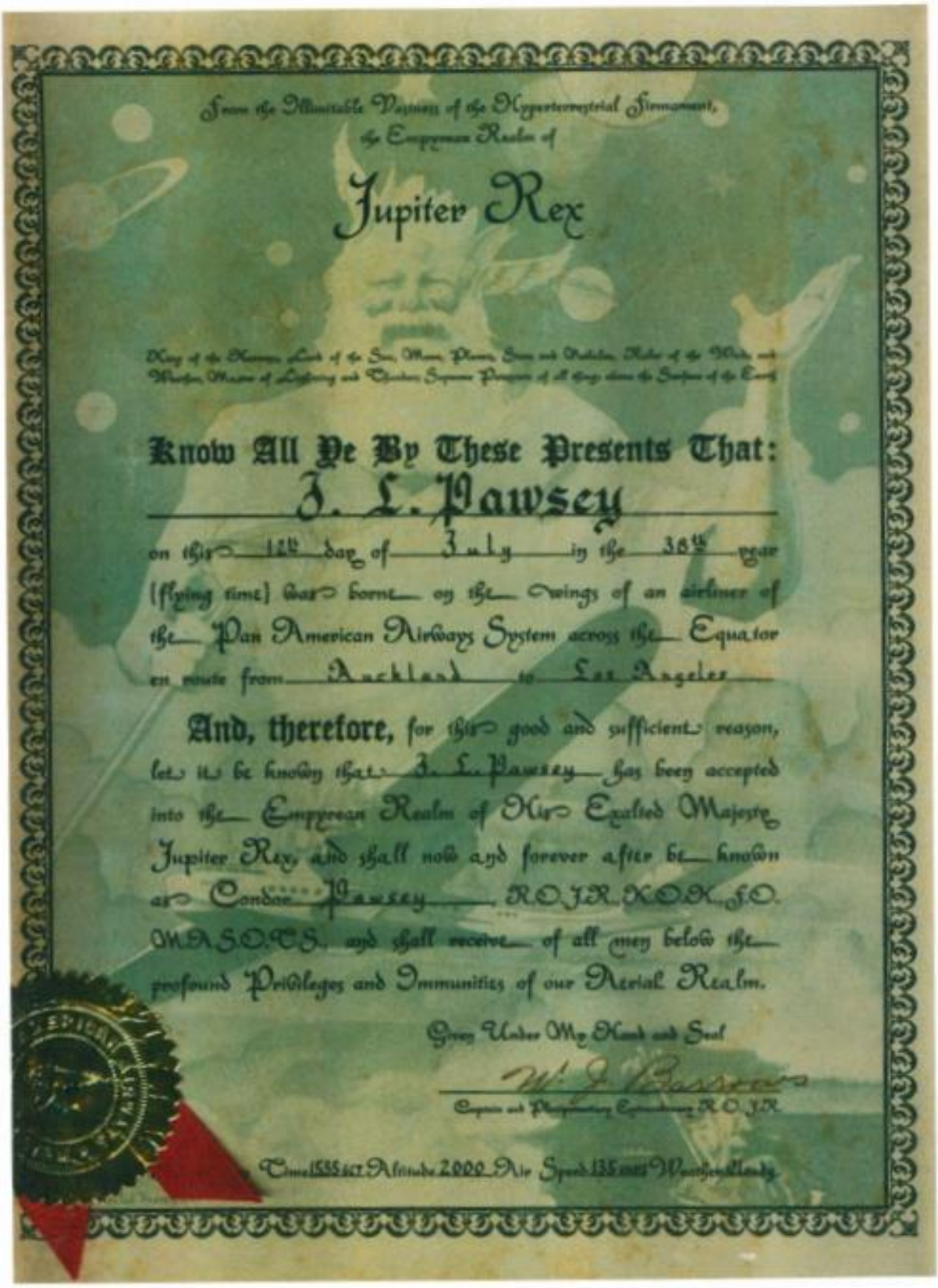
[12] Goss has vivid memories of meeting him in August 1967 for the first time, as he had just come to CSIRO as a Postdoc. A few months later, Goss received a letter from Bowen: "Dear Goss"- a very British greeting! By the early 1970s, Bowen addressed Goss as "Miller".

The long trip back home began after Pawsey's departure on 28 September 1941. Three days later (1 October), his visa was stamped at Boeing Field in Seattle, Washington, likely for a flight departing to Hawaii.

The return trip back to Australia was tedious, lasting about 9 days.

Most likely, he left from Seattle departing to Honolulu where he remained until 7 October. On 11 October 1941, the family in Sydney received a cable from Noumea, French New Caledonia: "Depart Noumea today may arrive Sydney Sunday [12 October 1941]. Pawsey". On his return home, he brought with him a "safe hand mail" package originating from George Munro from the Australian Embassy in Washington, weighing 47 pounds [22 kg], likely microwave components. He arrived home on 22 October 1941, about six weeks before the Pearl Harbour attack by the Japanese (7 December 1941), followed two months later by the attack at Darwin, Northern Territory, Australia (19 February 1942).

Fig 1 The US Visa Application form from 26 June 1941 signed by the Vice Consul US Department of State in Sydney for 2-3 months. Nationality “British” and born at Ararat,, Australia, 14 May 1908. Credit: Joe and Lenore Pawsey Family Collection.



From the Illimitable Vastness of the Hyperterrestrial Firmament,
the Empyrean Realm of

Jupiter Rex

King of the Heavenly Lords of the Sun, Moon, Planets, Stars and Orbital Rulers of the World and Universe, Master of Lightning and Thunder, Supreme Progenitor of All Things above the Surface of the Earth

Know All Ye By These Presents That:

J. L. Pawsey

on this 12th day of July in the 38th year [flying time] has borne on the wings of an airliner of the Pan American Airways System across the Equator en route from Auckland to Los Angeles

And, therefore, for this good and sufficient reason, let it be known that J. L. Pawsey has been accepted into the Empyrean Realm of His Exalted Majesty Jupiter Rex, and shall now and forever after be known as Condor Pawsey ROJR KOK SO. MASONS. and shall receive of all men below the profound Privileges and Immunities of our Aerial Realm.

Given Under My Hand and Seal

W. J. Pawsey

Captain and Plenipotentiary Extraordinary ROJR

Time 1555 GCT Altitude 2000 Air Speed 135 Weather Cloudy

Fig 2 . A whimsical award as Pawsey crossed the equator 12 July 1941 between Auckland and Hawaii. Altitude 2000 feet and air speed 135 knots under cloudy conditions. Time was 1535 or early morning in the mid-Pacific (distance about 7000 km with flying time about 40 hours) "From the Illimitable Vastness of the Hyperterrestrial Firmament of the Empyrean of Jupiter Rex…. know all be by those present that: …..J.L. Pawsey has been accepted into the Empyrean Realm of His Exalted Majesty of Jupiter Rex and shall now and forever after be known as Condor Pawsey…. [on the occasion of crossing the equator (Pawsey's 5th crossing)…] with all the profound privileges and immunities of our aerial realm." Signed by the pilot W.J. Barrows Captain and Plenipotentiary. Credit: Joe and Lenore Pawsey Family Collection.

North America 1947-1948, Pawsey establishing international networks[13]

Introduction

The most important overseas trip of Pawsey's career occurred during a 13-month period starting in September 1947; the contacts that he made in the US, Canada and Europe would be decisive throughout his career.[14] He and his wife left the three children in Sydney while they visited the US, Canada and then Europe. Details of this experience are described in Chapter 17, describing the establishment of an international set of networks in the overseas trip of 1947-1948. In Canada, they visited Lenore's relatives in Saskatchewan and Ontario. Pawsey had astronomy colleagues in Toronto and Ottawa from mid-February to early March 1948. A highlight of these visits was meeting Ralph Williamson at the David Dunlap Observatory of the University of Toronto. Pawsey tried unsuccessfully over a ten-month period to convince Williamson to accept a position at RPL in Sydney.

The planning of the 1947-48 trip began in 1945. Pawsey had suggested a visit to David Rivett (CEO of CSIR) on 28 March 1945 as WWII approached an end:

[13] Pawsey Personnel File (CSIR and CSIRO). A8520, PH/PAW/1B. Part 1. Pawsey family archive

[14] Key contacts included connections with Lenore Pawsey's relatives in both western and eastern Canada. The key contact with astronomers in 1948 was with Ralph Williamson in Toronto (Additional Notes 1, 2 an3). (see below and also Additional Notes 4 and 5 for contacts with McKinley, which had begun during his visit to Australia at the end of WWII.)

> I could profit most through an extended trip of a year or so, most of my time being spent working in a suitable laboratory and the remainder in visiting others ... If I went I should wish my family to go also, at any rate as far as Canada to my wife's relations, as my wife's health has been poor in Sydney and she would be most unhappy if left here alone … I appreciate your compliment in saying I am one of the people you have to rely on to develop sound fundamental work in radiophysics after the war, but I suggest I could do this a lot better after a period spent overseas.

On 25 September 1947, Pawsey and Lenore left Sydney by sea for San Francisco, arriving on 13 October 1947. The two grandmothers (Mabel Nicoll had travelled from Canada) looked after the three children, until the parents returned 29 October 1948. In 1947, the ages of the children were Margaret, 10, Stuart, 8, and Hastings, 2 ½.

After visits with colleagues at the University of California, Stanford and then Cal Tech, the Pawseys departed Pasadena on 31 October 1947 for the Grand Canyon. Then they visited W.O. Roberts at the Solar Observatory in Climax, Colorado. The next stop on their tour was the University of Nebraska, Lincoln. Their host was Carl Borgmann, Dean of the Faculty at the University of Nebraska and a former classmate of Pawsey at Cambridge. Borgman was to play a major role later in Pawsey's career. (see e.g. Chapters 32, 38 and 40)

The next stage of the trip was a visit to Saskatchewan, Canada, Lenore's home province. This was the first occasion that Lenore had to visit Canada since she left in the mid-1930s to travel to the UK. Pawsey was in Saskatchewan from about 14 November to 25 November, 1947. Lenore remained in Canada from 14 November to 14 December. Pawsey and his wife spent time in Milestone, followed by Regina (including an ice hockey game) and then 4-5 days in Lenore's hometown of Battleford. In Saskatoon on 24-25 November 1947, Pawsey gave a lecture at the weekly seminar at the University of Saskatchewan, "Rain Making", which was reported in the local paper, *The Star*. Pawsey left Lenore in Saskatchewan on 25 November 1947; he then travelled to Chicago, reporting that he was a passenger on a "fancy train, a Zephyr with an on-top observation dome".

The Pawsey family had opportunities for tourism during the visit to Saskatchewan in November 1947. In Figures 3-5 we show some of the photos made by Pawsey and Lenore in November 1947.

Fig 3 . Lenore Pawsey in Saskatchewan, November 1947. Credit: Joe and Lenore Pawsey Family Collection.

