

NRAO ONLINE 45

1959-“Taitwister II”, GRT Construction – MAN (Maschinenfabrik Augsburg-Nürnberg) , Plans for GRT Science

Epigraph:

Roberts at FFP to R.G. Casey, Minister for the CSIRO 13 February 1959:

The implication ... that we have not been doing our best for you is completely unjustified. It strikes at the root of the confidence which should exist between client and consultant ... To hold me to the date [6-9 months for tenders] I gave more or less “off the cuff” and to infer that the delay of 3 or 4 months is the fault of me and my firm is, to say the least of it, unfair.

By December 1958, Bowen’s Operation “Taitwister I”¹ had come to an end; the problems with FFP and the future of the contracts had been identified. In the first months of 1959, Bowen returned to the US and the UK as he began to break the logjam; by July 1959, a contract with MAN (*Maschinenfabrik Augsburg-Nürnberg*) AG had insured that the GRT would be completed by the end of 1961. Bowen’s energetic activities from the end of 1958 to mid-1959 were key in the complex GRT saga.

After Bowen’s arrival in Sydney on 23 December 1958, many activities and conferences were organised for January 1959.² On 21 January 1959, Bowen was to meet with White, Walter Basset (consulting engineer and member of the CSIRO Executive) and R.G. Casey, the Minister for the CSIRO, for a full report on his visit to the UK. Major items to discuss were the plan of action for the next month governing interactions with FFP, as well as the preparation of the official letters from the CSIRO and the Minister to FFP. Bowen also started planning his return visit to the UK via the US starting on 7 February 1959.

In his report to CSIRO, Bowen reiterated his frustrations with FFP: “Freeman Fox have clearly not treated the project with the vigour and sense of urgency expected” and “there is evidence

¹ Jack Roderick, Prof of Civil Engineering at Sydney University, invented the term on 16 January 1959 in a letter to Bowen: “Many thanks for letting me see the various letters concerned in your operation ‘taitwister’: I think you have done an excellent job in the circumstances. One can offer explanations for the way in which these consultants [FFP] go about their business, but the important thing as you point out is to get things done quickly despite these shortcomings.” “Taitwister I” is used by us to describe the trip in 1958 and “Taitwister II” for the trip in 1959, starting 22 February 1959 in London.

² NAA, C3830, A1/3/11/1, Part 12.

that the project was not pursued very actively from the time of Roberts's return from Sydney in February-March 1958 until perhaps [mid-year 1958]". Bowen predicted that when the Metrovick contract appeared in early 1959, the costs would be "up by 100 per cent".³ Before the meeting Bowen provided a list of key points that should be included in the proposed "official" letters from CSIRO and the Minister to FFP. Bowen suggested that the CSIRO Executive write their own letters to FFP, ignoring his own drafts! "On the whole, it might be better if I did not draft it for you; a letter of this kind would carry more weight if it did not use any of my words and phrases".

Bowen was in a foul mood when he wrote Roberts on 15 January 1959: "I cannot say that [the CSIRO Executive] are very pleased with the rate at which the telescope is progressing." He told Roberts that he was soon returning to London, with the expectation that the Metrovick tender would be far in excess of the roughly £ A 500,000 predicted by FFP. Bowen ended his letter to Roberts with a warning: "I am looking forward to coming back to London, but I am not exactly looking forward to the task. I expect we are in for a difficult time."

An especially acute problem was the search for an alternative contractor for the master equatorial to replace Grubb Parsons; their long delivery time of about 2 ½ years was the major road block to completing the GRT by the end of 1961.

Bowen told Roberts about Harry Minnett's⁴ visit to the US from London (from 17 January to 29 January 1959). Minnett was getting advice from Bruce Rule and John Bolton of Caltech, John Findlay of NRAO and Ron Bracewell of Stanford. Minnett told Bowen that the master equatorial could be built in the US at a comparable price compared to Grubb Parsons, with, however, a delivery time of about a year instead of 2 ½ years.⁵

³ Bowen also was anticipating that CSIRO would have to "canvass the foundations for more funds".

⁴ NAA C3830 A1/3/10/11, Part 4. Minnett to Bowen on 9 January 1959 before his departure to the US. As far as the Master Equatorial (ME) was concerned, Minnett pointed out the tricky issue of the ME design: "Although the basic patent on the ME system is held by Barnes Wallis and Vickers Armstrong Aircraft Ltd., Grubb Parsons were responsible for the optical concept [which was adopted]. All existing drawings of the ME ... are therefore by Grubb Parsons. Clearly we cannot hand this detailed information over to other organisations. I therefore plan simply to explain what the ME has to do, its general form and to specify our performance requirements."

⁵ Minnett was also visiting potential US vendors for the GRT in California. During the visit, nine firms had expressed interest in the master equatorial; Rule reported to Bowen that "four were brash enough to give approximate cost and time estimates ..." One of the firms visited was the well-known telescope manufacturer Boller and Chivens in South Pasadena. Bowen was especially pleased by the reports of the vastly shorter delivery times in the US compared to the 2 ½ years proposed by Grubb Parsons: "It does look as if we will have a big stick with which to beat Metrovick [and Grubb Parsons] and they will have to come down on their delivery date."

Casey's letter to FFP (27 January 1959)⁶ did not pull any punches:

I regret to have to tell you that we are not satisfied that the progress since that time [Roberts's visit to Sydney in February 1958] has been consistent with the time-table that Mr Roberts led us to believe would be practicable. We were convinced by him that the dates he suggested could be met.

Casey did point out that the CSIRO found the design of the GRT "excellent" and that "this instrument will be one of the finest as well as one of the largest radio telescopes in the world". A major complaint was the unanswered letter from CSIRO to FFP of the previous year, 25 February 1958. In addition to telling FFP that the Australians had decided on a 210 foot dish, CSIRO had requested the London firm to prepare the "detailed design and specifications" of the GRT, "preparatory to the invitation of public tenders". The deadline for the work outlined was mentioned as 6-9 months, i.e. at the latest by November 1958!

A key request in the letter of 11 months earlier was that FFP "act as Consulting Engineers and outline the duties to be performed, the responsibilities to be carried [out], and the terms under which such services would be performed". The bottom line was: "[A]lthough we are aware that work has been proceeding, we have so far not received any reply to this letter".

The complaints from CSIRO continued. Due to the delays at Metrovick, it was clear that the estimates of the costs and delivery times would not be available until mid-February 1959.⁷ Casey pointed out that due to the investments of many stakeholders (Carnegie, Rockefeller, the Australian government and private donors in Australia) it was important "to see to it that we do not incur financial embarrassment. I can do this only if I receive, with the help of your firm, the most realistic estimates of costs". In summary, Casey asked for a response to the earlier February 1958 letter and requested an "indication of your views as to how the difficulties of the present situation might be overcome". Casey mentioned that Bowen was to return to the UK by 22 February 1959 to continue the discussions with FFP the following day.

⁶ NAA, C3830, A1/3/11/1, Part 12. Bowen reported to Minnett about the events of January 1959 in Australia after his report of the discussions with FFP of late 1958: "[Casey and White] were a great deal more perturbed than I expected and reacted quite vigorously." Casey had heard rumours from Lord Chandos about the "slap-dash procedures of FFP... [A] stiff letter is on its way to FFP, signed by one of its most responsible Ministers [Casey]. It is a good deal stiffer than I would have written and is going to give them a considerable jolt. You may therefore see some unusual activity among the Partners in the near future." Bowen pointed out that Minnett was in a position of deniable accountability: "You are ... in a fairly comfortable position- you know of the existence of the letter from the Minister, but you don't know what is in it."

⁷ Casey also added: "We feel that we have not had as yet from your firm satisfactory statements on these important points [costs and time of delivery]."

Given the critical tone of the Casey letter, the strong, defensive responses of both FFP and Roberts (two letters) posted in London on 13 February 1959 to Casey are not surprising. They did apologise for “omitting to reply to your letter of 25th February (1958!) dealing with the conditions of our proposed appointment as consulting engineers”.⁸ Their excuse was the remaining uncertainty of the Metrovick response and the degree of responsibility this firm was willing to accept: “It did not occur to us that you would be urgently requiring a reply to the letters and Dr Bowen did not refer to the point on his visit in November [1958, Tailtwister I].” FFP asserted that the main reason for the delays (over the estimate of 6-9 months) was the completion time for the design of the instrument, required to keep the costs to an acceptable level. FFP mentioned “[R]adical economics would have to be affected ... if any further decreases in the size of the dish [below 210 feet] were to be avoided ... Our aim has been to get as firm a price as possible for the 210 foot [GRT] ..., at the same time ensuring ... that the firm price will be within your means ... [There] has never been any consideration ... of attempts to save time by spending more money.”⁹ In summary, FFP defended themselves against the three main criticisms: (1) The longer delays: “We can only say that we do not see how we could have done it more quickly, and we do not believe that anyone else would have obtained a result in shorter time”; (2) The long delays with Metrovick: “This has been due largely to effects outside our own control”; (3) Lack of leadership and enthusiasm: “We would point out that work of this kind is not helped by large numbers of staff. It requires a particular quality of brain work and all the most suitable brains in the firm have been applied to it.”¹⁰

FFP saved their most pointed response for a parting shot:

Finally may we say that while we understand your anxieties, we regret the note of recrimination in your letter, which we feel quite sure we have done nothing to deserve. The best efforts of which we are capable have gone into this work and if you are not satisfied with the progress that has been made we can only assure you that we could do no more.

Roberts’s letter contained a weakly defended justification, written in a defensive tone:

The implication ... that we have not been doing our best for you is completely unjustified. It strikes at the root of the confidence which should exist between client and consultant ... To hold me to the date [6-9 months for tenders] I gave more or less “off

⁸ NAA, C3830, A1/3/11/1, Part 12.

⁹ FFP did admit that Metrovick had only received the final specification at the end of December 1958.

¹⁰ Also FFP claimed that the Metrovick and Grubb Parsons engineering staff had been inspired to work harder by FFP in the face of opposition from the two firms’ managements.

the cuff” and to infer that the delay of 3 or 4 months is the fault of me and my firm is, to say the least of it, unfair.

Clearly at this time in early 1959, the relations between CSIRO and FFP were at a low point.

