Reflective surface analysis of the 33-foot and 150-foot paraboloid antennas at the Algonquin Radio Observatory

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REFLECTIVE SURFACE ANALYSIS OF THE 33-FOOT AND 150-FOOT PARABOLOID ANTENNAS AT THE ALGONQUIN RADIO OBSERVATORY

R. W. BREITHAUPT AND R. O. MARKS

OTTAWA

JUNE 1968

ABSTRACT

This report describes computer programs which provide a statistical analysis of surface measurement data from both the 33-foot and 150-foot paraboloid antennas at the Algonquin Radio Observatory. Mean, standard deviation, median, quartile deviation, and skewness are calculated for the nominal paraboloid parameters assumed. The parameters of a best-fit paraboloid are then calculated, as well as corresponding values of the statistical quantities above.

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ALGONQUIN RADIO OBSERVATORY 33-FT AND 150-FT PARABOLOID REFLECTIVE SURFACE ANALYSIS

- R.W. Breithaupt and R.O. Marks -

INTRODUCTION

Gain of a reflector antenna is decreased by phase errors due to an imperfectly shaped reflecting surface. This loss depends on both the spatial nature of the correlation, and on the frequency distribution of these errors. Ruze (1) has given an extensive experimental and theoretical treatment of the relation between phase error due to roughness and gain loss for a circular aperture.

If correlation regions are small with respect to the antenna diameter and if the phase deviations are distributed randomly in a Gaussian population of standard deviation δ, the gain of a circular aperture is decreased by a factor of

$$-4.343\left(\frac{4\pi\varepsilon}{\lambda}\right)^2 \text{db}$$

where

ε = rms error (or standard deviation) on a shallow reflector which produces a phase front variance $\overline{\delta}^2$

λ = free space wavelength

Therefore it is extremely useful to know the standard deviation from a nominal or "best fit" reflector surface, as well as the distribution of these errors. The sense in which a theoretical surface gives a best fit must, of course, be defined.

The purpose of this report is to describe a computer program for each of the 33-foot and 150-foot paraboloids which does the following:

1. The mean, standard deviation (SD), median, quartile deviation (QD), and skewness between measured and nominal surface values are given for the entire antenna and for each of the radial stations. A difference table between nominal and measured values is printed, which is in fact the raw data.

2. New theoretical paraboloid parameters (either three or six) are given for the best-fit paraboloid (BFP) to the measured data. "Best fit" will be defined differently for the two antennas.

3. The calculations and output of paragraph 1 are repeated for the BFP.

4. The variation of (measured value — nominal value) with azimuthal station is plotted for each radial station. A histogram showing the distribution of (measured value - nominal value) errors is plotted for the entire antenna, with the statistics calculated in paragraph 1 being indicated on the plot.

5. Plots as in paragraph 4 are given for best-fit data.

The remainder of this report is divided into two parts which deal separately with the 33-foot and 150-foot antennas.

REFLECTIVE SURFACE ANALYSIS FOR THE 33 FOOT PARABOLOID

MEASUREMENT

Two reports by Diether (2) and Diether and Henry (3) of Philco regarding reflective surface analysis of 400-inch Philco paraboloids are presently available. Pertinent specifications for the 33-foot (400-inch) Algonquin Radio Observatory antenna obtained from Philco, regarding tolerances, wind loading, etc., are contained in their quotation (4).

The surface is supported by twenty main ribs and twenty half ribs as shown in Fig. 1 and 20 × 12 azimuth stations for surface measurement were chosen as indicated. Ten radial stations per azimuthal station were chosen at the nominal radii shown in Fig. 1.

Surface measurements on this antenna during and after 1967 were made with a template produced at the National Research Council.

Spring loaded helipot linear gauges are used to measure deformation in the axial direction. The gauge reading is made directly on a digital VTVM, with a scale factor of 1 volt per inch. In their mid-range position the gauges read 700 mV which increases as the probes rise toward the template. All ten gauges on the template were separately calibrated with gauge blocks. The average helipot linearity measured was 325 ± 1.5 mV, 700 ± 1 mV, 1200 ± 0 mV, aside from backlash. Average backlash for a gauge at midposition was 2.5 mV.

The gauges were not connected exactly on the nominal parabolic curve, and corrections to observed data, and accurate radial values are given in the program.

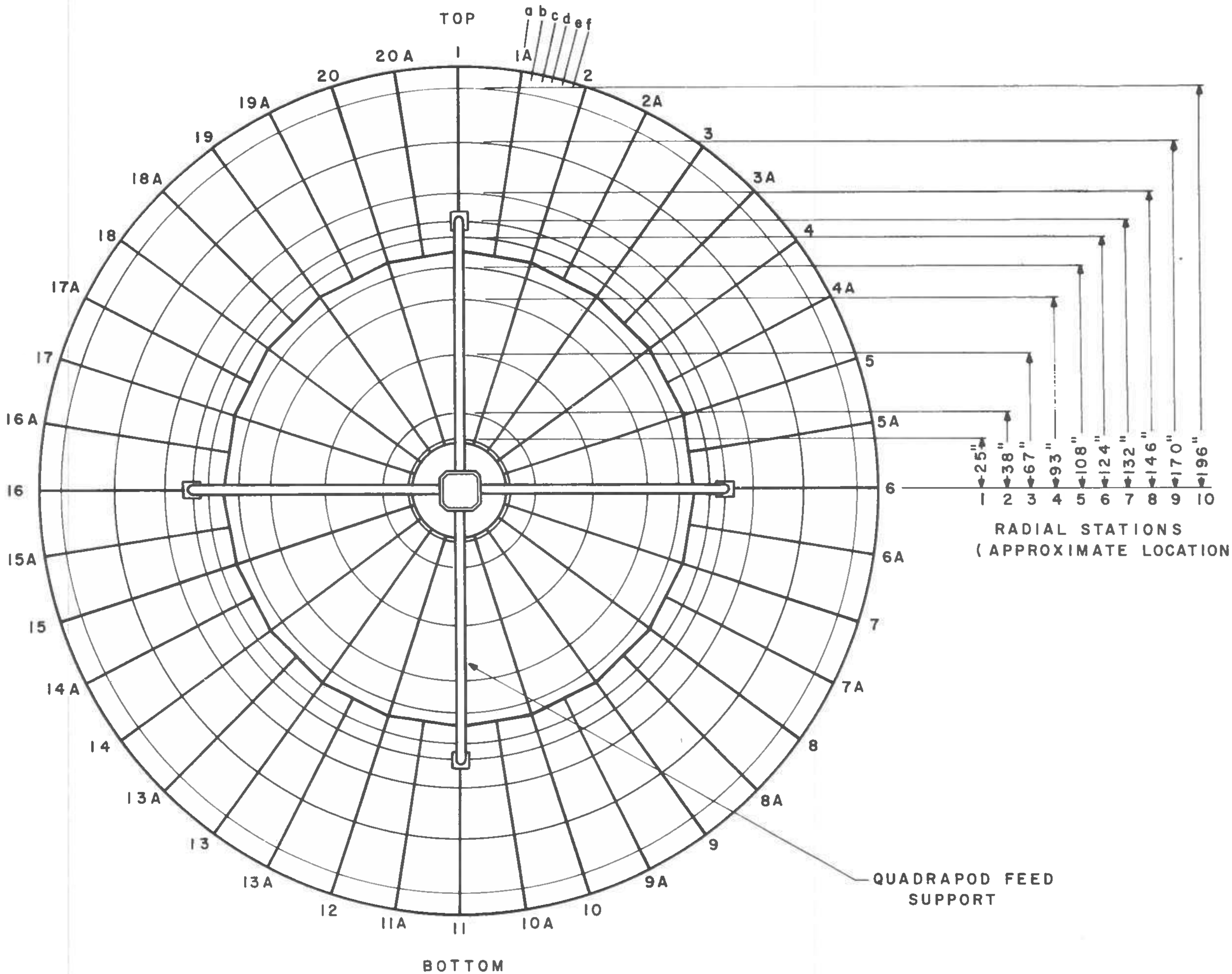

Fig. 1 Station locations for surface measurement on 33-foot paraboloid

The computer program is described in the following section under several subheadings.

COMPUTER PROGRAM

Purpose

The purpose of this program is stated in the five items listed in the introduction. A best-fit paraboloid will be found which has no vertex movement in the transverse plane.

Method

The program is written as a set of subroutines, each performing some specific task. The names of these subroutines are listed below.

FLYER	-	eliminates nonsensical measured points
MEANSD	-	calculates means, SD's
FDIST	-	calculates several frequency distributions
MTILE	-	calculates medians, QD's
SKEW	-	calculates skewness
OUT1	-	provides printed output
PIKTUR	-	plots variation of (measured value - nominal or best-fit value) about the mean versus azimuthal station for each radial distance
PIKTWO	-	plots a histogram of the distribution of errors between measured and nominal or best-fit values for the entire antenna
TILT	- -	determines the position of the best-fit axis with respect to the nominal axis
EQN	-	calculates focal length of the best-fit parabola by least squares

These subroutines are called in the desired order by MAIN, and will be described briefly in the following. The complete program, REE 240, written in FORTRAN IV G for OS/360, may be found in Appendix A. Note that there are many explanatory comment cards in the program. No weighting of data points was used in this program so that these results would be consistent with those taken previously. All lengths are given in units of inches × 1000.

MAIN

This subprogram initializes the following parameters:

NP = total number of measured points used

NR = number of radial stations

NAL = number of azimuthal points per radial distance used

NAS = number of azimuthal sectors

NSP = number of azimuthal points per azimuthal sector

I = refers to I^{th} radial station for indexing ($1 \leqslant I \leqslant NR$)

J = refers to J^{th} azimuthal station for indexing ($1 \leqslant J \leqslant NAL$)

NA(I) = number of azimuthal points used at I^{th} radial positions

NAP(K) = number of points used in the K^{th} sector

Y(I) = radius in inches × 1000 of I^{th} radial stations

R(I) = correction to be added to data at I^{th} radial stations to give correct axial distances from the nominal paraboloid. These are corrections for template gauge location errors.

The first time subroutines OUT1, PIKTUR, and PIKTWO are called, the output is raw data plus statistics, and when called after TILT and EQN, the output is best fit data plus statistics. The subroutines should be called in the sequence shown in Appendix A.

FLYER

This subroutine eliminates any data point which is more than five standard deviations from the over-all mean (i.e., its probability of occurring in a Gaussian distribution is < 1/1000). Any such points are printed out and the appropriate parameters NP, NA(I), and NAP(K) are each reduced by one.

MEANSD

Means and standard deviations are calculated for the whole antenna, for each radial station, and for each azimuthal station. Expressions for the entire antenna are

$$\text{mean} = \frac{\sum_{I,J} DATA(I,J)}{NP} \tag{1}$$

$$SD = \left[\sum_{I,J} \frac{(\text{mean-DATA}(I,J))^2}{NP} \right]^{\frac{1}{2}} \quad (2)$$

Results are stored in COMMON block LIST2.

FDIST

The number of points in each $\frac{\text{inches}}{1000} \times 10$ interval was calculated for the entire antenna, for each radial station, and for each azimuthal station. Results are stored in COMMON block LIST3.

e.g., NUM(32) = number of points between 0.315 and 0.324 inches, inclusive

MTILE

Medians and quartile deviations are calculated for the three cases considered in MEANSD. The quartile deviation is defined as $\frac{1}{2}$(3rd quartile - 1st quartile). Results are stored in COMMON block LIST4.

SKEW

The skewness or lopsidedness of the distribution is calculated for the whole antenna, for each radial station, and for each azimuthal station. The skewness is defined as

$$G_1 = \frac{V_3 - 3V_2V_1 + 2V_1^3}{(V_2 - V_1^2)^{3/2}} \quad (3)$$

where

$$V_n = \sum_{I,J} \frac{(\text{DATA}(I,J))^n}{NP} \quad (4)$$

OUT1

Line printer output is provided for the statistical calculations. The current DATA(I, J) values are printed and are either raw data plus template correction or best-fit data. Then mean, SD, median, QD, and skewness are printed for the entire antenna and for each radial station. Other results such as histograms have been calculated, but are not printed out here as they are not of immediate importance and can readily be obtained by including appropriate write statements.

TILT

The position of the best-fit axis of the paraboloid is determined with respect to the nominal axis in the following way. The means of opposite azimuthal sectors are compared, and the position of the pair having the greatest difference in means is determined. The theoretical axis is tilted so as to nearly equalize these two means, a new data set is calculated, and the whole procedure is iterated 10 times. Tilt is given from the nominal axis to the best-fit axis in the direction $(\theta + 180)°$, and the magnitude is ϕ (always positive). Values of θ and ϕ for incremental and cumulative tilt are both printed after each iteration. Note that this subroutine assumes a fixed vertex position for the paraboloid.

EQN

The focal length (FL) of the BFP is determined by a least-squares curve fit. From the parabola equation

$$x = ay^2 + b \tag{5}$$

where y corresponds to the radial distances Y(I), it is desired to make

$$\sum_{I,J} (x_{obs.} - x_{calc.})^2_{I,J} = M \tag{6}$$

a minimum. Putting

$$\frac{\partial M}{\partial a} = \frac{\partial M}{\partial b} = 0 \tag{7}$$

yields

$$a = \frac{NP \sum_{I,J} x_{obs} y^2 - \sum_{I,J} x_{obs} \sum_{I,J} y^2}{NP \sum_{I,J} y^4 - (\sum_{I,J} y^2)^2} = \frac{1}{4(FL)} \qquad (8)$$

$$b = \frac{\sum_{I,J} x_{obs} \sum_{I,J} y^4 - \sum_{I,J} x_{obs} y^2 \sum_{I,J} y^2}{NP \sum_{I,J} y^4 - (\sum_{I,J} y^2)^2} \qquad (9)$$

The standard deviation of the FL is also calculated, and is defined as

$$SD_{FL} = \frac{1}{4a^2} \left[\frac{\sum_{I,J} (x_{obs} - x_{calc})^2}{NP - 2} \times \frac{NP}{NP \sum_{I,J} y^4 - (\sum_{I,J} y^2)^2} \right]^{1/2} \qquad (10)$$

This subroutine was written in double precision to maintain sufficient accuracy.

PIKTUR

This plotter output of the DATA(I,J) array is self explanatory; see the sample output at the end of Appendix A.

PIKTWO

A plotted histogram of errors in the DATA(I,J) array is given, and an example is included at the end of Appendix A (see also FDIST).

Use

The data for all radial stations at each of the 240 azimuthal stations is punched on a card according to the format 10F7.0. These cards must be in the following order of azimuthal stations: #1a .... #1f, #1Aa ... .. #1Af, #2a .... #2f, #2Aa .... #2Af, ... 20Af. Thirty-two additional data cards follow which contain headings for the 6 plots. It is necessary to change only the 7th, 10th, 23rd, and 26th of these 32 cards when changing data sets, as these cards give the survey number and date.

The subroutines should be called in the sequence given in Appendix A. Best-fit statistics and plots are obtained by recalling the subroutines listed after calling EQN. A sample output for survey #1 of May 15, 1968 is included at the end of Appendix A. At present this program reads 1007 cards, prints 1938 lines, and has a 3.2-minute execution time on OS/360/Model 50.

REFLECTIVE SURFACE ANALYSIS FOR THE 150-FOOT PARABOLOID

MEASUREMENT

The surface of this antenna is supported by 36 radial ribs, and 8 surface measurement stations are located on each rib. Twenty-four of these 288 stations are unobservable, lying behind the four focal cabin support legs, as seen in Fig. 2. Surface measurements are made optically from the hub or vertex, by noting very accurately the difference between the expected and observed elevation angle of a given target. These values are then converted to axial height corrections between the nominal and measured paraboloid surface. This is the form of the raw data to be analyzed.

It is expected that surveys will be made at frequent intervals to observe various environmental effects on the antenna.

COMPUTER PROGRAM

Purpose

This program provides the five items listed in the introduction. The best-fit paraboloid is arbitrarily located in space with its vertex translated in three dimensions so that pointing errors between the nominal and BFP will be accurately known.

Method

The general organization of this program and the method of obtaining best-fit parameters is quite different from that for the 33-foot antenna. Subroutines used by MAIN are listed in their normal sequence as follows:

MRQRDT - this is the NRC Computation Centre subroutine CLPG00158 for general minimization

DERIV - evaluation of functions required by MRQRDT is done here

CNFDLM - contained in CLPG00158, giving various confidence limits

MEANSD - calculates means and SD's

FDIST - calculates frequency distributions

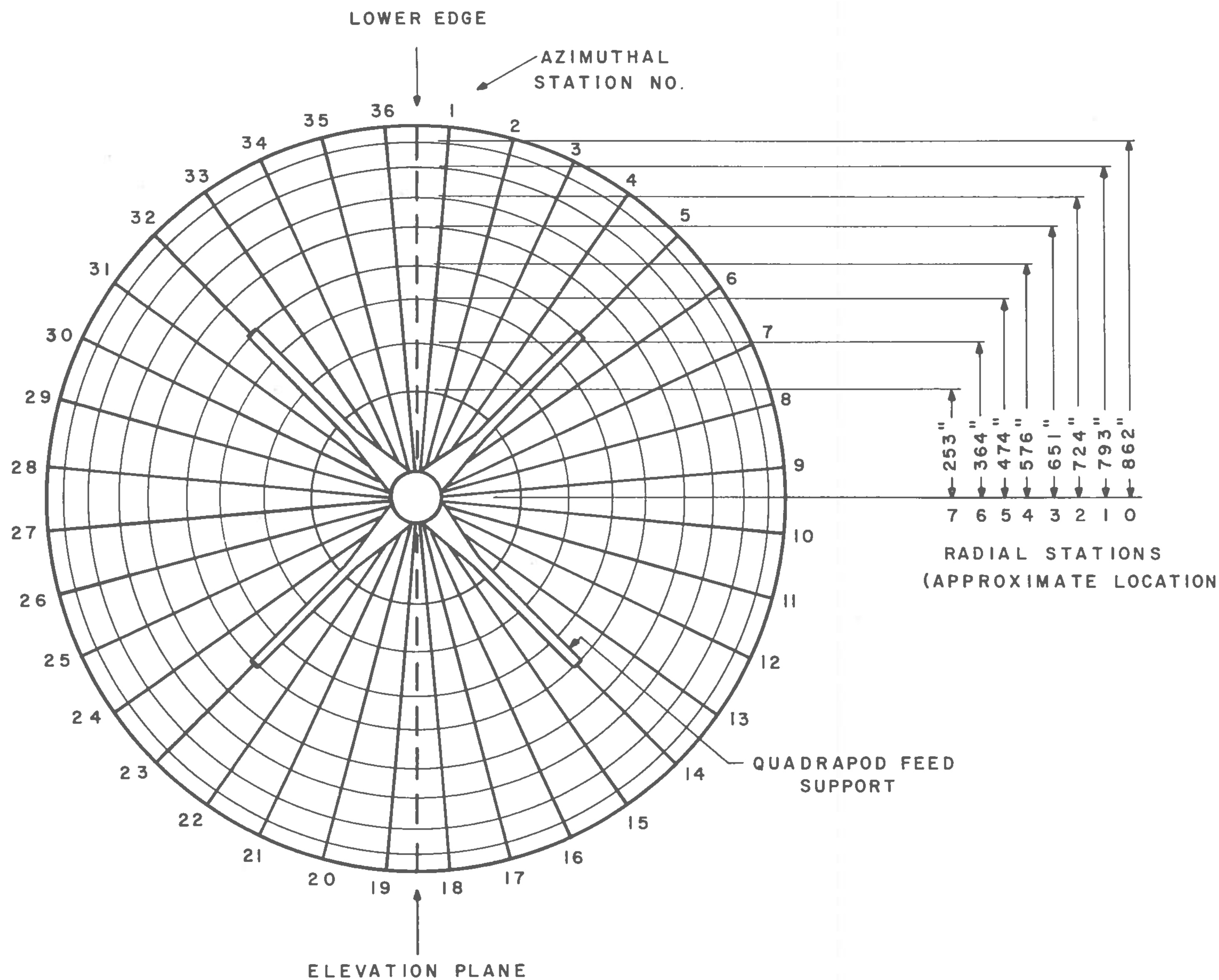

Fig. 2 Station locations for surface measurement on 150-foot paraboloid

MTILE - calculates medians, QD's

PIKTUR - plots variation of measured value − nominal/best-fit value about the mean versus azimuthal station for each radial distance

PIKTWO - plots a histogram of the distribution of errors between measured and nominal/best-fit values for the entire antenna

This program, written in FORTRAN IV for OS/360 is listed in Appendix B. Data areweighted according to a 10-db taper in aperture distribution.

The method used to obtain a BFP will now be described. The nominal paraboloid is chosen to lie in the r, s, t coordinate system with its vertex at the origin, and axis of symmetry coinciding with the r axis. The best-fit paraboloid lies in the x, y, z system with vertex at the origin, and x the axis of symmetry. Figure 3 illustrates the relationship between the two coordinate systems. A rotation of the x, z axes in the xz plane by an

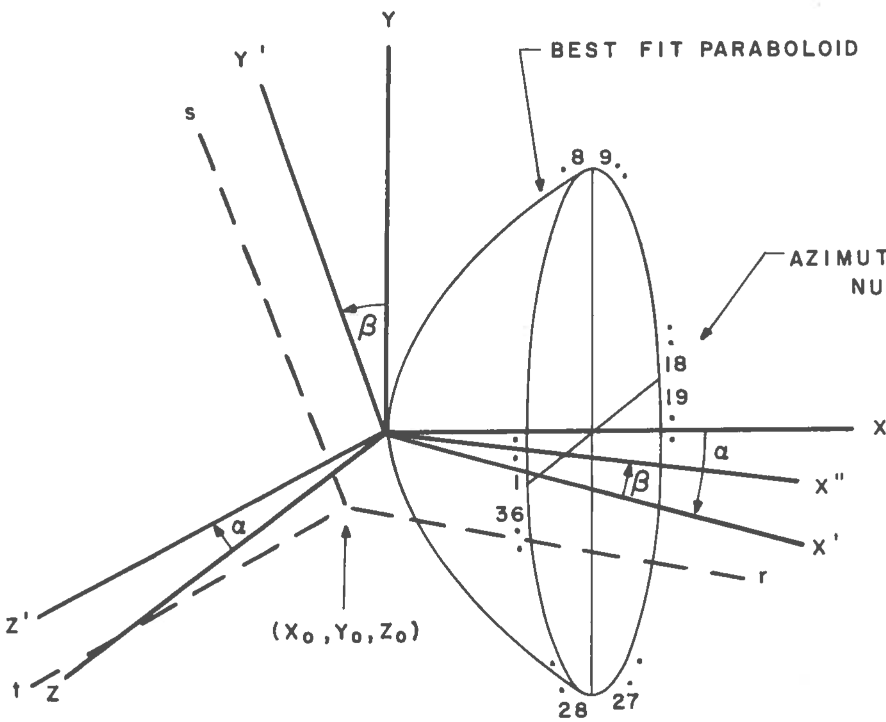

Fig. 3 Nominal and best-fit paraboloid coordinate systems for 150-foot paraboloid; rt is elevation plane of nominal paraboloid; azimuth stations 18 and 19 are at top of antenna

angle α is followed by a rotation of the x', y axes in the $x'y$ plane by an angle β. Finally, a translation of the origin to (x_0, y_0, z_0) yields the r, s, t coordinates.

Over-all coordinate relations are

$$\begin{aligned} x &= (x_0 + r)\cos\beta\cos\alpha - (y_0 + s)\sin\beta\cos\alpha - (z_0 + t)\sin\alpha \\ y &= (y_0 + s)\cos\beta + (x_0 + r)\sin\beta \\ z &= (x_0 + r)\cos\beta\sin\alpha - (y_0 + s)\sin\beta\sin\alpha + (z_0 + t)\cos\alpha \end{aligned} \tag{11}$$

The best-fit paraboloid equations are, for the (x, y, z) and (r, s, t) coordinate systems respectively:

$$y^2 + z^2 = 4px \tag{12}$$

and

$$[(y_0 + s)\cos\beta + (x_0 + r)\sin\beta]^2 + [(x_0 + r)\cos\beta\sin\alpha - (y_0 + s)\sin\beta\sin\alpha + (z_0 + t)\cos\alpha]^2 = 4p[(x_0 + r)\cos\beta\cos\alpha - (y_0 + s)\sin\beta\cos\alpha - (z_0 + t)\sin\alpha] \tag{13}$$

Rewrite equation (13) in the form

$$r = f_1(s, t, x_0, y_0, z_0, \alpha, \beta, p). \tag{14}$$

The vertex of the BFP is at $(-x_0, -y_0, -z_0)$ in the (r, s, t) coordinates.

A least-squares fit of measured data r_k, where k indicates a general k^{th} measured point, to the BFP requires that

$$\sum_{k=1}^{NP} w_k (r_k - f_1(s_k, t_k, x_0, y_0, z_0, \alpha, \beta, p))^2 = M \tag{15}$$

be a minimum, where NP = total number of measured points. This in turn requires that

$$\frac{\partial M}{\partial x_0} = \frac{\partial M}{\partial y_0} = \frac{\partial M}{\partial z_0} = \frac{\partial M}{\partial \alpha} = \frac{\partial M}{\partial \beta} = \frac{\partial M}{\partial p} = 0 \tag{16}$$

The solution of this last set of nonlinear simultaneous equations for x_0, y_0, z_0, α, β, p is done by the NRC Computation Centre subroutine CLPG00158 for general minimization, which is partially described under MRQRDT and in

Appendix B. A brief description of MAIN and of the subroutines listed earlier will now be given.

MAIN

After the height correction data for 8 × 36 stations is read into the DATA (I, J) array, a set of weights WW(I) is provided for the eight radial stations. These weights correspond to a 10-db cosine-on-pedestal aperture distribution given by

$$A(r) = 0.1 + 0.9 \cos \frac{r\pi}{D} \tag{17}$$

where D is the aperture diameter. The points in any small area must be weighted proportionally to the power received by that area. Therefore the weights WW(r) vary as a function of r as

$$WW(r) \propto \frac{dP(r)}{dr} \propto rA(r) \tag{18}$$

because the distribution of stations on the surface with radius is constant.

