NRAO ONLINE 59

Radio Astronomy Becomes a New Discipline: J. L. Pawsey in North America and the United Kingdom, 1947-1948

> I like the term "radio astronomy" much better than Burrows's efforts ["microwave astronomy"] and we might very well consider adopting it generally. E. G. Bowen to J. L. Pawsey, 20 February 1948. (also ESM_17.1.pdf)
>
> I have mentioned that, while we have been doing rather well on the experimental side of solar noise, we continue to be deficient on the theoretical side ... What we require … is a first-rate mathematician … who would spend most of his time on solar noise ... Such a man would almost certainly produce excellent theoretical results. E G Bowen to J L Pawsey, March 1948

Prior to Pawsey's departure in late September 1947, numerous universities, observatories and scientific institutes in the US and Canada were contacted about his impending visit. N.A. Whiffen of the Australian Embassy in Washington (Australian Scientific Research Liaison Office, ASRLO[1]) did much of the organisation for the visit in the US, including resolving the issue of military clearance at a number of US institutes (e.g. Naval Research Laboratory in Washington) that were carrying out unclassified radio astronomy.[2] Navigating post-war security was never easy. White wrote Whiffen on 7 October 1947: "I do not know how well you will succeed in clearing Pawsey with the military authorities [in the US] by telling them he is willing to give information about our work in Australia … [T]he only thing we can do is to state our position [of openness] clearly and leave it to [the Americans] to decide what they are willing to do about our visitors." In the end, this issue was not a serious obstacle since the US colleagues adopted a practical approach to the new non-military research in radio astronomy.

Sydney to California 1947

On 25 September 1947, Joe and Lenore Pawsey left Sydney on the converted US cargo ship, *SS Marine Phoenix*.[3] On the ship there were 493 passengers, including 50 Australian war brides

[1] After 1949 the ASLO—Australian Scientific Liaison Office.
[2] Pawsey Personnel archive, Fred White to Whiffen 7 October 1947.
[3] C4-class ship, T-AP-195 built by Kaiser Co., Inc., Vancouver, Washington, USA. Completed 9 August 1945. Later used during the Korean War as a troop carrier.

and 16 Australian fiancées of US servicemen. On 13 October 1947, the ship arrived in San Francisco with disembarkation the next day.

Pawsey had a busy social and scientific schedule during the week's visit to the San Francisco Bay area. On arrival he gave an interview to the *San Francisco Chronicle*[4]; he and Lenore attended a cocktail party at the Australian Consul General's house (General Edward K. Smart) and visited the campuses of the University of California, Berkeley and Stanford. On 15 October Pawsey was at Berkeley, where he likely met Ernest Lawrence (Nobel Prize in Physics 1939), courtesy of a letter of introduction from E.G. Bowen. Strikingly no visits were made to the Berkeley Astronomy Department. Pawsey was not impressed by the Berkeley campus: "[It] was collosal [sic] and appalling …" Likely the multitude of World War II temporary buildings left this negative impression.[5]

By contrast he termed Stanford "an inspiration," personified by microwave electronics Professor William W. Hansen (1909-1949[6]) who made a major impression on Pawsey. Both scientists were of similar ages and interests. George H. Briggs (physicist at CSIRO and Chief of the Division of Physics 1949-1958), was visiting the US at this time; the two Australian colleagues visited Berkeley and Stanford several times during this period in October 1947.

By 22 October 1947, the Pawsey family were in Pasadena where they remained until 31 October. A number of social events were organised. Lenore Pawsey was invited to lunch by Edith Baker, the secretary of Lee Dubridge, President of Caltech.[7] On 31 October a visit to the Griffin Observatory in Los Angeles was arranged. Besides visiting Caltech, Pawsey also met colleagues at the University of Southern California, Los Angeles, to discuss rainmaking research.

[4] The article of 15 October had a headline "Australian Rain Maker Claims Six Successful Tests" summarising the initial tests (with dry ice pellets) to initiate rain made earlier at RPL. The article also included a description of the radio astronomy observations of the sun carried out by Pawsey, showing the association of sunspots with enhanced emission at radio frequencies.

[5] When Goss was a graduate student in astronomy from 1963 to 1967 at the University of California Berkeley, his office was in one of these WWII barracks near Campbell Hall, the mathematics and astronomy departments.

[6] Hansen, a pioneer in the field of modern microwave electronics, became a professor at Stanford at age 36 and along with the Varian brothers (Russel and Sigurd), was one of the co-founders of Varian Associates, a pioneering firm in microwave components. Pawsey described in a letter to Bowen an ingenious proposal that Hansen had to measure the speed of light using microwave circuits. The suggestion was that this could lead to a factor of 300 improvement in the determination of the value of the speed of light.

[7] WWII Director of the Radiation Laboratory at MIT, the main centre of civilian radar research under the direction of the OSRD (Office of Scientific Research and Development), under the leadership of Vannevar Bush.

Pawsey's visit to the California Institute of Technology (Caltech) and the Mt Wilson Observatory (Carnegie Institution of Washington) consisted of an enthusiastic welcome by Dubridge and Prof Robert Millikan (1868-1953, former Chairman of the Executive Council of Caltech, the effective President of Caltech, Nobel Prize in Physics 1923). Pawsey also met William Pickering (a New Zealander), Professor of Electrical Engineering and a former PhD student of Millikan. Pawsey's welcome was likely influenced by the enthusiastic reception that E.G. Bowen had received a year earlier during a Caltech visit.

Pawsey wrote Bowen on 30 October 1947 from Pasadena: "Things are going very well. Most of it is interesting but not exciting. I am giving you a short note on the exciting items at the end of the letter.[8] I find you [Bowen] made a great impression here [in 1946]. They all remember your lecture."

Millikan was so impressed by Pawsey that he suggested that the originally scheduled colloquium on 29 October be postponed in order to accommodate Pawsey's talk, "Solar Noise". Over 100 people from Caltech and the Mt Wilson Observatory attended.

Numerous discussions were carried out with the Mt Wilson staff.[9] Seth Nicholson and Rudolf Minkowski were the main contacts; the interest elicited was to pay handsome profits in the future. An additional important astronomical fact was also passed on to Pawsey: the precession of the equinoxes that caused the positions of stars to move as the earth's axis moves slowly over time (Pawsey was learning elementary astronomy fast).

The Mt Wilson astronomers were interested in a possible optical identification of the radio source Cygnus A based on the early Bolton position. Pawsey wrote back to Sydney: "They immediately searched out the region given by Bolton and Stanley [for a possible Cygnus A optical identification] but found nothing …" Due to the large offset (1.2 deg mainly in declination) in Bolton's position in late 1947 and the positional accuracy at that time (see Sullivan 2009, p. 318 Fig 14.1), the lack of identification with such a faint galaxy is no surprise. Mills and Thomas and Smith were to publish much improved accurate positions in 1951 that would play a role in the identification of Cygnus A in 1954 by Baade and Minkowski (see Chapter 18)., based on the more accurate Cambridge position published in 1951 by F.Graham Smith (*Nature*, vol. 168, p 555).

Leaving Pasadena on 31 October 1947, the next stop on the train journey to the east coast of the US (via Canada) was the Grand Canyon in northern Arizona. Lenore is shown in Fig 1, taken

[8]The list included news about the Berkeley synchrotron developments, the conversations with Professor of Meteorology at Caltech, Irving Krick, the Alvarez aircraft identification project and the discussions with Nicholson and Minkowski at Mt Wilson concerning the optical identification of Cygnus A.
[9] The details of these are described in ESM_17.3.pdf.

with Pawsey's camera. (Figures at the end of text) On 3 November 1947, they continued the trip via train from Arizona to Denver, followed by a visit to the Solar Observatory at Climax, Colorado, hosted by Walter Orr Roberts of Harvard (see below for a later meeting at Harvard).

By 11 November 1947, Lenore and Pawsey were with their friends Carl Borgmann and his wife in Lincoln, Nebraska. Pawsey and Borgmann had been postgraduate students at the University of Cambridge.[10] In 1947, Borgmann was the Dean of the Faculty of the University of Nebraska. Borgmann would later play a key role in organising the Ford Foundation's grant for the Culgoora Radio Heliograph in 1962[11] (see Chapter 40). Pawsey spent some time in Lincoln dictating seven letters for colleagues back in Sydney, most to Bowen. Two of the letters from Pawsey concerned cloud physics issues.[12] These seven letters provided a thorough summary of Pawsey's activities and impressions for the first month of the US visit.[13]

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 while Lenore was 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."

Pawsey arrived at Harvard, Illinois, on the day before Thanksgiving (Thursday, 27 November 1947) to be driven to Williams Bay, Wisconsin, and Yerkes Observatory of the University of Chicago, close to the border with Illinois. He spent that Friday at Yerkes, a visit coordinated by former Director Otto Struve (1897-1963), hosted by the new director Gerard Kuiper (1905-1973).[14] By good fortune, two prominent European astronomers were also present, long term

[10] Borgmann had received a degree in Chemical Engineering in 1927 from the University of Colorado.
[11] Borgmann became the Program Director of Science and Engineering at the Ford Foundation.
[12] One letter was addressed to Bowen, and the other to Bowen and colleagues Eric Kraus and Pat Squires. In NRAO ONLINE 25 we provide a summary of Pawsey's reporting on cloud physics research in the US.
[13] Clearly, Pawsey had extensive secretarial help, possibly at the University in Lincoln, that allowed him to dictate numerous letters to colleagues in Australia.
[14] The visit was originally coordinated by Otto Struve (letter to Pawsey on 11 October 1947). Pawsey had a number of questions about the optical identification of Cygnus A, clearly thinking that Struve would have insights about the association with a nearby galactic star. Likely, Struve was not present at Yerkes in late November, since he is not mentioned in subsequent correspondence. Struve had been replaced

visitors Jan Oort (1900-1992), Director of the Leiden Sterewacht, who was thinking of starting radio astronomy in the Netherlands in collaboration with the Dutch Phillips Corporation (see Chapter 16)and Bengt Strömgren (1908-1987), Director of the Copenhagen Observatory. These contacts were to remain important throughout Pawsey's career. On Friday afternoon Pawsey gave a "formal round table talk on noise techniques leading up to the Cygnus work." He included a description of the principles of radio telescopes, especially the sea-cliff interferometer. Pawsey wrote Bolton on 9 December 1947[15]: "These people were extremely interested in your work on Cignus [sic]. In fact, we had a session which lasted 3 hours, so you see your work is appreciated."

Washington, D.C., Princeton and Boston, 1947-1948

On Saturday 29 November 1947, Pawsey left Chicago by train. On Monday 1 December, he travelled to Washington, D.C., where he would remain until 10 (or 11) December 1947, visiting the Australian Embassy, the Naval Research Laboratories (NRL) and especially the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards.[16] Already on 1 December 1947, N.A. Whiffen, the Officer in Charge of the Australian Embassy Scientific Research Liaison Office, reported that Grote Reber of the National Bureau of Standards, Central Radio Propagation Laboratory section, had been in communication with Pawsey. On 5 December, Pawsey visited the Experimental Ionospheric Research Section (a field station at Sterling, Virginia, about 70 km from Washington, DC) of the CRPL. On 12 December 1947, Reber circulated to colleagues a set of his extensive notes about Pawsey's presentation describing the

by Kuiper as the new Director of Yerkes Observatory. By this time, Struve was the Chair of the Astronomy Department of the University of Chicago. Struve moved to Berkeley in 1950 as Chair of the Astronomy Department there. In 1959 he became the first National Radio Astronomy Observatory Director for two-and-a quarter years. He was succeeded in this position by Pawsey in 1962 (Chapters 38 and 40). In 1947, Struve was also keen that Pawsey meet Jesse Greenstein, who "is also interested in problems of radio static. [Thus] I hope that you will be able to arrange your schedule in such a way as to include Williams Bay …" Greenstein was in the process of moving to Caltech. Unfortunately, Pawsey missed Greenstein who had already written one of the first review papers on radio astronomy ("Radio Frequency Investigations of Astronomical Interest" from February 1947 with Grote Reber in *Observatory*, vol. 67, p. 15; Chapter 20).

[15] In ESM_17.3.pdf.

[16] Sullivan, W. T., III. (2009). Cosmic Noise: A History of Early Radio Astronomy. Cambridge University Press, Cambridge, UK, page 71. The CRPL had been founded in May 1946 as it replaced the war-time Inter-Service Radio Propagation Laboratory. The goal of the CRPL was to obtain and distribute information on the propagation of electromagnetic waves and to study radio interference and the impact of radio telecommunications. The first director in 1946 of the CRPL was J. Howard Dellinger (until 1948). In 1954 CRPL moved to Boulder, Colorado; Reber did not make this transition as he moved to Hawaii. He had not been pleased with the bureaucracy of the CRPL (Sullivan,2009, p. 72).

Cygnus A results as well as the 60 and 200 MHz solar work. Reber also preserved Pawsey's original notes for the presentation in Pawsey's handwriting.[17] Reber told Pawsey about the 21 cm hydrogen line, which could be used to investigate a major constituent of the interstellar medium in the Milky Way line, in a conversation that left a deep impression on Pawsey and was reported to Bowen in a letter of 23 January 1948 (see Chapter 20).

We can see the extensive network of connections that Pawsey established during this visit. Pawsey's presentation had been given in K.A. Norton's office (ionosphere research). In attendance were A.R. Beach, Alan Shapley[18] (ionospheric physicist), Jack Herbstreit (tropospheric propagation[19]), Thomas J. Carroll (microwave research), Herman Cottony (antenna research)[20] and Morris Schulkin of the Naval Research Laboratory (later an expert on underwater acoustics). Pawsey also reported that he met Howard Dellinger (Chief of the Central Radio Propagation Laboratory), Ross Bateman (ionospheric scientist and meteor astronomer) and J.F. Denisse[21] (who was to play a major role in the post-war development of radio astronomy in France). During the afternoon of 5 December 1947, Pawsey was taken to the Sterling Virginia field station (located near the site of the Dulles Airport) by Reber, Cottony, Norton and Herbstreit. Reber wrote: "Considerable discussion was had on amplifier stability, antenna directivity etc." See Fig. 2 (Reber) and Fig. 3 (the Würzburg aerial), photos made by Pawsey during the visit to the field station on 5 December 1947.

In his summary report "Solar and Cosmic Noise Research in the US and Canada" of April 1948 (see below), Pawsey provided a detailed description of Central Radio Propagation Laboratory activities. Reber had three 7.5 metre Würzburg aerials, originally provided by the US Army Signal Corps from post-war Germany. In 1947-48 one was ready for use with a polar mount for observations at 480 MHz. The others were to be used at 51 and 160 MHz for solar monitoring.

