Chapter 9: J.L. Pawsey's Role in Australian Radar Research in WWII
Joe Pawsey and the Founding of Australian Radio Astronomy- Early Discoveries, from the Sun to the Cosmos
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ESM_9.1.pdf: Radar History: An Australian Perspective, 1930s

> There has been through the ages, always existed a vital interplay between war and contemporary scientific discovery. The more highly organised the world becomes, the more drastic the adjustment necessary to absorb the impact of new techniques. Aerial bombing had emerged from the growth of aviation in the First World War, to stimulate in turn, the perfection of RDF [radar] equipment as a logical reaction to the menace of air raids. Evans (1970, p 32)

As the 1930s advanced, particularly after Adolf Hitler's installation as Chancellor of Germany in 1933, progression towards war in Europe was widely regarded as inevitable. This assumption was reflected in Pawsey's letters to his parents, which in turn reflected the many preparations for war then taking place in all the shortly-to-become Axis and Allied nations.

Introduction: Concept of radar, pre-World War II

The dominant story of radar, focused on "top-down", "great country", "great man" and "great achievement", can be distorting. For example, any story about radar that begins with how radar was "discovered" is simply incorrect. There was no single "discovery" or discoverer. Instead, there were fast, multiple iterations of radio direction finding technologies, which evolved in many different places, over the same period of time. For example, Tuve and Breit (Chapter 5), observed aircraft echoes with their pulse-echo ionospheric sounding method in the early 1930s, writing their observations in a report classified as "secret" (Tuve, 1974). Similarly, any story that speaks only of key figures like Sir Robert Watson-Watt distorts the fact that the development of radar required many, many people to be involved. Additionally, a story that is focused only on the key achievements of key figures obscures the fact that the invention of various radars, and their successes, were determined as much by institutions as by skilled scientists and engineers.

The story of radar in Australia, and the central role played by Joe Pawsey in its development, is one of adaptation and collaboration. It is not a story of one or two great men or of single discoveries. The Australian story is included in the larger official histories, albeit marginally (MacLeod, 1999), and is also published in various places, including a special issue of *Historical Records of Australian Science* (CSIRO Publishing) (MacLeod, 1999, p 411). So our objective here is not to repeat what is already published—instead we retell the events as briefly as we can and refer interested readers on to the existing record. Our objective is to construct a different perspective on the history of radar than those that dominate the mainstream. Instead of a story about the “centres” of the UK and the US, ours is focussed on a smaller nation, Australia. Instead of a focus on one or two leading men, our lens is on Pawsey’s position, contributions and experiences.

Radar: precursors and beginnings, 1930s

Who discovered or invented radar? Many people noticed radio waves being reflected from both ships and, after the first World War, airplanes (Brown, 1999, p. 456). It is tempting to see the precursor to radar in ionospheric sounding, but ionospheric sounding used much greater pulse widths than would radar (Brown, 1999, p. 459), and outside Britain (where ionospheric physicists played important roles), radar development was driven as much by electrical engineers, particularly those who worked in television, as by physicists. A better metaphor is to think of radar as an entity that emerged from the right connections between components, rather than a phenomenon discovered through the scientific method. Once the component parts had come into existence—especially the focused cathode ray tube and the pentode—then radar, almost inevitably, emerged.

Many people around the world observed radio signals being reflected from boats and aircraft in the 1920s and 1930s. Similarly, it occurred to several electronic and radio communications companies in the commercial explosion that followed WWI (discussed in Chapter 4) that they might be able to construct and market a radio location device (see Brown, 1999, Swords, 1986 and Guerlac, 1987 for the UK story).

Brown comments that had radar not required moderate financial support, radio amateurs would have evolved thousands of them by the 1930s (Brown, 1999, p 457). That is, all the elements were already available. It was not hard for many people to discover for themselves that transmitter tubes could be driven in pulsed operation to produce power beyond their normal maxima; or that an array of dipoles could produce a narrow beam with consequently high antenna gain. The basic idea behind lobe switching was already being used to help fliers “fly the beam”[1] and thus reach their destination. Methods of protecting a sensitive receiver from the transmitter when using a common antenna were evolving.

So the fact is that by 1939, Britain, Germany, France, Hungary, Italy, the United States, Japan, the Netherlands, Russia, and Switzerland all had operational radars. But this is not to dismiss the fact that the process of development was quite dramatic in each country, and,

[1] “Flying the beam” in the 1930s and 1940s meant using radio range stations to navigate. Pilots hoped to hear a steady tone on the radio that meant they were on course. See https://en.wikipedia.org/wiki/Low-frequency_radio_range

as is common with new technologies, that uptake outside the small circle of engineers and physicists directly involved, was slow. The British, and to some degree the Australians, actively drove radar development in anticipation of war, whereas in both Germany and the US the first developments were undertaken by radio engineers, who then had to convince the non-scientist military higher-ups of the usefulness of their not inexpensive inventions (Brown, 1999, p 460).