Bowen’s Trip to the US and Europe 1959 Tailwister II- Delayed Metrovick Contract 4 March 1959

After leaving Sydney on 7 February 1959¹¹, Bowen spent two days at Stanford visiting Ron Bracewell and then a few days at Caltech. Bruce Rule at Caltech had found a number of potential prime contractors (mainly in California) who would possibly be interested in the GRT. In the beginning Rule had contacted 20 firms: “The interest is high”, he reported to Bowen on 30 January 1959. Bowen interviewed 6-8 firms and in the eastern US, a similar number. On 24 February 1959, Bowen wrote Dick Emberson, Assistant to the President of AUI, thanking him for his help in organising the interviews in the US, eastern region. Bowen mentioned that the list of potential bidders was: Judson Pacific-Murphy (who had been the contractor for the 120 inch telescope at the Lick Observatory), Consolidated Western Steel (who had the contract for the ill-fated 600 foot telescope at Sugar Grove, West Virginia), Bethlehem Pacific Steel, Loewy-Hydropress, D.S. Kennedy and Co., General Bronze, Blaw-Knox¹² and E. W. Bliss (prime contractor for the 140 foot of NRAO). Of these, Loewy-Hydropress, Bliss and Judson-Pacific eventually submitted tenders for the GRT later in 1959.

Bowen was quite enthusiastic. On 13 February 1959, he wrote White and Pawsey: “[I] have found a remarkable interest in radio telescopes compared even with that which existed last December [1958].” Bowen reported that by early 1959, \$35 million had been let for contracts for large aerials to be used in various space tracking endeavours. “The main reason is that they are no longer regarded as rare scientific instruments but have suddenly become of tremendous practical importance in the missile and satellite field”, in the post Sputnik (October 1957) era. Although the US firms’ tenders in mid-1959 would put them out of the running for the GRT contract, Bowen’s US experience provided useful information about the possibilities of finding a prime contractor outside the UK. In addition, the enthusiastic response in the US was a major morale booster for the Australians.

Bowen summarised his first impressions to White and Pawsey: “At this rate the three years which have elapsed on the design of our telescope and the 3 ½ years we are being quoted for

¹¹ NAA C3830 A1/3/11/10, Part 4. Bowen to Minnett on 6 February 1958.

¹² The Blaw-Knox design used the Carnegie Institute of Washington design; the firm had made a number of 85 foot telescopes for the University of Michigan, NRAO and NASA.

completion from the UK are ludicrous ... This [rapid development in the USA] leaves me speechless and further comment is unnecessary. Clearly we have to inject this kind of enthusiasm into our project in some way, and draw on the energy and resources of this country [US] to the very utmost.”

After his arrival in the UK on 22 February 1959, Bowen waited on the Metrovick tenders, which were to arrive 1 ½ weeks later (4 March 1959). During this period he had an instructive visit to the Jodrell Bank 250 foot radio telescope¹³, where he met Bernard Lovell and R. Hanbury-Brown. Bowen was impressed with the newly commissioned radio telescope, which worked well at 400-500 MHz (although with pointing errors of 3-5 arc min while tracking). At the hydrogen line, 21 cm (1420MHz), the nature of the dish was “practically useless for astronomical purposes ... Lovell would be subject to less criticism if he recognised [this low efficiency at 21 cm] and concentrated his attention ... on the frequencies at which the dish can do a good job.”¹⁴ Bowen felt good about the GRT design, sensing that “our telescope [GRT] represents a real improvement on that at Jodrell Bank.” A major lesson that Bowen learned from the mistakes made at the University of Manchester was the absolute necessity for a prime contractor. He expressed a strong view that a telescope could never be built without a prime contractor, responsible for the whole job. He doubted whether any consulting engineering group, however competent, could coordinate the work to complete the GRT, and this would be especially true in their case if the telescope construction was supervised from a distance of 10,000 miles.

Bowen was vastly relieved when the tenders from Metrovick arrived on 4 March 1959; the costs and delivery times of the subcontractors Grubb Parsons and Arrol had been available earlier. The period 2-6 March was a period of confusion, a “Keystone-Cops” experience (a completely chaotic series of mishaps and misunderstandings) at FFP¹⁵. Originally Bowen had been promised the Metrovick cost estimates on 15 February 1959. Since this deadline could not be met, Bowen arrived in London on 22 February 1959 from the US, having been promised the cost figures on 27 February. Bowen was, as always, frustrated with FFP: “... [A]fter 3 ½ years,

¹³ NAA, C3830, A1/3/11/1, Part 12. Bowen to Pawsey 3 March 1959.

¹⁴ Rod Davies was struggling to observe at 21 cm, “worrying about lobe patterns” (see Chapter 29, the visit of Pawey JLP and Minnett). Don Mathewson, a PhD student from CSIRO RP, described some of his observations at 75 cm of a region near M31- the Andromeda Galaxy. He described that: “One team can produce a useful scientific paper on the basis of one week’s observing, followed by four week’s analysis and two weeks of writing. This may be optimistic [from a modern perspective the times seem vastly underestimated], but is an indication of the pace which could be set with a steerable telescope working within its capacity.” The forward gain of the Jodrell Bank 250 foot antenna at 21 cm was only comparable to that of a standard 25 m aerial.

¹⁵NAA, C3830, A1/3/11/1, Part 12. 7 March 1959, the long “Keystone-Cop” letter from Bowen to White and Pawsey.

FFP was still fiddling around with problems of the attachment of the mesh.” The estimates did not arrive on 27 February 1959.

On Monday (2 March 1959), receipt of the figures was postponed until Tuesday, followed by the same delay on Wednesday. Bowen:

On Wednesday I held a pistol at various heads and said if the figures were not forthcoming by noon our negotiations with FFP could be regarded in a very parlous [sic, perilous] state. The estimated costs appeared during the next hour and were as given in my cable [6 March 1959 to White and Pawsey in Australia]. No delivery date was quoted, but we were told this would be telephoned to FFP by the end of the day. At 5:15 pm Roberts rang to say that he had received these dates from Metrovick and wanted to talk to me about them. I went to see him at 5:45 pm but by that time he had forgotten [!] what the figures were, and further discussion was fruitless. On Thursday morning I asked Harry Minnett to telephone Metrovick himself and find out [the dates].

The total cost of the GRT reported by Metrovick was £A 715,000, compared to the available £A 500,000 (the earlier estimated cost produced by FFP). The time to completion of about four years was equally disappointing, implying the operation of the GRT only in 1963. On the next day, Wednesday 4 March 1959, Bowen could not find Roberts and went to see Ralph Freeman with a series of ultimata. Bowen reported:

(1) As reported in Casey’s letter of 27 January 1959, CSIRO was “still a very dissatisfied client of FFP”.

“... [The] dealings with Roberts were becoming increasingly difficult and that his idiosyncrasies made it extremely hard to make progress. [On the positive side, CSIRO was impressed with the design.] ... but it was nearly impossible to have a business discussion with him. The same complaint had also been made by Metrovick. I said that we would much prefer to deal with someone like himself [Freeman] who listened to what was being said and gave firm answers.” Freeman was sympathetic, but the partners of FFP had the same problems in dealing with Roberts. “However, he did not feel that he could intervene at this stage.”

(2) CSIRO intended to go out for competitive bids and a prime contractor, especially from US firms. Freeman agreed with this plan: “He seemed to agree that we were wasting time on the present negotiations [with Metrovick]”.

At this time, in March 1959, CSIRO gave up on Metrovick as the main contractor; FFP could continue the negotiations if the delivery time could be cut in half. CSIRO demanded that tenders be invited on a competitive basis within the UK, Europe and the US. Tenders were to be received only from firms who would act as a prime contractor. (CSIRO hoped that parts of the project such as the dish and the tower could be sub-contracted to Australian firms.)

On Friday 6 March 1959, Bowen reported to White that Roberts was still missing but “his wife thought he was somewhere in Essex. I finally caught up with him about 5:30 pm and I told him my conclusions [perhaps on the telephone].” A confused conversation occurred. Bowen was completely exasperated. During the next week, he was to try again to convince Roberts to understand what CSIRO wanted in terms of the tendering activities.

[I will] try again ... to get our wishes across, and to get Roberts to issue simple instructions within FFP necessary for us to get [within a week, reproductions] of a set of technical specifications and drawings for each of the contractors we expect to bid. If it does not work out, I will simply [demand a meeting or write to the partners of FFP].

Bowen finished his letter of frustration to White with a text containing some metaphorical exaggeration:

I can quite understand why this project has taken such an appalling time. The procedure is never under any circumstances to cross a bridge when you come to it, but to camp on the near side, indulge in a round of lunches, telephone calls and trips to the country, by which time the bridge has washed away anyhow.

On 6 March 1959, Bowen asked White’s permission to (1) canvas for extra funds from US foundations and (2) to go out for the competitive bids from non-UK firms in order to obtain a better price and an expedited delivery. Casey and White immediately cabled their approval as long as FFP would continue as consulting engineers. Clearly it was too late to find another firm of consulting engineers who might replace FFP.

White also wrote Bowen on 11 March 1959 with a question about the possible use of the GRT to track satellites or space probes; Casey had, in fact, raised this question earlier with White.¹⁶ Casey knew the Americans were using Jodrell Bank for tracking satellites and that there were plans afoot in 1959 for a NASA tracking station with a 25 metre antenna at Woomera in South Australia. White wrote to Bowen (11 March 1959):

My view would be that this telescope of ours must be designed principally for radio astronomy. However, if possible, one would like to be able to track those space vehicles

¹⁶ NAA, C3830, A1/3/11/1, Part 12.

as this might be an important selling point to the Government if we want more money from the Commonwealth... The Minister [Casey] reminded me that when he pressured us for practical uses of the telescope when we were originally approaching the Government we strongly denied that these possibilities could be clearly defined. He now points to this as a “practical” outcome. In his note to me he states “I don’t know what attitude Bowen would take to it. He might well tend to think it was a chicken-feed sideline that would deflect him and his radio telescope people from their real task of piercing the mists of outer space.”

On 24 March 1959, Bowen responded to White with detailed comments about satellite tracking. He pointed out that nearby artificial satellites of the earth (e.g. Sputnik, Explorer I etc.) did not require large aerials for the telemetry.

Solar and lunar probes present an entirely different problem to the radio physicist. Once they are reasonably distant from the earth the only [his emphasis] method of tracking them and receiving their information is by means of a giant radio telescope, the larger the better. This is an intensely interesting field in which we shall certainly become deeply involved, both from a scientific and practical point of view. I am sure the Minister will make good use of this fact in dealing with his colleagues.

Bowen did foresee that the Parkes GRT could play a role; his expectations were to be fulfilled in the next decades with participation in the Apollo missions starting with Apollo 11 in 1969 (20 July 1969) and numerous other NASA and ESA missions such as Mariner 2 and 4, Giotto Galileo, Cassini-Huygens and the Mars Rover Opportunity in 2012.

Tender Process- March –June 1959

On 12 March 1959, Bowen wrote FFP outlining his concept for competitive tendering. CSIRO had decided that the servo control system could be provided by Metrovick after all “if this proved to be the fastest and most economical procedure”. Quite a number of tasks were to be provided on a short notice by FFP, including the organisation of conferences with the prospective firms to discuss technical specifications and drawings.