Other important parameters initialized by MAIN are as follows

I, J, K	-	indices referring to station locations, $1 \le I^{th}$ radial ≤ 8, $1 \le J^{th}$ azimuthal ≤ 36, $1 \le K^{th}$ total $\le NP$
NP	-	total number of stations observed
NAL	-	number of azimuthal stations/radial station
DATA(I, J)	-	data read from cards, changed to be raw height correction data
R(I)	-	radial distance to I^{th} measurement stations
WW(I)	-	weight to be applied to the I^{th} radial stations
W(K)	-	array of <u>normalized</u> weights for all measured points where $\sum_{1}^{NP} W(K) = NP$
X(1, K)	-	calculated values of s_k, for entire antenna
X(2, K)	-	calculated values of t_k, for entire antenna
BFDATA(I, J)	-	height corrections for the best fit paraboloid
YCOMP(K)	-	final (best-fit) values of r_k
A(1) .. A(6)	-	initial estimates and later current values of x_0, y_0, z_0, α, β, p respectively

MAIN does the following in the sequence shown

- reads in raw data
- references subroutine MRQRDT to find BFP parameters
- calls subroutines MEANSD, FDIST, MTILE to calculate statistics for raw data
- prints and plots output for raw data
- calls subroutine MEANSD, FDIST, MTILE to calculate statistics for best-fit data
- prints and plots output for best-fit data

Further details may be obtained from the program REE298 listing in Appendix B.

MRQRDT

This is NRC Computation Centre subroutine CLPG00158 for General Minimization and is fully documented in its library description.

DERIV

Subroutine CLPG00158 requires many evaluations of f_1 (equation 14) and of each of the partial derivations of equation 16 at each data point. This is done in DERIV.

A quadratic is obtained by solving equation 13 for r or f_1. The square root may be expanded in a power series for convenience in calculation. A three-term expansion gives

$$\begin{aligned} r &= f_1(s, t, x_0, y_0, z_0, \alpha, \beta, p) \\ &= -\frac{b_3}{b_2}\left(1 + \frac{b_1 b_3}{b_2^2}\right) \end{aligned} \tag{19}$$

where

$$\begin{aligned} b_1 &= a_2^2 + a_4^2 \\ b_2 &= 2a_1 a_2 + 2a_3 a_4 - 4pa_6 \\ b_3 &= a_1^2 + a_3^2 - 4pa_5 \\ a_1 &= (y_0 + s)\cos\beta + x_0 \sin\beta \\ a_2 &= \sin\beta \end{aligned} \tag{20}$$

$$a_3 = x_0 \cos\beta \sin\alpha - (y_0 + s)\sin\beta\sin\alpha + (z_0 + t)\cos\alpha$$

$$a_4 = \cos\beta\sin\alpha$$

$$a_5 = x_0\cos\beta\cos\alpha - (y_0 + s)\sin\beta\cos\alpha - (z_0 + t)\sin\alpha$$

$$a_6 = \cos\beta\cos\alpha$$

Computed values of f_{1_k} are put into the F(K) array, and the six partial derivatives are stored in DF(I, K) array where in this case I refers to the six parameters, x_0, y_0, z_0, α, β, p from 1 to 6, respectively. Intermediate output from this subroutine is presently suppressed by the use of IDS = 0.

CNFDLM

This is contained in CLPG00158 and calculates various confidence intervals. Output from this is presently suppressed by using IPRINT = 0.

MEANSD

Means and standard deviations are calculated for the whole antenna and for each radial station. Expressions use weighted data, and are, for the whole antenna

$$\text{mean} = \frac{\sum_{I,J}^{NP} WW(I)\ DATA(I,J)}{\sum_{I,J}^{NP} WW(I)} \tag{21}$$

$$SD = \left[\frac{\sum_{I,J}^{NP} WW(I)\ (\text{mean}-DATA(I,J))^2}{\sum_{I,J}^{NP} WW(I)} \right]^{1/2} \tag{22}$$

Results are stored in COMMON block LIST2.

FDIST

Histograms consisting of number of data points in each $\frac{\text{inch}}{1000} \times 10$ interval are calculated for the entire antenna. Results are stored in COMMON block LIST3.

MTILE

Medians and quartile deviations are calculated for the entire antenna, and stored in COMMON block LIST4.

PIKTUR, PIKTWO

Examples of these output plots may be found at the end of Appendix B.

Use

The first data card, punched according to 2I6, contains JTEST and NR, in that order.

The following 36 cards are punched according to the format 8F7.0, and each contains all height correction data (or 500 minus this) for one azimuthal station, beginning with No. 1 (see Fig. 2). A value of zero should be used for the 24 stations that cannot be read, and an interpolated value for any other unread station. The program will ignore the 24 unmeasurable stations (at azimuthal stations Nos. 5, 14, 23, 32) where the feed legs prevent measurements from being made.

A sample output from Survey No. 14 of May 4, 1967, using M.H. Jeffrey's data is included at the end of Appendix B. This program presently reads 1246 cards, prints 1746 lines (including listing), and has an execution time of 4.4 minutes on OS/360/Model 50.

ACKNOWLEDGMENT

The program REE240 was substantially written by R.O. Marks during the summer of 1967. Help from the NRC Computation Centre in providing the General Minimization subroutine for the difficult problem of solving a set of 6 nonlinear simultaneous equations is appreciated.

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3. P. A. Diether and H. W. Henry. University of California 400 inch reflector reflective surface analysis. Philco WDL-TR-1267, February 29, 1960
4. Quotation to N. K. Smith, Purchasing Agent for NRC, from G. M. Rouzee of Philco, dated March 23, 1960

APPENDIX A

PROGRAM FOR 33-FOOT ANTENNA REE240

```
C *** REE 240 REFLECTIVE SURFACE ANALYSIS
C *** GREEN CARDS ARE CHANGES IN PROG BY RW BREITHAUPT  12/10/67
      REAL R(10)
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
C     REAL R(10)
      NP=2400
      NR=10
      NAL = 240
      NAS = 20
      NSP = 12
      DO 1 I = 1,NR
    1 NA(I) = 240
      DO 2 I = 1,20
    2 NAP(I)=120
      Y(1)=25001.
      Y(2)=38001.
      Y(3)=66987.
      Y(4)=92982.
      Y(5)=107987.
      Y(6)=123985.
      Y(7)=131991.
      Y(8)=145994.
      Y(9)=169987.
      Y(10)=196002.
      READ(1,100)((DATA(I,J),I = 1,NR),J = 1,NAL)
  100 FORMAT(10F7.0)
C *** THIS ADDS A CORRECTION FOR EACH RADIAL STATION SO THAT
C     THE MODIFIED DATA SET CONTAINS DISTANCES FROM THEORETICAL
C     PARAB PT ON TEMPLATE AND NOT ACTUAL PIN LOCATION - SEE
C     TEMPLATE BLUEPRINT FOR EXPLANATION
C     THIS MAKES OVERALL STATISTICS SENSIBLE
      R(1)=0.0
      R(2)=0.0
      R(3)=7.0
      R(4)=15.0
      R(5)=4.0
      R(6)=19.0
      R(7)=17.0
      R(8)=4.0
      R(9)=12.0
      R(10)=11.0
      DO 3 I=2,10
      DO 3 J=1,240
    3 DATA(I,J)=DATA(I,J)+R(I)
      CALL FLYER
      CALL MEANSD
      CALL FDIST
      CALL MTILE
      CALL SKEW
      CALL OUT1
      CALL PIKTUR
      CALL PIKTWO
      CALL TILT
```

```
      CALL EQN
      CALL MEANSD
      CALL FDIST
      CALL MTILE
      CALL SKEW
      CALL OUT1
      CALL PIKTUR
      CALL PIKTWO
      CALL PEND
C *** NUM(NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR ENTIRE DISH
C *** NUMR(I,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10X NN FOR RADL STN I
C *** NUMA(K,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR AZML MN RIB SCTN K
      STOP
      END
```

```
      SUBROUTINE FLYER
C *** ELIMINATES 'FLYERS' - POINTS WHICH ARE FAR AWAY FROM THE MAIN
C *** GROUP, AND HENCE ARE STATISTICALLY IMPROBABLE
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
      REAL MEAN
C *** CALCULATE MEAN AND STANDARD DEVIATION OF 'DATA'
      SUM = 0.
      DO 71 I = 1,NR
      DO 71 J = 1,NAL
   71 SUM = SUM + DATA(I,J)
      MEAN = SUM/NP
      SDEV2 = 0.
      DO 72 I = 1,NR
      DO 72 J = 1,NAL
   72 SDEV2 = SDEV2 + (MEAN-DATA(I,J))**2
      SD = SQRT(SDEV2/NP)
C *** TEST POINTS - IF A POINT IS MORE THAN 5 STANDARD DEVIATIONS AWAY
C     FROM THE MEAN, SET IT EQUAL TO ZERO AND REDUCE THE CORRESPONDING
C     PARAMETERS BY 1
      WRITE(3,121)
  121 FORMAT(1H1,63H THESE POINTS ARE 'FLYERS' AND ARE NOT INCLUDED IN C
     1ALCULATIONS)
      TEST = 5.*SD
      DO 73 I = 1,NR
      DO 73 J = 1,NAL
      IF(TEST.GE.ABS(MEAN-DATA(I,J))) GO TO 73
      WRITE(3,122) I,J,DATA(I,J)
  122 FORMAT(1H0,'DATA(',I2,',',I3,') = ',F7.0)
      DATA(I,J) = 0.
      NP = NP - 1
      NA(I) = NA(I) - 1
      K = (J-1)/NSP + 1
      NAP(K) = NAP(K) - 1
   73 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MEANSD
C     CALCULATE MEANS AND STANDARD DEVIATIONS
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1       /LIST2/ MEAN,SD,MEANR(10),SDR(10),MEANA(20),SDA(20)
      REAL MEAN,MEANR,MEANA
      SUM = 0.
      DO 2 I = 1,NR
      SUMR = 0.
      DO 1 J = 1,NAL
      SUM = SUM + DATA(I,J)
    1 SUMR = SUMR + DATA(I,J)
    2 MEANR(I) = SUMR/NA(I)
      MEAN = SUM/NP
      DO 3 K = 1,NAS
      SUMA = 0.
      KKK = NSP*K
      KK = KKK - NSP + 1
      DO 4 I = 1,NR
      DO 4 J = KK,KKK
    4 SUMA = SUMA + DATA(I,J)
    3 MEANA(K) = SUMA/NAP(K)
      SDEV2 = 0.
      DO 5 I = 1,NR
      SDEVR2 = 0.
      DO 6 J = 1,NAL
      SDEV2 = SDEV2 + (MEAN-DATA(I,J))**2
    6 SDEVR2 = SDEVR2 + (MEANR(I)-DATA(I,J))**2
    5 SDR(I) = SQRT(SDEVR2/NA(I))
      SD = SQRT(SDEV2/NP)
      DO 7 K = 1,NAS
      SDEVA2 = 0.
      KKK = NSP*K
      KK = KKK - NSP + 1
      DO 8 I = 1,NR
      DO 8 J = KK,KKK
    8 SDEVA2 = SDEVA2 + (MEANA(K)-DATA(I,J))**2
    7 SDA(K) = SQRT(SDEVA2/NAP(K))
      RETURN
      END
```

```
      SUBROUTINE FDIST
C *** CALCULATE FREQUENCY DISTRIBUTIONS
C *** NUMA(K,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR AZML MN RIB SCTN K
C *** NUMR(I,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10X NN FOR RADL STN I
C *** NUM(NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR ENTIRE DISH
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1       /LIST3/ NUM(150),NUMR(10,150),NUMA(20,150)
C *** SET ALL VALUES EQUAL TO ZERO
      DO 1 J = 1,100
      NUM(J) = 0
      DO 2 I = 1,10
    2 NUMR(I,J) = 0
      DO 1 K = 1,NAS
    1 NUMA(K,J) = 0
C *** CALCULATE DISTRIBUTIONS
      DO 10 K = 1,NAS
      KKK = NSP*K
      KK = KKK - NSP + 1
      DO 10 I = 1,NR
      DO 10 J = KK,KKK
      IF(DATA(I,J).EQ.0.0)GO TO 10
      NN = DATA(I,J)/10. + 0.5
      NUM(NN) = NUM(NN) + 1
      NUMR(I,NN) = NUMR(I,NN) + 1
      NUMA(K,NN) = NUMA(K,NN) + 1
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MTILE
C *** CALCULATE MEDIANS AND QUARTILE DISTRIBUTIONS
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1        /LIST3/ NUM(150),NUMR(10,150),NUMA(20,150)
     2        /LIST4/ MDN,QD,MDNR(10),QDR(10),MDNA(20),QDA(20)
      REAL MDN,MDNR,MDNA
      MED = 0
      I1 = 100
      I2 = 100
      DO 14 I = 1,100
      MED = MED + NUM(I)
C *** FIRST QUARTILE
      IF(I1.LT.I)GO TO 17
      IF(4*MED-NP)14,15,16
   15 I1 = I
      FQTL = 10*I + 5.
      GO TO 14
   16 I1 = I
      FQTL = 10*I - 10.*(MED-NP/4)/NUM(I) + 5.
      GO TO 14
C *** MEDIAN (SECOND QUARTILE)
   17 IF(I2.LT.I)GO TO 18
      IF(2*MED-NP)14,19,20
   19 I2 = I
      MDN = 10*I + 5.
      GO TO 14
   20 I2 = I
      MDN = 10*I - 10.*(MED-NP/2)/NUM(I) + 5.
      GO TO 14
C *** THIRD QUARTILE
   18 IF(4*MED-3*NP)14,22,23
   22 TQTL = 10*I + 5.
      GO TO 24
   23 TQTL = 10*I - 10.*(MED-3*NP/4)/NUM(I) + 5.
      GO TO 24
   14 CONTINUE
C *** QUARTILE DEVIATION
   24 QD = (TQTL-FQTL)/2.
C *** REPEAT FOR RADIAL STATIONS
      DO 25 I = 1,NR
      MED = 0
      I1 = 100
      I2 = 100
      DO 26 II = 1,100
      MED = MED + NUMR(I,II)
      IF(I1.LT.II)GO TO 27
      IF(4*MED-NA(I))26,28,29
   28 I1 = II
      FQTLR = 10*II + 5.
      GO TO 26
   29 I1 = II
      FQTLR = 10*II - 10.*(MED-NA(I)/4)/NUMR(I,II) + 5.
```

```
      GO TO 26
   27 IF(I2.LT.II)GO TO 30
      IF(2*MED-NA(I))26,31,32
   31 I2 = II
      MDNR(I) = 10*II + 5.
      GO TO 26
   32 I2 = II
      MDNR(I) = 10*II - 10.*(MED-NA(I)/2)/NUMR(I,II) + 5.
      GO TO 26
   30 IF(4*MED-3*NA(I))26,33,34
   33 TQTLR = 10*II + 5.
      GO TO 35
   34 TQTLR = 10*II - 10.*(MED-3*NA(I)/4)/NUMR(I,II) + 5.
      GO TO 35
   26 CONTINUE
   35 QDR(I) = (TQTLR - FQTLR)/2.
   25 CONTINUE
C *** REPEAT FOR AZIMUTHAL STATIONS
      DO 36 K = 1,NAS
      MED = 0
      I1 = 100
      I2 = 100
      DO 37 I = 1,100
      MED = MED + NUMA(K,I)
      IF(I1.LT.I)GO TO 38
      IF(4*MED-NAP(K))37,39,40
   39 I1 = I
      FQTLA = 10*I + 5.
      GO TO 37
   40 I1 = I
      FQTLA = 10*I - 10.*(MED-NAP(K)/4)/NUMA(K,I) + 5.
      GO TO 37
   38 IF(I2.LT.I)GO TO 41
      IF(2*MED-NAP(K))37,42,43
   42 I2 = I
      MDNA(K) = 10*I + 5.
      GO TO 37
   43 I2 = I
      MDNA(K) = 10*I - 10.*(MED-NAP(K)/2)/NUMA(K,I) + 5.
      GO TO 37
   41 IF(4*MED-3*NAP(K))37,44,45
   44 TQTLA = 10*I + 5.
      GO TO 46
   45 TQTLA = 10*I - 10.*(MED-3*NAP(K)/4)/NUMA(K,I) + 5.
      GO TO 46
   37 CONTINUE
   46 QDA(K) = (TQTLA - FQTLA)/2.
   36 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SKEW
C *** CALCULATE SKEWNESS
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1       /LIST5/ G1,G1R(10),G1A(20)
      V1 = 0.
      V2 = 0.
      V3 = 0.
      DO 47 I = 1,NR
      V1R = 0.
      V2R = 0.
      V3R = 0.
      DO 48 J = 1,NAL
      V1 = V1 + DATA(I,J)
      V2 = V2 + DATA(I,J)**2
      V3 = V3 + DATA(I,J)**3
      V1R = V1R + DATA(I,J)
      V2R = V2R + DATA(I,J)**2
   48 V3R = V3R + DATA(I,J)**3
      V1R = V1R/NA(I)
      V2R = V2R/NA(I)
      V3R = V3R/NA(I)
   47 G1R(I) = (V3R-3.*V2R*V1R+2.*V1R**3)/(V2R-V1R**2)**1.5
      V1 = V1/NP
      V2 = V2/NP
      V3 = V3/NP
      G1 = (V3-3.*V2*V1+2.*V1**3)/(V2-V1**2)**1.5
      DO 49 K = 1,NAS
      V1A = 0.
      V2A = 0.
      V3A = 0.
      KKK = NSP*K
      KK = KKK - NSP + 1
      DO 50 I = 1,NR
      DO 50 J = KK,KKK
      V1A = V1A + DATA(I,J)
      V2A = V2A + DATA(I,J)**2
   50 V3A = V3A + DATA(I,J)**3
      V1A = V1A/NAP(K)
      V2A = V2A/NAP(K)
      V3A = V3A/NAP(K)
   49 G1A(K) = (V3A-3.*V2A*V1A+2.*V1A**3)/(V2A-V1A**2)**1.5
      RETURN
      END
```

```
      SUBROUTINE OUT1
C *** OUTPUT
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1       /LIST2/ MEAN,SD,MEANR(10),SDR(10),MEANA(20),SDA(20)
     1       /LIST3/ NUM(150),NUMR(10,150),NUMA(20,150)
     3       /LIST4/ MDN,QD,MDNR(10),QDR(10),MDNA(20),QDA(20)
     4       /LIST5/ G1,G1R(10),G1A(20)
      REAL MEAN,MDN,MEANR,MDNR,MEANA,MDNA
      DIMENSION INUM(100)
      DO 52 I = 1,100
   52 INUM(I) = 10*I
  101 FORMAT(1H )
  103 FORMAT(1H1)
      WRITE(3,103)
      DO 60 I = 1,5
      DO 61 I2 = 1,4
      DO 62 I3 = 1,2
      DO 63 I4 = 1,6
      KK = (I-1)*48 + (I2-1)*12 + (I3-1)*6 + I4
      WRITE(3,102)(DATA(II,KK),II = 1,NR)
  102 FORMAT(1H ,10X,10F10.0)
   63 CONTINUE
      WRITE(3,101)
   62 CONTINUE
      WRITE(3,101)
   61 CONTINUE
      WRITE(3,103)
   60 CONTINUE
      DO 31 J = 1,100
      IF(NUM(J)) 9998,31,9998
 9998 IND1 = J
      GO TO 41
   31 CONTINUE
   41 DO 32 J = IND1,100
      IF(NUM(J)) 9999,32,9999
 9999 IND2=J
   32 CONTINUE
      WRITE(3,104)MEAN,SC,MDN,QD,G1
  104 FORMAT(1H0///5X,'FOR THE WHOLE ANTENNA, MEAN = ',F8.2 ,',S.D. = ',
     1F6.2,',MEDIAN = ',F7.2 ,',Q.D. = ',F6.2,',SKEWNESS = ',F7.3 ///)
      DO 54 I = 1,NR
      DO 33 J = 1,100
      IF(NUMR(I,J).EQ.0) GO TO 33
      IND1 = J
      GO TO 42
   33 CONTINUE
   42 DO 34 J = IND1,100
   34 IF(NUMR(I,J).NE.0) IND2 = J
      WRITE(3,106)I,MEANR(I),SDR(I),MDNR(I),QDR(I),G1R(I)
  106 FORMAT(/5X,'FOR RADIAL STN NO. ',I3,',MEAN = ',F8.2 ,',S.D. = ',
     1F6.2,',MEDIAN = ',F7.2 ,',Q.D. = ',F6.2,',SKEWNESS = ',F7.3 )
   54 CONTINUE

      RETURN
      END
```

```
      SUBROUTINE TILT
C *** CALCULATE BEST FIT AXIAL TILT
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1        /LIST2/ MEAN,SD,MEANR(10),SDR(10),MEANA(20),SDA(20)
      REAL MEAN,MEANR,MEANA
      REAL MEAND
      DIMENSION INSAVE(10)
C *** DETERMINE AVERAGE OF RADIAL STATIONS
      SUMY = 0.
      DO 204 I = 1,NR
  204 SUMY = SUMY + Y(I)
      AVGY = SUMY/NR
C*** AVGY IS AVERAGE RADIUS
      XN = 0.
      YN = 0.
      NAS2 = NAS/2
      ANG = 360./NAS
      WRITE(3,103)
  103 FORMAT(1H1,'CALCULATION OF BEST FIT AXIS')
      DO 210 IJK = 1,10
C*** IJK IS ITERATION NO.
C *** FIND POSITION AND MAGNITUDE OF GREATEST DIFFERENCE BETWEEN MEANS
C     OF OPPOSITE AZIMUTHAL STATIONS
      GDIFF = 0.
      DO 201 K = 1,NAS2
      DIFF = ABS(MEANA(K) - MEANA(K+NAS2))
  202 IF(GDIFF.GT.DIFF)GO TO 201
  203 GDIFF = DIFF
      IN = K
  201 CONTINUE
      IF(MEANA(IN+NAS2).GT.MEANA(IN))IN = IN + NAS2
      INSAVE(IJK) = IN
C*** INSAVE(IJK) IS SECTOR HAVING GREATEST MEAN FOR(IJK)TH ITERATION
C *** DETERMINE AMOUNT AND DIRECTION OF TILT
      NN = 1
      DO 101 J = 1,IJK
  101 IF(IN.EQ.INSAVE(J)) NN = 2*NN
      PHI = GDIFF/(2.*AVGY)/NN
      THETA = (ANG*(IN-1) + ANG/2.)/57.29578
C*** NEW BF AXIS IS IN DIRN (THETA+180) FROM NOM AXIS
      XN = XN + PHI*COS(THETA)
      YN = YN + PHI*SIN(THETA)
      XPHI = PHI*57.29578
      XTHETA = THETA*57.29578
C *** MODIFY 'DATA'
      DO 205 K = 1,NAS
      FAC = COS((180. + (K-1)*ANG + ANG/2.)/57.29578 - THETA)
      KKK = NSP*K
      KK = KKK - NSP + 1
      DO 205 I = 1,NR
      XINC = Y(I)*PHI*FAC
      DO 205 J = KK,KKK
      IF(DATA(I,J).EQ.0.0)GO TO 205
```

```
      DATA(I,J) = DATA(I,J) + XINC
  205 CONTINUE
C *** CALCULATE NEW MEANS
      SUM = 0.
      DO 207 K = 1,NAS
      SUMA = 0.
      KKK = NSP*K
      KK = KKK - NSP + 1
      DO 208 I = 1,NR
      DO 208 J = KK,KKK
      SUM = SUM + DATA(I,J)
  208 SUMA = SUMA + DATA(I,J)
  207 MEANA(K) = SUMA/NAP(K)
      MEAND = SUM/NP
      SDEV2 = 0.
      DO 95 I = 1,NR
      DO 95 J = 1,NAL
   95 SDEV2 = SDEV2 + (MEAND - DATA(I,J))**2
      SDD = SQRT(SDEV2/NP)
  209 THETA = ATAN2(YN,XN)
      PHI = ARSIN(SQRT(XN**2 + YN**2))
      YPHI = PHI*57.29578
      YTHETA = THETA*57.29578
      WRITE(3,251) IJK,XPHI,XTHETA,YPHI,YTHETA,MEAND,SDD
  251 FORMAT(1H0//' TILT NO.',I3,5X,'PHI = ',F9.5,5X,'THETA = ',F6.0//
     1 ' CUMULATIVE TILT',5X,'PHI = ',F9.5,5X,'THETA = ',F6.0//
     2 ' MEAN OF DISH = ',F7.2,'  WITH S.D. = ',F6.2)
  210 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE EQN
C *** CALCULATE BEST FIT PARABOLIC EQUATION
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /LIST1/NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA1(10,240)
      REAL*4 Y,DATA1
      DIMENSION DATA(10,240)
C *** CONVERT DATA TO ABSOLUTE MEASURE, DOUBLE PRECISION
      DO 211 I = 1,NR
      XX=Y(I)**2/676.D3
      DO 211 J = 1,NAL
      DATA(I,J)=XX+DATA1(I,J)
      IF(DATA1(I,J).EQ.C.) DATA(I,J) = 0.
  211 CONTINUE
C *** COMPUTE SUMS
      SUMY2 = 0.
      SUMY4 = 0.
      SUMX = 0.
      SUMXY2 = 0.
      DO 212 I = 1,NR
      Y2 = Y(I)**2
      SUMY2 = SUMY2 + Y2*NA(I)
      SUMY4 = SUMY4 + Y2*Y2*NA(I)
      DO 212 J = 1,NAL
      SUMX = SUMX + DATA(I,J)
  212 SUMXY2 = SUMXY2 + DATA(I,J)*Y2
C *** COMPUTE COEFFICIENTS OF   X = A*Y**2 + B
      A = (NP*SUMXY2 - SUMX*SUMY2)/(NP*SUMY4 - SUMY2**2)
      B = (SUMX*SUMY4 - SUMXY2*SUMY2)/(NP*SUMY4 - SUMY2**2)
C *** COMPUTE S.D. OF 'A'
      SX = 0.
      DO 213 I = 1,NR
      YYY = A*Y(I)**2
      DO 213 J = 1,NAL
      IF(DATA(I,J).EQ.0.0) GO TO 213
      SX = SX + (DATA(I,J) - YYY - B)**2
  213 CONTINUE
      SX = DSQRT(SX/(NP-2))
      SA = SX*DSQRT(NP/(NP*SUMY4 - SUMY2**2))
C *** COMPUTE ACTUAL FOCAL LENGTH AND S.D.
      P = 1./(4.*A)
      SP = SA/(4.*A**2)
C *** RETURN DATA TO RELATIVE MEASURE, USING NEW FOCAL LENGTH
      DO 214 I = 1,NR
      XX = A*Y(I)**2
      DO 214 J = 1,NAL
      IF(DATA(I,J).EQ.0.0) GO TO 214
      DATA1(I,J)=-XX+DATA(I,J)
  214 CONTINUE
      WRITE(3,261) P,SP
  261 FORMAT(1H1,'THE FOCAL LENGTH OF THE BEST FIT PARABOLA (METHOD OF L
     1EAST SQUARES) IS'//15X,F14.4,'  WITH STANDARD DEVIATION',F12.4)
      RETURN
      END
```

```
      SUBROUTINE PIKTUR
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1       /LIST2/ MEAN,SD,MEANR(10),SDR(10),MEANA(20),SDA(20)
      REAL MEAN,MEANR,MEANA
      REAL MODE
      DIMENSION XAR(240),YAR(240),XPAR(9),YPAR(9),YCOR(5),TEXT(80)
     1,TEXT1(80),TEXT2(80),TEXT3(80),TEXT4(80),TEXT5(80),TEXT6(80)
      EQUIVALENCE (XCOR,XPAR(1)),(XSIZE,XPAR(2)),(YSIZE,YPAR(2)),
     1 (XORIG,XPAR(3)),(YORIG,YPAR(3)),(XSCALE,XPAR(4)),(YSCALE,YPAR(4))
     2 ,(MODE,XPAR(5)),(PEN,YPAR(5)),(XSPACE,XPAR(7)),(YSPACE,YPAR(7)),
     3 (PEN2,YPAR(8))
      READ(1,101,END=102,ERR=102) TEXT
      READ(1,101) TEXT1
      READ(1,101) TEXT2
      READ(1,101) TEXT3
      READ(1,101) TEXT4
      READ(1,101) TEXT5
      READ(1,101) TEXT6
  101 FORMAT(80A1)
  102 CONTINUE
      DIFF = 0.
      DO 10 I = 1,NR
      DO 10 J = 1,NAL
      IF(DATA(I,J).EQ.0.) GO TO 10
      IF(ABS(DATA(I,J)-MEANR(I)).GT.DIFF) DIFF = ABS(DATA(I,J)-MEANR(I))
   10 CONTINUE
      DIFF = 40.*(AINT(DIFF/20.) + 1.)
      YCOR(1) = 0.
      YCOR(2)=4.0
      YCOR(3)=8.0
      YCOR(4)=12.0
      YCOR(5)=16.0
      XCOR=2.0
      XSIZE=24.0
      YSIZE = 3.5
      XORIG=0.0
      XSCALE = 10.
      YSCALE = DIFF/YSIZE
      XSPACE = 0.6
      YSPACE=10.0/YSCALE
C *** SIX AZIMUTHAL STATIONS (1/40 CIRC.) PER X GRID SPACE
C *** TEN THOU INCHES PER Y GRID SPACE
      PEN2 = 8.
      DO 1 K = 1,2
      CALL PAGE
      CALL PSTART(2.0,0.0,26.0,21.75,0.,0.,1.,1.,IJK)
      CALL NAME(TEXT,80)
      CALL PTEXT(TEXT2,79,7.0,21.5,.15,0.0,1)
      CALL PTEXT(TEXT6,50,9.25,21.0,.15,0.0,1)
      CALL PTEXT(TEXT3,46,10.,20.,.15,0.0,1)
      CALL PTEXT(TEXT4,57,10.,19.6,.15,0.0,1)
      CALL PTEXT(TEXT5,68,10.,19.2,.15,0.0,1)
```

```
      DO 200 III=1,5
      II=5*K+1-III
      CALL CONVRT(II,TEXT1(20),2,4,1,IERR)
      XX=-4*(III-1)+16
      CALL PTEXT(TEXT1,21,10.,XX,.15,0.0,1)
  200 CONTINUE
      DO 1 IK = 1,5
      I = 5*(K-1) + IK
      IF(I.GT.NR) GO TO 3
      YPAR(1) = YCOR(IK)
      YORIG = 1.75
      IND = 3
      PEN1 = 8.
      CALL AXIS(IND,PEN1,XPAR,YPAR)
      MODE = 6.
      PEN = 8.
      XAR(1) = 0.
      XAR(2) = NAL
      YAR(1) = SDR(I)
      YAR(2) = SDR(I)
      CALL LINE2(XAR,YAR,2,XPAR,YPAR)
      YAR(1) = -SDR(I)
      YAR(2) = -SDR(I)
      CALL LINE2(XAR,YAR,2,XPAR,YPAR)
      NN = 0
      DO 2 J = 1,NAL
      IF(DATA(I,J).EQ.0.) GO TO 2
      NN = NN + 1
      XAR(NN) = J
      YAR(NN) = DATA(I,J)
    2 CONTINUE
      YORIG = 1.75 - MEANR(I)/YSCALE
      MODE = 3.
      PEN = 6.
      CALL LINE2(XAR,YAR,NN,XPAR,YPAR)
    1 CONTINUE
    3 RETURN
      END
```

```
      SUBROUTINE PIKTWO
C *** PLOT FREQUENCY DISTRIBUTIONS
      COMMON /LIST1/ NP,NR,NAL,NAS,NSP,NA(10),NAP(20),Y(10),DATA(10,240)
     1        /LIST2/ MEAN,SD,MEANR(10),SDR(10),MEANA(20),SDA(20)
     1        /LIST3/ NUM(150),NUMR(10,150),NUMA(20,150)
     3        /LIST4/ MDN,QD,MDNR(10),QDR(10),MDNA(20),QDA(20)
      REAL MEAN,MDN,MEANR,MDNR,MEANA,MDNA
      REAL LS,MODE
      DIMENSION XPAR(9),YPAR(9),XARG(100),YARG(100),TEXT(80)
     1,TEXT1(80),TEXT2(80),TEXT3(80),TEXT4(80),TEXT5(80),TEXT6(80),
     2TEXT7(80),TEXT8(80)
      EQUIVALENCE (XCOR,XPAR(1)),(YCOR,YPAR(1)),(XSIZE,XPAR(2)),
     1 (YSIZE,YPAR(2)),(XORIG,XPAR(3)),(YORIG,YPAR(3)),(XSCALE,XPAR(4)),
     2 (YSCALE,YPAR(4)),(MODE,XPAR(5)),(PEN3,YPAR(5)),(XSPACE,XPAR(7)),
     3 (YSPACE,YPAR(7)),(PEN2,XPAR(8))
      CALL PAGE
      CALL PSTART(0.0,0.0,12.0,12.0,0.0,0.0,1.,1.,IJK)
      READ(1,101,END=102,ERR=102) TEXT
      XSIZE=12.0
      YSIZE=12.0
      READ(1,101) TEXT1
      READ(1,101) TEXT2
      READ(1,101) TEXT3
      READ(1,101) TEXT4
      READ(1,101) TEXT5
      READ(1,101) TEXT6
      READ(1,101) TEXT7
      READ(1,101) TEXT8
      CALL PTEXT(TEXT1,25,4.,10.,.15,0.0,1)
      CALL PTEXT(TEXT2,50,2.5,9.5,.15,0.0,1)
      CALL PTEXT(TEXT3,35,2.0,9.,.15,0.0,1)
      CALL PTEXT(TEXT4,34,2.,8.6,.15,0.0,1)
      CALL PTEXT(TEXT5,33,1.75,2.,0.0,.15,2)
      CALL PTEXT(TEXT6,25,1.45,2.4,0.0,.15,2)
      CALL PTEXT(TEXT7,24,4.5,1.5,.15,0.0,1)
      CALL PTEXT(TEXT8,18,4.75,1.0,.15,0.0,1)
  101 FORMAT(80A1)
      CALL NAME(TEXT,80)
  102 CONTINUE
      MAX = 0
C *** NUM(NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR ENTIRE DISH
C *** NUMR(I,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10X NN FOR RADL STN I
C *** NUMA(K,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR AZML MN RIB SCTN K
      DO 21 I = 1,100
      IF(NUM(I).EQ.0) GO TO 21
      IND1 = I
      GO TO 22
   21 CONTINUE
   22 DO 23 II=1,100
      I=101-II
      IF(NUM(I).EQ.0) GO TO 23
      IND2=I
```

```
      GO TO 24
   23 CONTINUE
   24 DO 25 I=IND1,IND2
      IF(NUM(I).GT.MAX) MAX = NUM(I)
   25 CONTINUE
      LS=IND1-1
      RS=IND2+1
      TS=MAX+2
      XCOR = 2.
      YCOR = 2.
      XSIZE = 9.
      YSIZE = 6.
      XSCALE = (RS - LS)/XSIZE
      YSCALE = TS/YSIZE
      XORIG = -LS/XSCALE
      YORIG = 0.
      IND = 3
      PEN1 = 11.
      XSPACE=1./XSCALE
      YSPACE=10./YSCALE
C *** X AXIS HAS 10 THOU PER GRID SPACE
C *** Y AXIS HAS 10 MEASURED POINTS PER GRID SPACE
      PEN2 = 8.
      CALL GRID2(IND,PEN1,XPAR,YPAR)
      IND2 = IND2 + 1
      N1 = 0
      DO 1 I = IND1,IND2
      N1 = N1 + 1
      XARG(N1) = I - 0.5
      YARG(N1) = NUM(I-1)
      N1 = N1 + 1
      XARG(N1) = I - 0.5
    1 YARG(N1) = NUM(I)
      MODE = 3.
      PEN3 = 6.
      CALL LINE2(XARG,YARG,N1,XPAR,YPAR)
      XARG(1) = MEAN/10.
      XARG(2) = XARG(1)
      YARG(1) = 0.
      YARG(2) = TS - 5.
      MODE = 6.
      PEN3 = 10.
      CALL LINE2(XARG,YARG,2,XPAR,YPAR)
      XARG(1) = (MEAN-SD)/10.
      XARG(2) = XARG(1)
      N3 = XARG(1) + 0.5
      YARG(2) = NUM(N3)
      CALL LINE2(XARG,YARG,2,XPAR,YPAR)
      XARG(1) = (MEAN+SD)/10.
      XARG(2) = XARG(1)
      N3 = XARG(1) + 0.5
      YARG(2) = NUM(N3)
      CALL LINE2(XARG,YARG,2,XPAR,YPAR)
```

```
XARG(1) = MDN/10.
XARG(2) = XARG(1)
YARG(2) = TS - 5.
PEN3=7.
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
XARG(1) = (MDN-QD)/10.
XARG(2) = XARG(1)
N3 = XARG(1) + 0.5
YARG(2) = NUM(N3)
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
XARG(1) = (MDN+QD)/10.
XARG(2) = XARG(1)
N3 = XARG(1) + 0.5
YARG(2) = NUM(N3)
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
RETURN
END
```

