

9th May 1961,  
C.S.I.R.O.,  
Stowell Avenue,  
Hobart, Tasmania,  
Australia.

Dr. Alan T. Waterman, Director  
National Science Foundation  
Washington 25, D.C.

Dear Dr. Waterman:

Thank you for your interesting letter of the 20th April. In accordance with your desire to learn more of this subject, I have prepared a synopsis of the evidence as follows.

1. The Design is Poor:

A. The most fundamental parameter of a radio telescope is the size of the aperture. 140 feet is a poor choice. See Emberson and Ashton, Proc. IRE, Jan 1958, bottom right page 30 and top left page 31.

B. The second most important parameter is the type of mounting. The decision for equatorial mounting is based on "bias of astronomers" and "in some instances the bias is intuitive". See above, bottom left page 31.

C. Waves of a few centimeters suffer severe aberrations and absorption at low elevation angles. By turning to the horizon, a large price is paid in size of mounting without adequate return of performance.

D. It is good engineering practice to spread out the load of large moving equipment over several bearings. The mount in question has effectively less than one bearing because the force of second bearing adds to, not subtracts from, the load force on first bearing.

E. The modern way of handling, is to drive by preloaded cables over sheaves and determine axial position by electronic means.

F. The design incorporates difficult (large gears) and untried (large hydrostatic bearing) features. These incur penalties in price and time.

2. The Execution is worse:

A. Engineering experience demonstrates that a complete and detailed working scale model be built of any large structure, particularly machines involving difficult, new and untried features. A fine, one fifth size model should have been constructed with the money expended on consultants fees of very dubious value.

B. The section of a sphere has had a long and unsavoury history. After reading the third paragraph of your letter I predict the end is not

in sight.

C. The internal forces in periphery plates and webs of main axis are reversed. The center holes in webs do not line up. The periphery plates do not line up by several times the allowed amount. Multiple welding beads are applied at joints in an attempt to disguise the above. The exterior has many scars where handling lugs were applied and removed.

D. Various pieces of yoke were deformed after fabrication by rough handling. Much of the above can be traced to inadequate inspection and supervision.

E. It is unusual for people to attempt to carry out projects which they themselves realize in the beginning to be a poor thing. I wonder why this affair has been persisted in so long?

3. It has already Cost Twice what it Should:

A. Ned Ashten at an early date secured independent bids on the major components. The sum of these plus a suitable figure for erection came out about 1.5 million dollars.

B. A liberal figure for good grade steel work erected in the field is \$500 per ton. The telescope weighs about 2500 tons. On this basis the cost would be 1.25 million dollars.

C. If the design were as good as the Parkes instrument, and using your figures we have:

$$(140/210)^3 \times 2.2 \times 10^6 \times 2 = 1.3 \text{ million dollars.}$$

D. Bliss is without any responsibility for performance in terms of time and money.

E. A literal interpretation of the sixth paragraph of your letter is that you approve of entering into large projects without having solid and convincing information on ultimate cost as well as time of completion.

Most of the above is raking over the ashes of dead fires. Items 4 and 5 will be discussed at a future date. In the mean time I will be pleased to learn your comments, suggestions and explanations.

I am

Sincerely yours,

Greta Reber

Copy to:

Dr. Jerome B. Wiesner.

- 1 a, diameter poor choice Edalmonore + Astor
- b, mounting based on prejudices
- c, excess mount to cover low angles unnecessary + unhelpful
- d, drive by gear is 19th century
- e, load not distributed <sup>concentrated on</sup> less than 1 bearing
- f, absolute Ned Astor
- 2 a, No model, 1/5 sig could be built for worthless consultant fees
- b, Shell made first spiders invented, strains reversed
- c, axis doesn't line up due to nature of assembly
- d, plates don't join, offsets plastered with beads
- e, outside all scammed up
- g, rough handling deforms pieces, see photo & lot more
- f, spherical piece welded & reworked after much tearing & pitted up
- h, Bliss does good work. Why do botch?

3, a, Ned Astor got bids at \$1.5 · 10<sup>6</sup>, over \$3 · 10<sup>6</sup> now spent.  
~~with sub, members in sight~~  
 Post like raking over the ashes of dead fires.

- 4 a, No responsibility on part of Bliss for quality of performance, time of performance or cost. End of ~~contract~~ <sup>contract</sup> in sight
- b, Bliss unlikely to accept a reasonable contract at this late date. Not possible to find alternate contractor when job partly completed. <sup>alternatives are</sup> ~~contract~~ <sup>contract</sup> continue open ended Bliss affair or ~~blatant~~ <sup>blatant</sup> ~~blatant~~ <sup>blatant</sup> or do it yourself for which no competent physicist or mechanics are available; or abolish the project.

- 5, a, at  $\lambda > 20$  cm outclassed by existing equipment .250 + 210 ft.
- b, at  $3\text{cm} < \lambda < 15\text{cm}$  small opening. However 2:1 improvement is least ~~significant~~ <sup>significant</sup> particularly for statistical work. actual ratio ~~is~~ 1.6:1 which is hardly worth anything even over a small range of wavelengths.
- Q, Money <sup>should</sup> be expended to finish 140 could be much better put to use on a whole variety of other resources.
- Q, Peronnation after I've studied the Pierce report.

which will give a worthwhile improvement of results is (3) a factor of two. A factor of three is usually required to get into new ground.  $140/85 = 1.65$  which is distinctly minimal.

B. A radio telescope is limited in performance by Resolution or Sensitivity. The 85 ft dish is resolution limited in regions of Sagittarius and Orion. Elsewhere it is sensitivity limited. The same situation will hold for 140 ft dish. The performance is easily predicted.

C. In regions of resolution limiting, the peaks and valleys of the traces will be accentuated and narrower by a factor of one third. The asymmetries of slopes will be enhanced but not sufficiently to show clearcut new features.

D. In regions of sensitivity limiting a few new sources will be picked up. The number of sources available in terms of magnitudes  $m$  is according to the relation  $n = m^2$ . The sensitivity of the instrument in terms of magnitudes is  $m = 2.4 \log_{10} \frac{D}{\lambda}$ . Thus the 140 ft dish will reach magnitudes below the 85 ft dish. Only about a score of sources may be found with the 85 ft dish at 3.75 cm wavelength. This excludes the members of the solar system and the sources which are inferred to exist by various statistical devices. Accordingly the 140 ft dish will pick up about 17 sources. There is no reason to expect these few additional sources to be any different in constitution from those already known. The small total number will not shed new light on the constitution of the universe or give appreciable added spectral information. The cost of finding these sources of dubious astronomical value will be several hundred thousand dollars each. Many much more worthwhile projects are available which can be readily carried out.

4, Two or three millions of dollars plus several more years will be required to finish it.

<sup>practical</sup> A. In view of 3C, the above is very conservative. The alternatives are to secure a new and responsible arrangement with Bliss or to discontinue the affair. Serious consideration should be given the latter in view of 5 below.

B. If it is elected to continue, a very clear understanding should be reached as to not only technical performance, but equally important, time and money, with a penalty for failure of any one of the three.

5. When finished, the scientific usefulness will be close to zero.

A. a fundamental practical proposition of experimental physics may be stated as: The smallest improvement of equipment

~~3C. Bliss is without <sup>any</sup> responsibility for performance in terms of time or money.~~