To understand what occurred in Australia, we will first sketch the evolution of radar in Britain. In the early 1930s, with concerns rising about Germany, H. Wimperis (1876-1960), Director of Scientific Research Air Ministry, proposed that a committee of scientists be set up under the chair of H.T. Tizard (1885-1959), Rector of Imperial College of Science and Technology, "to intensify research into new defence measures, chief among which was the development of a ray of energy capable of putting the engine ignition out of action … or having deleterious or dangerous effects on the human body or up the metal structure of the plane [a 'death ray' (Guerlac, 1987, p 127)]." Wimperis approached Robert Watson-Watt (1892-1973), since July 1933 Superintendent of the Radio Department of the National Physical Laboratory, who at once dismissed the "death ray" fantasies; but then (with A.F. Wilkins) submitted a memo on 12 February 1935 on the possibilities of radar. He made some back-of-the-envelope calculations and then wrote, "It turns out so favourably that I am still nervous as to whether we have got a power of ten wrong, but even then it would not be fatal. I have therefore thought it desirable to send you the memorandum immediately rather than wait for close rechecking."[2] Air Force staff wanted more convincing than figures on paper, and a rapid demonstration was carried out on 26 February 1935, using the Daventry 50 metre (6 MHz) overseas broadcast beam of the BBC to detect an airplane (Rowe, 1948, p 8). A Weyford two engine bi-plane (metal fuselage and fabric wings) was flown by a pilot who knew nothing about the test. Beats were observed when the aircraft was 12 km distant. The experiment was a success.

Unlike America, Japan and Germany, the British immediately funded developments in radar. Watson-Watt and his colleagues organised the project with a team that included a young Welsh researcher who would later become an enormously important figure in Pawsey's professional life—Edward G. Bowen (1911-1991) (Bhathal, 2014). Bowen had completed a PhD under Appleton and was now assigned to work on developing an appropriate transmitter. Work began at Orfordness, starting at 50 m (6 MHz), although better results were expected at 7 m (43 MHz). Techniques were better developed at 50 m; direction-finding was expected to be easier at this wavelength; and at this wavelength, any German detection of the test signals would be interpreted as ionospheric research. The transmitter was expected to provide 6 kW. Bowen described this initial equipment as "[a] marvel of

[2] The Memorandum is published in Watson-Watt's book *Three Steps to Victory*, 1957 and is the final version which was submitted on 28 February 1935, with a date of 27 February 1935! (Guerlac, 1987, p. 171)

crudity", all makeshift, with an awkward variable capacitor created by fitting two ordinary cans of different sizes one inside the other.[3]

It is worth revisiting how daunting the task was in its initial stages. To the young "Eddie" Bowen, the ultimate requirements were staggering. The reflected signal was expected to be only 10^{-19} of the transmitted signal. Existing ionosphere transmitters had a peak power of about 1 kilowatt and pulse width of 200 microseconds; the bandwidths had to be increased from 10 to 50 kHz as the pulse width was shortened. (We note that in 1925 Tuve was already using 10 kilowatts and 150 microsec pulses, and was undertaking aircraft tracking in 1934 (Tuve, 1974). Bowen would later recall the surprise of the British when they discovered how much had already been done in the US. (Bowen, 1998) The new aircraft radar needed an increase of about 100 in power with pulse width of about 20 microseconds or less (one microsecond corresponds to 300 metres). Initially the pulse-width achieved was an impressive 25 microseconds with a pulse power of 20 to 25 kilowatts, later increasing to 100 kilowatts. With an anode voltage of 10000 volts, loud arcs were caused that extended over a distance of about 70 cm (audible from a mile away). Soon a power of 200 kilowatts was achieved. At 6 MHz, ionospheric returns were received at a range of 60 miles and long range land echoes from the continent of Europe were also observed, the first example (to the British, at any rate) of over-the-horizon-radar by reflection of glancing incidence off the ionosphere.[4]

The system produced by this work, the "Chain Home" radar, was designed by physicists specialising in long waves, rather than by electrical engineers experienced in the metre wavelengths used in television, despite the abundance of the latter, as we know from Chapter 8. Although in some ways constrained by this design, it served its purpose. The Chain Home set acted like a large radio floodlight over the English Channel and into France. An alternative approach might have been to have a relatively narrow beam of radio signals move systematically across an area, more like a searchlight, an approach with a greater economy in power. Other radar sets would later be developed on these principles. By the end of summer 1935, the peak power in the Chain Home radar had been raised to 150, then 200 kilowatts, and a change of wavelength to 24 m (12.5 MHz) was made to avoid radio frequency interference. With 75-foot masts, the group was soon obtaining reliable echoes with ranges of 40 to 50 miles, and a scheme to determine accurate direction finding. Bowen began to investigate if a radar could be installed in aircraft to provide night-time aircraft detection and interception (the transmitters were too heavy) or to find ships. There were multiple challenges associated with each early effort.

[3] Watson-Watt also predicted that ships could be detected up to 20 miles, in addition to aircraft.
[4] There was, of course, a considerable failure rate in the equipment and tests conducted as work progressed. On one occasion Bowen had to work through the night to resurrect a failed transmitter in time to persuade a sceptical Chief Air Marshall of the technology's reliability.

