NATIONAL RADIO ASTRONOMY OBSERVATORY

MEMORANDUM

May 14, 1975

12 METER MILLIMETER WAVE TELESCOPE
MEMO No. 3

To: Addressee

From: J. Payne and J. Hollis

Subj: Further Measurements on the 36-ft Surface

You may be interested in some additional measurements we have made on the 36-ft surface using the method developed by J. W. Findlay and ourselves.

We have now measured the 36-ft on three separate occasions: July 1974, October 1974, and March 1975. The July measurements were intended to demonstrate the feasibility of the method and to provide an estimate of the accuracy of the system which we measured as approximately 0.05 mm RMS.

The October and March measurements were intended to give an accurate measurement of the antenna. We have used these results to produce contour maps of the surface deviations from the best fit parabola, to analyze the antenna astigmatism and to investigate the damage caused when the feed legs fell.

The geometry of the measurements, with the antenna viewed from above, is shown in Figure 1.

The October and March contour maps are given in Figures 2 and 3, the orientation of the maps being the same as Figure 1.

The damaged area of the antenna shows clearly. The points at which the two feed legs hit the dish surface may also be seen.

The scalloped areas around the edge of the reflector coincide with the radial ribs of the back-up structure.

The inner half of diameter of the surface was also analyzed and plotted. The two relevant maps are shown in Figures 4 and 5. The concentric circles in the center of the maps are a result of the contouring program interpolating into a region of no data points.

The results of the two sets of measurements are summarized in the table. The RMS departures from the best fit paraboloid weighted by a 10 dB illumination pattern are about 0.21 mm, and this compares with a value of 0.18 mm inferred from radiometric testing at a wavelength of 3 mm.

It should be noted that the focal length is shorter in the March data than in the October data despite the fact that the average temperature was higher in March. This apparent anomaly is explained by the fact that the focal length is a strong function of temperature differences at various points on the dish; the automatic focusing of the antenna during normal observations uses this empirical relationship between the various temperatures and focal length.

When these individual temperatures are considered, we find that the October focal length should indeed be longer than the March value.

Figure 6 is a plot of the focal length of the best fit parabola to each set of radial data. The damage to the antenna is dramatically seen in this figure.

Figure 7 is the result of an astigmatism analysis on the October data. Two opposite quadrants of data were best fitted to a parabola and the focal length plotted as a function of "butterfly" rotation angle. This is made clear in the drawing on Figure 7. The astigmatic effects seem to be symmetrical about the elevation axis and the point where the damaged area switches in and out of the data butterfly are apparent.

The average temperature during these tests was 8.75°C and the zero astigmatism point is 11°C according to radiometric data taken by Ned Conklin. The agreement between the radiometric data and the results obtained by our method is surprisingly good; the azimuth focal length should be 2.2 mm longer than the elevation focal length according to the radio measurements and our measurements give approximately 3 mm.

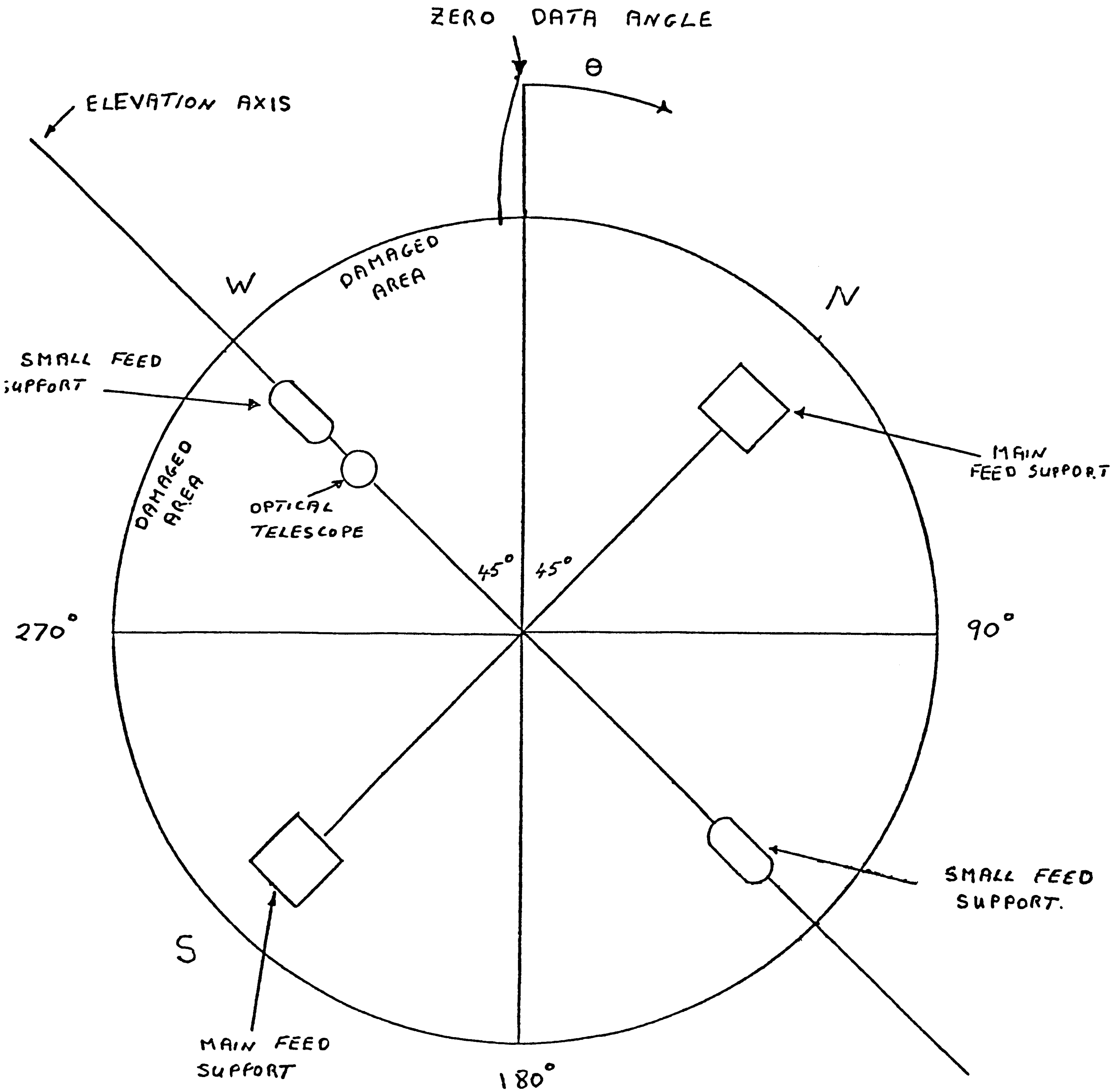
Figure 8 is a plot showing how the focal length and RMS for the October data vary as a function of the diameter of the circle of data analyzed. The RMS plot is as one would expect, steadily increasing as the diameter of the data circle increases. The shape of the focal length curve is probably explained by the fact that the minimum focal length approximately coincides with the main support ring for the dish. With the dish in the vertical position, a cantilever effect would tend to flatten out the center of the dish and also the outer regions. Figure 9 is a similar set of curves for the March data.

