

## **NRAO ONLINE 46**

### **GRT 1960: The Beginning of the End- Pawsey-Radiophysics Schism**

The year 1960 was pivotal for developments at RPL; the GRT construction was underway in Europe and at Parkes in Australia. Christiansen and Mills left for new positions at the University of Sydney in mid-year and Bowen and White also began the process that led to John Bolton's return to CSIRO in early 1961.

The conflicts that arose in 1960 were complex, involving a number of scientists in Australia and the US. CSIRO made a decision to start the Paul Wild Radioheliograph project after the GRT was to be completed in 1961-1962. The Super-Cross project of Mills was put on hold as he left CSIRO for the University of Sydney (School of Physics). Christiansen had moved earlier to the University of Sydney (Electrical Engineering). This new diversity led to an end to the CSIRO monopoly in radio astronomy in Australia, initiating a reinvigoration as a generation of young scientists were nurtured at the University of Sydney and the Australian National University in Canberra. Australian radio astronomy flourished as different directions for Australian radio astronomy accelerated during the remainder of the 20th century. (See Chapters 19, 30, 32 and 41)

Pawsey's doubts about his own future at CSIRO increased during the year, finally leading to his decision to depart for the US in 1961. A major factor for Pawsey was the CSIRO decision to not fund the Super-Cross and the subsequent loss of Mills. Although the public perception of Pawsey's departure was presented in a positive manner, behind the scenes Pawsey felt betrayed by the CSIRO administration. The first phase of the successful era of post-war radio astronomy in Australia was coming to an end.

### **Conflict over the proposed Mills Super-Cross ,1960, Christiansen and Mills leave RPL for the University of Sydney**

After the decision of August 1959 to de-emphasize the Super-Cross, Bernie Mills began to look elsewhere for employment/funding. In early September 1959, Mills wrote his colleague Merle Tuve at the Carnegie Institution of Washington. He summarised the current status at RP.<sup>1</sup> Then on 24 September 1959, Tuve responded with his "Dear Bernie" letter:

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<sup>1</sup> Mills archive University of Sydney. P154-Series 8 File 2. Tuve's response of 24 September 1959, Mills to Tuve 13 October 1959, Mills to Oliphant 25 January 1960. The original Mills letter from early September 1959 has not been located. Also additional correspondence from Heeschen and Wade at NRAO, Green Bank, Mills archive University of Sydney.

I have been somewhat unhappy to read your letter [of early September 1959] with the indication that you feel the overwhelming emphasis in the RPL division for the next few years will be on the 210-foot dish, to the neglect of important possibilities with large antenna arrays ... I think your work with large antenna arrays has been and is an outstanding example of accomplishments with modest investments. The interferometer technique with crossed aeriels is not entirely beyond pitfalls ... and it should not be carried out without corroboration by various other procedures ... <sup>2</sup>

A number of developments then quickly occurred. On 18 September 1959, David Heeschen, the Head of the Astronomy Department of the newly founded National Radio Astronomy Observatory at Green Bank, West Virginia, USA, offered Mills a one year visiting appointment (on a leave of absence from CSIRO) to design a Super--Cross at Green Bank. Campbell Wade had just returned from a postdoctoral position at RPL (from 1957 to 1959). He knew Mills well, possibly suggesting that Heeschen contact Mills<sup>3</sup>. A few weeks later, a related proposal (7 October 1959) was made by Bowen (with the concurrence of Pawsey) to Lloyd Berkner (President of AUI, NRAO's parent organisation) that a joint AUI, RPL project might "co-operate to build [Mills] crosses in both the North and South".<sup>4</sup>

In his letter of 13 October 1959, Mills wrote Tuve, discussing the rationale leading to the Super-Cross proposal:

[The Super-Cross] did not originate purely from a chance to build a bigger and better instrument, but because the astronomical observations which, in my opinion, are crying out to be made, require such an instrument. I know of no other way of making them with comparatively limited funds. The scientific reasons for establishing a "Super-Cross" in Australia to work in conjunction with the 210-foot dish are so compelling that it makes me rather sad to see the large sums which are to be lavished on Northern Hemisphere instruments (at Leiden, Bologna and now perhaps at Green Bank).

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<sup>2</sup> Tuve was well known to be very anti-big science so he applauded Mills's accomplishment with small innovative investments but he is still apprehensive about some aspects, such as the enhanced sidelobes, of the cross.

<sup>3</sup> Mills archive University of Sydney P 154-Series 8 File 2. Heeschen thought that Mills might stay longer than one year. A handwritten postscript read: "[I hope] ... we can ultimately induce you to stay for considerably longer than a year". Mills considered the offer and turned it down in the course of early 1960 when the negotiations with the University of Sydney began. Wade wrote to Mills: "On the whole, I am very favorably impressed with Green Bank, and I'm glad to be here. Will you join in, sir?" In a turn of events, Mills offered Wade a position at the University of Sydney a year and a half later, 1961; see Chapter 38 and 40.

<sup>4</sup> *Ibid.* Letter from Mills to Tuve 13 October. Robertson (1992) has described these events, including an instructive interview with Mills in 1984. The Bowen initiative did not lead to further action.

On 25 January 1960, Mills wrote a frank letter to Oliphant (Director of School of Physical Sciences, ANU) about his vision of the Super-Cross/GRT conflict.<sup>5</sup> Mills was aware that Pawsey and Oliphant had been in contact; (see below for the correspondence between them in late February 1960). Mills expressed his frustration:

Now that RPL is getting the 210 foot dish it has become quite clear that this will absorb the major part of an unincreasable vote for [cosmic] radio astronomy and most of the remainder has been allocated for solar work. The result is that the possibility has been removed of significant increases in galactic and extragalactic problems at the lower frequencies, where the size of the dish is inadequate. This will in, my estimate, lead to a serious unbalance in the research programme and undermine the good position which Australian Radioastronomy has built up over the years. For this reason, I was particularly interested in the Melbourne Chair<sup>6</sup> as a possible means of filling the gap and further, in giving some stimulus to the subject which would help to overcome the **atmosphere of complacency and scientific stagnation [our emphasis]** which some of us detect here [RPL] in increasing amounts...

There is little evidence of this “complacency and scientific stagnation”; the arguments for building a Super-Cross need to be examined. We are now in the interesting position that lets us look at these events in relation to what actually happened in the future. Both the GRT and what was effectively the Super-Cross (the Molongolo Radio Observatory MRO) were built and both made significant impact in astronomy but not in the ways that were being discussed. The low frequency surveys made little impact but surveys with the MRO to find new pulsars, which were still to be discovered at the time of these discussions, had a major impact. At Parkes the unexpected discovery of a quasar through a lunar occultation in 1962 (Chapter 32 and NRAO ONLINE 47) not only opened a new field of research but showed that the radio emission immediately surrounding the black hole was stronger at higher frequencies and not weaker as had been assumed. We can now see that the arguments for the Super-Cross that were being made by both Mills and Pawsey, and which seemed justified at the time, were largely irrelevant and were being driven more by the personalities and relationships than by the science. Likewise the GRT was driven more by Bowen’s ambition than by the science case.

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<sup>5</sup> University of Sydney Archive, P154-Series 8.

<sup>6</sup> University of Sydney Archive, letter from Oliphant to Mills, P154-Series 8, 9 October 1959. “I do believe that as head of the physics department in Melbourne you could develop your own work and play a very important part in the future of academic physics in this country. You can be sure I would press very strongly for adequate facilities for your research ...” Oliphant also thought that it would be possible to hire a number of additional colleagues at Melbourne

Mills applied for a number of other positions in Australia, but his demands were too high and none of these possible appointments worked out.

In January 1960, Ron Bracewell turned down the offer of the Chair of Electrical Engineering at Sydney University; Mills never followed up on the offer from Stanford<sup>7</sup>. Bracewell was to remain at Stanford in the US until his death in 2007.

There remained another possibility. Mills told Oliphant that: "Pawsey has ... suggested the possibility of ANU entering the field and tells me [Mills] that you have shown some interest in the idea." Mills also mentioned a "long-shot" proposal that had been discussed at RP: "Another possibility which has been canvassed here, and which both Christiansen and I support, is the removal of the whole of Radioastronomy group from CSIRO to ANU." Mills thought "this may be too large a step for practical politics. Pawsey [also] thinks so and therefore has done nothing about it, but I know he would be in favour if the suggestion came from outside."

Given the politically charged nature of Mills's letter, Oliphant did not directly respond, suggesting that his earlier enthusiasm had cooled.<sup>8</sup> Rather, the matter was handled by Bart Bok, the director of Mount Stromlo Observatory. Bok wrote Mills a personal letter<sup>9</sup> on 14 March 1960 stating:

It is obviously not possible for Oliphant to make a positive move unless a clear-cut proposal that seems feasible is before him. In order to have some chance of succeeding, such a proposal should have general support – or at least acquiescence – from Fred White [Chairman of the CSIRO] and Leonard Huxley [a member of the CSIRO Executive and soon to be Vice-Chancellor of ANU], and at the moment we just do not see how this may be done. My one bit of advice to you personally is to discuss the whole matter very freely with Leonard Huxley, who, I can assure you, is as much concerned about the situation as Radiophysics as anyone. He has great respect for you as a scientist and he

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<sup>7</sup> University of Sydney Archive, letter from Bracewell to Mills, P154-Series 8. 16 January 1960. Also Bracewell to Pawsey, C3830, Z3/1/ Part 10. 16 January 1960. Bracewell told Mills (16 January 1960) that "it seems very likely that the Chair [of Electrical Engineering] will now be offered to you, but under difficult conditions for radio astronomy." Ironically, in this letter and a letter from 16 February 1960, Bracewell offered Mills a position at Stanford in his new Institute of Radio Astronomy, with some expectation that the US Air Force funds might support the construction of a Super-Cross. "I do not know what to think about your working for Messel. However, I am sure that in the US you could not do better than here, taking into account ... supporting facilities of all kinds, and proximity to the California astronomers."

<sup>8</sup> Harry Wendt has provided these two paragraphs about Mills, based on the University of Sydney archives Mills's collection

<sup>9</sup> Letter from Bok to Mills dated 14 March 1960, University of Sydney Archive – P154 – Series 8.

will do anything he can to support a solution within the framework of the CSIRO, or outside it, which will ensure your staying in Australia.<sup>10</sup>

Christiansen had always been critical of Bowen's push to build a large dish, "the last of the windjammers" being one of his favourite derogatory quotes.<sup>11</sup> Christiansen was more driven by innovative technology and felt that new ideas were being suppressed in the push to build the biggest dish; Christiansen had also written Bok outlining his dissatisfaction with the direction Bowen was taking Radiophysics. Unfortunately for Christiansen, a copy of this letter found its way to Bowen via Oliphant<sup>12</sup>. Bowen, understandably, would have been incensed at the suggestion that responsibility for radio astronomy should be removed from the CSIRO and transferred to the ANU. Christiansen was summoned to Bowen's office where a fiery exchange took place and Christiansen tendered his resignation. Fortunately, Christiansen had an offer for the position of Chair of Electrical Engineering at Sydney University, the position that had been declined by Ron Bracewell. Christiansen moved in the period March-April 1960 to Electrical Engineering at the University of Sydney.

At about the same time, Mills secured a position at the University of Sydney's School of Physics. On 25 May 1960, Mills met with Harry Messel to finalise the terms for his offer of appointment as a Reader in the School of Physics at Sydney University and a funding grant of £A100,000 and £10,000 - £15,000 in annual running costs excluding staff, to establish a new radio astronomy section<sup>13</sup>. On 6 June 1960, Mills's appointment was officially approved by University Senate<sup>14</sup>, thus ending a 27-year career at the CSIRO Division of Radiophysics which had begun in 1942.

The resignations from CSIRO by Christiansen and Mills had major consequences for the evolution of radio astronomy in Australia, both events disturbing for Pawsey, who earlier in the

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<sup>10</sup> Earlier letter from Bok to Mills dated 20 February 1960. *Ibid.* This handwritten letter from Bok contained a similar message. Bok had received a letter from Mills that had been passed on to Oliphant. Bok suggested that Oliphant might go to the Prime Minister with a proposal if Christiansen and Mills were to prepare a proposal "which is not from the start objected to by Fred White and Co. [i.e. Bowen]. Huxley and Bok hoped that Christiansen and Mills could be persuaded to stay in Australia, "even if this can only be achieved outside the CSIRO.... Let me assure you I am back of you and Chris without reservation and without any thing up my sleeve." This Bok letter mentions that he had shown Oliphant correspondence from both Mills and Christiansen.

<sup>11</sup> Haynes, R., Haynes, R. D., Malin, D., & McGee, R. (1996). *Explorers of the southern sky: a history of Australian astronomy*. Cambridge University Press, p.233

<sup>12</sup> Based on an interview that Rosalynn and Raymond Haynes had with Christiansen in 1992 (Haynes et al 1996, p.233). Christiansen had sent a letter to Bok in 1960 with critical comments about Bowen in which he complained about Bowen's interference with the radio astronomy group and was less than complimentary about Bowen's scientific achievements.

<sup>13</sup> Letter from Messel to Mills dated 25<sup>th</sup> May 1961, University of Sydney Archive – P154 – Series 8.

<sup>14</sup> Letter from Registrar to Mills dated 7<sup>th</sup> June 1960, University of Sydney Archive – P154 – Series 8.

year had written a glowing letter of recommendation for Christiansen.<sup>15</sup> Christiansen had a long-standing invitation from Jan Oort of the University of Leiden to visit the Netherlands to work on the newly planned Benelux Cross and he took this up after he moved to Sydney University. Christiansen left in July 1960 for a 15 month visit to Leiden continuing the tradition of international collaboration championed by Pawsey.<sup>16</sup>

During the period May-July 1960, the impact of the two resignations was discussed by Bok, Pawsey, Bowen, White and Bolton. On 23 May 1960, Bart Bok wrote Pawsey<sup>17</sup>: “Would you tell Ben [Gascoigne, on a visit to Sydney on behalf of ANU] about the latest developments with respect to Bernard Mills and yourself, for we continue to be very concerned about it all.” Then on 6 June 1960, Pawsey wrote to Bok now with a sense of resignation: “ ... [T]he current situation re Bernard is that he is proposing to accept a Messel job which he rather expects to have offered to him today (or following a meeting today). He is keen ... to get off on his own. So that is that.”

Bowen reacted to these events with a tone of relief, writing to White on 22 June 1960<sup>18</sup>:

The news from the Lab [RP] is encouraging. The recent excitement in the radio astronomy group has died down. Christiansen has settled in at [Electrical Engineering at Sydney University] and leaves in a month's time for seventeen months at Leiden. I am not sure how this ties up with the need for more teaching at the university to produce better graduates and more of them. Bernie has dickered successfully with the Universities of New South Wales and Adelaide and, leaving a trail of hard feelings behind him, has now fallen to the blandishments of Harry Messel. Although he has not finally made up his mind, it looks as if he will take a Readership at the School of Physics, plus £A1000 for himself and £A 100,000 to build a Cross. I wish him luck.