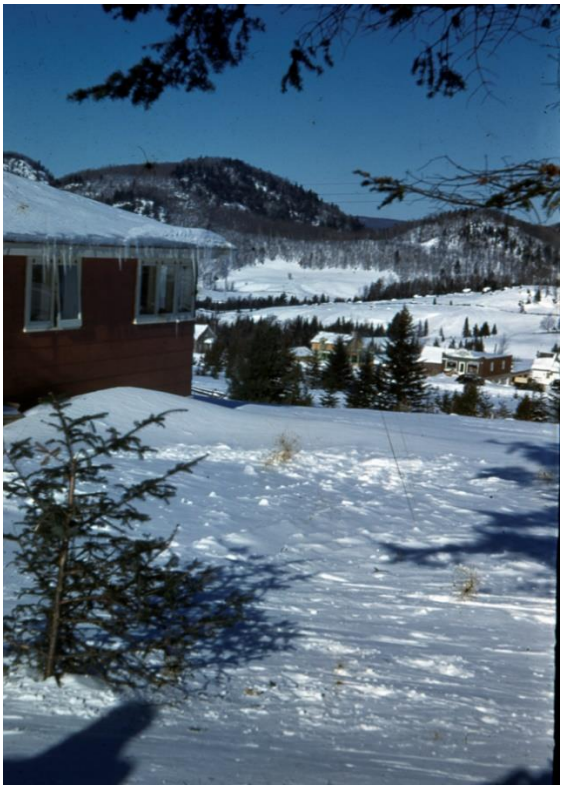


Fig 4 . Saskatchewan, November 1947. Credit: Joe and Lenore Pawsey Family Collection.

Fig 5. J.L. Pawsey on a snow sleigh, Saskatchewan November 1947. Credit: Joe and Lenore Pawsey Family Collection.

As we have described in Chapter 17, Pawsey had extensive visits in the US at the Yerkes Observatory, followed by visits to Washington, DC, and Boston in the period from late November 1947 to mid-February 1948. Among the many highlights of the following months, Pawsey was to meet Oort, Stromgren, Shapley, Bok and Spitzer. In Washington, Pawsey had numerous visits with Grote Reber. Also, in New Jersey he met Karl Jansky for the second time.

On 8 February 1948, Pawsey and Lenore travelled for the second time to Boston to visit Bart Bok at Harvard. Afterwards an extended visit to Canada, followed with visits to Montreal and Ottawa. On 12-13 February, Pawsey visited the National Research Council (NRC). The *Ottawa Evening Citizen* of 12 February 1948 described the visit:

> Dr. Pawsey spent this morning in discussion with the president of the NRC Dr. C.J. McKenzie … Dr. Pawsey is studying the latest developments made in Canada in certain lines of radio research. He is particularly interested in radiation from the sun … [He] is also interested in "rain-making". He was associated with the experiments in Australia in which certain types of cloud were sprinkled with dry ice which caused them to develop into rain clouds.

No details were found in the archives about likely visits with two friends of Pawsey at the NRC : Donald R.W. McKinney (who had visited RPL from the NRC for radar discussions with Pawsey and others at the end of 1943, even visiting the front lines in New Guinea) and William J. Henderson the classmate at Cambridge (chapter 6 and 8 for connections at Cambridge and NRAO ONLINE 36 for Henderson's discussion of the role of Pawsey in the Australian responses to the Alan Nunn May Canadian spy scandal of 1946), the Microwave Section Head in 1948.[15] (See below for additional meetings of McKinney and Pawsey in later years.)

On two subsequent days Pawsey met Arthur Covington, whose 10 cm monitoring of the sun with a small dish had begun in February 1947. In Pawsey's report to CSIR in April 1948, "Solar and Cosmic Noise Research in the US and Canada", he summarised his opinion of Covington:

[15] NAA C3830 A1/1/1 Part 1 1945-1946. Henderson wrote: "Many thanks for your letter and copy of paper [*Nature* paper of February 1946 by Pawsey, Payne-Scott and McCready]. I have been interested in solar and cosmic noise for the past year, and have had a recording set running for some months on 10 cm." (The project of Covington). Bowen had been in Ottawa and reported on the Sydney solar noise work. "My congratulations on a fine piece of work. You have certainly found some interesting things, and no doubt more are to come. It looks like a new astrophysics tool." In the 1950s, Henderson transferred to the Reactor Physics Branch of Atomic Energy of Canada Ltd, becoming head of this branch. He died in late September 1963 at age 53.

"At Ottawa, Covington is a young and inexperienced man working in relative isolation. He has got some thoroughly good results by good honest work and perseverance."

Pawsey pointed out that Covington's results had three major themes:

(1) "Probably bursts of noise of non-solar origin – very difficult to investigate. [Also suggested by Reber and never confirmed]"
(2) "A steady level of solar intensity which shows (a) a regular variation of order 2/1 with sunspot number; (b) a base level of about 70,000 K which is steady decreasing now we have apparently passed the maximum of the solar cycle; (c) a marked 25-day periodicity over a year."
(3) "Sudden increase in solar noise, probably corresponding to our 'outbursts' [Type II] which show a very high correlation with solar flares and 'fade outs'."

Fortunately, Arthur Covington has also provided his own summary of Pawsey's visit. In the Sullivan 1984 collection *The Early Years of Radio Astronomy: Reflections Fifty Years after Jansky's Discovery*, "Beginnings of Solar Radio Astronomy in Canada" (p 317, Cambridge University Press):

> Early visitors to the Radio Field Station and to Goth Hill whom I can recall and were interested in the radio astronomy program were: E.V. Appleton, W.R. Piggot, B.W. Currie, J.S. Hey, J. Ratcliffe, J.G. Bolton, H.T. Friis, J.L. Pawsey and H. C. van de Hulst. I was introduced to Pawsey during one of his early visits to the RFS by W.J. Henderson [then the National Research Council Microwave Section Head and a classmate at Cambridge with Pawsey]; they attended Cambridge at the same time … When Pawsey was being shown, sometime in 1949 [sic was early 1948], the 10-30 cm broadband radiometer with its horn antenna for absolute flux determination, he told me about the 21 cm hydrogen line prediction and wondered whether I could make, or would plan to make, any observations for its confirmation. As it stood, the instrumentation was hardly suitable. This was the first time that I had heard of the prediction and is one occasion when I realised the magnitude of the difficulties of switching from one promising area to another. I readily gave a negative reply and realised that I would be continuing solar noise work …

The course of Canadian radio astronomy would likely have changed if Covington had followed Pawsey's suggestion.

On 28 or 29 February 1948, Pawsey travelled to Toronto. Lenore had been in Toronto a week earlier visiting her uncle. Pawsey spent several days visiting colleagues at the University of

Toronto David Dunlop Observatory at Richmond Hill: Dr Frank Hogg (Director), Dr Helen Sawyer Hogg and Dr Ralph Williamson.

Ralph Williamson (1917-1982) and J.L. Pawsey Meet in Toronto end February 1948 (see ESM_17.4)

In Toronto, Pawsey met a young (31 years) US astronomer who had completed a PhD with Chandrasekhar at Chicago. Ralph E. Williamson[16] impressed Pawsey more than any of the other young astronomers he met in North America. As we will see, Williamson was a scientist with a bright future; aspects of his short career as a radio astronomer are described in detail in three Additional Notes. (see Additional Note 1, "Obituaries for Williamson by MacRae and Covington. Reflections on Ralph Williamson by John Heard", Additional Note 2 "Two of Williamson's Radio Astronomy Publications: 'The Present Status of Microwave Astronomy' and 'The Atmosphere of the Sun'" and Additional Note 3, *The Globe and Mail* newspaper article about Williamson, 20 February 1952 "Study Hissing Star Mystery"). [17]

Pawsey wrote in his report on radio astronomy in the US and Canada (see Epigraph):

> In Toronto Williamson is a young astronomer who is thoroughly interested in one subject. In fact, he is acting as a sort of promoter of such research. He was formerly at Cornell and says he and Seeger prompted Burrows [at Cornell] to start. He has now written a review for [the *Journal of the Royal Astronomical Society of Canada* Vol 42, page 9, 1948 "The Present Status of Microwave Astronomy"[18]] to attempt to push the subject among Canadian astronomers.

Major efforts to recruit the theoretical astrophysicist Ralph Williamson were begun by Pawsey after this first meeting at the end of February-early March 1948. The Williamson role in the quest to detect the 21 cm HI line is described in Chapter 28. After Pawsey wrote Williamson on

[16] Pawsey described Williamson to Bowen on 15 March 1948: "He is a likeable, young theoretical astronomer, who is enthusiastically trying to get in to this solar and cosmic noise field … He would be delighted to visit Australia, but could not leave at short notice as the Toronto University is short staffed."
[17] Additional Note 4 and 5 describe the visits of McKinley to Australia during WWII and the Sydney URSI of 1952.
[18] The title of the article clearly influenced by the name of the new discipline ("Micro-wave astronomy") adopted by the Cornell group of Burrows. As we discussed in ESM_17.1, in a letter to Pawsey, Bowen was not impressed with the term for the new discipline proposed by Burrows of Cornell in 1948: the new field was not "microwave" and it was also not "astronomy." The Cornell group used the term to describe their observations at 205 MHz (about 1.5 m) as "microwave astronomy".

27 April 1948[19] with a more formal offer for a position at RPL, they exchanged four letters. After 10 months, Williamson turned down the offer in February 1949, only three months after Pawsey's return from Europe. The final rejection from Williamson ended with a long-winded statement from Williamson:

> I don't need anyone to tell me that I am a terrible correspondent. In this case, however, I have shred of an excuse. I have been hoping against hope that something would turn up to make the chance of a trip to Australia more likely. Since that doesn't seem even any nearer now than it did two months ago, I must regrettably postpone any hope of immediate collaboration.
>
> I am very glad, however, that you feel the advantages of the close collaboration of an astronomer in a radio astronomy project, and I hope that you will be able to secure one. [Campbell Wade, a recent astronomy PhD from Harvard, would come to Australia in 1957 for two years.]
>
> … It is with real regret that I must lay aside any prospects of immediate participation in the work of the CSIR, but I look forward to our continued collaboration, and to the time when we shall see you again. My wife joins me in sending our best regards to you and Mrs. Pawsey.

If Williamson had gone to Australia in the early 1950s, we can imagine that his impact would have been substantial. His extensive astronomical and astrophysical knowledge would have provided a major stimulus to the RPL group.

Williamson can be credited in playing a major role in initiating radio astronomy in Canada, a fine achievement for a theoretical astrophysicist. He, along with Covington, McKinley and later MacRae (appointed by Heard in 1953 as Williamson's replacement), would have provided diverse leadership.

Williamson's astronomy career began in the early 1940s. In 1943, he received a PhD, working with S. Chandrasekhar at Yerkes- University of Chicago, working on the problems of stellar dynamics and negative H ions in stellar atmospheres. Williamson knew Grote Reber [20] and

[19] As a part of the exchanges of March 1948 between Pawsey and Bowen about long term scientific visitors to RPL, Pawsey had written Bowen (before the receipt of Bowen's letters of 8 and 9 March) independently suggesting scientific exchanges with the US. He had suggested W.O. Roberts, Jack Evans, Ralph Williamson and at least one of the scientific staff of the McMath Solar Observatory in Michigan.

[20] As we discuss in Additional Note 1, Arthur Covington wrote a biographical memoir for Williamson in the *Journal of the Royal Astronomical Society of Canada* , vol 77, p 97, 1983 : "Williamson's intense desire to participate in radio astronomy was stimulated by hearing Grote Reber present his Wheaton observations at a seminar in the Astronomy Department at the University of Chicago [in October 1939]

participated in planning of the initial radio astronomy efforts at Cornell, working there from 1944 to 1946, along with MacRae (see below). As an example, he and Charles Seeger published "The Pole of the Galaxy as Determined from Measurements at 205 Mc/sec" in the *Astrophysical Journal* in 1951 based on Cornell observations. He wrote one of the first review papers on radio astronomy: "The Present Status of Micro-Wave Astronomy" in 1948 (*J Royal Astron Soc Canada,* vol 42, p.9, 1948). Additional Note 2.