During our measurements in March, we made repeated measurements along one radius of the antenna with the results shown in Figure 10. These results have been corrected in the programs for the effects of temperature changes on the measuring instrument. When edge movement is plotted as a function of temperature, the result is virtually linear.

We are currently investigating two possibilities of improving the performance of the antenna. The first method involves machining the subreflector in such a way as to reduce the phase errors introduced by the imperfections in the main reflector. This method has the obvious disadvantage of not improving prime focus operation. The second method is to project a contour map onto the surface of the antenna at nighttime and to build up the low areas of the surface with aluminum foil. The antenna could then be remeasured and again built up. A photograph of the surface with the contour map projected on it is shown in Figure 11.

JMP/cjd

Enclosures



October '74 & March '75

GEOMETRY OF MEASURMENTS, ANTENNA VIEWED FROM ABOVE.

~~Figure 1~~

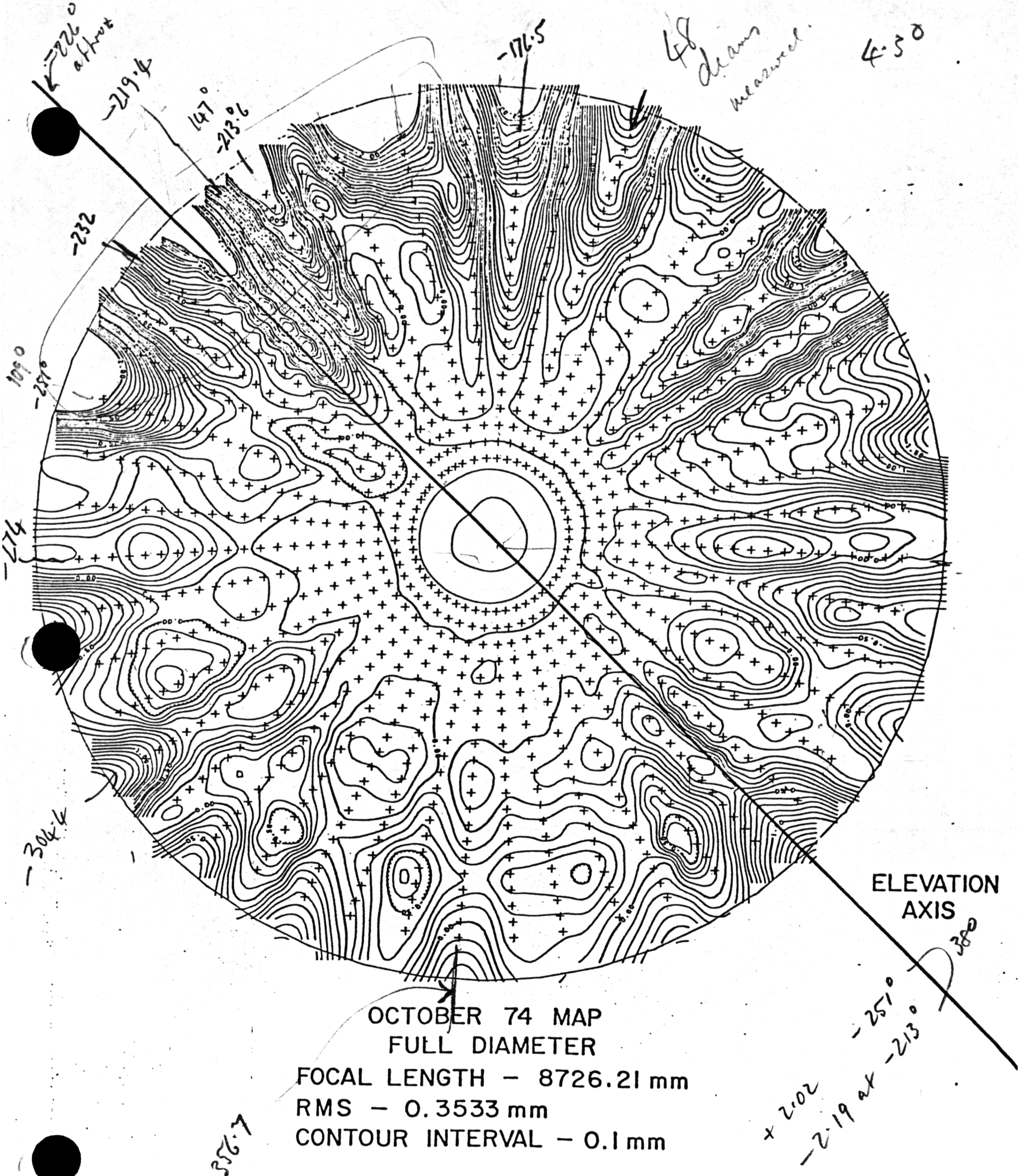
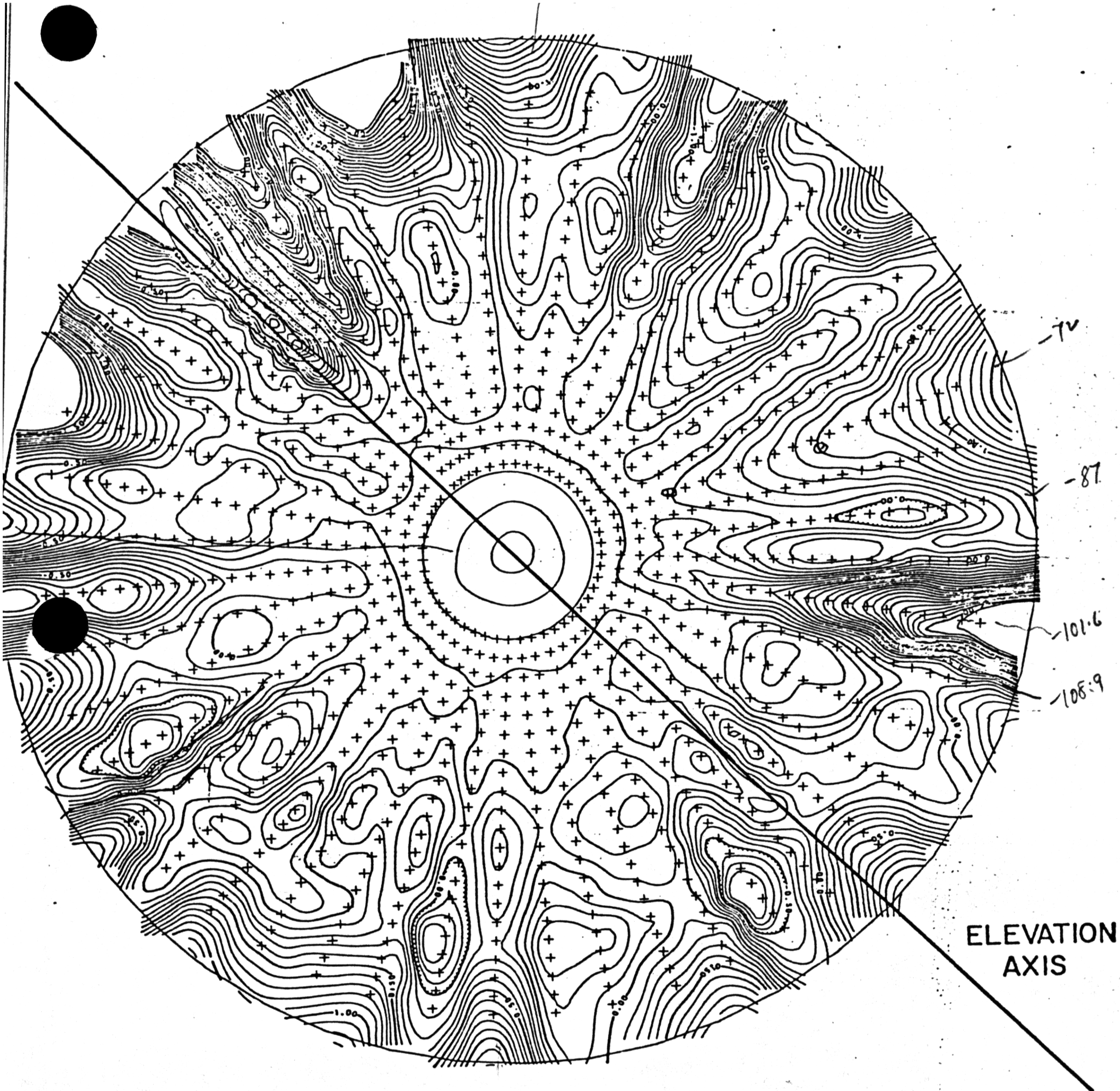
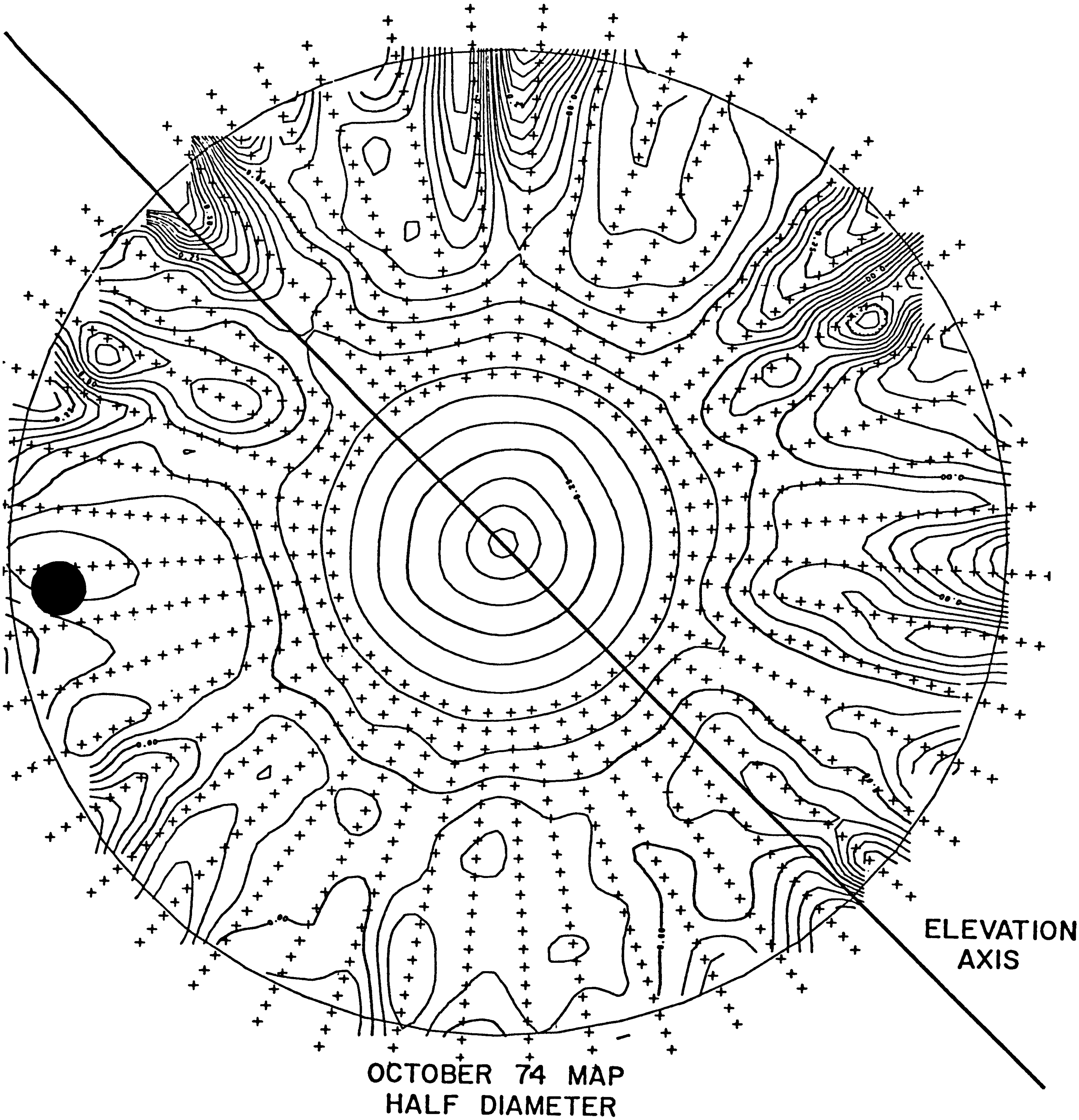