Some months later in 1960 (31 July 1960)<sup>19</sup>, Pawsey expressed his ongoing resignation to these events as his two colleagues left RP. In a letter to Fred White, who was then visiting the UK, he wrote:

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<sup>15</sup> NAA, C3830, Z3/1/X. On 4 March 1960 to the Sydney University registrar: “I consider him an exceedingly good candidate, better than any of the previous applicants with the possible exception of B.Y. Mills, who may be a slightly more brilliant researcher but might not prove to be such a good teacher. Christiansen is a brilliant research physicist ...”

<sup>16</sup> Christiansen and his family were to return in 1961, presumably just before the Parkes telescope opening on 31 October 1961. In Leiden, Christiansen had been the leader of the international design team for the Benelux Cross Project.

<sup>17</sup> NAA C3830, Z3/1/ Part 10.

<sup>18</sup> NAA, C3830, Z1/7/B Part 1. Bowen to White in London.

<sup>19</sup> Pawsey

I presume that you have heard that Bernard Mills has now left us and is a member of Messel's staff and is planning to build a big Cross. His departure became inevitable about a year ago when the conflict in ideas between him and Taffey [sic] became apparent. But I had hoped rather that he might have gone to ANU. With Chris and Bernard gone and also Alex Shain [deceased 11 February 1960] the old team is not what it used to be. However I hope that we can continue to work together.

### **February 1960- ANU as Possible Partner for the Super-Cross**

We now return to earlier in 1960, February. As expected by early February 1960, Bowen was less optimistic about the future of the Super-Cross. On 10 February 1960, Bowen wrote White<sup>20</sup>. He was in damage control mode: "I am afraid there are quite a few mis-statements and misconceptions going around, some of them in the Laboratory and it is just as well to get them straight."

Bowen claimed that he was "a strong supporter" of the Super-Cross. This new major instrument would not fit into the current budget of the RPL. "We have most definitely not made a decision against it. This, unfortunately, does not satisfy Mills, who is burning to go ahead and is exploring alternative ways of doing so." Bowen provided both negative and positive comments about his colleagues:

[My] comment is that **we have the world's best radio astronomers, but they are the world's worst estimators. [our emphasis]** All told, the Chris Cross cost between £A 50,000 and £A 100,000, not the figure [sic] quoted [£A 20,000, attributed to Pawsey. Bowen also claimed the astronomers at RPL habitually underestimated the manpower requirements]. There is a tendency [at RP] to think of a Mills Cross as something which is built in the background by two men and a few boys. The simple facts are that we have at the RPL perhaps the most cohesive group of radio astronomers in existence, with a budget which is larger than most. It was a major constructional effort on the part of this group to build the first Mills Cross and the Chris Cross over a period of four or five years ... The Super-Cross is a much larger project than any of these. If it were built at RPL, we would need to augment our present resources.

Bowen's comments here are quite perceptive; he has captured the essence of practical management issues which arise when scientists engaged in basic research are too protected from practical reality. He went on to make a final point that was highly relevant: "There has not been a decision in this Laboratory to go ahead with the GRT in preference to a Super-Cross. The GRT was a going concern long before the Super-Cross came into the picture." The question for

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<sup>20</sup> NAA, C3830, Z1/7/B/2, Part 1.

the group was the choice of a new large radio astronomy project, Wild's new imaging solar instrument or a Super-Cross. Only one could be built and the radio astronomy group chose the solar instrument, not the Super-Cross.

Pawsey wrote Oliphant in late-February 1960<sup>21</sup>:

On my last visit to Canberra we discussed the question of an Australian institution other than CSIRO entering the field of radio astronomy in order to carry on work which CSIRO was not able now to follow up. In particular, CSIRO cannot now proceed with Mills's metre wavelength cosmic investigations, which have probably been the most significant part of the RPL's program and Mills is looking for an Australian University appointment which would permit him to proceed with these studies while the time is still ripe. At the time of my visit I promised to inform you of the estimated cost of such a program, but I postponed writing pending discussions with Huxley ... It would only have been possible to avoid cancellation of worthwhile projects if CSIRO had been willing to expand considerably the CSIRO expenditure on radio astronomy. Fred White has stated that he cannot justify this and I do not wish to question his judgement on this matter ... I myself would consider very favourably the possibility of the RPL supporting a joint project with another Australian institution, on the understanding that our contribution should begin only when the job of setting up the Parkes telescope is over, say in two years' time. Mills's proposal is to build a "Mills Cross", working at a wavelength of about a metre, which shall have considerably higher sensitivity [several times that of Parkes] and resolution [about 4 arc min, compared to 8 arc min for the Parkes dish at 10 cm] than any other instrument we have or expect to have ... What is called for is a design study which might take one or two years ... I should add that on the basis of Mills's and Christiansen's work in this field I am confident that it is technically feasible to go to at least 3 minutes of arc. The purpose of the instrument would be to provide the most detailed radio picture of the sky ... For the galaxy this would provide a wealth of detail covering the regions of both the galactic centre and the [galactic] poles. For external galaxies, we have a monopoly on the Clouds of Magellan, and the instrument should be

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<sup>21</sup> An incomplete undated draft letter from Pawsey to Oliphant was found in the Pawsey family archive in 2010. Pawsey has written on the draft: "incomplete". Later in 2015, Hastings Pawsey found a ten page undated handwritten document in Pawsey's handwriting: "Desirable Lines for Research in Radio Astronomy in Australia". Likely the latter document was an attachment to the earlier letter to Oliphant. (We are indebted to Harry Wendt for this suggestion.) In 2010, Mills wrote Goss (24 March 2010) with his response after reading the undated Pawsey letter to Oliphant: "Wow! This letter certainly stirred up some memories and explained why [Oliphant] had suggested me for the vacant Chair of Physics at Melbourne. However, I could not persuade them to support such a large project. The letter [Pawsey to Oliphant] would have been written in [late] 1959 ... or early 1960." Since the letter was written after Shain's death (11 February 1960), the likely date is late February 1960.



able to “see” further [*sic*] into space than any other, optical or radio, with the exception of possible similar instruments. The picture would be a single frequency picture and its value would be greatly enhanced by comparison with observations at other frequencies. In this respect the instrument would beautifully complement the 210 ft dish, which has high resolution only at much higher frequencies<sup>22</sup> ... My summary of the position is this: Mills’s past work has been outstanding; **his contribution has probably been the greatest single factor in giving Australia the high prestige it now enjoys** [our emphasis]... [T]he simultaneous development of the metre wavelength studies proposed by Mills and the decimetre wavelength studies which will be undertaken at Parkes would provide Australian radio astronomy with complementary facilities in radio astronomy which no other country possesses.

It seems that in early 1960 Pawsey considered Mills **as his successor, the future leader of Australian radio astronomy**. [our emphasis]

In conclusion, Pawsey wrote Oliphant that unfortunately there was discouraging news: “Since [my last visit to Canberra], Bowen has spoken with you [Oliphant] and I subsequently gathered from him that ANU would not be a likely starter in this matter [of taking over a new Super-Cross project]. However I think I should give my assessment of the situation on the chance that something useful might turn up.” At this stage in discussing the reality of a new Super-Cross, Pawsey would have recognised that building a new instrument with Australian funds was unlikely. He appeared to be “grasping at straws”. But within a few years, Messel had found the path to new funding with National Science Foundation (US) funds.

In Additional Note 1, we summarise the accompanying document “Desirable Lines for Research in Radio Astronomy in Australia” (Pawsey, late February 1960).

Also at the end of February 1960, Bowen and Oliphant had an exchange of letters. Bowen summarised the history of the Super-Cross in the context of the RPL programme of radio astronomy (24 February 1960): “I am afraid one or two aspects of our radio astronomy programme are being discussed in somewhat exaggerated terms and it is just as well to get them straight.” Bowen pointed out that the policy in the past had been to execute one major project at a time.

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<sup>22</sup> Pawsey described a competing project, the more ambitious Benelux [actually a joint project of the Netherlands and Belgium] Cross, a one arc min instrument at 400 MHz. Also he discussed the impact of funding for the Super-Cross: “These costs are very large by any standards, particularly so when we consider the other large investments in radio astronomy [in Australia]. I find it difficult to assess whether it is proper for Australia to invest so much in a single branch of science. I think my part should be to attempt to set out the facts as I see them and leave the decisions to those responsible for the administration of science in Australia.”

The choice lay between a new solar spectrometer [sic] which Paul Wild is thinking about and a Mills Super-Cross. The decision of the Radio Astronomy group was to go for the Wild spectrometer. This unfortunately did not satisfy Mills, who is a dedicated man and wants to see a Super-Cross built at all costs – hence the present excitement. My own view is that the sensible course for us is to push as hard as we can to get the 210-ft telescope going as a research instrument, see how the results pan out in the next two to three years and then consider the possibility of going for a Super-Cross as an adjunct to the present instrument. The decision as we have made, therefore, is not against the SC but to defer it until we have adequate manpower and resources to bring to bear on it<sup>23</sup> .... [Bowen also pointed out that the Super-Cross would be a narrow band instrument restricted to] just a few MHz compared as against [a tuning range of] 2000 or 3000 MHz for the GRT... Just one final thought. When a Super-Cross is built ... a strong case can be made for building it right alongside the GRT at Parkes; used in conjunction with each other... This is what we always had in mind and was one of the reasons for the choice of Parkes in the first place. We have five to ten miles of flat terrain available in the east-west and north-south directions for just this kind of development.<sup>24</sup>

In the archive copy of this letter, three detailed comments are hand written in the margins by Pawsey. In addition, an adjacent entry in the archive is a three-page handwritten letter [with no date, likely late February to early March 1960] to Bowen from Pawsey that began:

[Pawsey to Bowen] There is a serious error in your letter to Mark Oliphant of February 24 [1960] with regard to the major features of a proposed Cross. [Bowen had asserted that the “sensitivity of a Cross is down by a factor of 10 or more on the GRT”...] The essential feature of the design of a Cross is that the sensitivity can be balanced to the resolution. [Pawsey provided a calculation showing that the sensitivity of a 6000 ft by 50 ft Cross would be a factor of at least three higher at a frequency of 300 MHz compared to the GRT.] The higher resolution of a Cross relative to a big dish demands a correspondingly higher sensitivity and it can have it ... I suggest you contact Oliphant and tell him of this considerable difference of opinion.<sup>25</sup>

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<sup>23</sup> Bowen then repeated to Oliphant his message from 10 February 1960 to White: the RPL scientists were “the world’s best radio astronomers, but the world’s worst [cost] estimators ... I have several times advised [Mills] in his own interests to put his figures up by a factor of 2 or 3 otherwise he and his possible sponsors may end up disillusioned men.”

<sup>24</sup> We have no evidence that co-location of the Super-Cross was a significant factor when selecting the Parkes site. In reality Parkes was also not suitable for the solar heliograph of the 1960s because of insufficient space.

<sup>25</sup> It is hard to reconcile these noise estimates without knowing more about the assumed specifications. In hindsight we can see that it was not the sensitivity but the versatility that made the biggest

There is no evidence that Bowen wrote again to Oliphant.

On 25 February 1960, Bowen replied to Oliphant at ANU, continuing the discussion of their meeting the previous week, answering Oliphant's questions concerning the GRT: (1) completion plans, (2) scientific use and (3) staffing plans. "I am afraid there are some loose statements going around, many of them. I am sorry to say having their origin in the Laboratory. The plain facts are that, as one would suspect with a project of this magnitude, there are some carefully laid plans for the telescope at Parkes." The construction was in good shape, for the first time ever at RPL construction was being done by outside firms, and the time scale was ahead of schedule (in the end with delays of only seven months). Three people were working on receivers overseas: Brian Robinson at Leiden, Alec Little at Stanford and Brian Cooper at Harvard. Bowen wrote that these staff would return to the lab in 1960 with high expectations ... Pawsey had proposed a research programme for the GRT. (One half of the research staff was to be associated with the GRT, the remainder with solar work). Jim Roberts and Mathewson were overseas, at Caltech and Jodrell Bank, respectively. They "were burning to get to the 210-footer" and had many ideas for the use of the GRT. "Roberts is one of our best up-and-coming radio astronomers and already has first-rate work to his credit in this Laboratory<sup>26</sup>." Bowen reported that Mathewson was "one of our brightest hopes, at least as promising as John Bolton was at the equivalent stage in his development ... We have one or two people on the staff who are not keen ... anxious to go along their own lines. [Presumably Christiansen and Mills]. It is a pity that in making the very good case which exists for the construction of the Super-Cross it is accompanied by scare stories about the rest of our Radio Astronomy programme."

On 29 February 1960, Oliphant replied to Bowen:

It is very useful to have these clear statements of your policy and I will certainly use them in the future. I have not heard anything about the preparations for staffing at Parkes, loose or otherwise, but such may come my way later. I am sorry that you are facing these problems but such difficulties are bound to arise when a highly successful project breeds a set of **prima donnas** [our emphasis] whose ideas of what should be done next come into conflict. There is the point, too, that men who have been given fine facilities and protected from multitudinous tasks of administration etc., are apt to take

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difference; a single dish was the superior performer. However, none of the proponents raised this point at the time. In discussions with one of the authors a decade later, John Bolton asserted that he was well aware of the advantage of flexibility of a system with few elements, thus his rationale for supporting the big dish.

<sup>26</sup> Later in this text, we provide a letter from Jim Roberts at Caltech on 26 October 1960 to Pawsey. He wrote Pawsey that his only aversion to working with the GBT was related to the associated politics at RPL.

such chores for granted and become very unrealistic in estimating costs and effort required.

Oliphant seems to have been well aligned with Bowen on this issue. Oliphant copied this letter on to Bart Bok so he could have an “authoritative statement about the position. We appreciate Mills’s position but the problem seems to be an internal one for you [Bowen] and your boys [at CSIRO] to work out between you.”

The implication from this letter is that Oliphant realised that bringing Mills to ANU would lead to a complex process, filled with controversy, given the issues and personalities involved. Apparently, he lost interest in a radio astronomy department at ANU at this time.<sup>27</sup>

On 29 February 1960 (Monday), Bowen wrote to White. The letter was a summary of points discussed in person on the previous Thursday (25 February 1960). He had forwarded copies of the two letters to Oliphant on to White.<sup>28</sup> The main topic of the letter was the need for a thorough revamping of the structure of the radio astronomy group at RP. Bowen’s disaffection for Pawsey became obvious:

I agree with your view that what we conspicuously lack in the Laboratory at present is the young man who is going to run and make a success of the research programme on the GRT at Parkes. [Clearly he is not referring to Pawsey who was 52 years old at this time.] The three possibilities on the staff are Mills, Christiansen and Wild<sup>29</sup> and, of these Paul Wild is the ideal choice, at age 37 but unfortunately for us, he wants to stay with the solar work for another five years or so. Neither Christiansen nor Mills are interested - in fact they tend to be hostile to the [GRT]. I would be happy for Mills to play a dominant role in the research programme of the telescope but unfortunately he has very firmly set himself on another course. As you know, the indications are that we shall lose both Christiansen and Mills. This will be a real loss to the Laboratory but I do not regard this quite as seriously as other people. In the first place, it will make room for some of our bright younger men [Jim Roberts, Brian Robinson and Don Mathewson, all who had been overseas for some time].