After the start of WWII on 1 September 1939, the Chain Home system played an important part in the defence of the UK. Bowen summarised it thus:

> … [T]he air-warning network ... became the crucial element in the great air battle which was fought over Britain in the autumn of 1940 [Battle of Britain 10 July 1940 to 31 October 1940] … The [British] Spitfires and Hurricanes of the day were superior to the [German] aircraft against them, but they were too few. The pilots and men of Fighter Command put up a magnificent defence but their endurance was strained to the limit before the battle ended. The chain system allowed them to stay on the ground until the last possible moment and then steered them unerringly to their targets ... [A] numerically inferior force was able to beat back an enemy which would otherwise have overwhelmed them. (Bowen, 1974. p.28)

Despite their equivalent system, Freya, the Germans did not work out just how effective the Chain Home system was and did not focus their attacks on the aerials. Lord Douglas [William Sholto Douglas, Head of Fighter Command the successor to Dowding in October 1940] wrote: "I think we can say that the Battle of Britain might never have been won ... if it were not for the radar chain." (Bowen, 1974, p. 28)

Radar in Australia as WWII begins in Europe and the Pacific

As we have said, the Australian radio researchers were not slow in realising the potential of radio to be used for location. In particular, David Martyn was conscious of it during 1936 when he travelled to Europe and New Zealand partly supported by CSIR and a Carnegie Corporation grant (Evans, 1973, p 128). Martyn was flourishing as an ionospheric researcher. Schedvin (1987, p 239) records:

> [He] found himself something of a celebrity in scientific circles. Increasingly the Australian contributions were appreciated outside Appleton's laboratories [London, then in 1936 Cambridge], and Sydney was accepted as a leading centre of an international scientific exploration of the upper atmosphere.

During his visit, Martyn attended many conferences: Oxford, Cambridge, Paris, London and Edinburgh. He also met many luminaries: Edward Appleton (1892-1965, Cambridge), J.A. Ratcliffe (1902-1987Cambridge), Ernest Rutherford (1871-1937, Cambridge), Robert Watson-Watt (1892-1973NPL, Slough), Sydney Chapman (,1888, 1970, Oxford), Harry Wimperis (Air Ministry, London), Lloyd Berkner (1905-1967), the powerful scientific entrepreneur from the Carnegie Institution of Washington, who would come to Perth and then Sydney in 1938 as part of his global geomagnetism research (Needell, 1987) and Fred Whipple (1906-2004, Harvard). He also met Fred (F.W.G) White (1905-1994, Chapter 6 and Chapter 9), who was then at King's College, London, working with Appleton, and David

Rivett (1885-1961, CEO of the Australian CSIR), who was visiting the UK during this period. In addition, he received an invitation from the BBC to visit the Alexandria Palace television transmitter, where he may have met Pawsey. Martyn also found time to visit his family in Scotland during July 1936 before returning by October.

On 29 June 1936, Martyn became aware "of the high-power pulse research being undertaken under the closest secrecy by Watson-Watt's group on the east coast of England. He had no trouble in guessing the underlying purpose of this enterprise." (Evans, 1973, p 137). Martyn wrote Madsen on 29 June 1936:

> It appears that the ultrashort and microwave work takes on a new importance. Fading, and serious fading, is found on both these ranges due to atmospheric influences, and this is almost certainly due to the low layers found by Watson-Watt. [not confirmed in later experiments, see NRAO ONLINE.5] This, therefore provides us with a new tool for exploring the lower regions, and generally opens up a new field in propagation studies. Watt discovered these layers while using their **secret** high power (several hundred kilowatt) pulse transmitter [and short pulses of 20 microseconds with the consequent increase in bandwidth to detect the shorter pulse without distortion], and published the information only when the Americans made a similar discovery. They are on **very secret war work** [our emphasis], though you will probably guess its object from what I have said. I of course have not been told, but Rutherford seems to think it quite likely that we in Australia might have to undertake similar work before long.

During this trip Martyn also visited Jack Piddington (1910-1997, from the University of Sydney) (Melrose and Minnett, 1998), who was at the Cavendish Laboratory of the University of Cambridge working on a PhD with Appleton, thanks to a Walter and Eliza Hall Fellowship.[5] For his Cavendish research, Piddington's ionosonde was designed to provide high resolution of echoes with small time separation; the ostensible scientific objective was investigation of the elusive regions below the D layer at the lowest levels of the ionosphere (5 to 60 km). Later on, he and Appleton actually carried out their own ionospheric experiment at Orfordness, with the cooperation of the Air Ministry. Ironically Appleton and Piddington failed to confirm Watson-Watt's observations of low level returns in the ionosphere—5 to 50 km, a fact that was of as much interest to Martyn as were the preparations for war.[6]

[5] The degree was completed in 1938 with a Cambridge PhD: "The Scattering of Wireless Waves".
[6] The details of this episode in the history of ionospheric research were a surprise to meticulous historian of ionospheric research Stewart Gilmor (correspondence with Goss in 2019). See NRAO ONLINE.5.