An important conference occurred on 16-18 March 1959 at FFP in London. Bruce Rule and John Bolton from Caltech were the outside experts present along with Bowen and Minnett of CSIRO and Roberts, Mike Jeffery¹⁷, T. Wyatt and G. Blackwell all of FFP. The purpose was to look at the FFP design in detail, especially to uncover serious oversights. For example, to minimize

¹⁷ Jeffery was to be the FFP engineer in residence at Parkes in 1960-1961.

vibration at the master equatorial, Rule suggested that the column should be carried down to the ground level foundation with no connections to the surrounding tower at the intermediate floor level. To allow the adjustment of the positions of panels (“setting the surface”), it was suggested that removable bolts and oversize holes be used so the mesh position could be adjusted at any future time after the initial setting of the dish to the best fit parabola.

There was considerable resistance from Roberts during March 1959 against giving up on Metrovick as the main contractor; he took Bowen to visit their headquarters in Trafford Park (Manchester) on 10 March 1959. Metrovick remained inflexible: “They were obviously not inclined to take any drastic steps to meet [our demands].”¹⁸ An additional problem was FFP’s reluctance to “the calling of competitive bids” for the GRT. Bowen had to enforce this process by appealing to all the partners, especially Ralph Freeman. Bowen wrote: “After initial resistance, during which I was told about the glories of the British Empire and the ties which bind the Commonwealth together [hence the insistence that the contractor be a British firm], R.E. Fordham [the senior partner] finally conceded that we were taking the only possible course ... and that FFP would cooperate.” Thus FFP would enable the calling of tenders by prospective contractors. In particular, Roberts would attempt to find UK and European firms who were potential contractors while Bowen would do the same in the US.¹⁹

The sending of the technical specifications and drawings by FFP in a form suitable for the submission of tenders was delayed from 26 March to 17 April 1959.²⁰ Bowen, Harry Minnett and Mike Jeffery were to go to the US to meet candidate firms on the East coast of the US during the week of 27 April and then the West coast during the week of 6 May 1959.

The run-up to the tender documents distribution on 17 April 1959 was, as expected, troubled. On 9 April, Bowen wrote White with the report²¹ that even though FFP had agreed to approach potential contractors in the UK and Europe “as of 3 April 1959, Roberts had run true to form and done precisely nothing about it. In this respect he had not been lax, but positively delinquent”. Bowen had suggested some firms but was told by Roberts that the firm could not do the job or were not interested. On 3 April 1959, Bowen appealed to Ralph Freeman to contact some of the UK firms: e.g. CJB- Contractors John Brown, shipbuilders of Clydebank

¹⁸ NAA, C3830, A1/3/11/1, Part 12. 18 March Bowen to White.

¹⁹ *Ibid*, Pawsey had been in contact with Bowen about the tender process. 23 March 1959.

²⁰ CSIRO archive, TZ 797/31/2. 8 April 1959. During this frustrating period, Bowen sent a humorous letter to Fred White thanking him for support during these trying times in London: “[My letters] also allow me to reduce the head of steam which builds up each time I have contact with our friends at Victoria Street [FFP]. When this job started I had quite the wrong idea about what a **sleeping partner** [our emphasis] meant. Now I really know. Yours, Taffy.”

²¹ NAA, C3830, A1/3/11/1, Part 13.

Scotland. In addition, Strachan and Henshaw-a nuclear power station firm- of Bristol approached Bowen directly.

Bowen made the initial contacts with MAN (Maschinenfabrik Augsburg-Nürnberg), Demag, and Krupps, three major steel companies in West Germany. Bowen wrote: "To sum up, all three of these German firms are clearly competent and interested." On 13 April 1959, Bowen made a three day trip to Germany to visit the three prospective contractors.²² Bowen had last been in Germany in 1951 when the major impact of WWII was still visible. Bowen was impressed with the prosperity of West Germany compared to the UK: "The country is bursting with activity and productivity ... I have no great love for the Germans [his former enemy during the Battle of Britain - 1940], but there is no doubting their vigour and efficiency." He visited the firms and found that they shared enthusiasm for the GRT, comparable to the Americans in contrast to the British firms. Both Krupp and MAN were certain that they could finish the steel work within 12 months; the 500 tons of steel for the telescope represented a few per cent of their yearly output. MAN dismissed the challenge of the delivery time: "They treated this as a rich joke." Bowen was also optimistic they would suggest a price for the GRT that was about 50 per cent of the Metrovick price of February 1959. During the tendering process, Bowen would be in the US, thus unable to provide detailed input to the German and UK firms. Based on his distrust of FFP, he was worried that Roberts and colleagues could provide satisfactory answers to queries from the firms. "I hope it works out, but I do not have much confidence in the home team."

In the end, on 17 April 1959 tender documents were sent to three UK, two German and eight US firms. By early June 1959, seven tenders were received. On 21 April 1959, Bowen went again to the US to make preliminary arrangements for meeting the potential contractors.²³

Bowen met with a number of companies in the US including firms in Ohio, Pennsylvania and California. He then spent a week at Caltech and several days in Washington, D.C. before returning on 1 June 1959 to London. He was in an optimistic mood, expecting firm tenders from five companies in the US; the firms were favourably impressed with the quality of the FFP design and filled with "admiration for the ... [GRT] drawings".

FFP wrote White on 6 May 1959 with the details of their terms of engagement for their role as Consulting Engineers²⁴, based on the assumption that a single main contractor would be chosen in June-July. This was the long awaited answer to the 25 February 1958 letter, with a delay of

²² *Ibid*

²³ *Ibid*. Bowen was relieved that Roberts left for Paris during the last frenzied days before the documents were distributed. "Roberts went off to Paris for mysterious reasons ... and it is not know [sic] when he is coming back."

²⁴ *Ibid*. Surprisingly, FFP had not given a copy of this letter to Bowen. He finally received a copy from CSIRO in Australia at the end of May 1959.

15 months. FFP wrote: "... [W]e should undertake the duties of design and supervision and be responsible for the inspection and testing during manufacture of the component parts, whether fabricated in this country or abroad." The fees for FFP were to be 7.5 per cent of the total expenditure. Bowen, White and the CSIRO Executive were all convinced that the appointment of a Consulting Engineer should only be made **after** the contractor had been selected in July 1959.²⁵

On 25 May 1959, Martin Grace (Secretary Finance and Supplies of CSIRO) wrote Bowen with the reaction of the CSIRO Executive to the FFP proposal of 6 May 1959. W.E. Bassett of the CSIRO Executive was quite critical: "[He] expressed himself in very forceful terms concerning the inadequacy of [FFP's] letter and he was very critical of the basis upon which [FFP] proposed to act as the Consulting Engineer. Items of concern were the fact that FFP did not indicate the number of personnel working on the GRT project and the special problem of the expected expenses of the inspection tests. The latter were not covered in the 7.5 per cent fee; thus CSIRO was expected to pay for these expenses as extras. The CSIRO Executive assumed that FFP anticipated that the main contractor would be a non-UK firm; thus the costs of these visits were to be passed on to CSIRO.

On 15 May 1959, Bowen communicated with White in a reflective letter about his future concerns with FFP²⁶. The frustrations of the past year had accumulated. The design phase was completed; the next critical step of appointing a prime contractor and the supervision of construction was to begin in mid-1959. Bowen was determined to avoid the mistakes that had characterised their dealings with FFP since 1956. He insisted that FFP be maintained as consultants on "the structural design ... [the] inspection of materials etc" and be responsible for the telescope "meeting our specification of requirements", including responsibility "for the specified accuracy in cutting [materials] and fabricating the structure and erecting it". Bowen was acutely aware of the areas in which FFP were "known to blunder badly, e.g. in coordinating a complex effort or attempting to keep to a time table". Based on experience with the management of the other major telescope projects of the late 1950s (Jodrell Bank, the AUI 140 foot and the 90 foot twin telescopes at Caltech) , it was clear to Bowen that a strong team consisting of FFP and the CSIRO "are required to see a project of this magnitude to completion". Bowen considered that a team of two individuals from CSIRO and one from FFP would suffice. His choices at the time: Harry Minnett and Paul Wild from RP and Mike Jeffery from FFP. (See Additional Note 1 for a description of the interaction of Wild and Bowen in the period May-June 1959.) Bowen continued: "I feel we have to be quite firm and frank about [Roberts]. We now have a long record of misunderstanding and failures to do essential things which ... we

²⁵ *Ibid.* 25 May 1959.

²⁶ NAA, C3830, A1/3/11/1, Part 13.

cannot allow to continue.” Bowen reiterated that the chaotic relation between Metrovick and Roberts had a clear-cut cause. “Metrovick have told me explicitly that the long blank period during 1958 when no progress was made was due to continued failures on Roberts’s part to answer legitimate queries to which they might reasonably have expected prompt answers.” In addition Grubb Parsons had complained that they had been “mislead by Roberts about the terms [of the study] of the master equatorial unit”. Then there was the “unfortunate business” of Barnes Wallis: “[H]e is still well-disposed to us, but very outspoken about Roberts and his ways” (See Additional Note 1 NRAO ONLINE 44). Finally, there were the problems of early 1959: “[U]ntil I appealed to the other Partners, he refused to do anything about going out for competitive bids.”²⁷

In summary, Bowen blamed Roberts for the 12-15 month delay²⁸, 2 May 1959:

... I am now sure that the big mistake was made in January 1958. Very little improvement had been made in the design since, and what we should have done at that time was to go out for competitive bids on the basis of the design study. Any competent contractor would have brought the drawings up to their present state in about 3 months. It took FFP 15 months. All this is being wise after the event and I am not sure how it might help in any discussion with Roberts [in case White was to meet him in Melbourne in June]. [By following his advice in Sydney in 1958], we are now 12 or 15 months behind where we might have been.

As the prime contractor was about to be chosen, Bowen was convinced that he had to be wary of continued reliance on Roberts²⁹: “It would be disastrous if our contractor were exposed to this kind of thing [misunderstandings with Roberts].” Bowen suggested that future relations with FFP should insure that: “Roberts ... be excluded from active participation ...” He could be

²⁷In a letter to White a week later (22 May 1959), Bowen was quite explicit: “Of the 13 companies we are now dealing with, I made the arrangements with 11 of them, R. Freeman with one (Contractors John Brown).” Roberts did contact Sir William Arrol, his former employee. In the same letter, Bowen reported a confusing meeting with Roberts in Pasadena on 15 May on his way to the Auckland Harbour Bridge opening of 30 May 1959. “As usual he was a little mixed up about his intentions. He told me that he would go on to Sydney about June 1, but would not go to Melbourne [to the CSIRO Head Office]. A short time later he told Harry Minnett he was going to Melbourne to see you: so anything can happen.” In the end, Roberts did visit Sydney only for a brief visit. On 5 June 1959, Pawsey wrote Bowen with news of the visit. He appeared in Sydney unannounced on 2 June. Pawsey tried to organise a meeting. There was a plan for a meeting on Thursday morning (4 June) at the lab between Pawsey and Roberts. Roberts arrived later in the day after Pawsey had already departed to give a lecture in Melbourne. Roberts met McCready and Higgs: “Nothing of note came out of [the meeting].” On Friday, Pawsey was back in Sydney and paid a “short courtesy call” at the airport to Roberts on his way to San Francisco. “The main thing is that he considers the MAN bid a good one ...”