Victor Gaizauskas has written a fascinating and insightful article, "Early Years at the David Dunlap Observatory", in the *J Roy Astron Soc Canada*, 2008, vol 102, p.224. Goss and Bob Hayward had an interesting interview with Vic Gaizauskas by telephone in Ottawa in late January 2010.) He wrote:

> … During the two weeks of our 1950 Christmas vacation, I observed [stars with the 74 inch reflector at the David Dunlap Observatory] every night with the exception of Christmas. New Year's Eve was bitterly cold, but I was rejoicing in my new fleece boots and ex-RCAF flight jacket. I was nodding off while seated next to an electrical heater in a small room on the east side of the observing floor when the telephone rang to shake me fully awake around 3 a.m. Prof. Ralph Williamson gave me the shocking news that Frank Hogg had just died of a heart attack [at age 47]. He told me to close up immediately, to go home, and not to return until further notice.
>
> Ralph Williamson was the only theorist on the staff. He was appointed in 1946 to take up the position vacated by R.K. Young. He was very much an ideas man and did not take easily to observing. Normally good-natured, he could be downright grouchy on matters related to the operation of the 1.9-m telescope during his watch. A brilliant early Ph.D. student of Chandrasekhar's at Chicago, Ralph was the staff member who was best attuned to recent developments in astrophysics. All four of the 1950 crop of summer students enrolled in his final-year course in astrophysics. It was probably the most stimulating lecture series I attended in all my undergraduate years. He gave us a fascinating introduction to stellar interiors and stellar atmospheres at a time when there

… Williamson was a graduate student then working under Chandrasekhar's direction …" Covington had heard Reber complain about the "scepticism with which his evidence for cosmic noise was greeted … I feel certain ... that Williamson was a sympathetic listener." Starting in February 1948 up to April 1950, there are six letters from Reber and four letters from Williamson in the NRAO Reber correspondence file. The topics concerned mainly the galactic background radiation (observations and interpretation), with one letter (25 January 1949) from Reber describing his activities as a radio amateur from 1932 to 1934 and his transition to a radio astronomer after he read Jansky's papers. A letter of 19 November 1950 is a confusing discussion of the physics of the predicted HI line, which was to be discovered on 25 March 1951 by Ewen and Purcell.

were no student textbooks on these subjects.[21] Lawrence Aller's *Astrophysics: The Atmospheres of the Sun and Stars* was not yet published, but Ralph distributed copies to us of chapters in the manuscript that he managed to obtain from Aller. Barbara Creeper [later to marry Victor] and I were so impressed with Ralph as a teacher that, along with graduate student Gary Hanes from the physics department, we enrolled in his graduate tutorial courses for the next two academic years.

Before coming to Toronto, Williamson had been at Cornell where he was associated with Charles Seeger in sparking interest in radio astronomy. He was deeply interested in the subject and wrote papers for a lay audience that are lucid summaries of a newborn discipline (Williamson 1948,1951) [see Additional Note 2]. He spoke on the subject to Royal Astronomical Society of Canada Centres in Ottawa and Toronto, and participated in several action committees advising the American and Canadian governments on the value of radio astronomy. Ralph spent seven years at the University of Toronto Astronomy Department, but at the end there was little physical evidence that radio astronomy had arrived. Would it have had he stayed longer? The question became moot at the end of the 1953 academic year, when he abruptly resigned from the university. His personal relations had deteriorated to the point where he saw leaving Toronto as his only alternative. He joined the Los Alamos Scientific Laboratory in New Mexico, where he spent the rest of his career working on weapons design, dying in 1982. For his former students, it was a disappointing end to a promising professorial career.

In Fig 6, we show a photo of the astronomy staff at the David Dunlap Observatory in early 1953.

[21] Gaizauskas has provided to the authors 11 pages of his classroom notes from the Williamson stellar interior course (one page), radio astronomy course (8 pages, from April 1951) and even two pages of a colloquium given on 2 November 1950 by John Bolton in Toronto. He was traveling back to Australia after a long visit he and Letty Bolton made to the UK and Europe earlier in 1950. Williamson certainly gave the first radio astronomy course in Canada. Vic Gaizauskas told Goss on 26 January 2010: "Note that the Bolton seminar was delivered towards the beginning of my final year, on Nov. 2, 1950. When I look now at my meagre notes, I remember that he was an incomprehensible speaker … It was my first introduction to Aussie-speak!" Goss adds: "But Bolton was English, not Australian! In his seminar, Bolton did introduce the concept of interferometry with a nice drawing of a sea-cliff interferometer (shown in Gaizauskas's notes) with interference between the direct and reflected wave at a sea-cliff like Dover Heights..

Fig 6 Credit: from Gaizauskas: *Journal of the Royal Astronomical Society of Canada* Dec 2008, p 227. ”Early Years at the David Dunlap Observatory”. Seated individuals are from the left Helen Hogg, Clarence Chant, Williamson and a visiting astronomer Nancy Roman. In the back row, Jack Heard (Director in 1953) is 4th from the right. Barbara Creeper, a graduate student and Secretary-Librarian, and the future wife of Victor Gaizauskas (1954) is in the middle, sitting on the floor.

David E. Hogg (NRAO) and Paul A. Feldman (former NRC radio astronomer) have provided us with a few additional details. The “personal relation” referred to above concerned Williamson’s liaison with a school teacher in Richmond Hill. Williamson left his wife Dorothy behind, as he departed in 1953 after leaving a letter on the desk of the new Director John F. Heard. (1907-1976). David E. Hogg has explained that his mother, the prominent astronomer Helen Sawyer Hogg (1905-1993) was irate; henceforth any mention of Williamson in the Hogg household was forbidden.

The Pawsey visit to Canada concluded in early March 1948 with a visit to Niagara Falls with Lenore. During the following days, Pawsey carried out a short visit to Michigan, Ann Arbor and Lake Angelus to visit the University of Michigan solar observatory. The Pawsey's were to leave from New York for the UK a few weeks later on 27 March 1948.

In Figures 7 and 8 we show two images made by Pawsey in February-March 1948. Fig 7 shows an impressive view in Ottawa in February 1948 and Fig 8 shows the Niagara Falls the following month.

A main goal of Pawsey in 1947-1948 was to recruit the astrophysicist Ralph Wiliamson to visit Australia for a long period. As we have seen, this attempt failed in February 1949 as Williamson turned down Pawsey's offer for an appointment in Sydney at RPL.

Fig 7. A view in Ottawa from the Chaudiere Bridge, close to the Quebec side of the Ottawa River made by Pawsey in February 1948. View to Parliament Hill, left to right, the Library of the Parliament, the Peace Tower (and the House of Commons and Senate Chambers) and then to the right the East and West Blocks (parliamentarian offices). Credit: Joe and Lenore Pawsey Family Collection.

Fig 8. Pawsey's image of the Niagara Falls in March 1948. Note the excursion boat in the foreground. Credit: Joe and Lenore Pawsey Family Collection.

Pawsey's visit to Canada 1954

D.R.W. McKinley (1912-1984), a Possible Long-term visit to Canada by Pawsey-Deliberations: 1952-1954

Don McKinley and Pawsey had a friendship that began in the final years of WWII in Australia (Additional Note 4), with contacts throughout the 1950s. Pawsey visited McKinley in Ottawa in 1954 and 1957. Lengthy discussions continued from 1952 to 1954 about a possible long-term visit for the Pawsey family to Canada, an event that never occurred.

McKinley had a successful career as member of the team of Peter Millman (Dominion Observatory, 1906-1990) and Donald R.W. McKinley (National Research Council, 1912-1984).

They started an effective collaborative study of meteor, optical (Millman) and radar (McKinley), from 1947, that continued for over a decade. In 1955 Millman transferred from the Dominion Observatory in Ottawa to the NRC.[22]

Canada- 1954[23]

As discussed in Chapter 24, the complex visit to the US and Canada in 1954 was a rushed affair. Pawsey had 19 days in North America with only five days in Canada.

Before the trip to Europe and North America (left Australia 7 July and returned 21 October 1954), Pawsey had received his yearly letter on his birthday (14 May) from his mother. In 1954 he was 46 years old.

In an all-encompassing summation, he looked back on his successful career at CSIRO as he responded to his mother on 23 May 1954:

> I look back with a considerable degree of wonder that I made the grade that I did … I have been very lucky in my career in that I always followed my nose and yet the way opened up ahead … The 1851 [1851 Research Fellowship awarded to Pawsey for his studies at Cambridge] of course was my first great break. It gave me a real scientific chance. The move to EMI was made because there was a reasonable scientific group … The move to Sydney [late 1939] was stimulated by the idea of getting the family out the bombing area [of the WWII] but a first-class scientific opportunity after [the period in the UK].
>
> The future is difficult to visualize. My career seems to be bound up with the development of physics in Australia. I am in the ground floor so I guess I stick by that as a general objective. I am personally interested in a bit of travel so I should be able to work

[22] Sullivan (*Cosmic Noise*, 2009, p 239-240) had described the pioneering work carried out at the Dominion Observatory and the National Research Council. The work was inspired by Appleton's visit to Ottawa in November 1946 as he described the British work on meteor radar. Initial optical and radar data at 32.5 MHz were obtained in Canada for the Perseid shower of 1947. See Millman and McKinley ("Stars Fall Over Canada", 1967 *JRASC*, vol 61, p 277) for a review of their pioneering work. In 1955, the future of the meteor programme was in doubt due to an increased administrative load for McKinley at the NRC. Thus, Millman transferred to the NRC, becoming the Head of the Upper Atmosphere Division (until retirement in 1971). See Ian Halliday "Peter Mackenzie Millman, 1906-1990)" *JRASC*, vol 85, p. 67, 1991.

[23] NAA C3830 F1/4/PAW/ Part 3, Z3/3/A (Pawsey correspondence for trip to Europe and US-Canada 1954), AH 8520, Pawsey Personnel File, PH/PAW/B/Part 1, 1940-1954, Pawsey family archive, also see Chapter 24 from the main book. Additional Note 3 describes the visit that Don McKinley (NRC radar scientist) had in Australia in the last year of WWII, meeting Pawsey during this period. Also McKinley visit Australia again in 1952 for the URSI meeting in Sydney.

> the two in together. This trip in July [1954] is a Cook's Tour type but I should like to go and have a look at Canada sometime on a more leisurely basis [presumably planning a long visit in the future]. I think this is possible in the next year or so. Just at the moment I should like to develop a little perspective and not personally get too much involved in detail for a while.

A major objective in the trip to North America in 1954 was to visit the National Research Council in Ottawa for a few days to discuss a long-term visit to Canada in the following year or two. On 5 May 1954, Pawsey began the organisation of this four day visit near 10 October 1954. He wrote to Frank Davies (head of the Radio Physics Laboratory of the Defence Research Board in Ottawa) and to his colleague from 1943-1944 Don McKinley on the same day (Assistant Director of the Radio and Electrical Engineering Division) of the National Research Council.) Pawsey wrote McKinley: " … [B]ut I have got around to the idea of surveying the possibilities of a later extended visit to your part of the world. We can talk over such possibilities when I see you."[24]

McKinley responded on 12 May 1954 with an enthusiastic welcome, "we shall get out the red carpet for you and Covington will be tickled." But he was not optimistic about major expansion in either ionospheric research or radio astronomy in Canada. McKinley:

> We are planning to initiate a program on upper air research touching [only] on those parts of ionospheric and aurora work that are particular to Canadian conditions and, of course, on meteors, which are not necessarily native by any means but which, for obvious reasons, I would like to stir up again. Covington has had three other scientific workers on his solar noise project, and at this moment it is not contemplated that we might expand the effort in the extra-terrestrial field, but this would depend entirely on the drive and enthusiasm of the group, including any new personnel acquisitions, and the program could grow. The situation outlined while at Sydney in 1952 has not changed materially (that is to say, we have not acquired a senior radio physicist) but this is mainly because we have simply let it lie dormant.

