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Weighted Triangulation Adjustment

by

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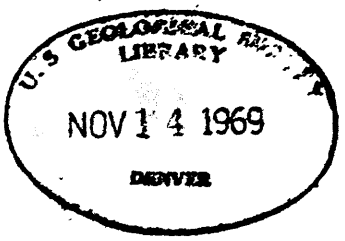

Program Number:	W8250
Sponsor:	William H. Chapman
Equipment:	IBM 360/65
Operating System:	IBM System 360
Language:	Fortran IV (H-LEVEL)

Open File Report

69-10

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WEIGHTED TRIANGULATION ADJUSTMENT

by Walter L. Anderson

ABSTRACT

The variation of coordinates method is employed to perform a weighted least squares adjustment of horizontal survey networks. Geodetic coordinates are required for each fixed and adjustable station. A preliminary inverse geodetic position computation is made for each observed line. Weights associated with each observed equation for direction, azimuth, and distance are applied in the formation of the normal equations in the least squares adjustment. The number of normal equations that may be solved is twice the number of new stations and less than 150. When the normal equations are solved, shifts are produced at adjustable stations. Previously computed correction factors are applied to the shifts and a most probable geodetic position is found for each adjustable station. Final azimuths and distances are computed. These may be written onto magnetic tape for subsequent computation of state plane or grid coordinates. Input consists of punch cards containing project identification, program options, and position and observation information. Results listed include preliminary and final positions, residuals, observation equations, solution of the normal equations showing magnitudes of shifts, and a plot of each adjusted and fixed station. During processing, data sets containing irrecoverable errors are rejected and the type of error is listed. The computer resumes processing of additional data sets. Other conditions cause warning errors to be issued, and processing continues with the current data set.

INTRODUCTION

This program determines the most probable positions of stations in a horizontal network using the method of variation of coordinates (U. S. Geological Survey, 1966). A certain number of "fixed" station latitudes and longitudes are given along with approximate geodetic positions for "adjustable" stations as well as observed directions, azimuths, and distances between stations in the net. All observations are assumed to have been previously corrected for station eccentricity, swing, reduction to sea level, and so forth, and therefore must be the equivalent of sea level,

tablet to tablet, observations. Observation equations are generated for: (1) observed directions, (2) observed astronomic azimuths, and (3) observed distances (or lengths). In addition, a selection of one of five different ellipoids may be used for the adjustment computations. A minimum of two fixed stations must be given.

This program (W8250) is a direct revision of program W5603 entitled "Triangulation Adjustment" (Anderson, 1967). Program W5603 performed a similar adjustment for unweighted observed directions. W5603 also provided for "rigid condition equations" for astronomic azimuths and lengths. Such equations have not been included in the revised program W8250. However, a condition equation can be simulated with program W8250 by using an azimuth or length-observation equation with a sufficiently large weight (e.g., w=999999999.0; see p. 12 below).

The card input to W8250 is a slight modification of the input to W5603 in order to accommodate the weight values. If the observation weight is omitted, a value of 1.0 is assumed. Therefore, W5603 data cards (with blank or zero weights) may be used directly by this program. The weighted triangulation adjustment program evolved from a need to combine different kinds of measurements (direction, azimuth, and distance) in an adjustment and to control the influences of each observation by the application of an appropriate weight.

USE

This program is primarily intended to perform the final geodetic position adjustment in a survey net used in topographic mapping. The program may also be used to find errors and blunders in the input data caused when certain program tolerances are exceeded. Various tolerances and other parameter options make the program adaptable to many survey areas and field situations.

DESCRIPTION

A latitude ϕ and a longitude λ are required for every station in the triangulation net. For ease of identification a number is assigned to each station. New or adjustable stations are numbered 1, 2, ..., NS, where NS is the number of new stations. Fixed stations are numbered NS+1, NS+2, ..., NTS, where NTS is the total number of stations, both fixed and adjustable.

Assuming all NTS stations latitudes and longitudes are known, the following correction factors M and P (in seconds) are computed and stored for later use in computing all adjustable latitudes and longitudes:

$$M=\rho/R, \quad P=\frac{\rho}{N\cos\phi} \tag{1}$$

where $\rho=206264.8062470964$,
R=radius of curvature in the meridian of the selected ellipsoid at the latitude ϕ,
N=radius of curvature in the prime vertical at ϕ,
and $N\cos\phi$=radius of the corresponding latitude parallel.

Then

$$R=\frac{a(1-e^2)}{(1-e^2\sin^2\phi)^{3/2}}, \quad N=\frac{a}{(1-e^2\sin^2\phi)^{1/2}} \tag{2}$$

where e^2=square of eccentricity of the ellipsoid=$(a^2-b^2)/a^2$,
a=semimajor axis of the ellipsoid,
and b=semiminor axis of the ellipsoid.

The ellipsoid is defined by the value of the parameter ISPHER from the following table (Chapman, 1967):

ISPHER	Ellipsoid	Semimajor axis (a) (meters)	Semiminor axis (b) (meters)
0	Clarke 1866	6,378,206.4	6,356,583.8
1	Clarke 1880	6,378,249	6,356,515
2	Bessel	6,377,397	6,356,079
3	Everest	6,377,276	6,356,075
4[1/]	International	6,378,388	6,356,075

1/ Lambert and Swick (1935)

The program uses pairs of constants (a,e^2) for each entry in the table and the selection of the ellipsoid is determined by the value of ISPHER from the card (see Input Requirements and Data Description, p. 8).

For each line observed, a preliminary inverse geodetic position computation is made using the subroutines GEDINV and LOCAZ (Chapman, 1967). The results for given stations (ϕ_b,λ_b) and (ϕ_a,λ_a) are denoted by

α_{ba}=forward azimuth (seconds),
α_{ab}=back azimuth (seconds),
and s=distance (feet).

The three types of weighted observation equations are described next. It should be noted that each type of observation equation (distance, azimuth, or length) has an associated weight (w) value which is supplied along with the observation given. The weight value is assumed to be unity (1.0) if not known (see p. 12). The weight w is applied in the formation of the normal equations in the least squares process (Hildebrand, 1956).

Observation Equation For Directions

For each line associated with an observed direction and a given reorientation z-number (defined below), the observation equation, with given weight w, has the form

$$v=C_\alpha+(A-O)+z, \tag{3}$$

$$C_\alpha=\frac{\rho}{10s}(S_a\sin\alpha_{ab}+E_a\cos\alpha_{ab}+S_b\sin\alpha_{ba}+E_b\cos\alpha_{ba}) \tag{4}$$

where v=residual (seconds),
C_α=change in direction of line (seconds),
A-O=assumed minus observed direction (seconds),
z=reorientation term,
s=computed length of line (feet),
α_{ba},α_{ab}=computed forward and back azimuths,
S_a,E_a=shifts to be determined for station A, in southerly and easterly directions, respectively,
and S_b,E_b=shifts to be determined for station B.
(All shifts S_a,E_a,S_b,E_b are in units of decifeet.)

The symbol z has four related uses in this paper:

1. "z-number" is the consecutive number used in the input list to identify each group of observed directions.

2. "z-equation" is the fictitious observation equation used to determine reorientation.

3. "z-value" is the actual reorientation, in seconds, as determined in the adjustment and appearing in the output listing.

4. "z-term" is the actual z variable appearing in equation (3).

Schreiber's method (Rainsford, 1957, p. 175-178) is used to eliminate the normal equations associated with the z or reorientation terms. This method reduces the number of normal equations that would be required if z-terms were included directly. The algorithm is performed while weighted observation equations (3) are being formed for any one z-number, where sums of corresponding weighted terms are being accumulated. These sums when multiplied through by $i\sqrt{n}$ (n=number of lines associated with a given z-number and $i=\sqrt{-1}$) represent the coefficients of a fictitious observation equation (z-equation) which may be treated exactly as other observation equations while the normal equations are being formed.

Schreiber's method is slightly modified to handle a weighted z-equation in which the weight function can be shown to be

$$w_{n+1}=f(w)=\frac{n}{\sum_{1}^{n} w_i} \qquad (5)$$

where n is as defined above and where the w_i are the associated weights for $i=1,2,\ldots,n\geq 2$.

Observation Equation for Astronomic Azimuths

For observed astronomic azimuths, the observation equation, with given weight w, has the form

$$v=C_\alpha+(A-O). \qquad (6)$$

The term C_α is defined by (4), A-0 is the assumed minus the observed azimuth, and v is the residual in seconds. Note the absence of the z-term in equation (6) in contrast to the observed direction equation (3). This absence will be noted in the results, the actual reorientation z-value being identically equal to zero (0.0).

Observation Equation for Lengths

For observed lengths, the observation equation, with given weight w, has the form

$$v=C_s+10(A'-0'), \tag{7}$$

$$C_s=-S_a\cos\alpha_{ab}+E_a\sin\alpha_{ab}-S_b\cos\alpha_{ba}+E_b\sin\alpha_{ba} \tag{8}$$

where v=residual (decifeet),
C_s=change in length of line (decifeet),
A'-0'=assumed minus observed length (feet),
and S_a,E_a,S_b,E_b=shifts to be determined for stations A and B in southerly and easterly directions, respectively (units in decifeet).

Normal equations are formed by the method of least squares (Adams, 1915) using the weighted observation equations (3) and (7). This well-known technique can be found in many references (e.g., Hildebrand, 1956). The resulting normal equations become a real symmetric matrix of order 2NS, where the total number of observations must exceed this order, and NS is the number of new stations.

The symmetric normal equation matrix is stored in vector fashion by eliminating the symmetrical elements below the main diagonal. The normal equation system with $a_{ji}=a_{ij}$ is

$$\begin{aligned}
&a_{11}x_1+a_{12}x_2+\ldots+a_{1n}x_n+b_1=0\\
&a_{21}x_1+a_{22}x_2+\ldots+a_{2n}x_n+b_2=0\\
&\qquad\vdots\\
&a_{n1}x_1+a_{n2}x_2+\ldots+a_{nn}x_n+b_n=0.
\end{aligned} \tag{9}$$

The coefficients are then stored in a vector in the form $a_{11},a_{12},\ldots,$ $a_{1n},b_1,\ a_{22},\ldots,a_{2n},b_2,\ \ldots,a_{nn},b_n$. The constants b_i may be regarded as $a_{i,n+1}$. The number of unknowns is n=2NS where $NS\leq 75$ and is the number of new stations. The solution of the normal equations (9) produces the shifts (S's and E's) for all adjustable stations. These shifts are then converted to give corrections of latitude and longitude in seconds,

$$\Delta\phi''=-S\frac{M}{10},\ \Delta\lambda''=E\frac{P}{10} \tag{10}$$

where M and P were computed previously from equations (1) and (2).

The most probable geodetic positions are now found by applying the corrections (10) to all adjustable stations. Final azimuths and distances are computed from the inverse geodetic position subroutine GEDINV. These final station positions along with the fixed stations may be written on magnetic tape to be used later as input to the grid coordinates program (Buehrer, 1967) for state plane or grid coordinates calculations (see ZONE option, p. 9).

The probable error (p.e.) of an observation of weight unity is computed by the formula

$$\text{p.e.}=0.67449\left(\frac{\sum_{i=1}^{N} w_i v_i^2}{N-(2NS+NZ)}\right)^{1/2} \tag{11}$$

where N=total observations,
w=weight of an observation,
v=the residual,
NS=new stations,
and NZ=z's used.

The expression (2NS+NZ) represents the total number of independent unknowns.

RESTRICTIONS

The main restriction is the number of normal equations that may be solved simultaneously. This number is twice the number of new stations and may not exceed 150. The appropriate dimension statements in the FORTRAN program could be increased perhaps to 200, but an arbitrary limit of 150 was chosen because this should satisfy most standard nets.

Latitudes may not exceed 90° N. or 90° S. and longitudes may not exceed 180° E. or 180° W. Directions or azimuths are always measured clockwise from south and are given to the nearest thousandth of a second in degrees, minutes, and seconds; they may never exceed 359° 59' 59.999".

INPUT REQUIREMENTS AND DATA DESCRIPTION

Data for triangulation adjustment using the USGS Computing System (IBM System 360/65) may be presented on any 80-column general-purpose data form as long as card-column requirements are followed as described below.

In preparation for the adjustment all new (adjustable) stations are to be assigned sequential numerical values, beginning with 001. A maximum of 75 new stations can be adjusted by this program. Stations to be held fixed in the adjustment must be assigned sequential numbers immediately following those of the new stations. The total number of stations, fixed and new, must not exceed 200. Final positions will be computed for all new stations by using preliminary (approximate) positions on input.

For each occupied station, the list of observed directions, oriented approximately to true south, must be corrected for any station eccentricity existing at the time of observation. At each station, one or more z-numbers (station reorientation) may be used according to field conditions. Usually one z-number is needed at each occupied station and at least two lines must be sighted from this station.

Card Formats

Each 80-column card must be properly punched according to the following instructions. On each card, column 80 is reserved for the card type identification. There are four types of cards in each data set:

Column 80	Type of Card
1	Header (1 needed)
2	Parameter (1 needed)
3	Position (as needed)
4	Observation (as needed)

Columns	Format	Description
Header Card		
1-62	15A4, A2	Project identification. May include any alphabetic and (or) numeric characters.
63-66	I4	ZONE (1) option. If final grid coordinates are desired for all stations, record the proper zone number as defined in Buehrer (1967). When ZONE (1) is not zero, the program will write all final positions on tape for subsequent processing by the grid coordinates program. Where ZONE (1) is zero (or blank), this option is not selected and ZONE (2),..., ZONE (4) below are irrelevant.
67-70	I4	ZONE (2). May be selected only if ZONE (1) is non-zero.
71-74	I4	ZONE (3). Same as ZONE (2).
75-78	I4	ZONE (4). Same as ZONE (2).
80	I1	Must be "1".

Parameter Card

The total number of stations (NTS) in columns 3-5 must be at least two greater than the number of new stations (NS) in columns 1-2; i.e., at least two stations must be held fixed.

If length or azimuth tolerance is exceeded in absolute value, the program rejects the observation equation and terminates after all observations have been read; no adjustment will be provided for rejected lines because such rejection would probably indicate a data error and the results would be invalid. If observations are rejected, the program will print all observation equations with appropriate messages to aid the user in identifying sources of error (see Diagnostic Messages, p. 17).

1-2	I2	Number of new stations NS ($1 \leq NS \leq 75$).
3-5	I3	Total number of stations NTS ($NS < NTS < 200$). Note: NTS must be greater than NS. Thus the number of fixed stations in the net is NTS minus NS.

6-8	I3	NZ=last z-number used.
9-12	I4	ISPHER=type of ellipsoid selected. Use ISPHER=0 (or blank) for Clarke 1866 ISPHER=1 for Clarke 1880, ISPHER=2 for Bessel ISPHER=3 for Everest, ISPHER=4 for International. ISPHER>4 will be used as though ISPHER=0.
27-31	F5.2	Length tolerance (maximum allowable absolute difference between observed and computed lengths (times 10.0) in the assumed figure-- required in testing length observations equations, if any) scaled to xxx.xx decifeet. If no length tolerance is specified, then the program automatically allows a default tolerance of 250.00 decifeet. When recording a number with two decimal places, the decimal point need not be punched; however, the decimal point may be punched anywhere in the field 27-31. Therefore, numbers as large as 9999. may be used by punching the decimal point in column 31.
32-37	F6.3	Azimuth tolerance (maximum allowable absolute difference between observed and computed azimuths in the assumed figure-- required in testing all observation equations and azimuth observation equations) scaled to xxx.xxx seconds. If no azimuth tolerance is specified, then a default value of 60.000 seconds is assumed by the program. Numbers as large as 99999. may be used by overriding the assumed decimal position.
80	I1	Must be "2".

Position Card

If more than one station is on a card, the additional (if any) station(s) must be consecutive with respect to the first station number. The order of position cards is irrelevant as long as all stations are recorded with the general convention that new stations be numbered consecutively from 1 to NS and that fixed stations be numbered consecutively from NS+1 to NTS. Any number of position cards may be included until all NTS stations are recorded.

4-6	I3	First station number on this card.
7-9	I3	Last station number on this card.
10-20	A1, 2I2, F6.4	Latitude of first station in the form ±DDMMSS.SSSS.
21-32	A1, I3, I2, F6.4	Longitude of first station in the form ±DDDMMSS.SSSS.
33-43		Latitude of second station, or blank.
44-55		Longitude of second station, or blank.
56-66		Latitude of third station, or blank.
67-78		Longitude of third station, or blank.
80	I1	Must be "3".

Observation Card

One observation card is required for each observation (direction, azimuth, or length). A line observed in both directions requires two cards.

The type of observation (A,B,C) is defined by the rules:

(A) Observed direction given if $z \neq 0$ (z in columns 3-5);

(B) Astronomic azimuth given if $z \neq 0$ and length=0.00 (length in columns 45-52);

(C) Length given if z=0 and length$\neq$0.00.

Any and all azimuth and (or) length observations (with z=0) must be placed in the deck ahead of the $z \neq 0$ observed direction cards. The order and number of azimuth and length observation cards are arbitrary. However, the observed direction cards must be grouped and ordered consecutively by z-number (column 3-5) and must begin with 001 for the first group. Each z-group must have at least two observed directions per group.

In order to perform a least squares analysis, the total number of observation cards must exceed the number of equations to be solved simultaneously. The program will count the number of observations and check this before proceeding with the solution of the normal equations.