ELEVATION AXIS
OCTOBER 74 MAP
FULL DIAMETER
FOCAL LENGTH - 8726.21 mm
RMS - 0.3533 mm
CONTOUR INTERVAL - 0.1 mm

Figure 2



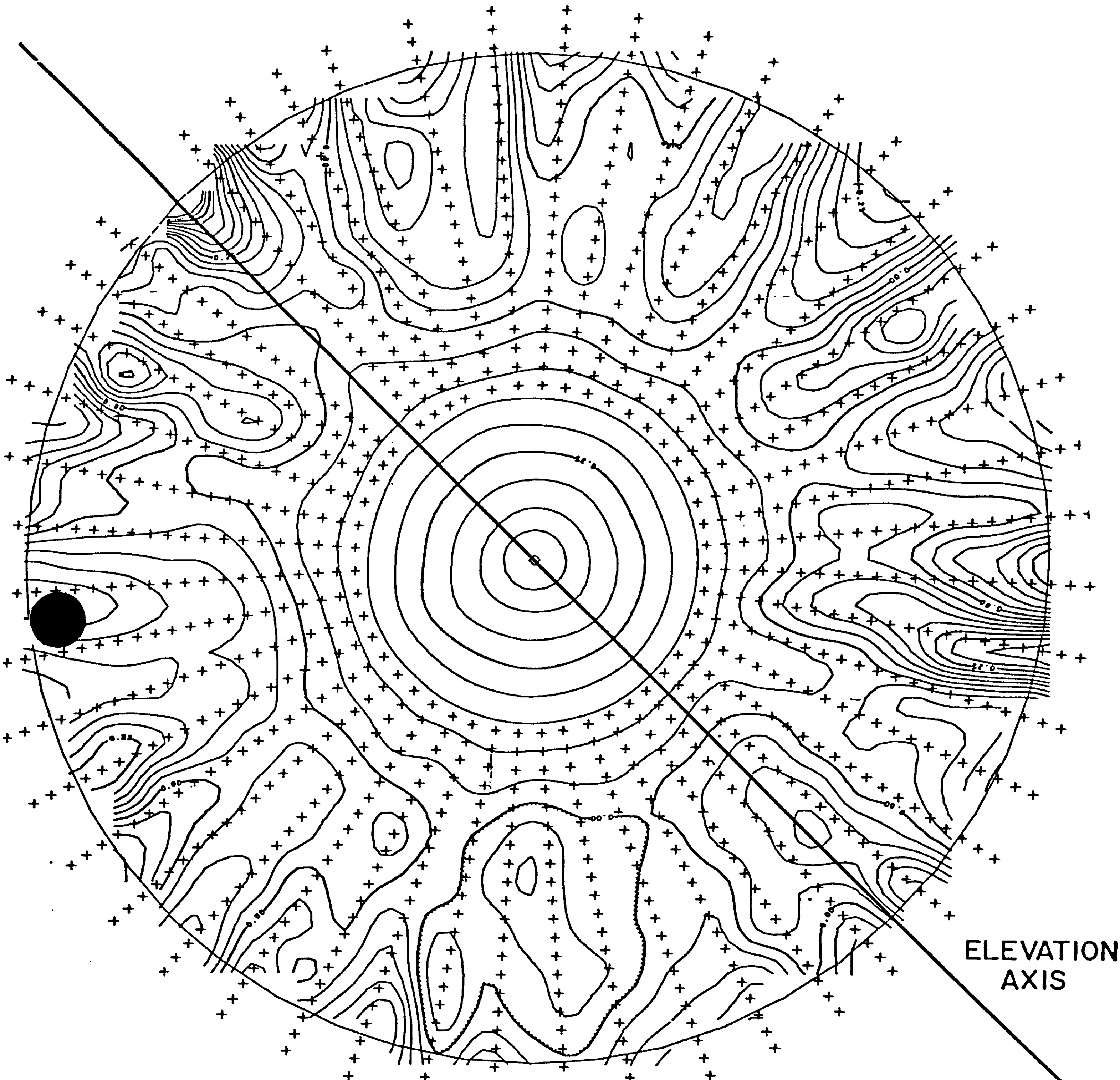
MARCH 75 MAP
FULL DIAMETER
FOCAL LENGTH – 8721.33 mm
RMS – 0.3469 mm
CONTOUR INTERVAL – 0.1 mm

Figure 3



OCTOBER 74 MAP
HALF DIAMETER
FOCAL LENGTH – 8721.89 mm
RMS – 0.1204 mm
CONTOUR INTERVAL – 0.05 mm

Figure 4



MARCH 75 MAP
HALF DIAMETER
FOCAL LENGTH – 8718.03mm
RMS – 0.1150 mm
CONTOUR INTERVAL – 0.05mm

Figure 5

SUMMARY OF RESULTS

NOMINAL FOCAL LENGTH OF ANTENNA = 8778.3 MM

PARAMETER	OCTOBER 1974	MARCH 1975
AVERAGE DISH TEMPERATURE	8.75 °C	9.02 °C
FOCAL LENGTH	8726.21	8721.33
RMS DEVIATIONS FROM BEST FIT PARABOLA	0.3533 MM	0.3469 MM
RMS WITH 10 dB ILLUMINATION TAPER	0.2123 MM	0.2074 MM
RMS OF HALF DIAMETER	0.1204 MM	0.1150 MM
FOCAL LENGTH OF HALF DIAMETER	8721.89 MM	8718.03 MM