[17] At the bottom of the second page in Reber's handwriting: "These are notes left by Pawsey about workers in Australia and New Zealand." The list includes research activities of Ruby Payne-Scott (solar work), Lehany and Yabsley (simultaneous at 200, 600 and 1200 MHz solar noise), McCready (solar spectrum analyser), Treharne (planning interferometry for solar work at 100 MHz) and Smerd (theory). Based on NRAO Reber archive.

[18] Son of the prominent astronomer from Harvard Harlow Shapley.

[19] Herbstreit published a paper in *Nature* 1948 about the spectral index of the galactic background between 25 and 110 MHz (Herbstreit and Johler, 1948). Pawsey pointed out that Herbstreit and Bateman had visited RPL during the war, likely as part of the of US scientists at RPL in 1944.

[20] NRAO Reber archive. In addition, Robert Hayward has provided an annotated version of this Reber material with details about the scientists whom Pawsey met in 1947-48.

[21] Pawsey wrote "M.J. Denise" in his correspondence

As Sullivan (2009, page 71) has pointed out, these antennas collected copious data over many years, resulting, however, in minimal output in publications or even internal reports.[22]

Few details are available about the visit to the Naval Research Laboratory (NRL) where John Hagen (1908-1990) and Fred Haddock (1919-2009)[23] were his hosts. Fortunately, there no problems with "security" at NRL; Pawsey was able to visit with minimal restrictions. Fred White's anticipation of problems with a foreigner visiting the NRL radio astronomers did not arise.

The first week of December, Pawsey worked on revisions of the "survey paper"[24]; the updates had been promised to Bowen in Sydney "well before 31 December [1947]". Pawsey wrote Bowen on 1 December: "I am promptly going into retirement to get this [rewrite of the survey] and hope to post it this week." On 4 December 1947, Pawsey reported to Bowen that substantial progress had been made; then on 9 December, the corrected manuscript was posted to Sydney: "I have revised the paper and have added a number of paragraphs which I think will serve to clarify the subject." Additional work remained to be done in Sydney on some of the figures and the bibliography. The agonising history of the survey paper is described in Goss and McGee (2009); the paper was finally published almost three years later.

Pawsey departed Washington for New Jersey on 11 December 1947. He spent 12 December in New York City organising finances and the passage for the following March to London via the *SS Queen Elizabeth*. Pawsey then travelled to Princeton, staying with Lenore's brother Ted Nicoll and his family (his wife Kate, and their four (living) children, Pat, Ruth, Roger and Matt). Given Joe and Lenore's intimacy with Ted and Kate in the UK, it is unsurprising that spending considerable time with the Nicolls was of high importance during this trip, and, as will be seen, the Pawseys did return to Princeton frequently while they remained in North America. After staying the weekend in Princeton, Pawsey met up with Lenore, who had spent time visiting friends and relatives in Saskatchewan, in Boston, on 14 December 1947. During the period December 1947 to March 1948, Pawsey presented a number of lectures in Princeton at Princeton University and other nearby institutes (summarised in Additional Note 1).

Pawsey went via Schenectady, New York, for a one-day visit with the pioneers of cloud seeding (based on the experiment in the Berkshires on 13 November 1947) Irving Langmuir (1881-

[22] Reber was to leave NBS in 1951, moving to Hawaii where he remained for a few years before moving semi-permanently to Tasmania in Australia in 1954.
[23] John Hagen was the head of the Naval Research Laboratory Centimeter Wave Research Branch; Haddock was the number 2 man.
[24] See Goss, W.M., and McGee, R. (2009). "Under the radar: the first woman in radio astronomy: Ruby Payne-Scott." Vol. 363. Springer Science & Business Media, Appendix E "Pawsey's Review Paper of 1950: Solar Radio-frequency Radiation"

1957, Nobel Prize Chemistry 1932) and Vincent Schaefer (1906-1993) at General Electric. Pawsey sent an informal report to Bowen on 20 December 1947 from Boston and a formal report on cloud seeding in the US, "Informal Notes on Rain Making in the US", on 13 January 1948.[25]

A nagging problem returned to Pawsey in December 1947, the chronic conflict between John Bolton and Ruby Payne-Scott.[26] The issue arose again on 8 December 1947 as Pawsey wrote Bowen about the rivalry between the two colleagues back at RPL. He was exasperated with the continued conflict; his absence from Sydney had meant that his constant support of Payne-Scott was not possible. (see ESM_17.2.pdf)

Arriving in Boston on 15 or 16 December, Pawsey stayed in Cambridge until 24 December 1947 (see Fig. 4, Lenore in Cambridge, Mass, Fig. 5, Pawsey in Cambridge; both from Pawsey family archive). Their contact was Prof J.A. Stratton of MIT.[27] Pawsey visited Henry Haughton and James Austin (New Zealander) at the Department of Meteorology at MIT, but spent the majority of his time at the Harvard College Observatory. His hosts were Shapley, Donald Menzel, W.O. Roberts[28] and Bart Bok. He also met Charles Federer of *Sky and Telescope*, the well- known popular US magazine for amateur astronomy, with offices in Cambridge. Pawsey gave a Harvard colloquium on "Solar and Cosmic Noise" that began at 4:30 pm with discussions extending to 06:45 pm. Also, during the Harvard visit, Pawsey participated in an interview about Australian radio astronomy for a shortwave educational radio station, broadcast to Europe.

After spending Christmas and New Years with the Nicoll family in Princeton, Pawsey began an intensive three-month period in early 1948 with visits in the US and Canada before he and Lenore departed on 27 March 1948 for the UK.

On 4 January 1948, Pawsey went to Ithaca in upstate New York where he visited Cornell University, meeting with J.R. Burrows, Charles Seeger and Martha Stahr, later Martha Stahr Carpenter. Burrows had been awarded a contract with the US Navy to organise radio noise investigations at Cornell and was in the process of putting together a conference, "Micro-Wave Astronomy", which in the end was postponed.[29] The plan for the conference had originally

[25] See NRAO ONLINE 25.
[26] See Goss and McGee, 2009, chapter 9, p.129 and Goss, 2013, p. 150
[27] Stratton (1901 to 1994), President of MIT 1957-1966 and key staff member of the Rad Lab in WWII, where he likely met Pawsey in 1941. Stratton was a physicist and electrical engineer.
[28] Roberts had a joint appointment between the High Altitude Observatory at Climax, Colorado and Harvard. Earlier in the trip Pawsey had visited Roberts in Colorado.
[29] Although Pawsey wrote that the date of the meeting had been "changed … to fit in with my departure for England," in the end it was postponed by seven months; instead a two-day meeting was held on 5 and 6 October 1948 without Pawsey. Don Campbell of Cornell provided the information about the

consisted of five talks (among others) in which Pawsey would present the newest Australian results: (1) Cosmic noise and the variable source in Cygnus, (2) Thermal radio frequency radiation and the hot corona, (3) Solar noise and the new high frequency observations, (4) A survey of solar noise based on the new survey paper of Pawsey and (5) Solar and cosmic noise techniques. When it went ahead in October 1948 (without Pawsey), it had a number of radio astronomer guests in attendance: Ron Burgess (of the British Embassy in Washington[30]), Denisse of NBS, Hagen of NRL, Covington of NRC, Williamson of Toronto, Menzel of Harvard and Haddock of NRL. Menzel showed films of the motions of solar prominences in the light of the hydrogen alpha line in the red region of the optical spectrum.

The proposed name of the conference, "Micro-Wave Astronomy", almost certainly inspired Pawsey to think up a new name for the disciplines of "cosmic noise" and "solar noise": **radio astronomy**. He used the term in correspondence with Bowen and with a UK colleague in January, 1948. As Sullivan (2009, p 424) has documented, others, including Martin Ryle from Cambridge, had independently proposed the same name, which became widely taken up over the next 2 years (see ESM_17.1).

On 8 January 1948, Bowen responded to Pawsey about the proposed "Micro-Wave Astronomy" conference: "It seems a good idea and it will provide an excellent opportunity for you to put your work across in a very effective way. By all means use and present all the subject matter listed in your letter together with anything which you thought up since." He added only one note of caution: "The only restriction I would suggest is making any statement about Bolton's additional sources. There are now six[31] but he is not sufficiently sure of them to justify publicity at this stage." [It was to be mid-1948 before the six sources would be published in *Nature,* 24 July 1948.][32]

---

postponed conference. *The New York Times* reported on the meeting in a front-page article "Radar Yields New World of Sound; Brings 'Music of the Spheres' to Earth" by the famous science writer William L. Laurence on 6 October 1948. The theme seems to be based on the false parallel between electromagnetic signals from the cosmos and acoustic communication. "These wailings have opened up a new land for exploration by every inquisitive man. They promise to open up vast regions of cosmos. What man cannot now see of the universe he may be able to hear." *The New York Times* followed with a bizarre editorial "Celestial Radio" on 10 October 1948: "We have been squinting at stars through lenses ever since Galileo's time. Now, it seems from the discussions of physicists at Cornell, we must also listen to them." The Laurence article also spawned a most unusual song "The Song of the Universe" by James C. Steel—Additional Note 2, "JC Steel's Song." Steel also was under the impression that the radio astronomers could listen to the universe. Steel sent his song to the CSIRO Head Office in Melbourne, received 20 December 1948. (NAA archive).

[30] See NRAO ONLINE 20

[31] See ESM_17.3.pdf

[32] On 9 January 1948, Bowen wrote Pawsey with the news that Fred Lehany had moved from the CSIR Division of Radiophysics to the CSIR Division of Technology. (Within a year he was the Chief of this

Pawsey spent about three weeks in Washington starting 8 January 1948. Based on a noteworthy letter on 23 January 1948, it is likely that Pawsey visited NBS again, with a key conversation with Grote Reber about the HI line (See Chapter 20). On 28 January 1948, Pawsey visited Karl Jansky (1905-1950), Harald Friis (1893-1976), W.M. Sharpless and A.B. Crawford (1907-1990) at Bell Labs at Holmdel.[33] Pawsey reported that Jansky had dropped out of cosmic noise research; but he expressed his continued interest to Pawsey, who sent him frequent preprints in the few years remaining before his death in 1950 at age 45. On 29 January 1948, Pawsey was in New York City, likely for a meeting of the American Meteorological Society (28-29 January at the Hotel Astor and the American Museum of Natural History).[34]

On 8 February 1948, the Pawseys travelled for the second time to Boston to visit Bart Bok at Harvard. There followed an extended visit to Canada with stops in 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.

On two subsequent days Pawsey met Arthur Covington (1913-2001) at NRC in Ottawa. Covington had started the first radio astronomy measurements in Canada using WWII radar

---

Division). "One good result is that it has opened the way to the appointment of Christiansen. The Executive has finally approved …" Within the next decades Christiansen was to have a major impact on the evolution of radio astronomy in Australia, first at CSIRO and later in 1960 (Chapter 30) at the University of Sydney.

[33] Friis was a pioneer in radio engineering. In 1944, he invented the term "noise factor" or "noise figure" to characterise the sensitivity of a microwave receiver (Friis, H.T. (1944). "Noise figures of radio receivers." *Proceedings of the IRE*, 32(7), pp.419-422). He had assisted Karl Jansky in the design of the 20 MHz system used to detect the galactic background in the early 1930s. He and colleague Alfred Beck designed a horn reflector used by the military in WWII. This system is related to the Hogg or horn reflector antenna that became the famous antenna used by Arno Penzias and Robert Wilson in 1964 to detect the 2.7 K cosmic background radiation at 7.35 cm. These two were awarded the Nobel Prize in Physics in 1978. The architect of this unique instrument was A.B. Crawford. The commemorative plaque on the antenna reads: "This unique antenna was designed and built for the pioneering Echo satellite communications experiments. Its existence and the scientific results produced through its use are due in large measure to the technical leadership and human inspiration of Arthur B. Crawford 1907-1990."

[34] We thank Jinny Nathans and Sophie Mankins of the American Meteorological Society for information about the 1948 AMS conference. At this conference Vincent J. Schaefer of General Electric gave a talk "Methods of Detecting Ice Nuclei in the Free Atmosphere."

technology as mentioned in Chapter 16. On 28 or 29 February 1948, Pawsey went to Toronto. Lenore had been there already for a week 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 (see below). The visit to Canada concluded 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. At the University of Michigan (Ann Arbor, host Leo Goldberg), he gave a joint colloquium for the Physics-Astronomy department on "Solar and Cosmic Noise". Then he visited the McMath Hulbert Solar Observatory of the University of Michigan at Lake Angelus, Michigan.

The Pawseys then returned to Princeton, which remained their home base until their departure on 27 March 1948. A determination of his itinerary during this period remains unclear. Based on a confusing letter from Pawsey to Bowen in Sydney, written 17 March 1948 from the Australian Embassy in Washington, it seems that Pawsey travelled from Princeton to Washington, D.C., and also to New York several times, while Lenore remained in Princeton. Likely Pawsey visited a number of colleagues in both New York and Washington, D.C., spending considerable time on the train.[35] It needs no effort of imagination to grasp the importance, for Lenore, for this period of time spent with the Nicolls, her brother and his family.

Pawsey attended the Institution of Radio Engineers Convention in New York City from 22 to 25 March 1948 where 15,000 attendees were at the Hotel Commodore and the Grand Central Palace. Keynote speakers were Wiener (1894-1964), Shannon (1916-20010), von Neumann (1903-1957) and Rabi (1898 -1988).[36] Even then Pawsey gave one last talk at the Institute of Radio Engineers at the Radio Corporation of America in Princeton on the evening of 25 March 1948, two days before departure.

Impacts on Radio Astronomy at RPL

Pawsey clearly found meeting with his scientific colleagues across North America invaluable. He was able to gain insight into how new equipment was being developed by radio and electronic

[35] Near this date (12 March 1948), Arthur Higgs (RPL Divisional Secretary) sent the disturbing news to Pawsey that B.Y. Mills had been diagnosed with TB and was to be out of action for at least three months, confined to a sanatorium.