There was no plan to expand to the same level of support that the Australians had executed in radio astronomy or ionospheric research. McKinley expected that the total staff in Canada would not exceed five or six scientists. The emphasis in Canada would remain in engineering fields. McKinley: "However, the two groups [science and engineering] are sufficiently closely allied that, if both exist, there will be plenty of mutual interplay and inspiration."

[24] Pawsey also described the completed book *Radio Astronomy* written with Bracewell (NRAO ONLINE 53) as well as the completed Mills Cross (Chapter 24).

With this meagre leadership and vision in 1954, non-solar radio astronomy in Canada had to await the founding two Canadian radio astronomy observatories after 1960, the Dominion Radio Astrophysical Observatory in Penticton, B.C. (initially a 25 m radio telescope, opened in 1960) and the 46 m Algonquin radio telescope opened in 1966 in Ontario (about 250 km west of Ottawa). As we shall see below, Pawsey was to witness the early stages of these new endeavours in 1957 on his next and last visit to Canada.

On 10 June 1954 Pawsey wrote to Don McKinley again: "I am very much interested in the possibility of an extended visit to Ottawa in the year following if we could work out a suitable arrangement. My short visit this year would give me a chance to discuss possibilities."

Pawsey was quite interested in working on "the elucidation of ionospheric phenomena of the auroral zone". He was anxious to try out the partial reflection technique (NRAO ONLINE 22). "I should like to see whether one can, in the auroral regions, observe the thermal background of radiation from the D-region at the appropriate frequency." Pawsey was unclear about radio astronomy prospects for him in Canada; this question would await discussions in Ottawa.

He finished the letter to McKinley with an admission of one of the motivations for a Canadian visit, a family visit to Canada:

> I should also like to spend some time at one or two American Observatories, and I am hoping to explore the possibilities of combining this with a spell at Ottawa in a visit to North America which would be long enough to bring the family. **Lenore pines for some snow and central heating**. [our emphasis]

The visit to Ottawa began in the afternoon of 7 October 1954, extending to the afternoon of 11 October, when he departed initially for Windsor, Ontario, and the nearby University of Michigan in Ann Arbor (near Detroit) in the US. On arrival in Ottawa, Pawsey gave a lecture at the "Science Association" of the NRC, "Some Research Activities of the Radiophysics Laboratory, Sydney". The main emphasis in his lecture was the CSIRO radio astronomy research.

A photo of McKinley at the 20 June 1960 opening of the Dominion Radio Astrophysical Observatory, White Lake, Penticton, British Columbia, is shown in Fig 9.

Fig 9. In the middle, Don McKinley on 20 June 1960, opening of the DRAO in British Columbia. Behind McKinley (black jacket), Norm Broten. (G.J. Odgers,1960, JRASC, vol 54, p 269 "Official Opening of the Dominion Radio Astrophysical Observatory, White Lake, Penticton, BC, June 20, 1960")

The meeting with McKinley was disappointing in regard to the long-term visit. We know the details based on a handwritten letter[25] (date 11 October 1954-Monday- on United Airlines letter paper written during the trip from Detroit, Michigan, to Denver with intermediate stops in Chicago and Omaha, Nebraska) from Pawsey to his wife Lenore, found in the Pawsey family archive in 2014. He would spend a day with W.O. Roberts in Denver and then go on to Los Angeles. He would leave Los Angeles on Sunday for Honolulu for the plane home to Sydney on

[25] Credit: Joe and Lenore Pawsey Family Collection.

Tuesday night- 19 October 1954. (This was clearly a trip that consisted of continual trips to and from numerous airports.)

The letter to his wife contains a number of short statements that illustrate both the feelings of achievement and frustrations of his career in 1954: "(1) At long last I feel I am headed for home … It will be great to be home. (2) I certainly am in demand [as he described his over-crowded schedule in the US during October 1954] … Life is one hectic round."

The crux of the letter described the surprising misunderstanding with McKinley:

> This Canadian trip [in the future] is still up in the air. Don McKinley who suggested it started a bit of hedging. The proposition under discussion was a transfer from CSIRO to NRC for about a year—bonds of Empire and all that. This would be ok for both parties. Don wants me to apply for a job with NRC. That I was sure was a back-door method [i.e. Pawsey was to be forced to apply for an open position at NRC] so I went for a private talk with Herzberg (Chief of NRC Division of Physics). He and I saw eye-to-eye and with Herzberg's approval I put my foot down. I wrote Don saying the next move was [in the hands of] NRC - to write Fred White [CEO of CSIRO] asking for me for a year (or else no me). So we shall see what we shall see.
>
> One good thing which came up was that I got to know Herzberg. I and Herzberg are likely to walk hand in hand. This Canadian possibility has a lot of queries to it, the scientific politics here are not good—but I should venture for a short while. Similarly, on the US side there are rivalries which complicate what I thought was a nice simple situation. However, I can wait and see.[26]

The letter also contained summaries of his quick visits to New York, Princeton (the Nicoll family and their children), Boston (two days with Bart Bok and others at Harvard), Washington (half a day with Tuve at the Carnegie Institution) and a rushed day at the University of Michigan solar observatory (McMath Hulbert Observatory) with Leo Goldberg and Helen Dodson. "I certainly am in demand."

Immediately on return to Australia, the National Research Council in Canada sorted out the confusion caused by McKinley. Likely, Herzberg had contacted B.G. Ballard, the Vice-President (Scientific) of the National Research Council in Ottawa. He wrote Fred White (CEO of the CSIRO)

[26] This letter to his wife exposes the fragile nature of Pawsey's health. He was ill at both ends of the trip. He had been hospitalised in late May in Sydney for varicose veins, before his departure in July 1954. On his return to Sydney, he was again ill with the flu. Christiansen wrote him in Sydney from London on 16 November 1954: "I have heard that you are back in Australia and had celebrated your return by getting gastric flu. I hope you are now fit and well."

on 21 October 1954[27]; he had been on a trip and had missed Pawsey's visit the first week of October. Ballard tried to sort out the ill-will:

> … I missed meeting Dr Pawsey on this trip, but his reputation is well known to me. Dr McKinley and Mr Covington inform me that Dr Pawsey's short visit was most helpful and an inspiration to the work here.
>
> We have been so impressed with Dr Pawsey's contributions to radiophysics that we would like to have him come again for a longer stay. We would like to suggest a minimum period of one year—longer if you can possibly spare him. Not only would we benefit greatly from such an arrangement but I am sure there would be a considerable gain from your viewpoint in the broadened experience and additional contacts that would result.
>
> We earnestly hope that you will look favourably upon this proposal. Without going into detail at this stage … we should pay him a salary on a level with our top senior scientists, and that you might arrange for his travel to and from Ottawa. In effect we are proposing a "sabbatical year" arrangement, and we shall await your reaction with interest. [The letter was also forwarded by White to Bowen at RPL.]

On 5 November 1954, White responded to Ballard. He pointed out that: "Pawsey personally would very much appreciate an opportunity of spending more time in Canada". White would discuss the issue with Bowen and Pawsey. However, after an exchange of a letter from White on 5 November 1954, the story died with no additional correspondence. White to Bowen:

> I know that Joe is quite keen on the idea of spending some time in Canada in the future, and while I would like to help him do so, I think both you and he will agree that much depends on the way things turn out in connection with the large radio telescope. It may be important for Joe not to be away at certain stages of this development if it is to go ahead effectively. There are probably other considerations too which we can discuss when we meet.

The latter statements may presage the impending conflicts between Bowen and Pawsey regarding the Giant Radio Telescope (GRT), the appointment of John Bolton in 1960 (Chapter 30) and the long absences from Australia in 1957 and 1958 (Chap 27 and 29). However, discussions of the long Canadian visit for Pawsey seem to have ended in late 1954.[28]

[27] NAA AH8520, PH/PAW/B Part 1 (Personnel file)

[28] Earlier in 1954, Pawsey may have anticipated a long Canadian visit in 1955 in a letter to Dr C.M. Focken, Secretary Section A of the Australian New Zealand Association for the Advancement of Science Melbourne Meeting on 6 July 1954. (NAA C3830 Z3/1/ Part 5), Pawsey replied to an invitation to

Surprisingly, the next letter in the archives to or from McKinley is three and a half years later. On 13 March 1957, Pawsey wrote McKinley.[29] Pawsey was resigned to the failure of the prospect of a Canadian long-term visit as he anticipated a new visit to Canada in 1957:

> It is a great pity that your plot about my year in Canada broke down. I shall tell you the story when I see you. I shall be coming over to URSI [in Boulder Colorado] and after that I am to spend six months in the US at NSF expense. I am planning a fortnight in Canada in the middle of this. Would it be convenient to your people if I spent a fortnight in Ottawa beginning December 2 next? I also have hopes of bringing the family, a last fling before they disperse. [Margaret and Stuart were in university at this time.]

However, the details of "the story" were not revealed in the letter.

Pawsey's last trip to Canada, late 1957[30]

The Pawsey family were in the US and Canada from 9 August 1957 to April 1958. The complex itinerary and the partial participation of the three children is summarised in Chapter 28 of the main book. Lenore and Pawsey traveled together to most destinations in the US and Canada. The trip was partially funded by the National Science Foundation, the grant administered by the Carnegie Institute of Washington, Department of Terrestrial Magnetism via Merle Tuve. Informally, the trip functioned as a "try-out" for Pawsey as the NSF and AUI (Associated Universities, Inc.) focused on assessing a candidate as a possible future Director of the National Radio Astronomy Observatory (See Chapter 38, main book).

In mid-August, Pawsey attended the American Astronomical Society in Urbana Illinois, followed in late August by the U.S. URSI (International Union of Radio Science) in Boulder, Colorado. In early September they moved to Ann Arbor, Michigan, to the University of Michigan for 2 ½ month visit with Leo Goldberg as host. Side trips were made to Ohio State (John Kraus) and to NRAO, Green Bank (16 and 17 October, for the ceremony transferring the site from the NSF to AUI and for a meeting of the AUI/NRAO Advisory Committee).

---

become President of Section A in August 1955. " … [T]here is some uncertainty as to whether I shall be in Australia at the time. Please treat this as confidential to yourself and committee, as my plans are quite indefinite. My guess as to the probability of absence is about 1 in 2 or 3." In fact, he was present in Australia in 1955.

[29] NAA C3830 Z3/3/B.

[30] Source material is Joe and Lenore Pawsey Family Collection, C3830, F1/4/PAW Part 5 and Z3/3/B.

In mid-November, Lenore and drove east to Massachusetts, visiting Harvard and the Massachusetts Institute of Technology.

The two-week trip (4 December to 16 December 1957) to Canada. During this period, the family was united as Hastings (age 12) arrived in Montreal from Princeton, where he was in school for some months. The older children, Margaret (age 20) and Stuart (age 18), arrived from Australia, traveling to Vancouver by air, then by train across Canada to Ottawa.

On Wednesday 4 December 1957, the Pawseys arrived in Ottawa, visiting the Australian High Commission (Embassy) and then the National Research Council. Pawsey visited his friend D.R.W. McKinley, the head of REED (Radio and Electrical Engineering Division, NRC) in the morning. Don McKinley joined fellow meteor radar scientist Peter Millman and Arthur Covington for lunch. In the afternoon, Pawsey visited the Goth Hill Solar Noise Observatory with Covington, followed by a visit with Peter Millman to the Springhill Meteor Observatory.