3-5	I3	z-number.
6-7	I2	Number of observation cards associated with current z-number; required only on the first card of each z-number group but must be greater than 1 if $z \neq 0$.
8-10	I3	Occupied station B; must be the same for all cards with the same z (except if z=0).
11-13	I3	Observed station A.
14-23	I3, I2, F5.3	(A) Observed direction B to A in the form DDDMMSS.SSS.
24-34	A1, I3, I2, F5.3	(B) Observed (astronomic) azimuth of B to A in the form +DDDMMSS.SSS. For an azimuth observation of due south, record the symbol "-" or "S" in column 24.
35-44	F10.5	Weight (w) of an observation (applies to any type, A,B, or C). w=1.0 is assumed if columns 35-44 are left blank or punched as zero (0). If the assumed decimal is overridden, the largest weight that may be used is 999999999..(N.B. it will be printed as ********** if used).
45-52	F8.2	(C) Observed length scaled to two implied decimals, in feet. Leave blank (or use 0.00) if a length observation is not given.
80	I1	Must be "4".

PROGRAM RUN PREPARATION

The following deck setup includes OS/360 control cards as well as the triangulation adjustment data deck requirements. The deck arrangement cannot be changed if the standard USGS production program on disk is being used.

The OS/360 control cards are identified by //'s in columns 1-2. Each control card must be punched on an IBM 029 keypunch or equivalent card codes must be used. The symbol "b" denotes a blank card column. The deck order must be:

1. Users JOB card
2. //JOBLIBbDDbDSNAME=SYS1.LOADLIB,DISP=(SHR,PASS,KEEP)
3. //bEXECbW8250
4. //GO.SYSINbDDb*
5. Data deck in the following order:
   (a) Header card (column 80=1)
   (b) Parameter card (column 80=2)
   (c) Position cards (column 80=3) as many as needed; in any order desired.
   (d) Observation cards (column 80=4) as many as needed; arranged in consecutive order with respect to the z-number (columns 3-5) groups.
   (e) End-of-observation (EOB) card
   An EOB card is a delimiter card with columns 1-79 blank and column 80=9.
   (f) Repeat steps a-e for as many independent problems as desired.
   (g) End-of-data card (always required following last EOB card; the format is columns 1-80 blank or all zeros.
6. /* End-of-file card. Contains "/*" in columns 1-2.

Input/Output Devices

The following devices are required:

1. Card reader/tape (SYSIN file).
2. Line printer/tape (SYSOUT file).
3. Three scratch disk files. The catalog procedure W8250 in step 3 above will automatically allocate the required disk space.
4. One 2400 9-track tape when the grid coordinates tape option (ZONE (1)≠0) is selected. This file is automatically setup to use USGS tape volume serial number 1008, unless otherwise overridden by including between cards 3 and 4 the control card //GO.FT10F001b DDbVOLUME=SER=xxxx, xxxx being the particular tape number.

The format of the grid coordinates tape is written with unblocked 80-character BCD records in the following order:

Columns	Description
a. Header record where	
1-62	Project identification.
63-66	ZONE (1), not zero.
67-70	ZONE (2).
71-74	ZONE (3).
75-78	ZONE (4).
80	0.
b. Final position records in the following form where the implied decimal in the latitude and longitude seconds is SS.SSSS	
1-3	Station number.
21-31	Latitude in ±DDMMSSSSSS.
32-43	Longitude in ±DDDMMSSSSSS.
80	2.
c. End record after last position	
1-79	blanks.
80	6.
d. Other grid coordinate data sets in order of a-c above.	
e. End-of-file mark follows the last end record.	

The "Grid Coordinates Program" (Buehrer, 1967) reads data from file FT10F001 if the data is not from cards. Instead of using a tape as permanent storage for the final positions (ZONE option), one may use a disk work file as temporary storage and obtain the grid coordinates immediately after the triangulation adjustment. The final positions are not retained on the disk work file as with tape, but retention may not be necessary.

The deck arrangement for automatically obtaining grid coordinates after adjustment is then:

1. Users JOB card

2. //JOBLIBbDDbDSNAME=SYS1.LOADLIB,DISP=(SHR,PASS,KEEP)

3. //bEXECbW8250

```
4.  //GO.FT10F001bDDbUNIT=,LABEL=,VOLUME=,DISP=OLD,DSNAME=SYS1.WORK4

5.  //GO.SYSINbDDb*

6.  Data deck in order (a) - (g) above -- with ZONE option selected
    in desired problems

7.  /*

8.  //bEXECbPGM=D0154,REGION=252K

9.  //FT06F001bDDbSYSOUT=A

10. //FT10F001bDDbDSNAME=SYS1.WORK4,DISP=OLD

11. //FT11F001bDDbDUMMY

12. //FT05F001bDDb*

13. /*
```

OUTPUT LISTING

In general, the printout is presented in the following order (refer to the attached example output listing, p. 19-26):

Part 1. Preliminary positions and observation equations (p. 19-21).

Part 2. Solution of normal equations, showing magnitudes of the station shifts. Also given is the back substitution check using the solution vector in the normal equations (p. 22).

Part 3. A plot of the adjusted and fixed stations with each station identified. The plot is included mainly as a visual check showing the final data and is not intended as an accurately scaled plot (p. 23).

Part 4. Final positions and residuals (p. 24-26).

Parts 2 and 3 are of little practical importance to the user but may be useful in a detailed study of the adjustment. Parts 1 and 4 are the basic input and output data. In each, two printout lines are devoted to one field observation. In a general way, the left half of each printout refers to the station occupied (B) and the right half to the station observed (A).

In Part 1 the first line of each pair lists the data of the assumed net in the following order:

Numerical designation of occupied station B

Preliminary LAT B, LONG B, and forward azimuth AZBA

Inversed distance between stations (denoted by S)

Numerical designation of observed station A

Preliminary LAT A, LONG A, and back azimuth AZAB

The second line of each pair contains observation equation coefficients and constants as follows:

The z-number associated at station B

The shift coefficients at B (if adjustable)

The observed direction (appears under AZBA column)

The observation weight (denoted by WT)

The shift coefficients at A (if adjustable)

The equation constant term

Except for the z-number and azimuth, the coefficients are all expressed in exponential form which consists of a decimal number times a signed two-digit power of 10 (e.g., 0.12345678D-02 represents the number 0.0012345678, etc.).

In Part 4 (final positions and residuals) the first line of each pair has the same format as the corresponding line of Part 1: B,LAT B, LONG B, AZBA, S, A, LAT A, LONG A, AZAB. These values are based on the final geodetic positions found after applying the adjustment and inverse computations. The second line of each pair shows the shift corrections to the assumed latitude and longitude at both stations (i.e., adjustable stations). The term denoted by V is the residual (or adjustment correction) for the observation; the z-value (station reorientation term) for the occupied station is given at the end of the line. The maximum absolute residual and probable errors are given after the final position listing (p. 26).

DIAGNOSTIC MESSAGES

Errors detected in the header, parameter, position, or observation cards will be noted at run time and printed along with any results collected at the time the error is detected. Attempts are made to process the entire data file even if errors are discovered.

If a severe or irrecoverable error is detected in a data set on the header, parameter, or position cards, the message "DATA SET FLUSHED FROM FOLLOWING CARD" is given. The program will first flush all remaining cards until an EOB card (column 80=9) is read, and will then resume processing any subsequent data set(s). If a severe error on an observation card is encountered, the program will print the message "$$$$$ OBSERVATION REJECTED $$$$" and continue reading and editing all remaining observation cards. This procedure permits detection of other possible errors in the data following the first severe observation card error. After the last observation card is read, the program will print the number of rejected observations and resume processing any subsequent data set(s).

Messages will be printed upon detection of errors and will contain:

Card-type identification

Error message in detail

Card-column guide lines

Card contents

Certain warning errors will permit the program to continue with the current data set but may indicate a possible source of error. For example, the message "...MINUTES OR SECONDS.GT. 60.0" may be a result of a card-punching error. However, the program allows the minutes or seconds portion of angles to be greater than 60.0 during the processing.