[36] These prominent colleagues were: Wiener, mathematician at MIT, Shannon, mathematician at Bell Labs, and von Neumann, mathematician at Princeton, said to be the most prominent mathematician of the mid-20th century. Rabi had been the assistant Director of the MIT Radiation Laboratory at MIT in WWII and as President of Associated Universities would hire Pawsey in late 1961 as the NRAO Director (see Chapter 40). Rabi was a Nobel Laurate in Physics (1944); he was the Associated Universities President from 21 April 1961 to 19 October 1962.

engineers. He became informed about questions and possibilities that would soon become significant in the field, and he could access resources—especially the valuable resources of speculation and discussion with his colleagues—to supplement the limitations in Sydney. The trip gave him the needed space to gain some perspective on the rush of discovery research at RPL until this point, and to reflect on which research questions, methods and investments should best be made now. This was all the more important because his absence was sorely felt in Sydney.

Conscious of all the information he had gained, Pawsey asked the personnel at the ASRLO in Washington, D.C., to prepare an extensive report, "a comprehensive account of research on solar and cosmic noise in America", before he left for the UK. On 8 April 1948, he wrote N.A. Whiffen of ASRLO in Washington about the status of the report; he feared it had been lost in the post between the US and the UK. However, the report was completed and posted by Pawsey from the UK on 15 April 1948. It was received in Sydney well before 18 May 1948, the date of Bowen's response (see below).

"Solar and Cosmic Noise Research in the United States and Canada" was a 10-page summary which included chapters on "Personalities" (a remarkably frank assessment), "Work in Progress" at various institutes and "Research Problems", followed by a listing of the 18 institutes which had been visited with an accompanying list of personnel.[37]

Pawsey's main conclusion was that the US astronomers and astrophysicists were impressed by the Australian success story in radio astronomy:

> Since my arrival [in the US] I have been struck by an anomaly. Astronomers and physicists have displayed a great interest in our work, but have not undertaken similar work themselves. Stromlo and RPL has [sic] not … had any serious competition in the solar field. In the cosmic field our work has supplied a very vigorous stimulant to work which was progressing slowly, chiefly under the impetus given it by an amateur, Reber, working alone in his spare time. The position now is that the astronomers of the US, who form a group who maintain exceedingly close contact with one another, have now become thoroughly interested in the implications but have not yet taken the plunge of tackling a totally new technique. Meanwhile, the physicists, who at the close of the war had the skill and inclination to undertake the radio side but failed to interest the astronomers then, now have other interests. The result is that we have a first-class opportunity to establish the lead which we at present hold.

[37] NAA C4659/4 and C3830 F1/4/PAW/1 Part 1 and Part 2

Pawsey pointed out that the greatest attraction was the Cygnus source, a "new astronomical entity".

> However, I feel myself that this subject is merely a part of the whole and that the solar observations are not only of interest in their own rights but have a good chance of supplying keys to the interpretation of the cosmic noise. The most fundamental problem which is already apparent is that of the structure of the galaxy. Cosmic noise studies may give the answer, but we are still ignorant of basic mechanisms [of the non-thermal emission process- see Chapter 34].

The main radio observatories doing solar research were at the National Radio Council in Canada (10 cm observations), Naval Research Laboratories (3 cm), and at the Bureau of Standards (20 to 100 MHz—some work also on the galactic background). Research programmes were to begin soon at the Bureau of Standards (decimetre) and Cornell (decimetre).

Pawsey was interested in the "personalities" in the US, realising the importance of ambition and ability in the beginning phases of a new field. The new cadre interested in radio astronomy were (1) often young men, most of whom had been active in radar research in US and Canada in WWII (in contrast to Australia where Ruby Payne-Scott was a major participant in early radio astronomy, there were no women until Nan Hepburn Dieter Conklin (1926-2014) joined the NRL group in the early 1950s[38]) and (2) the optical astronomers, including established scientists, with whom Pawsey formed life-long contacts. As the prime member of group (1) he was "impressed most favourably" by Reber. Pawsey wrote:

> I forgive the imperfections in his papers when I consider how he worked, alone with no encouragement, working in his spare time and buying equipment with his own money. He lacks the research background which many of us have, but I believe he "has what it takes" to make a success of things. He is a young bachelor and has a delightfully direct personality. My feeling is that if there is anything we can do to help him along, let us do it. He will give back as much as he gets.

Pawsey had a negative assessment of Charles Burrows at Cornell[39]:

[38] However, Martha Stahr Carpenter of Cornell participated in both US and Australian radio astronomy when she spent a sabbatical year from Cornell at RPL from mid-1954 to mid-1955 working at Potts Hill (see Chapters 16, 24). See *Two Paths to Heaven's Gate*, an autobiography by Nan Dieter Conklin 2006, published by NRAO, Charlottesville, Virginia.

[39] The group consisted of Charles Burrows (1902-1970, from 1945-1956, Director of the School of Electrical Engineering at Cornell, then Vice President for Engineering at Ford Instrument Company), Charles Seeger (1913-2002, later career in Europe including Leiden and the US at a number of universities including Stanford), Edward Hamlin (1905-1948), Martha Stahr (later Martha Stahr

> … Burrows is head of a large department so that he himself is likely to be busy with other things. I should like to wait till observations commence before assessing the likely importance of the Cornell contribution. So far they have overstressed elaborate equipment and hence have no results … Burrows has a Navy contract [to start] "Micro-Wave astronomy" … [He also] has a 25-ft diameter parabolic mirror capable of elaborate gymnastics in course of construction. The initial plan includes measurements in the decimetre range, a search for the 1420 Mc/s line [our emphasis][40], and measurements on a separate 200 Mc/s set … They have chosen to make elaborate equipment and naturally it takes a long time to get going.

From the perspective of RPL's momentum and progress, Pawsey could comment on the slower beginning of radio astronomy in North America. He wrote of the radio group at the Naval Research Laboratory (NRL) that "I suspect NRL lack inspiration." He saw similar issues at the NRC in Ottawa, writing that "Covington is a young and inexperienced man working in relative isolation. He has got some thoroughly useful results by good honest work and perseverance." As with Reber (and Jansky), Pawsey was a sympathetic supporter of those with interest and enthusiasm for radio observation.

Pawsey provided additional details of solar monitoring activities in his report of US and Canadian solar and cosmic noise research. He discussed five aspects of the NRC-Ottawa group's efforts: (1) "Probable bursts of non-solar origin" (Pawsey was dubious; these were never confirmed); (2) "A steady level of solar intensity which shows a regular variation of order 2/1 with sunspot number"; (3) "A base level [at 10 cm] of about 70,000 K which is steadily decreasing now that we have apparently passed a maximum of the solar cycle"; (4) "A marked 25 day periodicity [with the solar rotation period] over a year"; and (5) Covington's observed sudden increases at 10 cm, (corresponding to the metre wave "outbursts"), which could be associated with solar flares and "fade outs".

In Toronto, Pawsey met a young (31 years old in 1948) US astronomer who had completed a PhD with Chandrasekhar at Chicago (see Chapter 16). Ralph E. Williamson[41]) impressed Pawsey more than any of the other young astronomers he met in North America. Pawsey spent

---

Carpenter, 1920-2013, see Chapters 16 and 24) and a consultant from Toronto, an American Ralph Williamson (1917-1982). For Williamson see also NRAO ONLINE 26.

[40] See Sullivan, 2009, page 417

[41] 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."

considerable effort to recruit Williamson to spend some time in Australia[42], in the end to no avail.[43] Pawsey wrote:

> 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*, "The Present Status of Microwave Astronomy"[44]] to attempt to push the subject among Canadian astronomers.

Later in this text, we summarise the connection between the Williamson recruitment exercise with the attempts to attract other theoretical scientists to either join of visit RPL

During the period late 1947 and early 1948 in the US and Canada, Pawsey was indeed fortunate to meet some of the more senior astronomers of the mid-20th century. J. Oort (Leiden) and Strömgren (Copenhagen) were at Yerkes when Pawsey visited at the end of November 1947. Pawsey was partially impressed by Harvard: "I consider Harlow Shapley an inspiring scientific leader. In the solar physics group, Menzel is experienced and imaginative, while Walter Roberts and John Evans are young and full of enthusiasm about their art [of narrow band filters[45]]." Pawsey also praised Robert R. McMath (1891-1962), bridge builder, engineer, businessman and the astronomy directory of the McMath-Hulbert Observatory at Lake Angelus, Michigan, part of the University of Michigan.

After visiting a number of well-known optical observatories such as Mt Wilson, Yerkes and Harvard, Pawsey went into some details discussing four future research projects which had special interest for RPL, all stimulated by his visit to the US:

(1) The Cosmic Point Source or Sources.[46] "This is the subject in which astronomers have displayed outstanding interest." The determination of the position, size and parallax of the source was essential (the assumption still was that the sources were galactic objects, perhaps stars). Other aspects that should be determined were the detection of additional sources and a characterisation of the time variations. The most important aspect was an "attempt at visual

[42] See ESM_17.4 for details about Williamson and Pawsey. Additional details are summarised in NRAO ONLINE 26 and Chapter 20.
[43] In 1948 to 1949 there were exchanges of four letters between Williamson and Pawsey about the RPL offer of a position made on 27 April 1948. After 10 months, Williamson turned down the offer in February 1949.
[44] The title of the article clearly influenced by the name of the new discipline ("Micro-wave astronomy") adopted by the Cornell group of Burrows.
[45] To use for imaging of solar features such as flares and prominences.
[46] Pawsey had begun to use the term "radio point source" in place of "radio star".

identification. It is also yet to be proved that the variations do not originate in the ionosphere and this point must be met in the very near future" [his emphasis].

(2) Solar optical-radio correlation. The main issue here was to determine if the "outbursts" (Type II) "could be associated with an outstanding mass of matter from the sun. The slender evidence which there is suggests that this might be the velocity of anything up to a few hundred km per second outwards. The particular phenomenon occurs in conjunction with a solar flare."[47] Due to the rarity of these events (once every few days during solar maximum), continuous coverage was required. To observe the "surge", a coordinated optical-radio programme was required. Evans had written to Pawsey on 8 March 1948, pointing out: "The only thoroughly tested device [optical instrument] ... is the spectroheliograph", using special filters to control the fine tuning of the wavelength such as the H-alpha line at 656 nm.

(3) The next section was titled: "The Search for Atomic Spectral Lines in Noise". Since hearing of the HI line from Reber, Pawsey had made additional inquiries among physicists and also astronomers about the practicalities of the line's detection and the astronomical potential (see Chapter 20). He now wrote: "The utility of such a line, could it be found, is obvious … I have learned that it is a complex problem and I have not progressed far. A lot of people know scraps of it but it is not coordinated." (Chapter 20)

Pawsey discussed the fine structure transitions of HI at 10.9 GHz of width 100 MHz and also the high quantum level radio recombination lines. (See Chapter 38 for a calculation carried out by Pawsey in 1961 about H radio recombination lines; in Chapter 20, we examine the early work in Sydney in 1951 on the confirmation of the detection of the HI line by Ewin and Purcell at Harvard).

(4) Following the meeting with Reber at NBS (National Bureau of Standards) in January 1948, Pawsey was again convinced of the necessity of a full sky southern survey to supplement Reber's northern sky images at 160 MHz (beam about 12.5 deg) and 480 MHz (beam about 4 deg). Pawsey wrote:

> … studies of the distribution at different wavelengths may give an idea of the distribution of the source material in space. This source probably follows the general distribution of the galaxy and … the measurement of the noise distribution may give quite basic astronomical information not otherwise available. This is behind the great interest of the astronomers.[48]

[47] NAA C4659/8. Letter from Pawsey to Jack Evans, High Altitude Observatory. 14 February 1948.
[48] Pawsey was well aware of the prominent role that free-free absorption due to the interstellar electrons would play in the different appearances of the galactic background at higher frequencies (low

Two southern all sky images were to be published in 1950, at 100 MHz (beam 17 deg with the steerable 9 Yagi antenna completed in 1949 by Bolton and Westfold, 1950) and Allen and Gum (1950) at 200 MHz (beam about 26 deg, based on Mt Stromlo data). At these low resolutions discrete sources were not discernible, only the galactic background. Major progress with a more productive southern hemisphere all sky survey had to wait for the Piddington and Trent (1956) 600 MHz survey with a 3.3 deg resolution made with the 36-foot Potts Hill parabola in 1956. Forty-nine discrete sources were detected. Pawsey ended his discussion of an all sky image with a plea: "One aspect justifies special study. What comes from the Magellanic clouds [sic], the nearest external galaxies?"

(5) The final item for continued research was the necessity to provide continuous coverage of the sun at a number of frequencies. Pawsey wrote: "Is the Dover equipment now semi-automatic? If so, could our people take it in turns, say a week at a time, to operate and to analyse and record results?"

On 18 May 1948, Bowen sent his assessment of the "omnibus report on solar and cosmic noise". Bowen was still optimistic about the cosmic noise work on "point sources" (not "radio stars") and was convinced that Bolton had most of the points discussed by Pawsey in hand. "The New Zealand expedition—due to leave at the end of the month—should provide a precise determination of the size and position of the Cygnus source and more details about its variation. Observations made simultaneously at Dover and New Zealand should at last settle the origin of the variations." However, he was lukewarm about starting spectral line radio astronomy as proposed by Pawsey at this time (see Chapter 20) and responded negatively to the suggestion that Bolton should start the southern all sky survey, since he (Bolton) was busy with the New Zealand Cosmic Noise Expedition in 1948. "Such a survey will be much more worthwhile when the new aerial [the 9 Yagi antenna at 100 MHz] is available," Bowen concluded.[49] The survey was carried out in 1949.

The final topic for research suggested by Pawsey in the April report was "continuous observations of the sun" on a number of frequencies. Bowen reported that by the time of Pawsey's arrival in late October 1948 "we hope that records on 60, 100, 200, 600, 1200 and

---

opacity to electrons) and low frequencies where some of the background would be blocked by the opacity of the intervening ionised gas. Of course, a more precise understanding of the complex interactions of non-thermal and thermal emission awaited the appreciation of the role of synchrotron emission. See Chapter 34.

[49] Bowen was optimistic that the new Dover Heights antenna (under construction) would bring decisive advances. The increased sensitivity due to the larger size would increase the number of sources detected; but contrary to Bowen's assertion, the resolution of the sea-cliff interferometer would remain the same since the cliff height was fixed.

24000 Mc/s will be running. [This turned out to be too optimistic.] At the moment only 60 and 24000 Mc/s are regularly on the air, with Stromlo still recording on 200 MHz."

Directing the Laboratory

The importance of leadership and direction in science became obvious during Pawsey's 13-month absence. The group at RPL had enjoyed startling early successes, but by this time, the limitations imposed by the mutual lack of understanding and knowledge between (optical) astronomers and the new radio observers, the absence of underpinning theoretical understanding of the phenomena observed, the equipment available at the time, and personnel of sufficient diversity, confidence and experience to develop new lines of research, were being felt.