These ionospheric fascinations aside, Piddington guessed very early the defence purpose of the Watson-Watt group and wrote of it to Martyn from 22 July 1937: “There is another job looming, which is hard to write about. It concerns Watson-Watt’s present transmitter and our use of it as a blind for other users. This is strictly hush-hush, naturally.”

Despite all the concerns for secrecy that dominated at this time, the publication by Appleton and Piddington (1938, “The Reflection Coefficients of Ionospheric Regions”) may have provided a partial description of the defence project:

> [Using] the British Television Service … **a substantial number of ghost images noted [in the TV image] were found to be due to aeroplanes** [our emphasis], and we are not at all sure that any of the cases noted were due to reflexion from [ionised] scattering centres [i.e. the hypothetical low layers at 10s of km, NRAO ONLINE.5].

The development of radio direction finding in all nations was shrouded by an anxious secrecy that is understandable on the part of the military authorities. To be sure, there was no question that knowing what the enemy did—or didn’t—know, both about radio technology and about one’s own knowledge and capabilities, turned out to be critical to the advantages that different radar instruments briefly conferred in various key episodes during the war. However, given that both the concepts and the component parts were widely understood and used, much of the secrecy was not only fairly useless but, as we will see, was, more often than not, extremely costly.[7] This was the case for the war in the Pacific, the course of which was arguably influenced by the secrecy that held back Australia’s involvement in radio direction finding.

The Australians tried to get involved early, but two years were to elapse before these discussions began with Martyn’s visit to the UK in mid-1939, below.

Piddington returned to Australia at the end of 1938, re-joining Madsen‘s Department of Electrical Engineering, still supported by the Walter and Eliza Hall Fellowship. He continued to have a close association with the Radio Research Board, which formally suggested that he undertake at least some initial research into radio direction finding. His reports, presented to the 36th meeting of the RRB in September 1938, were explicit about his research in the UK (Evans, 1970, p.286-7):

> Dr Piddington gave a brief account of the work he had done abroad in the field of finding aeroplanes by radio methods. He stated that one of his reports [“Atmospheric Scattering of Ultra-Short Waves”] was descriptive of this work and of the results he had obtained. He was awaiting permission for its publication from the

[7] An excellent analysis is provided by Brown, 1999, p 444-455

> authorities concerned [as expected the publication was not approved]. He explained that it had been arranged that while in England he would explore the possibilities of only one portion of the spectrum … for aeroplane finding, and that the particular section he had been given was not necessarily the best to use for the purpose. To find an aeroplane at any considerable distance, it appeared that a very high power station would be required; the cost would be proportionately high.
>
> It was finally agreed that the object of the work proposed for Dr Piddington should be to carry out investigations with short waves and not to make a special point of aeroplane finding. At the same time, it was realised that, with the apparatus that would be obtained, it would be desirable to spend the short time involved in acquiring a knowledge of local conditions affecting aeroplane finding, e .g ., the power required, the best sites, and the best wavelength to use.

Piddington later claimed that the British did not agree to his continuing this research, commenting "that was the official end of the story, but no means its conclusion."[8] He later wrote (letter from Piddington to R. Home 20 June 1987, *Boffins of Botany Bay*, "The Radiophysics Laboratory at the University of Sydney" by Harry Minnett, p 420 and 425):

> Madsen was a determined organiser, not adverse to using other methods. He found the money and I built a powerful radar set, the first in Australia, in the basement of the Electrical Engineering Department of Sydney University ... For safety it was enclosed in a cyclone-wire cage and, as I found out later, tests caused severe interference in the Sydney area.

The experimental system was Australia's first Radio Directional Finding (RDF) system. In 1939, Piddington was working on this set during the period that Martyn spent in the UK [see below] to learn about advances in radio direction finding there. Although a functional system, the apparatus remained in an experimental stage.

1939: Science and war

"Australia's official cooperation, together with that of the other Dominions," David Martyn recorded, "was invited by Britain in February, 1939."[9] Schedvin (1987, p 240) wrote: "The Australian government was advised that the British Air Ministry was prepared to disclose to Dominion governments details of 'new developments in defence applicable particularly to air but also probably capable of development for other services."

[8] From Boffins, 1999, MacLeod, Minnett, "The Radiophysics Laboratory at the University of Sydney", p. 420
[9] Details of the Martyn 1939 visit to the UK are described in NRAO ONLINE.6.

The person who was the most obviously placed to lead radar research in Australia was David Martyn. He was clearly the leading scientific thinker, a major contributor to all aspects of ionospheric research, thus able to ignite interest and capacity for research in his colleagues. Martyn was duly appointed Australia's representative in the Committee of Imperial Defence, travelling to England on a flying boat and placing orders for about £100,000 worth of radio equipment, an expenditure that was approved by the then Prime Minister, Mr Lyons, within 24 hours of receiving the High Commissioner's cable.

