NRAO ONLINE 39

***1953*- Solidification of the GRT Vision--- a Strategy for Fund Raising in the US**

In 1953, the RP leadership, Bowen and Pawsey, continued their interest in a large antenna, in spite of the initial rejection from the Carnegie Corporation of New York in December 1952. With the support of Fred White, continued contacts were made with the Carnegie Institution of Washington and the Carnegie Corporation of New York. These contacts paid off with financial support for the GRT as initial funds were to be approved in April-May 1954 by the Carnegie Corporation of New York.

In March 1953 Pawsey wrote "Notes on Big Aerial"[1], a proposal for a lower cost radio telescopes that would nevertheless provide a large increase in collecting area and resolution. Likely, the proposal was a response to the negative news from the Carnegie Corporation of New York in late 1952. As in the 1952 proposals of Bowen and Pawsey, the default frequency was 200 MHz, a wavelength of 1.5 m. But the large aerial was also designed to be partially effective at the HI line at 21 cm. (Pawsey anticipated that the experience being gained with the 36 foot transit telescope at Potts Hill by Frank Kerr, Jim Hindman, Brian Robinson, Campbell Wade and others would guide future plans for the use of the GRT at the HI line.) Also the sky coverage of the proposal aerial was discussed; clearly a zenith angle range of 60 degrees was anticipated; with this range 62 per cent of the sky could be covered, including the south equatorial pole.[2] Pawsey pointed out that the 60 deg tilt (a zenith angle limit of 60deg or 30 deg above the horizon) "covers nearly all the useful sky". Pawsey proposed (1): a transit instrument. This "tilting dish" (only moving in elevation) had an estimated cost of £A 30,000, an order of magnitude lower cost compared to a steerable radio telescope. The "tilting" transit dish was to

---

[1] Sullivan archive from RPL. 11 March 1953. At almost the same time (26 March), Bowen (NAA, C3830, E2/3 Part 2) continued to complain to White about Pawsey's lukewarm support of the GRT concept. Bowen asserted that some major institutions in the post war era (e.g. the Royal Institution in the UK and the National Research Council of Canada) were falling behind because they were not willing to take risks. "At one time both of these institutions were models of their kind and in the forefront of some particular line of research. Then they started to produce reasons why they should not embark on new lines of work and from there on the end was inevitable. ….As you know, I have had a tough time with Joe on the questions of a big aerial. He knows all the reasons why we should not have one. This… is exactly the way to put our feet in the grave as far as radio astronomy is concerned. If we cannot find the money for a big aerial, that is an entirely different matter. But to produce arguments against it will not get us very far."

[2] In C3830 A1/11/3/1 Part 1, John Bolton has presented a fascinating plot of the relevant sky coverage for observations of a GRT at the latitude of Sydney for various tilt angles (eg 30 deg, 60deg, 90deg). For a modest tilt of less than 10 degrees the galactic centre could be observed. A more interesting tilt range was 34 deg, enabling observations of the Magellanic Clouds and the "most interesting Puppis, Vela, Carina regions of the southern Milky Wave. However a more favourable tilt angle was 60 deg: "I would suggest that … [60 deg] would be a most reasonable range for a 250 foot [aerial]."

be 200-250 feet in diameter with a “tilting - barrel” system. (2): The fixed dish option was to be a section of a sphere with a diameter of 230 by 450 feet. The sky coverage of plus and minus 30 deg was provided by moving the feed in the focal plane. This was an attempt to plan an Arecibo type radio telescope with large collecting area.[3] The stationary dish was to be supported by a large number of points fixed by supports from the ground. In 1957, A.J. Head (see Robertson, 1992, p 134 and p. 209) from the Aeronautical Research Laboratories of the Australian Department of Supply did propose an ambitious spherical reflector, a project that was never attempted in Australia. Robertson has pointed out the connection between the Head design and the 1000-foot Arecibo telescope built in the early 1960s in Puerto Rico by Cornell University.