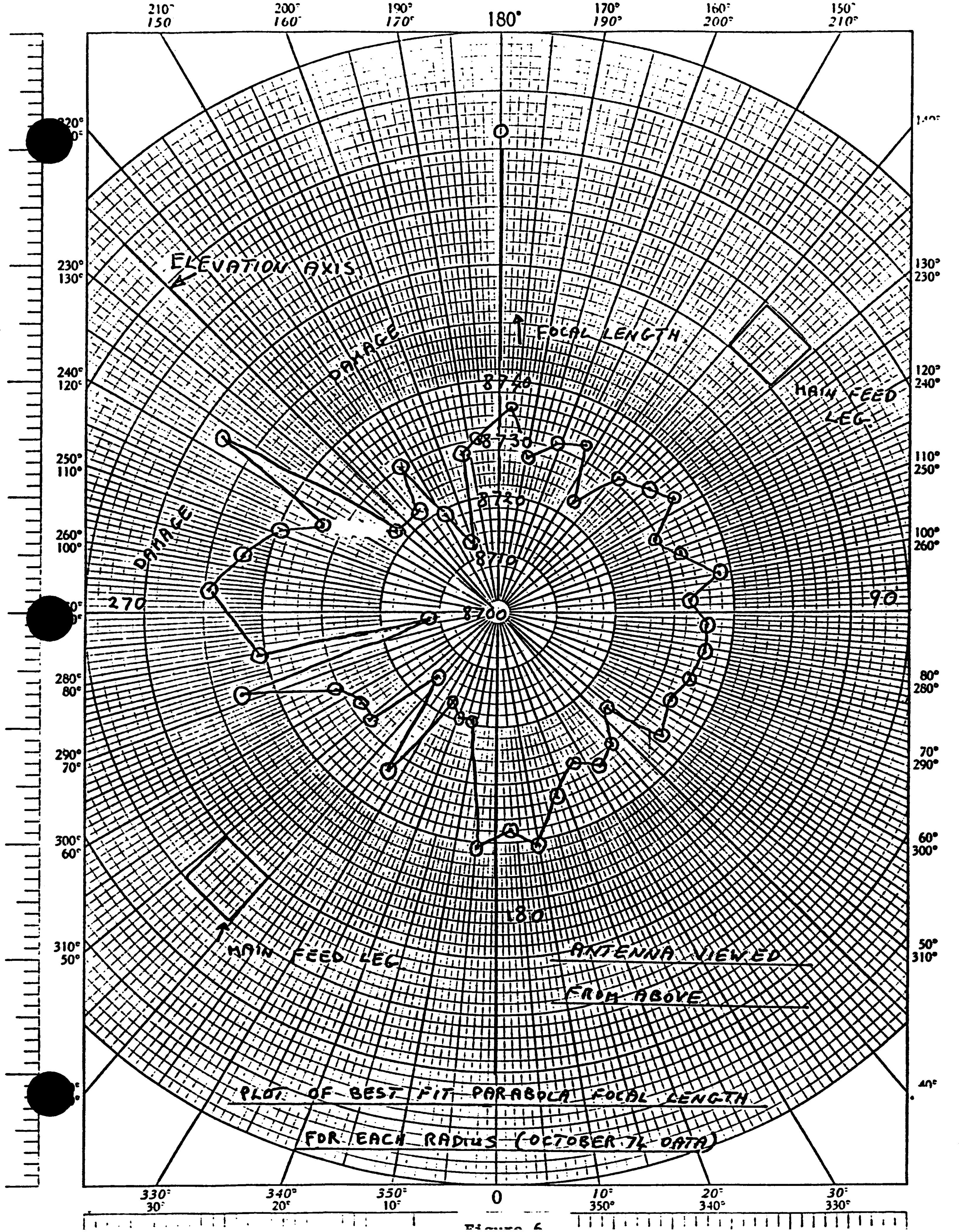
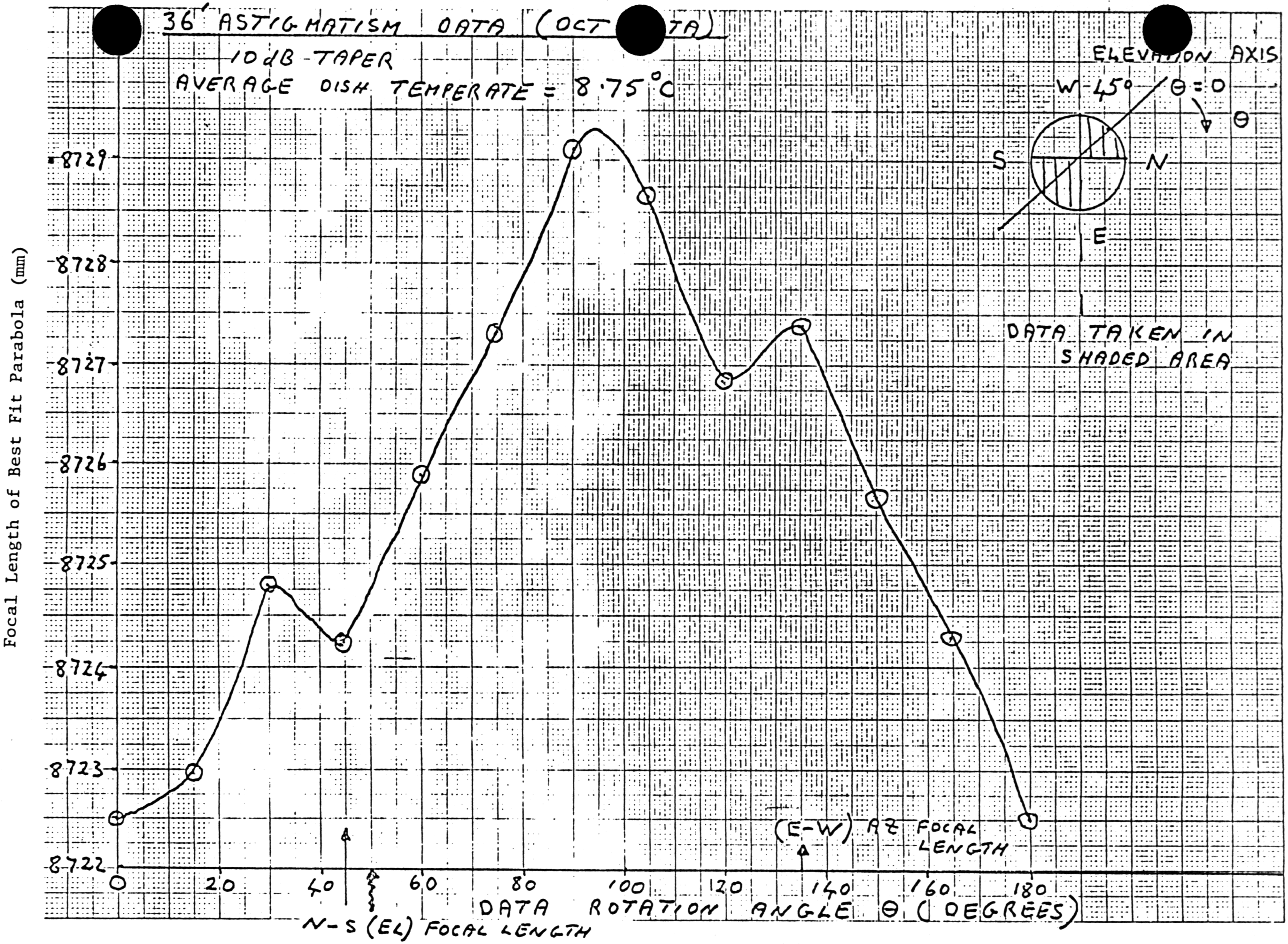