²⁸ NAA, C3830, A1/3/11/1, Part 13, 2 May 1959, Bowen (Pasadena) to White.

²⁹ NAA, C3830, A1/3/11/1, Part 13. Bowen (London) to White 15 May 1959.

an advisor but “should not appear in any active role as between the prime contractor, FFP and ourselves”.

Later in the year, CSIRO and FFP reached agreement on most issues raised by the 6 May 1959 letter from FFP to CSIRO describing the agreement outlining the role of the Consulting Engineer for the GRT. On 27 October 1959, Grace reported to FFP³⁰ that most objections had been settled. Martin Grace wrote: “... [W]e would like to be understood that Mr. Ralph Freeman will visit Australia at least twice [during the construction].” Also CSIRO would like confirmation that FFP would have permanent staff at Parkes during construction and testing of the GRT. FFP replied on 20 November 1959, indicating that they would not agree with the CSIRO manoeuvre to exclude Roberts:

When a visit to Australia becomes necessary you must rely on us to send the Partner best fitted to conduct the particular business in view. You have entrusted us with the engineering direction of this project and we cannot accept dictation in the exercise of our professional responsibilities. Our aim is to give the best possible attention to the job as the circumstances demand. Mr. Roberts is directly responsible to the Partnership for the design and overall supervision of construction of the instrument.

Roberts was to be on site when the GRT erection was close to completion to supervise the end phases and testing of the radio telescope. One earlier visit (“to review the contractor’s ... erection processes such as the placing of the turret and the fabrication and assembly of the dish structure”) was also required. Ralph Freeman would likely also visit Parkes during the travels he planned to Southeast Asia or New Zealand. The resident staff of FFP at Parkes would consist of Mike Jeffery (Resident Engineer) and four additional personnel to be recruited in Australia.

CSIRO, and especially Taffy Bowen, obviously reluctantly went along with this arrangement as far as Roberts’s role was concerned.

MAN Chosen as Prime Contractor and Plans for Acceptance Tests

On 2 June 1959, the GRT was at a crucial crossroads: the reception of seven tenders for the 210 foot radio telescope. The prices quoted ranged over a surprising factor of three. The lowest bid at £A 593,000 and a delivery time of 21 months was submitted by MAN in Germany. The next lowest tender was from Constructor John Brown (CJB, UK) with a price of £A 725,000 and delivery time of 24 months. This was a “not fixed price contract”.³¹ All the tenders were based

³⁰ *Ibid*, Part 14. Grace to FFP.

³¹ CJB would lower their price to £A 655,000 if they used their own, and not the Metrovick, designed servo system and gear boxes.

on the Metrovick servo system. Substantial savings were achieved in the MAN tender by using an Askania design for the master equatorial unit, a saving of £A 20,000. The old Metrovick tender from early March would have been in the range £A 725,000 to £A 750,000 (the uncertainty was the missing final costs for the tower and the dish structure).

Tenders were received from four firms that had had previous discussions with FFP and CSIRO: Loewy Hydropress, E.W. Bliss, Judson Pacific (with Judson Steel) and D.S. Kennedy, with prices ranging from £A 786,000 (Loewy Hydropress) to £A 1,980,000 from Kennedy. An additional tender for £A 986,000 was received from Strachan and Henshaw, the Bristol nuclear power plant and aerospace firm.³²

Already on 3 June 1959, Bowen was convinced “that the odds are distinctly in favour of MAN”. He was worried that R.G. Casey (a decorated WWI veteran) would be worried by “political considerations” (i.e. anti-German). The Rockefeller Foundation had told Bowen that “they have positively no preferences on where a contract is placed”. There was no mention of possible Australian contracts. During all these negotiations in London, Bowen also made a point of keeping Pawsey well informed.

An immediate problem faced Bowen and the CSIRO: the available funds were £A 540,000 while the total cost was likely to be £A 650,000 (the MAN tender plus the FFP fee of about £A 50,000). The shortfall was thought to be about £A 100,000 in mid-1959. Bowen was willing to take a chance: “My view is that we should now commit ourselves finally to one of the contracts and then start raising the extra funds which are required.”³³ Bowen had been told by Warren Weaver (still at the Rockefeller Foundation, but soon moving to the Sloan Foundation) that “the way is open to approach both Rockefeller and Sloan for [extra funds] we might need.” In addition, Pawsey had independently come to the same conclusion on 5 June 1959: choose MAN and try to obtain additional funds of £A 100,000 to £A 200,000.

In early June 1959, Bowen and Pawsey began detailed planning³⁴ for the acceptance tests that were to be negotiated with the prime contractor. The pointing accuracy tests as specified by FFP were straight forward. The surface accuracy evaluation was complex: “The question of acceptance tests for surface accuracy is one of several subjects on which we failed to reach agreement with Roberts, and nothing went into the technical specifications.” Bowen asked

³² Krupp from West Germany and the US firms Kaiser Steel, Consolidated Western Steel and General Bronze had withdrawn.

³³ NAA, C3830, A1/3/11/1, Part 13. Bowen to White

³⁴ *Ibid*, Bowen to Pawsey, 4 June 1959. In a letter of 5 June, Pawsey congratulated Bowen on the MAN contract. “The first battle of your long campaign is now nearly over and I imagine that you are breathing a sigh of relief. If the money question is not too difficult [more funds required from the US foundations] we shall look forward to seeing you home soon.”

Pawsey and the Technical Advisory Committee for comments on specifications and methods of testing, especially the impact of wind on the figure of the aerial. On 12 and 18 June 1959, Pawsey reported on progress with the surface accuracy acceptance tests after discussions with Roderick and Puttock (CSIRO Metrology). In the second letter, Pawsey enclosed three documents, two written by himself (“Some Geometrical Factors” and “Acceptance Tests on Shape of Reflector”) and “Notes on a Desirable Method for Determining the Shape of the Reflector” by Arthur Higgs. Pawsey wrote in “Acceptance Tests ... : “The errors in the shape of the reflector surface will be specified in terms of the departure of points on the actual surface from the nominal paraboloid (measured perpendicular to the surface of the latter).” The idea was to check the shape of the dish by determining the positions of 100-400 designated target points on the surface. For the acceptance tests, the dish was to be measured during the initial setup procedure. Then the process was to be repeated a week later and then a third time after six months. The expectation was then that the process would be repeated at regular intervals in the future.

Frank Kerr (19 June 1959) was also working on “Acceptance Tests of Pointing Accuracy”. Kerr described a number of activities to test the master equatorial. He suggested numerous changes to the acceptance document, proposing one arc min accuracy in a 10 mph wind within 20 degrees of the zenith and two arc min accuracy in a 20 mph wind within 60 degrees of the zenith. A method was proposed using optical observations of stars by coupling the theodolite system (proposed for the surface accuracy determinations) at the hub of the dish with the master equatorial telescope. Later tests would be based on actual radio source observations, using sources with known astronomical positions.

In June 1959, the ball was rolling on collecting information from the two firms who had not been involved earlier in the planning for the GRT: Askania in Berlin for the master equatorial including the control desk³⁵ and MAN. Harry Minnett visited the Askania Scientific Instruments Division on 10-11 June 1959. Askania had manufactured a number of astronomical instruments, including a 1.5 m optical telescope for the Caracas Observatory. Minnett was favourably impressed; given the £A 20,000 cheaper price and especially the shorter delivery time compared to Grubb Parson, their offer was attractive. The Australian’s choice was obvious. “The personnel with whom the project was discussed appeared to be entirely competent and keen to produce a high-quality job.”³⁶

³⁵ The control desk was where the telescope operator controlled the position of the telescope during observations.

³⁶ *Ibid.* Minutes of Harry Minnett meeting with Askania.

In the week of 8 June 1959, Bowen visited MAN in Gustavsburg, West Germany: “ ... I was completely satisfied with MAN’s capacity to handle this project as prime contractor and had no hesitation in recommending them to receive the contract.”

During the first two weeks of June 1959, Jeffery and Minnett, in London, evaluated the tenders. None of the US tenders were taken seriously due to the higher prices, likely caused by the increased wage scales in the US.

Ironically, all of Bowen’s and Minnett’s activities in 1958 and 1959 in the US were directly useful in gathering information; in the end no bids were competitive with MAN’s. In mid-June, Bowen and colleagues only looked in detail at the MAN and CJB tenders. The latter had major problems as this was not a fixed price bid: “ ... [T]here were hints that the price would go up during contract negotiations.” There were also major questions about CJB’s competence to undertake responsibility for the servo-system. The MAN tender was firm and did not appear to contain any hidden pitfalls.³⁷

Fund Raising Mid-1959, Final Contract with MAN

On 15 June 1959, Bowen rang Warren Weaver of the Rockefeller Foundation, reporting that a deficit (funds for the GRT) of £A 250,000 remained (to be split 50-50 with the Australian Government). Weaver was optimistic that the Rockefeller Foundation could help with additional funds. Bowen recommended to the CSIRO Executive that MAN be asked “to commence on 1 July on a letter of intent and to defer signing the actual contract until September [when the Rockefeller Foundation trustees were to meet].” White agreed with this plan if Bowen returned to Australia via the US in July 1959, having a personal meeting with Warren Weaver at the Rockefeller Foundation in New York. However there was a major complication: Weaver was to leave the foundation at the end of July to take up a new job at the Sloan Foundation. Dr Robert Morison (M.D.) was to take over the position at the Rockefeller Foundation as Director for Medical and Natural Sciences; he and Dr J George Harrar, newly appointed Vice-President of the foundation would handle the negotiation with the CSIRO. Weaver wrote Bowen on 19 June 1958: “When you come here in July Dr Morison will be ready to talk to you about a possible formula under which the officers would be prepared to recommend to our Trustees the future assistance to your project.”³⁸ On 24 June 1959, Morison

³⁷Also at this time (16 June 1959), White wrote Bowen with the suggestion that NASA might well be interested in using the GRT for space tracking in the future. “It would ... be a mistake to rely on them [NASA] at this stage for financial assistance if [funds can be found from the US foundations].” The problem would have been that NASA would have been a part owner of the GRT.

³⁸NAA, C3830, A1/3/11/3, Part 5. Dean Rusk would remain President of the Rockefeller Foundation until he joined the Kennedy administration as Secretary of State in 1961.

wrote Bowen that he would meet him at the Rockefeller Foundation during the first days of July.