Pawsey's staff of research scientists were hopeful about the information that Pawsey's trip would bring back to RPL. They also needed to consult him via correspondence. Both Kevin Westfold[50] and Lindsay McCready wrote to Pawsey with concerns regarding the solar noise programme in Sydney.

On 20 April 1948, Westfold wrote Pawsey with a comprehensive summary of his research activities since Pawsey's departure the previous year: "The problem I am trying to solve with these equations is the ionosphere problem of propagation in a plane-stratified medium under a uniform magnetic field. We would then be in a better position to attack the problem of propagation in the solar atmosphere."

The crux of the uncertainty in the solar noise group was described by Westfold:

> As you are probably aware, the theoretical knowledge of conditions in the solar atmosphere and in particular of the interactions between the radiation and the high temperature medium has always been far behind the experimental knowledge we have gained [by observations]. We need to know more about the dynamical state of the corona, the collision processes involving absorption and emission of radio frequency energy, why the apparent temperature discontinuity between chromosphere and corona etc. etc. Radio frequency observations have not discovered more about the physical state of the solar atmosphere than the astrophysicists already knew [i.e., using radio observations to determine local density, filling factor, temperature, velocity, and magnetic field had raised a number of questions] … We were wondering whether…. you had found out anything which would enable the programme to enter a new phase of

[50] NAA C4659/4. 1921-2001, a young theoretical physicist at RPL, see Chapter 16, Chapter 20

> making some critical experiments which would help to decide some astrophysical question or to find out something to decide the next step to take in attacking some astrophysical problems. Since you left us we have missed very much the help of your stimulating criticisms and suggestions. We would therefore be grateful to hear what you think of the present programme and what future steps it should take, as well as your impressions of similar work you have now seen in the US and UK.

As viewed with historical perspective, it is clear that the generation of solar bursts was the combination of many complex processes, and a simplistic model with theoretical predictions and experimental tests wasn't going to be fruitful. It took decades of observations and classification of the different types of activity (see Chapters 26, 33 and 34) to make progress. Although not visible to the solar theory group at the time, experimentalists like Payne-Scott and Christiansen were in fact developing the techniques that did enable Paul Wild to make huge advances in the following decade.

Pawsey wrote a letter to the scientific staff of RPL on 18 May 1948[51], in a wide-ranging missive, setting out broadly a philosophy of science that could serve as a framework for the group as they developed new ideas and methods. (Chapter 33). Pawsey's main concern was to solve the "solar noise" problems in two main areas: (1) the thermal component of the solar emission and (2) the non-thermal emission processes (see Chapter 34). He pointed out that the steps required to understand the non-thermal solar radiation in 1948 were: "(1) the enumeration of a detailed theory, (2) a study of the consequences susceptible to experimental verification, and (3) verification of such consequences. What are the crucial observational checks? Until the nature of the radiation is established its study is unlikely to yield worthwhile evidence about the sun?"

Pawsey completed the letter by listing two projects, which could be decisive in understanding the nature of solar radio emission. Projects 1 and 2 concerned the statistics of solar emission: (1) "Is the waveform that of random noise?" and (2) "What is the waveform (envelope) of bursts?" These projects had been suggested to Pawsey by the well-known English radio scientist Ron Burgess (see Sullivan, 2009, p. 114 for a description of Burgess's contributions.) Payne-Scott (1949) published her results on projects 1 and 2 in 1949, based on data obtained at the Hornsby site in Sydney.

Then, as an afterthought, Pawsey added to the document in his characteristic handwriting: (3): Can we observe the atomic hydrogen spectral lines or others? Clearly, Pawsey was thinking of future research areas for the RPL group (discussed in detail in Chapter 20). The RPL group

[51] NAA C3830 F1/PAW/1 Part 2

missed the opportunity to discover the HI line by the Ewen and Purcell at Harvard on 25 March 1951), but made major contributions to HI research in the following years.

On to the UK

It must have been with considerable reluctance that the Pawseys completed their North American sojourn and turned their eyes to the UK and Europe. The wealth of scientific contacts and colleagues had been as enriching as his own, now eminent, position among them was gratifying. This network was to be central to the progress of radio astronomy at RPL over the ensuing decade. In particular, Pawsey maintained close connections with the University of Michigan solar astronomers until his death in 1962. Walter Roberts and Bart Bok were to play major roles in Pawsey's recruitment to NRAO at the end of the decade.

Departure to Europe on 27 March 1948 [52]

A cold, rough voyage began on 27 March 1948 on the *SS Queen Elizabeth* (Fig. 6) that was to have serious consequences for Lenore Pawsey. Toward the end of the voyage, she contracted pneumonia. After arrival in Southampton on 1 April 1948, she was taken to the local hospital in for the next ten days. The circumstances of the Pawseys' visit to the UK were partially dictated for the next four months by various illnesses experienced by Lenore. After treatment in Southampton with sulfa drugs, she moved to her sister's (Bessie Whitford) house in Iver, 30 km west of London in Buckinghamshire, close to Slough. This location was to remain the temporary home for both Pawseys until late September 1948.

On 11 May 1948, Pawsey reported that Lenore was still ill with bronchitis, "still unable to get about at all". On 8 June 1948, he wrote: "Lenore has not returned to good health yet. She is not suffering from any obvious disease, but has some bronchitis and has continued to feel out of sorts since arrival here." Not surprisingly, Pawsey remained close to Iver, spending weekends with Lenore. The distance to Cambridge was only 150 km; thus starting in late April he was able to visit colleagues at the Cavendish Laboratory. However, Lenore's ill health took another bad turn. On 6 July 1948, Pawsey wrote to Bowen:

> I am optimistic about Lenore's health but she has had a bad spin. She has spent the last two weeks in hospital having her appendix removed. It may have a focus [?] of infection.

[52] All references are either to NAA C3830 F1/PA//1 Part 2 and/or NAA C4659/8. Many letters are located in both sources. Pawsey and Lenore were to remain in the UK and Europe from 1 April to 23 September 1948, then departing for the return trip by sea to Australia.

> Anyway she is a lot brighter now. The whole business has been worrying and disturbing to me so that I have not appreciated England as I should have done.

Lenore's illness caused lasting disappointment. At the end of the visit to the UK, Pawsey wrote Bowen (from the ship off the coast of Malta on 29 September 1948) regretfully: "… it was a shocking waste of a good time [about 4 months] in England. However, she was well enough to go to Oslo [for a conference] and has continued to improve."

Immediately after arrival, Pawsey sent his first impressions of post-war life in the UK to Whitten (ASRLO) in Washington: "I am quite favourably impressed with life in England. Things are nowhere sumptuous and very often dingy … [But] I think my previous impression based on overseas reports definitely too pessimistic." Fortunately, Pawsey was able to visit a number of radio astronomy institutes in addition to the Cavendish Laboratory.

Soon after arriving in the UK, two important short conferences were held, allowing Pawsey to present the Australian radio astronomy results and providing an opportunity to meet some of the leading players in the UK scene: Jack Ratcliffe, Martin Ryle and J. Stanley Hey.[53] The first conference was the Institution of Electrical Engineers (IEE) which met on 7-8 April 1948 in London. Most likely Ratcliffe had invited Pawsey to speak. Pawsey presented two talks in "Session III—Radio Noise". The longer presentation was on solar and cosmic noise with four slides and then a shorter presentation on radio refraction effects at 200 and 60 MHz. Pawsey published an "abbreviated copy" of his presentation in a later publication of the IEE. In his introduction, he praised Hey for his fundamental discoveries[54]:

> I welcome the opportunity of opening this discussion, particularly as Mr Hey is a pioneer in the field of solar noise. The observation which he described in 1942 gave the first definite evidence of which I am aware of high intensity solar radiation on radio frequencies. The science to which that observation gave birth has now given astronomy a new tool and may give important results of the generation of electro-magnetic waves in ionised gases.[55]

[53] Possibly Pawsey met Hey and Ryle for the first time. Ratcliffe had been Pawsey's PhD advisor at Cambridge a decade earlier.
[54] From the original text.
[55] The original text (before editing by Pawsey for publication l) read that the new science may "offer things of considerable importance in the field of solar physics and stellar physics, although perhaps I had better broaden that to astronomy, and possibly the generation of waves." The original text had some descriptions of both the sun and the Cygnus A source, while the final text only described the Cygnus observations.

Then Pawsey credited Hey with the "second fundamental discovery made by Mr Hey and his colleagues, the short period variations[56] in cosmic noise originating in an area less than 2 deg in the constellation of Cygnus." Pawsey described the new Australian observations at Dover Heights carried out by John Bolton and Gordon Stanley: "In Australia we use an interferometer technique which is very similar to that used by Ryle, but instead of using two separate aerials we use a single aerial on a cliff overlooking the sea, and obtain interference between the reflected wave from the sea and from the source."

Pawsey presented the preliminary position of Cygnus as well as the upper limit of only 8 arc min for the angular size. The Australian position was at this time 1.2 deg north of the true position, while the Cambridge determination was about 1 deg south. It was to take a few years before Mills and Thomas (1951) and Smith (1951, 1952b) sorted out this discrepancy.

Pawsey mentioned that the source was not moving across the sky (no detectable parallax) over a period of several months. He showed an overlay of the radio position on a photograph of the Milky Way (presumably the overlay shown in the 1948 publication of Bolton and Stanley, 1948a). "There is nothing we can recognise as peculiar in that part of the [sky]. It is an ordinary part of the Milky Way." The intensity of Cygnus was

> … surprisingly high. It is the same order at 100 Mc/s as that of the sun at quiet periods despite a presumed vastly greater distance. The facts, together with that of rapid variations, scarcely fit the hypothesis of the origin in thermal radiation from vast clouds of interstellar gas. There must exist localised regions emitting vast amounts of radio frequency energy. Perhaps they may prove to be new types of astronomical bodies.

Pawsey could not have realised in 1948 how prophetic this prediction would become within a few years as Cygnus A was identified with a galaxy at redshift 0.056, an implied distance of 211 Mpc or about 700 million light years.

Pawsey then provided a "teaser" to the audience at the IEE conference. "Finally the Cygnus source is not unique. It is only the most studied of the discrete sources of cosmic noise." No additional information was provided. In fact, Bolton had just submitted his paper to *Nature* on 30 March 1948 "Discrete Sources of Galactic Radio Noise". This was published in late July 1948, including the new sources detected at Dover Heights by Bolton and colleagues, Taurus A, Virgo A and Centaurus A. The optical identifications of these three with the Crab Nebula, M87 and NGC 5128 would be proposed the following year after the successful conclusion of the New Zealand Cosmic Noise Expedition.

[56] by 1950 recognised as being generated in the earth's ionosphere—see Chapter 26

In conclusion, Pawsey was warm in his praise of Ryle:

> Turning to Mr Ryle's paper [at the conference] I should like to express acclaim for the experimental techniques which he evolved. His use of interference between spaced aerials for discrimination against cosmic noise, for source diameter measurements, and for polarisation represents an economy in equipment quite in the Cavendish Laboratory tradition. The results … have been largely duplicated in Australia utilising somewhat different methods and I am happy to be able to say we agree on the main conclusions.

As we shall see (especially Chapters 26, 35), this sense of collegiality did not continue in the following years as the source count controversy began.

About three weeks later, Pawsey was given another opportunity to present RPL results in London. A special meeting of the Royal Astronomical Society was held 23 April 1948. Pawsey presented: "A Geophysical Discussion on Solar Radio Noise" (Pawsey, 1948). The speakers included some of the most recognised names in the field of ionospheric research: Sir Edward Appleton (Chairman of the session), Sydney Chapman (1888-1970, Oxford) and D.F. Martyn (Australia). Additional speakers were Pawsey, Hey, Ryle, Hoyle and Stratton. After Appleton's introduction, there were a number of short presentations, and Hey discussed solar noise observations of the increased radio emission associated with the major sunspots of February and July 1946.

Pawsey began his contribution: "I'm afraid I shall be accused of collusion with Mr [Fred] Hoyle when I show my first slide, which gives the observational evidence … that he asked for concerning the relation between temperature and wave-length of observation."

Pawsey gave a description of his observational evidence at 200 MHz for the million degree corona. He showed that the radiation had a thermal origin: (1) the wave form was consistent with that expected from fluctuation noise, (2) the area of the emission was that of the entire sun and (3) the radio emission was shown to have no circular polarisation.

Ryle and Hoyle, in separate talks, discussed models for the radio bursts originating in a thermal process from gas at a temperature of 10^6 K in the corona and 10^{10} K in sunspots.

Martyn began his presentation:

> The discussion has shown that there is agreement on the quiet sun so in this respect I propose to let sleeping dogs lie! With the disturbed sun, there is a divergence of views on the possible mechanism of production of radiation. Mr Hoyle and Mr Ryle incline to the thermal origin [with extreme electron temperatures]. I suggest … that we should

> therefore look to plasma oscillations, which are a more efficient source in a limited wave-length range than thermal radiators.

Hoyle invoked an existing theory of magnetic storms in the ionosphere due to Chapman and Ferraro from 1930 in which "… the motion of a slab of ionised material perpendicular to the magnetic field" produced "oscillation of the electrons on the walls of the slab".

It was given to Appleton to provide a summary of the afternoon meeting, and he did so by noting the growing strengths of the field—now drawing in others from established areas of research. Appleton noted that theories of solar emission were heavily influenced by the physics of the ionosphere. He commented on the cross disciplinary interest of the research.

> More recently when we began to detect meteor trails by radio, we have collaborated with the people who use visual methods—though here I must say that although I begged them to take notice of us, this only came after some time! Now that we have begun to study solar radio noise, we are delighted to see that solar physicists like Mr Hoyle are willing to lend a hand on the theoretical side.

Immediately after the RAS meeting, Pawsey expressed his first impressions of the UK radio astronomy and ionospheric scene in a hand-written note to Bowen on 27 April 1948: "So far I have been a little disappointed in the lack of <u>new (his emphasis)</u> work on solar and cosmic noise but have not visited Cambridge."[57] The disappointment was to be dispelled within the next months as new results at both the Cavendish and Jodrell Bank became apparent.