The hectic pace continued on Monday 9 December 1957, as Pawsey visited the Defence Research Establishment Ottawa (DREO), located at Shirleys Bay, west side of Ottawa. A number of activities of interest were carried out at this laboratory, such as ionospheric research (including whistlers), auroral (500 MHz) and solar noise research (30, 50 and 500 MHz).

On 10 December 1957, Pawsey again visited NRC in Ottawa, continuing the discussion with Covington about his S band (10 cm) solar work. On the following day, Pawsey gave a lecture on recent Australian research in radio astronomy to the "Science Association." Here he met Norm Broten (1921-2015), who was to visit Australia in the early 1960s as a prominent user of the newly completed Parkes telescope. At the REED office, Pawsey had lunch with Bristow Ballard, Norm Broten, C.S. Beals[31] and Jack Locke. Beals was the Dominion Astronomer at the Dominion Observatory. Locke[32] was the Chief of the Stellar Physics Division. After a tour of the observatory with Beals, Locke described the plans for a new radio observatory in Penticton, British Columbia, recently approved by the Canadian government. (see Fig. 9 caption for reference Odgers, 1960, the DRAO at Penticton British Columbia opening).

The trips to Canada in 1941, 1947-1948, 1954 and 1957 were important but had no major consequences to Pawsey's career. As we have pointed out, the failure to recruit Ralph Williamson was a disappointment in 1949. Williamson would have brought a level of

[31] In his obituary for Beals, Wright (1980) has written: "[As Dominion Astronomer], [Beals] was able to expand and develop astrophysics and geophysics in Canada. In Ottawa he particularly strengthened the divisions relating to the time service, solar physics, meteors and seismology."

[32] In 1966, Locke (1921-2010) moved to the Radio Astronomy Group within REED of the NRC. In 1970, he became the Chief of the Astrophysics Branch of the merged NRC (DO, DRAO- Penticton, ARO – Algonquin Radio Observatory and the Stellar Physics Division of DO) and Associate Director of REED. In 1975, Locke became the first Director of the Herzberg Institute of Astrophysics (HIA).

astrophysical understanding that could have been quite beneficial at RPL. Another major disappointment was the surprising failure of the possible "sabbatical" trip of circa 1954. Don McKinley and Pawsey experienced a major misunderstanding. Even the intervention of Herzberg was promising but did not lead to a major visit of the Pawsey family to Canada; Lenore's desire for snow and central heating was unrequited.

ADDITIONAL NOTE 1

Obituaries for Williamson (1917-1982) by MacRae and Covington. Reflections on Ralph Williamson by John Heard in 1976

In 1982-1983, two obituaries were published after the death of Ralph Williamson in New Mexico, June 1982. His friend Don MacRae wrote a short text in the *Doings of the David Dunlap Observatory* in November 1982 (Vol 15 Number 17, Ralph Williamson, 1917-1982). This text was followed by an "official obituary" in 1983 by Arthur Covington in the *Journal of the Royal Astronomical Society of Canada,* vol 77, p 97. Both texts reported on their first meeting with Williamson. The Heard text of 1976 reflects Heard's memories of Frank Hogg hiring Williamson in 1946.

Donald MacRae, November 1982 and 1998:

MacRae (*Doings of the David Dunlap Observatory*, vol 15 No 7, 1 November 1982) :

> ... Ralph joined the staff of the Department of Astronomy and the David Dunlop Observatory in 1946 as lecturer. He was Assistant Professor from 1947 to 1952, when he was promoted to Associate Professor. However, he left in 1953, relocating at the Los Alamos Scientific in New Mexico.
>
> I first met Ralph in 1944 when he came to Cornell from Chicago. The US Navy was training its midshipman there and we taught the course in navigation. Apart from some elementary radio astronomy sparked by Charles L. Seeger Jr. in the Electrical Engineering Faculty, astronomy at Cornell seemed unlikely to develop, and both of us left with regrets in 1946- Ralph to take the junior position at Toronto which followed upon R.K. Young's resignation as DDO Director. But Ralph kept in with Seeger and later he and Ruth Northcott published the first two papers on radio astronomy from the University of Toronto.
>
> ... His PhD was with Chandrasekhar, whom he admired very much. His training was therefore in stellar atmospheres, stellar dynamics and stellar interiors. When they came

> along in the 50s he was one of the first to apply electronic computers to such problems. At Los Alamos [in New Mexico] his work was in weapons physics and design. His contacts with astronomers soon became infrequent, although he remained a member of the American Astronomical Society …
>
> Ralph was a brilliant colleague and a charming and good-natured friend. When I knew him, he was very fond of astronomy, working with great enthusiasm, fascinated by the new ideas just then coming forth. He would have made a great professor. [33]

MacRae's career was influenced in a maor fashion by Williamson. E.R. Seaquest has written an extensive obituary[34] for MacRae after his death at age 90 on 6 December 2006. During WWII, he and Williamson worked together at Cornell. In 1946, MacRae obtained a position at Case Institute of Technology in Cleveland, Ohio, staying until 1953. "In 1953, he accepted a position at the University of Toronto, replacing Ralph Williamson, who had earlier introduced MacRae to the emerging field of radio astronomy while they were both at Cornell."

MacRae added an additional note about his friend Ralph Williamson in 1998, 16 years after Williamson's death. Likely MacRae had found a photo of Williamson taken by Ruth Northcott from November 1950. MacRae's whimsical description (in a note published in 1998; see www.rasc.ca/re-williamson, web site of the Royal Astronomical Society of Canada) f *l :*

> MacRae: This man, with the Mephistophelian/Orson Wellsian visage [Fig 10], is Ralph E. Williamson, Ph.D. Chicago, a student of Chandrasekhar. Ralph came to University of Toronto/DDO [David Dunlap Observatory] in 1946 or so. He and I had been great friends together at Cornell. At the start of WWII, we found ourselves teaching navigation to US Navy Midshipmen recruits. Then I went to Oak Ridge, Tennessee. Ralph stayed on for a bit, working with Charles Seeger on the Cornell radio astronomy project (now Arecibo) that Charles initiated. Ralph left DDO abruptly to go to Los Alamos, in 1952 or 1953, leaving behind his wife Dorothy Williamson. I think Dorothy W. worked for a while at the Ross Street RASC office after that. Ralph died several years ago [1982]. Ralph and Ruth Northcott wrote I think two articles analysing Reber's early observations of Milky Way radio astronomy and published them in the Journal in the early 50's. [the only

[33] Clearly Williamson had a high regard for MacRae. In the acknowledgements to the Cornell based observational paper of 1951 by Seeger and Williamson, the authors wrote: "Dr D.A. MacRae, of the Warner and Swasey Observatory, participated in the early stages of this investigation and was a source of continuous encouragement and helpful suggestions."

[34] *Cassiopeia Newsletter* of the Canadian Astronomical Society No 131, Winter Solstice, 2006

paper was “Galactic Noise and the Plane of the Galaxy” by Northcott and Williamson. 1948, JRASC, vol 42, p269]

Fig 10. Williamson in 1950, photo by Ruth Northcott. In 1998, MacRae described the image as Ralph E. Williamson with a Mephistophelian/Orson Wellsian visage. See www.rasc.ca/re-williamson. (Pointed out to the authors by Robert Hayward.)

Arthur Covington, the “official” obituary in *JRASC*, vol 77, p 97, 1983

Covington met Williamson at Cornell in the era of 1945; Covington was studying 200 MHz solar bursts.

> In 1946, when Frank S. Hogg succeeded R.K. Young as Director of the David Dunlap Observation, Williamson joined the Astronomy Department of the University of Toronto. On January 20, 1949, he gave a lecture to the Ottawa Centre of the Royal

Astronomical Society of Canada on “Radio Waves from the Sun and Stars” which repeated the following month at the Toronto Centre. These lectures brought up to date the material Williamson had gathered and organised for a report on the “Status of Microwave Astronomy” that he had prepared for Cornell University under a contract from the US Navy during and after the Second World War.

… Williamson was associated with Charles L. Seeger and C.R. Burrows in the founding of the Cornell Radio Observatory, and he participated in early meetings of the U.S. National Committee of URSI (Union Radio Scientifique Internationale). I recall one URSI meeting after Jansky's death at which it was resolved to call the unit of radio flux (watts per square metre per cycle per second) the “jansky”. A brightness unit had been adopted at an earlier meeting of URSI (Washington, May 6, 1948), at least partly on the urging of Williamson, Seeger and Burrows. Although I was not present at that early meeting, the records show that Jansky himself was.

In the late 1940s and early 1950s, I enjoyed many discussions with Ralph Williamson. As a theoretical astronomer, he was always ready to help those of us devising instruments. His own interest, at that time was the statistical relationship between the planes of optical and radio galaxies. In 1953, he left the University of Toronto to assume a position at Los Alamos, where he hoped that his work would be more useful to a troubled world! I succeed him as chairman of the Canadian National Committee of URSI, which had been formed in 1949 under the chairmanship of Donald W.R. McKinley. In 1950, Williamson was appointed chairman of Commission 5 of URSI (Radio Astronomy) and edited its first report. At that time there were only two active radio astronomy groups in Canada. Ralph Williamson will be remembered as one of a small group who opened new windows to the heavens.

John H. Heard, former DDO Director: his assessment of Williamson, February 1976 (*David Dunlap Doings* Vol 9, no2, 24 February 1976):

A remarkable assessment of Williamson was written by the DDO Director, Jack Heard, six years before Williamson’s death. Tragically, Heard died on 5 October 1976 at age 69. He had retired as DDO director in 1965. Heard’s text illuminates Williamson’s achievements and potential.

Editorial “The Early Post-war Years 2. Ralph Wiliamson

In last month’s Editorial I wrote of the appointment of Dr. C.S. Yu in 1946….During 1946, Frank Hogg was negotiating with another to the teaching staff.

One of the applicants was Ralph E. Williamson, an Oklahoman by birth, A.B. (Phillips 1938), A.M. (Drake 1939) and PhD. (Chicago 1943). In 1946 he was completing a second year as lecturer in astronomy at Cornell. Williamson's research training under Chandrasekhar in the field of stellar structure seemed made to order for our requirements. We lacked anyone on our staff who claimed proficiency in any theoretical field, much less in the new and important developments in stellar structure and evolution. Frank was delighted to be able to come to an agreement with Ralph, and he arrived in September of 1946. Although he was with us for only seven years that was long enough to establish a chain of theoretical astrophysicists which included Bev Oke, Leonard Searle and Pierre Demarque, and to give us a role in the field of stellar structure of which we could be justly proud.

Bev Oke was a physics graduate of U. of T., 1949, who became one of Ralph's first graduate students. His Master's thesis in 1950 entitled "A Theoretical HR Diagram for Red Dwarf Stars" included the first demonstration that it is the proton-proton reaction that dominates energy production in the sun's interior. On the strength of this good piece of work Bev became our first student to be accepted for a Ph.D program at Princeton. When Bev finished there in 1953, the year that Williamson left us, we offered him a job in the Department, which he accepted …

To return to the Williamson story, Ralph, in addition to his stellar structure interest, was one of the few young astronomers who, in the 40s, began to recognise the importance of the not-yet-quite- respectable subject of radio astronomy. He had a way of infecting others with his enthusiasm. Ruth Northcott, usually timid and un-self-confident about anything new, cheerfully teamed up with Ralph in a paper on the galactic radio equator. Ralph, no great observer himself, persuaded me to help him try to identify optically the strong radio source Cas A. On a terribly windy November night in 1951 we actually photographed Cas A with the 74-inch, anticipating Baade by some months. Unfortunately the quality of our image did not permit us to distinguish it from a plate smudge..