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ATTACHMENTS

```
//JCBLIB DD DSNAME=SYS1.LCADLIB,DISP=(SHR,PASS,KEEP)
// EXEC W8250
//GC.SYSIN DD *
8 EQUATION PROGRAM CHECKOUT                                                    1
04CC8007                                                                       2
   CC10030361GC722000106106456000036085961000106105852000361309480001060531310C 3
   CC4CC6036144028CCC10557C7130003615462870010621174850036080672300106204027800 3
   CC7CC8036114521800105523442300362000075001055612354C                       3
  CC1060010G2C012416400                                                        4
  CC1C6CC10C6045081930C                                                        4
  CC106C01005087423410C                                                        4
  CC1U6001CC82514148900                                                        4
  CC106C01C042772422300                                                        4
  CC1C6001CC33045342700                                                        4
  CC2C5CC2C06C833911200                                                        4
  CC2C5CJ2CC5129C4531CC                                                        4
  CC2C5CC2CC1181240C2400                                                       4
  CC2C5CC2C042430646400                                                        4
  CC2C5CC2CC72592539000                                                        4
  CC305C03CC20464413900                                                        4
  CC3C5CC3CC11245642800                                                        4
  CC3C5CC3CC82274427700                                                        4
  CC3C5CC3CC42572540400                                                        4
  CC305C03C07277333590                                                         4
  CC405CC4CC2U6315013C0                                                        4
  CC405CC4CC30773C34200                                                        4
  CC405CC4C01C973219500                                                        4
  CC4C5CC40C81875322000                                                        4
  CC405CC4CC73C82152300                                                        4
  CC5C3CC5CC12673618800                                                        4
  CC503CC5C023C658471C0                                                        4
  CC503CC5CC63561432500                                                        4
  CC603CC6CC51761454400                                                        4
  CC6C3CC6CC1225C2220CC                                                        4
  CC6C3CC6CC2263332980C                                                        4
  CC704CC7JC20793635500                                                        4
  CC704CC7CC309741166C0                                                        4
  CC704CC7JC4128244C90C                                                        4
  CC704CC7CC81602319400                                                        4
                                                  END OF OBSERVATIONS          9

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PRELIMINARY POSITIONS AND EQUATIONS -- 8 EQUATION PROGRAM CHECKOUT

ISPHER= 0 ZONE= 0 0 0 0

B	LAT B	LONG B	AZBA	S	A	LAT A	LONG A	AZAB
1	36 16 7.2200	106 10 45.6000	1 24 13.641	43254.03	2	36 8 59.6100	106 10 58.5200	181 24 6.009
1	0.11682461D-01	0.47672526D 00	1 24 16.400 WT=	1.00000		-0.11664821D-01	-0.47672570D 00	-0.27590829D 01
1	36 16 7.2200	106 10 45.6000	45 8 17.612	68822.81	6	36 8 6.7230	106 20 40.2780	225 2 26.375
1	0.21243348D 00	0.21141095D 00	45 8 19.300 WT=	1.00000				-0.16883898D 01
1	36 16 7.2200	106 10 45.6000	87 42 34.135	51791.73	5	36 15 46.2870	106 21 17.4850	267 36 20.355
1	0.39793997D 00	0.15916959D-01	87 42 34.100 WT=	1.00000				0.34943971D-01
1	36 16 7.2200	106 10 45.6000	251 41 44.485	75261.16	8	36 20 0.0750	105 56 12.3540	71 50 21.471
1	-0.26019821D 00	-0.86074044D-01	251 41 48.900 WT=	1.00000				-0.44147390D 01
1	36 16 7.2200	106 10 45.6000	277 24 15.471	67610.77	4	36 14 40.2800	105 57 7.1300	97 32 19.516
1	-0.30253295D 00	0.39315244D-01	277 24 22.300 WT=	1.00000		0.30243986D 00	-0.40025095D-01	-0.68293694D 01
1	36 16 7.2200	106 10 45.6000	304 53 36.907	31399.22	3	36 13 9.4800	106 5 31.3100	124 56 42.724
1	-0.53880861D 00	0.37578842D 00	304 53 42.700 WT=	1.00000		0.53846986D 00	-0.37627366D 00	-0.57925294D 01
2	36 8 59.6100	106 10 58.5200	83 39 10.438	48016.77	6	36 8 6.7230	106 20 40.2780	263 33 27.319
2	0.42693518D 00	0.47489359D-01	83 39 11.200 WT=	1.00000				-0.76188291D 00
2	36 8 59.6100	106 10 58.5200	129 4 53.021	65303.94	5	36 15 46.2870	106 21 17.4850	308 58 47.401
2	0.24518168D 00	-0.19912158D 00	129 4 53.100 WT=	1.00000				-0.78828432D-01
2	36 8 59.6100	106 10 58.5200	181 24 6.009	43254.03	1	36 16 7.2200	106 10 45.6000	1 24 13.641
2	-0.11664821D-01	-0.47672570D 00	181 24 2.400 WT=	1.00000		0.11682461D-01	0.47672526D 00	0.36085989D 01
2	36 8 59.6100	106 10 58.5200	243 6 51.600	76358.99	4	36 14 40.2800	105 57 7.1300	63 15 2.592
2	-0.24092747D 00	-0.12215370D 00	243 6 46.400 WT=	1.00000		0.24121756D 00	0.12157986D 00	0.52002280D 01
2	36 8 59.6100	106 10 58.5200	259 25 43.949	92063.28	7	36 11 45.2180	105 52 34.4230	79 36 35.615
2	-0.22024423D 00	-0.41102717D-01	259 25 39.000 WT=	1.00000				0.49493651D 01
3	36 13 9.4800	106 5 31.3100	46 44 20.976	36851.13	2	36 8 59.6100	106 10 58.5200	226 41 .794
3	0.40761447D 00	0.38359079D 00	46 44 13.900 WT=	1.00000		-0.40725503D 00	-0.38397238D 00	0.70756137D 01
3	36 13 9.4800	106 5 31.3100	124 56 42.724	31399.22	1	36 16 7.2200	106 10 45.6000	304 53 36.907
3	0.53846986D 00	-0.37627366D 00	124 56 42.800 WT=	1.00000		-0.53880861D 00	0.37578842D 00	-0.76383853D-01
3	36 13 9.4800	106 5 31.3100	227 44 26.590	61796.89	8	36 20 0.0750	105 56 12.3540	47 49 57.314
3	-0.24703261D 00	-0.22446166D 00	227 44 27.700 WT=	1.00000				-0.11098763D 01
3	36 13 9.4800	106 5 31.3100	257 25 35.620	42316.01	4	36 14 40.2800	105 57 7.1300	77 30 33.618
3	-0.47574929D 00	-0.10611102D 00	257 25 40.400 WT=	1.00000		0.47590209D 00	0.10542358D 00	-0.47802550D 01
3	36 13 9.4800	106 5 31.3100	277 33 31.111	64238.21	7	36 11 45.2180	105 52 34.4230	97 41 10.028
3	-0.31830357D 00	0.42236933D-01	277 33 35.900 WT=	1.00000				-0.47892613D 01
4	36 14 40.2800	105 57 7.1300	63 15 2.592	76358.99	2	36 8 59.6100	106 10 58.5200	243 6 51.600
4	0.24121756D 00	0.12157986D 00	63 15 1.300 WT=	1.00000		-0.24092747D 00	-0.12215370D 00	0.12917687D 01

PRELIMINARY POSITIONS AND EQUATIONS -- 8 EQUATION PROGRAM CHECKOUT

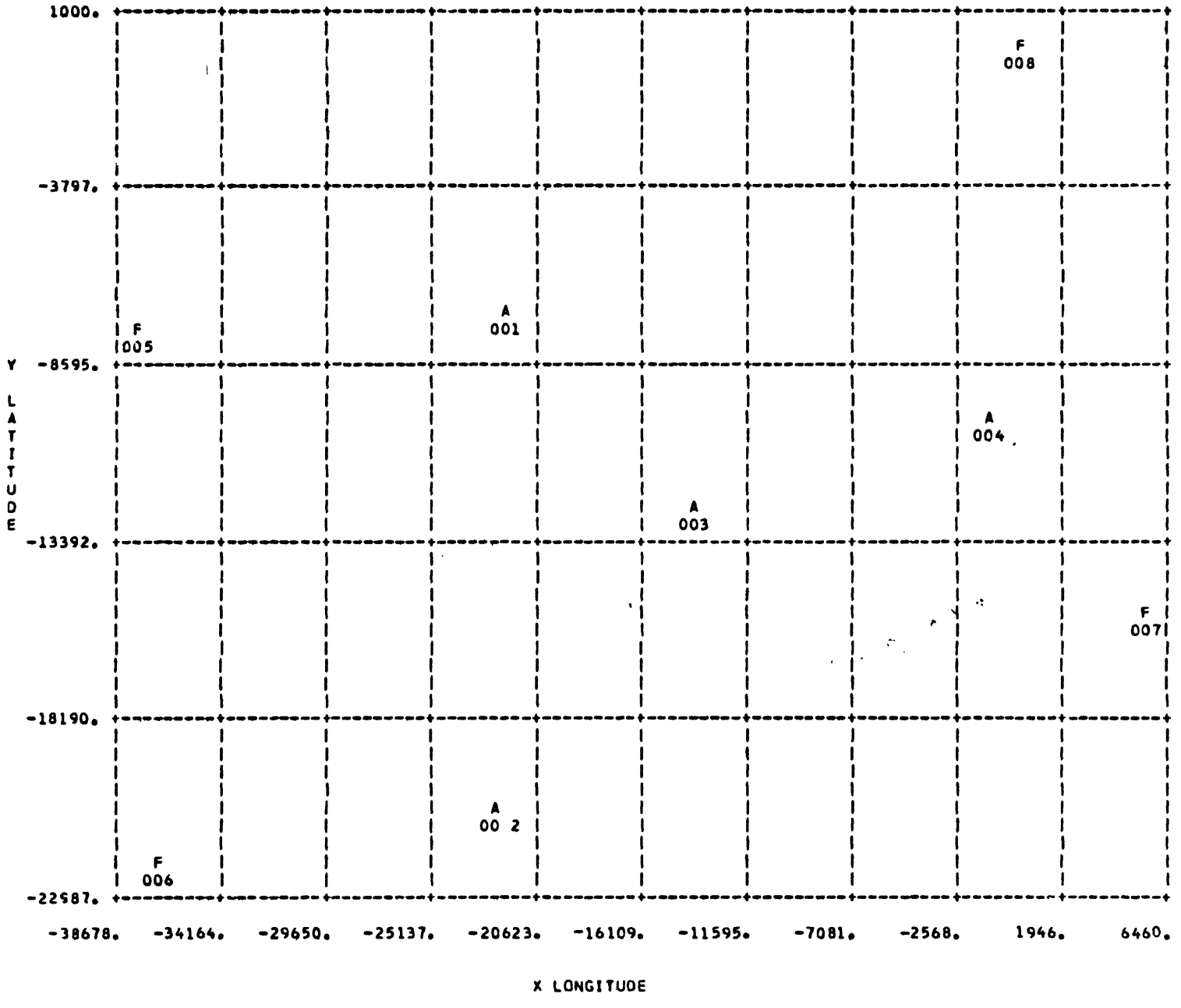
ISPHER= 0 ZONE= 0 0 0 0

B	LAT B	LONG B	AZBA	S	A	LAT A	LONG A	AZAB
4	36 14 40.2800	105 57 7.1300	77 30 33.618	42316.01	3	36 13 9.4800	106 5 31.3100	257 25 35.620
4	0.47590209D 00	0.10542358D 00	77 30 34.200 WT=	1.00000		-0.47574929D 00	-0.10611102D 00	-0.58203338D 00
4	36 14 40.2800	105 57 7.1300	97 32 19.516	67610.77	1	36 16 7.2200	106 10 45.6000	277 24 15.471
4	0.30243986D 00	-0.40025095D-01	97 32 19.500 WT=	1.00000		-0.30253295D 00	0.39315244D-01	0.16259396D-01
4	36 14 40.2800	105 57 7.1300	187 53 26.106	32648.43	8	36 20 0.0750	105 56 12.3540	7 53 58.526
4	-0.86731275D-01	-0.62579393D 00	187 53 22.000 WT=	1.00000				0.41063358D 01
4	36 14 40.2800	105 57 7.1300	308 21 49.673	28508.77	7	36 11 45.2180	105 52 34.4230	128 24 30.813
4	-0.56729667D 00	0.44905047D 00	308 21 52.300 WT=	1.00000				-0.26273517D 01
5	36 15 46.2870	106 21 17.4850	267 36 20.355	51791.73	1	36 16 7.2200	106 10 45.6000	87 42 34.135
5			267 36 18.800 WT=	1.00000		0.39793997D 00	0.15916959D-01	0.15548601D 01
5	36 15 46.2870	106 21 17.4850	308 58 47.401	65303.94	2	36 8 59.6100	106 10 58.5200	129 4 53.021
5			308 58 47.100 WT=	1.00000		0.24518168D 00	-0.19912158D 00	0.30100959D 00
5	36 15 46.2870	106 21 17.4850	356 14 32.576	46572.22	6	36 8 6.7230	106 20 40.2780	176 14 54.550
5			356 14 32.500 WT=	1.00000				0.75965010D-01
6	36 8 6.7230	106 20 40.2780	176 14 54.550	46572.22	5	36 15 46.2870	106 21 17.4850	356 14 32.576
6			176 14 54.400 WT=	1.00000				0.15013501D 00
6	36 8 6.7230	106 20 40.2780	225 2 26.375	68822.81	1	36 16 7.2200	106 10 45.6000	45 8 17.612
6			225 2 22.000 WT=	1.00000		0.21243348D 00	0.21141095D 00	0.43747971D 01
6	36 8 6.7230	106 20 40.2780	263 33 27.319	48016.77	2	36 8 59.6100	106 10 58.5200	83 39 10.438
6			263 33 29.800 WT=	1.00000		0.42693518D 00	0.47489359D-01	-0.24806834D 01
7	36 11 45.2180	105 52 34.4230	79 36 35.615	92063.28	2	36 8 59.6100	106 10 58.5200	259 25 43.949
7			79 36 35.500 WT=	1.00000		-0.22024423D 00	-0.41102717D-01	0.11478090D 00
7	36 11 45.2180	105 52 34.4230	97 41 10.028	64238.21	3	36 13 9.4800	106 5 31.3100	277 33 31.111
7			97 41 16.600 WT=	1.00000		-0.31830357D 00	0.42236933D-01	-0.65719133D 01
7	36 11 45.2180	105 52 34.4230	128 24 30.813	28508.77	4	36 14 40.2800	105 57 7.1300	308 21 49.673
7			128 24 40.900 WT=	1.00000		-0.56729667D 00	0.44905047D 00	-0.10087416D 02
7	36 11 45.2180	105 52 34.4230	160 23 19.317	53129.27	8	36 20 0.0750	105 56 12.3540	340 21 10.407
7			160 23 19.400 WT=	1.00000				-0.83322349D-01

	NORMAL EQUATION SOLUTION VECTOR
1	-0.95010246D 01
2	0.21982318D 01
3	0.7591C971D 01
4	0.42597115D 01
5	-C.897934140 01
6	0.23454888D 01
7	-0.36907295D 01
8	C.68091969D 01

	-BACKSUBSTITUTION CHECK- CONST.TERM	COMPUTED TERM	DIFFERENCE
1	0.517693060 01	0.517693060 01	0.22204460D-14
2	0.14713480D 01	0.14713480D 01	0.22204460D-15
3	-0.90152261D 01	-0.90152261D 01	0.44408921D-15
4	-0.42840682D 01	-0.42840682D 01	0.66613381D-15
5	0.690712930 01	0.690712930 01	0.44408921D-14
6	0.393112630 01	0.393112630 01	0.0
7	0.209924450 01	0.209924450 01	0.44408921D-14
8	-0.630002810 01	-0.630002810 01	-0.222044600-15

PLOT OF ADJUSTED STATIONS---DENOTED BY 'A'
AND FIXED STATIONS---DENOTED BY 'F' WITH STATION NUMBERS PLOTTED BELOW POINTS



X AND Y COORDINATES IN METERS VIA POLYCONIC PROJECTION WITH ORIGIN AT STATION 8

FINAL POSITIONS AND RESIDUALS -- 8 EQUATION PROGRAM CHECKOUT

ISPHER= 0 ZONE= 0 0 0 0

B	LAT B	LONG B	AZBA	S	A	LAT A	LONG A	AZAB
1	36 16 7.2294	106 10 45.5973	1 24 12.460	43255.74	2	36 8 59.6025	106 10 58.5148	181 24 4.829
	0.0094	-0.0027		V= 0.3333E-01		-0.0075	-0.0052	Z= 0.3975E 01
1	36 16 7.2294	106 10 45.5973	45 8 16.060	68823.63	6	36 8 6.7230	106 20 40.2780	225 2 24.821
	0.0094	-0.0027		V= 0.7327E 00				Z= 0.3975E 01
1	36 16 7.2294	106 10 45.5973	87 42 30.391	51791.99	5	36 15 46.2870	106 21 17.4850	267 36 16.609
	0.0094	-0.0027		V= 0.2638E 00				Z= 0.3975E 01
1	36 16 7.2294	106 10 45.5973	251 41 46.770	75260.65	8	36 20 0.0750	105 56 12.3540	71 50 23.754
	0.0094	-0.0027		V= 0.1843E 01				Z= 0.3975E 01
1	36 16 7.2294	106 10 45.5973	277 24 17.044	67611.30	4	36 14 40.2836	105 57 7.1217	97 32 21.093
	0.0094	-0.0027		V=-0.1283E 01		0.0036	-0.0083	Z= 0.3975E 01
1	36 16 7.2294	106 10 45.5973	304 53 37.137	31399.26	3	36 13 9.4889	106 5 31.3071	124 56 42.953
	0.0094	-0.0027		V=-0.1590E 01		0.0089	-0.0029	Z= 0.3975E 01
2	36 8 59.6025	106 10 58.5148	83 39 13.884	48017.11	6	36 8 6.7230	106 20 40.2780	263 33 30.762
	-0.0075	-0.0052		V= 0.2948E 00				Z=-0.2387E 01
2	36 8 59.6025	106 10 58.5148	129 4 54.037	65304.75	5	36 15 46.2870	106 21 17.4850	308 58 48.414
	-0.0075	-0.0052		V=-0.1452E 01				Z=-0.2387E 01
2	36 8 59.6025	106 10 58.5148	181 24 4.829	43255.74	1	36 16 7.2294	106 10 45.5973	1 24 12.460
	-0.0075	-0.0052		V= 0.3975E-01		0.0094	-0.0027	Z=-0.2387E 01
2	36 8 59.6025	106 10 58.5148	243 6 49.192	76359.73	4	36 14 40.2836	105 57 7.1217	63 15 0.185
	-0.0075	-0.0052		V= 0.4020E 00		0.0036	-0.0083	Z=-0.2387E 01
2	36 8 59.6025	106 10 58.5148	259 25 42.105	92063.00	7	36 11 45.2180	105 52 34.4230	79 36 33.768
	-0.0075	-0.0052		V= 0.7158E 00				Z=-0.2387E 01
3	36 13 9.4889	106 5 31.3071	46 44 13.490	36852.13	2	36 8 59.6025	106 10 58.5148	226 41 0.310
	0.0089	-0.0029		V= 0.2494E 00		-0.0075	-0.0052	Z= 0.6613E 00
3	36 13 9.4889	106 5 31.3071	124 56 42.953	31399.26	1	36 16 7.2294	106 10 45.5973	304 53 37.137
	0.0089	-0.0029		V= 0.8126E 00		0.0094	-0.0027	Z= 0.6613E 00
3	36 13 9.4889	106 5 31.3071	227 44 28.284	61796.12	8	36 20 0.0750	105 56 12.3540	47 49 59.005
	0.0089	-0.0029		V= 0.1243E 01				Z= 0.6613E 00
3	36 13 9.4889	106 5 31.3071	257 25 38.606	42316.33	4	36 14 40.2836	105 57 7.1217	77 30 36.607
	0.0089	-0.0029		V=-0.1134E 01		0.0036	-0.0083	Z= 0.6613E 00
3	36 13 9.4889	106 5 31.3071	277 33 34.070	64238.10	7	36 11 45.2180	105 52 34.4230	97 41 12.985
	0.0089	-0.0029		V=-0.1171E 01				Z= 0.6613E 00
4	36 14 40.2836	105 57 7.1217	63 15 0.185	76359.73	2	36 8 59.6025	106 10 58.5148	243 6 49.192
	0.0036	-0.0083		V=-0.2232E 01		-0.0075	-0.0052	Z=-0.1112E 01

FINAL POSITIONS AND RESIDUALS -- 8 EQUATION PROGRAM CHECKOUT
ISPHER= 0 ZONE= 0 0 0 0

B	LAT B	LONG B	AZBA	S	A	LAT A	LONG A	AZAB
4	36 14 40.2836	105 57 7.1217	77 30 36.607	42316.33	3	36 13 9.4889	106 5 31.3071	257 25 38.606
	0.0036	-0.0083		V= 0.1290E 01		0.0089	-0.0029	Z=-0.1112E 01
4	36 14 40.2836	105 57 7.1217	97 32 21.093	67611.30	1	36 16 7.2294	106 10 45.5973	277 24 17.044
	0.0036	-0.0083		V= 0.4763E 00		0.0094	-0.0027	Z=-0.1112E 01
4	36 14 40.2836	105 57 7.1217	187 53 22.170	32647.97	8	36 20 0.0750	105 56 12.3540	7 53 54.585
	0.0036	-0.0083		V=-0.9468E 00				Z=-0.1112E 01
4	36 14 40.2836	105 57 7.1217	308 21 54.829	28508.46	7	36 11 45.2180	105 52 34.4230	128 24 35.964
	0.0036	-0.0083		V= 0.1412E 01				Z=-0.1112E 01
5	36 15 46.2870	106 21 17.4850	267 36 16.609	51791.99	1	36 16 7.2294	106 10 45.5973	87 42 30.391
				V=-0.1924E 01		0.0094	-0.0027	Z= 0.2670E 00
5	36 15 46.2870	106 21 17.4850	308 58 48.414	65304.75	2	36 8 59.6025	106 10 58.5148	129 4 54.037
				V= 0.1581E 01		-0.0075	-0.0052	Z= 0.2670E 00
5	36 15 46.2870	106 21 17.4850	356 14 32.576	46572.22	6	36 8 6.7230	106 20 40.2780	176 14 54.550
				V= 0.3430E 00				Z= 0.2670E 00
6	36 8 6.7230	106 20 40.2780	176 14 54.550	46572.22	5	36 15 46.2870	106 21 17.4850	356 14 32.576
				V=-0.1161E 01				Z=-0.1311E 01
6	36 8 6.7230	106 20 40.2780	225 2 24.821	68823.63	1	36 16 7.2294	106 10 45.5973	45 8 16.060
				V= 0.1510E 01		0.0094	-0.0027	Z=-0.1311E 01
6	36 8 6.7230	106 20 40.2780	263 33 30.762	48017.11	2	36 8 59.6025	106 10 58.5148	83 39 13.884
				V=-0.3488E 00		-0.0075	-0.0052	Z=-0.1311E 01
7	36 11 45.2180	105 52 34.4230	79 36 33.768	92063.00	2	36 8 59.6025	106 10 58.5148	259 25 42.105
				V= 0.8594E 00		-0.0075	-0.0052	Z= 0.2592E 01
7	36 11 45.2180	105 52 34.4230	97 41 12.985	64238.10	3	36 13 9.4889	106 5 31.3071	277 33 34.070
				V=-0.1023E 01		0.0089	-0.0029	Z= 0.2592E 01
7	36 11 45.2180	105 52 34.4230	128 24 35.964	28508.46	4	36 14 40.2836	105 57 7.1217	308 21 54.829
				V=-0.2344E 01		0.0036	-0.0083	Z= 0.2592E 01
7	36 11 45.2180	105 52 34.4230	160 23 19.317	53129.27	8	36 20 0.0750	105 56 12.3540	340 21 10.407
				V= 0.2508E 01				Z= 0.2592E 01

MAX.ABS.RESIDUAL =0.2508E 01 AT LINE 7- 8 P.E. OBS. WT. UNITY =0.1185E 01

