ASSOCIATED UNIVERSITIES, INC.

350 Fifth Avenue
New York 1, New York

November 26, 1956

MINUTES
Meeting of Special ad hoc Committee
140-foot Equatorial Telescope Design

1. On November 14, 1956, the special ad hoc Committee on the design of a 140-foot equatorial telescope met in New York, the following being present:

N.L. Ashton	Park Road, Iowa City, Iowa
P.P. Bijlaard	Cornell University
J.G. Bolton	Mount Wilson & Palomar Observatories
N.A. Christensen	Cornell University
R.M. Emberson	Associated Universities, Inc.
A.M. Freudenthal	Columbia University
F.T. Haddock	University of Michigan
D.S. Heeschen	Associated Universities, Inc.
M.B. Karelitz	Brookhaven National Laboratory
T.C. Kavanagh	Praeger & Kavanagh
E.F. McClain	Naval Research Laboratory
B.H. Rule	California Institute of Technology
J.O. Silvey	Massachusetts Institute of Technology
H.E. Tatel	CIW-DTM

Prof. Ashton had agreed to work out the details of the design, with the advice and assistance of the Committee; and Dr. Kavanagh had been asked to serve as Chairman of the Committee.

2. The meeting was opened by Dr. Emberson, who reported on discussions of the 140-foot telescope at the October 16-17 meeting of the AUI Radio Astronomy Advisory Committee. These discussions were summarized in a memo "General Specifications for a 140-foot Equatorial Telescope", copies of which were distributed. Concerning Section 2 of the memo on sky coverage, Prof. Bolton pointed out that the limited sky coverage described therein would give some savings compared to complete hemispheric coverage, but additional savings of the same order could be expected if the hour angle coverage at the equator was reduced to four or five hours, east or west. The question of sky coverage was discussed at considerable length and the matter will be referred to the AUI Advisory Committee for additional advice.

3. In discussing Section 3 of the memo, on the precision of the parabolic surface, Dr. Emberson reported that the AUI Advisory Committee had indicated a desire for a 1/8-inch tolerance. He pointed out, however, that the budget of $2.2 million for a complete telescope (foundations, structure, drive and control) had been set more than a year earlier; that all costs had been rising; and there was some doubt, pending a firm bid, that a telescope with the original 1/4-inch tolerance could be obtained for the available money.

4. With reference to Section 5 of the memo, on the feed at the paraboloid focus, Prof. Haddock later brought out that in the past two years considerable progress had been made in feed designs; that feed clusters could be made for f/D = 0.42 or 0.43 as easily as could be done formerly for an f/D of 0.50; and that most military paraboloids were being made with an f/D of about 0.42, with effort being given to the development of improved feeds of various types to operate at this f/D value. Inasmuch as there was no structural objection to a deeper paraboloid, it was agreed that Prof. Ashton's design should have a paraboloid of 60-foot focal length (f/D = 0.428), thereby permitting us to take advantage of feed development work of others.

5. With reference to Section 6 of the memo, on bearings and drives, the discussion brought out that seldom, if ever, would the telescope be moved in declination at a slow precise rate, as is necessary in hour angle. Because of the simplification of structural problems that would result from a smaller radius for the declination drive gear, it was agreed that the minimum declination radius might be reduced from 50 to 35 feet. The discussion of the alignment problems brought out that not only must the polar and declination axes be adjustable, but also the geometrical axis of the paraboloid must be made adjustable with respect to the declination axis. In accordance with all of the above discussions, the general specifications memo has been revised and is attached hereto.

6. Concerning the $2.2 million figure for the total cost of the 140-foot telescope, Messrs. Kavanagh and Silvey gave some preliminary results from the pricing study that is being made of the available telescope designs. These figures are not reproduced here, because the final report will be available soon and will be distributed to the recipients of these minutes. Dr. Kavanagh pointed out that fabrication costs might be the same for a reflector, whether it was to be employed on any of several types of mounts, but the erection cost might vary considerably, depending on whether the assembly could be done on the ground or had to be done on staging 70 feet or more in the air. As a consequence, he was finding that some steel was costing $800-1000 per ton. He also mentioned that Mr. Husband had just given numerical values on relative costs, as follows:

All steel altazimuth telescope	1.738
All steel equatorial telescope, complete coverage	2.408
All steel equatorial, telescope, partial coverage	2.268
Aluminum-steel equatorial telescope, complete coverage	2.128
Aluminum-steel equatorial telescope, partial coverage	1.988

It was not clear from Mr. Husband's communication how much of the drive and control system, foundation, etc., is included in these estimates.