Don MacRae, then at the Warner and Swasey Observatory, and beginning also to flirt with radio astronomy, paid us many visits for long conferences

> with Ralph. As it turned out, Don was appointed as Ralph's replacement in 1953, and one of his first projects here was to involve our Department in an observational radio astronomy program with the Department of Electrical Engineering.
>
> Ralph's departure in 1953 stemmed partly from personal circumstances at the time and partly from a tempting offer in the very different field of the physics and design of weapons at the Los Alamos Scientific Laboratory. I believe he waged quite a battle with his conscience, prompted on the one hand by feelings of patriotism (he had retained his American Citizenship) and on the other by a natural revulsion against war[35]. However, he took the job, and apparently he abandoned astronomy immediately and completely. So far as I know he never attended another astronomy meeting or wrote another paper in the subject.[36]

In fact, we have evidence of at least two conferences that Williamson attended. He was a participant at the January 1954 "Washington Conference on Radio Astronomy" sponsored by the National Science Foundation, Caltech and the Carnegie Institution of Washington. He was not a speaker. At a meeting of the American Astronomical Society in 20 to 23 June 1954 at the University of Michigan, a joint meeting was held with the Association for Computing Machinery. Williamson gave a talk describing "the stupendous possibilities of the machines for problems of stellar dynamics." Williamson has numerous publications with colleagues at LASL, including Albert G. Petschek (a former professor at the New Mexico Institute of Mines and Technology and friend of Goss and Ekers). An example is "Penetration of Radiation with Constant Driving Temperature", Technical Report LAS-2411 LASL May 1960.

[35] Heard's opinion is slightly at odds with Covington's assessment of Williamson's rationale for joining the LASL (Los Alamos Scientific Laboratory) in New Mexico.

[36] Richard Jarrell (1997. JRASC, vol 91, p 20, "The Formative Years of Canadian Radio Astronomy") has written a brief summary of Williamson's impact on Canadian astronomy: his comments about Williamson may well underestimate the impact that Williamson had on the future acceptance of radio astronomy in Canada, especially on Donald MacRae. "It was Williamson who introduced Canadian academic astronomers … to the newly-emerging field [of radio astronomy] … [He]was primarily a theoretician and during his tenure at Toronto no graduate students were attracted to radio astronomy, nor were experiments undertaken."

Additional Note 2

"Two of Williamson's Radio Astronomy Publications: 'The Present Status of Microwave Astronomy' and 'The Atmosphere of the Sun'" [37]

From late 1947 to 1951, Williamson wrote five papers related to the new radio astronomy. The entire radio astronomy literature was meagre; the number of references of his paper published in 1948 (written in 1947) was 35, 21 from *Nature.* The first publication in the semi-popular *Journal of the Royal Astronomical Society of Canada* "The Present Status of Microwave Astronomy" incorporates many ideas stimulated by the new radio astronomy, whose name was only suggested by Pawsey and Ryle in 1948 (see ESM_17.1). Williamson warned the reader to show caution due to the vast uncertainties in problems with calibration of radio telescopes and the severe problems due to the coarse angular resolution, some 10s of degrees in many cases.

Williamson provided the necessary background with descriptions of Jansky's pioneering work and the confirmation observations from Bell Labs and Caltech. Reber's work was described in detail starting in 1936 as he detected "cosmic static". Williamson described Reber's radio telescope (used at 160 and 480 MHz) as a "microwave telescope". Williamson pointed out the major differences between optical and radio astronomy, leading to possible misconceptions:

> Considering the many significant facts about our universe which have been wrung from the small optical region, the new microwave region is a rich mine of potential information to the astrophysicist who is able to interpret the observations. However, there exists an unusual obstacle to the immediate use of this powerful method of analysis. The customary training of the astrophysicist is such that, while he is quite at home with telescopes and spectrographs which analyse electromagnetic radiation at optical frequencies, he has no background in the complex techniques of antenna and high-frequency radio-receiver design which are required in the microwave region. On the other hand, the radio engineer, well-versed in this side of the problem and perhaps possessed of the equipment for taking observations, may well find himself at a loss to know best how to use it to obtain astrophysical data. Any realistic approach to the field of microwave astronomy will require attention to this unusual situation.

[37] Additional publications were "Galactic Noise and the Plane of the Galaxy" by Ruth Northcott and Williamson in JRASC, vol 42, p 269, 1948", "Concerning the Source of Galactic Radio Noise" by Williamson in JRASC, vol 44, p 12, "The Pole of the Galaxy as Determined from Measurements at 205 MHz" by Seeger and Williamson in *Astrophysical Journal*, vol 113, p. 21, 1951, based on Cornell data from October 1948.

Williamson also wanted to convince sceptical optical astronomers that the tenuous radio data were real. As Sullivan has pointed out in *Cosmic Noise* (page 431), Williamson "felt compelled, even as late as 1947, to explicitly list as his first conclusion" that cosmic noise really did exist. Williamson:

> How can we summarise the state of knowledge about the distribution of cosmic noise over the celestial sphere? It seems indisputable (1) that it exists; (2) that it is strongly concentrated to the plane of the galaxy; (3) that it has a strong maximum in the direction of the centre of the galaxy.

A final warning was provided by Williamson as he emphasised a major problem that faced the new radio astronomers in 1947, the origin of the non-thermal galactic background radiation; astronomers in the west would only acknowledge the relevance of synchrotron emission in the late 1950s early 1960s.[38]

> It is perhaps worthwhile to call attention to the extreme complexity of the problem of interpreting cosmic noise. This complexity is connected with the peculiar conditions of interstellar space, where the density of matter is very small (close approaches of charged particles occur at intervals to be measured in seconds), the density of radiation, which is governed by the radiation from the stars, is small, although its frequency-dependence is that of a very hot source. These complications, added to probable variations of density of interstellar material, of even its chemical composition, mean that the task of unravelling the causes of microwave radiation from the galaxy will be a complex one. However, it will be extremely rewarding, in that it will shed entirely new light on the conditions of interstellar matter in our galaxy.

"The Atmosphere of the Sun", *JRASC*, vol 45, p 232, 1951.

Williamson's last astronomical contribution appeared in late 1951 with an extensive review of solar physics. It has been a talk at the Royal Society of Canada in Kingston, Ontario, in June 1950 as part of a symposium on "The Atmospheres of the Sun and Planets". [39]

[38] Williamson also pointed out the fallacy of the suggestion of Pawsey, Payne-Scott and McCready in their *Nature* paper of February 1946 that the galactic plane emission observed by Jansky and Reber was the superposition of contributions of radio emission from a large number of stars. Following Greenstein, Henyey and Keenan *(Nature*, 1946, vol 157, p. 805), Williamson pointed out that this suggestion failed by factors of some thousands.

[39] Williamson was also prolific in the publications of scientific book reviews with one review each in 1947, 1948 and 1951, two in 1952 and 1953.The review of 1951 created a major controversy, a review

Understanding the Optical Emission of the Solar Photosphere

More than half of the 18-page paper is a thorough and lucid explanation of the new theories of the solar photosphere developed by Chandrasekhar and his students (including Williamson) at Yerkes observatory. Williamson explained the nature of the role played by the negative hydrogen ion (two electrons bound to one proton), an unstable structure unable to survive at atmospheric pressure but appreciable in the solar atmosphere. Williamson had played a key role doing the quantum mechanical calculation of the properties of H^{--}, and particularly the absorption coefficients. Thus, the well-known limb darkening could be explained with the central solar rays going deeper and thus hotter layers of the photosphere. At the limb the rays did not penetrate so deeply and thus from comparatively cooler regions. Details of the opacity as a function of wavelength from 0.4 to 22 microns were also important. ("The Negative Hydrogen Ion and Its Absorption Coefficient", 1942, *Astrophysical Journal*, vol 96, p 438 and "The Continuous Spectrum of Model Stellar Atmospheres", 1943, *Astrophysical Journal* Vol 97, p 51. Williamson thanked his wife, Dorothy, for "great assistance in much of the computing and in typing the manuscript".)

The 1951 paper concluded with a plot which showed a comparison of observations and theory for the theoretical (H^- and also H contributions) and empirical absorption coefficients for the solar atmosphere (his Fig 6). The agreement "is so satisfactory that there can be now no doubt that the mechanism of formation of the sun's continuous spectrum is as completely solved as any problem in astrophysics can ever be."

Radio Astronomy of the sun in 1951:

---

of Fred Hoyle's series of talks on the Nature of the Universe. Williamson gave a broadcast on the Trans-Canada radio network of the CBC on 27 June 1951. ("Fred Hoyle's Universe" JRASC, vol 45, p 185). Helge Kragh, in his book *Cosmology and Controversy, The Historical Development of Two Theories of the Universe* from 1996, has a fascinating discussion of Williamson's harsh criticism of Hoyle (p 194, 239). Williamson: "[There was a general dissatisfaction of astronomers with what Hoyle has said". Kragh suggested that there was "a feeling that [Hoyle] had gone far beyond the limits of decent presentations of astronomy and a fear that his immodesty and one-sidedness had harmed the profession ... Williamson asserted that Hoyle was barely a real astronomer at all. Williamson had even accused Hoyle of replacing 'honest facts' with untested theoretical views." Williamson: "He has had no real experience with handling the large telescopes which make modern astronomy possible." Kragh also discussed the public response to the extreme criticism made, not by Hoyle, but his colleague and fellow "steady-stater" Bondi. Kragh: "Bondi ridiculed the Canadian astronomer for his simplistic belief in 'facts' and his 'preposterous statement' that only people who had done observational work are entitled to discuss astronomy. Bondi: "It is on the same plane, as the statement that only plumbers and milkmen have the right to pronounce on hydrodynamics."

Williamson's description of the exciting new radio results for the sun in 1951:

> In the meantime, as our understanding of one part of the sun's atmosphere, the photosphere, was in a sense coming to completion, new and exciting questions were being raised about another portion of the sun: it was being realised for the first time that the sun emits radio waves, and this exciting discovery afforded --and is still affording-- a variety of puzzling and stimulating problems.

The description of Southworth's detections of the sun at cm frequencies (Chapter 11) followed. Williamson provided details of the new component of the sun detected by the CSIRO group in 1945-1946, the hot corona. Pawsey's detection of the quiet sun at 200 MHz (*Nature*, 2 November 1946, Chapter 14), with a detailed description of the million-degree corona at metre wavelengths was discussed in detail. A plot similar to the Pawsey and Yabsley (ESM_21.2) was included showing the temperature of the sun from cm wavelengths (the photosphere at about 6000 K to the corona at a million K at wavelengths frequencies below 300 MHz. Williamson then described in a cursory manner the variable component of the radio solar emission, bursts and outbursts. In 1951, Williamson was, of course, not aware of the 20 cm solar limb brightening which would be discovered a few years later by Christiansen and Warburton, published in 1953 (1 dimensional) and 1955 (2 dimensional). (see NRAO ONLINE 23).

Williamson concluded with an optimistic message, with predictions that would be fulfilled:

> But the existence of difficulties [such as insufficient angular resolution and the difficulties of observing the quiet sun in the presence of solar bursts] has never stopped the progress of science. The many gifted radio engineers who are interested in radio astronomy, working with astrophysicists who have an appreciation of the new methods as well as an understanding of what the necessary observations are, backed by the very generous grants of money from government research agencies in Canada, the United States, England, Australia and Holland, will overcome the technical difficulties involved. I am confident that within a decade we will have as satisfactory a solution of the problem of the sun's radio-frequency radiation as we now have of the sun's optical radiation.