SAMPLE OUTPUT FOR REE240

Survey No. 1 May 15, 1968

```
 THESE POINTS ARE 'FLYERS' AND ARE NOT INCLUDED IN CALCULATIONS
DATA( 8,238) =       4.
```

RAW DATA

803.	793.	726.	660.	570.	579.	574.	596.	563.	547.
803.	793.	726.	660.	570.	579.	574.	596.	563.	547.
804.	800.	721.	667.	572.	592.	587.	602.	582.	573.
808.	804.	738.	674.	594.	601.	602.	612.	607.	593.
809.	808.	749.	695.	626.	603.	609.	590.	580.	587.
810.	810.	757.	697.	632.	603.	609.	574.	546.	533.
804.	808.	757.	687.	628.	597.	617.	584.	546.	525.
798.	802.	749.	693.	606.	609.	619.	578.	556.	559.
796.	800.	745.	691.	600.	633.	629.	594.	588.	525.
798.	796.	733.	673.	592.	643.	641.	630.	624.	573.
804.	794.	721.	653.	590.	645.	633.	624.	608.	557.
812.	788.	717.	655.	602.	627.	615.	582.	540.	541.
816.	780.	727.	671.	624.	619.	623.	598.	562.	537.
810.	780.	723.	653.	608.	615.	611.	592.	548.	517.
806.	782.	727.	657.	602.	619.	627.	622.	574.	565.
802.	778.	731.	669.	612.	617.	631.	624.	596.	555.
804.	776.	735.	691.	634.	621.	633.	610.	584.	537.
802.	776.	745.	697.	670.	631.	623.	578.	540.	503.
806.	782.	753.	693.	650.	639.	627.	596.	558.	523.
804.	782.	755.	701.	616.	651.	643.	598.	578.	547.
800.	780.	755.	705.	616.	647.	645.	622.	606.	503.
800.	780.	749.	685.	624.	643.	659.	656.	634.	557.
800.	782.	747.	673.	620.	645.	649.	638.	612.	541.
814.	780.	757.	685.	614.	639.	613.	594.	550.	535.
814.	790.	765.	721.	620.	645.	599.	592.	570.	515.
812.	798.	769.	717.	626.	671.	627.	620.	598.	537.
808.	800.	769.	709.	630.	663.	653.	632.	598.	519.
808.	802.	761.	721.	636.	661.	673.	660.	630.	513.
808.	806.	761.	731.	636.	655.	661.	642.	602.	539.
809.	806.	764.	727.	628.	643.	642.	616.	576.	504.
805.	798.	770.	712.	641.	631.	645.	607.	573.	495.
797.	786.	772.	721.	648.	647.	637.	611.	579.	518.
790.	760.	771.	721.	620.	661.	649.	634.	610.	553.
796.	784.	763.	705.	618.	677.	679.	648.	652.	561.
800.	788.	751.	677.	614.	661.	665.	650.	622.	545.
822.	786.	757.	667.	618.	631.	655.	618.	574.	551.
824.	798.	767.	687.	646.	629.	659.	624.	592.	557.
823.	805.	755.	689.	640.	663.	685.	618.	624.	583.
822.	812.	743.	691.	634.	671.	683.	618.	652.	581.
822.	813.	763.	708.	656.	683.	693.	664.	658.	563.
822.	814.	783.	725.	678.	681.	679.	658.	632.	545.
821.	815.	787.	724.	677.	651.	657.	626.	590.	563.
820.	816.	791.	723.	676.	655.	661.	632.	594.	549.
813.	814.	788.	727.	665.	649.	667.	636.	608.	621.
806.	812.	785.	731.	654.	667.	683.	658.	630.	603.
807.	808.	770.	713.	643.	681.	695.	680.	652.	587.
808.	804.	755.	695.	632.	681.	715.	684.	676.	615.
814.	805.	756.	715.	641.	669.	669.	636.	610.	621.

820.	806.	757.	735.	650.	651.	657.	636.	620.	601.
818.	810.	761.	720.	652.	673.	667.	646.	620.	619.
816.	814.	765.	705.	654.	675.	685.	670.	652.	629.
818.	815.	775.	710.	652.	685.	691.	676.	674.	645.
820.	816.	785.	715.	650.	693.	677.	666.	656.	631.
820.	814.	791.	707.	654.	693.	647.	648.	606.	581.
820.	812.	797.	699.	662.	685.	643.	636.	622.	617.
816.	811.	791.	710.	654.	679.	699.	640.	638.	655.
812.	810.	785.	721.	646.	671.	683.	650.	656.	611.
815.	806.	772.	706.	644.	683.	699.	674.	710.	651.
818.	802.	759.	691.	642.	659.	667.	648.	684.	633.
821.	811.	767.	705.	646.	653.	639.	642.	652.	619.
821.	811.	767.	705.	646.	653.	649.	652.	652.	623.
821.	811.	767.	705.	646.	653.	649.	652.	652.	623.
824.	820.	775.	719.	650.	653.	659.	662.	652.	627.
828.	826.	785.	733.	666.	685.	685.	668.	680.	621.
832.	832.	795.	747.	682.	689.	681.	660.	658.	617.
826.	832.	796.	737.	684.	689.	677.	652.	624.	589.
820.	832.	797.	727.	686.	667.	667.	630.	618.	589.
808.	833.	793.	730.	679.	689.	697.	670.	648.	647.
796.	834.	789.	733.	672.	703.	711.	692.	648.	635.
799.	838.	785.	711.	659.	709.	749.	734.	686.	621.
802.	842.	781.	689.	646.	719.	745.	724.	662.	645.
810.	850.	786.	709.	653.	713.	717.	692.	636.	667.
818.	858.	791.	729.	660.	707.	701.	686.	672.	617.
809.	854.	781.	741.	670.	715.	713.	678.	668.	607.
800.	850.	771.	753.	680.	709.	719.	694.	686.	633.
804.	845.	786.	768.	692.	723.	729.	714.	710.	663.
808.	840.	801.	783.	704.	731.	719.	694.	704.	639.
810.	833.	808.	769.	709.	727.	711.	676.	658.	611.
812.	826.	815.	755.	714.	713.	701.	670.	644.	631.
810.	816.	809.	765.	693.	695.	703.	664.	646.	673.
808.	806.	803.	775.	672.	691.	717.	690.	674.	659.
810.	803.	794.	748.	659.	709.	741.	712.	702.	625.
812.	800.	785.	721.	646.	705.	755.	700.	684.	647.
823.	800.	782.	741.	630.	683.	703.	672.	636.	669.
834.	800.	779.	721.	614.	671.	693.	670.	652.	643.
831.	807.	773.	712.	628.	699.	707.	678.	668.	651.
828.	814.	767.	703.	642.	693.	701.	690.	670.	653.
830.	817.	774.	726.	666.	739.	715.	712.	718.	629.
832.	820.	781.	749.	690.	711.	707.	704.	704.	661.
831.	816.	764.	735.	701.	689.	703.	684.	662.	645.
830.	812.	747.	721.	672.	683.	703.	672.	654.	631.
821.	814.	761.	737.	673.	707.	719.	692.	668.	677.
812.	816.	775.	753.	674.	727.	729.	714.	682.	683.
815.	813.	775.	730.	670.	731.	761.	750.	720.	701.
818.	810.	775.	707.	666.	733.	743.	742.	682.	695.
824.	813.	779.	721.	671.	713.	699.	684.	638.	705.

830.	816.	783.	735.	676.	713.	697.	690.	670.	635.
827.	821.	780.	736.	680.	721.	713.	706.	700.	669.
824.	826.	777.	737.	684.	715.	725.	704.	718.	689.
826.	827.	786.	754.	694.	733.	737.	728.	734.	681.
828.	828.	795.	771.	704.	739.	725.	708.	708.	673.
826.	826.	797.	761.	699.	739.	723.	682.	652.	703.
824.	824.	799.	751.	694.	713.	715.	680.	668.	753.
819.	819.	792.	706.	689.	719.	737.	732.	692.	711.
814.	814.	785.	661.	684.	729.	745.	742.	694.	657.
811.	811.	773.	680.	670.	727.	747.	768.	730.	695.
808.	808.	761.	699.	656.	719.	719.	734.	680.	695.
817.	814.	765.	712.	666.	707.	695.	672.	646.	717.
826.	820.	769.	725.	676.	715.	707.	686.	682.	655.
828.	826.	776.	729.	680.	739.	725.	692.	714.	645.
830.	832.	783.	733.	684.	731.	735.	718.	702.	685.
830.	835.	794.	750.	685.	733.	753.	752.	746.	703.
830.	838.	805.	767.	686.	737.	769.	740.	732.	687.
823.	831.	807.	762.	690.	719.	725.	698.	674.	679.
816.	824.	809.	757.	694.	723.	721.	700.	684.	673.
808.	821.	804.	756.	686.	735.	721.	720.	714.	681.
800.	818.	799.	755.	678.	739.	753.	742.	738.	695.
800.	814.	789.	736.	676.	743.	789.	770.	776.	723.
800.	810.	779.	717.	674.	729.	775.	762.	776.	719.
809.	809.	801.	726.	669.	721.	741.	748.	752.	727.
809.	809.	801.	726.	669.	734.	733.	738.	739.	713.
809.	809.	801.	726.	669.	734.	733.	738.	739.	713.
818.	808.	823.	735.	664.	747.	725.	728.	726.	699.
817.	809.	819.	746.	676.	757.	735.	740.	750.	717.
816.	810.	815.	757.	688.	745.	733.	744.	738.	691.
814.	806.	805.	752.	697.	735.	749.	704.	682.	615.
812.	802.	795.	747.	706.	717.	741.	688.	688.	659.
808.	797.	790.	750.	686.	715.	743.	714.	700.	685.
804.	792.	785.	753.	666.	725.	771.	730.	710.	687.
806.	789.	782.	736.	660.	729.	767.	748.	754.	679.
808.	786.	779.	719.	654.	711.	749.	740.	748.	689.
817.	795.	778.	733.	667.	695.	707.	692.	660.	695.
826.	804.	777.	747.	680.	699.	705.	690.	680.	673.
822.	815.	781.	737.	677.	727.	723.	708.	680.	641.
818.	826.	785.	727.	674.	735.	729.	712.	702.	677.
814.	832.	793.	738.	690.	737.	731.	728.	726.	677.
810.	838.	801.	749.	706.	725.	719.	714.	708.	635.
809.	838.	810.	746.	700.	707.	713.	690.	662.	661.
808.	838.	819.	743.	694.	693.	703.	686.	662.	651.
805.	833.	811.	749.	684.	719.	729.	694.	696.	647.
802.	828.	803.	755.	674.	731.	737.	700.	730.	651.
805.	824.	784.	735.	666.	727.	745.	740.	744.	693.
808.	820.	765.	715.	658.	717.	745.	736.	724.	661.
815.	824.	772.	727.	664.	715.	715.	698.	674.	701.

822.	828.	779.	739.	670.	697.	707.	674.	688.	687.
820.	830.	792.	737.	678.	701.	713.	690.	672.	661.
818.	832.	805.	735.	686.	709.	723.	702.	680.	681.
817.	833.	813.	752.	694.	719.	739.	722.	726.	693.
816.	834.	821.	769.	702.	729.	719.	710.	728.	677.
815.	824.	820.	762.	709.	717.	707.	702.	678.	647.
814.	814.	819.	755.	716.	691.	701.	686.	672.	661.
807.	805.	811.	766.	703.	711.	727.	704.	680.	687.
800.	796.	803.	777.	690.	719.	721.	714.	688.	649.
807.	788.	784.	748.	673.	721.	743.	740.	738.	597.
814.	780.	765.	719.	656.	697.	729.	722.	714.	639.
818.	774.	766.	732.	658.	675.	685.	656.	634.	641.
822.	768.	767.	745.	660.	677.	677.	660.	654.	587.
811.	773.	770.	740.	666.	685.	695.	674.	656.	663.
800.	778.	773.	735.	672.	689.	701.	692.	666.	643.
797.	782.	790.	755.	676.	703.	717.	716.	702.	647.
794.	788.	807.	775.	680.	705.	707.	710.	682.	611.
791.	790.	802.	771.	684.	699.	687.	658.	614.	591.
788.	792.	797.	767.	688.	699.	685.	662.	624.	609.
788.	790.	783.	765.	675.	703.	709.	700.	652.	573.
788.	788.	769.	763.	662.	697.	711.	708.	664.	603.
792.	785.	763.	743.	656.	703.	721.	722.	698.	653.
796.	782.	757.	723.	650.	709.	697.	704.	676.	619.
799.	785.	758.	728.	649.	685.	665.	648.	612.	597.
802.	788.	759.	733.	648.	681.	651.	644.	630.	595.
800.	792.	756.	725.	648.	681.	669.	640.	610.	597.
798.	796.	753.	717.	648.	681.	681.	652.	634.	621.
800.	800.	769.	729.	651.	683.	697.	690.	676.	621.
802.	804.	785.	741.	654.	681.	681.	674.	664.	613.
802.	806.	787.	735.	660.	659.	661.	638.	600.	595.
802.	808.	789.	729.	666.	637.	627.	606.	568.	629.
801.	804.	780.	738.	657.	679.	691.	642.	612.	611.
800.	800.	771.	747.	648.	659.	683.	654.	642.	631.
799.	792.	764.	724.	636.	657.	691.	686.	690.	675.
798.	784.	757.	701.	624.	649.	683.	668.	668.	605.
805.	794.	761.	697.	618.	647.	665.	656.	638.	643.
805.	794.	761.	697.	618.	647.	645.	646.	635.	646.
805.	794.	761.	697.	618.	647.	645.	646.	635.	646.
812.	804.	765.	693.	612.	647.	625.	636.	632.	649.
818.	812.	777.	765.	635.	663.	655.	654.	662.	631.
824.	820.	789.	737.	658.	683.	655.	664.	640.	625.
823.	819.	787.	735.	657.	681.	661.	614.	582.	583.
822.	818.	785.	733.	656.	657.	643.	610.	580.	621.
813.	811.	780.	738.	666.	667.	669.	644.	628.	663.
804.	804.	775.	743.	676.	661.	667.	654.	666.	685.
796.	794.	760.	726.	662.	665.	683.	684.	696.	677.
788.	784.	745.	709.	648.	665.	675.	680.	680.	703.
797.	788.	739.	709.	628.	647.	647.	618.	616.	733.