At almost the same time (26 March 1953), Bowen (NAA, C3830, E2/3 Part 2) complained to White about Pawsey’s lukewarm support of the GRT concept. Bowen asserted that some major institutions in the post war era (e.g. the Royal Institution in the UK and the National Research Council of Canada) were falling behind because they were not willing to take risks. “At one time both of these institutions were models of their kind and in the forefront of some particular line of research. Then they started to produce reasons why they should not embark on new lines of work and from there on the end was inevitable. … As you know, I have had a tough time with Joe on the questions of a big aerial. He knows all the reasons why we should not have one. This … is exactly the way to put our feet in the grave as far as radio astronomy is concerned. If we cannot find the money for a big aerial, that is an entirely different matter. But to produce arguments against it will not get us very far.” These signs of disaffection were to increase in intensity during the 1950s, leading in 1960 to a break as Pawsey perceived the likely end of his career at CSIRO (Chapter 30).

In April 1953, White (then Chief Executive Officer of CSIRO) was clearly worried about the uncertain support from prospective US foundations.[4] White decided to write his own prospectus for the GRT extolling the virtues of CSIRO radio astronomy. His document was titled “Radio Astronomy, An Australian Achievement” which would provide a short history of the accomplishments of RP since October 1945. He explained his rationale:

> ... [I would like to provide a] general statement emphasising the outstanding contribution Radiophysics has made in the field of radio astronomy. I have in mind if we are going to approach various people to enlist their help in gaining the sum of money

[3] The Arecibo telescope was planned by the group at Cornell under the leadership of Bill Gordon starting in 1958 ; the opening of the National Astronomy and Ionospheric Center occurred in 1963 (Cohen 2009).

[4] C3830 A1/3/11/3 Part 1.

> we need for the big aerial it might be a good idea to have a statement available for them to read prior to a conversation. Even if we do not use it that way, I think we should be quite clear about the statements we want to make, both describing the contribution itself and the reasons why we think it important to keep a world lead in this field.

Since he had been a war-time Chief of RP before he joined the CSIRO Executive, he knew the RP story well. His role in supporting Bowen and Pawsey in the 1950s was to become a key component in creating the GRT in the years 1954-1961. White intended that the final text would be sent to potential donors, both in Australia and overseas. White's exhortatory text began:

> It is not often that the younger countries of the world succeed in achieving a uniquely outstanding place in any science--Australia has done so in the field of radio astronomy ...
>
> When the work began a few years ago there was only one other group in the world, that at Manchester University[5] ... which was making observations of comparable quality. The Australian group ... deserves great credit for the initiative they have displayed in pursuing this field of science, which has resulted in this country now having a unique and outstanding lead over any other country in the world, with the exception of the Manchester group. This subject has now, of course, excited such interest that others have entered the field ...
>
> Australian workers were, however, the first to identify "radio stars"- discrete sources in our galaxy and in extra-galactic space ...
>
> Here in "radio" signals is [sic] a new source of information which is giving a great deal more information about the universe than is possible from optical information alone.
>
> To the scientist this realm of science is to be encouraged for its own sake--it will undoubtedly have great scientific consequences and may have important **practical applications** [our emphasis] as well.
>
> This opportunity of leadership in one scientific field is one which should not be lightly sacrificed, for it has significant subsidiary consequences for this country. Australia is still developing, and in doing so must call upon scientific aid to a far greater degree than she does today. We are establishing a good reputation in science, and leadership in at least **one field** [our emphasis] will materially assist us in attracting to this country outstanding men from overseas and in encouraging our own men to enter our scientific services.

[5] Surprisingly there was no mention of the Cambridge group's contributions to the new radio astronomy.

Before the war this country was a scientific backwater. It is rapidly losing this reputation, partly, of course due to the more rapid means of communication with the older countries but, more importantly, because senior scientists find it worth their while to visit us. Radio astronomy, in addition to other outstanding radio work, was undoubtedly the means of attracting the first international scientific union to meet in Australia [URSI, 1952].

Real leadership on a world stage is rare; in several fields of science Australia has achieved an outstanding position--we hold our own in original research- but to have the best of two groups in the world [CSIRO and Manchester] is unique.

The greater part of radio astronomy has been carried out to date with relatively simple equipment [left over radar gear from WWII].

The next important discoveries are likely to be made with considerable extension in the size of the aerial system [to] ... systems which might be 200 feet or 300 feet in diameter. [Then the 250 foot Jodrell Bank antenna was described, partly funded by the UK government and partly by the Nuffield Foundation.]