Immediately, White responded via cable (17 June 1959) pointing out that the Minister [Casey] and the Executive could only sign the contract after “complete funds [were] available”. MAN agreed to delay the final contract signing; they only required a letter of intent. The expectation was that the final signing would likely occur in September 1959.³⁹

On 23 June 1959, a conference was held at FFP in London with Weber and Schneider of MAN, Freeman, Roberts, Jeffery and Blackwell of FFP and Bowen and Minnett of CSIRO. MAN was to be the prime contractor responsible for the main fabrication, the mechanical parts, erection in Australia and the final testing. On the following day (24 June 1959), the conference continued as the group was joined by Metrovick (soon to be called AEI, Associated Electrical Industries, a merged conglomerate which absorbed Metrovick, the subcontractor for the servo control system), Askania, (the West German firm) for the master equatorial and the control desk) and W. Wykeham and Company of Melbourne (the Australian representative of MAN).⁴⁰

The starting date for the temporary contract was quickly set for 10 July 1959. The project was underway; MAN was also convinced that the additional funds from the US foundations would be found.⁴¹

Bowen Returns to Sydney July 1959

Bowen reached Sydney on Thursday 16 July after the gruelling five months trip to the US and Europe (the end of Tailtwister II)⁴². CSIRO sent out a press release for the morning papers on this date. Bowen had prepared a draft statement 10 days earlier that concluded with: “The telescope was designed by Freeman, Fox, Partners, London, who are acting as Consulting

³⁹FFP had failed to complete the design of the mesh panels; thus an arrangement was required between FFP and MAN before the final contract was complete.

⁴⁰During this week bad news arrived from Australia. On 18 June 1959, Pawsey told Bowen that Ian Clunies Ross was critically ill (“... has had another coronary ...”). Clunies Ross died on 20 June 1959 at age 60. He had already suffered a stroke and heart attack a year earlier (June 1958) and had been quite weak in the intervening period (O’Dea, 1997). Fred White (Deputy Chairman of CSIRO since 1 January 1957) succeeded Clunies Ross as Chairman of CSIRO on 1 July 1957, serving in this position until 22 May 1970.

⁴¹During this period there was some additional horse trading by Metrovick to cover their development costs in 1958. Bowen had anticipated this problem; CSIRO blamed FFP for this oversight. The solution was to split the cost overrun (about A£9,000) between CSIRO and MAN. Bowen’s main concern, as the negotiations would down, was that Metrovick would have trouble meeting their 21 month delivery target: “[A] failure on their part could be embarrassing to the whole project.” Bowen suggested that early action would be required if signs of slippage appeared.

⁴² NAA, C3830, A1/3/11/7, Part 1.

Engineers on the whole project.” The actual press release (under R.G. Casey’s name) mentioned MAN but contained no mention of FFP; given all the controversy with FFP over the past several years, the blunder by CSIRO was certain to raise a storm of continued ill will. Apparently, the CSIRO wrote the press release to be used by the Minister. Bowen was immediately surprised by the omission of FFP’s participation. Bowen sent a clarification a few days later (24 July 1959) to the Australian Scientific Liaison Office in London: “It [the press release] did not get much space in the local newspapers and I do not know whether it reached London.” Unfortunately the press release did reach London. Bowen’s clarification mentioned FFP and contained a clear statement about the planned “open skies” policy:

It [the GRT] will be used primarily for radio astronomy purposes and the unique facilities it can provide will be available to any astronomer from within Australia or overseas⁴³ who has a problem for which this instrument is particularly suited should the need arise, a portion of its time will also be directed to the tracking of probes launched for the exploration of interplanetary space.

However, Bowen’s hoped for result in London with the amended press release did not occur. An angry letter was sent by FFP to White on 30 July 1959:

Last week we received from ASLO, London a copy of the press statement released in Melbourne on 16 July. We were astonished to see that this contained no mention of us. Bearing in mind that we have borne the brunt of producing for CSIRO the engineering designs and specifications for an instrument which is generally accepted as promising to be well in advance of anything of comparable size yet built or designed, this omission strikes us as a grave discourtesy.

FFP pointed out that during the last meeting with Bowen on 30 June 1959, Bowen had promised to give credit to them. FFP noted that since no mention of a British connection was made, there had been no mention in the UK newspapers. On 30 July, FFP put out their own press release with a prominent mention of the FFP connection to the project as well as a description of the role played by Barnes Wallis in the design of the “unique control system”.

On 6 and 10 August 1959, both Bowen and White wrote letters of abject apology to Ralph Freeman. Bowen sent a revised press release to Rob Richardson at ASLO in London to be distributed in the UK. This included Bowen’s original description of FFP, the statement omitted by CSIRO in Melbourne. Ralph Freeman responded with a friendly letter ⁴⁴ on 12 August. He stated: “The only option open to us ... was to send a statement to the Association of Consulting

⁴³ This clear enunciation of an “open skies” policy for the use of the GRT did not become the policy of RP after the Parkes Telescope was opened in late 1961.

⁴⁴ NAA, C3830, A1/3/11/7, Part 1.

Engineers, who ... might pass it on to one or more of the newspapers. They did in fact send it to the *Times*, and I am glad to say it had the desired effect ... except that the *Times* [10 August 1959 – ‘Britain’s Share in New Telescope’] did not mention your name.” Freeman finished the letter with: “I hope all goes well with you and your family and that you have recovered from the effect of excessive traveling earlier this year. We have a very good picture of you sitting in our drawing office.” Freeman was clearly anxious to contain the controversy.

But the agony was not over. The *New Scientist* of 8 August 1959 had a “Notes and Comments” article, “German Radio Telescope for Australia”: “[I]t may seem odd that no British firm approached was able to compete more efficiently for it. None of them was able to offer a better delivery date than four years hence, and all had difficulties about erecting the steel work on site.” Again FFP was not mentioned in the *New Scientist* article. Not surprising, Gilbert Roberts took issue with this report, followed by a letter of complaint to the journal, published on 20 August 1959 in the journal:

The note on the radio telescope ... contains a number of inaccuracies and misleading statements. As the consulting engineers retained by CSIRO for the project, we feel it is unfair to British engineering to describe the project as “German radio telescope”. The whole of the design and contract documents, comprising detailed drawings and comprehensive specifications have been prepared by us [FFP] in London. The designs for the control and drive system were developed *ab initio*, under our direction, by two British firms, Associated Electric Industries Ltd. and Sir Howard Grubb Parsons Ltd. to a stage at which requirements could be completely specified and drawn in outline to enable firm price bids to be invited. It is untrue to say that no British firm could “offer a better delivery than four years”... The completion times offered by the British firms were respectively 24 and 27 months ... It is incorrect to say that Dr Barnes Wallis “has developed a design by which a master-slave mechanism, controlled by a beam of light ...” Dr. Wallis invented the basic *principle* of the form of control. Its practical development and application by optical means was due to Messrs Grubb Parsons, under our direction ... The German firm Askania-Werke were, however, able to offer a quicker delivery time and lower price for this instrument and the subcontract for it has therefore gone to them and not Grubb Parsons. The servo-control system will be manufactured in England by AEI, who are nominated as subcontractors to MAN, who are the main contractors.⁴⁵

⁴⁵ *The Melbourne Age* of 15 August 1959 published an article about the GRT with FFP discussed in the text.

After his return to Sydney in July, Bowen wrote Sir Henry Tizard⁴⁶ with an update on the status of the GRT. They had clearly met for lunch or dinner earlier in the month:

As discussed at the Athenaeum [Club, Pall Mall], I am sending you a summarised statement of the steps leading up to the award of the radio telescope contract to a German company. We tried hard to have it built by a British firm, but obtained a very disappointing response. What does not appear from the cold figures in the attachment [a chronological list of the tortuous events of 1957-58 with FFP] is the almost complete lack of interest we found among British firms. The Germans and Americans were wide awake, keen and anxious to do business, but this was conspicuously lacking among the British firms.

Financing the GRT mid-1959

By the time of Bowen's visit to New York on 2 and 3 July 1959, the projected deficit in funding the GRT was £A 240,000. After the visit with Morison at the Rockefeller Foundation, Bowen received good news. In Figure 1 we show Bowen's summary of the financial situation circa 1 August 1959. Bowen wrote to White in Melbourne: ⁴⁷

Following my [Bowen's] talk with him [Morison] in New York on July 2, he indicated that the Rockefeller Foundation were prepared to make a further contribution in the same proportion, namely a one-fifth share or \$100,000.⁴⁸ This will require a formal request

⁴⁶ NAA C3830 Z1/14/A, Part 2. 20 July 1959. Bowen pointed out in the attachment that Roberts had told the CSIRO in January 1958 in Sydney that: "We were unlikely to find a prime contractor to handle the job and would have to break it up into a number of sub-contracts. He advised against calling for competitive bids and gave reasons why FFP should negotiate contracts with a number of firms of their choice ... In August and September 1958, it became clear that things were progressing badly in London, but the reasons were not apparent in Sydney. [On arrival in London in late 1958], I found a very muddled situation. The designs were not complete. There was disagreement with contractors on technical matters ... and both the cost of the telescope and the completion date in Australia looked considerably worse than we were being led to believe ... [The merits of competition soon became clear to CSIRO] and in March we decided to put the telescope up for competitive tender." CSIRO made a careful study of the eight US, three British and two German tenders. "We have no hesitation in awarding the contract to the lowest bidder, MAN."

⁴⁷ NAA, C3830, A1/3/11/3, Part 5.

⁴⁸ This apparently arbitrary formula of the Rockefeller Foundation was based on the fraction of foundation funds in the total £A 560,000 which was in hand in mid-1956; this included a highly inflated amount of claimed private donations from Australian sources (claimed £A 58,000 while the correct amount was closer to £A 26,000) and also the matching funds from the Commonwealth of Australia (£A 280,000). The interest on the funds from the Carnegie Corporation and the Rockefeller Foundation amounted to £A 31,000, a sum slightly larger than the total sum from private donations.

from CSIRO which would be considered at the September meeting of the [Rockefeller Foundation] trustees.

Bowen was also optimistic that his friend Warren Weaver, who had just moved to the Sloan Foundation as a Vice President, a position he held from 1959 to 1964, might help (1 August 1959): “Being the “new chum”, he cannot give a commitment as to their intentions at this stage; but he has promised to do all he can to raise a sum equivalent to that from the Rockefeller Foundation [\$100,000] and he is reasonably optimistic.”

But a few days later (4 August 1959), Weaver wrote with bad news; he had not been aware that the Sloan Foundation turned down a CSIRO request a few years earlier. “I am sorry to have to report that it does not seem feasible to the Sloan Foundation to change their former decision not to contribute to the cost of construction [of the GRT].” At this point Bowen was left with a hole of £A 70,000, with the understanding that the Commonwealth of Australia would match all contributions on a “pound for pound” basis.