Schedvin (1987, p. 240):

> Martyn spent [two] months in the United Kingdom [from 24 March to 25 May 1939, arriving back in Sydney by ship on 7 August 1939] … With other Dominion representatives he visited the chain air warning system along the east coast of England, and inspected new systems that were being developed, such as the compact air-to-surface vessel (ASV) equipment for installation in aircraft for sea reconnaissance, equipment for measuring the distance and the angles of azimuth and altitude of an aircraft from an anti-aircraft gun position (gunlaying), and a lighter and portable form of air warning (mobile air warning).

Martyn was excited by the possibilities but well aware of the challenges.

> Firstly, you may take my considered and emphatic view that this subject is a revolution in Defence matters, and in no application is anything approaching finality even in sight. Every model constructed is obsolete in a few months. It also bristles with scientific problems.

Martyn was told that for its radar program, Britain intended to invest in Appleton's continuous frequency change technique rather than in Watson-Watt's because it seemed more efficient. He at once pointed out the fallacy that he had found soon in this approach eight years earlier (Piddington and Oliphant, 1971) (Chapter 4).

While Martyn, Madsen and Piddington could easily envisage the tactical usage to which radio direction finding could be put, the same could not be said of the Australian Armed Services. Army leadership simply had too little technical knowledge of radio propagation to be able to imagine how it could be used. The importance of bringing the military up to speed on radio direction finding was voiced by Minister for Supply Richard Casey, in a letter to Rivett on 14 June 1939, while Martyn was on the ship returning to Australia from the UK:

> I am groping rather in the dark about all this until Martyn comes back and can lift the veil for us. I hope it is all as relevant to our Australian situation as he—and we—have assumed up to the present. We must not forget that we have to "sell" this matter to Defence as the first measure when Martyn arrives back. (Evans, 1970, p. 13).

Martyn commented in 1945 (in the *Blue Book* (see Additional Note, below: "Martyn, 1945, Article on "Radar" in the Australian Blue Book"):

> At the same time, I considered that it would be many months before equipment actually reached Australia so great were the demands in Britain, and I pressed for authority to commence research and manufacture in Australia. The British Chief of Air Staff was reluctant, on security grounds, to permit Australian manufacture, but I did get authority for research and development to commence.

In August 1939, when Martyn returned from England, and supported by Madsen, the Australian government approved the establishment of the discretely named Radiophysics Laboratory (RPL), a purpose-built extension of the National Standards Laboratory, then under construction at the University of Sydney. (The complex would eventually be named the J.P. Madsen Building). Placing the innocuously named Laboratory in the building site masked its defence research purposes. Martyn was appointed its Chief.

The research programme was to be the development of ASV (air to surface vessel), SA (ship to air), SS (ship to ship), value research, submarine detection, the determination of absolute altitudes in aircraft and the determination of upper air winds in a simple manner. In a supplementary memorandum dated 22 August 1939, it was pointed out that the new technique of radio direction finding was closely related to the work of the Sydney-based RRB research on ionospheric sounding and the propagation of radio waves. The memo of 22 August 1939:

> In fact we have actually in operation at the present moment high power equipment very similar to that which is being used in England in defence applications, and are ready to start preliminary observational work on aeroplanes immediately if suitable machines [presumably aircraft] can be provided.

Out of concerns regarding secrecy, private firms were excluded as manufacturers and suppliers of radar equipment, a task that fell to the Postmaster-General's Department in Melbourne, as an extension of their role in providing communications infrastructure. The same concern for secrecy amended Madsen's originally proposed name for the steering committee, the "National Security Research Board", to "Radiophysics Advisory Board".

Pawsey's recruitment to the Division of Radiophysics of CSIR, 1939

Martyn and Madsen had been tasked with the job of recruiting "top rank specialists in radio-physics and radio engineering, and [we] have suitable men in mind." (Evans, 1970) One of those was Pawsey. On 20 September 1939—after the declaration of war with Germany—

Madsen wrote[10] to David Rivett, from a location indentified as "*the Australian National Standards Laboratory, Radiophysics Investigations*", about appointing Pawsey to the staff of the newly formed Radiophysics Laboratory. Both he and Martyn had looked at the qualifications of Pawsey: "… [W]e consider that it is extremely desirable to get him on the staff of the Radiophysics Laboratory at the earliest possible date … Martyn got in touch with him while in London, and found that he would be willing to come to such a position here … at a [yearly] salary of £550."