A number of questions posed by Williamson were answered by Pawsey in a review article written in early 1953 and published in the *Journal of the Royal Astronomical Society of Canada*, "Radio Astronomy in Australia", 1953, vol 47, July to August 1953, p 157. Likely, the Canadian colleagues had solicited this article already in 1948 during Pawsey's successful visit to Toronto

and Ottawa. On a number of challenges set by Williamson a partial solutions had been achieved only four years later.

The Canadian publication by Pawsey contained the new data from Dapto, including the harmonic structure of Type II bursts (2 to 1 frequency interval). Publication was in *Nature* by Wild, Murray and Rowe (19 September 1953, vol 172, p. 533). Pawsey also described early results with the Potts Hill E-W multi-element grating interferometer with a 3 arc min beam at 21 cm. With superposed records of brightness, the lower envelope of intensity delineated the distribution of the thermal component from the quiet sun at 21 cm. Limb brightening was indicated. The time variable component at this frequency arose from the SVC- slowing varying component.

Pawsey also described the recent Australian observations of "radio stars", in fact not "stars" but radio nebula due to the finite angular sizes of some arc min in some cases. "Radio nebula" was a better name. In some cases these objects even had angular sizes of half a degree up to several degrees, now known to be large galactic supernova remnants.

The HI line was also described: "The outstanding development in radio astronomy of the past few years was the discovery by Ewen and Purcell of Harvard (on 25 March 1951) that the galaxy emits the 1420 MHz line of atomic hydrogen." The Australians had an immediate follow-up campaign, making a crude HI image of the southern Milky Way. Pawsey wrote in his 1953 JRASC conclusion:

> The cause of the development of some branch of science at a particular time and place is of interest to those concerned with the planning or the history of scientific research. Such developments do not follow a very obvious pattern. Radio astronomy, for example, has grown almost entirely outside astronomical observatories despite the fact that its objective is just that of conventional astronomy, the search for knowledge of the external universe.
>
> The Australian development can be traced to the concentration on radar development during World War II. This brought together in a well-equipped laboratory a group of able young physicists with experience of radio techniques. At the conclusion of the war these men [and one woman!] found themselves without definite commitments and anxious to establish themselves in scientific research. In some countries this situation led to an exodus of the most able people from the government radar laboratories. In Australia the high scientific reputation of CSIRO, which had been built up under men like its

> original leader Sir David Rivett, prevented this trend. The men were actively encouraged by the executive to develop their science within the Organisation.
>
> It was in this environment that the first tentative observations in radio astronomy were undertaken. These observations were immediately successful and the Laboratory was encouraged to venture further into the field. Thus, first-class men obtained access to first-class facilities and the subsequent developments in radio astronomy in Australia have followed from this beginning.

Whether Pawsey intended to compare the Canadian post-war experience with that in Australia is not at all clear. But as Jarrell (1997) has discussed:

> Because Canada developed a distinctive programme in nuclear research during the war, promising younger physicists were attracted to the ongoing work at Chalk River and other laboratories. Other promising new fields, such as geophysics, particle physics and aeronautics, attracted others. That contrasts with Australia, where there was less competition from other fields. Their radio astronomers capitalised on their early lead in the field, and established their work as a key national research programme.

Additional Note 3:

The Globe and Mail newspaper article about Williamson, 20 February 1952, "Study Hissing Star Mystery"

David E. Hogg has given the authors a copy of a remarkable newspaper article in the Toronto *Globe and Mail*, second section of the edition of Wednesday 20 February 1952. Ralph Williamson was the star attraction of this remarkably disjointed article. As was often the case with popular accounts of early radio astronomy, the authors gave the distorted impression that early radio astronomers detected **acoustic** signals from the universe. Mr David MacDonald excelled, the title of the article "Study Hissing Star Mystery" set the stage:

> … Dr Williamson is more concerned with Cassiopeia A- a star which has been serving up static for science … A radio star is a heavenly something which gives off radio waves that can be picked up on earth … [discovered] by a young engineer in New Jersey [20 years ago, Karl Jansky …] To Karl Jansky it sounded like a steady hissing. The cause baffled him.

After checking it for several months he found there was no earthly reason. It came from the general direction in which astronomers placed the centre of our stellar system.

For the first time man had heard a sound produced by radio waves from out of space. If opened up an entirely new means of examining the universe.

[Dr Williamson has been examining the universe using a sensitive telescope at Cornell University in Ithaca, New York. He has observed Cassiopeia A in the Milky Way.] He listens to the hissing noise at Cornell and returns to Toronto, Richmond Hill, to find out with pencil and paper just what it means. Dr Williamson is convinced that all stars and planets give off radio waves, but man-made receivers are sensitive enough to pick up those of only a few …

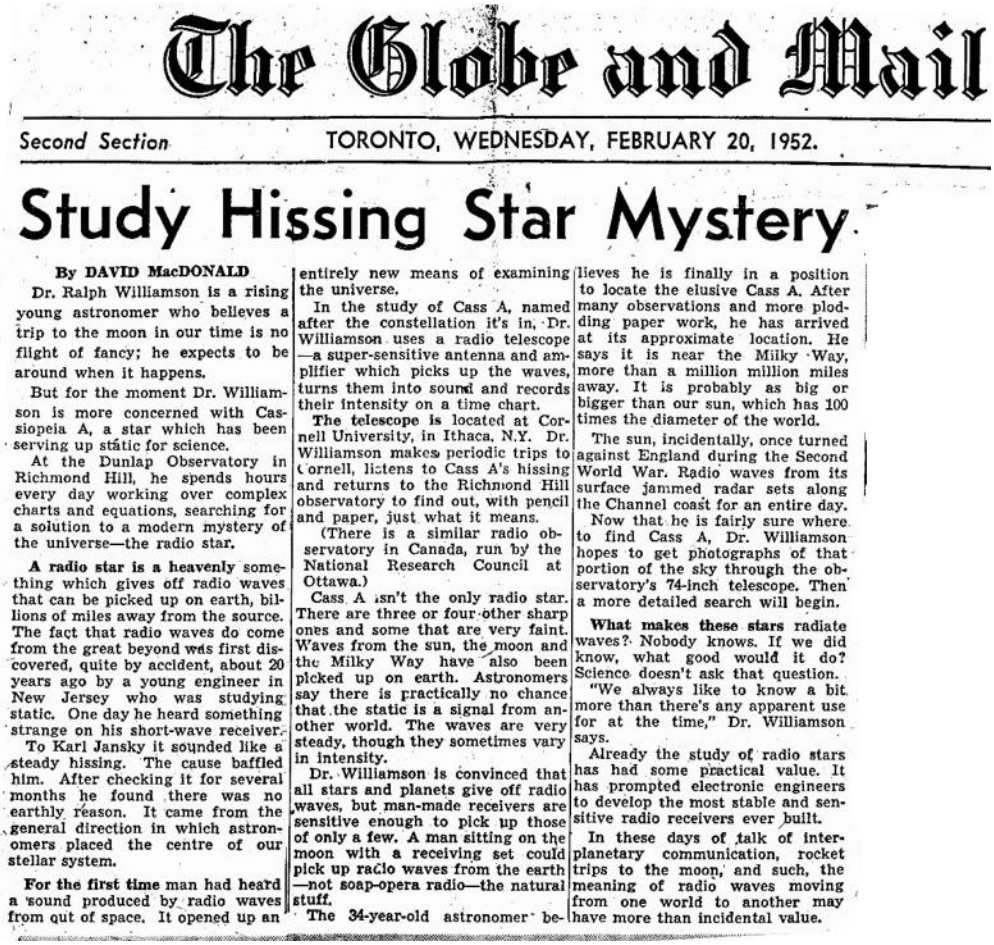
The 34 year-old Williamson believes he is finally in a position to locate the elusive Cassiopeia A. After many observations and more plodding paper work, he has arrived at is approximate location … Dr Williamson hopes to get photographs of that portion of the sky through the observatory's 74-inch telescope.

What makes these stars radiate waves? Nobody knows. If we did know, what good would it do? Science doesn't ask that question. "We always like to know a bit more that there's any apparent use for at the time," Dr Williamson says.

Already the study of radio stars has had some practical value. It has prompted electronic engineers to develop the most stable and sensitive radio receivers ever built.

In these days of talk of interplanetary communication, rocket trips to the moon, and such, the meaning of radio waves moving from one world to another may have more than incidental value.

In Fig 11, 12 and 13 we show the newspaper clipping from 20 February 1952. The astronomy professors Helen Hogg and John Heard are shown in Fig 11. Williamson is shown in Fig 13.



The Globe and Mail

Second Section TORONTO, WEDNESDAY, FEBRUARY 20, 1952.

Study Hissing Star Mystery

By DAVID MacDONALD

Dr. Ralph Williamson is a rising young astronomer who believes a trip to the moon in our time is no flight of fancy; he expects to be around when it happens.

But for the moment Dr. Williamson is more concerned with Cassiopeia A, a star which has been serving up static for science.

At the Dunlap Observatory in Richmond Hill, he spends hours every day working over complex charts and equations, searching for a solution to a modern mystery of the universe—the radio star.

A radio star is a heavenly something which gives off radio waves that can be picked up on earth, billions of miles away from the source. The fact that radio waves do come from the great beyond was first discovered, quite by accident, about 20 years ago by a young engineer in New Jersey who was studying static. One day he heard something strange on his short-wave receiver.

To Karl Jansky it sounded like a steady hissing. The cause baffled him. After checking it for several months he found there was no earthly reason. It came from the general direction in which astronomers placed the centre of our stellar system.

For the first time man had heard a sound produced by radio waves from out of space. It opened up an entirely new means of examining the universe.

In the study of Cass A, named after the constellation it's in, Dr. Williamson uses a radio telescope —a super-sensitive antenna and amplifier which picks up the waves, turns them into sound and records their intensity on a time chart.

The telescope is located at Cornell University, in Ithaca, N.Y. Dr. Williamson makes periodic trips to Cornell, listens to Cass A's hissing and returns to the Richmond Hill observatory to find out, with pencil and paper, just what it means.

(There is a similar radio observatory in Canada, run by the National Research Council at Ottawa.)

Cass A isn't the only radio star. There are three or four other sharp ones and some that are very faint. Waves from the sun, the moon and the Milky Way have also been picked up on earth. Astronomers say there is practically no chance that the static is a signal from another world. The waves are very steady, though they sometimes vary in intensity.

Dr. Williamson is convinced that all stars and planets give off radio waves, but man-made receivers are sensitive enough to pick up those of only a few. A man sitting on the moon with a receiving set could pick up radio waves from the earth —not soap-opera radio—the natural stuff.

The 34-year-old astronomer believes he is finally in a position to locate the elusive Cass A. After many observations and more plodding paper work, he has arrived at its approximate location. He says it is near the Milky Way, more than a million million miles away. It is probably as big or bigger than our sun, which has 100 times the diameter of the world.

The sun, incidentally, once turned against England during the Second World War. Radio waves from its surface jammed radar sets along the Channel coast for an entire day.

Now that he is fairly sure where to find Cass A, Dr. Williamson hopes to get photographs of that portion of the sky through the observatory's 74-inch telescope. Then a more detailed search will begin.