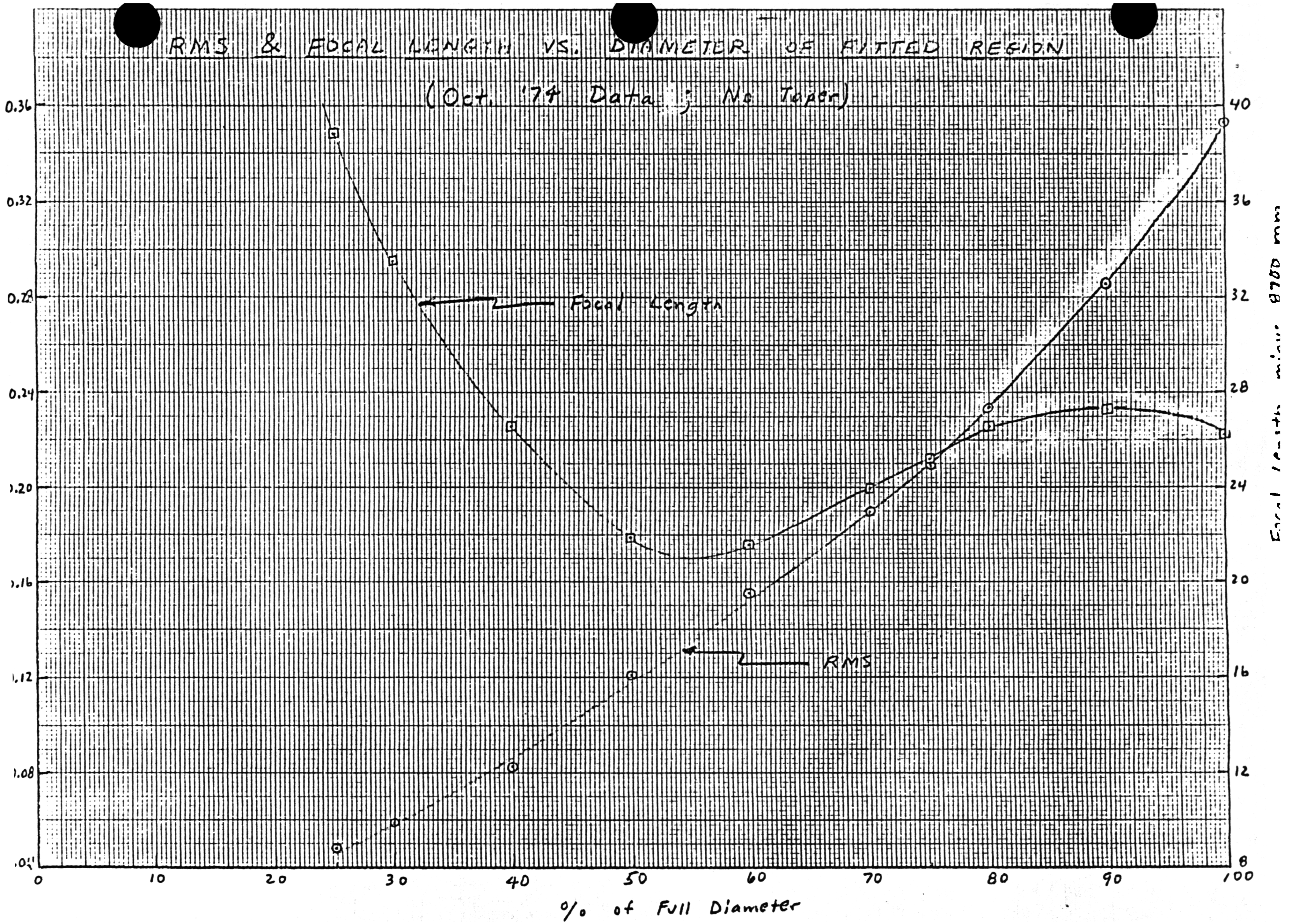