On 22 September 1939, Martyn wrote Pawsey in the UK with a direct offer:

> The work will be carried out in Sydney in a new building which is being constructed in the University grounds. There will probably be a staff of 12-18 physicists and engineers; the work will be both purely scientific and applied, and will be on a permanent basis. The opportunities both for doing high class research and advancement seem very promising indeed. Some of the work will have a Defence aspect, and some will not, and I do not anticipate that the type of work on which you will be engaged could interfere at all with any scruples you may have … [I hope] that you will be able to get your family transported out here.[11]

Lightfoot, Secretary of CSIR, sent a letter to R.G. Casey, Minister in Charge of the CSIR in Melbourne, on 25 September proposing the appointment of Dr J. Sayers (St John's College Cambridge) and Dr J.L. Pawsey (79 The Drive, Ickenham, Middlesex). A cable from the Prime Minister's Department was sent on 26 September to the Australian High Commissioner (Stanley Bruce) requesting that he ascertain whether Pawsey would accept the RPL offer. Pawsey replied to Australia House in London on 29 September 1939 that he would accept. The authorities in Melbourne were informed on 5 October 1939. Stanley Bruce sent a telegram to Australia on 10 October 1939 with the message that Pawsey was planning to cease duty at EMI on 21 October and then spend three weeks in the US and Canada, arriving in Sydney in January, and starting work on 1 February.

On 11 October, Madsen wrote Rivett[12]:

> Martyn has just received a letter from Pawsey written after the outbreak of war but before hearing from us, which removes one difficulty.

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[10] NAA A8520 PH/PAW 1Part1

[11] Evans (1970) gives the date as 12 October 1939. The letter found in the Joe and Lenore Pawsey Collection is dated 22 September 1939.

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

> From what we had heard previously we thought that Pawsey might possibly hesitate about becoming involved too closely in defence work. His letter makes it quite clear the he is prepared now to take an active part in such work.
>
> Under these conditions we consider it most important that arrangements should be made for Pawsey to spend one month with Watson-Watt's team before sailing for Australia. In view also of information which Marsden [from New Zealand] has given us it is most important that Pawsey should bring out with him certain essential supplies which we will need. I shall send you a further letter tomorrow setting out details of these orders, but in the meantime it is very urgent that a cable be despatched instructing Pawsey to spend a month with Watson-Watt's Air Ministry research team studying the latest developments. It will be necessary to send by airmail the details of the orders which we will be placing, and it will be desirable to have the Australia House people in touch with Pawsey in regard to the details of placing of the orders. [A PS was added by Madsen stating the necessary arrangements with Watson-Watt would be made by Australia House and the Air Ministry.]

Pawsey resigned from EMI in Haynes on 31 October 1939, leaving over a month for some overlap with Watson-Watt and colleagues[13]. On 14 October, the CSIR Secretary Lightfoot informed the High Commissioner of Madsen's and Martyn's negative decision about Pawsey's suggested visit to the US and Canada. Pawsey was to receive a month's salary for this extra period in the UK, starting on 1 November after his resignation from EMI. Before leaving the UK, the CSIR pointed out to Pawsey that "[Y]ou will be required to deal with confidential matters of importance and it will be necessary for you to sign the attached undertaking to keep secret all matters that come to your knowledge in the pursuance of your duties." Pawsey signed such a document in the UK on 25 November 1939 and a similar document ("… I have had explained to me the essential secrecy of the work in which I am engaged as such officer aforesaid"), 5 February 1940 in Sydney.

It was essential that Pawsey spend time with Watson-Watt's group: "[I]n view urgency work and necessity spend one month England and probable difficulties bringing supplies through American regret cannot approve proposed visit US and Canada."[14]

Lenore was disappointed that they would not travel to Australia via Canada and her home (letter to Joe 19 October 1939):

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[13] On 19 October 1939, Lenore (at the Ward farm in Yorkshire): "Will your contact with Watson-Watt etc take you farther afield than London? It would be nice if you had a few objectives up here in the North and could get over for weekends."

[14] NAA A8520 PH/PAW 1 Part 1. This message was repeated in a personal letter to Pawsey at his home in Hillingdon, Middlesex.

> I was terribly disappointed as you may imagine as we had always talked of someday going to Australia via Canada. I feel more reconciled however now. It will be a more trying trip in one way—more worrying for a longer time about safety—but I guess one has to take one's chance anywhere these days. The planes seem to be concentrating on the north ports—Hull, Forth etc even Bridlington has had air raid warnings but I don't feel worried about us here. I only hope they [Luftwaffe] won't go to London. [The Battle of Britain occurred 10 July to 31 October 1940, followed by the Blitz of 7 September 1940 to 11 May 1941.]

Eric and Francis Ward provided assistance as the Pawseys sold their family possessions (including their car and the radiogram, a radio and record player) and began packing for their 22 December 1939 departure for Australia by ship. "You'll be so glad when the house and contents are completely and finally off your hands."[15]

The first meeting of the Radiophysics Advisory Board (RAB) was held in Melbourne on 29 November 1939 with Madsen as chair and with Martyn (RPL Chief) in attendance. Rivett, CEO of the CSIR, was also present. The service chiefs (Air Force, Army and Navy) were represented as well as the PMG (Postmaster General Department). The duties of the newly appointed Research Officer, J.L. Pawsey were described in the minutes:

> The Chairman referred to the policy of continuous liaison with technical development of the work in Great Britain which had been approved [earlier]. He stated that Dr Pawsey had been carrying out such liaison activities since that officer's appointment early in November, but that [Pawsey] would shortly leave England for Australia. It, therefore, seemed desirable to consider steps that should be taken to continue the liaison.
>
> In that connection, it was hardly desirable to leave Dr Pawsey in England, as his special knowledge was urgently required in connection with the research work in Australia. The Chairman also stated that he and Dr Martyn considered that Mr Munro was the most suitable officer to continue the liaison and that he should be sent to England shortly after Dr Pawsey's return. [In late December 1939, both Madsen and Munro left for London; Munro was to remain and Madsen was to return to Australia in early March.]