```
C ---------------------------------                                        00000200
C WEIGHTED TRIANGULATION ADJUSTMENT (PROGRAM W8250 -- STAND ALONE)        00000300
C ---------------------------------                                        00000400
C     W.L.ANDERSON     U.S.GEOLOGICAL SURVEY                              00000500
C                      COMPUTER CENTER DIVISION                          00000510
C                      WASHINGTON, D.C.                                  00000520
C////////////////////////////  VERSION 3/13/69  ////////////////////////////00000530
C                                                                         00000600
C ***** THIS PROGRAM IS DESIGNED TO HANDLE WEIGHTED OBSERVATION EQS. FOR  00000700
C    (1) WT'D OBSERVED DIRECTIONS (USING ORIENTATED DIRECTIONS)           00000800
C    (2) WT'D OBSERVED AZIMUTHS (ASTRONOMIC AZIMUTHS)                     00000900
C    (3) WT'D OBSERVED DISTANCES (OR LENGTHS)                             00001000
C                                                                         00001100
C    FOLLOWING CODE IS SYSTEM/360 VERSION WITH MAX N = 150 UNKNOWNS.      00001200
C   FILE=7 IS EQUATION FILE (BIN) USED IN PHASE-2 TO COMPUTE RESIDUALS,   00001300
C   FILE=4 IS NORMAL EQ MATRIX FILE (BIN) USED IN BACKSUBSTITUTION        00001400
C   FILE=9 IS OBSERVATION LINE DATA FILE (BIN) USED ALSO IN PHASE-2       00001500
C   FILE=10 IS AN OPTIONAL GRID COORD FILE (BCD) WHEN ZONE(1).NE.0        00001600
C FILES (7,4,9) ARE ALL BINARY SCRATCH TAPE OR DISK FILES.                J0001700
C FILE (10) IS A BCD NINE -TRACK OUTPUT TAPE...     DEFINITIONS AND       00001800
C LIMITS SET FOR THIS VERSION ARE --                                      00001900
C         NS=NO.NEW STATIONS        NS .LE. 75                            00002000
C         NTS=NO.TOTAL STATIONS     NS .LT. NTS .LE. 200                  00002100
C         N=ORDER OF NORMAL EQ MATRIX  N=2*NS       N .LE. 150            00002200
C         LGTOL=LENGTH TOLERANCE..DEFAULT OPTION (IF 0.0 ON INPUT) IS     00002300
C               25.00 FEET                                                00002400
C         AZTOL=AZIMUTH TOLERANCE..DEFAULT OPTION IS 60.000 SECONDS       00002500
C         ISPHER=TYPE OF ELLIPSOID                                        00002600
C               =0 CLARKE 1866 (DEFAULTS TO 0 IF ISPHER .GT. 4 )          00002610
C               =1 CLARKE 1880                                            00002620
C               =2 BESSELL                                                00002630
C               =3 EVEREST                                                00002640
C               =4 INTERNATIONAL                                          00002650
C                                                                         00002700
C                                                                         00002800
      DIMENSION A(11475),PHI(200),LAM(200),MFAC(75),PFAC(75),             00002900
     *          IGN(6),IDEG(6),MIN(6),SECS(6),ID(16),                     00003000
     *          GSTA(2),STERM(2),CTERM(2),ZSTA(76),ZSIN(76),ZCOS(76),     00003100
     *          ZONE(4)                                                   00003200
      INTEGER ZSEQ,ZCNT,ZNO,BSTA,ASTA,G,TYPE,GSTA,ZSTA,COL80,ZONE,FIRSTB  00003400
      EQUIVALENCE (N,M)                                                   00003500
      COMMON /NORM/A   /ORDR/M                                            00003600
      COMMON /HEADS/LINE,ID,ZONE,ISPHER                                   00003700
      COMMON/CRD3/J1,J2                                                   00003800
      COMMON/CRD4/OLG,ZNO,NCZ,BSTA,ASTA,WT                                00003900
      COMMON/CRD5/SECS,IGN,IDEG,MIN,COL80                                 00004000
      COMMON/FAZ2/PHI,LAM,RHO,MFAC,PFAC,NOL,NS,NZ,NTS                     00004100
C                                                                         00004200
C THE FOLLOWING IS MANDATORY DOUBLE PRECISION --                          00004300
C                                                                         00004400
      DOUBLE PRECISION SECS,AZTOL,AVLG,PHI,LAM,ODIR,OAZ,OLG,AZBA,AZAB,    00004500
     *                 DIST,LGTOL,DTEM1,DTEM2,WT,SUMWT,WZ,TLAT,RHO       00004600
C-------------------------------------------------------------------------00004700
      DOUBLE PRECISION A,STERM,CTERM,EQCON,ZSIN,ZCOS,ZCON,                00004800
     *               MFAC,PFAC,ROOTN,ESQ,AFT,PHIB,PHIA,LAMB,LAMA          00004900
C-------------------------------------------------------------------------00005000
      NAMELIST/CARD2/NS,NTS,NZ,ISPHER,LGTOL,AZTOL,COL80                   00005100
      DATA MINUS,ISOUTH,IBLANK/1H-,1HS,4H    /                            00005200
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C                                                                       00005400
C LINE=50 IS USED TO EJECT PAGE AND PRINT HEADING LATER                 00005500
C                                                                       00005600
    1 LINE=50                                                           00005700
      DO 4 IJ=1,11475                                                   00005800
    4 A(IJ)=0.0                                                         00005900
      NREJ=0                                                            00006000
      REWIND 7                                                          00006100
      REWIND 4                                                          00006200
      REWIND 9                                                          00006300
C                                                                       00006400
C READ HEADER CARD (COL80=1) AND CHECK FOR GRID. COORD OPTION (FILE 10) 00006500
C                                                                       00006600
    7 READ(5,500) ID,ZONE,COL80                                         00006700
  500 FORMAT(15A4,A2,4I4,1X,I1)                                         00006800
      IF(COL80.EQ.0) GOTO 900                                           00006900
      IF (COL80.NE.1) GO TO 903                                         00007000
      IF(ZONE(1).NE.0) GO TO 908                                        00007100
C                                                                       00007200
C READ PARAMETER CARD (COL80=2) -- CHECK ALL VALUES AND RANGES          00007300
C                                                                       00007400
    8 READ(5,502) NS,NTS,NZ,ISPHER,LGTOL,AZTOL,COL80                    00007500
  502 FORMAT(I2,2I3,I4,14X,F5.2,F6.3,42X,I1)                            00007600
      IF(COL80.NE.2) GO TO 909                                          00007700
      IF(NS.LE.0.OR.NS.GT.75) GO TO 912                                 00007800
      IF(NS.GE.NTS.OR.NTS.GT.200) GO TO 914                             00007900
      NFS=NTS-NS                                                        00008000
      IF(NFS.LT.2) GO TO 916                                            00008100
C                                                                       00008200
COMPUTE ORDER OF SYSTEM = N = TOTAL UNKNOWNS.  N MUST BE .LE. 150       00008300
C                                                                       00008400
      N=2*NS                                                            00008500
      IF(N.GT.150) GO TO 918                                            00008600
C PRESET ANY DEFAULT PARAMETERS --                                      00008700
      IF(LGTOL.EQ.0.0D0)LGTOL=250.0D0                                   00008800
      IF(AZTOL.EQ.0.0D0) AZTOL=60.0D0                                   00008900
C                                                                       00009100
C READ POSITION CARDS (COL80=3) -- CONVERT TO SECONDS -- PERFORM CHECKS.00009200
C A FLAG FOR MISSING POSITIONS IS 1.0D30 SECONDS..CHECKED AFTER ALL     00009300
C       CARDS READ AND CONVERTED..THUS POSITION CARDS MAY BE IN ANY ORDER00009400
      DO 10 L=1,NTS                                                     00009500
      PHI(L)=1.0D30                                                     00009600
   10 LAM(L)=1.0D30                                                     00009700
      I=0                                                               00009800
   12 READ(5,503) J1,J2,(IGN(J),IDEG(J),MIN(J),SECS(J),J=1,6),COL80     00009900
  503 FORMAT(3X,2I3,3(A1,2I2,F6.4,A1,I3,I2,F6.4),1X,I1)                 00010000
      IF(COL80.NE.3) GO TO 920                                          00010100
      L=J2-J1+1                                                         00010200
      IF(J2.LT.J1.OR.J1.LT.1.OR.J2.LT.1.OR.J1.GT.NTS.OR.J2.GT.NTS.OR.   00010300
     *   L.GT.3) GO TO 924                                              00010400
C                                                                       00010500
CONVERT AND STORE ANGLES TO SECONDS VIA DMS SUBROUTINE (J1,J2 OK HERE)  00010600
C                                                                       00010700
      I=I+L                                                             00010800
      J=1                                                               00010900
      DO 14 L=J1,J2                                                     00011000
      IF(MIN(J).GT.60.OR.MIN(J+1).GT.60.OR.SECS(J).GT.60.0D0.OR.        00011100
     *   SECS(J+1).GT.60.0D0) GO TO 930                                 00011200
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   13 CALL DMS(IGN(J),IDEG(J),MIN(J),SECS(J),PHI(L))                        00011300
      CALL DMS(IGN(J+1),IDEG(J+1),MIN(J+1),SECS(J+1),LAM(L))                00011400
      IF(DABS(PHI(L)).GT.32400.0D1.OR.DABS(LAM(L)).GT.648.0D3) GO TO 928    00011500
      J=J+2                                                                 00011600
   14 CONTINUE                                                              00011700
      IF(I-NTS) 12,16,926                                                   00011800
C                                                                           00011900
CHECK IF ALL NTS-CONVERSIONS HAVE BEEN PERPORMED PROPERLY --                00012000
C                                                                           00012100
   16 DO 18 I=1,NTS                                                         00012200
      IF(PHI(I).EQ.1.0D30.OR.LAM(I).EQ.1.0D30) GO TO 927                    00012300
   18 CONTINUE                                                              00012310
C                                                                           00012400
COMPUTE MFAC AND PFAC -- USED LATER IN FINAL POSITION CALCULATION,          00012500
C       DOUBLE PRECISION VARIABLES --- OLG AND DIST USED AS TEMP HERE,      00012600
      RHO=206264.80624709640D0                                              00012700
      GO TO (19,20,21,22),ISPHER                                            00012710
      AFT=6378206.400                                                       00012720
      ESQ=6.768657997291 D-3                                                00012730
      GO TO 23                                                              00012740
   19 AFT=6378249.0D0                                                       00012750
      ESQ=6.803425359830 D-3                                                00012760
      GO TO 23                                                              00012770
   20 AFT=6377397.0D0                                                       00012780
      ESQ=6.674312325543 D-3                                                00012790
      GO TO 23                                                              00012800
   21 AFT=6377276.000                                                       00012810
      ESQ=6.637868287356 D-3                                                00012820
      GO TO 23                                                              00012830
   22 AFT=6378388.0D0                                                       00012840
      ESQ=6.722670022333 D-3                                                00012850
   23 AFT=AFT*3.28083333333333                                              00012860
      DO 25 I=1,NS                                                          00012870
      OLG=PHI(I)/RHO                                                        00012880
      MFAC(I)=RHO*(DSQRT(1.0D0-ESQ*DSIN(OLG)**2))**3/(AFT*(1.0D0-ESQ))      00012890
   25 PFAC(I)=RHO*DSQRT(1.0D0-ESQ*DSIN(OLG)**2)/(AFT*DCOS(OLG))             00013200
C                                                                           00013300
C PRESET FOR PROCESSING OB.LINE DATA AND FIRST Z-EQ.                        00013400
C                                                                           00013500
      ZCON=0.0                                                              00013600
      ZSEQ=0                                                                00013700
      ZCNT=0                                                                00013800
      LNCZ=0                                                                00013900
      KNO=0                                                                 00014000
      INO=0                                                                 00014100
C**********************************                                        00014200
C READ OB. LINE DATA CARD (COL80=4) -- CHECK AND CONVERT DATA               00014300
C**********************************                                        00014400
   24 READ(5.504) ZNO,NCZ,OSTA,ASTA,IDEG(1),MIN(1),SECS(1),IGN(2),          00014500
     *            IDEG(2),MIN(2),SECS(2),WT,OLG,COL80                      00014600
  504 FORMAT(2X,I3,I2,3I3,I2,F5.3,A1,I3,I2,F5.3,F10.5,F8.2,27X,I1)          00014700
      IF(COL80.EQ.9) GO TO 950                                              00014800
      IF(COL80.NE.4) GO TO 932                                              00014900
C                                                                           00015000
C SET WT=1.000 IF ZERO ON INPUT (NEGATIVE WTS ARE MADE POSITIVE)            00015100
C                                                                           00015200
      IF(WT.EQ.0.000) WT=1.000                                              00015300
      WT=DABS(WT)                                                           00015400
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C                                                                       00015500
CONVERT ODIR AND OAZ TO SECONDS AND FLUSH DATA IF NOT IN RANGE          00015600
C                                                                       00015700
      DO 26 I=1,2                                                       00015800
      IF(MIN(I).GT.60.OR.SECS(I).GT.60.0D0) GO TO 936                   00015900
   26 CONTINUE                                                          00015910
   27 CALL DMS(IBLANK,IDEG(1),MIN(1),SECS(1),ODIR)                      00016000
      CALL DMS(IGN(2),IDEG(2),MIN(2),SECS(2),OAZ)                       00016100
      IF(OAZ.LT.0.0D0.OR.ODIR.GE.1296.003.OR.OAZ.GE.1296.0D3)GO TO 938  00016200
      IGNOAZ=IGN(2)                                                     00016300
C                                                                       00016400
CHECK FOR LEGITIMATE BSTA AND ASTA VALUES                               00016500
C                                                                       00016600
      IF(BSTA.LT.1.OR.BSTA.GT.NTS.OR.ASTA.LT.1.OR.ASTA.GT.NTS.OR.       00016700
     *   BSTA.EQ.ASTA) GO TO 948                                        00016800
C                                                                       00016900
C TEST AND SET PROPER 'TYPE' OBS. EQ WITH                               00017000
C    TYPE=1 FOR ODIP..(ZNO .GT. 0)**USE TYPE=-1 FOR ASSOC. Z-EQ.****   00017100
C    TYPE=2 FOR OAZ...(ZNO .EQ. 0 .AND. OLG=0.0D0)                      00017200
C    TYPE=3 FOR OLG....(ZNO .EQ. 0 .AND. OLG .GT. 0.0D0)                00017300
C                                                                       00017400
      IF(ZNO-ZSEQ) 942,28,30                                            00017500
   28 IF(ZNO) 942,32,34                                                 00017600
   34 ZCNT=ZCNT+1                                                       00017700
      GO TO 40                                                          00017800
C                                                                       00017900
C ZNO=0 FLAG FOR TYPE 2 OR 3 OB.EQ.                                     00018000
C                SET'TYPE'TO PRINT AND PROCESS OB.EQ.                   00018100
C                                                                       00018200
   32 ISWICH=2                                                          00018300
      TYPE=2                                                            00018400
      IF(OLG.GT.0.0D0) TYPE=3                                           00018500
      WRITE(9) ZNO,BSTA,ASTA                                            00018600
      GO TO 41                                                          00018700
   30 ZSEQ=ZSEQ+1                                                       00018800
      IF(ZNO.NE.ZSEQ.OR.ZCNT.NE.LNCZ.OR.NCZ.LT.2) GO TO 942             00018900
C                                                                       00019000
C WRITE LAST Z-EQ.ACCUMULATED AND PREPARE FOR NEXT Z-EQ -- ACCUM NORMAL 00019100
C        EQS USING CURRENT Z-EQ AND RETURN TO PROCESS GIVEN OB.EQ.      00019200
C                                                                       00019300
      IF(ZNO.EQ.1) GO TO 39                                             00019400
      IFLAGZ=1                                                          00019500
   33 G=0                                                               00019600
      TYPE=-1                                                           00019700
      LZNO=ZNO-1                                                        00019800
      IOB=LNCZ                                                          00019900
   31 ROOTN=DSQRT(DFLOAT(LNCZ))                                         00020000
      EQCON=ZCON/ROOTN                                                  00020100
C                                                                       00020200
COMPUTE WT FOR Z-EQ   (NOTE SUMWT .GT. 0 FOR ALL Z-EQS)                 00020300
C                                                                       00020400
      WZ=DFLOAT(LNCZ)/SUMWT                                             00020500
C                                                                       00020600
C DETERMINE G AS ACCUMULATED FOR THIS LZNO -- 0.GT.G.LE.NS              00020700
C     STORE ZSTA,ZSIN,ZCOS CONSECUTIVELY FOR OUTPUT RECORD              00020800
      DO 36 I=1,NS                                                      00020900
      J=ZSTA(I)                                                         00021000
      IF(J.EQ.0) GO TO 36                                               00021100
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      G=G+1                                                                  00021200
      ZSTA(G)=J                                                              00021300
      ZSIN(G)=ZSIN(J)/ROOTN                                                  00021400
      ZCOS(G)=ZCOS(J)/ROOTN                                                  00021500
   36 CONTINUE                                                               00021600
      IF(G.EQ.0) GO TO 946                                                   00021700
C WRITE EQ.FILE FOR LAST Z-EQ ACCUMULATED                                    00021800
      IG=G+1                                                                 00021900
      WRITE(7)IG,LZNO,TYPE,IOB,WZ,EQCON,(ZSTA(I),ZSIN(I),ZCOS(I),I=1,IG)     00022000
C                                                                            00022100
C ACCUMLATE NORMAL EQS FOR THIS  Z-EQ  (ONE=-1.0 TO SUBTR Z TERMS,ETC)       00022200
C                                                                            00022300
   37 CALL NORMAL(-1.0D0,WZ,G,ZSTA,ZSIN,ZCOS,EQCON)                          00022400
C                                                                            00022500
C PREPARE FOR NEXT Z-EQ FOR CURRENT ZNO HAVING NCZ VALUES(IF IFLAGZ=1)       00022600
C                                                                            00022700
      GO TO (39,954),IFLAGZ                                                  00022800
   39 ZCNT=1                                                                 00022900
      LNCZ=NCZ                                                               00023000
      FIPSTB=BSTA                                                            00023100
      ZCON=0.0D0                                                             00023200
      SUMWT=0.0D0                                                            00023300
      DO 38 I=1,NS                                                           00023400
      ZSTA(I)=0                                                              00023500
      ZSIN(I)=0.0                                                            00023600
   38 ZCOS(I)=0.0                                                            00023700
C                                                                            00023800
C PROCESS THE GIVEN OBSERVATION(SWITCH ON TYPE BELOW)                        00023900
C                                                                            00024000
   40 TYPE=1                                                                 00024100
      INO=INO+1                                                              00024200
      IOB=INO                                                                00024300
      IF(BSTA.NE.FIRSTB) GO TO 942                                           00024400
C                                                                            00024500
COMPUTE PRELIMINARY INVERSE TO OBTAIN ASSUMED AZIMUTHS AND LENGTH FOR        00024600
C     THIS OBSERVED LINE -- BSTA TO ASTA.                                    00024700
C                                                                            00024800
      ISWICH=1                                                               00024900
   41 PHIB=PHI(BSTA)/RHO                                                     00024910
      PHIA=PHI(ASTA)/RHO                                                     00024920
      LAMB=LAM(BSTA)/RHO                                                     00024930
      LAMA=LAM(ASTA)/RHO                                                     00024940
      CALL GEDINV(ISPHER,PHIB,LAMB,AZBA,DIST,AZAB,PHIA,LAMA)                 00024950
      AZBA=AZBA*RHO                                                          00024960
      AZAB=AZAB*RHO                                                          00025000
      CALL PAGECK(0)                                                         00025100
C                                                                            00025200
C PRINT PRELIMINARY POSITION LINE AS DEFINED ON OB.CARD                      00025300
C                                                                            00025400
      CALL SMD(PHI(BSTA),IGN(1),IDEG(1),MIN(1),SECS(1))                      00025500
      CALL SMD(LAM(BSTA),IGN(2),IDEG(2),MIN(2),SECS(2))                      00025600
      CALL SMD(AZBA,IGN(3),IDEG(3),MIN(3),SECS(3))                           00025700
      CALL SMD(PHI(ASTA),IGN(4),IDEG(4),MIN(4),SECS(4))                      00025800
      CALL SMD(LAM(ASTA),IGN(5),IDEG(5),MIN(5),SECS(5))                      00025900
      CALL SMD(AZAB,IGN(6),IDEG(6),MIN(6),SECS(6))                           00026000
      WRITE(6,621) BSTA,(IGN(I),IDEG(I),MIN(I),SECS(I),I=1,3),DIST,          00026100
     *             ASTA,(IGN(I),IDEG(I),MIN(I),SECS(I),I=4,6)                00026200
      LINE=LINE+1                                                            00026300
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  621 FORMAT(1HO,I3,2X,A1,I2,I3,F8.4,2X,A1,2I3,F8.4,1X,A1,2I3,F7.3,4X,  00026400
     *       F10.2,4X,I3,2X,A1,I2,I3,F8.4,2X,A1,2I3,F8.4,1X,A1,2I3,F7.3)00026500
C                                                                       00026600
C SWITCH TO PROCESS WT'D OB EQ (TYPE=1),OR                              00026700
C                  WT'D OB AZ (TYPE=2),OR                               00026800
C                  WT'D OB LD (TYPE=3)                                  00026900
C                                                                       00027000
      GO TO (42,44,66),TYPE                                             00027100
C                                                                       00027200
C-------------------                                                    00027300
C                                                                       00027400
C--------------                                                         00027500
CONSTRUCT OB.EQ COEFFICIENTS (ISWICH=1 -- SEE STMT 41) IF OB.IS ACCEPTED00027600