ELEVATION AXIS
DAMAGE
DAMAGE
FOCAL LENGTH
8740
8730
8720
8710
8700
MAIN FEED LEG
MAIN FEED LEG
270
90
180
ANTENNA VIEWED FROM ABOVE
PLOT OF BEST FIT PARABOLA FOCAL LENGTH FOR EACH RADIUS (OCTOBER 72 DATA)

Figure 6



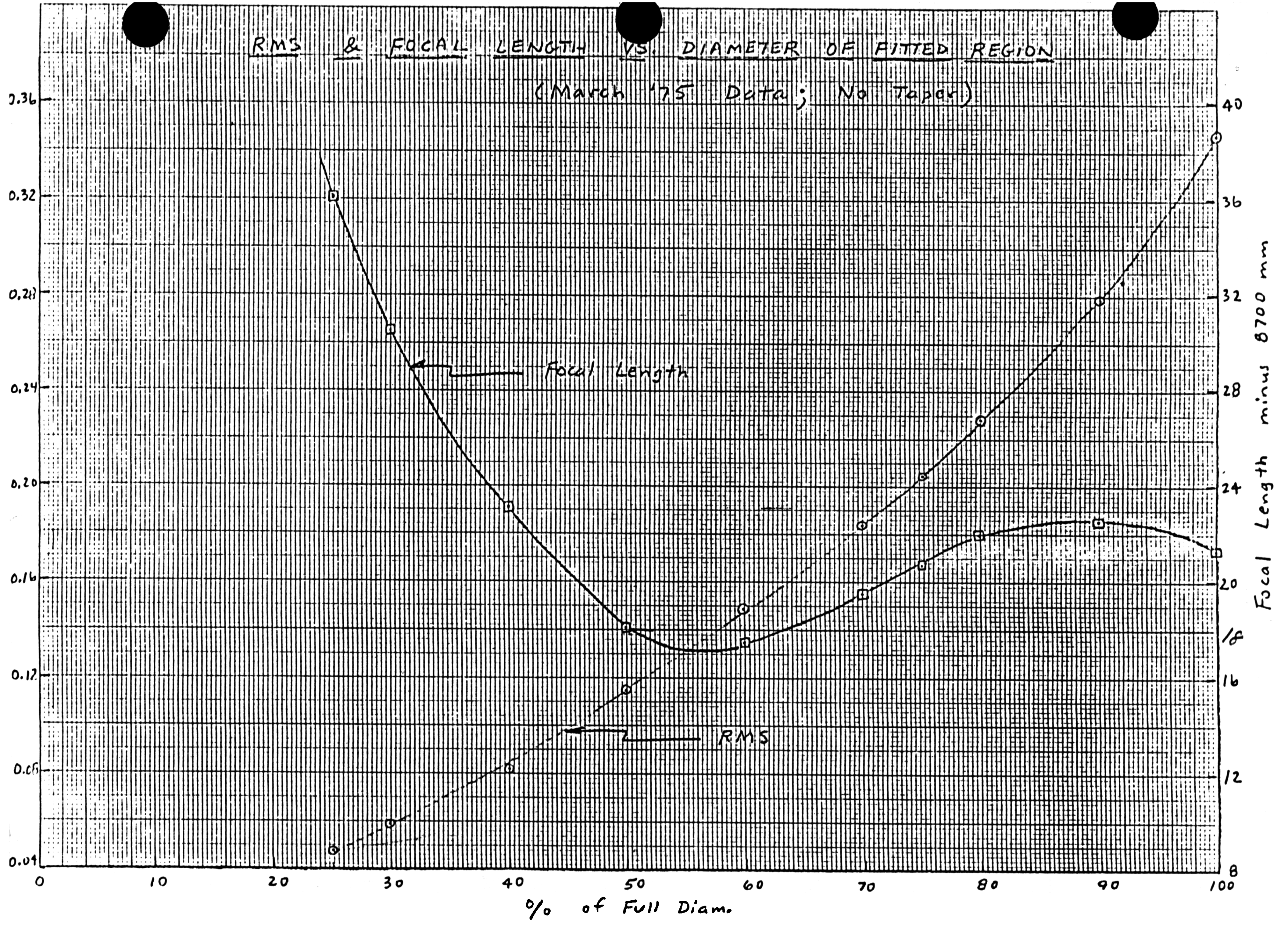
36' ASTIGMATISM DATA (OCT TA)
10dB TAPER
AVERAGE DISH TEMPERATE = 8.75°C
ELEVATION AXIS
W 45°
θ = 0
θ
S
N
E
DATA TAKEN IN SHADED AREA
Focal Length of Best Fit Parabola (mm)
8729
8728
8727
8726
8725
8724
8723
8722
0
20
40
60
80
100
120
140
160
180
DATA ROTATION ANGLE θ (DEGREES)
N-S (EL) FOCAL LENGTH
(E-W) AZ FOCAL LENGTH

Figure 7



RMS & FOCAL LENGTH VS. DIAMETER OF FITTED REGION
(Oct. '74 Data; No Taper)
Focal Length
RMS
% of Full Diameter
0
10
20
30
40
50
60
70
80
90
100
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
40
36
32
28
24
20
16
12
8

Figure 8



RMS & FOCAL LENGTH VS. DIAMETER OF FITTED REGION
(March '75 Data; No Taper)
Focal Length
RMS
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
40
36
32
28
24
20
18
16
12
8
0
10
20
30
40
50
60
70
80
90
100
% of Full Diam.
Focal Length minus 8700 mm