Pawsey plus the other three members of his family were to depart on *RMS Strathmore* (P. and O. line, Peninsular and Orient Steam and Navigational Company) on 22 December 1939. The family saved the PO Menu for Christmas, Monday, 25 December 1939. The fish served

[15] Joe and Lenore Pawsey Collection.

was “turbo lobster sauce” while the main course was ribs of beef and roast turkey. Stuart Pawsey remembers hearing family stories of how the ship practiced a zig-zag pattern in the Indian Ocean during the one-month trip from late December 1939 to late January 1940 en-route to Australia from the UK via the Suez Canal.

Martyn replied by telegram to the ship in Fremantle (Perth) and a letter to the ship in Adelaide on 19 January 1940. Pawsey’s request was turned down; he could not have a long stay in Melbourne due to the urgency of starting the new radar research in Sydney at RPL:

> I am afraid there is a going to be serious difficulty about letting you have a long stay with your parents. The trouble is that we are very anxious to get all information from you at the earliest possible moment, and while in normal times I would be very glad to see you have a week or two with them, I am afraid that such a course could not be justified under war conditions. I am afraid also that there is likely to be serious difficulty about your getting back to Melbourne for a week or two later as you will not be entitled to official leave till you have been a year or two on the Council’s staff. What I suggest you do therefore if you feel so inclined and do not mind the extra expense which you may incur is to leave the ship at Melbourne, stay a day or two there and arrive down at Sydney approximately at the same time as the ship does. I think we might turn a blind eye if you happen to be day or so late. I regret very much that circumstances prevent you having a longer stay with your people who must be looking forward greatly to seeing you there. I shall send a copy of this letter to your father … I am looking forward very much indeed to seeing you again soon.

We do not know which option Pawsey chose.

On 25 February 1940, Pawsey wrote one last letter to C.W. Hansell of RCA Communications in Rocky Point, New York. The 15 December 1939 letter from Hansell (Chapter 7) took a long time to reach Pawsey since it had been forwarded to Sydney during wartime. Pawsey’s reply gives us insight into the experiences of the Pawsey family:

> You will see from the address that I have succeeded in getting back to my home country. About the end of last year, I received a telegram offering me a job at this lab [RPL] and I accepted promptly despite a certain amount of argument with Mr. Condliffe [of EMI] who did not wish me to go. I sailed for Sydney on 26 Dec [sic- was in fact 22 December 1939] with my wife and my two babies, the family having increased by one boy baby since first I wrote you , and after an uneventful but trying voyage we arrived here safely about a month ago.
>
> The Radio Physics Lab is a Commonwealth Government research venture located in the grounds of the university and is an extension of the previously existing Australian

Radio Research Board. The head of the lab is D.F. Martyn well known in connection with ionospheric research. Things look fairly promising here and I expect to stay for some years at any rate.

I am very glad indeed to have got my family away from the danger zone. Up to the time at which I left, there had been no actual shortage of anything except petrol (gas) which was drastically rationed, and light out of doors at night. The blackout at night was our primary curse. It was pretty drastic in places like London where the nights are naturally very dark and the traffic remained thick. Near the beginning I was in central London and in a street full of buses and other traffic a pedestrian striking a match to light a pipe lit up the whole street. Our secondary curse was that we had to carry our gas masks where ever we went.

It is too difficult [to] summarise what people think of the war so I shall not try. One interesting commentary is that while opinions differ as to the expected severity of the war I never met anyone who considered the defeat of the Allies to be possibility worthy of consideration. I was interested to hear your comments as to the sympathy felt by people in the States for Democracies. At the beginning of the war I took my family up to a farm in Yorkshire belonging to my cousin [Frances Lade Ward, see above] and they remained there till we sailed. This evacuation, both public and private, has caused quite a major dislocation of life in England.

Television is finished in England for the duration. A station offers too good a landmark for enemy planes. Sound broadcasting stations evade the difficulty by having a number of stations broadcasting common programs on a common wavelength. That must give a would-be direction finder a headache. A similar procedure would not be effective in the television case. After the war you will be in an outstanding position in the States in the television field.

In conclusion I should like to thank you very much indeed for the help you gave me in looking for a job. If ever you should be coming to this part of the world I should be delighted to see you, and you would be very welcome to stay with us any time you liked. And Sydney appears the most beautiful city of my acquaintance.