C                                                                       00027700
   42 EQCON=AZBA-ODIR                                                   00027800
   43 IF(DABS(EQCON).GT.AZTOL) GO TO 940                                00027900
C                                                                       00028000
CHECK ON AZTOL PASSES FOR THIS OB.-- WRITE OB.LINE DATA FILE=9,ETC      00028100
C                                                                       00028200
      WRITE(9) ZNO,BSTA,ASTA                                            00028300
      DTEM1=RHO/(DIST*10.000)                                           00028400
      IF(BSTA.GT.NS) GO TO 46                                           00028500
      G=1                                                               00028600
      GSTA(1)=BSTA                                                      00028700
      DTEM2=AZBA*.4848136811095360-5                                    00028800
      STERM(1)=DTEM1*DSIN(DTEM2)                                        00028900
      CTERM(1)=DTEM1*DCOS(DTEM2)                                        00029000
      IF(ASTA-NS) 48,48,50                                              00029100
   46 IF(ASTA.GT.NS) GO TO 52                                           00029200
      G=1                                                               00029300
   49 GSTA(G)=ASTA                                                      00029400
      DTEM2=AZAB*.4848136811095360-5                                    00029500
      STERM(G)=DTEM1*DSIN(DTEM2)                                        00029600
      CTERM(G)=DTEM1*DCOS(DTEM2)                                        00029700
      GO TO 50                                                          00029800
   48 G=2                                                               00029900
      GO TO 49                                                          00030000
C******                                                                 00030100
C WRITE OB.EQ.(G=1 OR 2 HERE) FILE AND PRINT EQ. COEFFICIENTS           00030200
   50 IG=G+1                                                            00030300
      WRITE(7)IG,ZNO,TYPE,IOB,WT,EQCON,(GSTA(I),STERM(I),CTERM(I),I=1,IG00030400
     *)                                                                 00030410
      CALL SMD(ODIR,IGN(1),IDEG(1),MIN(1),SECS(1))                      00030500
      IF(G.EQ.1) GO TO 54                                               00030600
      WRITE(6,622) ZNO,STERM(1),CTERM(1),IDEG(1),MIN(1),SECS(1),        00030700
     *             WT,STERM(2),CTERM(2),EQCON                           00030800
  622 FORMAT(1H ,I3,2E16.8,3X,2I3,F7.3,4H WT=,F11.5,6X,3E16.8)          00030900
      GO TO 58                                                          00031000
   52 G=0                                                               00031100
C                                                                       00031200
C SPECIAL CASE -- BOTH BSTA AND ASTA FIXED (G=0) -- DUMMY COEFFS HERE --00031300
C                                                                       00031400
      IG=G+1                                                            00031500
      WRITE(7)IG,ZNO,TYPE,IOB,WT,EQCON,(GSTA(I),STERM(I),CTERM(I),I=1,IG00031510
     *)                                                                 00031520
      ZCON=ZCON+WT*EQCON                                                00031600
      SUMWT=SUMWT+WT                                                    00031700
      CALL SMD(ODIR,IGN(1),IDEG(1),MIN(1),SECS(1))                      00031800
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      WRITE(6,625) ZNO,IDEG(1),MIN(1),SECS(1),WT,EQCON                  00031900
  625 FORMAT(1H ,I3,35X,2I3,F7.3,4H WT=,F11.5,39X,E15.8)                00032000
      LINE=LINE+1                                                       00032100
C                                                                       00032200
C GO TO NEXT OBSERVATION                                                00032300
C                                                                       00032400
      GO TO 24                                                          00032500
   54 IF(BSTA.LE.NS) GO TO 56                                           00032600
      WRITE(6,623) ZNO,IDEG(1),MIN(1),SECS(1),WT,STERM(1),CTERM(1),EQCON00032700
  623 FORMAT(1H ,I3,35X,2I3,F7.3,4H WT=,F11.5,6X,3E16.8)                00032800
      GO TO 58                                                          00032900
   56 WRITE(6,624) ZNO,STERM(1),CTERM(1),IDEG(1),MIN(1),SECS(1),WT,EQCON00033000
  624 FORMAT(1H ,I3,2E16.8,3X,2I3,F7.3,4H WT=,F11.5,39X,E15.8)          00033100
   58 LINE=LINE+1                                                       00033200
C                                                                       00033300
C ADD OB.COEFFICIENTS INTO CURRENT Z-EQ  (ZSTA(J)=J FLAGS Z-EQ.TERM)    00033400
C                                                                       00033500
      DO 60 I=1,G                                                       00033600
      J=GSTA(I)                                                         00033700
      ZSTA(J)=J                                                         00033800
      ZSIN(J)=ZSIN(J)+WT*STERM(I)                                       00033900
      ZCOS(J)=ZCOS(J)+WT*CTERM(I)                                       00034000
   60 CONTINUE                                                          00034100
      IF(G.EQ.2.AND.BSTA.GT.ASTA) CALL ASCEND(GSTA,STERM,CTERM)         00034200
C                                                                       00034300
C ACCUMULATE OB.EQ INTO NORMAL EQS (ONE=+1.0 TO ADD PRODUCTS,ETC)       00034400
C                                                                       00034500
   61 CALL NORMAL(1.0D0,WT,G,GSTA,STERM,CTERM,EQCON)                    00034600
      ZCON=ZCON+WT*EQCON                                                00034700
      SUMWT=SUMWT+WT                                                    00034800
C GO TO NEXT OBSERVATION                                                00034900
C                                                                       00035000
      GO TO 24                                                          00035100
C------------------                                                     00035200
C TEST FOR SPECIAL CASE OF DUE SOUTH FOR AZ OBSERVATION                 00035300
C                                                                       00035400
   44 CONTINUE                                                          00035500
      IF(OAZ.NE.0.0D0) GO TO 62                                         00035600
      IF(IGNOAZ.EQ.MINUS.OR.IGNOAZ.EQ.ISOUTH) GO TO 62                  00035700
   64 CONTINUE                                                          00035800
C                                                                       00035900
C                                                                       00036000
C                                                                       00036100
C AZIMUTH OB. EQ. PROCESSING -- CONSTRUCT COEFFICIENTS (NO Z-EQ)        00036200
C                                                                       00036300
   62 INO=INO+1                                                         00036400
      IOB=INO                                                           00036500
      EQCON=AZBA-OAZ                                                    00036600
   63 IF(DABS(EQCON).GT.AZTOL) GO TO 956                                00036700
 6363 DTEM1=RHO/(DIST*10.0D0)                                           00036800
      IF(BSTA.GT.NS) GO TO 65                                           00036900
      G=1                                                               00037000
      GSTA(1)=BSTA                                                      00037100
      DTEM2=AZBA*.4848136811095360-5                                    00037200
      STERM(1)=DTEM1*DSIN(DTEM2)                                        00037300
      CTERM(1)=DTEM1*DCOS(DTEM2)                                        00037400
      IF(ASTA-NS) 67,67,70                                              00037500
   65 IF(ASTA.GT.NS) GO TO 958                                          00037600
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      G=1                                                                00037700
   68 GSTA(G)=ASTA                                                       00037800
      DTEM2=AZAB*.4848136811095360-5                                     00037900
      STERM(G)=DTEM1*DSIN(DTEM2)                                         00038000
      CTERM(G)=DTEM1*DCOS(DTEM2)                                         00038100
      GO TO 70                                                           00038200
   67 G=2                                                                00038300
      GO TO 68                                                           00038400
C                                                                        00038500
C LENGTH OB. EQ. PROCESSING -- CONSTRUCT COEFFICIENTS (NO Z-EQ)          00038600
C                                                                        00038700
   66 CONTINUE                                                           00038800
      INC=INO+1                                                          00038900
      IOB=INO                                                            00039000
      EQCON=(DIST-OLG)*10.000                                            00039100
   71 IF(DABS(EQCON).GT.LGTOL) GO TO 960                                 00039200
      IF(BSTA.GT.NS) GO TO 72                                            00039400
      G=1                                                                00039500
      GSTA(1)=BSTA                                                       00039600
      DTEM2=AZBA*.4848136811095360-5                                     00039700
      STERM(1)=-DCOS(DTEM2)                                              00039800
      CTERM(1)= DSIN(DTEM2)                                              00039900
      IF(ASTA-NS) 73,73,70                                               00040000
   72 IF(ASTA.GT.NS) GO TO 958                                           00040100
      G=1                                                                00040200
   74 GSTA(G)=ASTA                                                       00040300
      DTEM2=A?AB*.4848136811095360-5                                     00040400
      STERM(G)=-DCOS(DTEM2)                                              00040500
      CTERM(G)= DSIN(DTEM2)                                              00040600
      GO TO 70                                                           00040700
   73 G=2                                                                00040800
      GO TO 74                                                           00040900
C-----------                                                             00041000
C WRITE AZ OR LG OB.EQ.(G=1 OR 2) FILE 7 & PRINT COEFFICIENTS            00041100
   70 IG=G+1                                                             00041200
      WRITE(7)IG,ZNO,TYPE,IOB,WT,EQCON,(GSTA(I),STERM(I),CTERM(I),I=1,IG00041300
     *)                                                                  00041310
      IF(TYPE.EQ.3) GO TO 77                                             00041400
C AZ.OB.EQ -- TYPE=2                                                     00041500
      CALL SMD(OAZ,IGN(1),IDEG(1),MIN(1),SECS(1))                        00041600
      IF(G.EQ.1) GO TO 75                                                00041700
      WRITE(6,630) STERM(1),CTERM(1),IDEG(1),MIN(1),SECS(1),WT,          00041800
     *             STERM(2),CTERM(2),EQCON                               00041900
  630 FORMAT(5H AZEQ,E15.8,E16.8,3X,2I3,F7.3,4H WT=,F11.5,6X,3E16.8)      00042000
      GO TO 80                                                           00042100
   75 IF(BSTA.LE.NS) GO TO 76                                            00042200
      WRITE(6,631) IDEG(1),MIN(1),SECS(1),WT,STERM(1),CTERM(1),EQCON     00042300
  631 FORMAT(5H AZEQ,34X,2I3,F7.3,4H WT=,F11.5,6X,3E16.8)                00042400
      GO TO 80                                                           00042500
   76 WRITE(6,632) STERM(1),CTERM(1),IDEG(1),MIN(1),SECS(1),WT,EQCON     00042600
  632 FORMAT(5H AZEQ,E15.8,E16.8,3X,2I3,F7.3,4H WT=,F11.5,39X,E15.8)     00042700
      GO TO 80                                                           00042800
C LG.OB.EQ -- TYPE=3                                                     00042900
   77 IF(G.EQ.1) GO TO 78                                                00043000
      WRITE(6,633) STERM(1),CTERM(1),WT,OLG,STERM(2),CTERM(2),EQCON      00043100
  633 FORMAT(5H LGEQ,E15.8,E16.8,5H  WT=,F11.5,4X,F10.2,7X,3E16.8)       00043200
      GO TO 80                                                           00043300
   78 IF(BSTA.LE.NS) GO TO 79                                            00043400
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      WRITE(6,634) WT,OLG,STERM(1),CTERM(1),EQCON                        00043500
  634 FORMAT(5H LGEQ,33X,3HWT=,F11.5,4X,F10.2,7X,3E16.8)                 00043600
      GO TO 80                                                           00043700
   79 WRITE(6,635) STERM(1),CTERM(1),WT,OLG,EQCON                        00043800
  635 FORMAT(5H LGEQ,E15.8,E16.8,5H  WT=,F11.5,4X,F10.2,40X,E15.8)       00043900
   80 LINE=LINE+1                                                        00044000
      IF(G.EQ.2.AND.BSTA.GT.ASTA) CALL ASCEND(GSTA,STERM,CTERM)          00044100
C                                                                        00044200
C ACCUM AZ OR LG EQ INTC NORMAL EQS (ONE=+1.0 TO ADD PRODUCTS)           00044300
C                                                                        00044400
      CALL NORMAL(1.0D0,WT,G,GSTA,STERM,CTERM,EQCON)                     00044500
C                                                                        00044600
C               GO TO NEXT OB --                                         00044700
      GO TO 24                                                           00044800
C                                                                        00044900
C-----------/ P H A S E    2 /----------                                 00045000
C OK TO START PHASE-2 SINCE NREJ=0 ..NORMAL EQS A FORMED HERE BUT FIRST  00045100
CHECK IF NOL.GT.N IN ORDER TO PERFORM LEAST SQUARES -- ALSO              00045200
C    SAVE NORMAL EQS ON FILE=4 FOR CHECK PURPOSES IN BACKSUBSTITUTION    00045300
CHECK,ETC...          (SEE STMT 954)                                     00045400
C                                                                        00045500
   82 NOL=IND                                                            00045600
      IF(NOL.LE.N) GO TO 962                                             00045700
      CALL PHASE2                                                        00045800
C                                                                        00045900
C GO TO NEXT PROBLEM(IF ANY)                                             00046000
C                                                                        00046100
      GO TO 1                                                            00046200
C-------------------------------------------------------------------------00046300
C-------------------------------------------------------------------------00046400
C EOF CARD READ (COL80=0) AT STATEMENT 7  (PSEUDO EOF BEFORE ACTUAL EOF) 00046500
C                                                                        00046600
  900 STOP                                                               00046700
C                                                                        00046900
C HEADER CARD ERROR -- COL80.NE.1 --DATA SET FLUSHED (SEE STMT 7)         00047000
C                                                                        00047100
  903 WRITE(6,600)                                                       00047200
  600 FORMAT(32H1 HEADER CARD ERROR - COL80.NE.1)                        00047300
      WRITE(6,606)                                                       00047400
      WRITE(6,641) ID,ZONE,COL80                                         00047500
  641 FORMAT(1H ,15A4,A2,4I4,1X,I1)                                      00047600
C-------------------                                                     00047700
C A CARD ERROR HAS BEEN DETECTED --                                      00047800
C FLUSH REST OF CURRENT DATA SET UNTIL END-OB-CARD OR EOF FOUND -         00047900
C                                                                        00048000
  905 READ(5,501) COL80                                                  00048100
  501 FORMAT(79X,I1)                                                     00048200
      IF(COL80.EQ.9) GO TO 1                                             00048300
      IF (COL80.EQ.0) GO TO 900                                          00048400
      GO TO 906                                                          00048500
C                                                                        00048600
C GRID COORD. OPTION - ZONE(1).NE.0 -- PREPARE FOR FILE 10               00048700
C                                                                        00048800
  908 COL80=0                                                            00048900
      WRITE(10,500) ID,ZONE,COL80                                        00049000
      GO TO 944                                                          00049100
C                                                                        00049200
C PARAMETER CARD ERROR -- COL80.NE.2 -- DATA SET FLUSHED (SEE STMT 8)     00049300
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C                                                                       00049400
  909 WRITE(6,601)                                                      00049500
  601 FORMAT(35H1 PARAMETER CARD ERROR - COL80.NE.2)                     00049600
C                                                                       00049700
C PRINT PARA CARD CONTENTS AND FLUSH REST OF DATA SET BECAUSE OF         00049800
C           SOME NON-RECOVERABLE ERROR                                  00049900
C                                                                       00050000
  910 WRITE(6,606)                                                      00050100
  606 FORMAT(//40H DATA SET FLUSHED FROM FOLLOWING CARD --/)             00050200
      WRITE(6,CARD2)                                                    00050300
      GO TO 906                                                         00050400
C                                                                       00050500
C PARAMETER CARD ERROR IN NS VALUE -- DATA SET FLUSHED (SEE STMT 8)     00050600
C                                                                       00050700
  912 WRITE(6,602)                                                      00050800
  602 FORMAT(49H1 PARAMETER CARD ERROR -- NS NOT BETWEEN 1 AND 75)      00050900
      GO TO 910                                                         00051000
C                                                                       00051100
C PARA. CARD ERROR IN NS OR NTS --  DATA SET FLUSHED (SEE STMT 8)       00051200
C                                                                       00051300
  914 WRITE(6,603)                                                      00051400
  603 FORMAT(51H1 PARAMETER CARD ERROR -- NS.GE.NTS .OR. NTS.GT.200)     00051500
      GO TO 910                                                         00051600
C                                                                       00051700
C PARA. CARD ERROR IN NFS -- DATA SET FLUSHED (SEE STMT 8)              00051800
C                                                                       00051900
  916 WRITE(6,604) NFS                                                  00052000
  604 FORMAT('1 PARAMETER CARD ERROR -- NO.FIXED STATIONS =',I6)        00052100
      GO TO 910                                                         00052200
C                                                                       00052300
C PARA. CARD ERROR -- N.GT.150 -- DATA SET FLUSHED (SEE STMT 8)         00052400
C                                                                       00052500
  918 WRITE(6,605) N                                                    00052600
  605 FORMAT(50H1 PARAMETER CARD ERROR -- COMPUTED MATRIX ORDER N=,I6)   00052700
      GO TO 910                                                         00052800
C                                                                       00052900
C POSITION CARD ERROR -- COL80 .NE. 3 -- FLUSH DATA (SEE STMT 12)       00053000
C                                                                       00053100
  920 WRITE(6,607)                                                      00053200
  607 FORMAT(35H1 POSITION CARD ERROR -- COL80.NE.3)                     00053300
C                                                                       00053400
C PRINT POSITION CARD CONTENTS AND FLUSH REST OF DATA SET BECAUSE OF     00053500
C       SOME NON-RECOVERABLE ERROR                                      00053600
C                                                                       00053700
  922 WRITE(6,606)                                                      00053800
      CALL CARD3                                                        00053900
      GO TO 906                                                         00054000
C                                                                       00054100
C POSITION CARD ERROR IN J1 AND/OR J2 VALUES -- THUS DATA CANNOT BE     00054200
C          STORED PROPERLY -- FLUSH DATA  (SEE STMT 12)                 00054300
C                                                                       00054400
  924 WRITE(6,608)                                                      00054500
  608 FORMAT(55H1 POSITION CARD ERROR IN J1(COL.4-6) AND/OR J2(COL.7-9))00054600
      GO TO 922                                                         00054700
C                                                                       00054800
C POSITION CARD ERROR -- I.GT.NTS,WHERE I=COUNT OF GIVEN POSITIONS --   00054900
C                        FLUSH DATA  (SEE STMT 12 THRU 14)              00055000
C                                                                       00055100
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  926 WRITE(6,609) NTS                                                          00055200
  609 FORMAT(39H1 POSITION CARDS CONTAIN MORE THAN NTS=,I3,10H POSITIONS00055300
     *     //17H DATA SET FLUSHED//)                                          00055400
      GO TO 906                                                               00055500
C                                                                             00055600
C POSITION CARD ERROR -- I-TH POSITION MISSING -- DATA FLUSHED                00055700
C                        (SEE STMT 10 AND 16)                                 00055800
C                                                                             00055900
  927 WRITE(6,610) I                                                          00056000
  610 FORMAT(71H1 POSTION CARDS HAVE AT LEAST 1  POSITION MISSING BEGINN00056100
     *ING AT STATION ,I3//17H DATA SET FLUSHED//)                             00056200
      GO TO 906                                                               00056300
C                                                                             00056400
C POSITION CARD ERROR -- L-TH ANGLE EXCEEDS RANGE (SEE STMT 14)               00056500
C                                                                             00056600
  928 WRITE(6,611) L                                                          00056700
  611 FORMAT(30H1 POSITION CARD ERROR--STATION,I3,36H LATITUDE OR LONGIT00056800
     *UDE EXCEEDS RANGE)                                                      00056900
      GO TO 922                                                               00057000
C                                                                             00057100
C WARNING ERROR -- MIN OR SECS .GT. 60 ON POSITION CARD                       00057200
C                                                                             00057300
  930 WRITE(6,612) L                                                          00057400
  612 FORMAT(85HO POSITION CARD WARNING -- MIN OR SECS .GT. 60.0 FOR LAT00057500
     *ITUDE OR LONGITUDE OF STATION,I4)                                        00057600
      CALL CARD3                                                              00057700
      LINE=LINE+7                                                             00057800
      GO TO 13                                                                00057900
C                                                                             00058000
C OB.LINE CARD ERROR -- COL80 .NE. 4 -- FLUSH DATA                            00058100