### **The Present Difficulties in Australian Radio Astronomy, Pawsey 31 March 1960**

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<sup>27</sup> See Chapter 30. The loss of interest in starting radio astronomy at ANU had also occurred in 1951-52.

<sup>28</sup> NAA C3830 Z1/7/B Part 2. Bowen also wrote on 29 February 1960 that: “The general administration of the RPL has been tightened up as of 10 am Friday, 26 Friday” [likely a memo sent to the RPL staff; the content of the memo was not described] Also Bowen suggested that White attempt to invite HRH Prince Phillip to the opening of the Parkes telescope in 1961. This attempt did not succeed for the GRT opening on 31 October 1961.

<sup>29</sup> Bolton was not included in this list as he only joined RPL again in early 1961.

Pawsey prepared a major report “The Present Difficulties in Australian Radio Astronomy” for the CSIRO Executive which was sent to Fred White on 31 March 1960.<sup>30</sup> Pawsey began with a call for action:

This report examines the present situation in radio astronomy in Australia. It strongly supports, from the point of view of the development of Australian science, a proposal by Mills to develop and construct a greatly improved metre-wavelength Mills Cross in Australia, but recognises that CSIRO cannot now finance it.

Two recommendations followed: (1) The CSIRO should support Christiansen and Electrical Engineering at Sydney University in his continuing work using the ex-CSIRO site at Fleurs and (2) the CSIRO should communicate with ANU that metre-wave radio astronomy could not be pursued and would recommend that ANU might enter this field.

Pawsey began with a historical description of the origin of the schism within RP. The inability to divert funds to metre-wave radio astronomy in competition with the GRT had consequences: “These diverse opportunities have led to difficulties in the radio astronomy group. On the one hand, the **completion of the Parkes radio telescope should provide Australians with the most effective paraboloid in existence [our emphasis]** By 1959, RPL had five important observational programmes running simultaneously: (1) solar metre wavelength bursts with Paul Wild and colleagues, (2) solar decimetre wavelength observations by Christiansen et. al., (3) cosmic 21 cm hydrogen line observations by Kerr, (4) cosmic 3.5 m continuum by Mills and colleagues and (5) cosmic 15 metre continuum by Alex Shain. After the GRT completion, item (3) would accelerate as well as decimetre wave continuum observations. An ambitious new solar project proposed by Wild would lead to imaging the sun at 1 sec intervals. But RPL would have to drop or reduce items (2), (4) and (5). Christiansen was planning to move to non-solar work and the Fleurs Chris Cross would evolve into the Fleurs Synthesis Telescope in the 1970s. Item (5) would tragically end with the death of Shain in February 1960. Pawsey concluded “**But I regard the dropping of Mills’s programme ... as the most regrettable.**” [our emphasis]

Pawsey had consistently supported Mills throughout his career and had relied on his scientific advice during the period of controversy with Cambridge over the source counts. To Pawsey the departure of Mills was a huge loss. This event also led to the breakup of the Mills, Christiansen and Shain team, a major achievement created by Pawsey. On page two of the main report, he lists the five “stars” of RPL: Wild, Christiansen, Mills, Shain and Kerr; only two, Kerr and Wild, were to remain after mid-1960.

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<sup>30</sup> Joe and Lenore Pawsey Family Collection, located 2010. Also located in NAA, July 2014 in C3830, Z1/20. Additional associated documents (e.g. draft letter to Oliphant) were only found in the Joe and Lenore Pawsey Family Collection.

On the staff side, we expect to lose Christiansen and Mills through resignations to take up university positions. We have lost Shain through his death. This means we have lost one and expect to lose two more out of five of our outstanding men. The achievements of these three have played a big part in building the reputation of Australian science. A substantial break-up of the RPL team now seems almost inevitable. **These impending resignations are clear evidence of a crisis in Australian radio astronomy.** [our emphasis] It is imperative at this stage to recognise the significant factors. Proper moves now could lead to even greater achievements on an Australian-wide front; false moves could wreck the Australian effort.

Pawsey clearly was convinced that he needed Christiansen and Mills in the post-1960 era. Pawsey's report on the "present difficulties" continued: Since the end of WWII, the Australian RPL group had developed numerous "special devices", radio telescopes with high resolution such as the Mills Cross, the grating interferometer, the Chris Cross, Michelson interferometry and dynamic solar spectrographs (fast time and frequency response).

The most important point is that the [scientists] who have been using them believe that such 'devices' can be vastly improved, improved so far as to outdistance giant paraboloids in a large proportion of the fields of radio astronomy. No other country has an equivalent pool of scientific ability in this particular field. At the same time, [the GRT] will have a unique radio telescope providing first-class opportunities in the several branches of radio astronomy to which it is suited.

While at the time it was the case that no other country had such a pool of talented instrument builders, Pawsey's appraisal of the limited science potential for the GRT and his suggestion that the giant paraboloids would be outpaced by the low frequency arrays was well off the mark. This lack of impartiality may be indicative of the stress caused by the schism as well as his dependence on the views expressed by Mills. In reality it was the flexibility of the single dish, with the ability to respond to new discoveries, that was to be decisive.

Pawsey saw the combination of the two types of complementary instruments as a way to reconcile the value of the two groups. But with the 50/50 division between the GRT and all other RPL projects in radio astronomy, the new solar project of Wild would take up the remaining resources. White, the CEO of CSIRO, had ruled out any substantial increase for funding a new large project in addition to the solar project.<sup>31</sup>

Clearly, Pawsey was worried about the overall future of radio astronomy in Australia. "I regard the discontinuance of Mills's line of investigation as the throwing away of quite outstanding

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<sup>31</sup> Likely, Bowen would have agreed with this assessment.

possibility for Australian science.” Mills had written a proposal for a new Super- Cross, to be built in two stages. An initial instrument working at one metre (resolution 5 arc min) with arms of 1370 by 12 metres would cost about £A 220,000 (not including the land) over a three year period. A larger instrument with a 3 arc min resolution would consist of arms of 2130 by 15 m with construction time of four years at a cost of £A 335,000. These expectations were to be compared with the planned Bennelux Cross with a one arc min resolution at a cost of £ 1,000,000 sterling. Pawsey continued: “I consider a project of this nature the most significant open to us in radio astronomy today. At the same time, because it operates at a longer wavelength than the really effective range of the Parkes aerial, it is not competitive with, but beautifully complementary to, the latter.”

Pawsey thought a continued development of the Super-Cross would “provide in the future, as they have in the past, Australia’s answer to the challenge of America’s lavish expenditure.” If ANU or another Australian university could participate with new funding, the project could proceed. In fact the Molonglo Radio Observatory was built and fully completed in 1967. The operating frequency was 408 MHz with a resolution of 2.8 arc min. The MRO evolved into the MOST – Molonglo Observatory Synthesis Telescope- from 1978 to 1981, operating at a frequency of 843 MHz and a beam size of 43 arc sec. **In practise, the Molonglo Radio Observatory was quite comparable to the envisioned Super- Cross.**

#### **Bowen’s Response to “The Difficulties in Australian Radio Astronomy” April 1960**

On 4 and 5 April 1960<sup>32</sup>, Bowen sent two long letters to White with his response to Pawsey’s “The Difficulties in Australian Radio Astronomy”. The letters provided Bowen’s response to: (1) Pawsey’s assertions about the Super-Cross plans (4 April 1960) and (2) A response to general issues as well as his “personal views” on the points raised by Pawsey. Both letters were to be discussed later by the CSIRO Executive.

Bowen wrote on 4 April 1960:

In my view, the core of the problem is very simple: whether it is desirable to go ahead with a Super-Cross right now or whether it should be deferred for a year or two. (I think it is quite clear that the merits of a Super-Cross as a device are not in question <sup>33</sup>...) The first [scientific] attacks were carried out at about the same time by Mills using his original cross and Ryle using his interferometer at Cambridge ... It is generally agreed that the Mills Cross produced results which were more reliable and altogether of a better class than those of Cambridge, [due to confusion]. After some confusion [not of

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<sup>32</sup> NAA, C3830, Z1/20.

the radio astronomical variety] and differences of opinion, it is also now generally agreed in astronomical circles that neither has solved the cosmological problem.

As discussed in Chapters 35-36 on radio source surveys, the irony of this situation was that Ryle had the correct interpretation (evolution of radio galaxies) even though the Mills catalogue was more reliable. As Bowen stated, it was indeed the case that the astronomical community had not accepted the importance of the radio surveys, largely as a result of the ongoing controversy.

Bowen wrote that three additional instruments would be used to solve the problem:

Professor Lovell has repeatedly indicated ... that the solution of this same problem is one of the main goals of the Jodrell Bank telescope ... and he intends solving it ... The 210 foot telescope at Parkes will give us a beam width of 10 to 16 minutes of arc [at 20 cm]. This is significantly better than [the Mills Cross and the Jodrell Bank antenna at 400 MHz- 40 arc min] ... and it will be possible to take the matter substantially further than is possible [at Jodrell Bank] ... As a further step at Parkes, the 210 foot telescope will be used with the 60-footer as an interferometer to give a resolution of minutes of arc ... and will undoubtedly make important contributions to a variety of problems in radio astronomy.

In practice the 250' played only a minor and indirect role in source counts as no large-scale continuum survey was ever undertaken. The Parkes telescope 408 MHz survey of the early 1960s replaced the Mills Cross survey, but still had no significant cosmological impact. This was a combination of the loss of interest in the source count issue – the Cambridge 3C had become a reliable catalogue and the addition of a southern survey would not have represented a decisive step for cosmology. The Parkes catalogue suffered from confusion bias at its survey frequency of 408MHz so, although the high resolution 1.4GHz follow-up observations made it an extremely reliable catalogue, it was of limited value for cosmology. The 60-foot interferometer was never used for a continuum survey.<sup>34</sup>

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<sup>34</sup> Later surveys of the southern sky were made at 11 cm by Jasper Wall and colleagues. The Parkes telescope played an important role with the first of the surveys at a higher frequency (2.7GHz). These surveys selected a different population of extragalactic radio sources, many with flatter radio spectra. (Shimmins, A. J., Bolton, J. G., & Wall, J. V. (1968). Counts of Radio Sources at 2,700 MHz. *Nature*, 217(5131), 818-820. Many surveys were published in the 1970s, for example, "The Parkes 2700 MHz Survey- Catalogues for the  $\pm 4^\circ$  Declination Zone and for the Selected Regions, Wall, Shimmins, Merkelijn 1971, *Australian J Physics Astrophysical Supplement*, vol 18, p.1).



Bowen went on to note, “Logically, the next technical step is the one now under discussion, namely the construction of the Super-Cross with a beam width of 3 to 5 minutes of arc.” Bowen preferred to wait; the Super-Cross would take three to five years to complete and additional information from the other instruments might be available at that time.

However, Bowen was quite critical of the Cross concept when he wrote his friend John R. Pierce (Bell Labs), Chair of the US Advisory Panel on Radio Telescopes, on 6 October 1960 on the subject of “big dishes and the search for high resolution. This is a subject on which we now have a fair amount of experience and some definite views.” Bowen was convinced that the limit for a “gigantic steerable dish” was much beyond 200 to 250 feet.<sup>35</sup>

Bowen continued to Pierce:

There are clear signs that the 250 foot telescope at Jodrell Bank is near, or beyond, the limit of conventional fabricating techniques, hence our decision to stop at 210 feet. In this way we cut the cost by a factor of 2 and increased the precision by a factor of 8 or 10.<sup>36</sup> Similarly on Super-crosses, there are too many doubts and queries at the present time. The resolution of these devices is undoubtedly good, but the signal level at which spurious sources are introduced is uncertain- and it is this uncertainty which counts against them. My own view is that the right course for the next five or ten years is to go for the simple combinations of three to five steerable dishes, each dish being as large as can economically be constructed ... It is sobering thought that for the price of the 600-footer at Sugar Grove, one could buy one hundred [his emphasis] Australian dishes ... [or] for one-tenth the cost one could have the same total area as the 600-footer and, by spreading the dishes along a baseline, obtain a very much higher resolution.<sup>37</sup>

Bowen continued his criticism of Pawsey in the 4 April 1960 letter to White:

It is suggested [by Pawsey] that it is a disastrous thing that two senior members of our radio astronomy staff are considering leaving. On quite general grounds it could be argued that this event would be both reasonable and one which is to be expected.

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<sup>35</sup> NAA C3830 Z1/4

<sup>36</sup> The planned 250' diameter of the GRT was scaled down to 210' based entirely on the funds available. See NRAO ONLINE 43). In subsequent decades, successful antennas of larger diameter (100 m) were constructed in Germany (Effelsberg) and the US (Green Bank).

<sup>37</sup> This is a surprisingly astute projection – probably influenced by John Bolton’s vision (eg *Stars and Stellar Systems Vol 1 chapter 11: Radio Telescopes*, published 1960 in "Telescopes", ed Kuiper & Middlehurst, Chicago University Press). In 2020, we now appreciate that the dish arrays built at Cambridge, Westerbork, VLA and the Australia Telescope Compact Array were indeed the most successful of the future paths.

There is a marked absence of good candidates for the vacant Chairs of Physics and Electrical Engineering which exist in Australia today. At the RPL there is a notable concentration of people who might fill them. For a broad and balanced development of scientific effort in Australia, it could be argued that these are the people to fill them.

In the same way, we have a number of very bright young people coming up in the RPL, for example Jim Roberts, Brian Robinson and Don Mathewson. They are at least as bright as anyone we have had in the past and it is going to be exceedingly difficult or impossible to give them proper scientific opportunities or advancement at the appropriate stage with the large proportion of senior staff we have ...<sup>38</sup>

The tremendous team work that led to success after success in the late 1940s and early 1950s was evaporating. Two cultures were colliding; Bowen+Bolton top-down versus the more collaborative methods of Pawsey+Mills+Christiansen. All these scientists – close to 40 years old- were looking for leadership roles. John Bolton had proved himself as an inspiring leader at OVRO and had a remarkable influence on two of the co-authors of this book (one was his Phd student-(Ekers)- and the other his postdoc-(Goss)).

Bowen implied that he would be happy to see ANU start radio astronomy but noted that the funds would come from the same government sources as the CSIRO funds. His conclusion was: “... I see no advantage in the ANU proposal and every reason why the project should proceed at the appropriate time with RPL.”