At this time (3 August 1959), Bowen was still optimistic that GM Holden of Australia would make a major contribution; Bowen had lobbied for this with General Motors in New York. Bowen wrote a long letter with a summary of the history of the GRT project and the rationale for a large radio telescope in Australia to Harlow Gage, Managing Director of GM Holden in Melbourne.⁴⁹

After numerous letters, on 11 November 1959, Gage’s assistant wrote that GM New York had given permission to the Australian office of GM to donate the paltry sum of £A 1500.

There was again (2 September 1959) a lobbying exercise with the Rockefeller Foundation, consisting of correspondence with Dean Rusk, President. In addition, Casey visited Rusk in early October 1959⁵⁰:

Please tell Dr White CSIRO that I saw Dean Rusk who says that Rockefeller Foundation will almost certainly provide ... \$100,000 to the cost of the radio telescope, provided remainder of money necessary is guaranteed from other donors and Australian

⁴⁹ The letter to General Motors Holden included some flowery prose: “One of the most spectacular uses of the instrument will be an attempt to answer the riddle of the origin of the Universe. One theory of the origin implies that the universe has a finite size. Optical astronomers are capable of seeing halfway to this hypothetical limit. Some of our present radio telescopes are already seeing further [sic] than the optical telescopes, and a giant instrument [GRT] ... would be able to reach the boundary of the universe, if such a limit exists.”

⁵⁰ NAA, C3830, A1/3/11/3, Part 5. Cable to Australia from New York, 8 October 1959.

government. They will need this understanding prior to next meeting of Rockefeller Trustees early in December.

White had been given the same message by Morison on 15 September 1959. White responded with a carefully worded letter to Morison on 23 September 1959. White explained again the 50-50 Government-Private foundation funding scheme:

We feel under an obligation to seek sufficient private donations which, together with the Commonwealth subsidy, will cover the whole of the cost of the telescope. We are very confident that we will achieve this objective. I can, however, assure you that if the Rockefeller Foundation makes an additional grant [the \$100,000 promised in July 1959] to our funds we would not, of course, make a further approach to you.

Morison was satisfied; he agreed that The Rockefeller Foundation would consider the grant at their Trustee's meeting in early December 1959.

By late September 1959, Concrete Construction P Ltd was at work at Parkes on the tower of the GRT as excavation began; concrete was being poured in October 1959. The expectation was that the tower would be completed by mid-February or early March 1960. The steel work was ahead of schedule at MAN in Germany. By mid-June or early July 1960, the steel work was expected to be shipped to Australia, about the time of Mike Jeffery's arrival at Parkes. The derrick construction at Parkes for the lifting of the MAN GRT components was to start in November 1960.

On 8 December 1959, White and Casey were informed by the Rockefeller Foundation of a grant of an additional \$107,000 to CSIRO, to be spent by the end of 1962. At this point at the end of 1959⁵¹, the total deficit remaining was about £A 150,000. CSIRO realized that any additional funds from any foundation, US or otherwise, were not likely.

On the advice of White, Casey gave the message- there was no hope for additional donations from the US foundations- to Harold Holt, the Treasurer of the Australia Government⁵²:

In your letter of 29 July 1959, you approved the liability in entering into a contract with MAN for the construction of the telescope. I sincerely hope that you will agree to the deficiency we now anticipate being [met] by Commonwealth sources ...⁵³

⁵¹ NAA, C3830, A1/3/11/3, Part 5. 16 December 1959.

⁵² *Ibid*

⁵³ Holt discussed this extra funding issue with Robert Menzies, the Prime Minister. (White to Casey, 23 December 1959). The expectation was that Australian government Treasury department would approve this request.

CSIRO did not have to wait a long period for a response from Holt. He agreed “to this amount being met from the Capital Works and Services vote for CSIRO. This is on the understanding that no additional budget provision will be required in the current financial year.”

On 31 December 1959, a press release from Casey was distributed by CSIRO to the Australian press. The grant of \$107,000 was the third substantial grant from a US foundation to CSIRO for the GRT. Other Rockefeller Foundation grants had gone to the Division of Plant Industry and Entomology and \$30,000 had gone to the newly formed Division of Tropical Pastures in Queensland.

Bowen was ecstatic as he wrote Morison on 22 March 1960: “I am happy to say that our financial problems are over. [The addition of £A 150,000 – the amount of the extra funds from the Commonwealth from December 1959] will ensure completion of the device.” Construction of the GRT was coming along well: the supporting tower was complete and the steel work was 80 per cent complete at MAN.

RPL Scientific Staff Planning for the GRT -1959. GRT and the New Solar Instrument. CSIRO Non-participation in the Super-Cross Project.

During 1959, the RP scientific staff played an increasing role in GRT planning. By mid-1959, the GRT’s completion in late 1961 seemed likely. Three aspects of the planning were coordinated by Pawsey in 1959: (1) The receivers and backends that would be required, (2) the scientific programmes which would be carried out with the new GRT and (3) the future of low frequency radio astronomy at RP, both “cosmic” and “solar”. The last category became controversial in 1959, playing a major role in the splintering of RP in 1960-1962.

Preparations for Infrastructure at the GRT, including receivers, McCreedy’s meeting of 31 July 1959

The meetings of 3 March and 8 June 1959 dealt with staff replacement plans (e.g. the recently departed Colin Gum and Campbell Wade) and the plans for the 60 foot Kennedy antenna; this instrument was first located at Fleurs before it was moved to Parkes⁵⁴. An additional topic was automatic data recording and reduction with the use of simple digital technology.

One of the main meetings of the year was held on 31 July 1959; Pawsey was not present⁵⁵. The subject of the meeting was “Preliminary Arrangements for Operations at Parkes”. At this time

⁵⁴ See Chapters 30-31.

⁵⁵ Present were Bowen, Christiansen, Mills, Piddington, Kerr, Shain, McGee, McReady and Higgs. McCreedy wrote the minutes with copious direct quotes from Bowen. NAA, C4659/17

Bowen expected the telescope to be ready for routine use by March 1961; in fact the inauguration was to be on 31 October 1961 with routine use only in early 1962.

The operational requirements at Parkes were surveyed by McCready on 31 July 1959: (1) roads, (2) electrical power, (3) water, (4) wind breaks, (5) accommodation, (6) control and operation of the GRT, (7) design, construction and testing of receivers, (8) analysis and computing and (9) radio checks on surface and pointing accuracy at regular intervals.

Bowen was convinced that RP should adopt the Jodrell Bank model with a “controller” running the telescope, and the additional presence of a radio astronomer. Bowen suggested that a specialised receiver group should be established with “Cooper, Little and Robinson as its nucleus. Drs Christiansen and Mills thought that first-class people would not be content merely to design and make receivers for others to use. It was clearly the responsibility of the radio astronomy group to decide on the immediate projects to be tackled when the telescope became available and to ensure that adequate receivers were available for them well in advance.”

The decision of the location of the soon-to-arrive 60 foot Kennedy dish was discussed in some detail on 31 July 1959. This discussion was controversial with Bowen pleading for a Parkes location. From McCready’s minutes of the 31 July 1959 meeting:

Bowen suggested that the 60 foot dish should be erected at once on the site at Parkes rather than at Fleurs on the grounds that this would provide valuable practice and experience in the operation and sharing of time on a large instrument on a remote site, and that it would be more economical to install it there now than in several years’ time. Christiansen and Mills considered it should be erected at Fleurs so that the proposed trials in association with the Chris Cross could be carried out. They did not see how the instrument could be brought into effective operation at Parkes much, if any, before the GRT. Mr Kerr thought, at least from the point of view of hydrogen line observations, it would be best to erect the 60 foot instrument at Parkes right away. Mr McGee was unreservedly in favour of Parkes. This is obviously a matter on which a decision must be made in the very near future since the stand for the instrument is almost ready for delivery.

In the end, Pawsey made an executive decision to maintain the use of the 60 foot dish at Fleurs.⁵⁶ Christiansen was to be responsible for “the high resolution project [at Fleurs, with Norm Labrum as the section leader].”

Preparations for the GRT Science Program, the Balance of GRT and Non-GRT Activities

6 July 1959 – Pawsey’s Vision of the Future

A major meeting was held on 6 July 1959 to discuss the science program proposed by Pawsey in a 14 page document distributed on 29 June 1959. The “Radio Astronomy- Projected Programme” was the presentation of the vision of Pawsey for the future of radio astronomy in Australia. This meeting represented Pawsey’s response to the vision of the future discussed at the McCready meeting of 31 July 1959 (above) when Bowen’s plan was presented. The 29 June 1959 document began:

The impending construction of the GRT implies a considerable re-orientation of the Laboratory programme and it is desirable to set down in general terms a plan for experiment and observations for the period ending a year or so after construction ... The plan involves the completion of current observations, the development of equipment and techniques for use with, and early observations on, the GRT and a decision as to which of our current lines of investigation, if any, should be pursued independently of the GRT.

First Pawsey discussed the current (mid 1959) observations which had led to a “world leading” status in radio astronomy: (1) Wild’s observations of solar bursts, (2) Mills’s measurements of small diameter sources using the Fleurs Mills Cross at 80 MHz with a number of outlying stations (e.g. Goddard, 1960⁵⁷) and (3) Alex Shain’s 18 MHz low frequency observations at Fleurs. (Future new low frequency observations were to essentially cease with the death of Alex Shain in February 1960.) Only one of the three research topics came to fruition, the solar work of Wild and colleagues; the ground breaking results at Dapto lead to the imaging radioheliograph of 1967 at Culgoora.

New developments in receivers would be required: low noise front-ends such as masers or parametric amplifiers, automatic data recording and processing as well as high angular

⁵⁶ Minutes of the meeting of the radio astronomy group on 13 November 1959. The 60 foot antenna would be moved from Fleurs to Parkes a few years later with first use at Parkes as a the movable element of the Parkes interferometer in October 1965.

⁵⁷ The instrument was described by Goddard, Watkinson and Mills ((1960). An interferometer for the measurement of radio source sizes. *Australian Journal of Physics*, 13(4), 665-675). A second data set was published by Scheuer et al ((1963), “Apparatus for Investigating the Angular Structure of Radio Sources.” *Proc. Inst. Radio Engrs.*(Australia) 24: 185-90).

resolution (“we plan to carry out experiments with the 60 foot and other aerals at Fleurs”), and general experience in the use of large paraboloids (e.g. the 60 foot Kennedy dish at Fleurs).

Pawsey was reluctant to “jump the gun” with premature plans:

Detailed plans for the early use of the GRT several years hence should not now be set down, but it is possible to list the types of observations ... from which the early observations are likely to be selected. These observations will include hydrogen line observations of external galaxies and selected galactic objects, continuum surveys of the sky with special reference to discrete sources at about 10 and 20 cm and less exacting continuum surveys at longer (50 and 100 cm) wavelengths. In addition, observations concerned with items of current interest, e.g. polarisation, will form an important part of the programme which cannot well be predicted.