The fact that a decision has already been taken to build one in the Northern Hemisphere is no reason for omitting to do so in the Southern Hemisphere. On the contrary, the Manchester aerial will only be able to “see” approximately half the celestial sphere and it is important that one be built in the Southern Hemisphere to cover the remainder of the Universe.

A design study is being made at the present time of an aerial of comparable dimension which could be used here in Australia. It is possible that a number of savings can be made as compared with the Manchester aerial, but there is no doubt that the total cost would still be substantial, namely of the order of £A 100,000 to 200,000 [the final cost was to be about £A 900,000].

Certainly this impassioned summary was to become an argument for government, private and foundation support. White was clearly attempting to paint a picture of the unique Australian contribution being made to world scientific progress.

A few months later in July 1953, White was in the US. He had been lobbying the Carnegie Institution of Washington, communicating with the Executive Officer, Paul Scherer after the rejection from the Carnegie Corporation of New York the previous year.[6] White heard again

[6] NAA C3830 A1/3/11/3 Part 1. Letter from White in Washington to Bowen and Pawsey, also Z1/14.

about the special fund (Dominion and Colonies Fund) of the sister institution, Carnegie Corporation of New York (see Chapter 27, NRAO ONLINE 38) that might be used for funding the GRT. White was told that the largest grant made by this fund (about $100,000) had been made to the Bernard Price Geophysical Institute of the University of Witwatersrand in Johannesburg, South Africa. Shearer told White that "[The new large telescope] was the sort of proposition that the Corporation might consider." This represented a turn-around of the negative response of the previous December. However, White reported that there was still a problem: "... Bush is still concerned with 'Why a big aerial?'"

Based on his discussions with Tizard in the UK in 1953, White suggested four steps that Bowen and Pawsey should initiate: (1) decide whether they really wanted the GRT, then prepare a proposal for the GRT; (2) begin a design study in order to define and estimate the cost of the project; (3) if the CSIRO Executive were to agree to the project, then announce that the CSIRO would proceed with the understanding that half the funds for the GRT would be derived from private (i.e. non-government) sources; and, finally, (4) ask the Carnegie Corporation again for a grant of £A150,000 ("this is a big sum for them") with the sponsorship of Vannevar Bush and even look for additional funds in the US. White ended his exhortation with an additional push from Tizard: "I agree with Tizard that it would be wise to do some design and costing work to bring reality into the project." Apparently, White was frustrated by the fact that the GRT project had apparently stalled in the first half of 1953 after the rejection from the Carnegie Corporation the previous December.

In the course of 1953, RP was in contact with a number of firms in the US and the UK as well as colleagues in Australia for assistance in preparing a preliminary design.[7] A fascinating exchange of letters occurred between Bowen and the Chicago Bridge and Iron Company from April 1953 to May 1954. The proposal for the "eyeball" structure was Bowen's idea, the drawing he provided to the firm is shown in Fig. 1. Bowen was trying to provide a solution to a perceived flaw in the Manchester design, which had been proposed before the March 1951 discovery of the HI line: "An excessive proportion of the weight [of the Manchester antenna], and therefore the cost, goes into the supporting structure and not into the paraboloid itself." The proposed design spread the weight over a Horton-sphere.[8] Thus Bowen hoped that the company that had

[7] Robertson, P. (1992). "Beyond Southern Skies: Radio Astronomy and the Parkes Telescope." Cambridge University Press, chapter 6, has a detailed account of a number of these activities.

[8] NAA C3830 A1/3/11/1 Part 1. Bowen's first letter of 13 April 1953 was written to the "Horton Steel Works Ltd.", a mistaken name based on the name of the inventor (H. B. Horton) of the well-known "Horton sphere", a spherical pressurised vessel used to store compressed gases and also for nuclear power plants (a famous example was the West Milton, NY, 225 foot Horton-sphere). The correct name of the company was the Chicago Bridge and Iron Company, the CBI Company still in existence in 2013. Most correspondence between this company and Bowen was contributed by N. R. Hower, presumably a director of the firm.