The next letter (5 April 1960) represented general comments and “personal views” (about the Pawsey text of 31 March 1960) expressed by Bowen; these were to be reported to the CSIRO Executive:

Let me say how sorry I am to see the continuation of a process which has in fact been going on for a long time. One of the great strengths of the Radio Astronomy group of the RPL has been the way in which we have worked together as a team. The Radio Astronomy group has been, and probably still is, the largest and most cohesive group of its kind anywhere and this has been a large part of the reason for its success. Unfortunately, one or two sources [presumably Mills and Christiansen] of disaffection have been at work splitting the group for some time. **It is disappointing that Joe does**

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<sup>38</sup> Bowen advocated a steady flow of “scientific talent through [RPL], with bright young people coming in the bottom and some ... of our best people going out near the top.” He gave as examples Lehany, Burgmann, Bolton and Bracewell. “Some of our present worries come home to the fact this output of senior staff has not been taking place in recent years.”

**nothing to stop it and occasionally seems to foster it. [our emphasis]** [A schism between Bowen and Pawsey seemed imminent.]

It is particularly unfortunate that the difficulties have reached a head at this stage in the construction of the giant radio telescope and I do not understand why the proposals for a Super- Super-Cross are being pursued with such urgency at just this time. No doubt the reasons will emerge in due course ...

One reason why it has been possible to give so much encouragement to radio astronomy in the past is that it has taken place within the budget of the RPL. It has had to compete only with cloud physics and some of our activities and ... we have always given it lavish treatment. If the merits of radio astronomy had been argued out against nuclear and other branches of physics and against the merits of agricultural, biological and medical research in Australia, there is considerable doubt whether it would have obtained similar support. By ventilating more or less in public some of the present arguments and the expenditures involved, the group may be doing themselves a serious disservice.<sup>39</sup>

I am afraid that Joe's proposal does not do justice to the Executive or the Government generally, who have so generously supported radio astronomy in the past and are clearly committed to a large measure of support in the future. The present submission, while it lays claim to the cause of Australian science, does not pay any regard to the need for maintaining a proper balance between radio astronomy and the many other branches of scientific research which should be encouraged in Australia. I am all for more research and greater facilities for research in its many fields, but there are obviously some clear limits beyond which one cannot go in any one branch of science.

I have discussed all these points with Joe, but he is reluctant to see my point of view. Exactly what is done is clearly a matter for the Executive's decision. My own considered view is that this whole question of a Super- Super-Cross is not one to rush into. It is one on which, for once, we should be cautious and see how the results of existing projects pan out.

In this letter, Bowen's strategy seems to have been an intentional attempt to undermine Pawsey's position by arguing against any extension of radio astronomy in the broader community. Bowen had made a pre-emptive strike against a possible threat affecting the radio astronomical monopoly of CSIRO within Australia.

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<sup>39</sup> See NRAO ONLINE 25 report on Cloud Physics in the US.

Bowen also reacted to Pawsey's suggestion that only a limited number of the RPL staff were interested in the scientific programme of the future GRT. He included a copy of the document prepared by Pawsey in September 1959 "Proposed Early Investigations using the 210 foot Radio Telescope", showing that there was an enthusiastic perspective among many of the scientific staff. The expectation was also that the young returning staff (Roberts, Robinson and Mathewson) would "be full of ideas as a result of their experience at Caltech, Leiden and Jodrell Bank".

The Pawsey memo of 31 March 1960, "The Present Difficulties in Radio Astronomy", was discussed among members of the CSIRO Executive in April and May 1960. On 14 April 1960, Leonard Huxley (as a member of the CSIRO Executive) wrote Stewart Bastow (CEO of CSIRO from 1 January 1957 to 30 June 1959, then a member of the Executive until his death 23 January 1964<sup>40</sup>) describing the Pawsey document (and accompanying letters) plus two commentaries about the document by Bowen.<sup>41</sup> Huxley was positive about the Pawsey document and accepted Pawsey's analysis, especially the dangers of losing valuable scientific talent. Huxley would have seen through Bowen's plan; he was critical of Bowen's rejoinder:

Bowen's documents do not add much in way of new or relevant arguments. The upshot is that [he does] not support Pawsey's proposal which in fact has been agreed to but he [Bowen] objects to chiefly on the grounds that the money has to come ultimately from the government and that we should not ask ANU to enter this field but should ourselves build a Super-Cross in a few years' time. In arguing thus it seems to be that he [Bowen] is not facing the facts: (a) Christiansen has gone [to Electrical Engineering, Sydney], (b) Mills is already negotiating with the University of Sydney. In this situation I do not see why ANU should not also approach Mills if it feels inclined to do so and can raise the money. I have not [summarised] Bowen's arguments [the contents of the letters of 4 and 5 April 1960], but I am not greatly impressed by them.

Then, a month later, 2 May 1960<sup>42</sup>, the minutes of the 182rd Executive of CSIRO meeting included a report by Huxley on the radio astronomy programme of RPL. He described the current status of the Super- Cross, including the imminent departure of Christiansen and Mills from CSIRO: "It thus appeared that by staking the whole programme of the radio astronomy group on the GRT a major change of policy was evolving [to drop high resolution low frequency radio astronomy]." In effect the Executive made no substantial recommendation and the status was maintained. It was too late to reverse course.

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<sup>40</sup> Bastow was a member of the CSIRO Executive from May 1949 to his death.

<sup>41</sup> CSIRO Archive KE20/2, Huxley document. The Bowen reports were most likely the letters to White on 4 and 5 April 1960.

<sup>42</sup> CSIRO Archive KE8/3.

In Additional Note 2, we summarise the role of Lord [Robert G.] Casey in 1960; Casey had been the Minister for the CSIRO from 1950 to 1960.

### **Leadership of the GRT Programme in 1960 - John Bolton returns to RPL from Caltech**

As the end of the decade and as the completion of the GRT approached, John Bolton had reached a climax in his career with the very successful development of Caltech's Owens Valley Observatory. At this time White and Bowen contemplated their own visions for the evolution of Australian radio astronomy. For some time Bowen had begun to think of the future organisation of the RPL. On 29 February 1960, Bowen wrote Fred White<sup>43</sup>:

[The departure of Mills and Christiansen] will provide an opportunity of putting our house in order in a very desirable direction, namely in the appointment of two people under Joe to take charge of the radio telescope programme and our solar programme, respectively. Paul Wild is clearly the man for the latter and there is an obvious place for us to look for the former [i.e. John Bolton at Caltech, but not named in the letter].<sup>44</sup> To invite someone to take charge of the GRT now would be to invite some kind of explosion. When Mills and Christiansen are finally settled, I think we will have no difficulty making a new arrangement smoothly and agreeable to all concerned.<sup>45</sup>

As Bolton's return became more likely, unanimity at RPL remained elusive. At the end of February 1960, Pawsey likely knew nothing of this discussion between Bowen and White.<sup>46</sup> As Don Mathewson discussed with Goss in 2011, the actions of Bowen were not the main problem. Most of the RP scientists viewed Bowen's major mistake to have been the manner in which the transition occurred in 1960. If the process had been above board with no secrecy, the process would have been much less controversial and misunderstandings might have been at least partially avoided.

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<sup>43</sup> NAA, C3830, Z1/7/B/2, Part 1

<sup>44</sup> This may be the first time that Bowen had broached this sensitive subject in correspondence with White. A few months later (June 1960) Bowen was to make a direct approach to Bolton at Caltech about returning to Sydney and the GRT.

<sup>45</sup> Clearly Bowen realised that he could not raise the issue of having John Bolton's return while the situation involving Pawsey, Mills and Christiansen was so sensitive.

<sup>46</sup> NAA C3830 Z1/7/B Part 1. White replied to Bowen immediately on 2 March 1960 telling him that he agreed with offering the unnamed individual (clearly Bolton), "I am quite willing to rest on your judgment about point 4." (The requirement in the lab of "the younger man who is going to run and make a success of the research programme on the GRT.")

Previously, John Bolton had a discussion (in December 1958 in California- see below) with Bowen about a possible return to Sydney.

On 2 June 1960, Bowen wrote to Bolton suggesting he consider a position at RPL<sup>47</sup>: "... [I am asking] your present thoughts on returning ... to us at the RPL ... What I have in mind is creating two positions in the radio astronomy group, designated Officer in Charge, Director or any such title ... to look after solar work on the one hand and the research programme of the GRT on the other. Paul is obviously the man for the first of these and you for the other."

In an accompanying handwritten note (2 June 1960) from Bowen to Bolton, Bowen made disparaging remarks about Pawsey:

In the attached letter I have said nothing about Joe's part in all this, but he is in one of his uncertain moods and doesn't seem to know what he wants. He blows hot and cold as far as the GRT is concerned. If it is a gigantic flop, he clearly wants to say "I told you so." If it is successful, he wants to be in it ...<sup>48</sup> [The] arrangement a few years from now will probably be that Joe will continue in charge of the radio astronomy group, with two principal "bods" [sic, bodies or men] under him, one on solar work, the other predominately on the GRT. To what extent he will really play on the GRT I do not know. Right now, under the able help of [Higgs and McCready etc.] I have to carry the ball on the GRT.

Bowen reported to Bolton on 20 June 1960 that he was pleased with his response from 7 June (not found in the archive): "We would advertise the post in the normal way and this would automatically cover fares for an overseas candidate. As far as dates are concerned, I think we should shoot for January 1<sup>st</sup> 1961." The main reasons to delay the arrangements were two-fold: (1) Bowen was reluctant to settle the Bolton/Wild appointments until CSIRO Chairman White returned to Australia in early September 1960 and (2) Bowen suggested that White visit OVRO ("impress him with the good work you [Bolton] had done at Caltech"). "[White] knows about your interest in coming back to us and it would be most helpful if you were able to discuss it with him personally." In the end, a visit by White to OVRO (near Bishop California in the East Sierra region) was not possible. White and Bolton did meet in Berkeley, California, on 29 August 1960<sup>49</sup>.

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<sup>47</sup> Ibid

<sup>48</sup> This statement certainly did not represent Pawsey's way of thinking. Possibly, this suggested *schadenfreude* might have represented how Bowen would have reacted in case of failure.

<sup>49</sup> Ibid. White's itinerary included San Francisco to Sydney via Hawaii on 29 August. On this last day, White met Bolton in San Francisco. Bolton met Bowen twice in the coming months: at URSI in London (5-15 September, Bowen was visiting FFP in London) and Pasadena at Caltech while Bowen visited JPL (NASA was planning to build 200 foot plus size tracking antennas deep space tracking antennas).

Also on 4 July 1960, White weighed in again on the Super-Cross controversy. In a letter from White to Bolton, White quotes Bowen:<sup>50</sup>

In his letter, Taffy tells me that Mills has apparently decided to join Messel's staff. Whether Messel has been able to promise him the money to build a new and larger Cross I don't know. But I quite honestly think he seriously underestimates the sum required when he talks about something of the order of £A 100,000. [In fact, the final cost of the Mills Cross was about £A 450,000.]

After this time, there was little discussion of the Super-Cross at CSIRO; the project had moved to the University of Sydney.

In addition, in this period Bowen also commented about the staffing situation at RPL to Bolton on 29 July 1960.<sup>51</sup> "Our ranks are certainly thinning out, but I do not regard this as a bad thing. It gives us an opportunity of introducing some new blood, which we are badly in need of. With the recommendation you have given, there should be no difficulty... about engaging Robert Wilson<sup>52</sup> and we will put out an advertisement at the appropriate time."

Bolton wrote Fred White on 22 June 1960<sup>53</sup>:

**I told him [Bowen, during the Owens Valley Radio Observatory opening in December 1958] that I did not intend to spend the rest of my life at Caltech** [our emphasis]... I indicated that while I intended to stay here until the observatory I had built had got on its feet and was a scientific success, I would be glad of an opportunity to return to RP. Taffy recently asked me whether I was of the same opinion and whether I would like to go back to run the non-solar [sic] research on the GRT. As you know, several of the top staff have left RPL recently. There has been for many years a conflict of opinion on whether the correct way to do galactic and **radio star work** [a surprising term for Bolton in 1960] is with partially filled arrays at metre wavelengths or steerable dishes at the

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<sup>50</sup> NAA, C4633/1.

<sup>51</sup> NAA, C4633/3

<sup>52</sup> Robert Wilson had been Bolton's student at Caltech, PhD 1962. Wilson did not accept the position at RP. He joined Bell Labs in 1962 and shared the Nobel Prize in Physics in 1978 for the discovery (with Arno Penzias) of the 2.7K cosmic microwave background. If Bob Wilson had accepted the RPL position, his Nobel Prize of 1978 would likely not have occurred.

<sup>53</sup> NAA, PH/BOL/5, Part 2.

centimetre and short decimetre wavelengths. Those who have left RPL are of the former school and Taffy and I of the latter ...<sup>54</sup>

On 4 July 1960, White replied to Bolton: "I was very interested in your idea of returning to RP. You probably know that Taffy Bowen would like this very much. Your opinions about the use of the dish interest me greatly, because of my anxiety to see this telescope project really go ahead with first class work."<sup>55</sup>

On 22 June 1960, Bowen wrote White with details of his communication in the previous weeks with Bolton<sup>56</sup>:

I have had in mind for some time-namely to advertise two senior positions under Joe to look after our solar work and the GRT, respectively ... They would carry an appropriate title and a good salary and might attract Paul Wild and John Bolton, respectively. If this came off, it would then compensate Paul for the very attractive job [Cornell] he has turned down recently and should be good enough to bring John Bolton back to us ... I have been in touch with him in recent weeks and he is most interested in the prospect of returning ... he has done magnificently at Caltech, so he deserves the best possible position we can give him ... I will wait until you get back to discuss the details.

Two weeks later<sup>57</sup>, White wrote Bowen with a question about John Bolton (4 July 1960):

Before I see John Bolton [mid-August] you might drop me a note to let me know your considered views about him. Do you, for instance contemplate selecting one of your boys to be in charge of the telescope (including John Bolton in the choice), or do you suggest creating a specific post of Scientist-In-Charge of the telescope and advertising this? The latter course might in the long run avoid hard feelings amongst the staff, since everyone capable would have the chance of applying and being considered. I think the Executive might well find it easier to create a more senior post by this technique, since the job would be a very responsible one.

Bowen<sup>58</sup> responded to White with information "you require for a discussion with John Bolton in San Francisco" (1 August 1960):

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<sup>54</sup> This view is entirely consistent with Bolton's vision of the future of radio astronomy and was not a result of Bowen's influence.

<sup>55</sup> NAA, C4633/3.