In appendix 3 of his document, Pawsey described a number of key experiments that should occur with the GRT. He elaborated on HI line and continuum surveys. He suggested that a GRT 10 cm image of the sky could be compared with the proposed new Mills Super-Cross surveys. Pawsey emphasised the detection of HI from objects at high redshifts. A prescient proposal suggested the detection of “magnetic fields with circular (Zeeman effect) or linear (synchrotron mechanism) polarization”. His final suggestion concerned interferometry: “High-resolution studies should not be taken on at Parkes until sometime after erection. They form a natural second phase and involve a large constructional programme.”

Two major projects were being considered for the future: (1) Wild’s radio studies of the atmosphere of the sun at metre wavelengths- the ability to image fast enough to make a movie of the movement of bursts with a time resolution of the order of one second and (2) Mills’s studies of distant radio sources using the proposed Super-Cross.

In solar work, Pawsey was convinced that “the RPL is at present out in front and Wild is very keen to continue”. The GRT would play no role in metre wave solar observations.

Appendix 4 of the Pawsey document from 29 June 1959, by J.P.Wild, was “A Proposal for a Fast Radio-Heliograph at Metre Wavelengths.” Wild was trying to solve the problem of creating images of the sun at metre wavelengths at a time scale of seconds, the time scale on which metre burst exhibited prominent variations. Wild proposed an initial operating frequency of 80 MHz with angular resolution of 4-6 arc min, similar to the completed (1967) Culgoora Radioheliograph. Roughly 100 aerial elements would be required, each larger and cheaper than those of the Chris Cross elements. Wild suggested: “The Parkes area would be ideal for this purpose.” At this time the **form** of the solar array had not been specified; “one type of equipment would be an adaption of the cross-grating aerial (as used by Christiansen)”. The

completed Culgoora Radioheliograph was a circular array of diameter of 3 km consisting of 96 13-metre dishes.⁵⁸

In his 29 June 1959 report, Pawsey was insistent on continuing Mills's next project:

... [T]he field of study – galaxies at extreme distances -- is perhaps **the most intriguing problem of all astronomy, our [Australian] position is currently right in the front rank** [our emphasis] and Mills is keen to continue at longer wavelengths as well as at the short wavelengths for which the GRT is suited.⁵⁹ A cross can be constructed at a wavelength of about a metre [300 MHz] which, for the restricted purpose of a survey at one wavelength should be both more sensitive and more directive than the GRT at its optimum wavelength. Observations with this cross would be exceedingly valuable in their own right; in combination with the GRT at short wavelengths we should have spectral information. This last aspect is likely to be important, since the main emission mechanisms differ in the two wavelength ranges: [mainly non-thermal synchrotron at 1 metre and partly thermal sources (HII regions) at 10 and 20 cm.].⁶⁰

Mills wrote an appendix to the Pawsey document with additional details; the proposal was to build the Super-Cross in two stages, with the first stage providing an angular resolution of 12 arc min at 250 MHz and the extension of the arms to 4000 feet providing a resolution of 6 arc min. The initial stage would cost about £A 20,000 (no salaries) and require 18 months; the final cross would require similar funding and an additional year of construction.

The rationale was to continue the successful metre wave work on discrete extragalactic sources and galactic HII regions and supernova remnants. Mills wrote:

[Also], ... to act as a survey instrument for the detection and accurate location of very large number of radio sources, principally for extragalactic studies [several times more than possible with the GRT] ... The relation of an instrument of the type projects to the GRT would be that of a 'spotter', which could pick out the radio sources most promising for studies of spectra and brightness distribution, using the Parkes installations. For

⁵⁸ See Chapter 31 for a discussion of the Culgoora site.

⁵⁹ As we will see in Chapters 38 and 40, Pawsey was convinced that Mills should play a major role in the evolution of Australian radio astronomy after 1961 and the opening of the GRT.

⁶⁰ A first draft of the "Radio Astronomy- Projected Programme" has been found with notes written in the margins in Pawsey's handwriting. He was not pleased with the first description of the Super-Cross ("weak, replace with new text"). The original text distributed at the meeting did not emphasise the stand-alone role that the Super-Cross would fulfil. It would not just be used as a complement to the GRT.

straight identification work, the cross would probably be more accurate and certainly more sensitive than the GRT.

The first stage consisted of arms 2000 feet, with widths of 30 feet for the N-S arm and 18 feet for the E-W arm. In the second stage of the project, the arms would be expanded to 4000 ft, a factor of two. The frequency was to be 250 MHz with a beam width of 6 arc min (the Molonglo Cross, as completed in 1967, had resolution of 2.8 arc min at a frequency of 408 MHz). These parameters were chosen to match the GRT at 10 cm where the beam width would be about 7 arc min, corresponding to a source density of about 20,000 sources per steradian.

In summary Mills wrote: "This programme, instituted very soon, would keep us in the forefront of work in the extragalactic field." At this stage, a possible start of the Super-Cross would occur in mid-1960 with the new solar heliograph a year later. However, the proposal for Culgoora radio heliograph was completed in January 1962 followed by the awarding of the grant from the Ford Foundation in April 1962, a process in which Pawsey was to play a key role for the new radio heliograph. The development and installation of the equipment of this 80 MHz instrument occurred from mid-1962 to mid-1967. The opening of the Radioheliograph was August 1967. The Super-Cross became the Molonglo radio telescope (University of Sydney, School of Physics) with planning starting in in 1960. After initial construction in 1962, the official opening occurred in November 1965. Full Cross operations began in 1967.

During the meeting on 6 July 1959 (minutes written by Pawsey):

Dr Mills criticised the section [of Pawsey's 29 June document "Radio Astronomy-Projected Programme"]⁶¹ on the GRT programme in the present draft on the grounds that the investigations should be emphasized **before** equipment and he produced a list of possible investigations ... Dr. Pawsey agreed with the general criticism but emphasized that we want to introduce personal responsibility at this stage. We want not only to choose rewarding investigations but to arrange that [the RP scientific staff] should choose their own particular lines of investigation now and take a personal responsibility in seeing them carried through all stages.

11 August 1959- Radio Astronomy Group at RP

On 11 August, the radio astronomy group (Bowen, Pawsey, Christiansen, Mills, Piddington, Higgs, Kerr, McGee and Shain) met to follow up the decisions of the 31 July GRT planning meeting. The radio astronomy group would evolve into GRT and non-GRT activities, with an approximate equal division of resources and manpower. Bowen had stressed that no major increase in CSIRO operational funds was expected. Pawsey was still keen on "high directivity

⁶¹ NAA C3830 A1/1/7

development”, with the desire to observe small radio sources with a resolution of 5-10 arc sec and larger sources with 1-2 arc min resolution. A receiver group was to be established. The major decision was that of the three projects: the GRT, the new solar project and the Super-Cross. Only two could be funded. To maintain the balance between solar and cosmic research at RP, it would be impossible to fund the Super-Cross unless “adequate external help could be acquired”. Thus substantial financial support from outside CSIRO would be required and solar radio astronomy would be stimulated.⁶²

Pawsey gave⁶³ his immediate impressions to Paul Wild (still in Europe) on 11 August 1959. There were “fairly fierce discussions here in the last few weeks on our future programme.” On this morning, the decision was made to “proceed with a major solar project to be defined by you after your return. At the same time we decided largely we could not undertake Bernard’s [Mills] project – unless we could get major help from outside ... Your project ought to be made a really good one. We aim to supersede the Meudon (France) and Belgian people.”

Baade’s visit August 1959

In the course of a six month visit to Australia in 1959 (Frame and Faulker, 2003, *Stromlo – An Australia Observatory*, published by Allen and Unwin, p. 153), Baade spent time at RP arriving on 11 August 1959. Baade was an influential astronomer from Mt Wilson and Palomar Observatory. Earlier he had interacted with RP during the Cygnus A identification occurring in 1952-1954 (see Chapter 21) as well as the Sgr A discussions of 1954 (see Chapter 23).

Pawsey summarised Baade’s list of major astronomical programmes on which the GRT could contribute.⁶⁴ Baade was especially interested in the total gas content of galaxies in relation to galactic type and evolution state. The Clouds of Magellan would be an important research topic for the GRT. Also an important topic would be the galactic centre, located overhead in the middle of the Australian winter. Baade was also fascinated by the problem of double radio sources associated with external galaxies; he saw this as a new type of astronomical object that would require high resolution interferometry.

16 September 1959 Meeting

In early September 1959, each member of the radio astronomy staff was asked to write a proposal on their favourite scientific topic.⁶⁵ These were to be compiled into a single document

⁶²CSIRO was anxious that RP should also pursue “**practical**” research, such as **solar physics**.

⁶³ Deane archive. Pawsey to Wild 11 August 1959.

⁶⁴ NAA C4659/17

⁶⁵ NAA, C3830, C4659/17. Non-GRT proposals were also submitted by Piddington and Alex Shain (two proposals).

by mid-September. By 16 September 1959, Pawsey had received seven proposals for GRT projects from Kerr, Mills⁶⁶, Shain, Piddington, McGee, Christiansen and Pawsey (together) and Pawsey (on his own).

A few of the proposals were far-fetched as viewed from a perspective 60 years later. Even a few proposers suggested observations of sources in the north, outside the declination range of +27 dec north (e.g. Cygnus A, the Andromeda Nebula M31).

Frank Kerr provided a prescient text containing items of research interest, that turned out to be quite successful in the following 60 years. Kerr was convinced that “one of the fields where most benefit can be obtained from the GRT will be 21 cm [HI line] studies of external galaxies ... Full advantage can be taken of the high gain of the dish”. Several other staff were to suggest problems consisting of programmes to determine the HI properties of galaxies as a function of Hubble type from dwarf galaxies (e.g. in the nearby Sculptor-Fornax group) to earlier types of galaxies (for example SO's) and even clusters of galaxies. In a modest number of galaxies, the 12 arc min of the GRT at 21 cm would allow a determination of the resolved velocity field of the galaxy. Kerr even hoped that HI spiral structure would be observed in a few nearby galaxies. “The GRT will provide sufficient resolution for exploring the detailed structure of the Magellanic Clouds.” Clearly the Large and the Small Clouds of Magellan would be important targets for the GRT. This research area was to lead to major GRT results in the next decades, both HI and continuum.

Kerr also discussed higher redshifted HI absorption line observations of distant galaxies, even though the claimed detection at the Naval Research Laboratory by Lilley and McClain (1955) of a line in the direction of Cygnus A had not been confirmed. Additional observations were certainly required of other high redshift systems since Cygnus A was not observable with the GRT. Also the attempt to detect intergalactic HI absorption was suggested; this experiment was tried by Brian Robinson and Jim Koehler in 1963 in the early days of the Parkes telescope. The claimed detection of the absorption dip due to the intergalactic HI in the direction of 3C 273 by Robinson, van Damme and Koehler (1963) was also never confirmed.