invented this structure for the gas industry might find a new use for the sphere as a mount for a radio telescope. Sections A and B would be made of steel along the lines of a Horton-sphere (a hollow pressurised sphere with a thickness of 0.5 to 1 cm), while section C would be built of structural members with wire mesh for the reflector. The novel idea was the ground support in a pool of water or oil with the centre of gravity adjusted for nearly neutral stability; the support would be spread over a large area to avoid localised stresses. Thus the driving forces for motion of the antenna would be small. "The parabolic section could then be steered in azimuth by simple rotation in the pool and in elevation over an angle of approximately plus and minus 60 deg, which would be adequate for our purpose." Cables were to be attached to the reflector in order to move the antenna. Bowen mentioned a problem that would ultimately lead to the abandonment of this ambitious plan: the main problem was "wind loads and the driving mechanism would have to be specifically designed to look after this [problem]". In addition, Bowen likely assumed that another contractor would be required to provide the actual reflecting surface. No elaborate foundation was required.

At the Washington Conference on Radio Astronomy -1954 (Chapter 22), Bowen gave a detailed presentation on the "eyeball" radio telescope with an unusual title, "A New Radio Telescope Design; the Big Antenna versus the Interferometer Array". Surprisingly there was no mention in the printed text concerning interferometry! The presentation began:

> A disadvantage of a giant radio telescope mounted on a conventional altitude-azimuth mount is that by far the greatest proportion of … material goes into the mount and the foundation, and not into the parabolic dish itself ... An alternative design which overcomes these disadvantages is now proposed. In this design, a 250-foot paraboloid is mounted on a portion of a sphere ... and is allowed to float in a pool of water or light oil in the fashion of a ball joint. [see Fig. 2 Bowen in *Journal of Geophsical Research*, 1954, vol 59, p 184[9],].... [Advantages] are (a) No elaborate foundations are required, (b) Circular symmetry is maintained and there should be no problems maintaining the central portion of the paraboloid to sufficiently close tolerances to operate at [21cm], (c) The structure can be "parked" pointing in any required direction by reducing the level of fluid in the pool, (d) The total weight of the structure is estimated to be 300-400 tons as compared to 1500 tons for conventional designs ... [There are] certain disadvantages, perhaps the most serious being that of providing an accurate drive. One

[9] Bowen: "A disadvantage of a giant radio telescope mounted on a conventional alt-az mount is that by far the greatest proportion of constructional material goes into the mount and foundation, and not in the parabolic dish itself.. An alternative design which overcomes [this disadvantage is now proposed. In this design, a 250-foot [dish] is mounted on a portion of a sphere [120 feet in feet in diameter] and is allowed to float in a pool of water or light oil I the fashion of a ball joint."

> method of carrying this out would be by means of four cables in the north, south, east and west directions ...

A few months later Christian Arne of the Chicago branch of Chicago Bridge and Iron Company responded with two fanciful designs that were derivatives of the Bowen plan[10], shown in Fig. 3 and 4.[11]For the latter design, guide rails were to be installed for motion in elevation. The movement would be activated by cables. Hower, from the New York office, followed up with a letter from 6 August 1953. He doubted Arne's claim of accuracy of plus or minus 1 inch over the entire 250 foot surface; also he had strong misgivings about the pointing problems, " ... to make note that should this apparatus be floated in water, it is entirely probable that its motion while floating in water will probably cause the parabolic surface to move about to some extent- whether or not floating the structure in water is practical would again depend on whether or not such motion would place the instrument beyond the tolerances required."

Bowen clearly realized at this point that the design was not practical due to the problems of pointing the telescope, writing on 6 November 1953 to Hower: "... the chances of such an aerial being built in Australia are now small ..." Based on these doubts, it is surprising that Bowen still emphasised this design a few months later in Washington. Bowen visited Hower in New York in January 1954 after the Washington Conference.[12] By April-May 1954, Hower had lost interest in a possible Horton-sphere radio telescope; he realized that any "eyeball" antenna would be built of structural steel and not steel plate construction (as used in the Horton-sphere). At this time, Hower attempted to interest a construction company in Sydney (Bernard-Smith Pty. Limited) to become involved in the project. Apparently nothing came of this initiative.