<sup>56</sup> NAA C4633/3

<sup>57</sup> NAA C3830/Z1/7 Part 1

<sup>58</sup> NAA C3830 Z1/47/BOL



It is quite clear that he is excited by the prospect of coming back ... He did wonderfully well with us in the first place and still hankers after the Australian environment. Secondly, he is most decidedly in favour of big telescopes and looks forward to having under his charge the best of which is likely to exist for a year or so ... [My] intention is to advertise two positions under Joe- one scientist in charge of the telescope at Parkes and the other in charge of solar work. We shall probably have a number of good applicants, but it would be hard to find anyone better than John Bolton for the former and Paul Wild for the latter. An appointment dating from January 1<sup>st</sup> 1961 is the one to shoot for ... It is fairly certain that, when it is known that John is coming back, he will get a number of attractive counter offers in the USA. We should, therefore, be as generous as we possibly can, both in the salary and the prospects we hold out to him ... I think we should also clearly recognize one fly in the ointment, **namely that Joe is not entirely happy about John coming back.** [our emphasis] The reasons are probably deep seated and of the kind we are slowly learning to live with. However, Joe has no good alternative to suggest, and the alternatives open to us, namely not having anyone in a senior position to look after the research programme of the telescope, is too awful to contemplate.

Even though the agreement between Bowen and Bolton had been discussed (with the blessing of White) by late June 1960, many additional details were to be settled. The formal job application procedure had to be fulfilled, as well as Bolton's resignation at Caltech. Bolton announced the resignation at Caltech in August 1960, to the consternation of senior Caltech administrators, DuBridge, Greenstein, Bacher and others.<sup>59</sup> When Bowen visited Caltech at the end of September 1960, he wrote to Bolton after meeting his colleagues: "I spoke to Lee DuBridge, Bob Bacher and Jesse [Greenstein] about your impending departure from Caltech. They are still wondering what hit them and seem to be suffering from delayed reaction shock. They are understandably worried about a replacement and do not think they will be able to appoint anyone until at least June 1961. It would be ok for Jim Roberts to stay on a little longer, but in view of the above paragraph I would not be surprised to receive a request from Caltech for him to stay on for several months, or at least until they find a replacement for you."<sup>60</sup>

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<sup>59</sup> California Institute of Technology archive, L.A. DuBridge archive, Box 34. Letter 16 August 1960, DuBridge to Admiral Rawson Bennett, Chief of Naval Research

<sup>60</sup> Roberts remained at Caltech until March 1961.

On 15 October 1960, John Bolton sent his “formal application” for the senior research position to Bowen.<sup>61</sup> This was a hand-written letter with abbreviated curriculum vitae, including his nominated references Bob Bacher, Fred Hoyle, Rudolf Minkowski and R. Hanbury-Brown.<sup>62</sup>

On 14 November a very confused set of communications were transmitted to Bolton via the Australian Scientific Liaison Office in Washington, D.C., with the offer of a new position at CSIRO. The problem was that the ASLO personnel did not know any of the details of the new appointment. Bowen was especially frustrated by the confused bureaucracy (“... the clerks [in Canberra] thought they would make some work for themselves, so they sent it first to the Gestapo, then to Washington- who knew nothing about it- then to you! It looks as if we all have our private cross to bear!”) By necessity, Bolton had already organised the trip back to Australia from Los Angeles before the formalities were complete: he, Letty and their younger son Peter left on the SS *Orcades* on 12 December 1960, arriving in Sydney on 30 December 1960.<sup>63</sup>

Both Wild and John Bolton were appointed at the top of the Senior Principal Research Officer rank. By mid-1961, both Bolton and Wild had been approved by the Minister for CSIRO to be promoted to Chief Research Scientist. On Bolton’s “commencement of duty” form, signed on 3 January 1961, an ironic entry appears: “If not a new position indicate name of person replaced. [The name was] **B.Y. Mills.**” This choice was remarkably ironic.

### **Pawsey, Disillusioned with CSIRO – late 1960**

Pawsey’s concern for the future of RP, as well as his own future role, increased in the course of 1960. The departure of his senior colleagues Christiansen and Mills, plus the Super-Cross demise, were major factors. Also the management of RPL had been reorganised by Bowen with minimal input from the Assistant Chief, Pawsey.

In September 1960, Pawsey was at a crossroads in his career; after the founding of Australian radio astronomy in 1945-1950, he could see his influence dwindling. Pawsey’s discouraged state of mind in September 1960 can be gauged by his personal correspondence (located in the

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<sup>61</sup> A few weeks earlier, Bowen had pointed out to Bolton (6 October 1960, NAA C4633/2) that the application was a pro-forma exercise: “The wheels are turning slowly but inevitably in the direction I indicated when we spoke [in London and Pasadena]. An advertisement will be issued ... and I will send you a copy as soon as it appears. I might say that the Executive have already agreed to the appointment, but it is necessary for CSIRO to go through the motions so that there is no question about payment of fares and so forth.”

<sup>62</sup> NAA, PH/BOL/5, Part 2. It is unlikely that any of the referees were contacted by letter as there are no letters of reference in the Bolton personnel file at CSIRO (PH file).

<sup>63</sup> Ibid and NAA, C4633/3. The process involving the Australian Scientific Liaison Office in Washington, D.C was still standard practice decades later.

Pawsey family archive) during this period. A few weeks before Bowen returned to Sydney on 27 September 1960, Pawsey wrote letters to Leonard Huxley (CSIRO Executive and soon to be the Vice-Chancellor of ANU), Fred White (Chair of CSIRO from 1 July 1959 to 22 May 1970, there was no CEO of CSIRO from July 1959 to December 1986) and Bowen with expressions of concern.

Two “personal and confidential letters” were written on 5 September 1960 to Huxley and White, the letter to Bowen on 8 September. Huxley replied on 16 September 1960; no response from White has been found in the archives. However, White did visit Pawsey a week later, Tuesday 13 September 1960. Based on the immediate contact with Bowen, clearly the two discussed Bolton’s appointment at length.

Bowen responded from Washington on 22 September 1960. Both letters from 5 September 1960 were typed (likely in the Pawsey home), the one to White on a CSIRO RPL letterhead. The content of both letters is similar with additional elaboration in the Huxley letter. The letter to White (5 September 1960):

I wrote you while you were away [until about 1 September] saying that I was anxious to see you to discuss the possible appointment of John Bolton. I had previously advised Taffey [sic] that his appointment was likely to cause considerable internal friction ... The essential point the boys [the radio astronomy scientific staff] are querying is whether I, or John through Taffey, will be in control of the research program. I am told that they unanimously want me ... [Then a] second development took place ... A rumour reached RP that John had been appointed as from this November. I, as Assistant Chief of the Division and head of the radio astronomy section, have no word of this. If this rumour is true I am not going to quarrel with John whom I regard as a friend, but I want specific assurances from the Executive on certain points. Firstly on seniority, I regard Paul Wild as having definitely higher attainments than John and I want to be quite sure that John is not appointed over Paul’s head.

The letter to Huxley (5 September 1960) was similar with a number of additional points. The letter may be viewed as a “cry for help”, directed to the CSIRO Executive. Pawsey clearly felt he could be more frank with Huxley than White, his boss at CSIRO.

I am worried about the way certain things are working out in the RP laboratory and I should like to have a talk with you as soon as convenient after your return [from Europe and the US on 21 September 1960]. The problem is the differences in outlook concerning radio astronomy and whether in the circumstances, I should hang on or get out. I think it will be useful if I set down the essential factors so that you may have a

chance to think things over. These fall under three heads: (1) the RPL situation, (2) pressure on me to take a State university chair, and (3) my own ideas on what I can do best. Firstly the RPL situation. You are familiar with the general position. I shall add only the new developments. Taffey [sic] some time ago suggested a new senior appointment of a man to look after things at Parkes and suggested two possibilities: Hanbury-Brown<sup>64</sup> and John Bolton. I told him I should welcome Hanbury warmly but that I advised against John on the grounds that his appointment would cause grave internal friction. I have since repeated this argument to Taffey ... [At the lab, among the scientific and receiver groups] I find that the mistrust of John is far more widespread than I realised. The essential point is whether I or John through Taffey will be in control of the research program, and my unofficial informants tell me that the unanimous view is that they want me. [Then] the rumour that John has been appointed as from a date of about next November[1960], and already handed in his resignation at Caltech. As Assistant Chief and nominal head of the radio astronomy section I am not informed of this. **In simple terms I have notice to quit on the one hand and an appeal to hang on from the other. Where do the Executive stand?** [our emphasis, this entire quote from Pawsey] [Pawsey next described the suggestions that he might take a chair of physics at Adelaide or Melbourne.] ... I am obviously at a turning point. This RPL situation cannot go on indefinitely. I have to get out or establish a new independent basis with the Executive. The move should be based on what I can best do. It seems to be that what **strength I have lies in my ability to stimulate and develop [sic] scientists at the research level** [our emphasis]. An exceptional proportion of those who work with me seem to reach top level whereas others I have thought to have equal innate [sic] ability do not make the grade. If so my most useful contribution would seem to be in a "research institute" of some sort. The RPL has served me very well, but apart from the present difficulties, I should like to see some modification. **I do not think we have enough contact with the younger generation. What I should consider excellent would be a research group with the facilities of RPL but loosely tied in with a university and have a fair proportion of research students in its circle** ... I feel here that the potentialities of ANU are very considerable; if only one could transfer RPL or part of it to Canberra and fix up some sort

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<sup>64</sup> In the letter from Pawsey to White of 31 July 1960 (see above- Pawsey family archive), Pawsey wrote: "Taffey [sic] tells me that he is hoping to get either John Bolton or Hanbury-Brown to fill the gap. I, and I am quite sure I can also speak for others in the group, would be delighted to have Hanbury join us if he should be interested. John's appointment would raise some very tricky points and I wish you were here [in Australia, due to return in September 1960] so that I could discuss these with you. Taffey knows my doubts."

of amalgamation of resources.<sup>65</sup> I feel that I should like to play a part in an organization with a dual objective: research and the development of research scientists in Australia. [If I were to move to a State University] I should wish to continue in radio astronomy but I do not think it really feasible to build up another big radio astronomy group in competition with RP. So I should have to retire from, or to the outskirts of, this branch of science **after having built it up in Australia** [our emphasis]. If I continued in radio astronomy I feel that I could still play a very useful part in keeping Australia in the forefront. I am intensely interested in particular in the technical developments in our field ...

Huxley wrote from London (he had been at URSI) on 16 September 1960, a reserved, neutral but realistic response:

... [M]ay I say that it seems to me that you may find yourself out on a limb. Bolton's return has been muted for some time and the new set-up will be entirely built around the GRT. The Executive is not likely to sponsor any other group on the grounds of ceremony<sup>66</sup> ... I am afraid this is a [quickly composed] letter but the external conditions are not helpful.

A more significant letter was hand written<sup>67</sup> by Pawsey from 8 September 1960. Pawsey wrote to Bowen:

Just what is happening about John Bolton? There have been two developments here: (1) there is a rumour<sup>68</sup> to the effect that John is appointed from Nov. next and (2) there have been a series of questions at the lab. For (1) I have no official information and I

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<sup>65</sup> The co-supervision of University students by CSIRO staff started just a few years later, ironically lead by John Bolton and initially through an agreement with Bok at ANU. One of the authors (Ekers) was an ANU student.

<sup>66</sup> Huxley also encouraged Pawsey to make up his mind quickly about the Adelaide University offer since another candidate was about to be selected. Huxley also had some disparaging remarks about the Physics Department at Melbourne, "which in any case is a rundown department".

<sup>67</sup> A handwritten copy of this letter was found in May 2010 in the Pawsey family archive. The letter could only be deciphered with the assistance of Elizabeth Pawsey, J.L. Pawsey's daughter-in-law. No copy has been located in either the NAA or the CSIRO archives.

<sup>68</sup> The rumour had also reached the US. University of Sydney Archives, P154- Series 2. Letters to Mills- 9 September 1960. Campbell Wade (NRAO Green Bank) wrote Mills with a discussion of the radio properties of M84 in the Virgo cluster. Wade had heard about Bolton's appointment: "The imminent departure of the eminent JGB [Bolton] has occasioned a feeling of relief in certain quarters in this country. You mentioned that certain people at RPL are feeling sick over the matter, and that some recruiting might be possible as a result. Since I do not know the precise feelings many of them bear towards [Bolton], could you suggest the most likely prospective?" No response from Mills has been found in the University of Sydney archives.

definitely don't like being out on a limb. On (2) there were actually questions about "conditions of work at Parkes" in a GRT committee meeting ... [T]his is simply the John Bolton question and there is widespread distrust of John in RP. Much wider than I thought. You will remember that I warned you of this, but I find it extends to people I had not previously suspected- whom I had thought supporters.<sup>69 70</sup> On the other hand I agree with you that John is a good astronomer with the right range of interests and an excellent organiser. I find myself in a most awkward position. I myself have got on well with John in the past and definitely do not want this to build up into a personal quarrel with him. What then is the best to do? If this appointment is not yet made I definitely recommend a cooling period before appointment. I suggest the end of 1961 as suitable (if earlier is he not letting down Caltech?). He might well come here on a working visit ... If the appointment is made then I should like to see things more clearly defined. Firstly seniority with respect to Paul Wild. I regard Paul's scientific attainments over the last 10 years and his capacity for scientific leadership is definitely Super-ior to John's and I shall strongly oppose an appointment over Paul's head – secondly the broad balance of the RPL program. I want a firm assurance that John's coming will not block the GRT/non GRT balance that we have previously agreed on. The right way to proceed is the GRT will give us a blaze of glory in the near future. This will then become more of a routine instrument as bigger ones are completed elsewhere, and we must hope to score again on the "enhanced directivity" [i.e. interferometry] side. To be able to do this we must keep our hand in and back Paul's scheme when it comes good and in the nearer future keep going with Chris's Fleurs set up. Yours sincerely, Joe

Pawsey's perceptions about John Bolton seem at odds with Bolton's successful leadership of the Caltech radio astronomy group. In retrospect, we recognise that he was an effective leader of the GRT science and technology developments after his return to Australia. We think the

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<sup>69</sup> This perspective was succinctly summarised by Frank Kerr in a letter to Sullivan 12 Aug 1986 "Bowen and Bolton got on very well together, as they were similar types in many ways. Neither of them could be trusted, and they were both successful politicians." W.T. Sullivan, III, archive.

<sup>70</sup> In fact this animosity felt by the staff towards Bolton was later addressed by Bowen. (NAA, C4633/3, 8 November 1960), Bowen wrote to Bolton: "As you know Fred White and I are all for [your appointment] and look forward to you being responsible for a lively and really active programme of research on the GRT. However, there have been difficulties down the line in the Laboratory and a few people are not reacting too well to your return. This is unfortunate and reflects only on the people concerned. It will, I am sure, sort itself out in the end, but we have to face up to the fact that these difficulties exist. This is not the kind of thing one can write about easily, and I will have a full and frank discussion with you as soon as you arrive [30 December 1960]." Bowen urged Bolton to be cautious in writing to the Laboratory, also suggesting addressing "all questions on the research programme to Joe and myself..." and to be discrete in asking questions on aerial feeds and receivers. "I think you will quickly see the reason for this."

issue was that Bolton was not a team player in the style that Pawsey had cultivated. Bolton could be very dominating; he made it clear that he would lead the science. His support for the big dishes, or arrays of large dishes, was also certain to generate conflict with Mills's Super-Super-Cross proposal; Pawsey would likely have desired to minimise the controversy.