Visits to Conferences, to Jodrell Bank, other UK sites, and Scandinavia

In the coming months, Pawsey had at least two visits to Jodrell Bank of the University of Manchester: 31 May 1948 for a few days and then in September for a conference on meteor

[57] In the same letter (27 April 1948), Pawsey revealed some rumours he heard from Fred Hoyle at the RAS: "And now a few tit-bits of plain gossip. On Friday I attended a meeting of the Royal Astronomical Soc. at which Hey, Ryle and Hoyle (Cambridge mathematician or theoretical astronomer) I, and Martyn spoke. Hoyle spoke on some theoretical aspects and on the subject of higher intensity radiation—praised Giovanelli's various papers as a major contribution (he then gave his ideas on certain corrections). After the meeting I had a meal with him [Hoyle] and to my surprise he opened up on the subject of the deficiencies of Australian theoretical astronomers. In doing so he spoke of [Ron] Giovanelli as a real ray of light in the darkness and even made the remark that publications were accepted here as a matter of courtesy to Australia. Apparently Hoyle is a referee to various journals. Hoyle then made a partial retraction. [Cla] Allen's observations are sound, he said, but his bits of theory are often wrong because he is influenced by the atmosphere he lives in—apparently feelings run high in certain quarters here. The main point in writing this gossip is to suggest to you to encourage Giovanelli. He is working under difficulties of isolation and must need a bit of encouragement." Apparently, the "atmosphere" referred to was the Commonwealth Solar Observatory at Mt Stromlo under the direction of Richard Woolley.

astronomy, organised by Bernard Lovell.[58] He visited the Telecommunications Research Establishment (TRE, the main WWII radar research institution, Air Ministry) on 28 April 1948, with abbreviated visits later to J. Stanley Hey's Army Operational Research Group[59] in West Byfleet. He also visited Oxford University (visiting Chapman) and Appleton at DSIR (he was now Secretary of the Department of Science and Industrial Research) in London in late April. In May 1948, Pawsey started a 2 ½ month visit at the Cavendish Laboratory. As noted, he would frequently spend the work-week in Cambridge, then return to Iver during the weekend to visit his wife and her sister's family. .

At Cambridge Pawsey was fascinated, among other things, by the short-term variations in Cygnus A; his term for this was "wobbles". In a hand-written addition at the end of a preliminary report on UK radio research (10 June 1948), Pawsey wrote: "'Wobbles' on Cygnus A source vary from day to day and on 'wobbly' day on Cygnus, Cassiopeia is quiet steady. Strong evidence against ionospheric origin."

Pawsey had made the inference that both "radio stars" were of a similar nature; the fact that one showed scintillation and other did not suggested that the time variations were an intrinsic feature of each source. As the investigators were to discover in the next few years, this conclusion was incorrect; one source was compact (Cygnus A) and the other extended (Cassiopeia A).

In mid-1948, the nature of Cygnus A and Cassiopeia A were unknown. The identification of the former with a high redshift galaxy and the latter with a galactic supernova remnant would only become known after 1951 (see Chapter 26). The angular sizes would be recognised in late 1952 (Chapter 29) with Cygnus A's size of 1.5 arc min and Cassiopeia A with a size of about 6 arc min. It was then understood why the smaller source (Cygnus A) would show scintillation while the large source did not. The analogy was often made that "stars twinkle" and larger planets do not.

Also in 1948, new sources were being discovered by Bolton, Stanley and Slee after the New Zealand Radio Noise Expedition of mid-1948. Ryle became aware of these new radio sources (optical identifications of Taurus A, Virgo A and Centaurus A) which were to be published in *Nature* a year later on 16 July 1949. The two groups were also aware of the problem of the vastly different positions being determined for Cygnus A by the various groups (see Chapter 14, 26 and 29). Pawsey provided further details of the work at Cambridge in letters and reports to RPL, which we discuss below. Graham Smith's new accurate radio position from Cambridge for

[58] Edge, D. O., and Mulkay, M. J. (1976). "Astronomy transformed. The emergence of radio astronomy in Britain." New York: Wiley, page 41. Interview with Lovell by Goss, May 2006. Lovell showed Goss his Guest Book from the 1940s, including Pawsey's entry in 1948.
[59] See Pawsey's report to follow.

Cygnus A was published on 29 September 1951, leading to the optical identification of Cygnus A with a high redshift galaxy in 1952-1953 and published by Baade and Minkowski in early 1954.

After late April, Pawsey attended four additional conferences, three in Scandinavia. He departed London for Stockholm on 11 July 1948, where two conferences were being held: URSI, the International Union of Radio Science (URSI), 12 to 22 July 1947, and the meeting of the Consultative Committee on International Radio (CCIR) from 12 July to the end of the month. At URSI he gave a number of papers on extra-terrestrial noise, including a full report on the CSIR activities (cosmic and solar noise) as well as ionosphere research. Pawsey departed Stockholm on 24 July 1948, attending only one of the CCIR sessions. Lenore had remained behind in the UK, staying with Pawsey's cousin Francis Ward at Settrington in Yorkshire for a few weeks; Lenore must have been ill again as she was in the Malton Hospital for a short period, close to the Ward home.

The next conference was 4-7 August 1948 in London, the British Commonwealth Conference on Radio Research. Pawsey gave a presentation in section 6: "Radio Noise Section B: Solar and Cosmic Noise".

Fortunately, Lenore was able to join Pawsey on the last major trip of their UK-Europe visit, the International Union of Geodesy and Geophysics (IUGG) in Oslo, Norway, from 19-28 August 1948. Pawsey wrote Bowen on 27 August with a report (from Oslo) of his presentation of Frank Kerr's lunar radar experiments at 20 MHz (Kerr, F. J., Shain, C. A., & Higgins, C. S. (1949). Moon echoes and penetration of the ionosphere. *Nature*, *163*(4139), 310-313). Pawsey also reported his impressions of sessions on "radar for survey" and "rainmaking". Regarding the latter topic, Pawsey was irritated by its absence from the agenda. The US National Committee of IUGG had reported "that at no time in the US had rain been artificially produced except at times when it had fallen naturally within 30 miles!" Pawsey reported that hardly any discussion of the rain making trials in Australia occurred.

Report of UK Radio Astronomy, JL Pawsey, 11 June and 10 October 1948

As Pawsey had done after the US and Canada visits, he prepared summaries of UK radio astronomy groups after his visit. A preliminary report was written on 11 June 1948 (after 2.5 months): "Some Notes on English Radio Astronomy", followed by an extensive report prepared on the ship when he returned to Australia on 10 October 1948 (after 6 months): "Notes on Radio Astronomy in Europe".[60]

[60] NAA C4659 4. In fact, Pawsey did not visit any of the non-UK radio astronomy institutes in Europe. In the complete report he discussed J.L. Steinberg's group in Paris, having started observations of solar noise using the ex-German giant Würzburg antenna. He also mentioned J.F. Denisse, whom he had met

The latter report began by contrasting US and UK radio astronomy:

> In contrast to the American work, English research in these fields is already well established. It is in the hands of people with initiative, skill and drive … [For] the three primary discoveries in the whole field, that of cosmic noise itself [Jansky], that of the intense non-thermal solar radiation, which I rank as the least capable of prediction from prior knowledge, Hey was responsible for [the latter] two. Hey's facilities are however [now] limited and he has not been able to follow up his discoveries adequately. This has been done mainly by us in Australia with Ryle working independently a few months behind us.

Pawsey visited Hey at the MORU (Ministry of Supply Operations Research Unit, previously the Army Operations Research Group, AORG) at "Broadoaks", West Byfleet, Surrey. Pawsey wrote: :

> [Although a military establishment with] testing of some military devices … in practice Hey is able to continue his scientific work without hindrance by other duties and with reasonable technical assistance but very little scientific help….[Routine solar observations at [75] MHz continued.]He has investigated the relation between solar flares and large bursts by looking for an association between bursts of difference sizes and flares occurring near the same time [likely Type II events].

Hey found that the association probability increased markedly with the intensity of both the radio burst and the optical flare. An E-W asymmetry of the associated events was suggested at the time due to the free-free absorption in the corpuscular stream between the sun and the earth, the asymmetry caused by the rotation of the sun. Based on the marginal evidence shown in Hey's 1948 paper (Hey, J. S., Parsons, S. J., & Phillips, J. W. (1948). Some characteristics of solar radio emissions. *Monthly Notices of the Royal Astronomical Society*, *108*(5), 354-371), Pawsey's sceptical reaction was clearly justified.

Pawsey visited Jodrell Bank at least twice in the period from April to September 1948. In 1948, Bernard Lovell (UK, 1913-2012) and colleagues Clifton Ellyet (UK then New Zealand and Australia, 1915-2006), John Clegg (UK, 1913-1987), Nicolai Herlofson[61] (Norway then UK and Sweden, 1916-2004) and Victor Hughes (UK then Canada, 1925-2001) were busy planning and constructing the 218-foot (66 m) fixed "great mirror".[62] Most of the design had been carried out

---

in Washington, a "guest-worker" at NBS. The strong friendship that developed between Denisse and Pawsey continued for the next two decades.

[61] Norwegian scientist who worked at Oxford and Manchester in the 1940s. Later, Director of the Plasma Physics Laboratory at the Royal Institute of Technology in Sweden. Close colleague of Alvén.

[62] Robert Hanbury Brown was to join the group later in June 1949.

by Clegg. Pawsey wrote in the 10 June report that the mirror had been in operation for about a week: " … the erection was done mainly by the research people" with a total cost of £ 2,000.[63] In Fig. 7, we show Pawsey's sketch of the "Great Mirror", which remained the largest dish in the world for a decade.

This 218-ft transit dish (66 m) operated at 72 MHz and could observe a region of the sky within plus-and-minus 12 deg from the zenith. The focal length was 127 feet (39 m), the design based on the distorted catenary principle. The group was planning to use this antenna for three main purposes: (1) meteor radar echoes, (2) possible echoes from cosmic ray showers as had been earlier predicted by Blackett and Lovell in 1941 and (3) cosmic noise. Pawsey wrote in his report: "Both [1 and 2] seemed doomed to failure so I guess Lovell will simply discover something new. The possibility of drawing a blank I regard as both inartistic and unlikely." As Sullivan (2009, page 191) has commented, Pawsey was uncannily correct in this prediction. The cosmic noise work was to be the primary use of the 218-foot telescope, even though in 1948 Pawsey found that "the cosmic noise work is not being pushed vigorously". The glory days of the 218-foot dish were to occur after the arrival of Hanbury Brown and his graduate student Cyril Hazard over the following years. The noteworthy detection of the Andromeda Nebula by Brown and Hazard in 1951 was to be carried out with this instrument.

At Jodrell Bank Pawsey spent some time in discussions with Nicolai Herlofson who was "of first class theoretical ability: has worked on theory [of reflection from meteor trails] with some startling results." Pawsey and Herlofson had numerous discussions concerning the theory of scattering off the ionised tails of comets: "Herlofson could not explain it on physical grounds nor relate it to any familiar analogy. Later, he and I discussed the possible analogy of a short-tuned dipole which scatters nearly as effectively as a half wave one. Perhaps the cylinder shows an equivalent transverse resonance."

Pawsey had a somewhat negative opinion of the 218-ft dish, based on claimed detection of variable flux density determinations of discrete sources and observations of occasional large disturbances of unknown origin.[64] Pawsey wrote:

> The chief lesson for us to learn from the Manchester experience is that there is great difficulty in interpreting records of sporadic happenings observed on an aerial of fixed diameter [single dish]. I do not think we should plan to use such an aerial for any exploratory purposes without facilities for some sort of supplementary check.

[63] The construction occurred in the period 1946 to the end of 1947. Sullivan (2009) has presented a history of the early years of Jodrell Bank.

[64] Pawsey noted that these excursions did not show the characteristics of radio frequency interference.

Likely this impression remained with Pawsey in the early 1950s as the discussions of the Giant Radio Telescope (GRT) began; an auxiliary interferometer might be required.

Naturally, the Cavendish Laboratory at Cambridge figured largely in the report. Pawsey began by providing details of the ionospheric research in Ratcliffe's group. He summarised the 15-50 kHz research of Ron Bracewell (on a CSIR Fellowship) and colleagues. Other groups were working on: (1) 50-500 kHz propagation and (2) short waves (1.6 to 30 MHz). "Of these investigations the work at 15-500 kHz and at short waves all usefully associate with solar noise work. They give data on radio fadeouts and allied phenomena."

He then included detailed discussions of both solar and cosmic noise research at Cambridge. Martin Ryle and Derek Vonberg (1922-2015) had recently published a paper in the *Proceedings of the Royal Society*: "An Investigation of Radio Frequency Radiation from the Sun"(Ryle and Vonberg, 1948). In NRAO ONLINE 60 ("Pawsey, Coordination, Solar Noise Research, Interferometer Techniques with Cambridge -1948-1951"), we present the complex interactions of the two solar groups in 1958-1949. The particular case of Martin Ryle's conflict with Ruby Payne-Scott concerning the reality of Type III bursts is described in NRAO ONLINE 30.

Interferometer techniques, as well as solar and cosmic noise research, were discussed in detail during Pawsey's six months visit to the Cavendish Laboratory. Ryle had extended the interferometer baseline in Cambridge to 600 feet (183 m) with arrays of four Yagis at the ends. Pawsey reported:

> [I]t gets beautiful records of discrete sources at 80 MHz. The prominent ones are that in Cygnus and a new one in Cassiopeia below [the Sydney] horizon … Ryle uses direct interference by means of coaxial cables of a superlative German type.[65] I think the direct method may be superior to that involving frequency conversion at both aerials and interference at the intermediate frequency. (Ryle and Smith, 1948[66])

Pawsey included additional details about the "noise adding radiometer" method of observation described by Ryle and Vonberg in April 1948. This consisted of a system to balance the input noise in the aerial against noise from a diode (a type of Dicke switch). This method enabled the sun to be observed over long time intervals in the presence of the variable galactic background. Pawsey pointed out that the two-element Michelson interferometer (with a variable baseline) was straight forward to use, leading to a determination of source angular size and polarisation.

[65] These were the so-called "Jerry" [WWII slang for "German"] cables based on a km of captured war material. This was far superior to any contemporary UK produced cable. (Sullivan, 2009, p. 160)
[66] Published shortly after Pawsey's visit.

Within a short period, positions could also be determined based on the absolute phase of the interferometer fringes.