C                                                                             00058200
  932 WRITE(6,613)                                                            00058300
  613 FORMAT(43HO OBSERVATION DATA CARD ERROR -- COL80.NE.4)                   00058400
C                                                                             00058500
C PRINT OB LINE CARD CONTENTS AND FLUSH REST OF DATA SET BECAUSE OF           00058600
C       SOME NON-RECOVERABLE ERROR                                            00058700
C                                                                             00058800
  934 WRITE(6,6666)                                                           00058900
 6666 FORMAT('0$$$$ OBSERVATION REJECTED $$$$'//)                             00058910
      CALL CARD4                                                              00059000
      GO TO 957                                                               00059100
C                                                                             00059200
C WARNING ERROR -- MIN OR SECS .GT. 60 ON OB.LINE CARD                        00059300
C                                                                             00059400
  936 WRITE(6,614)                                                            00059500
  614 FORMAT(76HO OBSERVATION CARD WARNING -- MIN OR SECS .GT. 60 FOR   00059600
     * OBS-DIR(COL14-23)  ,21HOR ASTRO-AZ(COL24-34))                          00059700
      CALL CARD4                                                              00059800
      LINE=LINE+6                                                             00059900
      GO TO 27                                                                00060000
C                                                                             00060100
C OB.CARD ERROR -- ANGLE EXCEEDS RANGE (SEE STMT 27) -- FLUSH DATA            00060200
C                                                                             00060300
  938 WRITE(6,615)                                                            00060400
  615 FORMAT(81HO OBSERVATION CARD ERROR -- OBS-DIR(COL14-23) OR ASTRO-A00060500
     *Z(COL24-34) EXCEEDS RANGE)                                              00060600
      GO TO 934                                                               00060700
C                                                                             00060800
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C OBSERVATION REJECTION -- DUE TO EXCEEDING TOLERANCE (SEE STMT 42+)     00060000
C       UNLESS AZBA & ODIR ARE IN DIFFERENT QUADRANTS                    00061000
  940 IF(EQCON.LT.0.0D0) GO TO 941                                       00061100
      EQCON=EQCON - 1296.0D3                                             00061200
      GO TO 943                                                          00061300
  941 EQCON=EQCON + 1296.0D3                                             00061400
  943 IF(DABS(EQCON).LE.AZTOL) GO TO 43                                  00061500
      EQCON=AZBA-ODIR                                                    00061600
      NREJ=NREJ+1                                                        00061700
      WRITE(6,616) EQCON                                                 00061800
  616 FORMAT(53HO REJECTED OBSERVATION EQUATION -- TOLERANCE EXCEEDED    00061900
     *  53H...DIFFERENCE IN ASSUMED DIR AND OBS-DIR(COL14-23) IS,F12.5   00062000
     *,8H SECONDS/)                                                      00062100
      CALL SMD(ODIR,IGN(1),IDEG(1),MIN(1),SECS(1))                       00062200
      CALL SMD(OAZ,IGN(2),IDEG(2),MIN(2),SECS(2))                        00062300
      CALL CARD4                                                         00062400
      LINE=LINE+7                                                        00062500
      GO TO 24                                                           00062600
C                                                                        00062700
C OB.CARD ERROR IN ZNO,NCZ OR BSTA -- FLUSH DATA                         00062800
C                                                                        00062900
  942 WRITE(6,617) ZSEQ,NCZ,FIRSTB                                       00063000
  617 FORMAT(68HO OBSERVATION CARD ERROR IN ZNO(COL3-5),NCZ(COL6-7),OR 800063100
     *STA(COL8-10)/16H WHICH SHOULD BE, 3I5,13H RESPECTIVELY)             00063200
      GO TO 934                                                          00063300
C                                                                        00063400
CHECK IF ILLEGAL ZONE(L) -- PRINT WARNING IF ILLEGAL BUT CONTINUE---     00063500
C     THIS ONLY CHECKED WHENEVER ZONE(1).NE.0 (SEE STMT 7 AND 908)       00063600
C                                                                        00063700
  944 DO 945 L=1,4                                                       00063800
      IF(ZONE(L).EQ.0) GO TO 945                                         00063900
      LZ=ZONE(L)                                                         00064000
      IZ1=(LZ-3076)/25                                                   00064100
      IZ2=(LZ-3076)*100/25                                               00064200
      IZ3=IZ1*100                                                        00064300
      IF(IZ3-IZ2.NE.0.OR.IZ1.LE.0.OR.IZ2.LE.0.OR.LZ.LT.3101.OR.          00064400
     *   LZ.GT.6326) GO TO 1945                                          00064500
      GO TO 945                                                          00064600
 1945 WRITE(6,618) L,LZ                                                  00064700
  618 FORMAT(54HO HEADER CARD WARNING -- ILLEGAL ZONE NUMBER FOR ZONE(,  00064800
     *       I1, 2H)=,I5//)                                              00064900
      LINE=LINE+3                                                        00065000
  945 CONTINUE                                                           00065100
      GO TO 8                                                            00065200
C                                                                        00065300
C ERROR IN Z-EQ (G = 0) ACCUMULATED -- FLUSH DATA                        00065400
C                                                                        00065500
  946 WRITE(6,619) LZNO                                                  00065600
  619 FORMAT(50HO ERROR IN Z-EQ. ACCUMULATED (0-TERMS) FOR LAST Z=,I4)    00065700
      GO TO 934                                                          00065800
C                                                                        00065900
C OB.CARD ERROR IN BSTA OR ASTA -- FLUSH DATA                            00066000
C                                                                        00066100
  948 WRITE(6,620)                                                       00066200
  620 FORMAT(58HO OBSERVATION CARD ERROR IN BSTA(COL8-10) OR ASTA(COL11-00066300
     *13)                                                                00066400
      GO TO 934                                                          00066500
C                                                                        00066600
```

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C------END-OF-OBSERVATION CARD READ (COL80.EQ.9). PROCESS LAST Z-EQ,ETC 00066700
C                                                                       00066800
  950 IF(ZSEQ.EQ.NZ) GO TO 952                                          00066900
      WRITE(6,626) NZ,ZSEQ                                              00067000
  626 FORMAT(38HOPARAMETER CARD WARNING -- NZ(COL6-8)=,I3,               00067100
     *   14H BUT SHOULD BE,I4//21H LATTER VALUE ASSUMED//)              00067200
      LINE=LINE+5                                                       00067300
      NZ=ZSEQ                                                           00067400
  952 IFLAGZ=2                                                          00067500
      ZNO=NZ+1                                                          00067600
C                                                                       00067700
C WRITE LAST Z-EQ ACCUMULATED(ETC)AND RETURN VIA IFLAGZ=2 SWITCH        00067800
C                                                                       00067900
      GO TO 33                                                          00068000
C                                                                       00068100
C LAST Z-EQ ADDES TO NORMALS -- PREPARE FOR PHASE-2 IF NO REJECTS       00068200
C                                                                       00068300
  954 ENDFILE 9                                                         00068400
      REWIND 9                                                          00068500
      IF(NREJ.EQ.0) GO TO 82                                            00068600
C                                                                       00068700
C TERMINATE PROB DUE TO REJECTED LINES(NREJ.GT.0)                       00068800
C      CHECK TOLERANCES AND/OR OB.DATA AND TRY AGAIN                    00068900
C                                                                       00069000
      WRITE(6,627) NREJ                                                 00069100
  627 FORMAT(24H1PROB TERMINATED DUE TO ,I4,24H REJECTED DATA CARDS----/00069200
     *       51HOCHECK OBSERVATION DATA CARDS AS NOTED ABOVE AND/OR/     00069300
     *       48HOCHECK TOLERANCES SPECIFIED ON PARAMETER CARD2--)        00069400
      WRITE(6,CARD2)                                                    00069500
      GO TO 1                                                           00069600
C                                                                       00069700
C REJECT AZ EQUATION DUE TO EXCEEDING TOLERANCE                         00069800
C        UNLESS AZOA & OAZ ARE IN DIFFERENT QUADRANTS                   00069900
  956 IF(EQCON.LT.0.0D0) GO TO 959                                      00070000
      EQCON=EQCON - 1296.0D3                                            00070100
      GO TO 961                                                         00070200
  959 EQCON=EQCON + 1296.0D3                                            00070300
  961 IF(DABS(EQCON).LE.AZTOL) GO TO 6363                               00070400
      WRITE(6,628)                                                      00070500
  628 FORMAT('0 REJECTED AZIMUTH EQUATION -- TOLERANCE EXCEEDED'/)      00070600
      CALL SMD(ODIR,IGN(1),IDEG(1),MIN(1),SECS(1))                      00070700
      CALL SMD(OAZ,IGN(2),IDEG(2),MIN(2),SECS(2))                       00070800
      CALL CARD4                                                        00070900
      LINE=LINE+7                                                       00071000
  957 NREJ=NREJ+1                                                       00071100
      GO TO 24                                                          00071300
C                                                                       00071400
C SPECIAL CASE -- BOTH STATIONS ARE FIXED  (G=0) FOR AZ OR LG EQUATION  00071500
C                 WRITE  DUMMY COEFFS HERE -- SEE STMT 65 AND 72 --     00071600
  958 G=0                                                               00071700
      IG=G+1                                                            00071800
      WRITE(7)IG,ZNO,TYPE,IOB,WT,EQCON,(GSTA(I),STERM(I),CTERM(I),I=1,IG00071810
     *)                                                                 00071820
      IF(TYPE.EQ.3) GO TO 300                                           00071900
      CALL SMD(OAZ,IGN(1),IDEG(1),MIN(1),SECS(1))                       00072000
      WRITE(6,629) IDEG(1),MIN(1),SECS(1),WT,EQCON                      00072100
  629 FORMAT(5H AZEQ,34X,2I3,F7.3,4H WT=,F11.5,39X,E15.8)               00072200
      LINE=LINE+1                                                       00072300
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      GO TO 24                                                          00072400
  300 WRITE(6,301) WT,OLG,EQCON                                         00072500
  301 FORMAT(5H LGEQ,33X,3HWT=,F11.5,4X,F10.2,40X,E15.8)                00072600
      LINE=LINE+1                                                       00072700
      GO TO 24                                                          00072800
C                                                                       00072900
C REJECT LENGTH EQUATION DUE TO EXCEEDING TOLERANCE                     00073000
C                                                                       00073100
  960 WRITE(6,636)                                                      00073200
  636 FORMAT('0 REJECTED LENGTH EQUATION -- TOLERANCE EXCEEDED'/)       00073300
      CALL SMD(ODIR,IGN(1),IDEG(1),MIN(1),SECS(1))                      00073400
      CALL SMD(OAZ,IGN(2),IDEG(2),MIN(2),SECS(2))                       00073500
      CALL CARD4                                                        00073600
      LINE=LINE+7                                                       00073700
      NREJ=NREJ+1                                                       00073800
      GO TO 24                                                          00073900
C                                                                       00074000
C INSUFFICIENT NO.OBS TO PERFORM LEAST SQUARES -- PROB TERMINATED       00074100
C                                                                       00074200
  962 WRITE(6,637) NOL,N                                                00074300
  637 FORMAT(41H1 CANNOT PERFORM LEAST SQUARES WITH ONLY ,I4,            00074400
     * 24H TOTAL OBSERVATIONS AND ,I4,10H EQUATIONS//                   00074500
     * 19H PROBLEM TERMINATED)                                          00074600
      GO TO 1                                                           00074700
      END                                                               00074800
      SUBROUTINE PHASE2                                                 00074900
C                                                                       00075000
      DIMENSION A(11475),X(150),PHI(200),LAM(200),MFAC(75),PFAC(75),    00075400
     *          IGN(6),IDEG(6),MIN(6),SECS(6),DPHI(75),DLAM(75),        00075500
     *          ZSTA(75),ZSIN(75),ZCOS(75),ZONE(4),ID(16),VZ(100),W(100)00075600
      DIMENSION P(200),Y(200)                                           00075700
      INTEGER      ZCNT,ZNO,BSTA,ASTA,G,TYPE,ZSTA,ZONE                  00075900
      INTEGER*4  SCALE(5)/1,0,0,0,0/                                    00076000
      LOGICAL*1 C(10)/'0','1','2','3','4','5','6','7','8','9'/         00076100
      EQUIVALENCE (N,M)                                                 00076200
      COMMON/NORM/A  /SOL/X  /ORDR/N                                    00076300
      COMMON /HEADS/LINE,ID,ZONE,ISPHER                                 00076400
      COMMON/FAZ2/PHI,LAM,RHO,MFAC,PFAC,NOL,NS,NZ,NTS                   00076500
      DOUBLE PRECISION SECS,AVLG,PHI,LAM,AZBA,AZAB,DIST,DPHI,DLAM,WT    00076600
C-----------------------                                                00076700
      DOUBLE PRECISION A,X,EQSUM,EQCON,ZSIN,ZCOS,ZCON,MFAC,PFAC,RHO,    00076800
     *                 PHIB,PHIA,LAMB,LAMA                              00076810
      N1=IADDR(N,N+1)                                                   00077000
      WRITE(4) (A(IJ),IJ=1,N1)                                          00077100
      CALL SIMEQ(A,N,X,ICHK)                                            00077200
      IF(ICHK.NE.0) GO TO 966                                           00077300
      REWIND 4                                                          00077400
      READ(4) (A(IJ),IJ=1,N1)                                           00077500
      WRITE(6,639)                                                      00077600
  639 FORMAT( 1H1,5X,15HNORMAL EQUATION,30X,24H-BACKSUBSTITUTION CHECK-/00077700
     *  5X,15HSOLUTION VECTOR,23X,27HCONST.TERM    COMPUTED TERM,       00077800
     *  6X,10HDIFFERENCE)                                               00077900
      DO 84 I=1,N                                                       00078000
      EQSUM=0.0                                                         00078100
      DO 85 J=1,N                                                       00078200
   85 EQSUM=EQSUM+X(J)*A(IADDR(I,J))                                    00078300
      EQCON=-A(IADDR(I,N+1))                                            00076400
C ZCON IS USED HERE AS A TEMPORARY VARIABLE (SINGLE OR DOUBLE PRECISION)00078500
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      ZCON=EQCON+EQSUM                                                  00077700
      EQSUM=-EQSUM                                                      00078000
      WRITE(6,640) I,X(I),I,EQCON,EQSUM,ZCON                            00078800
  640 FORMAT(1H ,I3,E17.8,14X,I3,3E17.8)                                00078900
   64 CONTINUE                                                          00079000
C                                                                       00079100
COMPUTE LATITUDE AND LONGITUDE CORRECTION FACTORS                       00079200
C ZCON IS USED HERE AS A TEMPORARY VARIABLE (SINGLE OR DOUBLE PRECISION)00079300
C                                                                       00079400
      DO 86 I=1,NS                                                      00079600
      DPHI(I)=-X(2*I-1)*MFAC(I)/10.0D0                                  00079700
      DLAM(I)=-X(2*I)*PFAC(I)/10.0D0                                    00079800
C                                                                       00079900
COMPUTE THE ADJUSTED POSITIONS - AND STORE OVER PRELIMINARY POSITIONS.  00080000
C       ADJUSTED POSITIONS WILL BE PRINTED LATER WITH THE RESIDUALS...  00080100
C                                                                       00080200
      PHI(I)=PHI(I)+DPHI(I)                                             00080300
      LAM(I)=LAM(I)+DLAM(I)                                             00080400
   86 CONTINUE                                                          00080500
C                                                                       00080600
C PLOT ADJUSTED STATIONS (1 TO NS) AND FIXED STATIONS (NS+1 TO NTS)     00080700
C       USE MATRIX A AS IMAGE AREA FOR PLOTTING                         00080800
C------STATION NUMBERS WILL BE PLOTTED BELOW EACH POINT-------          00080900
      YORG=PHI(NTS)                                                     00081000
      CALL PLOT1(SCALE,5,10,10,10)                                      00081100
      DO 1 I=1,NTS                                                      00081200
      DX=LAM(NTS)-LAM(I)                                                00081300
      DY=PHI(I)                                                         00081400
      CALL POLY(YORG,DY,DX,P(I),Y(I))                                   00081500
    1 CONTINUE                                                          00081600
      XMIN=P(1)                                                         00081700
      XMAX=P(1)                                                         00081800
      YMIN=Y(1)                                                         00081900
      YMAX=Y(1)                                                         00082000
      DO 2 I=2,NTS                                                      00082100
      XMIN=AMIN1(XMIN,P(I))                                             00082200
      XMAX=AMAX1(XMAX,P(I))                                             00082300
      YMIN=AMIN1(YMIN,Y(I))                                             00082400
      YMAX=AMAX1(YMAX,Y(I))                                             00082500
    2 CONTINUE                                                          00082600
      XMIN=AINT(XMIN-1000.)                                             00082700
      XMAX=AINT(XMAX+1000.)                                             00082800
      YMIN=AINT(YMIN-1000.)                                             00082900
      YMAX=AINT(YMAX+1000.)                                             00083000
      CALL PLOT2(A,XMAX,XMIN,YMAX,YMIN)                                 00083100
      CALL PLOT3('A',P,Y,NS)                                            00083200
      L=NS+1                                                            00083300
      DO 3 I=L,NTS                                                      00083400
    3 CALL PLOT3('F',P(I),Y(I),1)                                       00083500
      WRITE(6,4)                                                        00083600
    4 FORMAT('1',20X,'PLOT OF ADJUSTED STATIONS---DENOTED BY ''A'''/    00083700
     *                  28X,'AND FIXED STATIONS---DENOTED BY ''F''',    00083800
     *                  'WITH STATION NUMBERS PLOTTED BELOW POINTS'//)  00083900
      DX=ABS((XMAX-XMIN)/25.0)                                          00084000
      DY=ABS((YMAX-YMIN)/50.0)                                          00084100
      DO 5 I=1,NTS                                                      00084200
      L1=I/100                                                          00084300
      XSYM=P(I)-DX                                                      00084400
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      YSYM=Y(I)-OY                                                      00084500
      CALL PLOT3(C(L1+1),XSYM,YSYM,1)                                   00084600
      L2=(I-100*L1)/10                                                  00084700
      XSYM=P(I)                                                         00084800
      CALL PLOT3(C(L2+1),XSYM,YSYM,1)                                   00084900
      L=I-100*L1-10*L2+1                                                00085000
      XSYM=P(I)+DX                                                      00085100
      CALL PLOT3(C(L),XSYM,YSYM,1)                                      00085200
    5 CONTINUE                                                          00085300
      CALL PLOT4(49,'                    Y LATITUDE                  ')00085400
      WRITE(6,6) NTS                                                    00085500
    6 FORMAT(//50X,' X LONGITUDE'//30X,'X AND Y COORDINATES IN METERS', 00085600
     *  ' VIA POLYCONIC PROJECTION WITH ORIGIN AT STATION',I4)          00085700
      ENDFILE 7                                                         00085800
      REWIND 7                                                          00085900
C                                                                       00086000
C EQ.FILE 7 AND OB.FILE 9 ARE BOTH REWOUND HERE                         00086100
C                                                                       00086200
      LINE=50                                                           00086300
      VMAX=-1.0E30                                                      00086400
      V2SUM=0.0                                                         00086500
C-------------                                                          00086600
C THIS IS BEGINNING POINT FOR EACH NEW Z-EQ FROM OB.EQ.FILE 7           00086700
C      NOTE PARTIAL RESIDUALS, VZ(ZCNT)=V-Z , ARE FORMED FIRST SINCE    00086800
C      Z-EQ OCCURS AFTER EACH SET OF OB.EQS ON FILE 7 FOR A GIVEN ZNO.  00086900
C NOTE ZNO.GE.1 (NEXTZ AT STMT 88 -- NEXTOB AT STMT 90)                 00087000
   88 ZCNT=0                                                            00087100
   90 READ(7)IG,ZNO,TYPE,IOB,WT,EQCON,(ZSTA(I),ZSIN(I),ZCOS(I),I=1,IG)  00087200
      G=IG-1                                                            00087210
      IF(ZNO.EQ.0) GO TO 120                                            00087300
      IF(TYPE.EQ.-1) GO TO 92                                           00087400
C                                                                       00087500
COMPUTE PARTIAL RESIDUAL FOR GIVEN OB.EQ.                               00087600
C                                                                       00087700
      ZCNT=ZCNT+1                                                       00087800
      IF(ZCNT.GT.100) GO TO 968                                         00087900
      IF(G.EQ.2.AND.ZSTA(1).GT.ZSTA(2)) CALL ASCEND(ZSTA,ZSIN,ZCOS)     00088000
      CALL EQVAL(G,ZSTA,ZSIN,ZCOS,EQCON,EQSUM)                          00088100
      VZ(ZCNT)=EQSUM                                                    00088200
      W(ZCNT)=WT                                                        00088300
      GO TO 90                                                          00088400
   92 IF(ZCNT.NE.IOB) GO TO 970                                         00088500
C                                                                       00088600
COMPUTE ZSUM VALUE FOR GIVEN Z-EQ.                                      00088700
C                                                                       00088800
      CALL EQVAL(G,ZSTA,ZSIN,ZCOS,EQCON,EQSUM)                          00088900
C                                                                       00089000
COMPUTE ACTUAL RESIDUAL FOR THIS Z-EQ.                                  00089100