806.	792.	733.	709.	608.	635.	639.	590.	606.	723.
810.	804.	740.	703.	623.	661.	647.	638.	626.	687.
814.	816.	747.	697.	638.	665.	657.	648.	652.	729.
815.	819.	759.	709.	653.	677.	677.	660.	698.	697.
826.	822.	771.	721.	668.	695.	679.	644.	696.	743.
808.	817.	777.	711.	660.	679.	661.	612.	644.	699.
800.	812.	783.	701.	652.	659.	645.	594.	628.	671.
797.	808.	777.	708.	648.	659.	647.	612.	648.	795.
794.	804.	771.	715.	644.	661.	649.	632.	658.	795.
797.	798.	762.	696.	643.	675.	681.	660.	700.	747.
800.	792.	753.	677.	642.	677.	673.	658.	694.	723.
806.	787.	748.	686.	646.	653.	647.	624.	642.	741.
812.	782.	743.	695.	650.	633.	645.	608.	644.	707.
811.	787.	742.	692.	642.	659.	657.	632.	620.	655.
810.	792.	741.	689.	634.	671.	675.	662.	654.	675.
809.	793.	757.	703.	646.	677.	681.	672.	664.	709.
808.	794.	773.	717.	658.	675.	649.	642.	628.	643.
802.	794.	775.	712.	666.	679.	659.	624.	598.	603.
796.	794.	777.	707.	674.	675.	669.	604.	576.	617.
790.	792.	771.	709.	672.	697.	685.	654.	622.	583.
784.	790.	765.	711.	670.	709.	693.	688.	652.	559.
796.	789.	740.	686.	673.	731.	729.	716.	684.	589.
808.	788.	735.	661.	676.	729.	733.	692.	656.	553.
816.	796.	740.	698.	690.	729.	715.	672.	622.	595.
824.	804.	745.	735.	704.	731.	703.	678.	618.	565.
816.	810.	743.	731.	702.	727.	709.	668.	592.	529.
808.	816.	741.	727.	700.	707.	717.	666.	620.	549.
804.	819.	746.	729.	680.	701.	711.	674.	632.	531.
800.	822.	751.	731.	660.	681.	667.	640.	608.	513.
800.	820.	753.	711.	657.	675.	675.	614.	566.	509.
800.	818.	756.	691.	654.	669.	665.	614.	546.	517.
798.	816.	747.	697.	641.	665.	655.	624.	582.	549.
796.	814.	739.	703.	628.	659.	659.	628.	596.	531.
805.	807.	734.	682.	636.	661.	665.	646.	620.	497.
814.	800.	729.	661.	644.	661.	651.	640.	590.	523.
819.	802.	737.	679.	631.	637.	631.	602.	548.	547.
824.	804.	745.	697.	618.	613.	627.	584.	542.	515.
824.	803.	741.	681.	603.	621.	615.	574.	522.	473.
824.	802.	737.	665.	588.	627.	613.	590.	548.	483.
818.	801.	749.	675.	595.	627.	621.	616.	584.	505.
812.	800.	761.	685.	602.	619.	601.	604.	548.	483.
800.	797.	766.	677.	601.	613.	587.	550.	510.	483.
788.	794.	771.	669.	600.	609.	581.	532.	508.	469.
784.	793.	763.	677.	582.	617.	599.	570.	542.	475.
780.	792.	755.	685.	564.	597.	597.	594.	572.	455.
791.	789.	743.	669.	566.	587.	583.	0.	596.	507.
802.	786.	731.	653.	568.	581.	573.	598.	568.	503.
803.	793.	726.	660.	570.	567.	561.	590.	544.	521.

FOR THE WHOLE ANTENNA, MEAN = 705.40,S.D. = 77.74,MEDIAN = 701.58,Q.D. = 60.88,SKEWNESS = 0.160

FOR RADIAL STN NO.	1,MEAN = 810.20	S.D. = 10.94	MEDIAN = 810.53	Q.D. = 8.46	SKEWNESS = -8.442
FOR RADIAL STN NO.	2,MEAN = 806.67	S.D. = 17.33	MEDIAN = 806.61	Q.D. = 12.89	SKEWNESS = -1.394
FOR RADIAL STN NO.	3,MEAN = 771.23	S.D. = 23.13	MEDIAN = 772.37	Q.D. = 16.27	SKEWNESS = -0.501
FOR RADIAL STN NO.	4,MEAN = 718.42	S.D. = 29.11	MEDIAN = 721.54	Q.D. = 20.73	SKEWNESS = -0.271
FOR RADIAL STN NO.	5,MEAN = 654.07	S.D. = 31.61	MEDIAN = 657.80	Q.D. = 20.55	SKEWNESS = -0.528
FOR RADIAL STN NO.	6,MEAN = 680.58	S.D. = 39.58	MEDIAN = 682.67	Q.D. = 29.76	SKEWNESS = -0.402
FOR RADIAL STN NO.	7,MEAN = 682.59	S.D. = 44.86	MEDIAN = 685.00	Q.D. = 32.82	SKEWNESS = -0.265
FOR RADIAL STN NO.	8,MEAN = 663.60	S.D. = 63.68	MEDIAN = 663.33	Q.D. = 34.27	SKEWNESS = -0.052
FOR RADIAL STN NO.	9,MEAN = 646.06	S.D. = 55.21	MEDIAN = 649.76	Q.D. = 36.86	SKEWNESS = -0.134
FOR RADIAL STN NO.	10,MEAN = 620.44	S.D. = 68.66	MEDIAN = 628.85	Q.D. = 55.56	SKEWNESS = -0.202

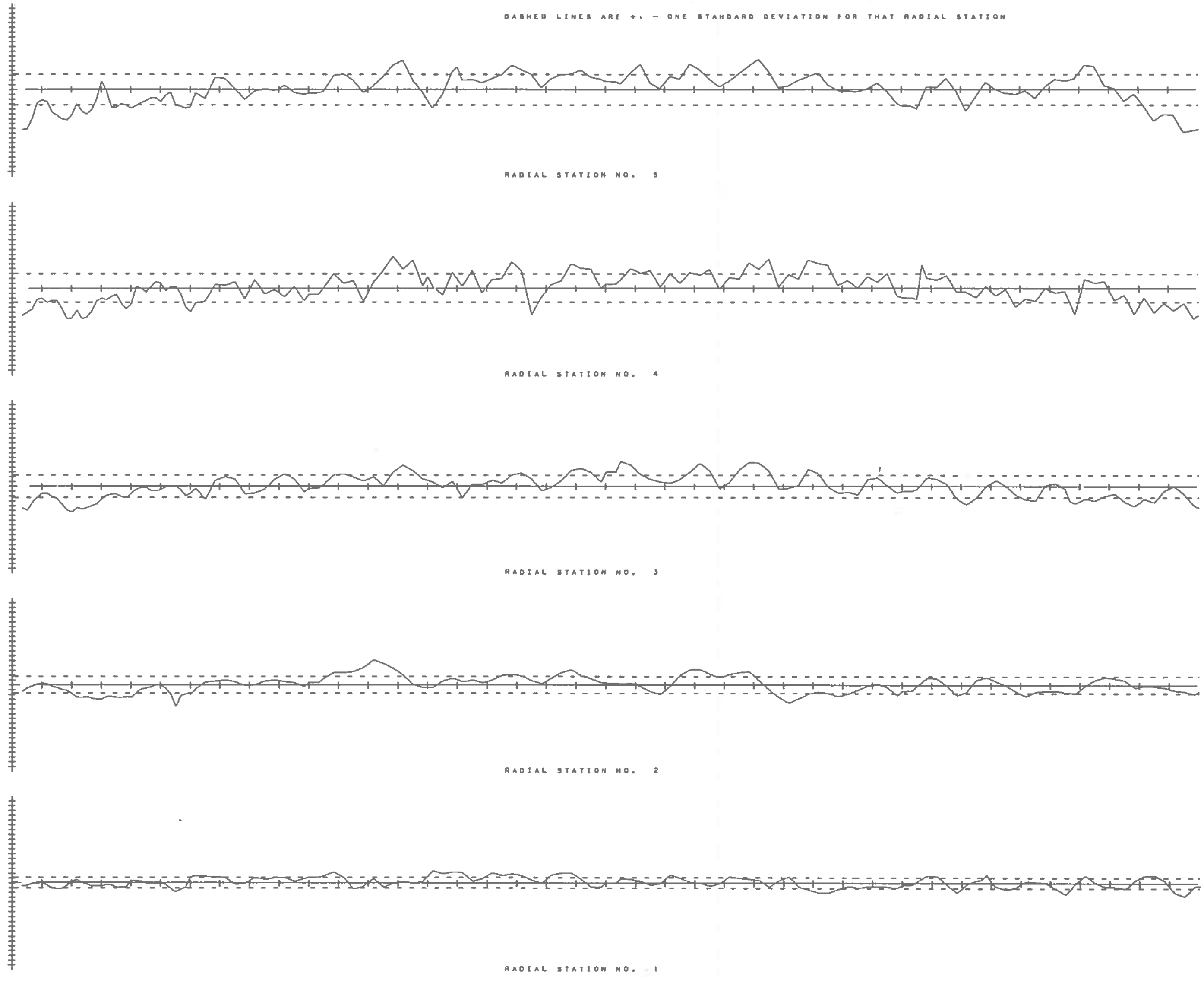
AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

33 FT. ARO PARABOLOID SURFACE MEAS MAY 15/68 NO 1

VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 6 AZIMUTHAL STATIONS PER GRID DIVISION

DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION



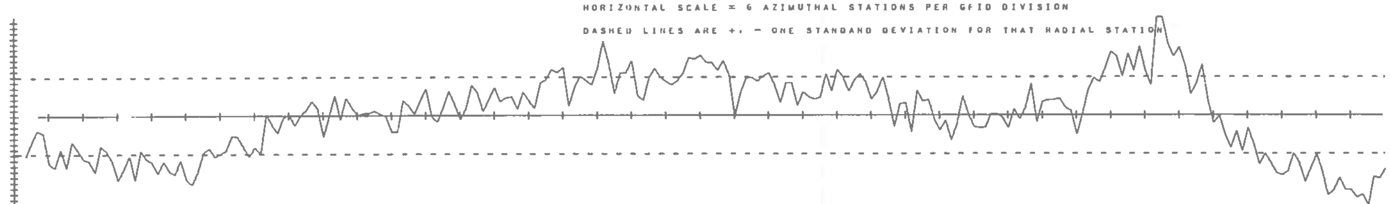
AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

33 FT. ARO PARABOLOID SURFACE MEAS MAY 15/66 NO 1

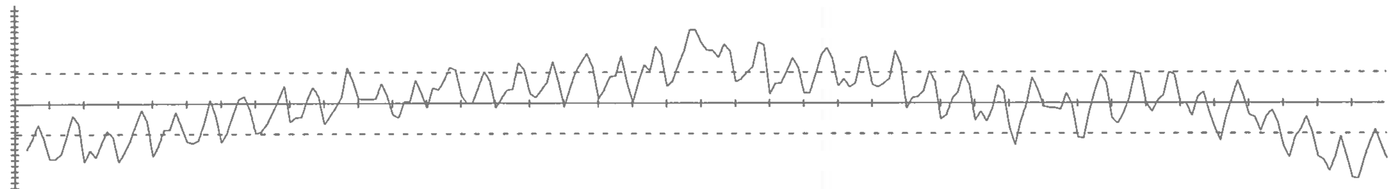
VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 6 AZIMUTHAL STATIONS PER GRID DIVISION

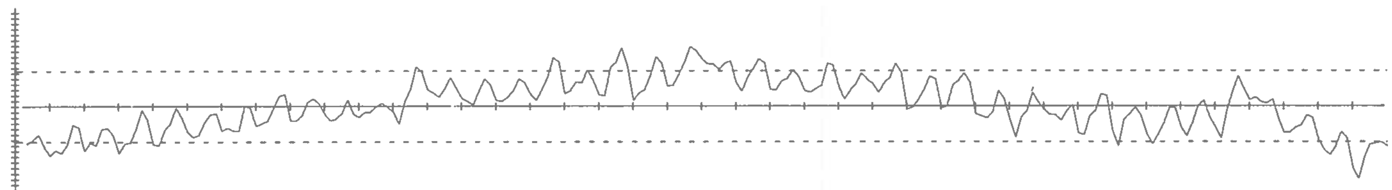
DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION



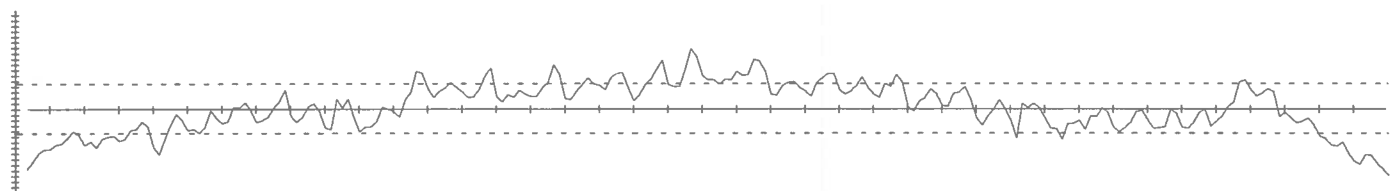
RADIAL STATION NO. 10



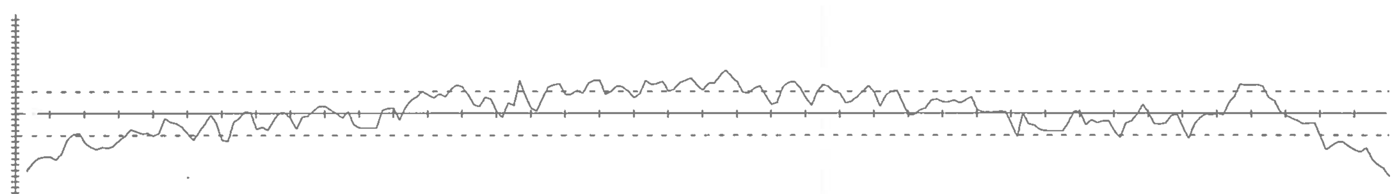
RADIAL STATION NO. 9



RADIAL STATION NO. 8



RADIAL STATION NO. 7



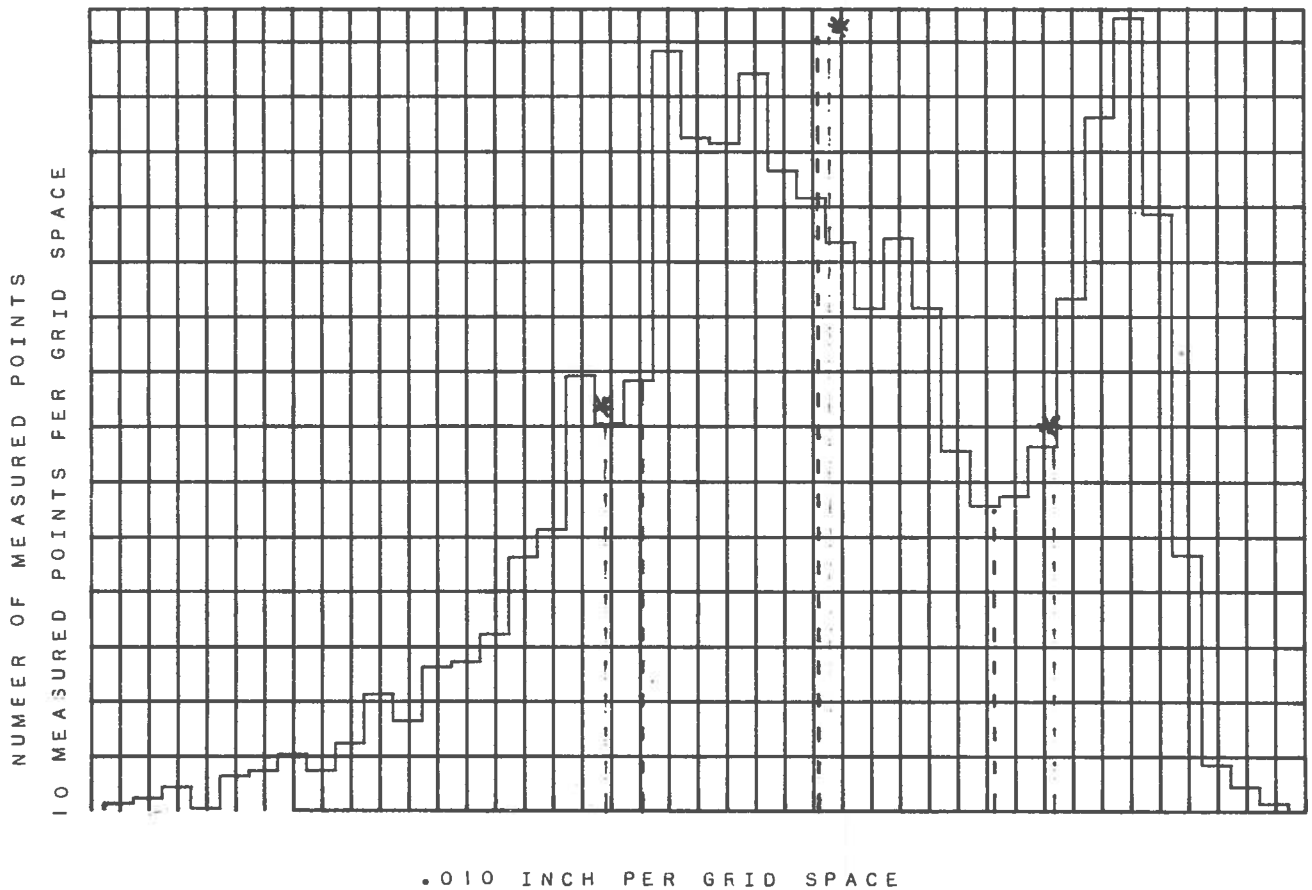
RADIAL STATION NO. 6

HISTOGRAM FOR ENTIRE DISH

33 FT. ARO PARABOLOID SURFACE MEAS MAY 15/68 NO 1

GREEN= MEDIAN, QUARTILE DEVIATIONS

* VIOLET = MEAN, STANDARD DEVIATIONS



ERROR DISTRIBUTION

CALCULATICN OF BEST FIT AXIS

TILT NC. 1 PHI = 0.01344 THETA = 171.

CUMULATIVE TILT PHI = 0.01344 THETA = 171.

MEAN OF DISH = 705.20 WITH S.D. = 72.48

TILT NO. 2 PHI = 0.00336 THETA = 171.

CUMULATIVE TILT PHI = 0.01680 THETA = 171.

MEAN OF DISH = 705.20 WITH S.D. = 72.00

TILT NC. 3 PHI = 0.00126 THETA = 171.

CUMULATIVE TILT PHI = 0.01807 THETA = 171.

MEAN OF DISH = 705.20 WITH S.D. = 71.91

TILT NO. 4 PHI = 0.00055 THETA = 171.

CUMULATIVE TILT PHI = 0.01862 THETA = 171.

MEAN OF DISH = 705.20 WITH S.D. = 71.88

TILT NC. 5 PHI = 0.00026 THETA = 171.

CUMULATIVE TILT PHI = 0.01888 THETA = 171.

MEAN OF DISH = 705.20 WITH S.D. = 71.87

TILT NO. 6 PHI = 0.00416 THETA = 315.

CUMULATIVE TILT PHI = 0.01570 THETA = 180.

MEAN OF DISH = 705.19 WITH S.D. = 71.89

TILT NC. 7 PHI = 0.00018 THETA = 171.

CUMULATIVE TILT PHI = 0.01588 THETA = 180.

MEAN OF DISH = 705.16 WITH S.D. = 71.87

TILT NC. 8 PHI = 0.00009 THETA = 171.

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CUMULATIVE TILT      PHI =   0.01597      THETA =   180.
MEAN OF DISH =  705.16  WITH S.D. =  71.86

TILT NO.  9     PHI =   0.00004      THETA =   171.
CUMULATIVE TILT      PHI =   0.01601      THETA =   180.
MEAN OF DISH =  705.16  WITH S.D. =  71.85

TILT NO. 10     PHI =   0.00002      THETA =   171.
CUMULATIVE TILT      PHI =   0.01603      THETA =   180.
MEAN OF DISH =  705.15  WITH S.D. =  71.85


THE FOCAL LENGTH OF THE BEST FIT PARABOLA (METHOD OF LEAST SQUARES) IS
                 169567.0416  WITH STANDARD DEVIATION      8.3114
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BEST FIT DATA

813.	811.	767.	728.	658.	689.	697.	742.	753.	791.
813.	811.	767.	728.	658.	689.	697.	742.	753.	791.
814.	818.	762.	735.	660.	702.	710.	748.	772.	817.
818.	822.	779.	742.	682.	711.	725.	758.	797.	837.
819.	826.	790.	763.	714.	713.	732.	736.	770.	831.
820.	828.	798.	765.	720.	713.	732.	720.	736.	777.
814.	826.	798.	755.	716.	707.	740.	730.	736.	769.
808.	820.	790.	761.	694.	719.	742.	724.	746.	803.
806.	818.	786.	759.	688.	743.	752.	740.	778.	769.
808.	814.	774.	741.	680.	753.	764.	776.	814.	817.
814.	812.	762.	721.	678.	755.	756.	770.	798.	801.
822.	806.	758.	723.	690.	737.	738.	728.	730.	785.
825.	797.	766.	737.	709.	726.	742.	740.	747.	776.
819.	797.	762.	719.	693.	722.	730.	734.	733.	756.
815.	799.	766.	723.	687.	726.	746.	764.	759.	804.
811.	795.	770.	735.	697.	724.	750.	766.	781.	794.
813.	793.	774.	757.	719.	728.	752.	752.	769.	776.
811.	793.	784.	763.	755.	738.	742.	720.	725.	742.
815.	799.	792.	759.	735.	746.	746.	738.	743.	762.
813.	799.	794.	767.	701.	758.	762.	740.	763.	786.
809.	797.	794.	771.	701.	754.	764.	764.	791.	742.
809.	797.	788.	751.	709.	750.	778.	798.	819.	796.
809.	799.	786.	739.	705.	752.	768.	780.	797.	780.
823.	797.	796.	751.	699.	746.	732.	736.	735.	774.
822.	805.	800.	782.	699.	745.	711.	726.	746.	744.
820.	813.	804.	778.	705.	771.	739.	754.	774.	766.
816.	815.	804.	770.	709.	763.	765.	766.	774.	748.
816.	817.	796.	782.	715.	761.	785.	794.	806.	742.
816.	821.	796.	792.	715.	755.	773.	776.	778.	768.
817.	821.	799.	788.	707.	743.	754.	750.	752.	733.
813.	813.	805.	773.	720.	731.	757.	741.	749.	724.
805.	801.	807.	782.	727.	747.	749.	745.	755.	747.
798.	775.	806.	782.	699.	761.	761.	768.	786.	782.
804.	799.	798.	766.	697.	777.	791.	782.	828.	790.
808.	803.	786.	738.	693.	761.	777.	784.	798.	774.
830.	801.	792.	728.	697.	731.	767.	752.	750.	780.
830.	810.	798.	741.	717.	721.	762.	748.	756.	772.
829.	817.	786.	743.	711.	755.	788.	742.	788.	798.
828.	824.	774.	745.	705.	763.	786.	742.	816.	796.
828.	825.	794.	762.	727.	775.	796.	788.	822.	778.
828.	826.	814.	779.	749.	773.	782.	782.	796.	760.
827.	827.	818.	778.	748.	743.	760.	750.	754.	778.
826.	828.	822.	777.	747.	747.	764.	756.	758.	764.
819.	826.	819.	781.	736.	741.	770.	760.	772.	836.
812.	824.	816.	785.	725.	759.	786.	782.	794.	818.
813.	820.	801.	767.	714.	773.	798.	804.	816.	802.
814.	816.	786.	749.	703.	773.	818.	808.	840.	830.
820.	817.	787.	769.	712.	761.	772.	760.	774.	836.

824.	815.	782.	782.	712.	732.	749.	748.	770.	799.
822.	819.	786.	767.	714.	754.	759.	758.	770.	817.
820.	823.	790.	752.	716.	756.	777.	782.	802.	827.
822.	824.	800.	757.	714.	766.	783.	788.	824.	843.
824.	825.	810.	762.	712.	774.	769.	778.	806.	829.
824.	823.	816.	754.	716.	774.	739.	760.	756.	779.

824.	821.	822.	746.	724.	766.	735.	748.	772.	815.
820.	820.	816.	757.	716.	760.	791.	752.	788.	853.
816.	819.	810.	768.	708.	752.	775.	762.	806.	809.
819.	815.	797.	753.	706.	764.	791.	786.	860.	849.
822.	811.	784.	738.	704.	740.	759.	760.	834.	831.
825.	820.	792.	752.	708.	734.	731.	754.	802.	817.

823.	816.	786.	744.	699.	723.	729.	751.	787.	804.
823.	816.	786.	744.	699.	723.	729.	751.	787.	804.
826.	825.	794.	758.	703.	723.	739.	761.	787.	808.
830.	831.	804.	772.	719.	755.	765.	767.	815.	802.
834.	837.	814.	786.	735.	759.	761.	759.	793.	798.
828.	837.	815.	776.	737.	759.	757.	751.	759.	770.

822.	837.	816.	766.	739.	737.	747.	729.	753.	770.
810.	838.	812.	769.	732.	759.	777.	769.	783.	828.
798.	839.	808.	772.	725.	773.	791.	791.	783.	816.
801.	843.	804.	750.	712.	779.	829.	833.	821.	802.
804.	847.	800.	728.	699.	789.	825.	823.	797.	826.
812.	855.	805.	748.	706.	783.	797.	791.	771.	848.

818.	860.	805.	760.	704.	767.	770.	773.	793.	782.
809.	856.	795.	772.	714.	775.	782.	765.	789.	772.
800.	852.	785.	784.	724.	769.	788.	781.	807.	798.
804.	847.	800.	799.	736.	783.	798.	801.	831.	828.
808.	842.	815.	814.	748.	791.	788.	781.	825.	804.
810.	835.	822.	800.	753.	787.	780.	763.	779.	776.

812.	828.	829.	786.	758.	773.	770.	757.	765.	796.
810.	818.	823.	796.	737.	755.	772.	751.	767.	838.
808.	808.	817.	806.	716.	751.	786.	777.	795.	824.
810.	805.	808.	779.	703.	769.	810.	799.	823.	790.
812.	802.	799.	752.	690.	765.	824.	787.	805.	812.
823.	802.	796.	772.	674.	743.	772.	759.	757.	834.