Figure 9

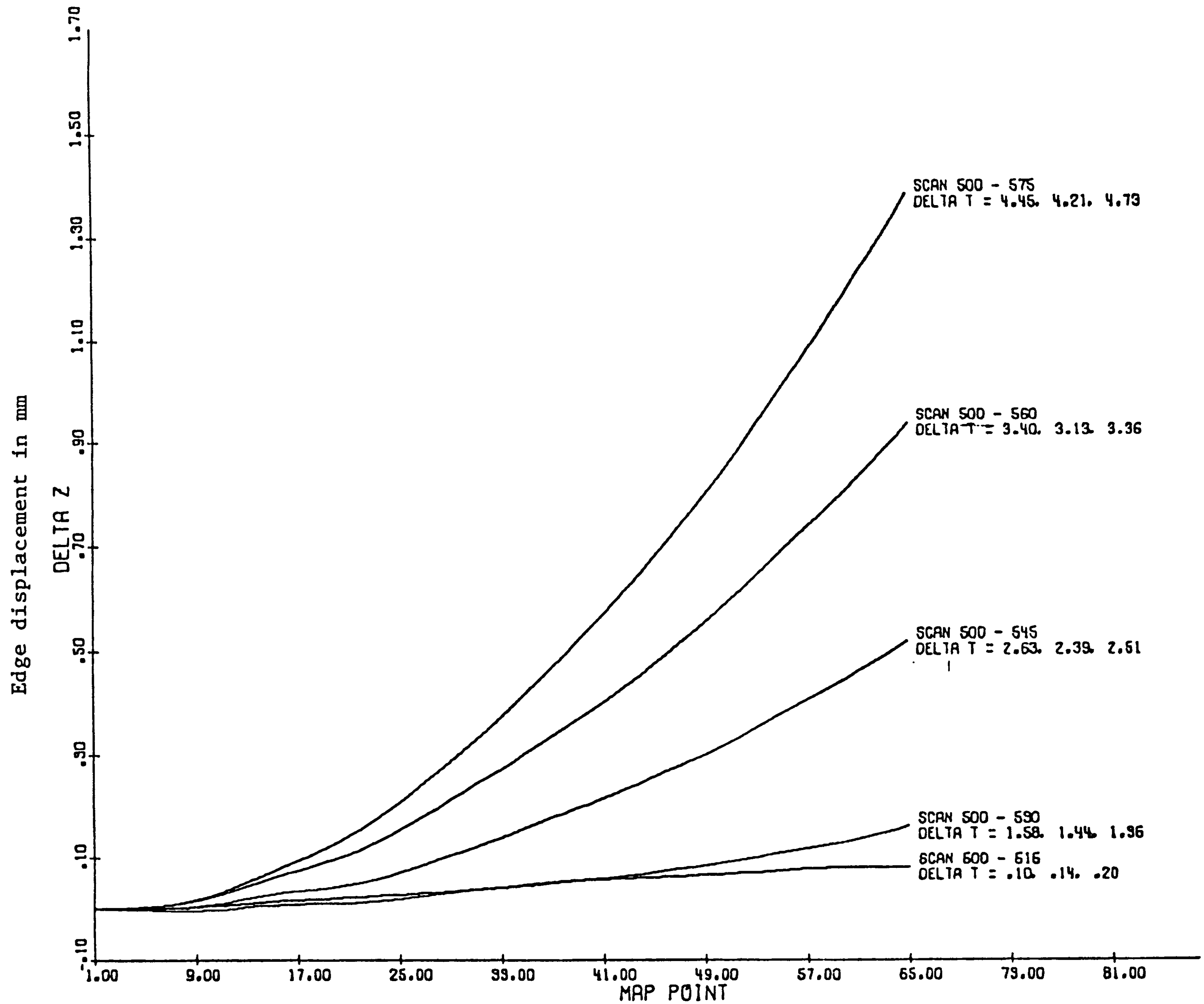
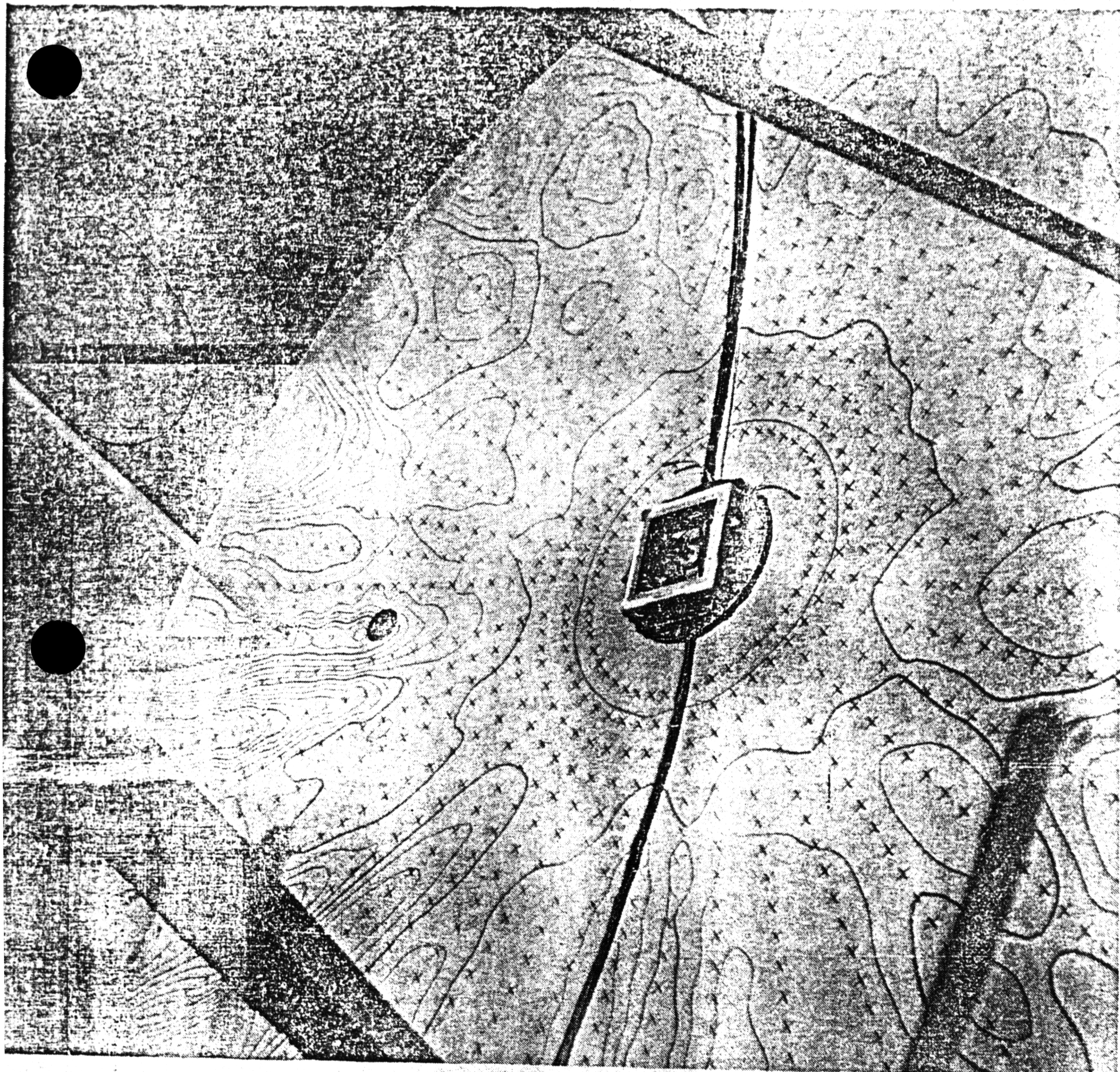


Figure 10 — Effects of Temperature on One Radial Measurement.

Note: The three Delta T's are temperature differences at three points on the antenna between scan 500 and the printed scan.



PHOTOGRAPH OF PROJECTION OF CONTOUR MAP ON 36' SURFACE

Figure 11