Solar work was being carried out at both 80 MHz and 175 MHz by Ryle and colleagues, with plans to move to lower frequencies. The intensities, sizes and the circular polarised state of the solar emission could be determined on a daily basis. Pawsey made a striking distinction as he described the differences between the two solar groups. The Cambridge group:

> depend on statistical treatment of all observations. This contrasts with the treatment we usually adopted of deriving results from outstanding cases [the prominent example was the huge 8 March 1947 Type II event published in *Nature* by Payne-Scott, Yabsley and Bolton on 23 August 1947]. (Chapter 13)

An example of the Cambridge method was an attempt to look for a periodicity in the solar radio emission close to the 27-day solar rotation period based on the auto-correlation method of the intensity as a function of time delay. If this were to be confirmed, this would indicate "directed emission of the radiation with [a finite] angular distribution which was different at the two frequencies [80 and 175 MHz]." Thus "spots within a day of meridian passage may be identified as [radio] sources in many cases [since absolute positions had not been determined by Ryle and Vonberg]." Pawsey thought the statistical techniques could offer the possibility of

> obtaining objective results … and [we should] be prepared to use them. However, the interpretation is very tricky and I feel sure that the desirable procedure is a combination of the direct method utilising outstanding cases and the statistical one. The first method introduces subjective uncertainty in the selection of the data, the second in the physical interpretation of statistical facts.

Contacts with Australian post-graduate students at Cambridge

An important aspect of Pawsey's visits to Cambridge was to meet the "Radiophysics-Cavendish" people. A report on this was sent to Bowen on 18 May 1948—a day filled with copious correspondence, as we will see below! A major point of contention was whether CSIR would maintain the policy of only supporting the post-graduate for two of the three years required for a PhD. Pawsey had written:

> [I suggest we adopt] the idea of deciding to grant a further year only in the case of first class work together with expected benefit from the stay, and no violent disruption of laboratory work in Australia. That scheme would cause a lot of worry in deciding who might stay, but [it] was the scheme during my "1851 Exhibition".

Both Joan Freeman and Ron Bracewell had come to the Cavendish Laboratory in 1946, leaving Sydney together on the *SS Orbita* in August 1946.[67] For both Bracewell and Freeman, Pawsey gave glowing reports of progress at Cambridge. Ron Bracewell had already been promised support for a third year from CSIR. He was engaged on low frequency ionospheric studies at the wavelength of 19 km (a frequency of 16 kHz). He had developed into an experimentalist, complementing his theoretical skills accrued earlier at RPL during and after WWII. "So far Bracewell has his coat off and [has] really worked hard at constructional and observation work." With this combination of skills, Pawsey predicted "he will come away as a real asset to us." Joan Freeman was to be given a small grant from CSIR to allow her a third year; this grant was to be combined with a Newnham College Studentship. She had gotten off to a slow start due to a mix up in the Cavendish organisation. By mid-1948, she had, however,, landed an excellent problem: the bombardment of elements (sodium and boron) with protons with the subsequent emission of alpha particles. In fact, Joan Freeman published two *Nature* papers later in 1948/1949 (30 October 1948 and 29 January 1949) describing her preliminary results.[68] At this point, Freeman's future was not at all clear. Freeman (1991, p 157) wrote:

> In Australia there appeared to be very little opportunity for nuclear studies. If I returned to the Radiophysics Laboratory I would probably go into radio astronomy. This, under Pawsey's leadership, was undoubtedly an exciting field, which I knew was progressing at a remarkable rate. Ron Bracewell, planning to return at the end of his third year, was in a good position to drop straight into this slot, having spent his time at the Cavendish in radiowave [sic] research. But for me, with quite different experiences in Cambridge, it would be a much more difficult transition.

Freeman saw her future leading to a position in nuclear research in the UK. Pawsey was impressed with the positive assessment of her advisor W.C. Burcham but did not foresee a bright future for Australian nuclear research for Freeman. Pawsey concluded: "I need scarcely say she is in love with Cambridge and the UK."[69]

On 8 June 1948, Bowen replied to Pawsey, in full agreement with the recommendations regarding Bracewell and Freeman.[70]

Pawsey's attempts to recruit theoretical colleagues

[67] Joan Freeman's *A Passion for Physics* (1991, CRC Press) for additional details.
[68] *Op cit,* page 157 for a detailed description of the negotiations with CSIR.
[69] Freeman's immensely impressive career after this date is also mentioned in Chapters 9, 11, 14 and 16 .
[70] The assessment of the third postgraduate, Frank Gardner (1924-2002), was negative: "[He] has not yet found his feet here. I shall try to find out why and help him to do so."

Pawsey's trip failed in one objective—that of recruiting a theoretician to RPL. Given the ongoing estrangement from David Martyn, the absence of a strong theoretician was a significant constraint on developments in Sydney. On 9 March 1948, Bowen wrote Pawsey with the suggestion that he meet scientists in Europe who might be interested in coming to RPL for short-term visits [Bowen to Pawsey]:

> … I have mentioned that, while we have been doing rather well on the experimental side of solar noise, we continue to be deficient on the theoretical side. We have only Westfold and Smerd. Westfold is finding his feet nicely but Smerd is of doubtful value [see Chapter 23]. There are people outside the Laboratory like Jaeger [Tasmania], Martyn [CSIR, Mt Stromlo] and Victor Bailey [University of Sydney], who can do outstanding work in the field, but from our point of view we also require someone inside the Laboratory. Together with Fred White I have been making a strong effort to get Jaeger but only succeeded in getting him to accept a part-time appointment. This is now in operation ... What we require … is a first-rate mathematician … who would spend most of his time on solar noise ... Such a man would almost certainly produce excellent theoretical results, and we would definitely get more value from Westfold and Smerd … I wonder if you could look for such a person in England.

The previous day Bowen had also written Pawsey that he should try to recruit visitors during his travels to Stockholm (URSI) in July 1948. He suggested to Pawsey that he contact Hannes Alvén (1908-1995, Nobel Prize 1970) who had expressed some interest to Bowen in spending a year in Australia. On 6 April 1948, Pawsey responded to Bowen; he would look for suitable candidates in England and would talk to Alvén in Stockholm. In the end nothing came of this proposed suggestion; a number of colleagues were reluctant to commit to a long Australian visit, far from Europe and North America. Scientific and geographic isolation was a major hurdle.

As mentioned in Chapter 17 and earlier in this text, major efforts to recruit the theoretical astrophysicist Ralph Williamson were begun by Pawsey after they met in early 1948 in Toronto. In ESM_17.4 and Chapter 17, we provide additional details concerning the interaction with Williamson in the late 1940s. (also see NRAO ONLINE 26 and Chapter 20). The attempt to lure Williamson to RPL failed in early 1949.

On 28 July 1948, a few days after returning from URSI in Stockholm, Pawsey reported to Bowen that he had met Olaf Rydbeck[71] of Chalmers University of Technology in Gothenburg, Sweden.

[71] See Radhakrishnan, V. (2006). "Olof Rydbeck and early Swedish radio astronomy: a personal perspective." *Journal of Astronomical History and Heritage* 9: 139-144. O. Rydbeck (1911-1999). Founder of the Onsala Space Observatory, in the early 1950s.

Since Rydbeck planned to visit India in 1949, he had asked Pawsey about combining this with a long visit to Australia. Pawsey wrote:

> … in view of Rydbeck's abilities and interests in the field of the mathematics of waves being associated with ours, Westfold in particular, I felt that he could be considerable stimulus to the laboratory if he could spend a [long time with us] … Rydbeck is the Director of the Research Laboratory of Electronics, Chalmers Institute of Technology … In brief he appears to be a very competent mathematician—not up to say Booker [see Chapter 16, WWII, for Booker's visit to Australia in 1944] in his physical interpretation—but of wide physical interests. Furthermore, he has a strong and pleasing personality, displays enthusiasm and I am sure he would be well liked here ... [His visit] would give Westfold and Pearcey someone to talk their own language and I feel could be a strong stimulant. Also Rydbeck is one of the senior Swedish scientists and as such would give us a worthwhile intimate contact with [an excellent] scientific group in Sweden.

Again, nothing came of this suggestion. Rydbeck was soon poised to begin radio astronomy at Onsala, south of Gothenburg. There is no doubt that he would have been quite stimulating if he had visited Sydney in the early 1950s.

The final suggestion for an eminent visitor was made by Pawsey to Fred White of the CSIR Executive. The candidate, Henry G. Booker, had been a student of Ratcliffe (at the Cavendish), about two years after Pawsey. Booker had been a prominent radar scientist in WWII at TRE, visiting RPL in October 1944 (see Chapter 16).[72] In the post-war era, Booker was at Cambridge University where he and Pawsey met in 1948. Booker was not satisfied with his position and had been offered a position at the National Bureau of Standards in Washington, D.C. Pawsey wrote "there is a certain reluctance to leave the British Commonwealth and he appeared quite interested in the possibility of joining CSIR in Australia." White was encouraged to visit Booker personally during an upcoming trip to the UK. Pawsey was not at all certain of the most suitable place for Booker: CSIR divisions such as RPL, Meteorology, or the Radio Research Board (with Martyn) or even a university post in Sydney or Melbourne were all possible. Pawsey concluded the letter to White: "I feel sure that if he could be induced to come out he would provide a first rate stimulant to Australian physics."

As previously, the Australian group lost the opportunity to recruit one of the more creative ionospheric physicists of the mid-20th century, Henry G. Booker (1910-1988). Charles Burrows at Cornell University made an offer in late 1948 that preceded any Australian CSIR offer. At

[72] NAA A8520 PH/PAW/1 Part 1

Cornell, Booker was involved in the Arecibo project for many years.[73] From 1965 to his death in 1988, he was a leader in the newly founded Department of Applied Electro-Physics at the University of California San Diego.

In the end, the efforts of Bowen and Pawsey to recruit prominent theoretical visitors were futile. Their choice of candidates showed excellent judgement, but in this era, the rapidly expanding US and European research groups meant that Australian offers were often not competitive. In the 1950s, Pawsey did succeed in bringing recent PhD astronomers to join the RPL staff: Colin Gum of Mt Stromlo in 1956 (Chapter 26, ESM_26.5.pdf and ONLINE 58.2) and Campbell Wade from Harvard in 1957 (Chapters, 28 and 40). Nonetheless the absence of strong theoreticians continued to hamper the Australians. This absence is a sustained theme in this book and was the most prominent aspect of the continued "tyranny of distance" experienced in Australian science.

The costs of absence: Bowen's review of the Laboratory, May 1948

Even though the extensive trip did provide invaluable contacts for the Australians, RPL paid a high price for Pawsey's absence as his indispensable personal leadership was missing for a 13-month period.

Pawsey and Bowen exchanged numerous letters about the current and future status of RPL. Pawsey had left Sydney barely two years after the end of WWII; many new activities had started, leading to new duties for the existing staff and the desirability of recruitment of new scientific personnel. As expected, many problems and challenges arose in this period. Extensive correspondence was no substitute for day-to-day contact. Lindsey McCready, left in charge, could not fill the gap left by Pawsey in 1947-48.

On 5 May 1948, Bowen provided Pawsey with a summary of activities at RPL: "… I have fallen behind in keeping you informed of the latest activities in the Laboratory … so [I will tell] you what has happened since the beginning [of 1948]." The solar work was coming along well. The new spectrum analyser[74] was progressing. The Penrith instrument was planned to give dynamic spectra in the range 70 to 140 MHz. No mention was made of the newly appointed Paul Wild, who, within a few years, was to become the leader of the solar radio astronomy group. Ruby

[73] From W.E. Gordon's *Biographical Memoir of the National Academy of Science* for Booker (National Academy Press, 2001, vol 79): "His work at Cornell emphasized propagation through irregular media beginning with the troposphere and extending through the stratosphere and the ionosphere and into the magnetosphere. In each he made major contributions to the theory and usually joined with others in applying the results to practical communication systems".

[74] Wild, J. P., and McCready, L. L. (1950). "Observations of the Spectrum of High-Intensity Solar Radiation at Metre Wavelengths. I. The Apparatus and Spectral Types of Solar Burst Observed." *Australian Journal of Scientific Research A Physical Sciences* 3: 387, and NRAO ONLINE 20

Payne-Scott's work at Hornsby on "delays" (the time delays for Type III bursts—high frequencies arriving some seconds before lower) was progressing well; she was writing this up at present and planning to take on the swept-lobe 100 MHz Michelson interferometer at Potts Hill.[75]

Bowen praised the newly appointed W.N. ("Chris") Christiansen: "[He] is settling in nicely. [His] continuum solar observations [at Potts Hill at 600, 800 and 1200 MHz] are going well. I feel sure that this programme is bound to produce interesting results and will undoubtedly lead to further detailed investigations which should be followed up …" Bowen was also optimistic about Don Yabsley's research since "[his] work is going well and he has obtained preliminary results giving evidence of limb brightening."[76] He was moderately pleased with the young theoretician Kevin Westfold, with some reservations,

> who has found his feet and is doing interesting and valuable work. The major deficiency is now on our side in providing him with proper guidance or kindred spirits. Perhaps there is no great harm in his paddling his own canoe, but he would certainly be happiest if there were someone like yourself [Pawsey] capable of helping him along.

Frank Kerr was progressing with his lunar radar ("echo") work and preparing a paper for *Nature* (Kerr et al, 1949). An investigation of the feasibility of solar radar observations had started. In the end, there were detailed plans but an experiment was never attempted. Finally, there were the expected positive comments about John Bolton, who was planning a mid-year trip to the north island of New Zealand as well as the construction of a larger aerial at Dover Heights for continued sea-cliff interferometer observations. In addition, in this period Bowen had decided that John Bolton was to cease solar work and concentrate on "cosmic noise" research.

There were both positive and negative assessments from Bowen: "The microwave work [at 8 and 23 GHz] is still in the doldrums due to Piddington's failure to provide any inspiration. Most of the work and ideas come from Harry Minnett and, while there is nothing exciting to report about the sun, he is getting quite interesting results on the moon. His estimates of the

[75] The activities of Payne-Scott in 1947-1948 are described in detail by Goss and McGee (2009, "Under the radar: the first woman in radio astronomy: Ruby Payne-Scott." Vol. 363. Springer Science & Business Media) and Goss (2013, "Making Waves: The Story of Ruby Payne-Scott: Australian Pioneer Radio Astronomer." Springer Science & Business Media). These include the discovery of Type II and III bursts at Dover Heights, the increasing conflicts with Bolton and the beginning of the Potts Hill interferometer. (See NRAO ONLINE 20).

[76] Yabsley was using 2 ex-WWII TPS-3 aerials as a spaced interferometer to look for limb-brightening. This was very similar to the work being done at Cambridge. Yabsley left RPL soon after this and Christiansen dropped the spaced-interferometer experiment in favour of his invention of the grating array. See Wendt, H., and Orchiston, W. (2018). "The contribution of the AN/TPS-3 radar antenna to Australian radio astronomy." *Journal of Astronomical History and Heritage* 21, no. 1: 65-80.

temperature of the moon during the lunar day agree fairly well with previous radiometric measurements but differ markedly during the lunar night. [This will] provide a very interesting paper.]" (Piddington and Minnett,1949, Microwave Thermal Radiation from the Moon. *Australian Journal of Scientific Research A Physical Sciences*, *2*, 63). The paper was published in 1949.