832.	800.	788.	745.	650.	722.	753.	746.	761.	794.
829.	807.	782.	736.	664.	750.	767.	754.	777.	802.
826.	814.	776.	727.	678.	744.	761.	766.	779.	804.
828.	817.	783.	750.	702.	790.	775.	788.	827.	780.
830.	820.	790.	773.	726.	762.	767.	780.	813.	812.
829.	816.	773.	759.	737.	740.	763.	760.	771.	796.

828.	812.	756.	745.	708.	734.	763.	748.	763.	782.
819.	814.	770.	761.	709.	758.	779.	768.	777.	828.
810.	816.	784.	777.	710.	778.	789.	790.	791.	834.
813.	813.	784.	754.	706.	782.	821.	826.	829.	852.
816.	810.	784.	731.	702.	784.	803.	818.	791.	846.
822.	813.	788.	745.	707.	764.	759.	760.	747.	856.

827.	814.	788.	755.	707.	758.	750.	759.	770.	776.
824.	819.	785.	756.	711.	766.	766.	775.	800.	810.
821.	824.	782.	757.	715.	760.	778.	773.	818.	830.
823.	825.	791.	774.	725.	778.	790.	797.	834.	822.
825.	826.	800.	791.	735.	784.	778.	777.	808.	814.
823.	824.	802.	781.	730.	784.	776.	751.	752.	844.
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808.	809.	778.	700.	701.	772.	800.	837.	830.	836.
805.	806.	766.	719.	687.	764.	772.	803.	780.	836.
814.	812.	770.	732.	697.	752.	748.	741.	746.	858.
822.	817.	773.	742.	704.	757.	757.	751.	778.	791.
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826.	829.	787.	750.	712.	773.	785.	783.	798.	821.
826.	832.	798.	767.	713.	775.	803.	817.	842.	839.
826.	835.	809.	784.	714.	779.	819.	805.	828.	823.
819.	828.	811.	779.	718.	761.	775.	763.	770.	815.
812.	821.	813.	774.	722.	765.	771.	765.	780.	809.
804.	818.	808.	773.	714.	777.	771.	785.	810.	817.
796.	815.	803.	772.	706.	781.	803.	807.	834.	831.
796.	811.	793.	753.	704.	785.	839.	835.	872.	859.
796.	807.	783.	734.	702.	771.	825.	827.	872.	855.
805.	806.	805.	743.	697.	763.	791.	813.	848.	863.
805.	806.	805.	743.	697.	776.	783.	803.	835.	849.
805.	806.	805.	743.	697.	776.	783.	803.	835.	849.
814.	805.	827.	752.	692.	789.	775.	793.	822.	835.
813.	806.	823.	763.	704.	799.	785.	805.	846.	853.
812.	807.	819.	774.	716.	787.	783.	809.	834.	827.
810.	803.	809.	769.	725.	777.	799.	769.	778.	751.
808.	799.	799.	764.	734.	759.	791.	753.	784.	795.
804.	794.	794.	767.	714.	757.	793.	779.	796.	821.
800.	789.	789.	770.	694.	767.	821.	795.	806.	823.
802.	786.	786.	753.	688.	771.	817.	813.	850.	815.
804.	783.	783.	736.	682.	753.	799.	805.	844.	825.
813.	792.	782.	750.	695.	737.	757.	757.	756.	831.
823.	802.	783.	767.	711.	744.	758.	759.	781.	814.
819.	813.	787.	757.	708.	772.	776.	777.	781.	782.
815.	824.	791.	747.	705.	780.	782.	781.	803.	818.
811.	830.	795.	758.	721.	782.	784.	797.	827.	818.
807.	836.	807.	769.	737.	770.	772.	783.	809.	776.
806.	836.	816.	766.	731.	752.	766.	759.	763.	802.
805.	836.	825.	763.	725.	738.	756.	755.	763.	792.
802.	831.	817.	769.	715.	764.	782.	763.	797.	788.
799.	826.	809.	775.	705.	776.	790.	769.	831.	792.
802.	822.	790.	755.	697.	772.	798.	809.	845.	834.
805.	818.	771.	735.	689.	762.	798.	805.	825.	802.
812.	822.	778.	747.	695.	760.	768.	767.	775.	842.

820.	828.	788.	763.	706.	749.	767.	751.	797.	838.
818.	830.	801.	761.	714.	753.	773.	767.	781.	812.
816.	832.	814.	759.	722.	761.	783.	779.	789.	832.
815.	833.	822.	776.	730.	771.	799.	799.	835.	844.
814.	834.	830.	793.	738.	781.	779.	787.	837.	828.
813.	824.	829.	786.	745.	769.	767.	779.	787.	798.
812.	814.	828.	779.	752.	743.	761.	763.	781.	812.
805.	805.	820.	790.	739.	763.	787.	781.	789.	838.
798.	796.	812.	801.	726.	771.	781.	791.	797.	800.
805.	788.	793.	772.	709.	773.	803.	817.	847.	748.
812.	780.	774.	743.	692.	749.	789.	799.	823.	790.
816.	774.	775.	756.	694.	727.	745.	733.	743.	792.
822.	770.	781.	776.	704.	737.	747.	747.	776.	752.
811.	775.	784.	771.	710.	745.	765.	761.	778.	828.
800.	780.	787.	766.	716.	749.	771.	779.	788.	808.
797.	784.	804.	786.	720.	763.	787.	803.	824.	812.
794.	790.	821.	806.	724.	765.	777.	797.	804.	776.
791.	792.	816.	802.	728.	759.	757.	745.	736.	756.
788.	794.	811.	798.	732.	759.	755.	749.	746.	774.
788.	792.	797.	796.	719.	763.	779.	787.	774.	738.
788.	790.	783.	794.	706.	757.	781.	795.	786.	768.
792.	787.	777.	774.	700.	763.	791.	809.	820.	818.
796.	784.	771.	754.	694.	769.	767.	791.	798.	784.
799.	787.	772.	759.	693.	745.	735.	735.	734.	762.
804.	794.	778.	772.	701.	752.	732.	743.	766.	777.
802.	798.	775.	764.	701.	752.	750.	739.	746.	779.
800.	802.	772.	756.	701.	752.	762.	751.	770.	803.
802.	806.	788.	768.	704.	754.	778.	789.	812.	803.
804.	810.	804.	780.	707.	752.	762.	773.	800.	795.
804.	812.	806.	774.	713.	730.	742.	737.	736.	777.
804.	814.	808.	768.	719.	708.	708.	705.	704.	811.
803.	810.	799.	777.	710.	750.	772.	741.	748.	793.
802.	806.	790.	786.	701.	730.	764.	753.	778.	813.
801.	798.	783.	763.	689.	728.	772.	785.	826.	857.
800.	790.	776.	740.	677.	720.	764.	767.	804.	787.
807.	800.	780.	736.	671.	718.	746.	755.	774.	825.
809.	803.	786.	744.	681.	729.	737.	758.	786.	845.
809.	803.	786.	744.	681.	729.	737.	758.	786.	845.
816.	813.	790.	740.	675.	729.	717.	748.	783.	848.
822.	821.	802.	812.	698.	745.	747.	766.	813.	830.
828.	829.	814.	784.	721.	765.	747.	776.	791.	824.
827.	828.	812.	782.	720.	763.	753.	726.	733.	782.
826.	827.	810.	780.	719.	739.	735.	722.	731.	820.
817.	820.	805.	785.	729.	749.	761.	756.	779.	862.
808.	813.	800.	790.	739.	743.	759.	766.	817.	884.
800.	803.	785.	773.	725.	747.	775.	796.	847.	876.
792.	793.	770.	756.	711.	747.	767.	792.	831.	902.
801.	797.	764.	756.	691.	729.	739.	730.	767.	932.

812.	804.	764.	764.	680.	727.	742.	714.	771.	938.
816.	816.	771.	758.	695.	753.	750.	762.	791.	902.
820.	828.	778.	752.	710.	757.	760.	772.	817.	944.
821.	831.	790.	764.	725.	769.	780.	784.	863.	912.
832.	834.	802.	776.	740.	787.	782.	768.	861.	958.
814.	829.	808.	766.	732.	771.	764.	736.	809.	914.
806.	824.	814.	756.	724.	751.	748.	718.	793.	886.
803.	820.	808.	763.	720.	751.	750.	736.	813.	1010.
800.	816.	802.	770.	716.	753.	752.	756.	823.	1010.
803.	810.	793.	751.	715.	767.	784.	784.	865.	962.
806.	804.	784.	732.	714.	769.	776.	782.	859.	938.
812.	799.	779.	741.	718.	745.	750.	748.	807.	956.
820.	797.	779.	756.	729.	734.	757.	742.	821.	936.
819.	802.	778.	753.	721.	760.	769.	766.	797.	884.
818.	807.	777.	750.	713.	772.	787.	796.	831.	904.
817.	808.	793.	764.	725.	778.	793.	806.	841.	938.
816.	809.	809.	778.	737.	776.	761.	776.	805.	872.
810.	809.	811.	773.	745.	780.	771.	758.	775.	832.
804.	809.	813.	768.	753.	776.	781.	738.	753.	846.
798.	807.	807.	770.	751.	798.	797.	788.	799.	812.
792.	805.	801.	772.	749.	810.	805.	822.	829.	788.
804.	804.	776.	747.	752.	832.	841.	850.	861.	818.
816.	803.	771.	722.	755.	830.	845.	826.	833.	782.
824.	811.	776.	759.	769.	830.	827.	806.	799.	824.
833.	821.	784.	801.	789.	838.	822.	820.	803.	804.
825.	827.	782.	797.	787.	834.	828.	810.	777.	768.
817.	833.	780.	793.	785.	814.	836.	808.	805.	788.
813.	836.	785.	795.	765.	808.	830.	816.	817.	770.
809.	839.	790.	797.	745.	788.	786.	782.	793.	752.
809.	837.	792.	777.	742.	782.	794.	756.	751.	748.
809.	835.	795.	757.	739.	776.	784.	756.	731.	756.
807.	833.	786.	763.	726.	772.	774.	766.	767.	788.
805.	831.	778.	769.	713.	766.	778.	770.	781.	770.
814.	824.	773.	748.	721.	768.	784.	788.	805.	736.
823.	817.	768.	727.	729.	768.	770.	782.	775.	762.
828.	819.	776.	745.	716.	744.	750.	744.	733.	786.
834.	822.	786.	765.	706.	723.	750.	730.	732.	759.
834.	821.	782.	749.	691.	731.	738.	720.	712.	717.
834.	820.	778.	733.	676.	737.	736.	736.	738.	727.
828.	819.	790.	743.	683.	737.	744.	762.	774.	749.
822.	818.	802.	753.	690.	729.	724.	750.	738.	727.
810.	815.	807.	745.	689.	723.	710.	696.	700.	727.
798.	812.	812.	737.	688.	719.	704.	678.	698.	713.
794.	811.	804.	745.	670.	727.	722.	716.	732.	719.
790.	810.	796.	753.	652.	707.	720.	740.	762.	699.
801.	807.	784.	737.	654.	697.	706.	0.	786.	751.
812.	804.	772.	721.	656.	691.	696.	744.	758.	747.
813.	811.	767.	728.	658.	677.	684.	736.	734.	765.

```
FOR THE WHOLE ANTENNA, MEAN =   778.49,S.D. =  43.93,MEDIAN =  780.90,Q.D. =  27.86,SKEWNESS =  -2.666

FOR RADIAL STN NO.   1,MEAN =   813.27,S.D. =  10.41,MEDIAN =  812.83,Q.D. =   6.47,SKEWNESS = -25.969
FOR RADIAL STN NO.   2,MEAN =   813.80,S.D. =  15.64,MEDIAN =  814.14,Q.D. =  10.46,SKEWNESS =  -6.515
FOR RADIAL STN NO.   3,MEAN =   793.41,S.D. =  16.23,MEDIAN =  792.78,Q.D. =  12.41,SKEWNESS =  -6.587
FOR RADIAL STN NO.   4,MEAN =   761.16,S.D. =  20.80,MEDIAN =  761.90,Q.D. =  13.77,SKEWNESS =  -4.110
FOR RADIAL STN NO.   5,MEAN =   711.74,S.D. =  23.18,MEDIAN =  710.64,Q.D. =  13.12,SKEWNESS =  -1.223
FOR RADIAL STN NO.   6,MEAN =   756.60,S.D. =  25.18,MEDIAN =  758.19,Q.D. =  15.37,SKEWNESS =  -1.711
FOR RADIAL STN NO.   7,MEAN =   768.75,S.D. =  28.34,MEDIAN =  769.36,Q.D. =  16.86,SKEWNESS =  -1.744
FOR RADIAL STN NO.   8,MEAN =   768.84,S.D. =  57.20,MEDIAN =  766.20,Q.D. =  19.97,SKEWNESS =  -1.632
FOR RADIAL STN NO.   9,MEAN =   788.99,S.D. =  34.59,MEDIAN =  788.70,Q.D. =  24.18,SKEWNESS =  -0.601
FOR RADIAL STN NO.  10,MEAN =   810.46,S.D. =  50.16,MEDIAN =  803.89,Q.D. =  26.78,SKEWNESS =   0.717
```

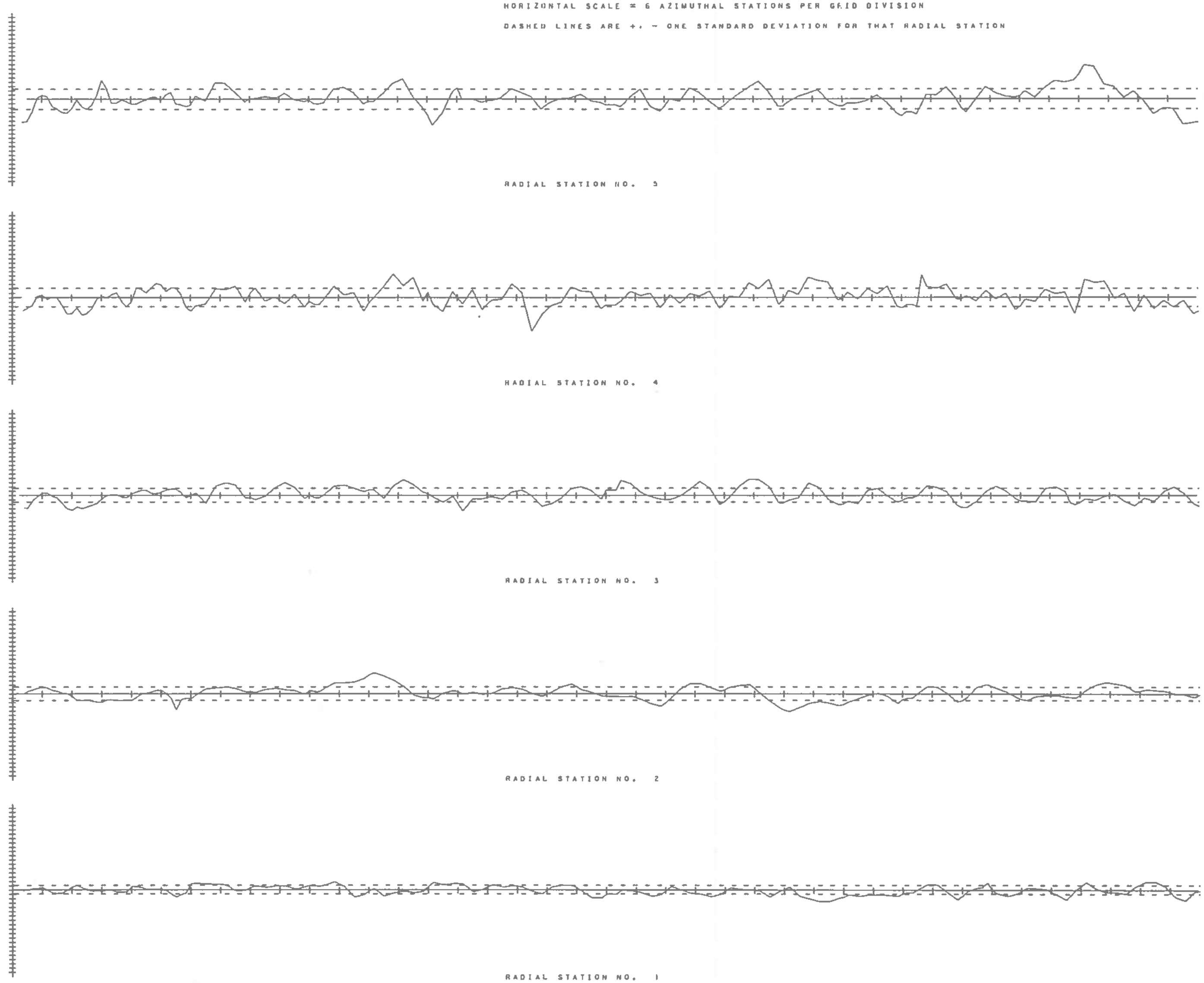
AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

33 FT. ARO PARABOLOID SURFACE MEAS MAY 15/68 NO 1

VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 6 AZIMUTHAL STATIONS PER GRID DIVISION

DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION



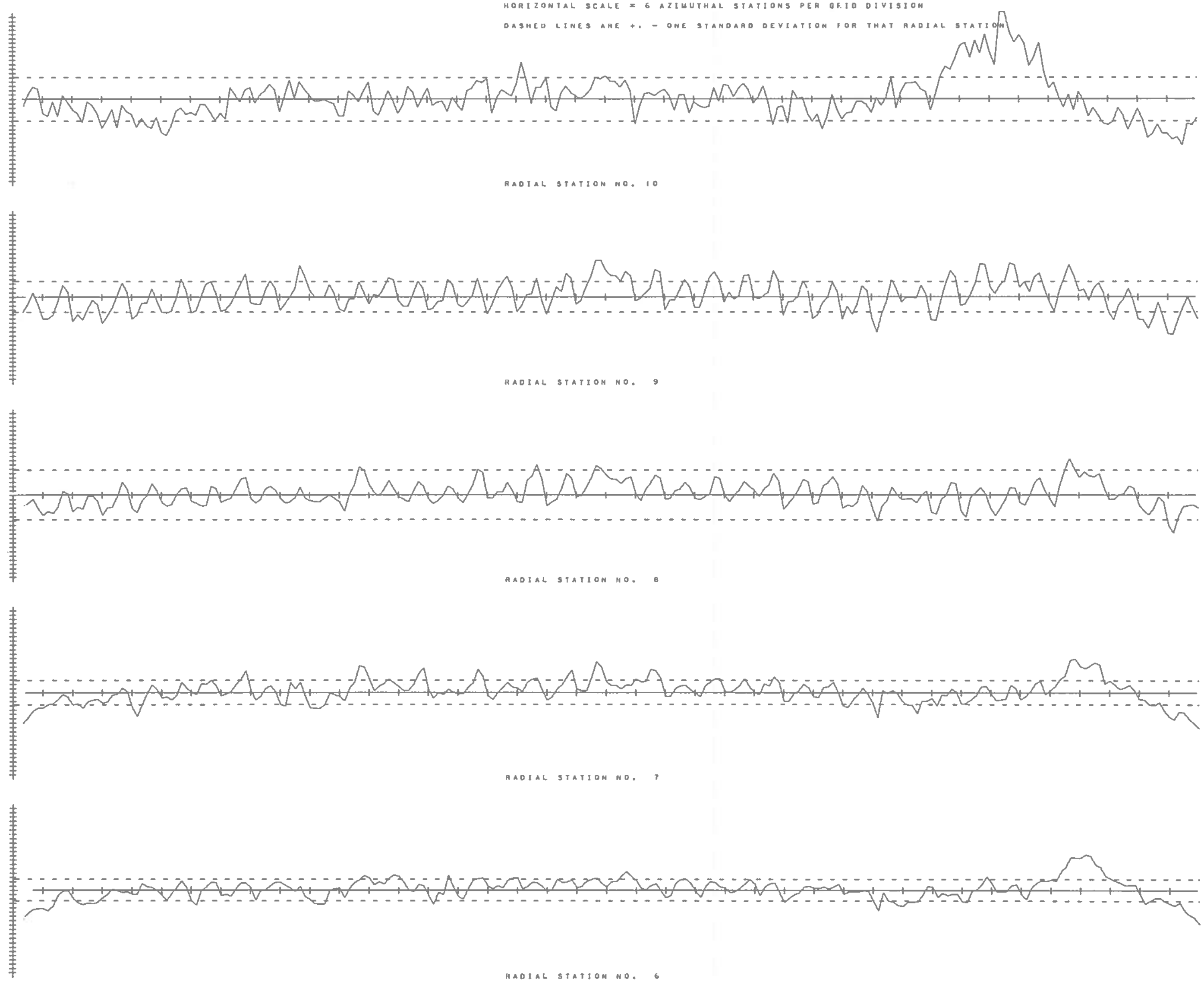
AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

33 FT. ARO PARABOLOID SURFACE MEAS MAY 15/68 NO 1

VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 6 AZIMUTHAL STATIONS PER GRID DIVISION

DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION

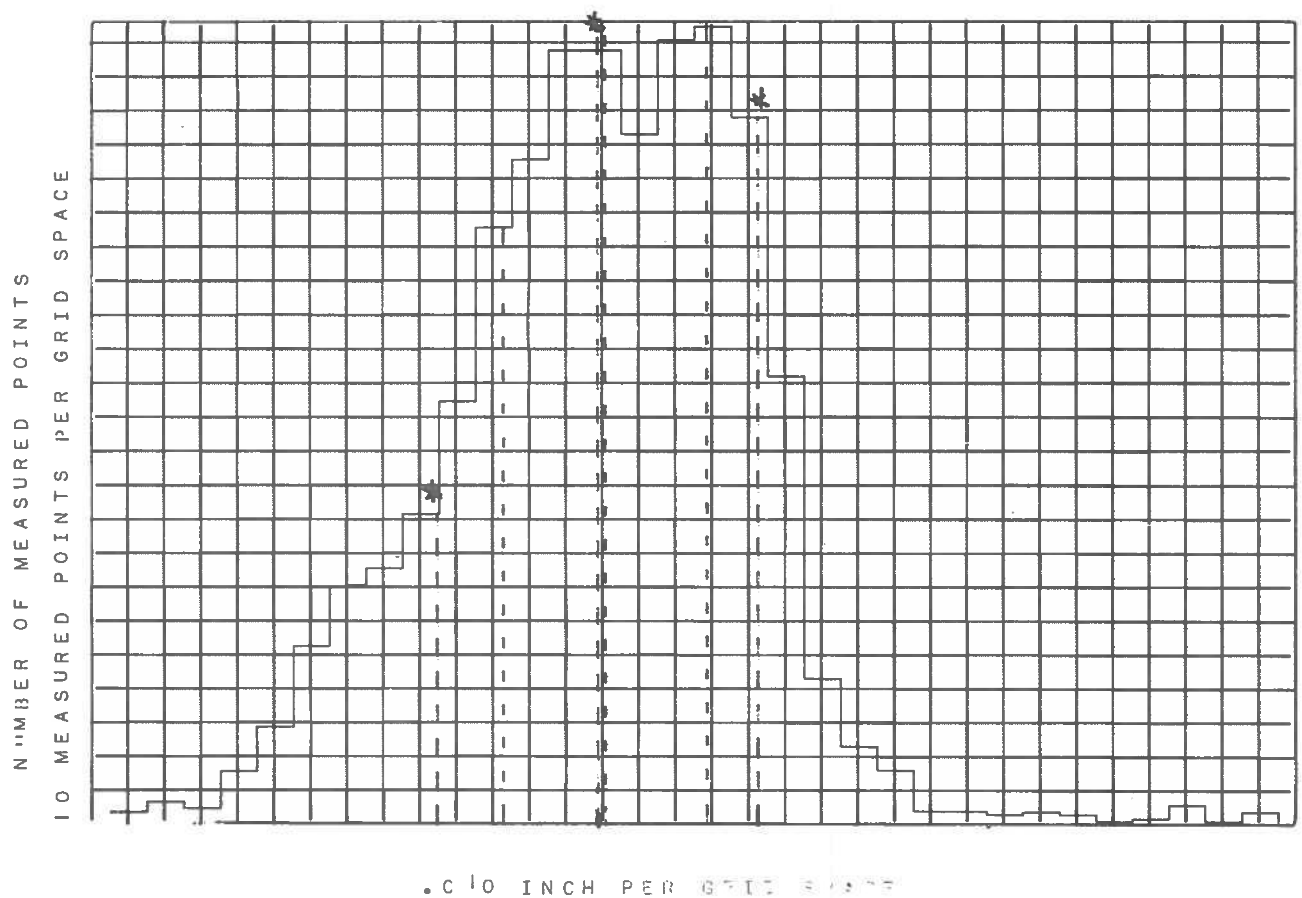


HISTOGRAM FOR ENTIRE DISH

33 FT. ARO PARABOLOID SURFACE MEAS MAY 15/68 NO 1

GREEN= MEDIAN, QUARTILE DEVIATIONS

* VIOLET = MEAN, STANDARD DEVIATIONS



APPENDIX B

PROGRAM FOR 150-FOOT ANTENNA REE298

```
C***BREITHAUPT REE298
C***LEAST SQUARES FIT OF DATA POINTS TO AN ARBRITRARILY ORIENTED
C   PARABOLOID SURFACE
      COMMON/LIST1/NP,NR,NAL,NAS,R(10),WW(10),JTEST
     $      /LIST2/MEAN,SD,MEANR(10),SDR(10),WNR(10)
     $      /LIST3/NUM(150)
     $      /LIST4/MDN,QD
      DIMENSION IPAR(6),ICONST(3)
      REAL*4 MDN,MEAN,MEANR
      REAL*8 W(288),X(2,288),Y(288),R,WW,DATA(8,36),A(6),
     $RCONST(6),W1(2036),W2(6),YCOMP(288),STDEVA(6),COV(6,6),AMIN(6),
     $AMAX(6),SDATA(8),BFDATA(8,36),PI,AA,XY,XX,AAA,TTEST,FTEST
C *** CALL SEQUENCE MUST BE MEANSD, FDIST, MTILE, PIKTUR, PIKTWO
      EXTERNAL DERIV
C***READ INPUT DATA AND PUT (R,S,T) INTO (Y,X)
      READ(1,101)JTEST,NR
  101 FORMAT   (2I6)
      NAL=36
      READ(1,100)((DATA(I,J),I=1,NR),J=1,NAL)
  100 FORMAT(8F7.0)
C***USE 100 FORMAT(8F7.0)IFNR=8
C***IF JTEST=1 USE NO R. STNS ON AZ STNS5,14,23,32
C***IF JTEST=2 DO USE R. STNS 6,7 ON AZ STNS 5,14,23,32
      R(1)=862141.
      R(2)=793203.
      R(3)=724234.
      R(4)=651500.
      R(5)=575781.
      R(6)=473813.
      R(7)=363828.
      R(8)=252641.
      WW(1)=.138
      WW(2)=.212
      WW(3)=.270
      WW(4)=.311
      WW(5)=.336
      WW(6)=.336
      WW(7)=.300
      WW(8)=.231
      AA=0.0
      PI=3.141592653589793
      K=0
      DO 1 I=1,NR
      XY=R(I)*R(I)/2.880D6
      DO 1 J=1,NAL
      IF(J.EQ.5) GO TO 2
      IF(J.EQ.14) GO TO 2
      IF(J.EQ.23) GO TO 2
      IF(J.EQ.32) GO TO 2
      GO TO 3
    2 IF(JTEST.EQ.1) GO TO 8
      IF(I-7)8,3,3
    3 XX=(5+(J-1)*10)*PI/180
```

```
      K=K+1
      X(1,K)=R(I)*DSIN(XX)
      X(2,K)=R(I)*DCOS(XX)
C***WRITE UNNORM WTS W(K)
      W(K)=WW(I)
      AA=AA+W(K)
C *** ORIG HT CORR = 500.-DATA PUNCHED ON CARDS
C *** NOW CHANGE  DATA(I,J) ARRAY SO IT CONTAINS ORIG HT CORR DATA
      DATA(I,J)=500.-DATA(I,J)
      Y(K)=XY-DATA(I,J)
C***Y(K) IS VALUE OF R(K)
      GO TO 1
    8 DATA(I,J)=0.0D0
C *** THIS NULLS THE RAW HT CORR VALUES NOT TAKEN
    1 CONTINUE
C***TOTAL NO. OF POINTS M=FINAL VALUE OF ABOVE  K
      M=K
      NP=M
      AAA=M/AA
      DO 4 K=1,M
    4 W(K)=AAA*W(K)
C*** THESE ARE PROPERLY NORM WTS W(K)
      N=6
      DO 5 I=1,6
    5 IPAR(I)=1
C***A(I)=INITIAL ESTIMATES OF A(I)
      A(1)=0.0
      A(2)=0.0
      A(3)=0.0
      A(4)=0.0
      A(5)=0.0
      A(6)=7.2DD5
      N1=6
      ICONST(1)=0
      ICONST(2)=10
      ICONST(3)=0
      RCONST(1)=.01D0
      RCONST(2)=10.D0
      RCONST(3)=1.0D-15
      RCONST(4)=45.0D0
      RCONST(5)=2.0D0
      RCONST(6)=0.0D0
C***THIS COMPLETES REFERENCING OF MRQRTD
      CALL MRQRDT(DERIV,M,X,Y,YCOMP,W,N,IPAR,A,STDEVA,COV,N1,SUM,
     1ICONST,RCONST,W1,W2,IEND)
      TTEST=2.0D0
      FTEST=4.0D0
      ISW=1
      IPRINT=0
      CALL CNFDLM(AMIN,AMAX,TTEST,FTEST,ISW,IPRINT,IEND)
C***FINAL VALUES OF A(I) ARE NOW AVAILABLE
C *** CALCULATE MEAN, SD, FDIST, QUART DEV, FOR RAW DATA
      CALL MEANSD(DATA)
```

```
      CALL FDIST(DATA)
      CALL MTILE(DATA)
C *** O/P SECTION FOR RAW DATA
    6 FORMAT('1 THE FOLLOWING IS ORIGINAL HT.CORR. DATA AS TABULATED'///
     1)
      WRITE(3,6)
C***ORIG HT CORR= 500.-DATA PUNCHED ON CARDS
      DO 7 KK=1,36
  102 FORMAT(1X,8F10.0)
      WRITE(3,102) (DATA(II,KK),II=1,NR)
    7 CONTINUE
  103 FORMAT(///' FOR THE ENTIRE PARABOLOID (IN INCHESX1000)'/)
      WRITE(3,103)
  104 FORMAT(' MEAN = ',F8.3,'    S.D.= ',F8.3,'    MEDIAN = ',F8.3,
     $'    QUART DEV = ',F8.3//)
      WRITE(3,104) MEAN,SD,MDN,QD
  105 FORMAT(' FOR EACH RADIAL STN STARTING AT ZEROTH, MEDIAN ABOVE S.D.
     $'/)
      WRITE(3,105)
  106 FORMAT(1X,8F10.3/)
      WRITE(3,106) (MEANR(I),I=1,NR)
      WRITE(3,106) (SDR(I),I=1,NR)
      CALL PIKTUR(DATA)
      CALL PIKTWO(DATA)
C *** O/P SECTION FOR BEST FIT DATA
    9 FORMAT('1 THE FOLLOWING IS HT CORR DATA TO B.F.P.'///)
      WRITE (3,9)
      K=1
      DO 10 I=1,NR
      DO 10 J=1,NAL
      IF(J.EQ.5) GO TO 11
      IF (J.EQ.14) GO TO 11
      IF(J.EQ.23) GO TO 11
      IF(J.EQ.32) GO TO 11
      GO TO 12
   11 IF(JTEST.EQ.1) GO TO 15
      IF(I-7)15,12,12
   12 BFDATA(I,J)=YCOMP(K)-Y(K)
C***BFDATA(I,J)=BFP HT CORR
C***R ACTUAL=Y(K)
C***R COMP=YCOMP(K)
C***HT CORR=YCOMP(K)-Y(K)
      K=K+1
      GO TO 10
   15 BFDATA(I,J)=0.0D0
C *** THIS NULLS THE BEST FIT HT CORR NOT CALC.
   10 CONTINUE
C***NOW HT CORR ARRAY BFDATA(I,J) CAN BE PRINTED OUT
      DO 13 KK=1,36
      WRITE(3,102)(BFDATA(II,KK),II=1,NR)
   13 CONTINUE
C *** CALCULATE MEAN, SD, FDIST, QUART DEV, FOR B.F. DATA
      CALL MEANSD(BFDATA)
```

```
      CALL FDIST(BFDATA)
      CALL MTILE(BFDATA)
      WRITE(3,103)
      WRITE(3,104) MEAN,SD,MDN,QD
      WRITE(3,105)
      WRITE(3,106) (MEANR(I),I=1,NR)
      WRITE(3,106) (SDR(I),I=1,NR)
  107 FORMAT(/' BEST FIT PARAM ARE XO = ',F8.3,'  YO = ',F8.3,
     $'    ZO = ',F8.3,'    ALPHA = ',F8.3,'SEC'/' BETA = ',F8.3,
     $'SEC    F.L. = ',F10.3)
      A(4)=A(4)*1.8D2*3.6D3/PI
      A(5)=A(5)*1.8D2*3.6D3/PI
C *** NOW ALPHA AND BETA ARE IN SEC.
      WRITE(3,107) A(1),A(2),A(3),A(4),A(5),A(6)
      CALL PIKTUR(BFDATA)
      CALL PIKTWO(BFDATA)
      CALL PEND
      STOP
      END
```

```
      SUBROUTINE DERIV(N,IPAR,M,N1,A,X,F,DF,ISW)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL*8 A(6),X(2,288),F(288),DF(6,288)
      INTEGER*4 IPAR(6)
      SA=DSIN(A(4))
      SB=DSIN(A(5))
      CA=DCOS(A(4))
      CB=DCOS(A(5))
C***IF ISW=0, THE PARTIAL DERIV OF F ARE TO BE CALC
C     IF ISW=1 THE FNS F ARE TO BE CALCULATED
      IF(ISW.EQ.1) GO TO 1
C***CALC PARTIALS HERE
      DO 2 K=1,M
      DO 2 I=1,6
      GO TO (3,4,5,6,7,8),I
C***PARTIAL WRT A(1) OR X SUB 0
    3 D1=SB
      D2=0.0D0
      D3=CB*SA
      D4=0.0D0
      D5=CB*CA
      D6=0.0D0
      DPDFY=0.0D0
      GO TO 9
C***PARTIAL WRT A(2) OR Y SUB 0
    4 D1=CB
      D2=0.0D0
      D3=-SB*SA
      D4=0.0D0
      D5=-SB*CA
      D6=0.0D0
      DPDFY=0.0D0
      GO TO 9
C***PARTIAL WRT A(3) OR Z SUB 0
    5 D1=0.0D0
      D2=0.0D0
      D3=CA
      D4=0.0D0
      D5=-SA
      D6=0.0D0
      DPDFY=0.0D0
      GO TO 9
C***PARTIAL WRT A(4) OR ALPHA
    6 D1=0.0D0
      D2=0.0D0
      D3=A(1)*CB*CA-(A(2)+X(1,K))*SB*CA-(A(3)+X(2,K))*SA
      D4=CB*CA
      D5=-A(1)*CB*SA+(A(2)+X(1,K))*SB*SA-(A(3)+X(2,K))*CA
      D6=-CB*SA
      DPDFY=0.0D0
      GO TO 9
```

```
C***PARTIAL WRT A(5) OR BETA
    7 D1=-(A(2)+X(1,K))*SB+A(1)*CB
      D2=CB
      D3=-A(1)*SB*SA-(A(2)+X(1,K))*CB*SA
      D4=-SB*SA
      D5=-A(1)*SB*CA-(A(2)+X(1,K))*CB*CA
      D6=-SB*CA
      DPDFY=0.0D0
      GO TO 9
C***PARTIAL WRT A(6) OR P
    8 D1=0.0D0
      D2=0.0D0
      D3=0.0D0
      D4=0.0D0
      D5=0.0D0
      D6=0.0D0
      DPDFY=1.0D0
    9 CONTINUE
      C1=(A(2)+X(1,K))*CB+A(1)*SB
      C2=SB
      C3=A(1)*CB*SA-(A(2)+X(1,K))*SB*SA+(A(3)+X(2,K))*CA
      C4=CB*SA
      C5=A(1)*CB*CA-(A(2)+X(1,K))*SB*CA-(A(3)+X(2,K))*SA
      C6=CB*CA
C ***
      B1=C2*C2+C4*C4
      B2=2.0D0*(C1*C2+C3*C4-2.0D0*A(6)*C6)
      B3=C1*C1+C3*C3-4.0D0*A(6)*C5
      B4=2.0D0*(C2*D2+C4*D4)
      B5=2.0D0*(C1*D2+C2*D1+C3*D4+C4*D3-2.0D0*A(6)*D6-2.0D0*C6*DPDFY)
      B6=2.0D0*(C1*D1+C3*D3-2.0D0*A(6)*D5-2.0D0*C5*DPDFY)
      ZA=B1/B2
      ZB=B3/B2
      ZDA=B4/B2-B1*B5/(B2*B2)
      ZDB=B6/B2-B3*B5/(B2*B2)
      DF(I,K)=-ZDB*(1.0D0+ZA*ZB)-ZB*(ZDA*ZB+ZDB*ZA)
    2 CONTINUE
      GO TO 11
C*** NOW CALC FN VALUES
    1 DO 10 K=1,M
      C1=(A(2)+X(1,K))*CB+A(1)*SB
      C2=SB
      C3=A(1)*CB*SA-(A(2)+X(1,K))*SB*SA+(A(3)+X(2,K))*CA
      C4=CB*SA
      C5=A(1)*CB*CA-(A(2)+X(1,K))*SB*CA-(A(3)+X(2,K))*SA
      C6=CB*CA
C***
      B1=C2*C2+C4*C4
      B2=2.0D0*(C1*C2+C3*C4-2.0D0*A(6)*C6)
      B3=C1*C1+C3*C3-4.0D0*A(6)*C5
C***
      ZA=B1/B2
      ZB=B3/B2

C***FUNC VALUE F(K) IS
      F(K)=-ZB*(1.0D0+ZA*ZB)
   10 CONTINUE
   11 RETURN
      END
```

```
      SUBROUTINE MEANSD(DATA)
C***CALCULATES MEANS AND STANDARD DEVIATIONS OF WTD DATA
      COMMON/LIST1/NP,NR,NAL,NAS,Y(10),W(10),JTEST
     1/LIST2/MEAN,SD,MEANR(10),SDR(10),WNR(10)
      REAL*8 Y,W,DATA(8,36)
      REAL*4 MEAN,MEANR
      WNPP=0.0
      SUM=0.0
C***FIND NP,WNP,WNR(I),MEAN,MEANR(I)
      DO 6 I=1,NR
      WNRP=0.0
      SUMR=0.0
      DO 1 J=1,NAL
      IF(J.EQ.5)GO TO 2
      IF(J.EQ.14)GO TO 2
      IF(J.EQ.23)GO TO 2
      IF(J.EQ.32)GO TO 2
      GO TO 3
    2 IF(JTEST.EQ.1)GO TO 1
      IF(I-7)1,3,3
    3 WNPP=WNPP+W(I)
      WNRP=WNRP+W(I)
      SUM=SUM+W(I)*DATA(I,J)
      SUMR=SUMR+W(I)*DATA(I,J)
    1 CONTINUE
      WNR(I)=WNRP
      MEANR(I)=SUMR/WNRP
    6 CONTINUE
      WNP=WNPP
      MEAN=SUM/WNP
C***NOW CALCULATE STANDARD DEVIATIONS
      SDEV2=0.0
      DO 5 I=1,NR
      SDEVR2=0.0
      DO 7 J=1,NAL
      IF(J.EQ.5)GO TO 8
      IF(J.EQ.14)GO TO 8
      IF(J.EQ.23)GO TO 8
      IF(J.EQ.32)GO TO 8
      GO TO 9
    8 IF(JTEST.EQ.1)GO TO 7
      IF(I-7)7,9,9
    9 SDEV2=SDEV2+W(I)*(MEAN-DATA(I,J))**2
      SDEVR2=SDEVR2+W(I)*(MEANR(I)-DATA(I,J))**2
    7 CONTINUE
      SDR(I)=SQRT(SDEVR2/WNR(I))
    5 CONTINUE
      SD=SQRT(SDEV2/WNP)
C***SD=STAND DEV FOR ALL POINTS SURVEYED ON DISH
C***SDR(I)=STAND DEV FOR ALL AZ PCINTS AT ITH RADIUS
C***WNP=SUM OF WTS FOR ENTIRE DISH

C***WNR(I)=SUM OF WTS FOR ITH RADIUS
C***MEAN=WTD MEAN FOR ENTIRE DISH
C***MEANR(I)=WTD MEAN FOR ITH RADIUS
      RETURN
      END
```

```
      SUBROUTINE FDIST(DATA)
C***CALCULATE FREQUENCY DISTRIBUTION OF DATA
C***NUM(NN)=NO PTS IN 10 THOU REGION CNTRD AT 10XNN+50.FOR ENTIRE DISH
C***THIS SUBROUTINE OPERATES ON UNWEIGHTED DATA
      COMMON/LIST1/NP,NR,NAL,NAS,Y(10),W(10),JTEST
     1/LIST3/NUM(150)
      REAL*8 DATA(8,36),Y,W
C***ZERO NUM( ) ARRAY
      DO 1 J=1,100
    1 NUM(J)=0
C***CALCULATE DISTRIBUTION
      DO 11 I=1,NR
      DO 11 J=1,NAL
      IF(J.EQ.5)GO TO 2
      IF(J.EQ.14)GO TO 2
      IF(J.EQ.23)GO TO 2
      IF(J.EQ.32)GO TO 2
      GO TO 3
    2 IF(JTEST.EQ.1)GO TO 11
      IF(I-7)11,3,3
    3 NN=DATA(I,J)/10.+.5+50.
      NUM(NN)=NUM(NN)+1
   11 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE MTILE(DATA)
C***CALCULATE MEDIAN AND QUARTILE DISTRIBUTION FOR ENTIRE DISH
      COMMON/LIST1/NP,NR,NAL,NAS,Y(10),W(10),JTEST
     1/LIST3/NUM(150)
     1/LIST4/MDN,QD
      REAL*4 MDN
      REAL*8 Y,W,DATA(8,36)
      MED = 0
      I1 = 100
      I2 = 100
      DO 14 I = 1,100
      MED = MED + NUM(I)
C *** FIRST QUARTILE
      IF(I1.LT.I)GO TO 17
      IF(4*MED-NP)14,15,16
   15 I1 = I
      FQTL = 10*I + 5.
      GO TO 14
   16 I1 = I
      FQTL = 10*I - 10.*(MED-NP/4)/NUM(I) + 5.
      GO TO 14
C *** MEDIAN (SECOND QUARTILE)
   17 IF(I2.LT.I)GO TO 18
      IF(2*MED-NP)14,19,20
   19 I2 = I
      MDN = 10*I + 5.
      GO TO 14
   20 I2 = I
      MDN = 10*I - 10.*(MED-NP/2)/NUM(I) + 5.
      GO TO 14
C *** THIRD QUARTILE
   18 IF(4*MED-3*NP)14,22,23
   22 TQTL = 10*I + 5.
      GO TO 24
   23 TQTL = 10*I - 10.*(MED-3*NP/4)/NUM(I) + 5.
      GO TO 24
   14 CONTINUE
C *** QUARTILE DEVIATION
   24 QD = (TQTL-FQTL)/2.
      RETURN
      END
```

```
      SUBROUTINE PIKTUR(DATA)
      COMMON/LIST1/NP,NR,NAL,NAS,Y(10),W(10),JTEST
     1/LIST2/MEAN,SD,MEANR(10),SDR(10),WNR(10)
      REAL*8 Y,W,DATA(8,36)
      REAL*4 MEAN,MEANR
      REAL MODE
      DIMENSION XAR(240),YAR(240),XPAR(9),YPAR(9),YCOR(5),TEXT(80)
     1,TEXT1(80),TEXT2(80),TEXT3(80),TEXT4(80),TEXT5(80),TEXT6(80)
      EQUIVALENCE (XCOR,XPAR(1)),(XSIZE,XPAR(2)),(YSIZE,YPAR(2)),
     1 (XORIG,XPAR(3)),(YORIG,YPAR(3)),(XSCALE,XPAR(4)),(YSCALE,YPAR(4))
     2 ,(MODE,XPAR(5)),(PEN,YPAR(5)),(XSPACE,XPAR(7)),(YSPACE,YPAR(7)),
     3 (PEN2,YPAR(8))
      READ(1,101,END=102,ERR=102) TEXT
      READ(1,101) TEXT1
      READ(1,101) TEXT2
      READ(1,101) TEXT3
      READ(1,101) TEXT4
      READ(1,101) TEXT5
      READ(1,101) TEXT6
  101 FORMAT(80A1)
  102 CONTINUE
      DIFF = 0.
      DO 10 I = 1,NR
      DO 10 J = 1,NAL
      IF(DATA(I,J).EQ.0.) GO TO 10
      IF(DABS(DATA(I,J)-MEANR(I)).GT.DIFF) DIFF=DABS(DATA(I,J)-MEANR(I))
   10 CONTINUE
      DIFF = 40.*(AINT(DIFF/20.) + 1.)
      YCOR(1) = 0.
      YCOR(2)=4.0
      YCOR(3)=8.0
      YCOR(4)=12.0
      YCOR(5)=16.0
      XCOR=2.0
      XSIZE=24.0
      YSIZE = 3.5
      XORIG=0.0
      XSCALE=1.5
      YSCALE = DIFF/YSIZE
      XSPACE=1.333333
      YSPACE=10.0/YSCALE
C *** SIX AZIMUTHAL STATIONS (1/40 CIRC.) PER X GRID SPACE
C *** TEN THOU INCHES PER Y GRID SPACE
      PEN2 = 8.
      DO 1 K = 1,2
      CALL PSTART(2.0,0.0,26.0,21.75,0.,0.,1.,1.,IJK)
      CALL PAGE
      CALL NAME(TEXT,80)
      CALL PTEXT(TEXT2,79,7.0,21.5,.15,0.0,1)
      CALL PTEXT(TEXT6,65,9.25,21.0,.15,0.0,1)
      CALL PTEXT(TEXT3,46,10.,20.,.15,0.0,1)
```

```
      SUBROUTINE PIKTWO(DATA)
C *** PLOT FREQUENCY DISTRIBUTIONS
      COMMON/LIST1/NP,NR,NAL,NAS,Y(10),W(10),JTEST
     1/LIST2/MEAN,SD,MEANR(10),SDR(10),WNR(10)
     1/LIST3/NUM(150)
     1/LIST4/MDN,QD
      REAL*8 Y,W,DATA(8,36)
      REAL*4 MEAN,MEANR,MDN
      REAL LS,MODE
      DIMENSION XPAR(9),YPAR(9),XARG(100),YARG(100),TEXT(80)
     1,TEXT1(80),TEXT2(80),TEXT3(80),TEXT4(80),TEXT5(80),TEXT6(80),
     2TEXT7(80),TEXT8(80)
      EQUIVALENCE (XCOR,XPAR(1)),(YCOR,YPAR(1)),(XSIZE,XPAR(2)),
     1 (YSIZE,YPAR(2)),(XORIG,XPAR(3)),(YORIG,YPAR(3)),(XSCALE,XPAR(4)),
     2 (YSCALE,YPAR(4)),(MODE,XPAR(5)),(PEN3,YPAR(5)),(XSPACE,XPAR(7)),
     3 (YSPACE,YPAR(7)),(PEN2,XPAR(8))
      CALL PSTART(0.0,0.0,12.0,12.0,0.0,0.0,1.,1.,IJK)
      CALL PAGE
      READ(1,101,END=102,ERR=102) TEXT
      XSIZE=12.0
      YSIZE=12.0
      READ(1,101) TEXT1
      READ(1,101) TEXT2
      READ(1,101) TEXT3
      READ(1,101) TEXT4
      READ(1,101) TEXT5
      READ(1,101) TEXT6
      READ(1,101) TEXT7
      READ(1,101) TEXT8
      CALL PTEXT(TEXT1,25,4.,10.,.15,0.0,1)
      CALL PTEXT(TEXT2,65,2.5,9.5,.15,0.0,1)
      CALL PTEXT(TEXT3,35,2.0,9.,.15,0.0,1)
      CALL PTEXT(TEXT4,34,2.,8.6,.15,0.0,1)
      CALL PTEXT(TEXT5,33,1.75,2.,0.0,.15,2)
      CALL PTEXT(TEXT6,25,1.45,2.4,0.0,.15,2)
      CALL PTEXT(TEXT7,24,4.5,1.5,.15,0.0,1)
      CALL PTEXT(TEXT8,18,4.75,1.0,.15,0.0,1)
  101 FORMAT(80A1)
      CALL NAME(TEXT,80)
  102 CONTINUE
      MAX = 0
C *** NUM(NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR ENTIRE DISH
C *** NUMR(I,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10X NN FOR RADL STN I
C *** NUMA(K,NN) = NO PTS IN 10 THOU RGN CNTRD AT 10XNN FOR AZML MN RIB SCTN K
      DO 21 I = 1,100
      IF(NUM(I).EQ.0) GO TO 21
      IND1 = I
      GO TO 22
   21 CONTINUE
   22 DO 23 II=1,100
      I=101-II
```

```
      IF(NUM(I).EQ.0) GO TO 23
      IND2=I
      GO TO 24
   23 CONTINUE
   24 WRITE (3,1000) IND1,IND2
 1000 FORMAT (1H0,2I5)
      DO 25 I = IND1,IND2
      IF(NUM(I).GT.MAX) MAX = NUM(I)
   25 CONTINUE
      LS=IND1-1
      RS=IND2+1
      TS=MAX+2
      XCOR = 2.
      YCOR = 2.
      XSIZE = 9.
      YSIZE = 6.
      XSCALE = (RS - LS)/XSIZE
      YSCALE = TS/YSIZE
      XORIG = -LS/XSCALE
      YORIG = 0.
      IND = 3
      PEN1 = 11.
      XSPACE=1./XSCALE
      YSPACE=3./YSCALE
C *** X AXIS HAS 10 THOU PER GRID SPACE
C *** Y AXIS HAS 10 MEASURED POINTS PER GRID SPACE
      PEN2 = 8.
      CALL GRID2(IND,PEN1,XPAR,YPAR)
      IND2 = IND2 + 1
      N1 = 0
      DO 1 I = IND1,IND2
      N1 = N1 + 1
      XARG(N1) = I - 0.5
      YARG(N1) = NUM(I-1)
      N1 = N1 + 1
      XARG(N1) = I - 0.5
    1 YARG(N1) = NUM(I)
      MODE = 3.
      PEN3 = 6.
      CALL LINE2(XARG,YARG,N1,XPAR,YPAR)
      XARG(1)=MEAN/10.+50.
      XARG(2) = XARG(1)
      YARG(1) = 0.
      YARG(2) = TS - 5.
      MODE = 6.
      PEN3 = 10.
      CALL LINE2(XARG,YARG,2,XPAR,YPAR)
      XARG(1)=(MEAN-SD)/10.+50.
      XARG(2) = XARG(1)
      N3 = XARG(1) + 0.5
      YARG(2) = NUM(N3)
      CALL LINE2(XARG,YARG,2,XPAR,YPAR)
      XARG(1)=(MEAN+SD)/10.+50.
```

```
XARG(2) = XARG(1)
N3 = XARG(1) + 0.5
YARG(2) = NUM(N3)
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
XARG(1) = MDN/10.
XARG(2) = XARG(1)
YARG(2) = TS - 5.
PEN3=7.
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
XARG(1) = (MDN-QD)/10.
XARG(2) = XARG(1)
N3 = XARG(1) + 0.5
YARG(2) = NUM(N3)
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
XARG(1) = (MDN+QD)/10.
XARG(2) = XARG(1)
N3 = XARG(1) + 0.5
YARG(2) = NUM(N3)
CALL LINE2(XARG,YARG,2,XPAR,YPAR)
RETURN
END
```

```
C
C-----------------------------------------------------------------------
C
C       IDENTIFICATION - CLPG00158
C
C       MRQRDT / GENERAL MINIMIZATION ROUTINE
C
C       AUTHOR / DATE
C       A.VELD / COMPUTATION CENTRE, NRC / FEBRUARY 1968
C
C       SOURCE LANGUAGE
C       IBM SYSTEM 360 FORTRAN IV
C
C       PURPOSE
C       1. TO CALCULATE THE LEAST SQUARES STATISTICS FOR A GIVEN MODEL AND
C          SET OF DATA
C       2. TO SOLVE A SYSTEM OF NON-LINEAR EQUATIONS
C
C       REFERENCES
C       SEE NRC PROGRAMMERS MANUAL, PROGRAM LIBRARY SECTION
C
C       ACCURACY---DOUBLE PRECISION
C
C       CALLING SEQUENCE
C          THERE ARE TWO ENTRIES DEPENDING UPON THE OPERATIONS DESIRED.
C       A MORE DESCRIPTIVE LIST IS GIVEN IN THE PROGRAMMER'S MANUAL.
C
C       1. CALL MRQRDT(DERIV,M,X,Y,YCOMP,W,N,IPAR,A,STDEVA,COV,N1,SUM,
C         1  ICONST,RCONST,W1,W2,IEND)
C
C          DERIV -NAME OF A USER SUPPLIED SUBROUTINE USED IN EVALUATING
C                 FUNCTIONS OR FUNCTIONAL DERIVATIVES W.R.T. THE A(I) SET.
C          M     -NUMBER OF DATA POINTS
C          X,Y,W -USER'S DATA
C          N     -THE TOTAL NO. OF A(I) PARAMETERS INCLUDING THOSE NOT
C                 ENTERING THE REGRESSION.
C          IPAR  -AN ARRAY SPECIFYING  WHICH PARAMETERS ARE TO ENTER THE
C                 MINIMIZATION.  IPAR(I)=1, YES, IPAR(I)=0, NO FOR THE    MRQRD
C                 I TH PARAMETER                                          MRQRD
C          A     -INITIAL ESTIMATES TO THE PARAMETERS.  FINAL ESTIMATES
C                 RETURNED VIA THIS ARRAY.
C          STDEVA-ESTIMATED STANDARD ERROR OF THE A(I) PARAMETERS.
C          COV   -CORRELATION MATRIX OF THE A(I) PARAMETERS.
C          N1    -FIRST DIMENSION OF COV (N.LE.N1).
C          SUM   -FINAL SUM OF SQUARES.
C          ICONST-AN INTEGER ARRAY CONTAINING ITERATION PARAMETERS.
C            ICONST(1)=1 IMPLIES NO WEIGHTS, W MAY BE ANY NAME AS IT IS
C                        NOT REFERENCED.
C                     =0 IMPLIES WEIGHTS ARE EMPLOYED.  THE SUM OF THE
C                        WEIGHTS MUST BE EQUAL TO M.
C            ICONST(2)=MAXIMUM NO. OF ITERATIONS.
```