When Bowen and Pawsey published their publicity book in May 1955 (Chapter 27 and NRAO ONLINE 41), various versions of the "eyeball" GRT were shown. Examples of the cable controlled aerial floating on water or oil are shown in Fig 5. A variation of this design is also shown in Fig.6, a reflector with a rack driven on the outside of a track mounted sphere. The motion in altitude was obtained by moving the reflector over guide rails on the sphere and in azimuth by rotating the sphere. (This design would have alleviated some of the pointing problems which had been of concern.) In the end this innovative proposal was dropped due to the problems of moving the radio telescope, especially in the presence of modest wind. As Arthur Wills wrote to Bowen: "The wind loads and the steering problem could be dealt with

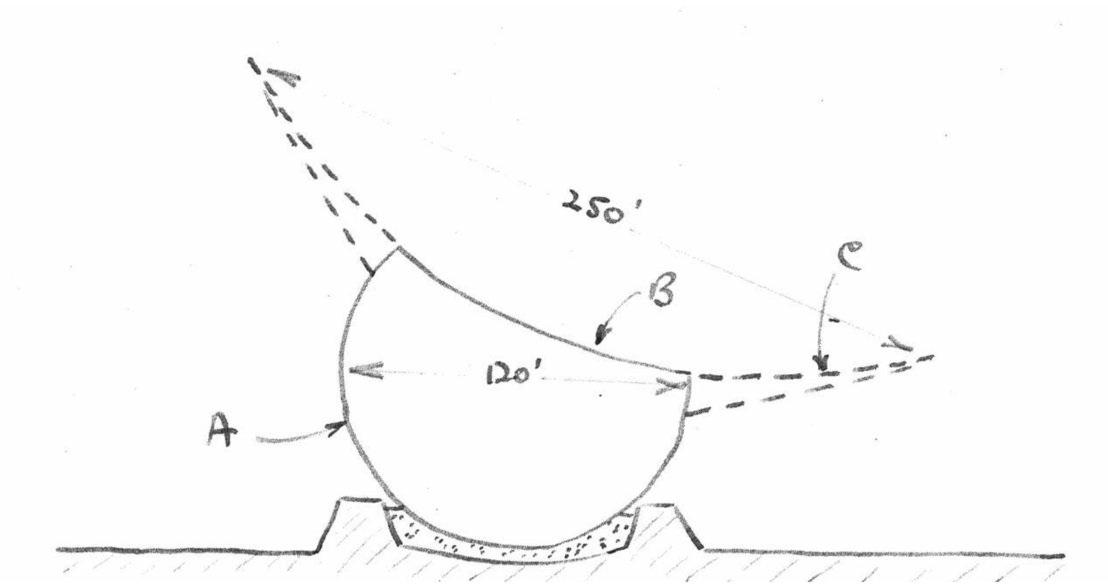
[10] *op cit*. 19 June 1953

[11] NAA A1/3/11/3 Part 1

[12] NAA A1/3/11/3 Part 1. On 24 February 1954, Bowen wrote Merle Tuve from Seattle with a positive report of his meeting with Hower. He proposed to strengthen the sphere in the "eyeball" design since he was worried about bulging of the sphere which could lead to a degradation of the pointing accuracy.

fairly easily if movement were limited to control in elevation, but to combine this with steering in azimuth would present quite difficult problems."[13]

Fig 1 Horton sphere.250-foot paraboloid. Bowen's sketch 13 April 1953 . "A" and "B" would be made of steel and C would be a structural member with wire mesh for the reflector. The ground support would be a pool of water or oil. The diameter of the partial sphere would be about 120 feet. The motion in azimuth would be simple rotation in the pool with a tipping of about plus and minus 60 deg in elevation. Credit: NAA C3830 A1/3/11/1 Part 1



[13] *op cit*. 1 May 1953. Wills was the assistant Controller for Research and Development in the Australian Government Department of Supply and played a major role on the Technical Advisory Committee for the GRT. Additional doubts were expressed by Charles Husband, the designer of the Jodrell Bank telescope, to Pawsey in August 1954 (NAA A1/3/11/3 Part 2). Husband thought that for a "flotation" aerial that the "troubles due to windage were so great as to render the scheme unsatisfactory".