Based on Frank Kerr's own scientific interests, numerous galactic HI observations were also suggested: HI studies of the Milky Way central region (less than 3 kiloparsecs from the Milky Way centre), spiral arm structure, statistical studies of the HI emission distributions in selected

⁶⁶ Ibid. After Mills had written his text (likely early August), the news of the Super-Cross funding problems was announced. Mills submitted an addendum to his proposal (added 4 September 1959) pointing out that a number of his projects were not feasible without the Super-Cross. As an example, he wrote that the planetary nebula research based on a comparison of GRT and Super-Cross results would clearly be impossible, as well as detailed investigations of the Magellanic Clouds and other nearby galaxies.

regions of the galactic plane, and especially HI absorption studies against discrete sources. Statistics of the gas temperature, size and number of HI clouds and “new information about the distances of sources” were also topics for study with the high resolution of the GRT. (e.g. Radhakrishnan and Goss, 1972). Kerr also suggested new spectral lines such as CH, OH, He³⁺. The GRT could have discovered the OH lines near 1665 MHz (the frequency given in Kerr’s table) in 1962; OH absorption lines were in fact discovered by Weinreb et al in 1963 and the strong maser lines by Weaver et al in 1965. Kerr was aware of the fact that a major limitation for the detection of weak absorption lines was gain stability of the receiver, rather than sensitivity. This limitation was due to the large antenna temperature of strong compact sources such as Sgr A, associated with the galactic centre. The absolute gain stability and bandpass stability would become major problems that were only gradually overcome as the GRT came into operation in 1962.

Mills was discouraged by the likely impossibility of GRT and Super-Cross comparison projects, i.e. the angular resolutions would not be compatible. He was, however, encouraged by the likelihood of cluster of galaxy continuum and HI observations that could be carried out with the GRT alone.

One of the most innovative proposals was written by C.A. (Alex) Shain from 7 September 1959; tragically Shain was to die at age 38 within five months on 11 February 1960. Based on Shain’s experience of observing the free-free **absorption** due to intervening HII regions at 19.7 MHz images of the Milky Way, he proposed a number of innovative high resolution GRT observations of the continuum of galactic HII regions at 10 cm. Physical conditions within HII regions could be determined as well as the relation between the ionized hydrogen due to the ultraviolet of the hot stars and the surrounding HI gas in the 21 cm HI line. The importance of large HII regions in the Large Magellanic Clouds, such as 30 Doradus, was recognised as an important observational target. Shain gave more emphasis to the galactic centre and Sagittarius A than any of his colleagues; the proposed observations of the radio sources associated with the galactic centre (which was straight overhead in the Australian winter sky), to separate the thermal and non-thermal components was to play a major role in the astronomy of the remaining years of the 20th century with the GRT playing a prime part in this quest. Finally Shain appreciated the possibility of **lunar occultations** to provide arc second resolution as the moon intercepted the radiation from the background source. This area of research was to provide one of the lasting GRT successes of the GRT in 1962; Cyril Hazard, a visitor at the University of Sydney, was invited to use the GRT by Pawsey for occultation observations in 1962. (see Chapter 32)

Dick McGee wrote an extensive proposal with emphasis on high resolution studies of galactic HI with the GRT. Examples were the search for observational evidence for the boundary between

HI and HII regions, and the determination of the cloud size spectrum of HI clouds in the interstellar medium of the Milky Way. McGee also presented an excellent proposal for studies of HI remote from the plane of the Milky Way: “a suggestion is that this work may lead to a detection of either the limits of HI gas in our Galaxy or of ‘bridges’ of intergalactic hydrogen.” This observation was clearly related to the detection of high velocity HI clouds in the Milky Way. Finally McGee had a number of prescient suggestions for HI observations from galaxy clusters at higher redshifts.⁶⁷

Pawsey provided a proposal to continue the search for interstellar magnetic fields based on linear polarisation observations. Both the extended galactic non-thermal background (200 to 600 MHz) and compact galactic and extragalactic discrete sources were to be observed at 1.4 to 10 GHz. Parkes was to play a major role in the study of magnetic fields and Faraday rotation in the coming decades. Pawsey also discussed the use of interferometers to study small degrees of polarisation at the 0.1 per cent level. “IF these are successful further observations on the GRT will be well worthwhile.”

A key meeting followed on 13 November 1959, with concrete plans for GRT receivers discussed earlier. Pawsey was chair of the meeting to set priorities. Again he emphasized that the list of instrumental projects from August 1959 provided special emphasis to the use of the GRT at 10 cm.

Pawsey suggested that Christiansen supervise three projects: the multi-channel backend with John Murray as section leader, the high-resolution project at Fleurs (60 foot compound interferometer with the original Chris Cross and (3) continuum observations with the Chris Cross. Frank Gardiner was in charge of the maser front-end receiver project with the assistance of Doug Milne.

In a retrospective written by Bowen 20 years later (Bowen, E. G. (1981). "History of Australian Astronomy: The Pre-History of the Parkes 64-m Telescope." *Publications of the Astronomical Society of Australia* 4, no. 2: 267-273), Bowen tempered his negative assessment of the FFP experience. The GRT had been a brilliant success after the three initial turbulent years of design and 2 ¼ years of trouble-free construction under the competent direction of Mike Jeffrey of FFP and the MAN personnel. Bowen (1981) wrote: “There followed a three-year period- the engineering design phase [starting in 1956] – and although it bothered us at the time, looking back on it it was three years extremely well spent ... There is no substitute for very -careful

[†] The monumental discovery of the Magellanic HI stream in 1974 (observations March to June 1973) by Mathewson, Cleary and Murray (*Astrophysical Journal*, 1974, vol 190, p. 291) was made with the 60 foot (18m) Parkes disk using the 210 foot HI backend receiver. This is a galactic “bridge of intergalactic HI”. The velocity range of the search was -360 km/s to +380 km/s, with most of the HI found at negative velocities.

consideration at the design stage. This saves an awful lot of headaches later on.” Additional comments from 1984 were added by Bowen in Additional Note 2.

Additional Notes

Additional Note 1. Wild and Bowen correspondence re the GRT, mid-1959

The first indication of Bowen’s interest in having Paul Wild spend time in London functioning in a liaison role with FFP (and looking after CSIRO interests) was in the letter to White on 15 May 1959. Even at this time, Bowen had his doubts: “... [A]t this moment, I do not know whether we can spare Paul for this particular job.”⁶⁸ The possible participation of Paul Wild came up again in early June 1959⁶⁹. Bowen was anxious to have a CSIRO scientific presence in London after he [Bowen] was to leave for the US and Australia in July. The telegram read: “If contract placed in Europe is Paul Wild prepared to leave middle or late June to take over where I leave off. He could make headquarters here. Watch progress of telescope. Also make his other visits. His departure from England might be deferred until November.” Likely Bowen wanted a prominent scientist to look after the project in London at this stage. Pawsey responded immediately (8 June 1959) to Bowen via telegram and post⁷⁰. Wild was reluctant to make a long commitment: “Paul is due to leave here on July 10th for Italy at the invitation of the Italian Physical Society ... [Paul] is up his eyes in what looks like a most fruitful branch of solar research and hopes to continue and extend it. This is a case where I feel sure he should be given his hand, particularly so in view of his turning down the Harvard offer [a chair of astronomy].”

Pawsey thought Minnett could stay on longer or even that Arthur Higgs or Frank Kerr might be available to look after CSIRO concerns at FFP in London. Pawsey explained that he could not leave Sydney due to Lenore’s [his wife] illness; in addition Lindsay McCready also had commitments that prevented his going to London.

On 9 June 1959⁷¹, Wild wrote Bowen in London with more details of his plans and his willingness to help “keep the flag flying in London”. Wild already had made plans and commitments in Europe but could postpone the US trip:

This matter is tied up with the broader question of my future relations with the construction of the GRT. I know that you want me to become more closely associated with its development. I have ... strongly supported the cause from the start, and will

⁶⁸ NAA C3830 A1/13/11/1, Part 13.

⁶⁹ *Ibid.* 5 June 1959 telegram Bowen in London to Pawsey in Sydney.

⁷⁰ *Ibid*

⁷¹ NAA C3830 Z1/9/1959.

always be willing to contribute to its program and welfare. On the other hand I think it would be wrong for me to abandon a field [metre wave solar radio astronomy] in which we are not only on top, but are approaching the “break-through”... I can understand your desire to keep the pressure up now that things are really moving.

On 23 June 1959⁷², Bowen wrote Pawsey that Paul Wild would only be needed in London for a few extra weeks in August or September. Wild’s visit to the US (on the way back home to Australia) was due to start 7 September 1959, but could be postponed; a visit to London before the visit to Varenna, Italy, was not possible. Then on 4 August 1959, Bowen wrote Wild, who was already in Europe: “I shall not be calling on you to do anything about the GRT when you go through Europe. Before leaving London, I made an alternative arrangement in which we shall depend on Bob Richardson at ASLO to keep us in touch with progress ... When you are in London, you may, however, like to discuss the whole progress with Minnett and Richardson and let me know the general impression you get, independent of any reports they may write.”⁷³ Wild returned to Sydney at the end of October or early November.

Additional Note 2- Bowen’s assessment of Roberts and FFP in 1984- twenty years after the construction of the GRT

In various perspectives written 2 plus decades after the opening of the Parkes telescope in 1961, Bowen had become less critical of FFP:

We sent Harry Minnett to act as our liaison [at FFP] man and to participate in the design of the drive and control systems... There followed a three-year period- the engineering and design phase... It was three years well spent. In the event, the telescope took three years to design and only two and a half to build...

The Freeman Fox design contract was completed in 1959, after which the MAN company... of West Germany was selected as prime contractor. We were extremely well served by both organisations and the telescope was completed during 1961...

At the time of writing (Bowen, 1984 in Sullivan *The Early Year of Radio Astronomy..* p 84), the telescope has completed 23 years of sterling service as a research instrument, during which a total of nearly 1000 research papers has been published. It seems

⁷² NAA C3830 A1/13/11/1, Part 13.

⁷³ Deane archive.

destined to remain an important component in the Australian research scene until the turn of the century.

In fact, the GRT has remained a valuable instrument for four more decades, up to its 60th anniversary in late October 2021.

Fig 1 August 1959, Bowen's assessment of the funding for the GRT – units Australian Pounds. At the time of the GRT (Parkes telescope) opening on 31 October 1961, the total cost was £A 900,000 or about US \$1.8 million. The final costs overrun of about £A 100,000 was covered by the CSIRO capital works budget. Robertson (1992, p. 169).

RADIO TELESCOPE FUND

TARGET £A 800,000