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C          ICONST(3)=0 IF NO INTERMEDIATE OUTPUT.
C                   =IDS IF THIS OUTPUT IS DESIRED.  USUALLY IDS=3.
C                      THIS OUTPUT IS SELF EXPLANATORY.
C        RCONST-A REAL ARRAY CONTAINING ITERATION PARAMETERS.
C              FOR FURTHER INFORMATION CONSULT PROGRAMMERS MANUAL
C              THE FOLLOWING VALUES ARE FOR THE AVERAGE SYSTEM.
C          RCONST(1)=0.01D0
C          RCONST(2)=10.0D0
C          RCONST(3)=CONVERGENCE TEST ON THE SUM OF SQUARES  GE.1.0D-15
C          RCONST(4)=45.0D0
C          RCONST(5)=2.0D0
C          RCONST(6)=0.0D0
C        W1     -WORK AREA OF DIMENSION ((N1+1)*M+3*N1)                MRQRD
C        W2     -WORK AREA OF DIMENSION N1
C        IEND   -SWITCH INDICATING TYPE OF ENDING.
C          IEND=1 INDICATES NORMAL ENDING.
C
C      2. CALL CNFDLM(AMIN,AMAX,TTEST,FTEST,ISW,IPRINT,IEND)
C
C         THIS ENTRY CALCULATES A VARIETY OF CONFIDENCE REGIONS.
C      SEE PROGRAMMERS MANUAL FOR A FULL DESCRIPTION.
C
C      USER SUPPLIED SUBPROGRAMS
C         THE USER SUPPLIED ROUTINE DERIV (SUBSTITUTE USERS NAME IF IT
C      IS DIFFERENT) CALCULATES FUNCTION VALUES AND DERIVATIVES.  THIS
C      ROUTINE IS CALLED BY THE MRQRDT ROUTINE.  PROGRAM SET-UP IS AS
C      FOLLOWS.
C
C      SUBROUTINE DERIV(N,IPAR,M,N1,A,X,F,DF,ISW)
C      REAL*8 A(2),X(2),F(2),DF(N1,2),IPAR(2)
C
C      IF ISW=1 CALCULATE THE FUNCTION VALUES F
C      IF ISW=0 CALCULATE THE DERIVATIVES OF W.R.T. THE A(I) SET.
C
C      FOR THE SOLUTION OF A SYSTEM OF NON-LINEAR EQUATIONS,
C           G(K,A)=C(K)  K=1,2,...,M
C      WHERE G(K,A)IS THE K TH FUNCTION, SUBSTITUTE C FOR Y AND G(K,A)
C      FOR F(X(K),A) TO OBTAIN THE MINIMIZATION.
C
C-------------------------------------------------------------
C
       SUBROUTINE MRQRDT(SUB007,M,X,Y,YCOMP,W,N,IPAR,AZERO,STDEVA,COV,N1,
      1SUMOLD,II,CONST,W1,A1,IE)
       IMPLICIT REAL*8(A-H,O-Z)
       DIMENSION X(2),Y(2),AZERO(2),W(2),YCOMP(2),A1(2)
       DIMENSION COV(N1,2),STDEVA(2),W1(2)
       DIMENSION II(2),CONST(2),IPAR(2)
       REAL*8 LMBDN,LMBD1,LMBD2,NU,LMBDMX,K,KDIV,LMBDMN
       EXTERNAL SUB007
C
C          INITIALIZE TEST PARAMETERS
C
       IWT=II(1)
```

```
      IMAX=II(2)
      IPRINT=II(3)
      JMAX=20
      LMBDN=CONST(1)
      NU=CONST(2)
      CONV=CONST(3)
      COSMAX=DCOS(CONST(4)*3.14159265358979/180.0D0)
      KDIV=CONST(5)
      LMBDMX=1.0D20
      LMBDMN=1.0D-16
      III=0
      IF(IPRINT.NE.0)WRITE(IPRINT,3009)
 3009 FORMAT('1')
C
C           CALCULATE INITIAL SUM OF SQUARES
C
      CALL SUB007(N,IPAR,M,N1,AZERO,X,YCOMP,W1,1)
      SUMOLD=0.0D0
      DO 300 L=1,M
      K=Y(L)-YCOMP(L)
      K=K*K
      IF(IWT.NE.1)K=K*W(L)
  300 SUMOLD=SUMOLD+K
C
C           INITIALIZE STORAGE AREAS IN SUB001
C
      I3=N1+1
      I2=I3+N1*(M+1)
      I1=I2+M
      CALL SUB001(SUB007,N1,N,IPAR,M,X,Y,W,IWT,W1(I3),W1(I2),W1(I1),
     1STDEVA,COV,W1,CONST(6))
      K=1.0D0
      I1=0
C
C           PRINT THE INITIAL PARAMERS AND ITERATION CONSTANTS
C
      IF(IPRINT.NE.0)WRITE(IPRINT,3000)I1,LMBDN,COSMAX,SUMOLD,K,
     1(IPAR(J),AZERO(J),J=1,N)
      DO 100 I=1,IMAX
C
C           PROCEED WITH THE ITERATION CYCLE
C
      K=1.0D0
C
C           SET UP THE MATRIX SYSTEM WITHOUT HAVING DETERMINED LAMBDA
C
      CALL SUB002(AZERO,YCOMP,N2)
      CONV1=CONV*SUMOLD
      IF(M.EQ.N2)CONV1=CONV
      IF(IPRINT.NE.0)WRITE(IPRINT,3001)I,SUMOLD
 3001 FORMAT('OR=',I4,'  R TH SUM OF SQUARES=',D23.15)
  201 LMBD1=LMBDN/NU
      IF(LMBD1.LT.LMBDMN)GO TO 400
```

```
C
C           TRY LAMBDA=LAMBDA(R)/NU
C
      CALL SUB003(LMBD1,COS1,IE)
      IF(IE.EQ.2)GO TO 200
C
C           STEP 1.
C
      CALL SUB004(A1,K,SUM1,YCOMP)
      I1=1
      IF(IPRINT.NE.0)WRITE(IPRINT,3000)I1,LMBD1,COS1,SUM1,K,
     1(IPAR(J),A1(J),J=1,N)
 3000 FORMAT('0',I2,'  LAMBDA=',D9.1,' COS(ALPHA)=',D23.15,'  SUM OF SQU
     1ARES=',D23.15,' K=',D23.15/(' ',I5,D18.10,I5,D18.10,I5,D18.10,
     2I5,D18.10,I5,D18.10))
      IF(SUM1.GT.SUMOLD)GO TO 400
      GO TO 129
C
C           TRY LAMBDA=LAMBDA(R)
C
  400 LMBD1=LMBDN
  401 CALL SUB003(LMBD1,COS1,IE)
      IF(IE.EQ.2)GO TO 200
C
C           STEP 2.
C
      CALL SUB004(A1,K,SUM1,YCOMP)
      I1=2
      IF(IPRINT.NE.0)WRITE(IPRINT,3000)I1,LMBD1,COS1,SUM1,K,
     1(IPAR(J),A1(J),J=1,N)
      IF(SUM1.LT.SUMOLD)GO TO 129
C
C           TRY LAMBDA=LAMBDA(R)*NU**S AS LONG AS ALPHA.GT.ALPHAO
C
      IF(COS1.GT.COSMAX)GO TO 140
      LMBD1=LMBD1*NU
      GO TO 401
  140 K=1.0D0
      DO 150 J=1,JMAX
C
C           EVALUATE S(DELTA/K**J)
C
      K=K/KDIV
C
C           STEP 3.
C
      CALL SUB004(A1,K,SUM1,YCOMP)
      I1=3
      IF(IPRINT.NE.0)WRITE(IPRINT,3000)I1,LMBD1,COS1,SUM1,K,
     1(IPAR(J1),A1(J1),J1=1,N)
      IF(SUM1.LT.SUMOLD)GO TO 129
      IF(DABS(SUM1-SUMOLD).LE.CONV1)GO TO 129
  150 CONTINUE
```

```
      IE=3
      RETURN
  200 LMBDN=LMBDN*NU
      IF(LMBDN.GT.LMBDMX)RETURN
      GO TO 201
  129 DO 133 J=1,N
  133 AZERO(J)=A1(J)
      LMBDN=LMBD1
      IF(DABS(SUM1-SUMOLD).LE.CONV1)GO TO 170
      SUMOLD=SUM1
  100 CONTINUE
      IE=4
      RETURN
  170 IE=1
      RETURN
C
C           ENTRY WHICH CALCULATES THE CONFIDENCE LIMITS FOR A
C
      ENTRY CNFDLM(AMIN,AMAX,TTEST,FTEST,ISW,IPRINT,IE)
      DIMENSION AMAX(2),AMIN(2)
      IF(III.NE.0)GO TO 551
      III=1
      CALL SUB005(SUM1,N2)
      IF(ISW.GT.1)GO TO 551
      IF(IPRINT.EQ.0)RETURN
      I1=0
      WRITE(IPRINT,3010)
 3010 FORMAT('1',11X,'A(I)',15X,'STANDARD ERROR',11X,'LAST CORRECTION')
      DO 312 I=1,N
      X1=0.0D0
      X2=0.0D0
      IF(IPAR(I).EQ.0)GO TO 312
      I1=I1+1
      X2=STDEVA(I1)
      X1=W1(I1)
  312 WRITE(IPRINT,3002)AZERO(I),X2,X1
 3002 FORMAT('0',3D25.15)
      WRITE(IPRINT,3011)
 3011 FORMAT('0 CORRELATION MATRIX')
      DO 310 I=1,N2
  310 WRITE(IPRINT,3003)(COV(I,J),J=1,I)
 3003 FORMAT('0',10F13.10)
      WRITE(IPRINT,3004)
 3004 FORMAT('0',20X,'OBSERVED',22X,'ESTIMATED',20X,'DIFFERENCE'//)
      DO 311 L=1,M
      K=Y(L)-YCOMP(L)
  311 WRITE(IPRINT,3005)L,Y(L),YCOMP(L),K
 3005 FORMAT(' ',I5,3D30.15)
      WRITE(IPRINT,3009)
      RETURN
  551 IE=1
      IF(ISW-3)500,501,502
C
```

```
C           CONVENTIONAL ONE-PARAMETER CONFIDENCE INTERVALS
C
  500 X1=TTEST
      GO TO 503
C
C           SUPPORT PLANE CONFIDENCE INTERVALS FOR EACH PARAMETER
C                                INDIVIDUALLY
C
  501 X1=DSQRT(N*FTEST)
  503 I1=0
      DO 504 I=1,N
      X2=0.0D0
      IF(IPAR(I).EQ.0)GO TO 505
      I1=I1+1
      X2=X1*STDEVA(I1)
  505 AMIN(I)=AZERO(I)-X2
  504 AMAX(I)=AZERO(I)+X2
      SCRIT=SUMOLD
      GO TO 590
C
C           NON-LINEAR CONFIDENCE LIMITS
C
  502 SCRIT=SUMOLD*(1.0D0+N*FTEST/(M-N))
      JMAX=20
      DO 510 I=1,N
      X2=AZERO(I)
      IF(IPAR(I).NE.0)GO TO 513
      AMIN(I)=X2
      AMAX(I)=X2
      GO TO 510
  513 X1=TTEST*STDEVA(I)
      DELTBJ=X1
      ISWT=-1
      IE=1
      GO TO 520
  511 AMAX(I)=X2+DELTBC
      DELTBJ=-X1
      ISWT=1
C
C           CALCULATE DELTBC
C
  520 AZERO(I)=X2+DELTBJ
      CALL SUB006(AZERO,PHI1,W1)
      IF(PHI1.GE.SCRIT)GO TO 521
      XMUP=2.0D0
      D=XMUP
      DO 530 J=1,JMAX
      AZERO(I)=X2+D*DELTBJ
      CALL SUB006(AZERO,PHID,W1)
      IF(PHID.GT.SCRIT)GO TO 550
      PHI1=PHID
  530 D=D*XMUP
      IE=2
```

```
      GO TO 570
  521 XMUP=0.5D0
      D=XMUP
      DO 540 J=1,JMAX
      AZERO(I)=X2+D*DELTBJ
      CALL SUB006(AZERO,PHID,W1)
      IF(PHID.LT.SCRIT)GO TO 550
      PHI1=PHID
  540 D=D*XMUP
      IE=2
      GO TO 570
C
C            PROCEED WITH THE NEWTON-RAPHSON ESTIMATES TO GET A BETTER
C                                DELTBC
C
  550 X3=D/XMUP
      DO 560 J=1,JMAX
      X4=D-(SCRIT-PHID)*(D-X3)/(PHI1-PHID)
      IF(X4.LT.0.0D0)X4=DABS(X4)
      PHI1=PHID
      DELTBC=X4*DELTBJ
      AZERO(I)=X2+DELTBC
      CALL SUB006(AZERO,PHID,W1)
      IF(DABS(X4-D).LT.0.5D-3*D)GO TO 570
      X3=D
  560 D=X4
      IE=2
  570 IF(ISWT)511,511,512
C
C             RETURN WITH THE CORRECT DELTBC VALUE
C
  512 AMIN(I)=X2+DELTBC
  510 AZERO(I)=X2
C
C            OUTPUT THE ERROR ANALYSIS RESULTS IF SO SPECIFIED
C
  590 IF(IPRINT.EQ.0)GO TO 599
      WRITE(IPRINT,3008)ISW,TTEST,FTEST,M,N2,IE
 3008 FORMAT('1 CONFIDENCE LIMIT CALCULATIONS USING TECHNIQUE NUMBER',
     1I3/' ','T(M-N)=',D23.15,'  F(N,M-N)=',D23.15,'  FOR',I5,
     2'  POINTS USING',I5,' PARAMETERS'/' THE OUTPUT TEST SWITCH IS',
     3I2//)
      WRITE(IPRINT,3007)SCRIT
 3007 FORMAT(' PHI CRITICAL=',D23.15/'0PARA',8X,'LOWER A',16X,'A',16X,
     1'UPPER A'//)
      DO 591 I=1,N
      X1=AZERO(I)-AMIN(I)
      X2=AMAX(I)-AZERO(I)
  591 WRITE(IPRINT,3006)I,AMIN(I),AZERO(I),AMAX(I),X1,X2
 3006 FORMAT(' ',I5,5D20.10)
      WRITE(IPRINT,3009)
  599 RETURN
      END
```

```
C
C-----------------------------------------------------------------------
C
C          SUBROUTINE WHICH PERFORMS ALL THE ACTUAL COMPUTATION FOR
C                    THE MAIN SUBPROGRAM CLPG00158
C
C-----------------------------------------------------------------------
C
      SUBROUTINE SUB001(SUB007,N1,N2,IPAR,M,X,Y,W,IWT,ASTAR,DELTY,ABAR,
     1DLTBR,D,DELTA,PREC)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(2),Y(2),DELTY(2),ASTAR(N1,2),ABAR(2),DLTBR(2),
     1D(N1,2),DELTA(2)
      DIMENSION W(2),IPAR(2)
      REAL*8 LAMBDA,K
C
C          INITIALIZE THE STORAGE AREAS IN SUB1
C
      RETURN
C
C          SET UP THE LINEAR SYSTEM AND GENERATE THE CORRESPONDING
C          NORMALIZED MATRIX SYSTEM
C                      ASTAR AND GSTAR
C
      ENTRY SUB002(AZERO,YNEW,N)
      DIMENSION AZERO(2),YNEW(2)
      CALL SUB007(N2,IPAR,M,N1,AZERO,X,YNEW,ASTAR,0)
      DO 100 L=1,M
  100 DELTY(L)=Y(L)-YNEW(L)
      X5=0.0D0
      N=0
      DO 110 I=1,N2
  110 N=N+IPAR(I)
      NP1=N+1
      I1=1
      DO 101 I=1,N
  111 IF(IPAR(I1).NE.0)GO TO 112
      I1=I1+1
      GO TO 111
  112 DO 106 L=1,M
      YNEW(L)=ASTAR(I1,L)
      IF(IWT.NE.1)YNEW(L)=YNEW(L)*W(L)
  106 CONTINUE
      J1=I1
      DO 102 J=I,N
  120 IF(IPAR(J1).NE.0)GO TO 121
      J1=J1+1
      GO TO 120
  121 X1=0.0D0
      DO 103 L=1,M
  103 X1=X1+YNEW(L)*ASTAR(J1,L)
      J1=J1+1
  102 ASTAR(I,J)=X1
```

```
      ABAR(I)=DSQRT(ASTAR(I,I))
      X4=0.0D0
      DO 104 L=1,M
  104 X4=X4+DELTY(L)*YNEW(L)
      X4=X4/ABAR(I)
      ASTAR(I,NP1)=X4
      DLTBR(I)=X4
      I1=I1+1
  101 X5=X5+X4*X4
      DO 105 I=1,N
      X1=ABAR(I)
      DO 105 J=I,N
  105 ASTAR(I,J)=ASTAR(I,J)/(X1*ABAR(J))
      RETURN
C
C           SOLVE  ASTAR(LAMBDA)*DELTASTAR=GSTAR
C
C           ALSO CALCULATE THE COSINE OF THE ANGLE BETWEEN
C           DELTASTAR AND GSTAR VECTORS
C
      ENTRY SUB003(LAMBDA,CSGMMA,IE)
      DO 200 I=1,N
      IP1=I+1
      D(I,I)=ASTAR(I,I)+LAMBDA
      DO 200 J=IP1,NP1
      X1=ASTAR(I,J)
      IF(J.GT.N)GO TO 200
      D(J,I)=X1
  200 D(I,J)=X1
      CALL SOLVD(D,N1,N,NP1,PREC ,DET,TEST)
      IF(TEST)202,203,202
  202 IE=2
      GO TO 999
  203 IE=1
      CSGMMA=0.0D0
      X1=0.0D0
      DO 204 I=1,N
      X2=D(I,NP1)
      DELTA(I)=X2/ABAR(I)
      CSGMMA=CSGMMA+X2*DLTBR(I)
  204 X1=X1+X2*X2
      CSGMMA=CSGMMA/DSQRT(X1*X5)
  999 RETURN
C
C           CALCULATE   PHI(AZERO+K*DELTASTAR,LAMBDA)
C
      ENTRY SUB006(A,SUM,YNEW)
      GO TO 302
      ENTRY SUB004(A,K,SUM,YNEW)
      DIMENSION A(2)
      I1=0
      DO 300 I=1,N2
      A(I)=AZERO(I)
```