Fig 2 below Washington conference 1954, a modified Horton sphere at ground level with a depression in the earth increasing the zenith angle coverage. The dish has a diameter of 250 feet, the sphere is 120 feet. The steel cables were to be used for elevation movement. Credit: Journal of Geophysical Research, 1954, vol 59, p 186, publication by Bowen on page 184 “A New Radio Telescope Design; the Big Antenna Versus the Interferometer Array”

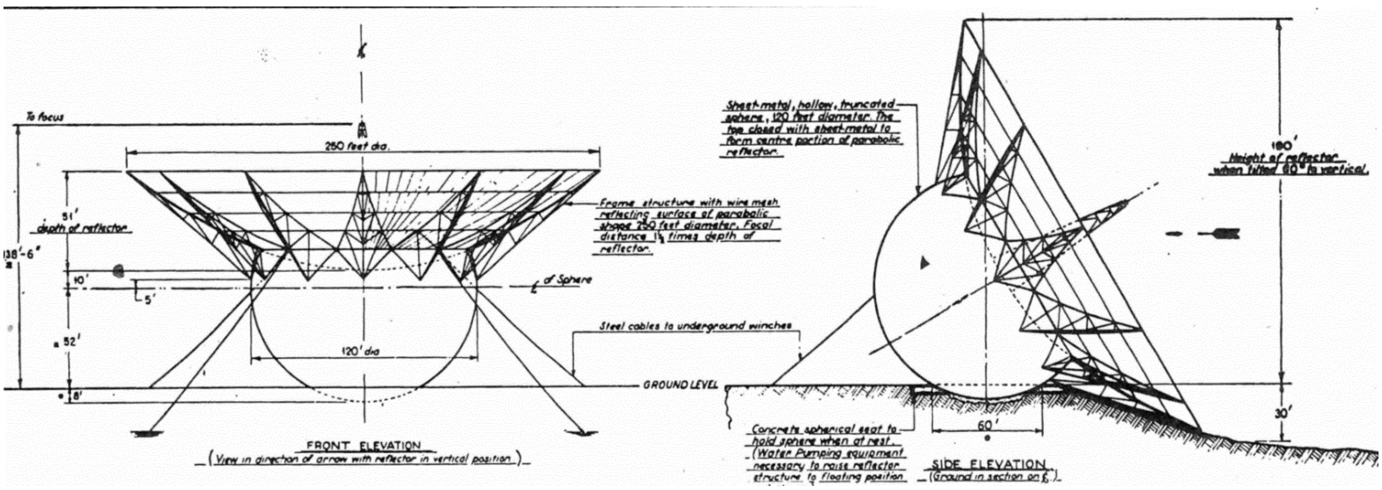


Fig 3 below Design of Christian Arne of Chicago Bridge and Steel 19 June 1953 Model A with a sphere floating in water. The internal water is to a lesser depth so the external pressure would be reduced, enabling a thinner steel shell thickness for the sphere. Credit: NAA A1/3/11/1 Part 1