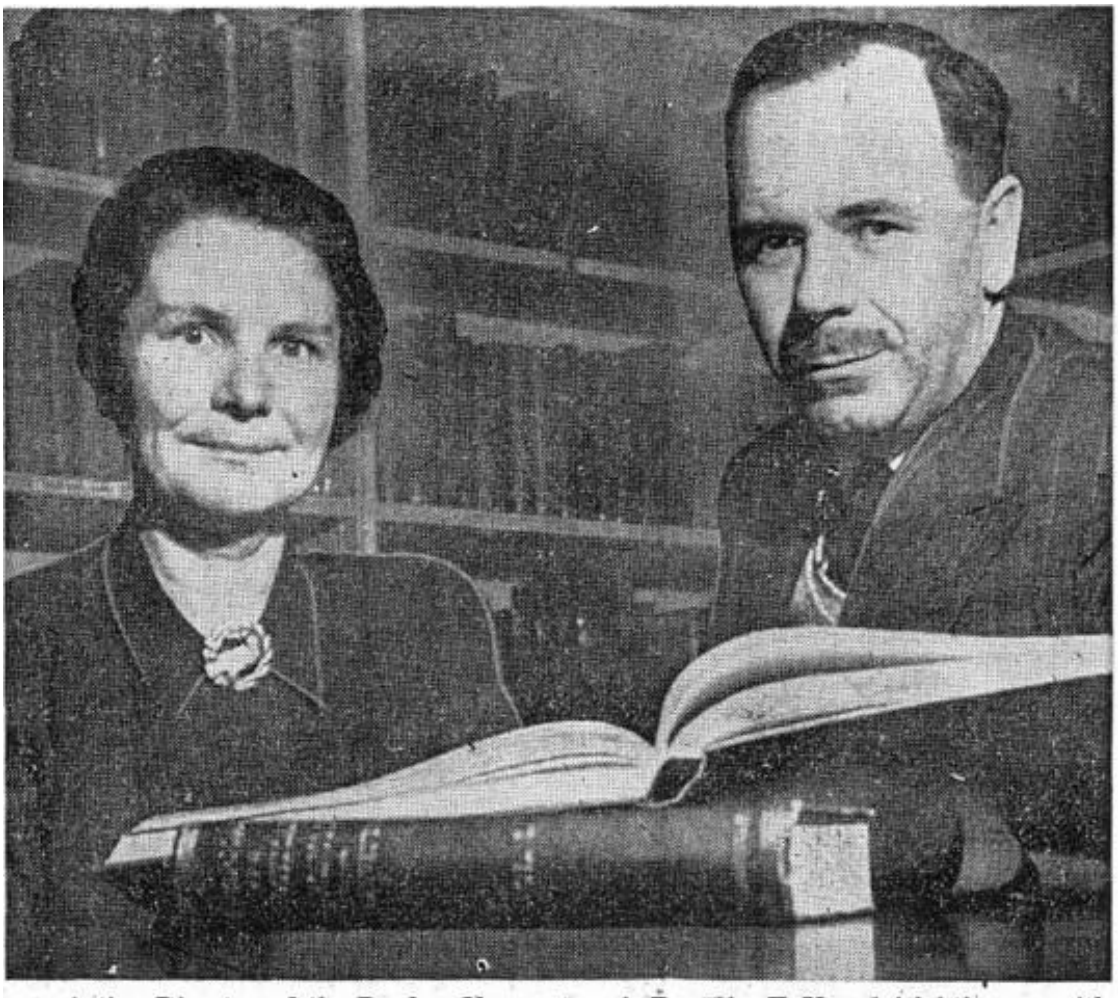
What makes these stars radiate waves? Nobody knows. If we did know, what good would it do? Science doesn't ask that question.

"We always like to know a bit more than there's any apparent use for at the time," Dr. Williamson says.

Already the study of radio stars has had some practical value. It has prompted electronic engineers to develop the most stable and sensitive radio receivers ever built.

In these days of talk of interplanetary communication, rocket trips to the moon, and such, the meaning of radio waves moving from one world to another may have more than incidental value.

Fig 11. The first page of the second section of Toronto The Globe and Mail for 20 February 1952. The astronomer Ralph Williamson was featured.



Acting Director of the Dunlap Observatory is Dr. John F. Heard (right), seen with Dr. Helen A. Hogg, assistant professor of astronomy and widow of the late director of the observatory, Dr. Frank Hogg. Mrs. Hogg is a leading woman astronomer.

Fig 12. Professors Helen Hogg and John Heard in February 1952.

—Globe and Mail.

Newest item interesting professional sky-watchers in their never-ending search of inter-stellar space is that of radio stars, which give off faint impulses now being recorded at Cornell University. Dr. Ralph E. Williamson, associate professor of astronomy at Dunlap Observatory, is a leading authority on this new stellar science.

Fig 13 Williamson in a characteristic pose. February 1952

Additional Note 4

McKinley's Visit to Australia during WWII, 1943-1944

Donald McKinley of the National Research Council of Canada became a good friend of Pawsey in 1943-1944 while he was in Australia; they continued their close association during the 1950s, leading to a close connection between Australian and Canadian radio astronomy.

The dates of McKinley's visit to Australia and New Guinea were summarised by Evans ("History of the Radiophysics Advisory Board", CSIRO, Supplementary Documentation, 1973, Document No 68, "Visitors from Overseas"), 17 December 1943 to 19 February 1944. The visit was initiated by White during a visit to Ottawa in late October 1943. Afterwards on 22 October 1943, White wrote Dean McKenzie, the head of the NRC, suggesting that Canada might take a greater interest in the design of equipment for Pacific since Canada was not so heavily involved in the European war. White pointed out that British design ideas needed complete re-orientation due to two distinguishing factors found in the SWPA (South West Pacific Area): (1) climate and (2) terrain and distances. White repeated that the CSIR hoped that Canada might send a visiting scientist to Australia. Mackenzie then passed on the letter to Col. F.C. Wallace at the NRC (of the Radio Board in Canada, previously a British Military member of the Tizard Commission of 1940). Don McKinley's visit (the deputy of the radio section of NRC) was organised by White and Wallace in a matter of weeks in November 1943. White hoped that Canada could help with the production of radar equipment from Canada. At the end of the first week of December 1943[40], McKinley arrived in Sydney; he was to stay a month in Sydney and then visit operational areas in New Guinea. The purpose of this visit was to familiarise himself with the radar problems of the SWPA and to guide Canadian policy in radar design. He left for New Guinea on 14 January 1944, returning to Sydney in early February. He departed for the return trip to Ottawa on 19 February 1944.[41]

[40] On 13 December 1944, White wrote Rivett (NAA, C3823 E16/2/1B) with the message that the Canadian Trade Commissioner in Canberra reported that McKinley had visited; he was to go to Melbourne in a few days.

[41] Mellor (D.P.) (1958, *Australia in the War of 1939-45. Vol V. The Role of Science and Industry*, p. 440) has also discussed briefly the visit of McKinley (called W.R. without the "Donald"). " … Mackenzie offered Australian liaison officers and visiting scientists full facilities for obtaining information about the Canadian program and Canadian research and development … for the manufacture of radar and other wartime equipment. Dr. W.R. McKinley, a Canadian authority on radar, visited Australia, spending much of his time at the Radiophysics Laboratory and the rest on an extensive tour of operational areas [near the front lines] in New Guinea." No dates were mentioned.

Undoubtedly, McKinley met Pawsey during the period in Sydney. The Canadian connection, through Lenore Pawsey, was clearly a factor in the establishment of a personal relation between the two families.

On the day before McKinley's departure of 19 February 1944, White wrote Col. Wallace of the NRC in Ottawa[42]:

> [McKinley and I] have discussed various aspects of his visit here and particularly our ideas as to how your organisation could assist in developing and making equipment which would be suitable for the Pacific War. Dr McKinley will have already told you a great deal of what is going on in Australia …

White was actually inquiring if the Canadians could assist in the design and manufacture of GCI and height finding radars, perhaps even in the microwave range. His main wish was to see if help could be given by sets providing "air warning with height finding at long distances, or the other giving GCI facilities with height finding".

He reported on a conference with RAAF officers from New Guinea which McKinley attended in Sydney a few days earlier:

> [McKinley] had raised the question of how best Canada could help in providing for these requirements … I believe that it is both necessary and desirable that either Canada or America should produce equally useful equipment in the Pacific Theatre … [Perhaps] Canadian research organisations could turn their attention to this problem with the idea of supplying the British Forces … I hope [McKinley] will go away with a great deal of information that will be of service to you in Canada. We have enjoyed having him here and I hope he will represent the first of a succession of visitors to come to this country from Canada.

Nine months after the departure of McKinley, Fred White met C.J. Mackenzie (President of the National Research Council of Canada) and McKinley in Ottawa (13 November 1944). On 21 November (while in Washington, DC), White reported on the status of the MAW (microwave air warning) design of the NRC. This was a portable 10.7 cm system (horizontal dimension 7 m, vertical 2.3 m). This set was basically a range azimuth set with some discrimination in

[42] Evans (1970, "History of the Radiophysics Advisory Board", CSIRO, Annexure 46), letter from White to Col. F.C. Wallace NRC, Ottawa, 18 February 1944 (day before McKinley left Sydney).

elevation[43]. The set had been fully designed but apparently no prototype was ever constructed. The project ran into difficulties according to White:

> It went ahead [at NRC] with some vigour to begin with, but since the Canadians have not succeeded in selling it to anyone in particular, the project has been given a low priority. As a range azimuth set, I think their ideas are sound, but the political difference in the way of their going ahead with it appears at present to be insuperable.[44]

Additional Note 5

McKinley in Sydney in August 1952, URSI

Eight years later, McKinley visited Sydney a second time. He was one of only three Canadian participants (Chair of the National Committee of URSI in Canada) during the 10th USRI General Assembly in Sydney in August 1952. Two other Canadian representatives were present: J.C.W. Scott, Assistant Superintendent of the Radio Physics Laboratory of the Defence Research Board (Ottawa) and Prof G.A. Woonton of McGill University in Montreal.

Just before the URSI meeting, McKinley wrote Bowen on 22 July 1952.[45] He addressed the letter to Eddie Bowen, clearly having known Bowen in the UK during WWII when McKinley was the Canadian radar liaison officer in London in 1940. (When moving to Australia in 1944, Bowen changed his nickname to "Taffy".) McKinley wrote:

> It was nice of you to welcome me so effusively in your letter of 15 July [to attend the URSI conference in Sydney in August 1952.] [Also could you] send me or Mr. B.G.

[43] The MAW weighed 5600 pounds; this was slightly higher than the maximum of 4000 pounds cut off for the Australian lightweight category, the maximum single piece was to be 400 pounds, excluding power supply. The maximum range was 120 miles, with a height precision of 1000 feet. The azimuth rotation was one rotation in 30 sec while in elevation there was automatic stepping during rotation with a manual control of continuous vertical scans for height determinations.

[44] Likely, White was apprehensive that the London Munitions Board would not approve the Canadian project for use by the Australians. This Board made decisions affecting transfers to Australia of UK, US and Canadian equipments. (Evans, 1970, "History of the Radiophysics Advisory Board", CSIRO, Annexure 53, White to Rivett 5 January 1944)

[45] NAA C3830 Z1/3/1 Part 3 (Bowen correspondence while overseas)

> Ballard, Director of this Division [Radio Section], the complete vitae of Joe Pawsey. Mr. Ballard is interested in Joe's application and it is possible that Joe might be interested in ours [position in Ottawa]. Of this more anon when I get [to Sydney in in a few weeks].

Clearly, a visit by Pawsey was suggested. But no action was apparently taken; a search of the NAA archives failed to locate any additional correspondence before March 1954.