C                                                                       00089200
      ZSUM=EQSUM                                                        00089300
C NOTE WT=ZCNT/SUMWT FOR Z-EQ RECORD (TYPE=-1)                          00089400
      SUMWT=FLOAT(ZCNT)/WT                                              00089500
      ZSUM=-ZSUM*SQRT(FLOAT(ZCNT))/SUMWT                                00089600
      DO 94 I=1,ZCNT                                                    00089700
      VZ(I)=VZ(I)+ZSUM                                                  00089800
   94 V2SUM=V2SUM+W(I)*VZ(I)**2                                         00089900
      LZNO=ZNO                                                          00090000
C                                                                       00090100
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MEMBER NAME W8250

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C READ OB.DATA FILE 9 AND                                                       00090200
COMPUTE THE ADJUSTED FINAL POSITIONS FOR LAST Z-EQ READ FROM EQ.FILE 7          00090300
C NOTE SPECIAL CASE IF ZNO=0 PRIOR TO 1ST Z-EQ.                                 00090400
C                    ***DO NOT USE 'I' BETWEEN STMT 96 AND 98***                00090500
   96 DO 98 I=1,ZCNT                                                            00090600
      READ(9) ZNO,BSTA,ASTA                                                     00090700
      ISWICH=1                                                                  00090800
      IF(ZNO.NE.LZNO) GO TO 972                                                 00090900
C                                                                               00091000
COMPUTE FINAL POSITION FOR THIS OB.DATA LINE USING ADJUSTED AND FIXED           00091100
C     ANGLES AS NOW STORED IN ARRAYS PHI AND LAM.                               00091200
C                                                                               00091300
      PHIB=PHI(BSTA)/RHO                                                        00091400
      PHIA=PHI(ASTA)/RHO                                                        00091410
      LAMB=LAM(BSTA)/RHO                                                        00091420
      LAMA=LAM(ASTA)/RHO                                                        00091430
   97 CALL GEDINV(ISPHER,PHIB,LAMB,AZBA,DIST,AZAB,PHIA,LAMA)                    00091440
      AZBA=AZBA*RHO                                                             00091450
      AZAB=AZAB*RHO                                                             00091460
      CALL PAGECK(1)                                                            00091500
C                                                                               00091600
C PRINT FINAL POSITION LINE FOLLOWED BY CORRECTIONS,RESIDUAL,AND Z VALUE        00091700
C                                                                               00091800
      CALL SMD(PHI(BSTA),IGN(1),IDEG(1),MIN(1),SECS(1))                         00091900
      CALL SMD(LAM(BSTA),IGN(2),IDEG(2),MIN(2),SECS(2))                         00092000
      CALL SMD(AZBA,IGN(3),IDEG(3),MIN(3),SECS(3))                              00092100
      CALL SMD(PHI(ASTA),IGN(4),IDEG(4),MIN(4),SECS(4))                         00092200
      CALL SMD(LAM(ASTA),IGN(5),IDEG(5),MIN(5),SECS(5))                         00092300
      CALL SMD(AZAB,IGN(6),IDEG(6),MIN(6),SECS(6))                              00092400
      WRITE(6,621) BSTA,(IGN(L),IDEG(L),MIN(L),SECS(L),L=1,3),DIST,             00092500
     *             ASTA,(IGN(L),IDEG(L),MIN(L),SECS(L),L=4,6)                   00092600
  621 FORMAT(1HO,I3,2X,A1,I2,I3,F8.4,2X,A1,2I3,F8.4,1X,A1,2I3,F7.3,4X,          00092700
     *       F10.2,4X,I3,2X,A1,I2,I3,F8.4,2X,A1,2I3,F8.4,1X,A1,2I3,F7.3)       00092800
      LINE=LINE+1                                                               00092900
      GO TO (99,107),ISWICH                                                     00093000
   99 V=VZ(I)                                                                   00093100
C PRINT CORRECTIONS FOR ANY ADJUSTED ANGLE,RESIDUAL,AND ASSOCIATED Z VAL        00093200
C                                                                               00093300
      IF(BSTA.LE.NS) GO TO 100                                                  00093400
      IF(ASTA.LE.NS) GO TO 102                                                  00093500
      WRITE(6,644) V,ZSUM                                                       00093600
  644 FORMAT(1H ,53X,2HV=,E11.4,41X,2HZ=,E11.4)                                 00093700
      GO TO 104                                                                 00093800
  100 IF(ASTA.LE.NS) GO TO 101                                                  00093900
      WRITE(6,645) DPHI(BSTA),DLAM(BSTA),V,ZSUM                                 00094000
  645 FORMAT(1H ,2X,2F17.4,17X,2HV=,E11.4,41X,2HZ=,E11.4)                       00094100
      GO TO 104                                                                 00094200
  101 WRITE(6,646) DPHI(BSTA),DLAM(BSTA),V,DPHI(ASTA),DLAM(ASTA),ZSUM           00094300
  646 FORMAT(1H ,2X,2F17.4,17X,2HV=,E11.4,5X,2F17.4,4H   Z=,E11.4)              00094400
      GO TO 104                                                                 00094500
  102 WRITE(6,647) V,DPHI(ASTA),DLAM(ASTA),ZSUM                                 00094600
  647 FORMAT(1H ,53X,2HV=,E11.4,5X,2F17.4,4H   Z=,E11.4)                        00094700
  104 LINE=LINE+1                                                               00094800
      IF(ABS(V).LE.VMAX) GO TO 98                                               00094900
C                                                                               00095000
C SAVE LINE(MXB-MXA) AT MAX RESIDUAL                                            00095100
C                                                                               00095200
      MXB=BSTA                                                                  00095300
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      MXA=ASTA                                                          00095400
      VMAX=ABS(V)                                                       00095500
   98 CONTINUE                                                          00095600
      IF(ZNO.LT.NZ) GO TO 88                                            00095700
      GO TO 110                                                         00095800
C                                                                       00095900
C                                                                       00096000
  106 ISWICH=2                                                          00096100
      GO TO 97                                                          00096200
C                                                                       00096300
C PRINT COPRECTIONS FOR ZNO=0 CASE  (BOTH ANGLES CANNOT BE FIXED HERE)  00096400
C                                                                       00096500
  107 IF(BSTA.LE.NS) GO TO 108                                          00096600
      WRITE(6,648) DPHI(ASTA),DLAM(ASTA)                                00096700
  648 FORMAT(1H ,71X,2F17.4)                                            00096800
      GO TO 96                                                          00096900
  108 IF(ASTA.LE.NS) GO TO 109                                          00097000
      WRITE(6,649) DPHI(BSTA),DLAM(BSTA)                                00097100
  649 FORMAT(1H ,2X,2F17.4)                                             00097200
      GO TO 96                                                          00097300
  109 WRITE(6,650) DPHI(BSTA),DLAM(BSTA),DPHI(ASTA),DLAM(ASTA)          00097400
  650 FORMAT(1H ,2X,2F17.4,35X,2F17.4)                                  00097500
      GO TO 96                                                          00097600
C--------------                                                         00097700
C WINDUP ROUTINE...ALL FINAL POSITIONS,RESIDUALS,AND Z-EQS (SEE STMT 98+00097800
C  TWO)  HAVE BEEN COMPUTED AND PRINTED. NOW--                          00097900
COMPUTE PROBABLE ERROR FROM V2SUM WITH NOL-(2*NS+NZ) DEG.OF FREEDOM.    00098000
C                                                                       00098100
  110 PE=0.67449*SQRT(V2SUM/FLOAT(NOL-(2*NS+NZ)))                       00098200
      WRITE(6,652) VMAX,MXB,MXA,PE                                      00098300
  652 FORMAT(/1HO,5X,18HMAX.ABS.RESIDUAL =,E10.4, 9H AT LINE ,I3,1H-,I3,00098400
     *  5X,22HP.E. OBS. WT. UNITY  =E10.4)                             00098500
      IF(ZONE(1).EQ.0) GO TO 114                                        00098600
C                                                                       00098700
C GRID COORD. OPTION -- ZONE(1).NE.0                                    00098800
C      WRITE FILE 10 USING ALL ADJUSTED AND FIXED POSITIONS.            00098900
C      ZSTA() IS USED AS A TEMPORARY INTEGER ARRAY HERE.                00099000
      DO 112 I=1,NTS                                                    00099100
      CALL SMD(PHI(I),IGN(1),IDEG(1),MIN(1),SECS(1))                    00099200
      CALL SMD(LAM(I),IGN(2),IDEG(2),MIN(2),SECS(2))                    00099300
      ZSTA(1)=(SECS(1)+.00005D0)*1000.0D1                               00099400
      ZSTA(2)=(SECS(2)+.00005D0)*1000.0D1                               00099500
      WRITE(10,653) I,(IGN(L),IDEG(L),MIN(L),ZSTA(L),L=1,2)             00099600
  653 FORMAT(I3,17X,A1,2I2,I6,A1,I3,I2,I6,36X,1H2)                      00099700
  112 CONTINUE                                                          00099800
      WRITE(10,654)                                                     00099900
  654 FORMAT(79X,1H6)                                                   00100000
C                                                                       00100100
C DO NOT REWIND FILE 10 IN CASE OF ANY MORE GRID. COORD. OPTION PROBLEMS00100200
C                                                                       00100300
C********  GO TO NEXT PROBLEM  *********                                00100400
C                                                                       00100500
  114 GO TO 1000                                                        00100600
C                                                                       00100700
COMPUTE RESIDUAL FOR ZNO=0 AZ/LG EQUATION  (TYPE 2 OR 3)..V=EQSUM HERE..00100800
C                    SEG STMT 90+1                                      00100900
  120 IF(G.EQ.2.AND.ZSTA(1).GT.ZSTA(2)) CALL ASCEND(ZSTA,ZSIN,ZCOS)     00101000
      CALL EQVAL(G,ZSTA,ZSIN,ZCOS,EQCON,EQSUM)                          00101100
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      VZ(1)=EQSUM                                                       00101200
      V2SUM=V2SUM+WT*EQSUM**2                                           00101300
      LZNO=0                                                            00101400
      ZSUM=0.0                                                          00101500
      ZCNT=1                                                            00101600
C                                                                       00101700
C PRINT V FOR AZ/LG EQ ... NOTE ZSUM=0.0 WHEN ZNO=0 (RETURN TO STMT 88) 00101800
C                                                                       00101900
      GO TO 96                                                          00102000
C SINGULAR SYSTEM -- WHERE DIAG ELEMENT 'ICHK' IS ZERO                  00102100
C       PROBLEM TERMINATED.   (SEE STMT 86+)                            00102200
C                                                                       00102300
  966 WRITE(6,638) ICHK                                                 00102400
  638 FORMAT(41H1 SINGULAR SYSTEM WHERE DIAGONAL ELEMENT ,I4,            00102500
     *        5H IS 0/19H PROBLEM TERMINATED)                           00102600
      GO TO 900                                                         00102700
C                                                                       00102800
C ZCNT .GT. 100  (SEE STMT 90+)                                         00102900
C                                                                       00103000
  968 WRITE(6,642)                                                      00103100
  642 FORMAT(44H1 ZCNT.GT.100 FOR VZ ARRAY -- JOB TERMINATED)           00103200
      GO TO 900                                                         00103300
C                                                                       00103400
C ERROR IN FILE 7 -- ZCNT.NE.IOB (SEE STMT 92)                          00103500
C                                                                       00103600
  970 WRITE(6,643) ZCNT,IOB                                             00103700
  643 FORMAT(47H1ERROR IN OBSERVATION EQUATION FILE 7 -- ZCNT= ,I4,      00103800
     * 15H BUT SHOULD BE ,I4,28H AS USED IN Z-EQ FOR VALUE N//          00103900
     * 15H JOB TERMINATED)                                             00104000
      GO TO 900                                                         00104100
C                                                                       00104200
C ERROR IN FILE 9 -- ZNO.NE.LZNO AS COUNTED FROM FILE 7..JOB TERMINATED.00104300
C                                                                       00104400
  972 WRITE(6,651) ZNO,LZNO                                             00104500
  651 FORMAT(30H1ERROR IN FILE 7 OR 9 -- ZNO= ,I4,33H FROM FILE 9 BUT SH00104600
     *OULD BE LZNO= ,I4,12H FROM FILE 7/15H JOB TERMINATED)             00104700
      GO TO 900                                                         00104800
C                                                                       00104900
C LAST STATEMENT NUMBERS USED WERE  120 FOR MAIN PROGRAM                00105000
C                                   656 FOR SYSOUT FORMATS, AND         00105100
C                                   972 FOR MAIN PROGRAM-ERROR ROUTINES.00105200
C                                                                       00105300
  900 STOP                                                              00105400
 1000 RETURN                                                            00105600
      END                                                               00105700
      SUBROUTINE SIMEQ(A,N,X,IC)                                        00105800
C SOL OF SIMUL EQS FX=C BY GAUSS ELIM FOR REAL SYMMETRIC SYSTEMS        00105900
C     WITHOUT PIVOTING. THE ORIG MATRIX F OF ORDER N AND AUGMENTED      00106000
C     BY THE CONST VECTOR C IN COL N+1 MUST BE SUPPLIED AS A SINGLE-    00106100
C     DIMENSION ARRAY A OF N*(N+3)/2 TERMS IN THE FORM'                 00106200
C     F(1,1),F(1,2),...,F(1,N),C(1),F(2,2),F(2,3),...,F(2,N),C(2),...,  00106300
C     F(N,N),C(N). SOL VECTOR IS X. ANY ADDR OF A WITH I.LE.J.LE.N+1 IS 00106400
C     GIVEN BY IJ=((2*N+4-I)*(I-1))/2 +J-I+1.. IC=I IF A IS SINGULAR    00106500
C     OTHERWISE IC=0.                                                   00106600
      DIMENSION A(1),X(1)                                               00106700
C FOR A DOUBLE-PRECISION VERSION, REMOVE C IN COL1 OF NEXT STATEMENT--- 00106800
      DOUBLE PRECISION A,X,DIV,FAC                                      00106900
      IC=0                                                              00107000
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      II=1                                                              00107100
      LI=N                                                              00107200
      LC=N-1                                                            00107300
      DO 1 I=1,N                                                        00107400
      J=I+1                                                             00107500
      JJ=II+LI+1                                                        00107600
      DIV=A(II)                                                         00107700
      IF(DIV.EQ.0.) GO TO 99                                            00107800
      DO 2 K=1,LI                                                       00107900
      L=II+K                                                            00108000
      FAC=A(L)/DIV                                                      00108100
      IF(J.GT.N) GO TO 4                                                00108200
      LC1=LC+1                                                          00108300
      DO 3 L=1,LC1                                                      00108400
      L1=JJ+L-1                                                         00108500
      L2=II+L-1+J-I                                                     00108600
    3 A(L1)=A(L1)-FAC*A(L2)                                             00108700
    4 J=J+1                                                             00108800
      JJ=JJ+LC+1                                                        00108900
      L=II+K                                                            00109000
      A(L)=FAC                                                          00109100
      LC=LC-1                                                           00109200
    2 CONTINUE                                                          00109300
      LI=LI-1                                                           00109400
      II=II+N+2-I                                                       00109500
      LC=LI-1                                                           00109600
    1 CONTINUE                                                          00109700
C     BACKSOLUTION                                                      00109800
      IM=N*(N+3)/2                                                      00109900
      LC=0                                                              00110000
      I=N                                                               00110100
    5 X(I)=A(IM)                                                        00110200
      J=N                                                               00110300
      IJ=IM-1                                                           00110400
      IF(IJ.LT.IM-LC) GO TO 7                                           00110500
    6 X(I)=X(I)-A(IJ)*X(J)                                              00110600
      J=J-1                                                             00110700
      IJ=IJ-1                                                           00110800
      IF(IJ.GE.IM-LC) GO TO 6                                           00110900
    7 LC=LC+1                                                           00111000
      IM=IJ-1                                                           00111100
      I=I-1                                                             00111200
      IF(I.GE.1) GO TO 5                                                00111300
    8 RETURN                                                            00111400
   99 IC=I                                                              00111500
      GO TO 8                                                           00111600
      END                                                               00111700
      SUBROUTINE DMS(IGN,IDEG,MIN,S,SEC)                                00111800
C CONV ANGLE TO SEC. SIGN OF SEC IS NEG IF IGN=1H-,1HE,OR 1HS ON CALL.  00111900
      DOUBLE PRECISION SEC,S,DG,DMIN                                    00112000
      DIMENSION NGI(3)                                                  00112100
      DATA NGI/1H-,1HE,1HS/                                             00112200
      DG=IDEG                                                           00112300
      DMIN=MIN                                                          00112400
      SEC=3600.0D0*DG+60.0D0*DMIN+S                                     00112500
      DO 1 I=1,3                                                        00112600
    1 IF(IGN.EQ.NGI(I)) SEC=-SEC                                        00112700
      RETURN                                                            00112800
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      END                                                                    00112900
      SUBROUTINE SMD(SEC,IGN,IDEG,MIN,S)                                     00113000
C CONV SEC TO ANGLE IN DEG,MIN,SECONDS WHERE IGN=1H- IF SEC NEG ELSE 1H      00113100
      DOUBLE PRECISION T,SEC,S, R                                            00113200
      DATA NGI/1H-/,IBLK/1H /                                                00113300
      T=DABS(SEC)                                                            00113400
      IDEG=IDINT(T/3600.0D0)                                                 00113500
      R=IDINT(T/3600.0D0)                                                    00113600
      R=T-R*3600.0D0                                                         00113700
      MIN=IDINT(R/60.0D0)                                                    00113800
      T=IDINT(R/60.0D0)                                                      00113900
      S=R-T*60.0D0                                                           00114000
      IF(SEC)1,2,2                                                           00114100
    1 IGN=NGI                                                                00114200
      GO TO 3                                                                00114300
    2 IGN=IBLK                                                               00114400
    3 RETURN                                                                 00114500
      END                                                                    00114600
      SUBROUTINE NORMAL (ONE,WT,G,GSTA,STERM,CTERM,EQCON)                    00119700
C  ACCUMULATE NORMAL EQ TERMS FOR GIVEN OBS-EQ OR Z-EQ.                      00119800
C     ONE=+1.0 TO ADD IN TERMS FOR GIVEN OBS-EQ INTO NORMAL EQS OR           00119900
C     ONE=-1.0 TO SUBTRACT TERMS FOR GIVEN Z-EQ (RE-SCHREIBER METHOD).       00120000
C     G=NO.GROUPS OF GSTA(I),STERM(I),CTERM(I),I=1,G.  G.LE.2 FOR OBS-EQ     00120100
C     G.LE.NS FOR Z-EQS. G.GE.1 FOR EITHER EQ TYPE. EQCON IS THE EQ CON.     00120200
      COMMON /NORM/A(11475) /ORDR/N                                          00120300
      DIMENSION TERM(200),GSTA(1),STERM(1),CTERM(1)                          00120400
      INTEGER GSTA,G2,G                                                      00120500
C  FOR DOUBLE PRECISION VERSION,REMOVE C IN COL 1 OF NEXT STATEMENT----      00120600
      DOUBLE PRECISION TERM,PROD,XMUL,ONE,A,STERM,CTERM,EQCON,WT             00120700
      DO 1 L=1,G                                                             00120800
      TERM(2*L-1)=STERM(L)                                                   00120900
    1 TERM(2*L)  =CTERM(L)                                                   00121000
      G2=2*G                                                                 00121100
      DO 2 IEQ=1,G2                                                          00121200
      ITEMP=MOD(IEQ,2)                                                       00121300
      L=IEQ/2+ITEMP                                                          00121400
      I=2*GSTA(L)-ITEMP                                                      00121500
      XMUL=WT*TERM(IEQ)                                                      00121600
      DO 3 JEQ=IEQ,G2                                                        00121700
      ITEMP=MOD(JEQ,2)                                                       00121800
      L=JEQ/2+ITEMP                                                          00121900
      J=2*GSTA(L)-ITEMP                                                      00122000
      PROD=XMUL*TERM(JEQ)                                                    00122100
      IJ=IADDR(I,J)                                                          00122200
      A(IJ)=A(IJ)+ONE*PROD                                                   00122300
    3 CONTINUE                                                               00122400
CONST VECTOR IS ALWAYS AT J=N+1 FOR ANY I                                    00122500
      J=N+1                                                                  00122600
      PROD=XMUL*(-EQCON)                                                     00122700
      IJ=IADDR(I,J)                                                          00122800
      A(IJ)=A(IJ)+ONE*PROD                                                   00122900
    2 CONTINUE                                                               00123000
      RETURN                                                                 00123100
      END                                                                    00123200
      SUBROUTINE EQVAL(G,ISTA,TSIN,TCOS, EQCON,EQSUM)                        00123300
C EVALUATION OF OBS-EQ OR Z-EQ USING SOLUTION VECTOR X IN COMMON /SOL/       00123400
C     G = NO.GROUPS OF ISTA(I),TSIN(I),TCOS(I), I=1,G.                       00123500
C     G IS BETWEEN 0 AND 2 IF OBS -EQ TERMS GIVEN OR                         00123600
```