7. Prof. Ashton discussed some of the available equatorial designs and presented his views on a design which would provide complete hemispheric coverage. He agreed that some savings could be achieved if the sky coverage were reduced, but he did not anticipate percentage savings as large as those estimated by Mr. Husband.

8. Prof. Bolton brought a preliminary set of plans for the CIT 90-foot telescopes and these were discussed by him and Mr. Rule. It was brought out that in this design, the declination axis had been kept close to the polar axis; but this had been achieved at the expense of a rather shallow reflector structure and a slender tower. There was agreement that the axis should be brought together as close as feasible.

9. Dr. Tatel discussed the CIW-DTM equatorial design, pointing out the following features: the polar axis would not be thrown out of adjustment by a change in temperature of the mount, because provision is made for horizontal motion of the base of the telescope; and the radius for the application of the polar and declination motions may be made as large as the radius of the reflector. (Subsequent to the meeting, he reported that detailed stress and deformation calculations for the design had just been completed and that a copy would be sent to Prof. Ashton).

10. Because of the preliminary nature of Prof. Ashton's sketches, and the related computations, copies will not be distributed as an attachment to these minutes. (Sufficient copies are available for distribution only to the structural consultants). In summary, the consensus was that the reflector design was adequate, a solid surface should be provided in preference to an open grid, and the

surface panels should be adjustable with respect to the supporting frame. The change of f/D to 0.43 would further improve the antenna feed support. Pending a decision on the amount of sky coverage, it should be assumed that the declination drive gear could be reduced to a 35-foot radius, thereby permitting a more compact design with less separation between the polar and declination axes. It was not obvious that there would be any interferences between the reflector, when turned to the southern horizon, and an extended polar axis and the consensus was that that polar axis could profitably be made longer.

11. There was agreement on the general concept for the mount to be of the type proposed by Messrs. Feld and Ashton, rather than the perimeter bearing, yoke supported structure suggested by Mr. Husband.

12. Among the suggested structural alterations were suggested a stiffening of the dish to resist torsion between the declination gear rings. There was general agreement that the use of aluminum alloys in the reflector dish structure and the elevating sectors would be desirable, but no conclusion was reached on the practicality of joining a steel gear mechanism without producing differential temperature effects.

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General Specifications for
140-foot Equatorial telescope
Revised 11/20/56

General Specifications
for a
140-foot Equatorial Radio Telescope

1. The specifications of October 25, 1955 apply in all matters not covered herein.

2. Minimum acceptable sky coverage:

   From the pole along a great circle to the east point on the horizon; thence along the horizon through the south point to the west point; thence along a great circle to the pole.

3. Precision of the paraboloid surface:

   For wind speeds up to 16 mph, the root mean square deviation from the best paraboloid shall be no more than ±1/4-inch for all positions of the paraboloid. Under a no-wind condition and for zenith distances of less than 60°, the surface accuracy should be as much better than ±1/4-inch as can be obtained without appreciably increasing the cost of the reflector. The paraboloid surface shall be adjustable by means of rear-mounted studs or other means. The number of rigid panels that make up the surface shall be kept as small as is consistent with the surface tolerances demanded of the panels.

4. Tracking and Pointing Accuracy:

Wind Condition	Zero Wind	16 mph Wind
Absolute pointing accuracy	±30"	± 40"
Relative pointing accuracy*	±10"	± 20"
Tracking accuracy over 15 min time	±10"	± 20"
Tracking accuracy over 1 hr or more	±20"	± 40"

*Relative pointing accuracy is defined as the accuracy with which the telescope can be moved from one point to another point, assuming the subtended angle between points is under 30 deg and that both points are 30 deg or more above the horizon.

5. Feed at paraboloid focus:

   Provide for a load of 1000 pounds, to be supported by a tripod or tetrapod mount, the mounting base or plate to be not less than four feet behind the focus. Deflections due to gravity, as the telescope is moved about the sky, should be not more than 1/8-inch laterally from the axis of the paraboloid. A tolerance of 1/16-inch is desirable if it can be achieved at no great additional expense. The focal length shall be 60 feet, making the f/D ratio about 0/43.

6. Bearings and Drives:

Oil pad bearings shall be provided for the polar axis. A minimum radius of 50 feet shall be provided for the application of the drive pinions for motions about the polar axis; the minimum radius for the application of the declination pinions shall be 35 feet. Adjustments shall be provided for the alignment of the axes; the polar axis shall be independently adjustable in azimuth and altitude; the declination axis shall be adjustable to lie in a plane perpendicular to the polar axis. Also, the geometrical axis of the paraboloid shall be adjustable to lie in a plane perpendicular to the declination axis.

Revised November 20, 1956