Staffing the new Radiophysics Laboratory in 1939

Finding sufficient trained staff to undertake a rapid and critically important radar research program was the first key issue for Martyn and Madsen. A memorandum dated 22 August 1939 included six additional items: (1) plans for the procedures to be following when war broke out, (2) or in the unlikely case that a peace agreement with Germany were to be concluded, (3) recruitment of research personnel (many physicists and radio engineers were already being discussed), (4) authority to purchase materials etc., (5) appointment of a research chemist and (6) future recruitment from the universities in Sydney and Melbourne.

The personnel of the Radio Research Board would be the obvious core of the new research staff. Writing of the daunting task that faced the Australians, Schedvin comments (1987, p 245): “Martyn was fortunate in one respect. The training undertaken by the Radio Research Board made possible the assembly of a highly qualified small team.” We emphasise this far reaching impact of investments in the basic science work of radio and ionospheric research made during the economically-restricted 1930s.

On 11 December 1940, Martyn sent Madsen a short report describing the activities of the lab in 1940. The staff consisted of 65 individuals, including 27 research staff (all levels), 18 workshop personnel, 5 clerical staff and 4 “Commonwealth Peace Officers” (security staff). Madsen noted that progress on the gun laying radar device was minimal, as only height finding (with no range determination) was possible with the prototype. As pointed out below, several factors influenced this slower-than-desired pace; the comment underscores the importance of the recruitment of trained personnel. The limited number of trained staff was to be even more significant in making radar an operational enterprise in the next year.

One interesting feature of RPL in comparison to Britain was the lack of a hierarchical culture within RPL, in which physicists and engineers worked collaboratively, side by side. In Britain, physicists dominated; Watson-Watt did not want electrical engineers involved too early because he considered them more likely to be conventional. Given that the American and German radar devices were largely engineer-led, the evidence of history does not seem to support this concern. Indeed, later the British radio astronomer Hanbury Brown remembered being impressed by the better techniques of the EMI engineers (Pawsey’s former colleagues) whom he encountered in radar work In the UK in 1939 (Brown, 1999, p 461).

Among the new recruits were two spectacularly talented women physicists, Joan Freeman (1918-1998) from Sydney University and Ruby Payne-Scott (1912-1981). While wartime created both the requirement for women’s work in non-traditional areas and the psychological acceptance of their presence for both Freeman and Payne-Scott, it was unequivocally Pawsey’s leadership that created a non-sexist workplace.

Freeman wrote endearingly about Pawsey’s reaction when she won a paid Studentship to pursue her dream of undertaking a PhD in nuclear physics at the Cavendish after the war—a place she had dreamed of ever since reading an account of splitting the atom in the 1930s.

> His face shone with pleasure. “Where will you go?” he asked enthusiastically. “To Cambridge, if I can,” I replied promptly. His enthusiasm was redoubled. “Splendid!

> You must go to my old College, Sidney Sussex," he exclaimed. Then reflecting for a moment, his face fell. "Oh, I suppose you'll have to go to a women's college," he said in a disappointed voice. Dear Joe, he still tends to think of me as "one of the boys", I reflected (Freeman, 1991, p 97).

Freeman went to the Cavendish Laboratory at Cambridge University in 1946 (at the same time as Ron Bracewell).[16] She went on to complete her PhD in 1948. She was to have an extraordinary career in nuclear physics that would make her the only woman to win the Rutherford Medal, until Christine Winterbourne in 2012.

Thus, many of the people who would contribute to radio astronomy after the war, were assembled and working together by mid-1941.

Additional Note: Martyn, 1945. Article on "Radar" in the Australian Blue Book[17]

> QUOTE: Australia's official cooperation, together with that of the other Dominions, was invited by Britain in February, 1939. Mr Casey, on the advice of Sir David Rivett, asked me to fly to England and bring back full details of developments. In England I obtained the best military advice and placed orders for about £100,000 worth of radio equipment. It is interesting to note that this expenditure was approved by Mr Lyons within 24 hours of receiving the High Commissioner's cable. At the same time, I considered that it would be many months before equipment actually reached Australia so great were the demands in Britain, and I pressed for authority to commence research and manufacture in Australia. The British Chief of Air Staff was reluctant, on security grounds, to permit Australian manufacture, but I did get authority for research and development to commence. On returning to Australia I recommended the setting up of the Radiophysics Laboratory, and the whole scheme was submitted to the Inner Cabinet by Sir David Rivett, Sir John Madsen and myself, and was adopted on the spot—early in September 1939. Sir John Madsen visited England in 1940 to set up a Scientific Liaison Office through which to secure full authority for Australian manufacture to proceed.

[16] Freeman began her study the year *prior* to the University's admission of women into full membership, for which the women's colleges had been fighting for decades.
[17] The Australian Blue Book was an almanac and national reference book that was published in Australia between 1942 and 1950. The 1942 (first) edition was edited by A. Moorehead, and the 1946-48 (second) edition by W. J. Beckett. Another part of the book was a supplement published in 1950. The book was published in Sydney and contained comprehensive photographs of people in administrative positions, as well as material from Australians involved in the second World War. It had extensive listings of all the local government areas in Australia at the time, with names of officials and descriptions of the areas. See https://trove.nla.gov.au/work/21601418