Bowen also had concerns regarding several of the scientific staff.

Steve Smerd (1916-1978) had arrived in Australia in May 1946 from the UK.[77] His first few years at RPL were troubled, leading to numerous critical conversations with both Pawsey and Bowen. The RPL management were clearly disappointed with Smerd's performance. He had been "called on the carpet" by Bowen in late February or early March 1948. Smerd wrote Pawsey on 10 March with a request for advice. On 7 April 1948, Pawsey responded to Smerd's crisis.

> I can understand that you are worried about what to do following your conversation with [Bowen] … My own criticism of your work was that you were very slow. Had you been able to get the more routine things done more quickly there would be much more chance of leading on to something new and worthwhile. You have now been on the job [theoretical solar research] long enough to form a fair opinion and it is clearly the time for you and Bowen to discuss your program and decide whether or not you are in a job in which you can be successful and happy. If either of these is negative, you should get out and try something else ... [The measure of success in a research organisation is] the papers which are produced. It is as you point out, not measured simply by number but essentially by quality. But number comes in virtually at one stage. If the number is <u>zero [Pawsey's emphasis]</u> the output is zero …
>
> Now for a specific example of tardiness. You have ideas of working up the 600 and 1200 MHz thermal data[78] along lines which I discussed with Lehany. J. Denisse arrived in the National Bureau of Standards [Washington, D.C.] last Christmas [1947] and soon got in the track of Covington's [Canadian, Ottawa] data which I recently sent you [in Sydney]. Denisse has already worked out a quantitative explanation [for the thermal component and the SVC, slowly varying component] and it is ready for publication … This will probably beat you despite your four months lead in knowing of corresponding data.

[77] Sullivan (2009, page 288) has provided an account of the arrival of Smerd, an Austrian refugee in the UK in 1938. During the war, he worked on radar research at the University of Birmingham and the Admiralty. He was recruited by Pawsey after the war to work at RPL, starting in 1946.
[78] Published later by Lehany and Yabsley in 1949 and later in 1949 by Pawsey and Yabsley.

> Do not forget that speed is a very important element in research work. People like [James] Clerk Maxwell, Lord Rayleigh etc. must have worked amazingly quickly to accomplish so much ...
>
> [I]t is the appropriate time for you and Bowen to assess your work. If you are getting somewhere worthwhile and have faith in your ability to make a success of a research career, then you should remain at RPL. If not, this is the time to get into some other line.

The next day Pawsey wrote to Bowen explaining that he had been optimistic about Smerd before he left Sydney six months earlier. He was impressed by Smerd's "critical ability in physical matters" but "he was terribly slow, he had produced no original ideas ... [S]ufficient time has not elapsed and I am happy to accept your present assessment."

Within the next month (6 May 1948 letter to Pawsey in the UK), Bowen was more optimistic about Smerd:

> [Your letter] agrees exactly with what Lehany and I have been saying, too. It leaves him [Smerd] in no doubt as to where he stands and gives him the simple alternatives of producing results quickly or looking for another job. I have had another talk with him and had separate assessments from McCready and Christiansen. Smerd has shown rather more activity since my first talk and may be on the verge of producing something useful. He thinks he can produce some tangible results by the end of May ... For his own sake I hope he has been stimulated to do some good work.

There was acceleration; Smerd produced two papers in 1950[79] followed by an impressive review co-authored with Pawsey and published in a book edited by Kuiper in 1953.[80] In addition, Smerd and Westfold (1949, "LXXVII. The Characteristics of radio-frequency radiation in an ionized gas, with applications to the transfer of radiation in the solar atmosphere." T*he London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 40, no. 307: 831-848) and Smerd (1950, "A radio-frequency representation of the solar atmosphere." *Proceedings of the IEE*-Part III: Radio and Communication Engineering 97, no. 50: 447-452) provided improved solar models.[81]

Within one to two years after Pawsey's return to Australia, Pawsey realised the value of Steve Smerd. He became one of the key scientists in the Sydney solar group, succeeded Wild in 1971

[79] The major paper was finally submitted on 30 August 1949 to the *Australian Journal of Scientific Research*, "Radio Frequency Radiation from the Quiet Sun" (Smerd, 1950).
[80] *The Sun* (Kuiper, ed., 1953), Pawsey and Smerd, "Solar Radio Emission"
[81] "The Characteristics of Radio-Frequency Radiation in An Ionised Gas, with Applications to the Transfer of Radiation in the Solar Atmosphere" and "A Radio-Frequency Representation of the Solar Atmosphere", respectively. [NRAO ONLINE 20].

as the head of the solar group at Radiophysics. By 1950, Smerd had become the repository of a mass of information about the sun. Pawsey called him a "walking encyclopaedia" (Wild 1980[82]) on solar matters. Smerd died on 20 December 1978 at age 62, while undergoing heart surgery.

RPL awaits Pawsey's return

Bowen concluded the 18 May 1948 letter concerning research plans with another topic, Pawsey's return to Sydney:

> In my review of the work of the laboratory last week I didn't say how much we are feeling your absence. For a long time the solar and cosmic noise work went along exceedingly well under its own momentum but there have been signs of slackening off since Christmas. There is no lack of keenness or enthusiasm, it is only that members of the Group are lacking the stimulus of day-to-day contact with someone like yourself who is completely on top of the job. Some of the setback might be due to the fact that, following the burst of activity before Christmas, people have got back to instrumental development. This is particularly true of interferometry, the spectrum analyser and the big aerials for Dover and Georges Heights. In that sense, perhaps, things will fit in very nicely. I expect everyone to be making observations with new equipment around August, that is they will have begun getting results before your return and will, therefore, have a lot of things waiting for you to examine.

The same sentiment of feeling Pawsey's absence had been expressed by Kevin Westfold and by Lindsay McCready in correspondence with Pawsey—for example, in Westfold's April letters requesting Pawsey's input for research directions, which had prompted a reply from Pawsey in which he had "let off a lot of steam" (Chapter 17 and Chapter 33). On 10 June 1948, Pawsey indicated to colleagues in Hobart, Tasmania, that he expected to return in September. On 17 June 1948, Bowen wrote Pawsey about the "boys" in the radio astronomy group: "The boys in the radio astronomy group are feeling your absence quite keenly, but I am taking the view that their present gropings [sic] are part of their education. I feel sure they will all be better men after having to fend for themselves for a time."

[82] Paul Wild (1980, "The SF Smerd Memorial Lecture: The Sun of Stefan Smerd." In Symposium-International Astronomical Union, vol. 86, pp. 5-21. Cambridge University Press) has provided a masterful account of his colleague: "I do not think [he will be remembered] especially for his writings and publications. Although these included some that were definitive and highly significant, they were rather few in number ..." Wild asserted that Smerd was the catalyst [his emphasis] for solar radio astronomy in Australia. "To his Sydney-based colleagues by far his most famous writings were universally known as 'the unpublished works of S.F. Smerd'—these, the mighty efforts that never quite came to the public eye, were voluminous indeed." (Also NRAO ONLINE 20)

On 9 August 1948 Bowen again asked Pawsey:

> … Have you made any plans for your return yet? I get the impression from your letters that your return may be imminent but I have not seen any dates mentioned. We are all anxious to see you back, particularly the solar noise people. There is no doubt that their work is suffering from your absence and I am looking forward to a great burst of activity and enthusiasm on your return.

On 11 August 1948, Pawsey wrote to RPL with the news that he and Lenore were booked on the *SS Orontes* on 23 September 1948.

Even Lindsay McCready was concerned about Pawsey's return. On 25 June 1948 he wrote Pawsey:

> We will all be greatly looking forward to your return and hope radio astronomy will not be tapered off or closed down for a while yet. I think you should enjoy yourself immediately on your return—you should have a lot of entirely new and better engineered tools to play with. Next year [1949] should see less time on equipment design and more on planned observing, etc.

Publications concerns at RPL

Among the difficulties that arose in Pawsey's absence were publication problems among the solar and cosmic staff, as these newcomers attempted to present their ground breaking results to the scientific community.

In March 1948, Pawsey became aware of the "publication" tensions at RPL via his "backchannel" in Sydney, frequent hand-written letters from Lindsay McCready. On 24 March 1948, McCready wrote[83]: "… Taffy [Bowen] is demanding a very high standard in report writing—so much in fact that it is … causing serious delays in publication. Again one's efficiency, morale and interest in his own paper falls off more or less in proportion to the number of times it has to be rewritten or typed up …"

McCready told Pawsey of papers that went through 10-12 drafts. The situation deteriorated, leading to a major rift in the publication office: "Miss Plunkett resigned … [due to] too much pressure from Taffy in getting reports out." McCready admitted: "We can all stand criticism in relation to the way we express ourselves in print." McCready asked Pawsey to bring back

[83] The nature of the "backchannel" was clear. McCready wrote: "I would not like you to let [Bowen] know I am writing you." During 1947-1948, McCready sent his (hard to read) letters every month or two to Pawsey. We thank Harry Wendt for assistance in deciphering these airmail letters, due to McCready's indistinct handwriting.

information on the publication process in other laboratories in the UK. McCready continued: "Was it necessary to have a uniform style—so much so that the author's personality is completely submerged? For example, was the royal 'we' to be 'verboten'?" McCready did concede that most of the "general criticism on papers is fair—but the detailed criticisms are far too severe and, of course, cause too many hold-ups … I have stimulated Taffy to give us a pep talk on what he really wants."[84]

On 17 June 1948, Bowen responded to the correspondence on research directions between Pawsey and Westfold in April and May (alluded to above). In addition to the "content of [research] work", Bowen was concerned:

> … [With] writing it up. It is true that those of us who have had a fair amount of experience can give a lot of help in choosing problems for the young people, keeping their sights on the target and in helping them snatch the odd pearl out of the tangled mess, but I am quite sure that what we are suffering from in the laboratory is not that there is too little of this help but too much [our emphasis]. With few exceptions our youngsters have not learnt to stand on their own feet and go for a line of their own. When they have done so, Bolton for example, the results have been exceptionally good.[85]

However, a month later (23 July 1948), Bowen's perception of the counter-productive effect of too much criticism had changed. He was frustrated with the number of papers rejected by the newly formed *Australian Journal of Scientific Research.*[86] Bowen wrote to Pawsey that the failure rate was due to the fact that the manuscripts had not been well written. "So far we have failed lamentably to [submit well written papers] and are getting ourselves a bad name in the process." The criticisms were (a) a lack of clear indication of the expected contents and (b) lack of logic in the treatment and (c) inclusion of extraneous conclusions not justified by the results.

> All [of] this is a sorry story and reflects on the management. I have tried hard to get people to see the light and although they are beginning to see it, there is not much improvement. I am sure I am following the right course in the long run by preferring to write people's papers for them. I intend continuing this policy for another three or four months at least but the day may come when we will have to take the short view for the sake of getting some good papers out. As I keep on telling the chaps, there is no doubt

[84] Pawsey responded on 6 April 1948. He was also concerned about the difficulty and slowness of paper preparation. He was already considering various options that would speed up the publication process.
[85] This self-critical message was an unusual admission for Bowen.
[86] NRAO ONLINE 27

about the excellence of the work being done in the laboratory but **the writing up is awful** [our emphasis].

Bowen continued a week later on 30 July 1948:

> I have been making myself very unpopular about publishing papers and am being freely criticised for holding them up without justification. My purpose has simply been to ensure that [our] published work … is of a high standard and to protect [RPL] from outside criticism. The time has come to protect myself. The only way I have of doing this is to send papers out for publication for judgement by the referee. I am doing this to an increasing extent with the result you know—a large proportion are being rejected. I am sorry to be so despondent about this but see no alternative. The solution is in the hands of the authors and I keep on reminding them of it.

Homeward Bound

As we have seen, one of the major rationales for Pawsey's trip of 1947-1948 was to overcome the continued effects of distance on scientific development in Australia. His publicity efforts in the US, Canada and Europe in 1947-48 were in the end successful. The connections he built with the international nascent radio astronomy community and, of course, with the ionospheric community, were valuable during this period. The trip also helped to familiarise the RPL staff (Pawsey included) with a number of astronomical concepts. RPL's isolation had as much to do with the Australians' meagre connections to the astronomy world; they were physicists and engineers. The connections Pawsey made, particularly in the USA, were to serve the RPL group well in the next two decades. As we have discussed earlier in this chapter, Ralph Williamson was Pawsey's choice for a colleague who would bring astronomical expertise to RPL. The failure of this attempt was a major disappointment (Endnote 5 of Chapter 24 and NRAO ONLINE 26).

On 23 September 1948, the Pawseys left the UK on the *SS Orontes* for the long trip home via the Suez Canal. On 22 October 1948, they were in Adelaide (after a stop in Perth) visiting Charles Duguid.[87] On 25 October the ship was in Melbourne for a short period: Pawsey met Bolton who was on his way to the Tasmania solar eclipse of 1 November 1948, along with Gordon Stanley. On 29 October 1948, after a trip of 13 months, the Pawseys arrived at Circular Quay in Sydney. They were met by Lindsay McCready and the two older children Margaret (age 11) and Stuart (age 9). The two grandmothers, Mabel Nicoll and Margaret Lade Pawsey remained at home with Hastings (age 3). (Fig 8 and 9).

[87] Charles Duguid, a well-known South Australian educator, a prominent advocate Aboriginal Australians. His wife Phyllis was J.L. Pawsey's first cousin. See NRAO ONLINE 55

Additional Note 1: Pawsey's Lecture Series, US 1947-1948

During various visits to the Nicoll home in Princeton in late 1947 and early 1948, Pawsey presented a number of reports describing the Australian cosmic and solar noise research. He visited Princeton University, both the Physics Department (R.H. Dicke) and the Astronomy Department, where he met Lyman Spitzer, Martin Schwarzschild and John Stewart. Pawsey gave a two-hour talk on "Solar and Cosmic Noise". (Just before Pawsey had left Sydney, Spitzer had written him in Sydney about any information on the new cosmic and solar noise results). Later, 25 March 1948, two days before departure for the UK, he visited the Radio Corporation of America Laboratory where he gave an evening lecture "Radio Observations in the field of Astronomy" for the Institute of Radio Engineers meeting. At some point, he also visited the Watson Laboratory of the US Army at Red Bank, New Jersey, at Fort Monmouth where he gave a lecture on "Solar and Cosmic Noise".