The comment by Pawsey about big dishes is revealing. Apparently the expectation was that a big dish such as the GRT would only be able to do a small range of projects well – hence the “blaze of glory” and also that it would be rapidly Super-seded by larger dishes. In reality the GRT has continued to make scientific contributions for more than 50 years. Some decades later bigger dishes were made such as the Effelsberg 100m MPI antenna in Germany and the Green Bank Robert C. Byrd, Greenbank Telescope (GBT) in West Virginia, USA. In the current era, these instruments are matched in productivity by the “enhanced directivity” of the arrays such as Cambridge, WSRT, VLA, ATCA and ALMA.

On 16 September 1960, Pawsey wrote a more tempered letter to Bowen at ASLO in Washington. The series of four cables are summarised in Additional Note 3 are referred to in the letter of 16 September. These had been initiated by Fred White's visit to RPL in Sydney on Tuesday 13 September:

Fred White was here on Tuesday [13 September 1960] and we discussed John Bolton's prospective appointment ... He recommended and I agreed to, the offer described in the cable he sent you. I have just received a copy of your cable in reply. I take it this will almost lead to an appointment, but I shall not announce this to the Laboratory until I receive confirmation that the negotiations are concluded. At this time it is important, from the point of view of harmonious relations in the Laboratory, that a fairly definite statement regarding working arrangements should be made. Both your cables [Additional Note 3] state that Bolton and Wild should be “appointed under Pawsey”. I wish ... to make a statement on fairly general lines on how I propose to organise the research program. [The main points were those discussed at the 4 October 1960 meeting to discuss “The Radio Astronomy Research Programme”, described below.<sup>71</sup>] ...

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<sup>71</sup> As an example of the mechanism to set the research programme, Pawsey wrote to Bowen: “It will be up to John and me jointly to encourage the most worthwhile projects; to interest appropriate persons in ones we initiate, or to filter proposals put forward by others. They will lead to a limited number of proposals of varying merits. The individual proposals will then be put forward by the individuals responsible for the investigation (including objectives and procedure) to a meeting of research staff ... at which the acceptance of the projects and allocation of telescope time will be discussed. I should have the right of veto, which I would never have to exercise on a project on which agreement was reached, and should be the person to decide in cases of disagreement.”

In view of the queries in my last letter, I have promised to give a preliminary talk to the Lab on the program at Parkes. [This meeting was held on 4 October 1960.]

Bowen replied on 22 September 1960<sup>72</sup>:

Your hand-written-letter of 8 September 1960 [the angry message] has only just reached me here in Washington simultaneously with your letter of 16 September. In view of the interchange of cables with Dr White on the 13<sup>th</sup>, there is no point in discussing prior events, except perhaps to say that up to that time, it was my intention to recommend to the Executive that we advertise two positions in the Radioastronomy Group under your direction, and to invite applications in the usual way. It was also my intention to do this on my return to Sydney after a full discussion with you and Dr White. However, Fred's cable of 13 September [see Additional Note 3] forced the issue and I think you will agree that in view of its wording I had no option but to make a definite recommendation in reply.

Bowen seemed to have dismissed the angry handwritten letter of 8 September 1960; he implied that he had no interest in discussing "prior events".

Both the cable exchanges and Bowen's 22 September 1960 seem inconsistent with the offer made by Bowen to Bolton in June; even White had been involved in the June and July correspondence. Bolton surely viewed the offer as a "done-deal" since he had resigned from Caltech in August 1960. Thus the claim by Bowen that he had intended to wait until his return to Sydney to discuss the new appointment seems disingenuous. Perhaps both Bolton and Bowen had made the arrangements in June 1960 without the CSIRO Executive's formal approval; then Pawsey found out via "rumour" in August 1960 that Bolton had been appointed starting in November 1960. Thus Bowen's claim "Fred's cable of 13 September forced the issue ... and I had no option but to make a definite recommendation" is inconsistent with the events of the previous months.

Two of Pawsey's colleagues also had comments about the Bolton appointment. On 1 December 1960, Frank Kerr wrote Pawsey<sup>73</sup> on his way from Amsterdam to Lisbon.

... [I]t is quite clear that John Bolton has been telling people all over Europe [during his visit to URSI in September 1960] that he is to be in charge of the GRT, and setting his plans in considerable detail ... At URSI, he is reported to have proclaimed to a group which included Lovell and Hanbury-Brown that he was going to be the "A.C.B. Lovell of the Southern Hemisphere". When John told Taffy this later apparently, Taffy said "Oh no

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<sup>72</sup> NAA C3830 Z1/47/BOL

<sup>73</sup> Joe and Lenore Pawsey Family Collection



you aren't, I am going to be!" ... John says that he had been actually persuaded into going back, and that it has not been his doing ... None of this seems to agree with the "official view" which was repeated at our last GRT meeting, and in particular **John gives no indication that he considers himself under your direction.** [our emphasis]

A telling exchange occurred in October 1960 between Jim Roberts and Joe Pawsey<sup>74</sup>. Pawsey had heard from Paul Wild (who had visited Caltech, September 1960) that Roberts was quite concerned about returning to RPL from Caltech in March 1961 after his two year visit to the US. On 1 October 1960, Pawsey wrote Roberts a letter from his home.. He summarised the events of 1960 at RP: Mills and Christiansen leaving RPL and Mills's new Super- Super- Cross project at Sydney University: "It seems that metre wavelength work will continue in Australia." Then Pawsey put forward an overly optimistic picture of the newly agreed upon management structure at RP: "In each case [GRT and solar] I propose a fairly careful committee type organization with me as chairman with a right of veto so that things have to be done very much in the open. There are quite clear difficulties but I hope I can make it work." Pawsey asked Roberts about his plans. Since he had experience in "theory, solar, interferometers, big dishes", Roberts had a bright future. Pawsey saw a complex management challenge ahead: "For limited objectives it [Pawsey's non-dictatorial style] is not as efficient as a dictatorship with restricted objectives. I think you win in the end. It definitely worked in the past. May it again."

Jim Roberts wrote from Pasadena on 26 October 1960: "After reading [your letter of reassurance] I felt quite a little relieved- I just don't know how much was being done completely behind your back ... I admire your optimism ... " Roberts did feel uncomfortable: "I hate any sort of political manoeuvring. I have told [Bolton and Bowen] that I do not want to be involved in any conflict." Thus, this was the reason to "shy off the big dish". But Roberts was keen to continue "the cosmic work" and Bolton's enthusiasm had been contagious at OVRO. Thus, he proposed to work on a mixture of solar and GRT projects. However, when he returned to RP, he did spend most of his subsequent career working on cosmic radio astronomy topics such as Jupiter decametric radiation, polarisation and propagation problems.<sup>75</sup>

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<sup>74</sup> *Ibid*

<sup>75</sup> A fascinating autobiographical, well-written text by J.A. Roberts "Have Gen Will Travel- Imperfect Images from the Life of a Radio Astronomer", privately published by Jim Roberts, July 2002. See NRAO ONLINE 49 for this invaluable text.

## MAN 1960- GRT steel works in Germany

In early 1960, Harry Minnett made plans at FFP (London) to return to Sydney by 21 May 1960. Bowen provided detailed information of the situation in Australia on 6 January 1960. Bowen was especially concerned about the lack of detailed drawings of the mesh panels for the surface.<sup>76</sup> On 1 April 1960, Bowen wrote with a detailed discussion about Minnett's long term plans after this return to the RPL. Bowen thought that he would only be occupied with the AEI and Askania engineers "on the servo and control systems and in the acceptance testing of the whole telescope" during the period from late 1960 to roughly April or May [1961] "when the telescope comes into operation as a research instrument". For the future, Bowen suggested that Minnett might either join the receiver group of Brian Cooper or join the research programme of the GRT under the Super-vision of Pawsey. Bowen was keen that Minnett take a break from the telescope design and construction issues: "... You have a complete break from telescope problems and associate yourself, perhaps on the analysis side, with one of the projects which are a going concern in the Laboratory."

On 2 May 1960, Harry Minnett and his wife were on a ship on the way back to Sydney. He wrote from Aden with a report of his last visit to MAN in Germany on 24 and 25 March 1960. The telescope was taking shape; some design issues at FFP were sorted out at the last minute before their departure from Tilbury. "I rather doubt if it will be practical [in the interim before completion of the telescope in 1961] to divorce myself entirely from telescope matters ...". He would certainly be full time preparing for telescope testing. For example,

... [T]he arrangements for computing the paraboloids of best fit and accessing errors should be looked into and agreed in advance. I doubt if FFP will take initiative in such details ... I have produced a draft programme, but further discussion and elaboration is best done in Sydney as FFP have not shown much interest in the details. With the above in mind, I don't think it would be profitable to become involved in a specific research problem for the present. As you know it is almost ten years since I was actively concerned with radio astronomy research and I now feel very much out of touch with the overall picture.

Minnett would look around at RPL, "before committing myself".

White's visit to Europe in June 1960 provided an opportunity to visit MAN in Gustavsborg to check on the progress of the GRT. Gilbert Roberts accompanied him to MAN Germany from London on 13 and 14 June 1960.<sup>77</sup> White wrote Bowen and Pawsey with a full report. The MAN

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<sup>76</sup> NAA C3830 A1/3/11/10 Part 5

<sup>77</sup> NAA C4633/3. Also White had reported to Pawsey (Pawsey family archive) in a handwritten aerogram from the UK on 15 May 1960: "Please tell Taffy lunched with FFP- Freeman, Roberts and the engineer

staff were beginning trials of the turret and the cylindrical hub with the associated AEI servo gear; trials of the alt-azimuth control were to be on 24 June 1960, a delay of 6-8 weeks compared to the 1959 schedule. (The master equatorial was not yet available.) The azimuth track had been levelled at the factory. The trials were to last eight weeks; then the telescope components were to be packed, ready for shipment from West Germany to Sydney. Mike Jeffery of FFP was to be present at the trials. On 22 June 1960, Bowen wrote to White that FFP had also done a thorough job of keeping RPL abreast of progress at MAN: "We are infinitely better off than appeared possible about a year ago and I am well satisfied. The important thing is that MAN is going at it with plenty of push and enthusiasm." Feelings of frustration with FFP seemed to belong to the past. "Tailtwister" visits to FFP in London by Bowen were no longer required.

White provided Bolton a summary on MAN activities in his letter of 4 July 1960: "I have just recently been to Frankfurt to see the turret of the telescope in its final stage of trial erection ... You probably know that the concrete tower is already completed in Australia." White reported to Bowen on 22 July 1960 (again from London, after discussions with Roberts) that the detailed tests at MAN had begun, likely to last two weeks. AEI (formerly Metrovick) were participating with the servo tests with their own personnel present.

Bowen continued his report to Bolton on 29 July 1960:

The telescope is at a very interesting stage. Weber, the MAN Director concerned with erection problems, arrived [in Sydney] last week, Mike Jeffery flew in this morning and some of MAN's erection gear is already en route from Germany. The turret and [cylindrical] hub will follow very shortly ...

MAN was still hoping for acceptance tests to occur in late April 1961.<sup>78</sup>

On 8 November 1960 (six weeks before Bolton arrived in Sydney), Bowen wrote Bolton in California<sup>79</sup>: "The more I see of the work MAN have done and are doing, the more I am convinced that we made the right choice ... [T]he derrick has been completed and the azimuth track is fitted to the top of the tower. The turret and hub structure have been off-loaded in Sydney and some of the parts are already on their way to Parkes. Things are really humming."

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who is coming out (liked him) [Mike Jeffery] ... I am going over to Germany with Roberts on 13 June ... Then they will be in midst of a test assembly of the turning [azimuth] gear. They have had troubles with the castings for the rails on the top of the tower ..."

<sup>78</sup> Also on 29 July 1960, Bowen wrote White with a few additional details. Weber had made most of the "arrangements for the arrival of his men and for the complete set of erection equipment which MAN are sending out. Jeffery ... is flat out getting the local arrangements [in Parkes] organised."

<sup>79</sup> NAA, C4633/3.

In Additional Note 4, we summarise the negotiations with NASA in 1960 for possible use of the GRT for tracking deep space probes.

### **Plans for the GRT- Sydney October 1960**

Soon after Bowen's return to Sydney on 27 September 1960 from the UK via the US, activities began at RPL for planning the detailed administration of the GRT. (Pawsey had initially suggested to hold the planning meeting on the day of Bowen's return; in fact the two meetings were held a week later on 4 October 1960.) Rumours, second hand knowledge of the arrangements with John Bolton, were floating around the corridors of RPL. There had been no official announcements. For example, on 5 August 1960<sup>80</sup>, Brian Cooper had written John Bolton about details of the receiver plans for the GRT: "Taffy [Bowen] tells that you may soon have a direct interest in the GRT and has asked me to let you know how the receiver program is shaping up. The program, which was decided some time ago, and which I have taken on in recent weeks may be summarised as follows ..." (A detailed summary of five projects going on at RPL followed.)

Even in early October 1960, Pawsey, the Assistant Chief of RP, was still not certain of Bolton's status as the future leader of the GRT. The detailed relation of Bolton and Pawsey remained uncertain.

On Tuesday, 4 October 1960, a meeting of the radio astronomy group at RPL was held: "General Arrangements Relating to GRT" lead by Bowen, followed by "The Radio Astronomy Research Programme, with Particular Reference to Parkes Radio Telescope Arrangements" organised by Pawsey.<sup>81</sup>

The Bowen document consists of a block diagram, an organogram. At the top, Bowen (Chief) and Pawsey (Assistant Chief) are shown, followed by radio astronomy (Pawsey) and Cloud Physics (Bowen). Under rubric "radio astronomy" there were four boxes: solar work (Wild), GRT (blank), receivers (Cooper), digital processing (Beard) and Misc (blank).

In the radio astronomy group, there will be two main research sections, one dealing with solar work under Paul Wild, the other dealing with researches [sic] on the GRT under a senior office yet to be appointed. It is proposed to have an advertisement for this position to invite applications in the usual way and to appoint the best applicant. We have been in touch with several [unlikely to have really happened] likely candidates.

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<sup>80</sup> NAA C4633/3

<sup>81</sup> NAA C4633/3 and W.T. Sullivan archive

It is already clear that John Bolton of Caltech will be an applicant and is highly likely to be appointed.<sup>82</sup>

The next meeting on 4 October 1960 was organised by Pawsey to refine the plans for the operation of the GRT, including equipment plans and major scientific programmes; for the first time, a **telescope observing program selection process** was proposed. In addition, the division of the scientific staff among the various GRT and solar programmes was to be determined. See Chapters 27, 31 and 33, “An Observatory Model for a New Radiophysics Laboratory, July 1954”.