```
      IF(IPAR(I).EQ.0)GO TO 300
      I1=I1+1
      A(I)=A(I)+K*DELTA(I1)
  300 CONTINUE
  302 CALL SUB007(N2,IPAR,M,N1,A,X,YNEW,ASTAR,1)
      SUM=0.0D0
      DO 301 L=1,M
      X1=Y(L)-YNEW(L)
      X2=X1*X1
      IF(IWT.NE.1)X2=X2*W(L)
  301 SUM=SUM+X2
      RETURN
C
C          CALCULATE THE SIMPLE CORRELATION MATRIX AND THE CONVENTIONAL
C          ONE-PARAMETER CONFIDENCE INTERVALS.
C          TO FIND THIS INTERVAL USE THE RELATION
C          A(I)-T(M-N)*STDEVA(I).LE.A(I)).LE.A(I)+T(M-N)*STDEVA(I)
C
C          WHERE T(M-N) IS THE TWO-TAILED 1-ALPHA POINT OF STUDENT'S T
C          DISTRIBUTION.
C
      ENTRY SUB005(SUM,N3)
      N3=N
      X3=0.0D0
      IF(M.GT.N)X3=DSQRT(SUM/(M-N))
      DO 400 I=1,N
      DO 400 J=I,N
      X1=ASTAR(I,J)
      D(I,J)=X1
  400 D(J,I)=X1
      CALL SOLVD(D,N1,N,N,PREC,DET,TEST)
      DO 401 I=1,N
      DELTY(I)=DSQRT(D(I,I))
  401 DLTBR(I)=X3*DELTY(I)/ABAR(I)
      DO 402 I=1,N
      X1=DELTY(I)
      DO 402 J=1,I
      X2=D(I,J)/(X1*DELTY(J))
      D(I,J)=X2
  402 D(J,I)=X2
      RETURN
      END
```

SAMPLE OUTPUT FOR REE298

Survey No. 14 MHJ Data May 4, 1967

THE FOLLCWING IS ORIGINAL HT.CORR. DATA AS TABULATED

81.	53.	22.	-13.	0.	-2.	25.	12.
94.	53.	44.	7.	-9.	-16.	-4.	5.
63.	53.	33.	10.	-17.	7.	14.	7.
58.	57.	26.	40.	-32.	0.	22.	47.
0.	0.	0.	C.	0.	0.	20.	29.
193.	82.	52.	66.	-3.	41.	22.	29.
148.	131.	111.	3.	35.	41.	38.	31.
162.	135.	74.	129.	35.	38.	45.	22.
148.	131.	89.	20.	20.	31.	7.	12.
139.	115.	67.	76.	26.	5.	11.	29.
130.	115.	89.	30.	46.	14.	22.	23.
121.	102.	78.	50.	20.	24.	4.	-17.
126.	107.	89.	86.	35.	34.	9.	-18.
0.	0.	0.	C.	0.	0.	27.	17.
95.	102.	115.	63.	29.	22.	0.	-27.
81.	102.	52.	30.	23.	2.	23.	-25.
81.	74.	52.	46.	0.	-22.	31.	-20.
81.	156.	11.	50.	-3.	7.	5.	16.
72.	53.	48.	7.	20.	17.	11.	-17.
67.	53.	52.	33.	0.	-5.	-4.	-16.
54.	57.	37.	40.	20.	-14.	5.	-66.
81.	61.	52.	46.	44.	5.	-4.	-20.
0.	0.	0.	0.	0.	0.	22.	5.
85.	82.	70.	53.	17.	2.	16.	3.
90.	98.	104.	89.	46.	26.	-2.	-1.
85.	-8.	70.	36.	-3.	7.	7.	10.
95.	90.	70.	66.	6.	17.	13.	22.
72.	135.	33.	46.	26.	24.	13.	4.
41.	41.	41.	33.	17.	12.	9.	-12.
58.	49.	26.	23.	15.	29.	2.	-10.
54.	61.	22.	C.	6.	19.	7.	18.
0.	0.	0.	0.	0.	0.	23.	22.
36.	41.	4.	13.	9.	-5.	7.	-4.
36.	41.	52.	26.	-6.	-17.	20.	21.
18.	45.	0.	-63.	-38.	0.	-14.	-1.
72.	53.	19.	10.	17.	5.	-5.	-10.

FOR THE ENTIRE PARABOLOID (IN INCHESX1000)

MEAN = 30.599 S.D.= 37.883 MEDIAN = 526.304 QUART DEV = 23.287

FOR EACH RADIAL STN STARTING AT ZEROTH, MEDIAN ABOVE S.D.

88.031	78.750	53.250	35.969	12.531	10.875	12.417	3.333
39.316	36.539	29.920	34.399	20.376	16.844	12.650	21.811

43 69

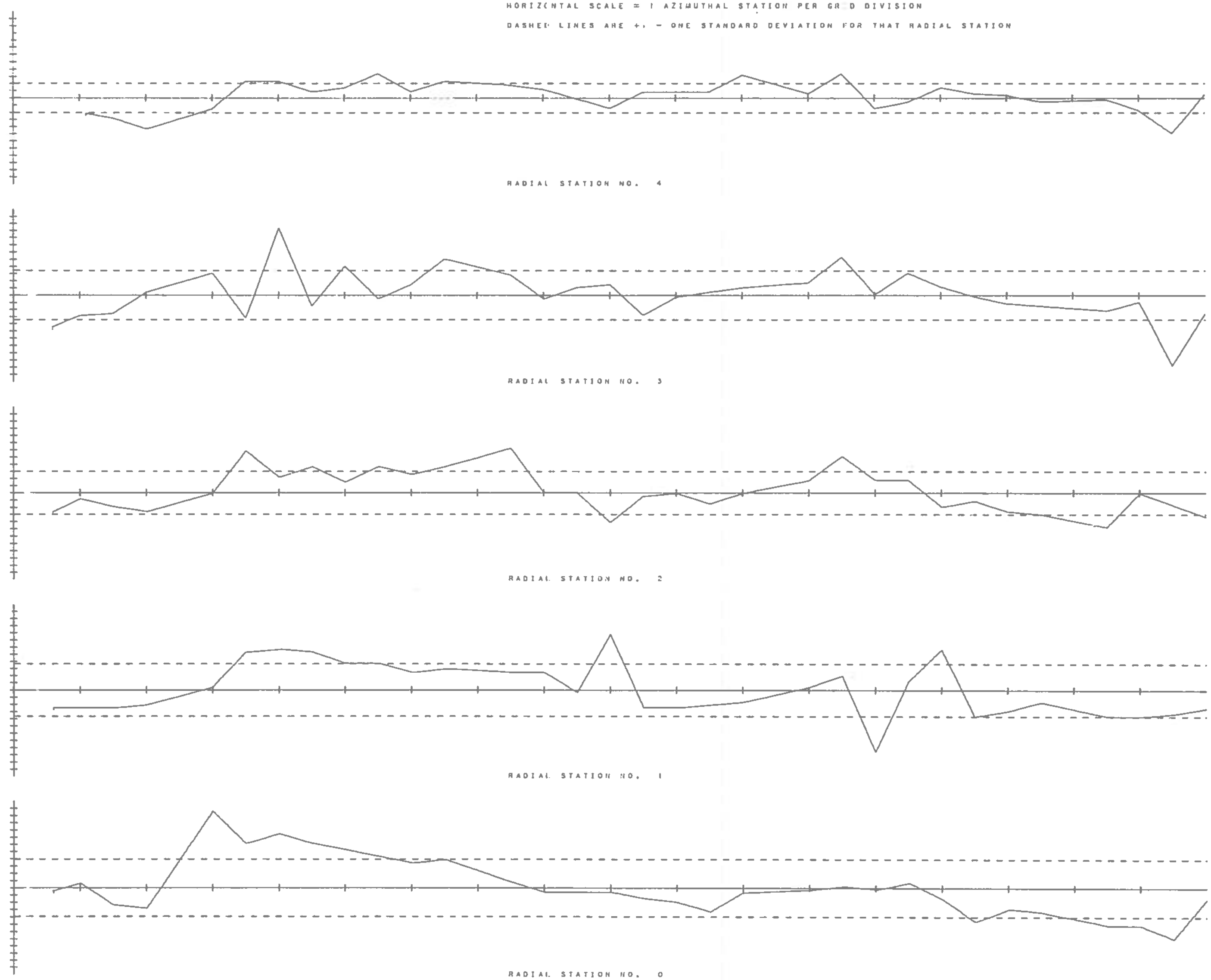
AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

150 FT ARO ANT.SURFACE MEAS.SURVEY NO 14 MAY67 MHJ RAW DATA

VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 1 AZIMUTHAL STATION PER GRID DIVISION

DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION



AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

150 FT ARO ANT.SURFACE MEAS.SURVEY NO 14 MAY67 MHJ RAW DATA

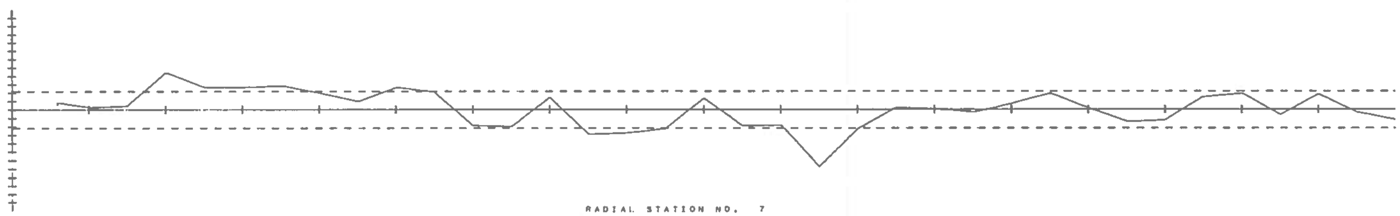
VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 1 AZIMUTHAL STATION PER GRID DIVISION

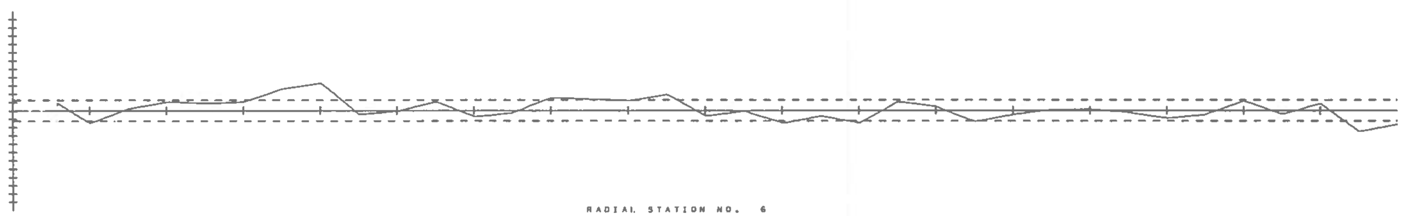
DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION

RADIAL STATION NO. 9

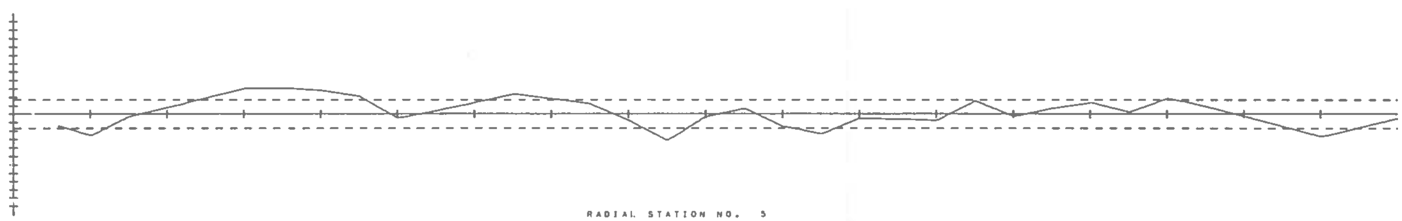
RADIAL STATION NO. 8



RADIAL STATION NO. 7



RADIAL STATION NO. 6



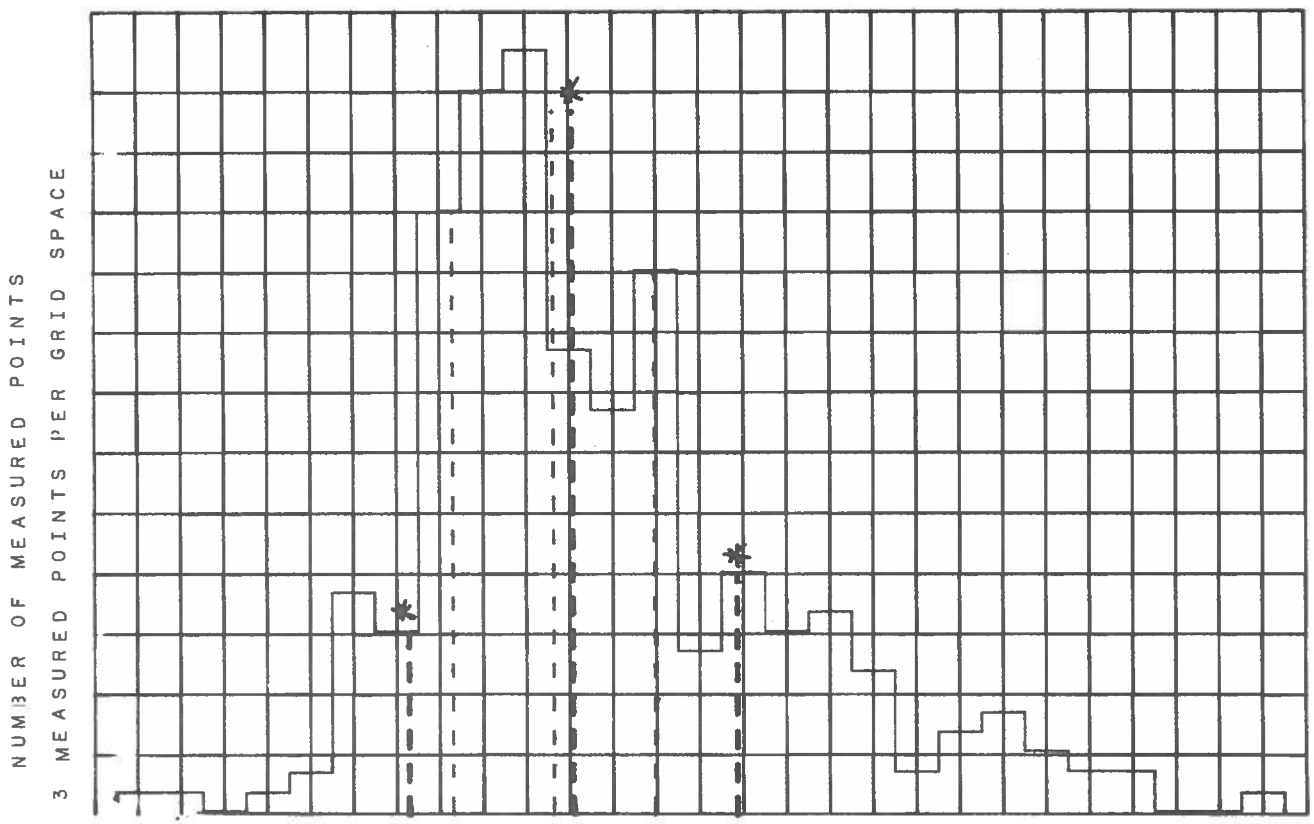
RADIAL STATION NO. 5

HISTOGRAM FOR ENTIRE DISH

150 FT ARO ANT.SURFACE MEAS.SURVEY NO 14 MAY67 MHJ RAW DATA

GREEN= MEDIAN, QUARTILE DEVIATIONS

* VIOLET = MEAN, STANDARD DEVIATIONS



.010 INCH PER GRID SPACE

ERROR DISTRIBUTION

THE FOLLOWING IS HT CORR DATA TO B.F.P.

19.	2.	-20.	-45.	-23.	-13.	23.	18.
26.	-3.	-1.	-27.	-33.	-28.	-6.	11.
-11.	-8.	-16.	-27.	-43.	-6.	12.	13.
-23.	-9.	-27.	0.	-60.	-14.	19.	53.
0.	0.	0.	0.	0.	0.	17.	34.
99.	6.	-9.	20.	-35.	24.	18.	34.
48.	50.	47.	-45.	1.	23.	34.	36.
56.	50.	7.	78.	-1.	19.	40.	27.
38.	42.	19.	-33.	-17.	11.	2.	17.
25.	23.	-6.	21.	-12.	-15.	5.	34.
13.	21.	15.	-26.	7.	-7.	16.	27.
2.	6.	2.	-7.	-20.	3.	-2.	-13.
7.	11.	13.	29.	-5.	12.	2.	-14.
0.	0.	0.	0.	0.	0.	20.	21.
-22.	7.	40.	7.	-11.	0.	-7.	-23.
-33.	9.	-21.	-25.	-16.	-19.	16.	-21.
-29.	-16.	-19.	-8.	-38.	-43.	25.	-16.
-25.	70.	-57.	-2.	-40.	-13.	-1.	20.
-28.	-29.	-17.	-43.	-15.	-2.	5.	-13.
-27.	-24.	-10.	-14.	-34.	-23.	-9.	-12.
-34.	-15.	-21.	-4.	-12.	-31.	-0.	-62.
-0.	-6.	-2.	4.	14.	-11.	-9.	-16.
0.	0.	0.	0.	0.	0.	18.	9.
17.	25.	24.	17.	-9.	-12.	12.	8.
28.	46.	61.	56.	22.	13.	-5.	4.
28.	-56.	31.	5.	-25.	-5.	4.	15.
43.	46.	33.	37.	-15.	6.	11.	27.
24.	94.	-1.	19.	6.	14.	11.	9.
-4.	2.	9.	7.	-2.	2.	8.	-6.
14.	11.	-5.	-2.	-3.	20.	1.	-4.
11.	24.	-9.	-24.	-12.	10.	6.	24.
0.	0.	0.	0.	0.	0.	22.	28.
-9.	2.	-28.	-12.	-9.	-14.	6.	2.
-12.	0.	18.	-0.	-25.	-27.	19.	27.
-34.	1.	-36.	-91.	-58.	-10.	-15.	5.
15.	6.	-19.	-20.	-4.	-6.	-6.	-4.

FOR THE ENTIRE PARABOLOID (IN INCHESX1000)

MEAN = -0.000 S.D.= 24.950 MEDIAN = 500.897 QUART DEV = 15.859

FOR EACH RADIAL STN STARTING AT ZEROTH, MEDIAN ABOVE S.D.

6.844	12.033	-0.197	-4.789	-16.443	-4.528	8.697	8.305
30.469	29.470	25.204	31.536	18.846	16.572	12.422	22.147

BEST FIT PARAM ARE XO = -13.111 YO = 308.534 ZO = -184.621 ALPHA = 26.881SEC
BETA = -43.797SEC F.L. = 720263.009

41 60

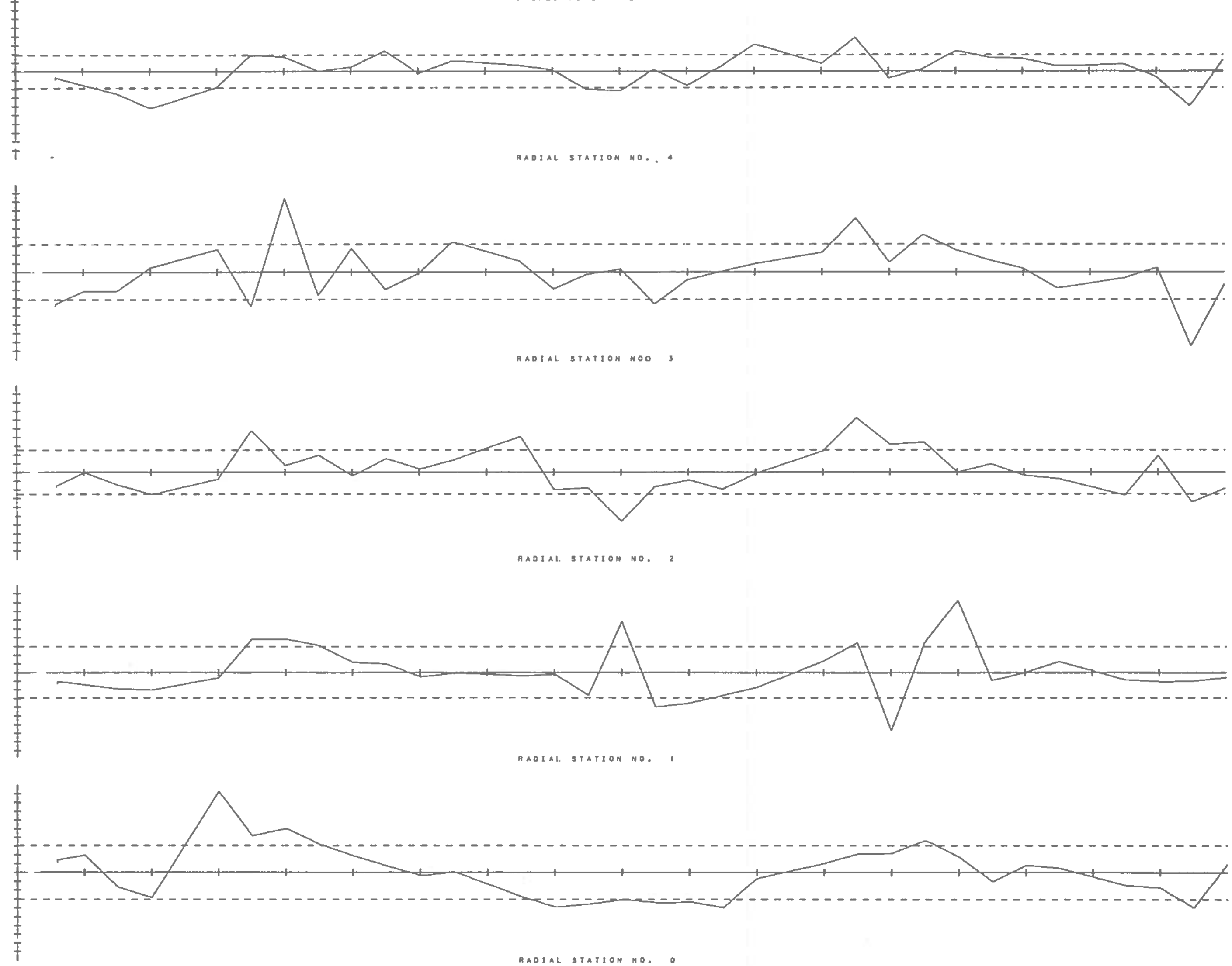
AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

150 FT ARO ANT.SURFACE MEAS.SURVEY NO 14 MAY67 MHJ B.F DATA

VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 1 AZIMUTHAL STATION PER GRID DIVISION

DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION



AZIMUTHAL ERROR DISTRIBUTION OF MEASURED DATA ABOUT THE MEAN OF EACH RADIAL STN

150 FT ARO ANT.SURFACE MEAS.SURVEY NO 14 MAY67 MHJ B.F DATA

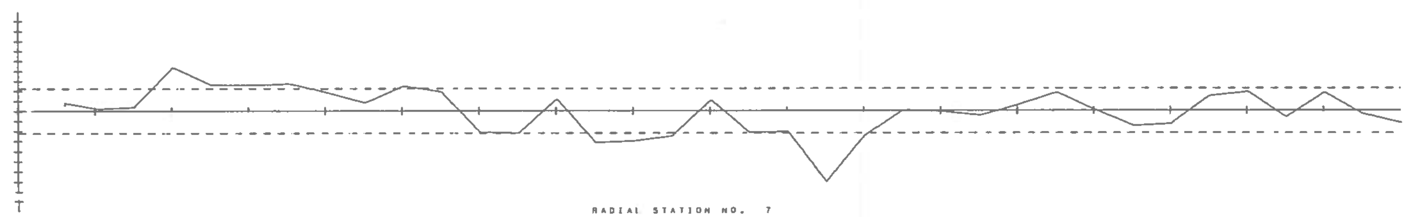
VERTICAL SCALE= .010 INCHES PER GRID DIVISION

HORIZONTAL SCALE = 1 AZIMUTHAL STATION PER GRID DIVISION

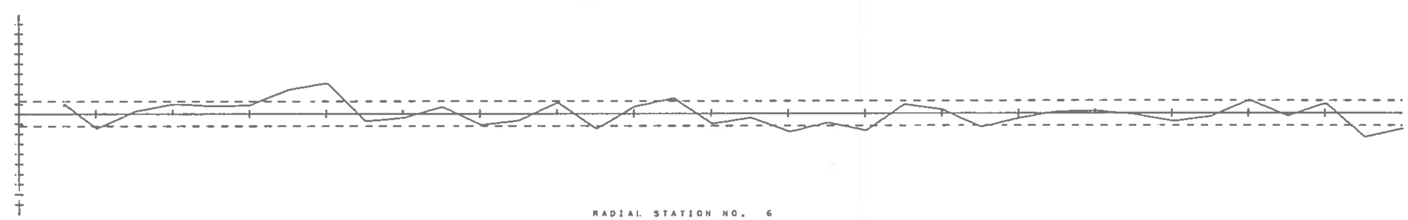
DASHED LINES ARE +, - ONE STANDARD DEVIATION FOR THAT RADIAL STATION

RADIAL STATION NO. 9

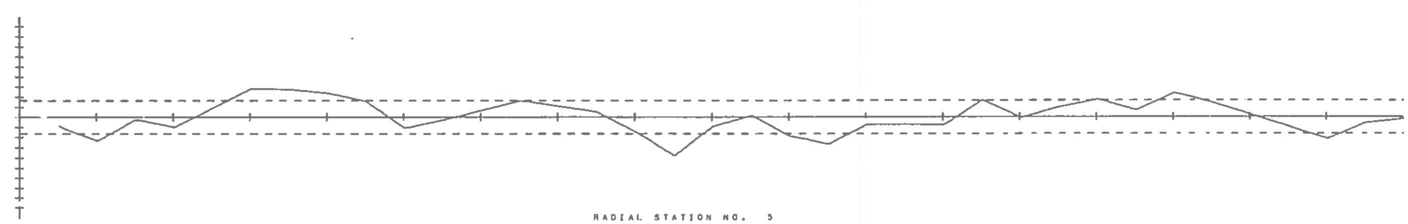
RADIAL STATION NO. 8



RADIAL STATION NO. 7



RADIAL STATION NO. 6



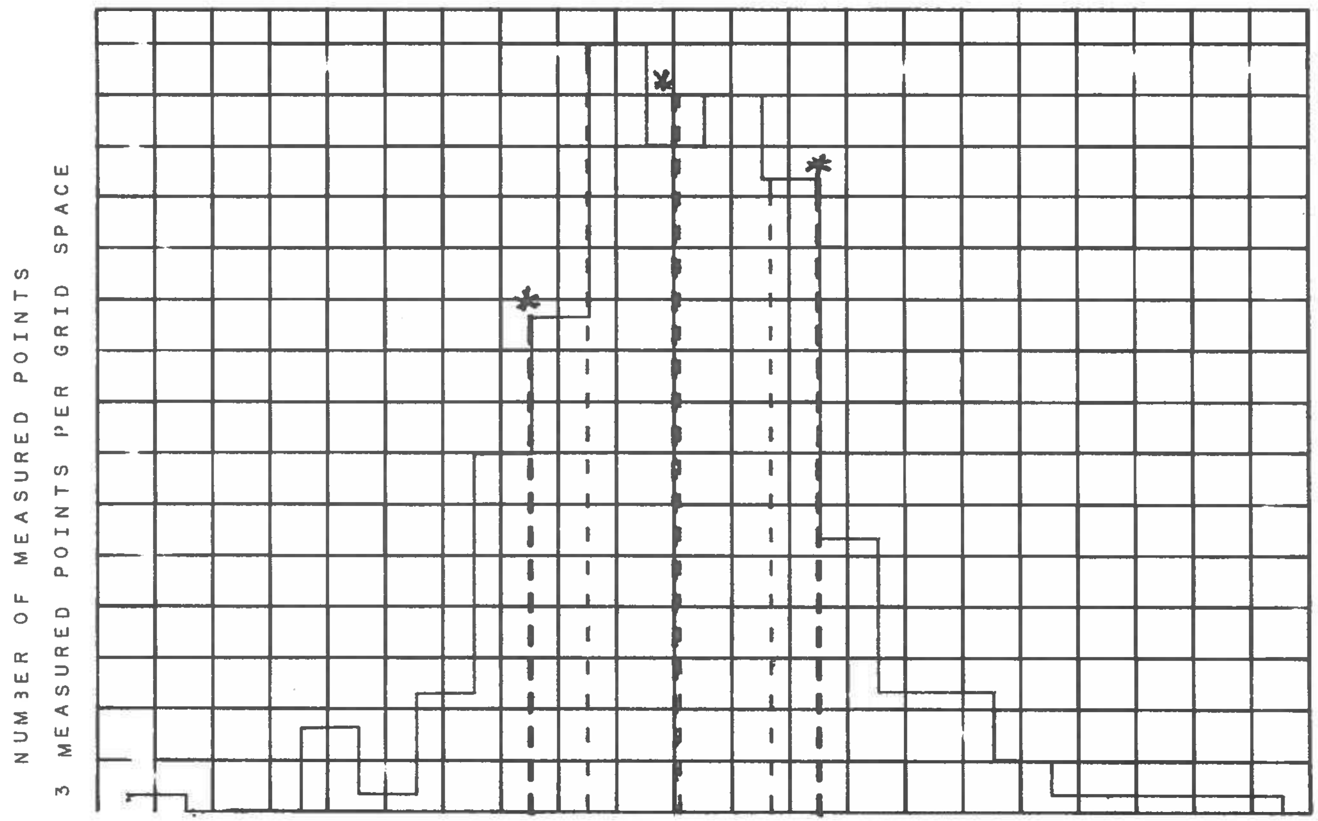
RADIAL STATION NO. 5

HISTOGRAM FOR ENTIRE DISH

150 FT ARO ANT. SURFACE MEAS. SURVEY NO 14 MAY67 MHJ B.F DATA

GREEN= MEDIAN, QUARTILE DEVIATIONS

* VIOLET = MEAN, STANDARD DEVIATIONS



.010 INCH PER GRID SPACE

ERROR DISTRIBUTION