Additional Note 2: A Song from J.C. Steele

"The Song of the Universe", October 1948 based on an article by W.L. Laurence of the *New York Times*. The introduction to the text: "A new Science has recently been discovered called Radio-Astronomy, and [we] can now listen-in and hear the sounds from these far-off Starry places in the Universe. This song was composed after reading an article about it in the *Montreal Gazette* of 6 October 1948 by Wm. L. Laurance of the *New York Times* Service." Posted by Jas C Steel to CSIRO in late 1948. Note the mistaken use of the phrase " radar's mystic waves" ! CSIRO archive. (Fig. 10)

Figures for NRAO ONLINE 59

Fig 1. Lenore Pawsey, taken by her husband. Early November 1947. Train trip from California to the east. Joe and Lenore Pawsey Family Collection

Fig. 2 (Reber) and Fig. 3 (the Würzburg aerial), photos made by Pawsey during the visit to the Bureau of Standards field station near Washington, D.C. on 5 December 1947. Joe and Lenore Pawsey Family Collection

Fig 4 and 5. Lenore and Joe Pawsey in Cambridge Mass, mid-December 1947 while visiting Harvard. Pawsey camera Joe and Lenore Pawsey Family Collection

Fig 6. A stormy voyage on the SS Queen Elizabeth leaving New York on 27 March and arriving in Southampton 1 April 1947. Towards the end of the voyage, Lenore became ill with pneumonia. Joe and Lenore Pawsey Family Collection

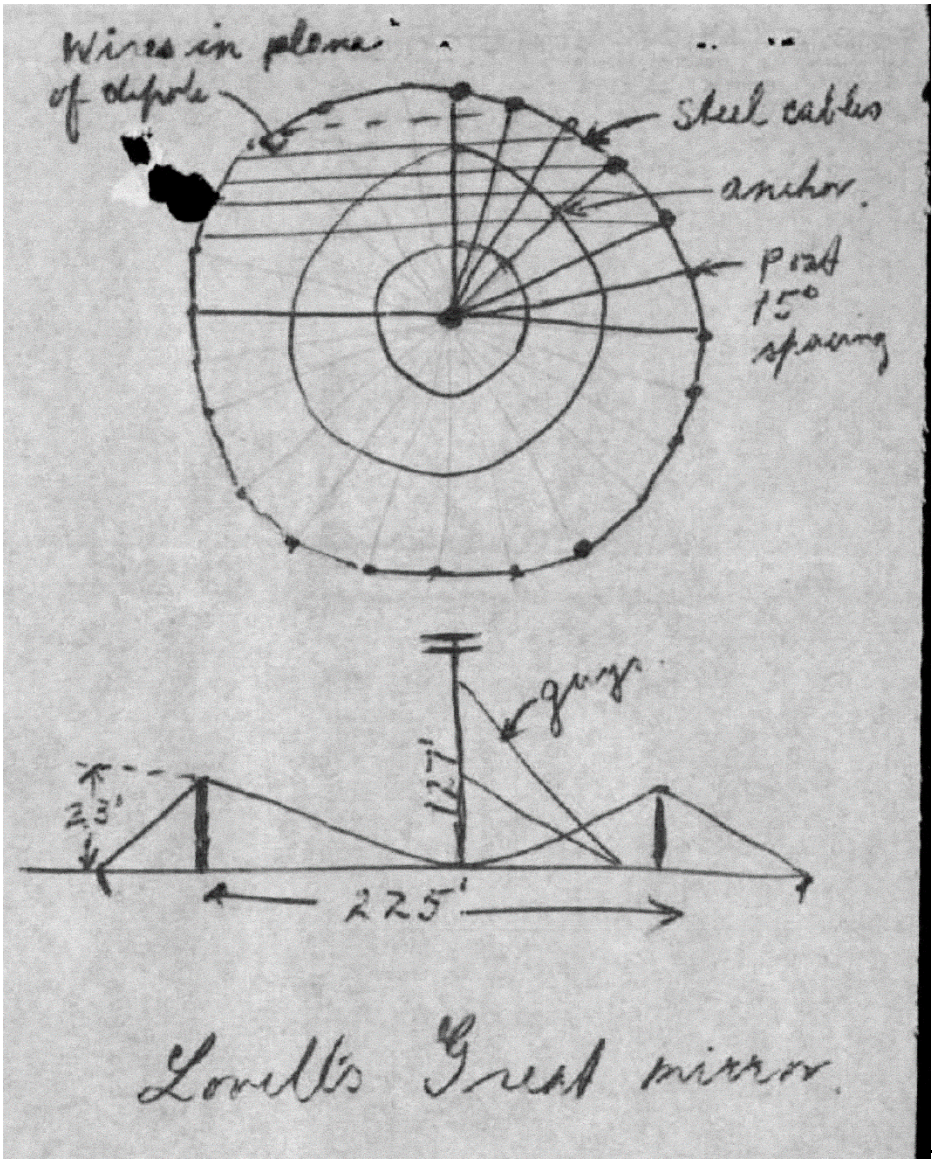

Fig 7 Pawsey visited the newly opened fixed “Great Mirror” at Jodrell Bank in early June 1948. The 218 foot dish was being tested as Pawsey made a drawing. Joe and Lenore Pawsey Family Collection

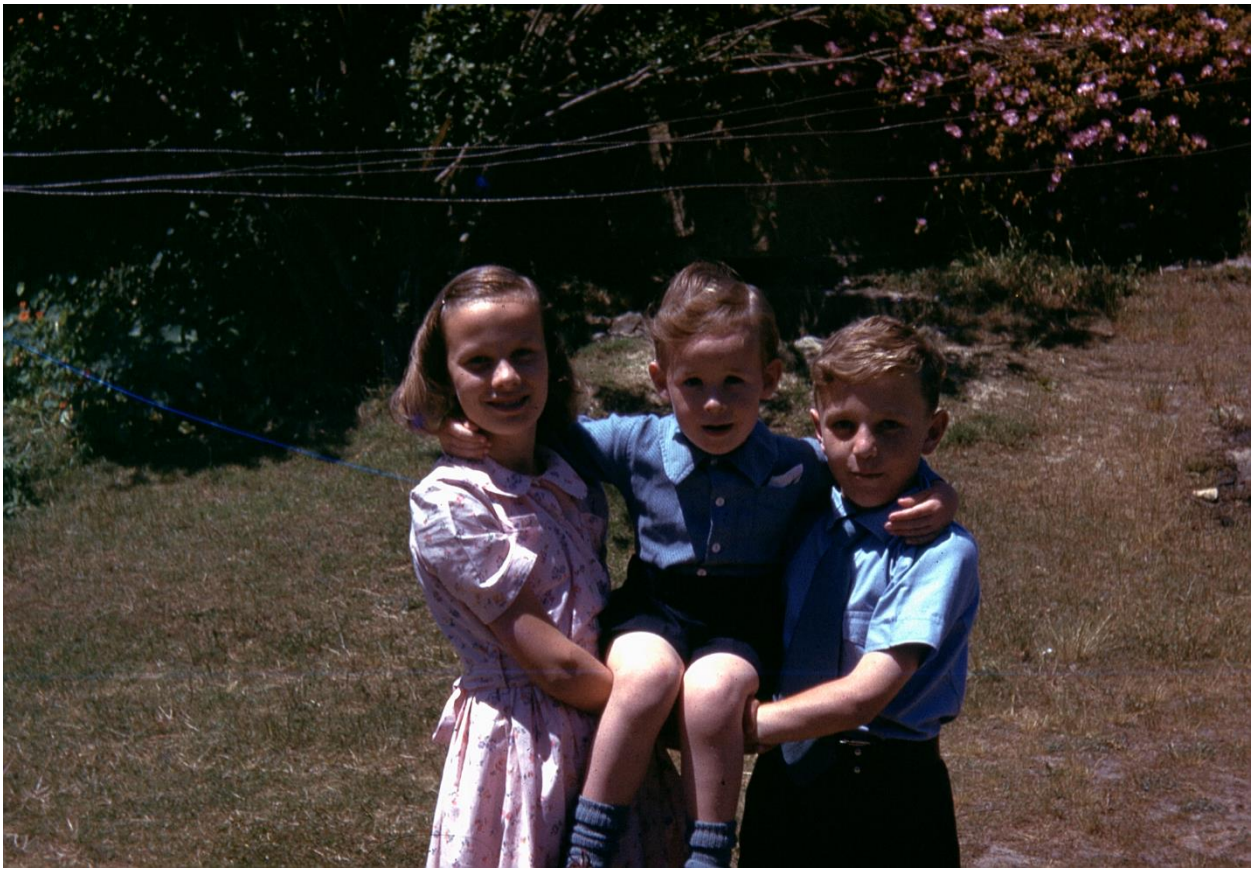

Fig 8 and 9. The Pawsey family and grandmothers re-united in Sydney on 29 October 1948 . Hastings (age 3), Stuart (age 9), and Margaret (age 11) were with the two grandmothers, Mabell Nicoll from Canada and Margaret Lade Pawsey from the Australian state of Victoria. Joe and Lenore Pawsey Family Collection

THE SONG OF THE UNIVERSE

words & music by
Jas. C. Steel

With the Compliments of
Jas. C. Steel
An amateur in
Radio-Astronomy

A new Science has recently been discovered called Radio-Astronomy, and it can now --in and hear the sounds that come from these far-off Starry spaces in the Universe. This song was composed after reading an article about it in the Montreal Gazette of 6th Oct. 1948 by Wm. L. Laurence of the New York Times Service. J.C.S.

THERE IS A SONG! AN EVERLASTING SONG -
IT COMES FROM OUT THE DEPTHS OF ENDLESS SPACE!
THE STARS ARE SINGING IT: AND EVEN OUR SUN,
IS SENDING FORTH THIS SONG FROM ITS BRIGHT FACE!

'TIS LIKE THE SONG OF LOVE, THE ANGELS SANG
ON THAT FIRST CHRISTMAS MORNING LONG AGO -
A SONG OF PEACE ON EARTH; GOOD WILL TO MEN!
WHERE'ER THEY BE; IN PLACES "HIGH OR LOW"

Refrain: THE HEAVENS ALL SING ONE GRAND SWEET SONG!
IN TUNE AND HARMONY, SO STRONG!
WITH RADAR'S MYSTIC WAVES; ITS SOUND
IS HEARD ON EARTH, WHILE WORLDS GO ROUND!

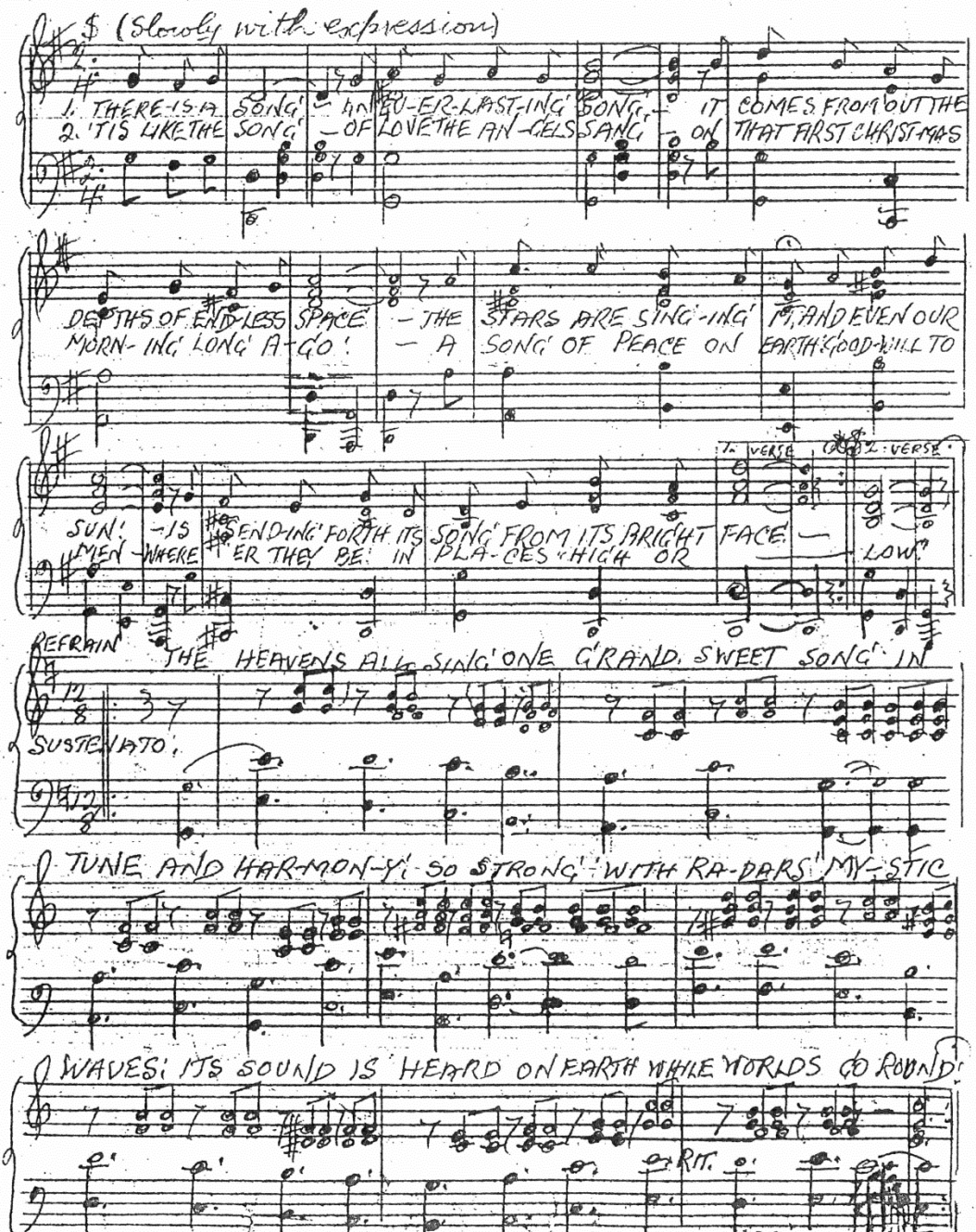

Fig. 10 J.A. Steele song “The Song of the Universe” stimulated by a newspaper article written by William Laurence (New York Times Service) in the *Montreal Gazette* on 6 October 1948 . NAA archive CSIR 1948.