Pawsey’s introduction on 4 October 1960 set the stage:

Our intention is (1) to progressively curtail pre-1960 projects, (2) to build up versatile facilities which will permit very flexible use of the Parkes telescope as soon as practicable, and (3) while observations are proceeding at Parkes, to undertake a new major solar development project under Wild ...<sup>83</sup> Subsequent plans must depend on the direction of development of radio astronomy. My guess is that there will be a demand for directivity greater than that given by the Parkes telescope itself, which will lead to our developing enhanced directivity systems [interferometry], possibly for the detailed mapping of restricted areas in the sky. I do not think we should commit ourselves on the desirable facilities (simple interferometer or more complex) until we are nearly ready to proceed.<sup>84</sup>

A number of receivers under development were described e.g. a 21 cm line receiver, the Brian Robinson Leiden paramp at 21 cm, a multi-channel 21 cm line receiver (backend) with narrow

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<sup>82</sup> The files show no evidence for any other candidates. As we have seen, Bolton had accepted the position on an informal basis earlier, June 1960. These statements would be a necessary part of the required formal appointment procedure. The second page of the Bowen document described the role of Harry Minnett (“in charge of all mechanical and operating details”) and Lindsay McCready (“officer in charge of arrangements at Parkes field station”). After May 1961 (expected completion date), the radio telescope was to become part of the radio astronomy programme, with a redefinition of the roles of Minnett and McCready.

<sup>83</sup> In a letter from Wild to Bolton of 21 October 1960 (NAA, C4633/3), Wild explained his early thinking of the instrument (“to obtain metre-wavelength pictures of the sun showing background and bursts” - Pawsey’s description used in the 4 October 1960 document. Wild wrote Bolton: “I am still thinking of the radio camera in terms of about 60 crude dishes [at frequencies below 200 MHz]. The instrument could go at Parkes, presumably close to the GRT facilities, or, if space does not permit some miles away.” This instrument, the Culgoora Radioheliograph of 1967, was to be located 400 km north of the Parkes telescope near Narrabri, NSW.

<sup>84</sup> Bowen’s interest in having an interferometer at Parkes is somewhat difficult to understand. He was always a strong supporter of moving the 60-foot Kennedy dish from Fleurs to Parkes and we speculate that this may have been Bowen’s response to a request from John Bolton to have an interferometer at Parkes for radio position measurement to make optical identifications.

channels for HI absorption and a 400 MHz receiver for a sky survey. In addition a series of test observations at 10 and 20 cm were suggested by Minnett to evaluate the high frequency performance of the dish. Scientific key programmes were also suggested: the galactic centre by Kerr, HI in external galaxies by Robinson and others, the detection of possible radio recombination lines at 1400 MHz by Murray, HI absorption by McGee and Murray, and the Magellanic Clouds (Mathewson) in HI and continuum. An innovative text followed, “selection of specific investigations” or a **telescope observing proposal selection committee**:

The procedure will be for members of the Parkes research team to select problems of special interest ... from the above list or elsewhere.<sup>85</sup> It will be the responsibility of the leader of the Parkes section [Bolton] and myself [Pawsey] to stimulate the selection. We shall also help arrange for necessary collaboration. The person concerned will then submit a research proposal (giving observations and ways and means) to the Parkes steering committee. This committee will consist of Bowen (*ex officio*), leader of the Parkes section (convenor), Cooper and research officers of the Parkes group. The committee will accept a proposal if it sees fit and will allocate telescope time. I [Pawsey] shall retain the right to make decisions in case of disagreement ... [A] limited number of projects have been tentatively accepted. Research proposals should be prepared for these. I am anxious to arrange for the preparation of future proposals. These should involve a reasonably limited observing time. They will be reviewed later, but are likely to be accepted ... This proposal is experimental and exploratory ... The objective is to make a truly flexible arrangement where the versatility of the equipment can be exploited ...<sup>86</sup>

### **GRT Receiver Plans – Discussions. Bolton and Brian Cooper**

A major source of conflict in the previous months had been the choice of receivers for the GRT; discussions had already started at RPL in 1959. In a letter to Pawsey of 1 December 1960, Frank Kerr reported that Bolton had suggested that the committee be disbanded. This was clearly a counterproductive idea since many decisions had already been made during the past year at

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<sup>85</sup> No mention was made of external members of this committee or of external users of the GRT. Bowen’s discussion of an “open skies” policy with the US foundations in the early 1950s was, however, acknowledged in 1961 discussions between Bowen and the Rockefeller Foundation (see Chapter 32 and NRAO ONLINE 47, 19 April 1961). Bowen described requests of overseas astronomers to use the GRT: “... [I]t is one of our objectives to throw the instrument open to any competent astronomer who has a worthwhile problem to tackle.” Bowen wrote the same message to Sir Walter Bassett after his visit in March 1961 concerning “open skies”.

<sup>86</sup> The proposed scheme was to schedule the GRT in one month blocks, with the possibility of longer term allocations. “Director’s Discretionary Time” was also to be possible. The minimum observing team consisted of an “astronomer” and a “radio man”, someone responsible for the equipment. The two were to share in the planning and interpretation of the observations.

RPL. The RPL staff still had no clear view of the role that Bolton was to play. The two meetings of early October 1960 had only partially cleared the air.

A confused discussion had begun on 5 August 1960, when Brian Cooper from RPL reported to John Bolton the receiver plans for the GRT.<sup>87</sup> Bolton responded with a critical letter questioning many of the decisions which had been made at RP. Most of the RPL staff members would have had no perception that Bolton was to be in charge of the GRT in a few months. But Bolton already had direct experience at OVRO. He dismissed the necessity of the 120 times 25 kHz spectral line backend: "I think this is a complete waste of effort." Based on current knowledge of the properties of the HI interstellar medium, we now recognise that 25 kHz (5.3 km/s at the 21 cm line) was only marginally suitable for HI emission studies and completely unsuitable for the narrower HI absorption lines. Bolton, thus favoured much narrower channels of 5 KHz (about one km/s) required for studies of the interstellar medium based on HI absorption. In addition Bolton also discarded the idea of an initial use of the GRT at 10 cm, 3 GHz until efficiency measurements had been made.

Based on contacts at the URSI meeting 5-15 September 1960 and the OVRO results obtained in 1959 by Radhakrishnan, Clark and Wilson, Bolton wrote a thorough description of his plans on 3 October 1960: "I have arrived at some fairly definite plans for the GRT. I believe that we should roughly divide the effort between investigations of the [radio] sources and investigations of normal galaxies- the latter both in continuum and the hydrogen line. 21 cm absorption spectra of sources comes in both these categories ..." With HI absorption it was possible to derive the properties of the interstellar medium as well as information on the distance of the background object. Bolton also insisted on a sky survey at 440 MHz of the southern sky, including the Magellanic Clouds and a survey to find 500 extragalactic sources. This was the genesis of the very successful Parkes Catalogue of more than 8000 radio sources and their optical identifications.<sup>88</sup>

Bolton was already considering

...projects involving the 210 foot as the principle element of more elaborate systems. One such system would be the addition of two smaller dishes for high precision positions where identification is suggested with very distant objects [referring to the identification of the radio galaxy 3C295, the most distant galaxy known at the time.], [Minlowski, 1960 ApJ voll 132, p.908]. Another major project would be the

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<sup>87</sup> NAA, C4633/3. Cooper had taken over the receiver group at RPL in July; Bowen had asked Cooper to contact Bolton: "Taffy tells me that you may soon have a direct interest in the GRT and he has asked me to let you know how the receiver programme is shaping up".

<sup>88</sup> "PKSCAT90 - the Southern Radio Source Database" Otrupcek, R. E.; Wright, A. E. *Proceedings of the Astronomical Society of Australia*, Vol. 9, Issue 1, p. 170, 1991

simultaneous combination of the 210 foot data with a number of close-by moveable small dishes and a number of radio-linked out-stations for synthesis of the brightness distributions of the sources. This investigation in my opinion is one of the most promising fields and our own first attempts [at OVRO] here have been very rewarding. It promises both the physics of the source mechanism and a method of continuing radio observations of the [high redshift] universe when we have to leave the optical correlation behind. For this sort of program, I believe we should use the highest frequency at which we can use the full aperture of the [GRT] ...

The suggested program involving the additional small dishes was implemented by moving the 60 foot Kennedy dish from Fleurs to Parkes in 1963.<sup>89</sup> The primary intention had been to use it as a connected interferometer to determine accurate positions in order to make optical identifications as Bolton had suggested. A secondary objective was to extend the successful OVRO program to measure the brightness distribution of southern radio sources. For the later project, Bolton had conceived an innovative modification of the OVRO interferometer by implementing a continuously variable baseline. This unique and highly flexible arrangement was successfully used to determine the structure of southern radio sources<sup>90</sup> and for spectral line absorption measurements.<sup>91</sup> However, the trailing cable used to connect the moving 60 foot telescope to the GRT did not have adequate phase stability to measure accurate positions. Fortunately, the pointing accuracy of the GRT alone was adequate; the interferometer was never used in this mode for accurate position determination.

Brian Cooper responded on 25 October and 9 November 1960. He was aware at this time of the conflicts: "With regard to your proposals for an observing program, I feel that this is properly a matter for committee discussion, and I believe that Taffy, in consultation with Joe, will be writing to you about this." Then in the second letter: "You are certainly coming with some interesting results in your extragalactic source work and I can appreciate that you are most anxious to press on with this on the 210 footer. However, the whole question of observing programs is a rather intricate one and we had best leave further discussion until you come over."<sup>92</sup>

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<sup>89</sup> Orchiston (2012), *Journal of Astronomical History and Heritage*, 15(2), 96-99. The 60 foot Kennedy antenna had been in operation at Fleurs since May 1961. The Parkes interferometer (the 210 dish and the 60-foot movable antenna) was to begin operation in October 1965.

<sup>90</sup> Ekers (1967), "The Structure of Southern Radio Sources", PhD thesis, Australian National University

<sup>91</sup> Goss et al (1970), *Proc ASA* 1, 332 and Radhakrishnan (1994) "Parkes 30 years of radio astronomy" ed Goddard and Milne.

<sup>92</sup> NAA, C4633/3.



## Pawsey-Bolton GRT Discussion- late 1960

In late 1960, as John Bolton was preparing to leave the US (12 December 1960), he wrote Pawsey on 16 November 1960. The letter contained a comparison of the Mills, Slee and Hill (MSH) 80 MHz catalogues with the newly obtained OVRO data at 960 MHz. Many of the extended sources in the MSH catalogue were not confirmed at OVRO or were smaller than 2 arc min; also the position errors in MSH were often underestimated. This may have been the trigger for Bolton to start a new discrete source survey using the Parkes dish.

The most striking paragraph in the Bolton letter of 16 November 1960 was about 3C 48. This letter (an aerogram) was written a month before the Bolton family departed from California by ship in mid-December 1960::

A couple of weeks ago I wrote to Taffy and said I thought we had a star [that is, detected a star in the radio]. It is not a star, Measurements [by Bolton] on a high dispersion spectrum [from the 200 inch, obtained by Allan Sandage] suggest the lines are those of Neon [V], Argon [III] and [IV] and that the red shift is 0.367. The absolute photographic magnitude is then -24 which two magnitudes greater than anything known is. The continuum is still going up towards the blue and may well be synchrotron. I think this must be the early stage of a radio galaxy, probably short lived and so very rare ... The source is 3C 48 and can be seen clearly on the 48 inch Schmidt plates... I don't know how rare these things are going to be but one thing is quite clear- we can't afford to dismiss a position in the future because there is nothing but stars.<sup>93</sup>

Pawsey replied<sup>94</sup> on 7 December 1960 with a frank discussion of their growing conflicts. The letter was posted in care of the P and O Steamship Company, SS Oriana in Los Angeles and also to an address in Honolulu, the first stop of the SS Oriana on the way to Australia. John, Letty and Peter Bolton were to depart on 12 December 1960. Pawsey discussed the "pseudo-star which turns out to be the brightest known astronomical object" (3C 48). He congratulated Bolton on his achievements in collaboration with Caltech optical astronomers. "You will find less facilities in this line available in Australia, but even more goodwill. Bart Bok [who was to leave ANU in 1966] is extremely interested and anxious to be cooperative. Until now, cooperation with regard to source identification has been unsuccessful [due to radio source position accuracies of at best a few arc min]."

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<sup>93</sup> Bolton has described the 3C 48 experience in 1990 (Bolton, 1990 "The Fortieth Anniversary of Extragalactic Radio Astronomy: Radiophysics in Exile", *Proc Astron Soc of Australia*, vol 8, page 381).

<sup>94</sup> NAA, C3830, Z3/1/X.

Pawsey described and enclosed the minutes of the meetings of 4 October 1960, establishing the division of responsibilities at RP. Pawsey tried to “clear the air”:

As you remarked in a recent letter to Taffy [not found in the archives], program discussions at a distance are too tricky. One picks on the wrong things. For example, you are critical of what you have heard [clearly Pawsey had seen the letters from Bolton to Brian Cooper] of our plans for a new multi-channel receiver. What I want is a receiver with facilities for narrow bands ... [for HI absorption] ... My guess is that you will agree with my policy. [This was the case, Bolton had suggested this to Cooper on 9 August] ... similarly I have heard gossip [via Cooper?] that you are very much against using 10 cm on the big dish ... [I]t appears imperative to me to get going soon at the shortest feasible wavelength [10 and 20 cm] ... The real point is that these programs require discussion here in Sydney and what goes on 10,000 miles away creates difficulties.

[Pawsey then provided advice about Bolton’s role at RP.] Programs involve both things and people and your role here should be a dual one: partly scientific leadership and partly individual research. It is terribly important that you should gain the confidence of the people under you, **both as regards scientific judgement and integrity and also from a personal point of view.** [our emphasis] You are familiar with this from your work in directing the Owens Valley Lab.<sup>95</sup>

Immediately, Bolton wrote (handwritten on SS. *Orcades* letter head) from Honolulu on 19 December 1960:

I am very much looking forward to my return to Sydney at RP. I hope I can contribute to getting the big dish and decimetre observations under way ... and later perhaps on the optical side from what I have gained in the last five years. The last few months have been somewhat difficult. A number of people from RPL have been through and there has been certain correspondence. Answers have been given to questions which when removed from context inevitably succeed in irritating someone ... [Bolton explained that he was against 10 cm use due to his doubts about the quality and over-size of the individual surface panels.] I have deliberately avoided writing to you as I felt it was foolish to run the risk of any pre-Sydney arguments. While 5 minutes of discussions across a table can reach amicable agreement, ten times the amount of letter writing can lead to all sorts of cross purposes. While there have been differences between us in the past, I believe, on what kind of GRT to build, I do not believe we have had had any

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<sup>95</sup> Pawsey ended the letter with a surprising message: Gilbert Roberts of FFP was in Parkes for a fortnight’s holiday with his wife. Pawsey asked “Will he last the distance?” Roberts did witness the completion of the GRT; he died 1 January 1978. (*Biographical Memoirs of Fellows of the Royal Society*, vol 25, 1979, p 477, by O.A. Kerensky)

differences on scientific aims. I would like to assure you of my complete cooperation. I shall do my best to avoid any unnecessary dissension within the group – or escalating any that exists. As I have said to Taffy, I am sure the GRT will succeed and once we begin a chain of research success and discovery – personal animosities quickly heal over. [Since we will only be one group- the users of the GRT], we will have to work a lot closer together than in the past ... It is always easier to dislike someone you don't know very well!<sup>96</sup>

Bolton ended his letter with a postscript on 3C 48, a disappointing conclusion that turned out to be incorrect.