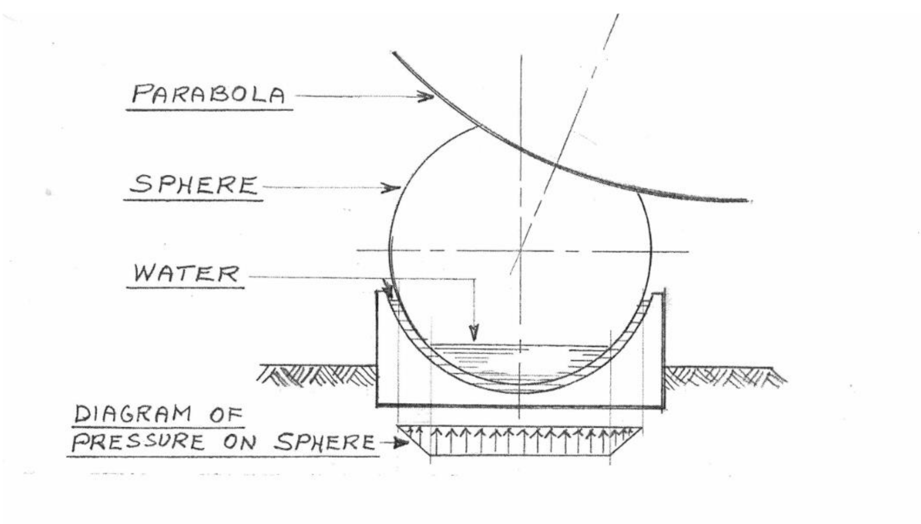


Fig 4. Below Model B for a sphere and paraboloid. A sphere with unobstructed mobility and a large trumpet shaped cavity were used for floating balance. The centre of gravity of the floating body was located above the geometrical centre of the spherical surface with equilibrium maintained in various positions. The sphere was smaller than model A. Cables were to be used for movement with guide rails for motion in the NS direction. Credit: NAA A1/3/11/1 Part 1

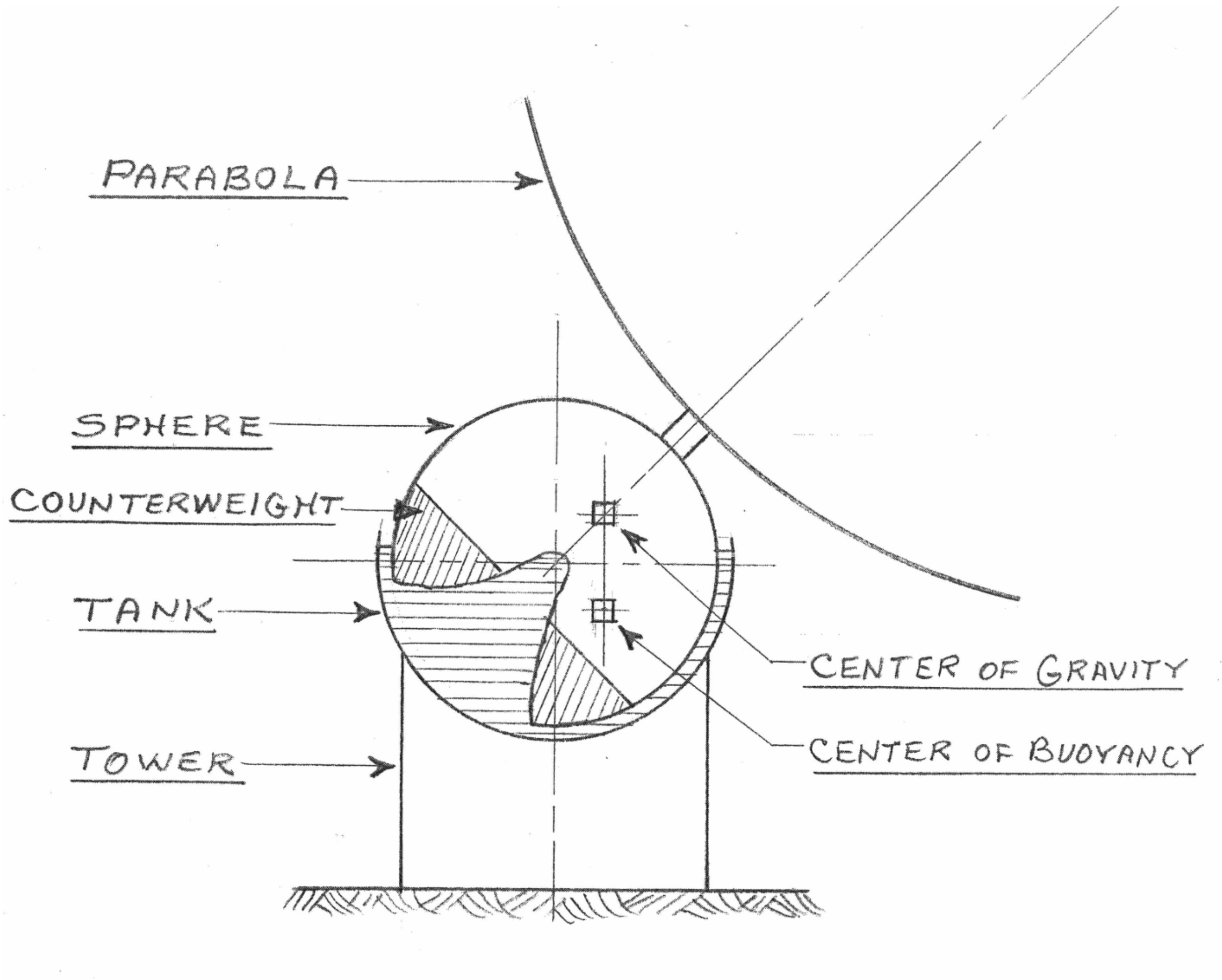


Fig 5. Below: GRT Model. From A Proposal for a Giant Radio Telescope. A floating sphere with the paraboloid fixed to a truncated sphere. The sphere floated in a pool of water or oil with the centre of gravity adjusted for nearly neutral stability. Fig 5 and 6 from National Archives of Australia, A1/3/11/6, Sydney 1955, by Bowen and Pawsey.

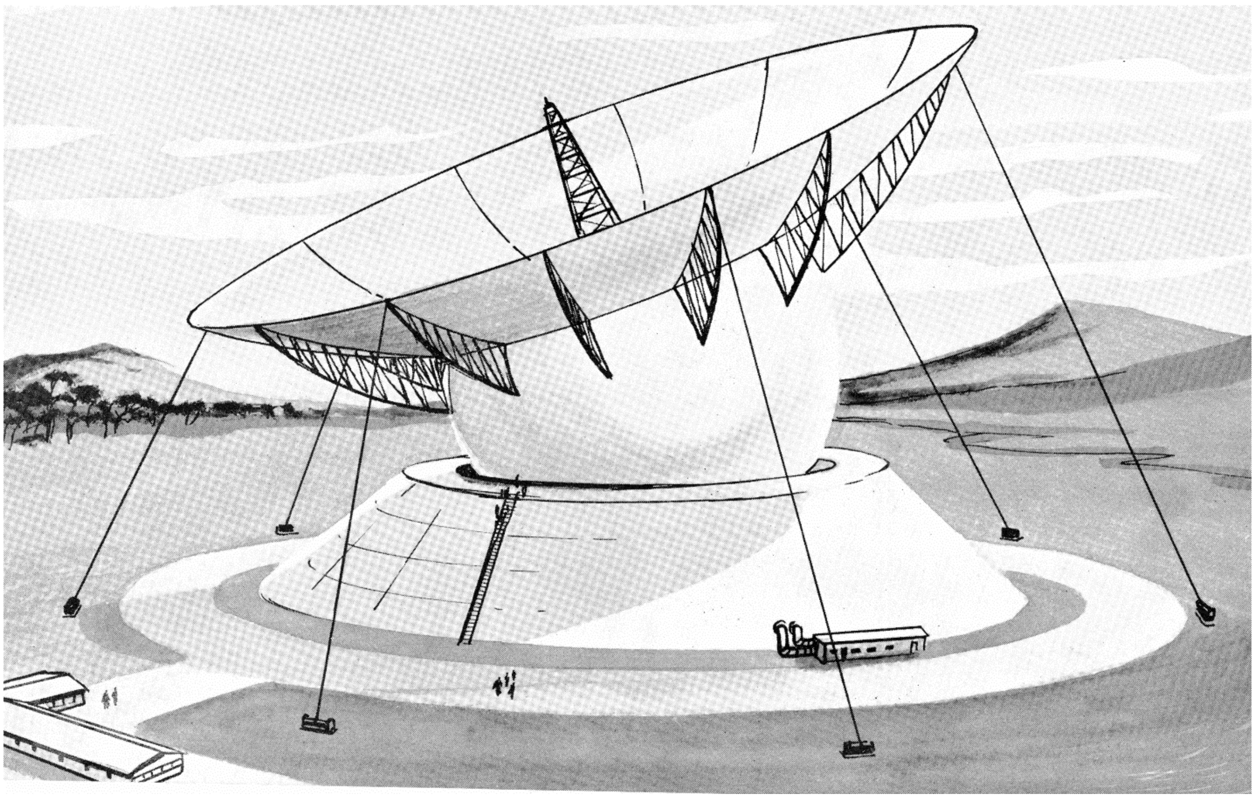


Fig 6. GRT Model. The support is on a concrete base. The reflector is rack-driven on the outside of a track-mounted sphere. The motion in altitude was obtained by moving the reflector over guide rails on the sphere and in azimuth by rotating the sphere.