The last news on 3C 48 as I left Caltech was – it is most likely a star- all astrophysicists had admitted defeat on identification of the lines and had agreed to publish same for open competition.

But as is now well known the redshift of 3C 48 was confirmed at 0.367 (which was the value originally suggested by Bolton in 1960 and then withdrawn) in 1963 by Greenstein and Matthews after the redshift of 3C 273 was determined by Schmidt based on the 1962 occultations of the radio source at Parkes<sup>97</sup>.

As 1960 ended, Pawsey could foresee a clouded future; he had lost three of his most trusted colleagues, he could see that his role as the leader of radio astronomy in Australia was diminished and he had perhaps lost the confidence of the CSIRO Executive. Was there a sense of betrayal? Was his management style obsolete? Should he “quit” or “hang on”? As Frank Kerr told Woody Sullivan in 1986:

Competition had to grow when radio astronomy became Big Science”... There were too many entrepreneurs for RPL to hold them anymore. It was inevitable that some would move [on]. It was a great pity that many of the people concerned didn't have a sense for this to happen without acrimony.<sup>98</sup>

The following year was to bring a new vision to Pawsey as he prepared to leave Australia for a new career in the US. In the end, Kerr asserts that the schism of RPL was due to the “Pawsey/Bowen” conflict. The two styles lead to the break of 1960-1961.

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<sup>96</sup> Bolton informed Pawsey that he had been quite ill since leaving California. He had been in bed with fever, treated with injections every four hours.

<sup>97</sup> See Hazard, Jauncey, Goss and Herald *Publication Astronomical Soc Australia* vol 35, p 6, 2018: “The Sequence of Events that led to the 1963 Publications in Nature of 3C 273, the First Quasar and the First Extragalactic Radio Jet”

<sup>98</sup> W.T. Sullivan archive

Pawsey's outlook can be summarised by a reflective exchange he had with one of his most trusted protégés Ron Bracewell. In mid-year 1960, Pawsey could confide in Bracewell as they discussed a long standing project to bring out a 2<sup>nd</sup> edition of the famous text book *Radio Astronomy*, published in 1954 by Oxford University Press; the second edition was never produced, even after attempting to recruit Paul Wild as a potential co-author. (NRAO ONLINE 53)

On 16 July 1960<sup>99</sup>, Pawsey sent a confidential letter to Ron (typed at the Pawsey home), as he described his state of mind in mid-1960:

Another intangible is my general feeling of unrest. A year ago we had what I was sufficiently egotistical to consider the outstanding radio astronomy group in the world. Now Alec [sic Alex] Shain is dead and Chris and Bernie gone. **I no longer see the future clearly.**

Ron Bracewell wrote back immediately from Stanford (27 July 1960):

All radio astronomers are puzzled as to the future in Sydney, and it is often discussed. The fragmentation that has taken place is an inevitable concomitant of maturity. I look forward to a rearrangement of the pieces that will favour continued successful development of radio astronomy in Australia and send my best wishes for your part in it.

The next year was to be decisive as Pawsey accepted the offer to become the second director of the US National Radio Astronomy Observatory in October 1961. This event and Pawsey's premature death in 1962 lead to a new era at the CSIRO Division of Radiophysics.

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## **ADDITIONAL NOTES**

Additional Note 1:

**“Desirable Lines of Research in Radio Astronomy in Australia”- Pawsey's plea for another institution to start a programme in metre wave length astronomy- the “Most exciting branch of radio astronomy” – February 1960**

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<sup>99</sup> NAA C3830 Z3/2, Part3.

This document accompanied the letter to Mark Oliphant from Pawsey in late February 1960. There is some overlap between the two.

The proposed RPL program is influenced greatly by the impending construction of the 210 foot radio telescope; it is not based primarily on the special interests of the individual research workers whose work has made Australia famous in radio astronomy. What effect is this likely to have on our position in the world scene? Firstly the opportunities available to the 210 foot radio telescope are sound. This telescope, if its main beams are sharp so as to permit work at 21 and 10 cm will be the largest in the world (the Manchester dish is distorted so as to be relatively poor for these wavelengths). The 21 cm possibilities are excellent and we have men experienced in H line work who are anxious to continue using the Parkes aerial. The short wavelength continuum [decimetre range] has so far contributed little to radio astronomy because equipment has been inadequate to cope with the weak cosmic signals. With the 210 foot dish and the new, much more sensitive receivers we plan to develop, it should be possible to obtain more detailed information than that currently available on metre wavelengths. The 210 foot dish should give details corresponding to the old Mills Cross at about 50 cm and correspondingly exceed this at shorter wavelengths. However, even larger paraboloids are planned overseas (600-foot telescope in the US about 1962) [the Sugar Grove antenna was never completed].

[Pawsey then pointed out that the decametric work of the late Alex Shain and the metre work of Mills would not be continued at RP.] ... [I]t seems unlikely that sufficient facilities to undertake new metre wavelength programs will be available for many years. It will be difficult enough to provide Paul Wild's solar program with adequate support...

The position with regard to the metre wavelength work is [challenging]. Mills's preliminary work with the original Cross has been essentially completed and the future objectives are now clear. The outstanding physical problems related to these observations are (1) the study of the distant observable sources (with cosmological implications) and (2) the study of galactic structure. For the first case it is clear that the original Mills Cross does not "see" far enough to give significant cosmological implications. From the results, Mills thinks that significant results require a large improvement in the techniques which he thinks requires factors of 2 or 3 orders of magnitude.

The 210 foot paraboloid should give an order of magnitude improvement but from Christiansen and Mills combined experience using high resolution techniques we feel sure that a properly developed metre-wavelength experiment can give at least a further order of magnitude, perhaps more. This sort of improvement offers a reasonable

prospect of extending the limits of observation so far that major cosmological effects should become apparent. It would also provide a major advance in investigations of galactic structure. The claim is that properly designed metre wavelength survey equipment should be able to see further [sic] and to resolve finer detail than can any big paraboloid in the foreseeable future.

The technical position is as follows. Using current techniques we think it possible to design a survey instrument having a resolution of 3 or 5 minutes of arc and adequate sensitivity.<sup>100</sup> The requirements are exacting and an extensive design study would be required. However new forms of receivers (parametric amplifiers) and new forms of survey instruments (Paul Wild) are being studied and it is possible that the incorporation of new techniques might lead to substantial savings (or to a decision to increase performance goals). [If system noise were a problem it might have been possible to move to a longer wavelength where the sources were stronger.] The paraboloids are inflexible in size and an increase in wavelength carries with it a decrease in angular resolution.<sup>101</sup>

In addition to the survey instrument, auxiliary equipment to measure angular sizes is desirable.

This project is beautifully complementary to the 210 foot paraboloid continuum work. Firstly, the two between them give high resolution spectral information. Secondly, with regard to timing, the two would provide a leap frogging progress in ultimate range and resolution. First the paraboloid, then the metre wavelength equipment.

I consider it most desirable that a project along these lines should start in Australia now. We are now in the forefront in this key branch of radio astronomy. If we do not act now we shall probably lose this position. Mills will probably go elsewhere, and we may never regain it! In the branch of radio astronomy, we have [no] competition [through-out] the world.

The present facilities of the RPL are not adequate to initiate this project. It has been decided that expansion of these facilities is undesirable. It seems very doubtful to me that the situation should change in the next few years. Therefore, if the project is to be

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<sup>100</sup> The Mills Cross would have super-heterodyne receivers. At one or two metres wavelength, the cross would require dimensions of 3km by 15 m.

<sup>101</sup> Mills had misrepresented the advantages of single dishes; a major property of the big dish was **flexibility** to perform numerous observations over a wide wavelength range.

undertaken in Australia I believe it must be sponsored by some organisation distinct from the RPL.

Additional Note 2.

### **Lord Casey and the GRT in 1960.**

Robert G. Casey (1890-1976) was made a life peer in January 1960; he resigned from politics on 4 February 1960. He had been the Minister for the CSIRO from 1950 to 1960, a major supporter of the GRT. He played an active role in the fund raising from the US foundations (see earlier Chapters 38 to 45.). On 8 March 1960, he and Sir Walter Bassett went to Parkes via a Cessna 310 from Sydney airport. The tour of the GRT site was organised by Bowen. Fig 1 shows Casey Bowen, McCreedy and others in the unfinished tower of the GRT at Parkes including the Mayor of Parkes, Mr. A.C. Moon, who was portrayed in the film *The Dish* (2000), directed by Rob Sitch. In real life, Moon was a man<sup>102</sup> “who likes his constituents to believe that he was personally responsible for persuading the CSIRO to site the telescope in Parkes”. Bowen continued, telling Casey that “Moon has a forceful personality, has been most helpful to us and is proud of the fact that the telescope is going to Parkes. The Shire Council shyly point out that the telescope is not in Parkes but in Goobang Shire and therefore in the areas under their jurisdiction. This has never caused any difficulty but is a point we have to be careful about in speaking to the local authorities.” The details of the 1960 visit are also summarised in ESM\_30.2.

Lord Casey wrote Bowen an effusive letter of thanks after the visit of 8 March 1960. On 11 March Casey wrote Bowen. “Walter Bassett and I were greatly interested to see the progress on the GRT site. We both realise your part in the whole project- and that it would not have matured but for your keenness and drive and ability. I was a little inhibited, by one thing and another, in what I said at the luncheon in Parkes as to your part in all this, but I made it clear in private conversation with Moon, Marshall [Goobang Shire President and Alectown farmer], etc. .. I look forward to seeing the GRT round the end of the year.”

On 21 December 1960, Bowen organised a second visit of Lord Casey to Parkes, 21 December (letter from White to Bowen 2 December 1960. By this point MAN had made substantial progress at Parkes; all the steelwork was on site, the azimuth track had been installed and MAN had started fabrication of the ribs. There was additional gossip:

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<sup>102</sup> Bowen explained to Casey on 3 March 1960. NAA C3830 Z1/14/A Part 2.

Roberts [Gilbert of FFP] arrived (with his wife) from Bermuda a few days ago. He is now out at Parkes “seeing that they get started on the right lines”. As usual, he is not at all clear how long he intends to stay, but some mention has already been made about Christmas dinner.

A photo of Roberts in December 1960 is shown in Fig.2

Additional Note 3.

**White, Bowen and Pawsey (Cable) communications 13 to 21 September 1960 – “Bolton’s Appointment”**

To Bowen in London, from White in Sydney on 13 September 1960, cable no 2872:

Believe you are causing uncertainties and rumour in RPL by delaying definite statement about your intention of naming Bolton and strongly recommend that you make definite recommendations soon to Executive reappointing Bolton as SPRO (Senior Principal Research Officer) under Pawsey. I have discussed this with Pawsey and he agrees.

On same day (13 September 1960), Bowen replied to both White and Pawsey from London, cable no.1257:

1. Reply to your 2872 have interviewed Bolton<sup>103</sup> in London and most strongly recommend his reappointment to staff RP. Suggest he be nominated scientist-in-charge radio telescope. With CRO (Chief Research Officer) rank under Pawsey.
2. Further recommend that Paul Wild be given exactly corresponding position in charge of solar work also under Pawsey.

Also on 13 September (1960) an immediate reply was sent by White to Bowen in London, cable no. 1299:

Executive appointment Bolton top senior principal research officer and level with Wild at this stage but willing to review this later. Request you agree not name Bolton officer in charge until your return for discussion.

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<sup>103</sup> Brian Robinson told Goss in the 1970s that he had by chance been at ASLO in London working in an adjacent office; he accidentally overheard most of the interview between Bolton and Bowen. Bolton was in London for the 1960 URSI Congress.



The cable exchange concluded after the arrival of Bowen in Washington (for a visit of a few days) on 21 September 1960 to White:

Many thanks your 1299 [13 September] reference Bolton- STOP- Agree no further action pending my return [on 27 September 1960].

Additional Note 4

## **NASA GRT 1960**

As the GRT neared completion, a number of contacts were made with NASA concerning *possible use of the new aerial to track space craft. Jodrell Bank had been used by the US government since Sputnik in 1957; in late 1958, Jodrell Bank was used at 960 MHz to track the US Army/JPL Pioneer-3 mission that managed to reach about 1/3 the distance to the moon. On 22 June 1960, Bowen wrote White<sup>104</sup>: “I am already in touch with NASA and they have expressed keen interest in using our dish for deep space probes ...”* CSIRO had already made the decision that they would not involve NASA in the design and construction of the GRT; negotiations were based on the possible future use of a complete Australian-owned aerial. . Bowen wrote White:

NASA was waiting for a proposition from us ... if you meet any of the people concerned when you are in the USA, you might indicate our continued interest. As you know, I have always been of the view that collaboration with them is important scientifically and a heaven-sent opportunity of augmenting the finances for Parkes ... we are hoping to divert half our radio astronomy budget [per year] to the research programme of the radio telescope, that is about £A 120,000. With luck we might conceivably acquire a comparable sum from these other sources. When the day comes, we shall have to play our cards very carefully to see that the money is devoted to our research programme and does not get mopped up by the Treasury.

A month later, Bowen continued his discussion with White after hearing of the lavish sums (£2,000,000) NASA was planning for the 85 foot (25 metre) Blaw-Knox dish for space tracking at Woomera, South Australia. “On the question of NASA and the possible use of the [GRT], I agree that life would be quieter without them. However, the possible financial gains are too good to miss ... With this kind of money going around, we cannot afford to be standoffish.” Finally Bowen visited JPL with Bruce Rule when he was in Pasadena, mid-September 1960. He heard that NASA was “... going for three dishes in the 200 foot class [similar to the GRT]. This is

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<sup>104</sup> NAA C3830 Z1/7/B/2 Part 1.

altogether a highly interesting situation.” These plans were the genesis of the NASA Deep Space 210 foot (64 m) tracking stations in California, Australia and Spain



Fig. 1 Bowen shows the former Minister for the CSIRO R.G. Casey the incomplete tower of the GRT in 1960. March 1960. Left to right, Bowen, unknown, McCready, Casey, unknown and unknown. (last 2 may be Herr Putz and Bassett. ????) Credit: CSIRO Radio Astronomy Image Archive 5930-54.

Below Fig 2 Gilbert Roberts at Parkes Dec 1960- Credit: Joe and Lenore Pawsey Family Collection