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C     G IS BETWEEN 1 AND NS IF Z-EQ TERMS GIVEN.                        00123700
C     EQCON AND EQSUM IS SELF-EXPLANATORY.                              00123800
      COMMON /SOL/ X                                                    00123900
      DIMENSION X(150),ISTA(1),TSIN(1),TCOS(1)                          00124000
      INTEGER G                                                         00124100
C  FOR DOUBLE PRECISION VERSION REMOVE C IN COL 1 OF NEXT STATEMENT---- 00124200
      DOUBLE PRECISION X,TSIN,TCOS,EQCON,EQSUM                          00124300
      EQSUM=0.0                                                         00124400
      IF(G.EQ.0) GO TO 1                                                00124500
      DO 2 L=1,G                                                        00124600
      I=ISTA(L)                                                         00124700
    2 EQSUM=EQSUM+X(2*I-1)*TSIN(L)+X(2*I)*TCOS(L)                       00124800
    1 EQSUM=EQSUM+EQCON                                                 00124900
      RETURN                                                            00125000
      END                                                               00125100
      SUBROUTINE PAGECK(IPHASE)                                         00125200
C                                                                       00125300
CHECKS LINE COUNT---IF LINE.GE.50 EJECT PAGE AND PRINT HEADINGS ELSE    00125400
C           INCREMENT LINE BY 1 AND RETURN. LINE SET TO 1 IF EJECTED.   00125500
C           IPHASE=0 FOR PRELIMINARY HEADINGS OR                        00125600
C           IPHASE.NE.0 FOR FINAL HEADINGS.                             00125700
C                                                                       00125800
      COMMON /HEADS/LINE,ID(16),ZONE,ISPHER                             00125900
      INTEGER ZONE(4)                                                   00126000
      IF(LINE.GE.50) GO TO 1                                            00126100
      LINE=LINE+1                                                       00126200
      RETURN                                                            00126300
    1 IF(IPHASE.NE.0) GO TO 3                                           00126400
      WRITE(6,10) ID                                                    00126500
   10 FORMAT(41H1 PRELIMINARY POSITIONS AND EQUATIONS -- ,15A4,A2)       00126600
    2 WRITE(6,11)ISPHER,ZONE                                            00126700
   11 FORMAT(1H 55X,7HISPHER=,I4,29X,5HZONE=,4I5/                       00126800
     *       3HO B,8X,5HLAT B,11X,6HLONG B,10X,                         00126810
     * 4HAZBA,13X,1HS,10X,1HA,8X,5HLAT A,11X,6HLONG A,10X,4HAZAB)       00126900
      LINE=1                                                            00127000
      RETURN                                                            00127100
    3 WRITE(6,12) ID                                                    00127200
   12 FORMAT(1H1,7X,33HFINAL POSITIONS AND RESIDUALS -- ,15A4,A2)       00127300
      GO TO 2                                                           00127400
      END                                                               00127500
      SUBROUTINE ASCEND(GSTA,STERM,CTERM)                               00127600
C ENTER ONLY IF(G.EQ.2 .AND. BSTA.GT.ASTA) FOR OBSERVATION OR CONDITION 00127700
C     EQUATION.... THEN ARRAYS GSTA,STERM,AND CTERM WILL BE STORED      00127800
C     IN ASCENDING STATION ORDER AS REQUIRED BY SUBR; NORMAL,ETC.       00127900
C FOR DOUBLE PRECISION VERSION REMOVE C IN COL 1 OF NEXT STATEMENT ---- 00128000
      DOUBLE PRECISION STERM,CTERM,SAVE1,CAVE1                          00128100
      DIMENSION GSTA(2),STERM(2),CTERM(2)                               00128200
      INTEGER GSTA                                                      00128300
      L=GSTA(1)                                                         00128400
      SAVE1=STERM(1)                                                    00128500
      CAVE1=CTERM(1)                                                    00128600
      GSTA(1)=GSTA(2)                                                   00128700
      STERM(1)=STERM(2)                                                 00128800
      CTERM(1)=CTERM(2)                                                 00128900
      GSTA(2)=L                                                         00129000
      STERM(2)=SAVE1                                                    00129100
      CTERM(2)=CAVE1                                                    00129200
      RETURN                                                            00129300
```

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      END                                                                   00129400
      FUNCTION IADDR(I,J)                                                   00129500
COMPUTES ADDRESS OF I-TH ROW AND J-TH COLUMN OF N BY N+1 ORDER SYMMETRIC00129600
C          SYSTEM STORED AS A SINGLE-DIMENSIONED ARRAY A OF N*(N+3)/2     00129700
C          TERMS.. N IS ASSUMED KNOWN IN LABELED  COMMON NAMED ORDR..     00129800
C          NOTE N MUST BE CONSTANT FOR ALL IJ OF ARRAY A(IJ)              00129900
C     ELEMENTS BELOW DIAGONAL (I.GT.J) FOUND BY REVERSING I AND J         00130000
      COMMON /ORDR/ N                                                     00130100
      IF(I.LE.J) GO TO 1                                                  00130200
      IADDR=((2*N+4-J)*(J-1))/2+I-J+1                                     00130300
      GO TO 2                                                             00130400
    1 IADDR=((2*N+4-I)*(I-1))/2+J-I+1                                     00130500
    2 RETURN                                                              00130600
      END                                                                 00130700
      SUBROUTINE CARD3                                                    00130800
C PRINT CARD3 CONTENTS IN CARD-COLUMN FORM                                00130900
      COMMON/CRD3/J1,J2                                                   00131000
      COMMON/CRDS/SECS,IGN,IDEG,MIN,COL80                                 00131100
      DIMENSION IDEG(6),MIN(6),SECS(6),IGN(6),ISEC(6)                     00131200
      DOUBLE PRECISION SECS                                               00131300
      INTEGER COL80                                                       00131400
      DO 1 L=1,6                                                          00131500
    1 ISEC(L)=(SECS(L)+.00005D0)*10000.0D0                                00131600
      WRITE(6,10) J1,J2,(IGN(L),IDEG(L),MIN(L),ISEC(L),L=1,6 ),COL80      00131700
   10 FORMAT( 95H CARD COLUMNS--000000000111111111122222222223333333333400131800
     *4444444445555555556666666666777777777778/1H ,14X,80H1234567890123400131900
     *5678901234567890123456789012345678501234567890123456789012345678900132000
     */15X,80(1H.)/                                                       00132100
     *  15H CARD CONTENTS=,3X,2I3,3(A1,2I2,I6,A1,I3,I2,I6),1X,I1)         00132200
      RETURN                                                              00132300
      END                                                                 00132400
      SUBROUTINE CARD4                                                    00132500
C PRINT CARD4 CONTENTS IN CARD-COLUMN FORM                                00132600
      COMMON/CRD4/OLG,ZNO,NCZ,BSTA,ASTA,WT                                00132700
      COMMON/CRDS/SECS,IGN,IDEG,MIN,COL80                                 00132800
      DIMENSION ISEC(2),IDEG(6),MIN(6),SECS(6),IGN(6)                     00132900
      DOUBLE PRECISION OLG,SECS,WT                                        00133000
      INTEGER ZNO,BSTA,ASTA,COL80                                         00133100
      DO 1 L=1,2                                                          00133200
    1 ISEC(L)=(SECS(L)+.0005D0)*1000.0D0                                  00133300
      IOLG=(OLG+.005D0)*100.0D0                                           00133400
      WRITE(6,10) ZNO,NCZ,BSTA,ASTA,IDEG(1),MIN(1),ISEC(1),IGN(2),        00133500
     *            IDEG(2),MIN(2),ISEC(2),WT,IOLG,COL80                    00133600
   10 FORMAT( 95H CARD COLUMNS--000000000111111111122222222223333333333400133700
     *4444444445555555556666666666777777777778/1H ,14X,80H1234567890123400133800
     *5678901234567890123456789012345678901234567890123456789012345678900133900
     */15X,80(1H.)/                                                       00134000
     *15H CARD CONTENTS=,2X,I3,I2,3I3,I2,I5,A1,I3,I2,I5,G10.5,I8,27X,I1)00134100
      RETURN                                                              00134200
      END                                                                 00134300
      SUBROUTINE POLY(P1,P2,IL,X,Y)                                       00134400
C  POLYCONIC PROJECTION OF POINT LAT=P2, DIFF LONG=IL FROM ARBITRARY     00134500
C     CENTRAL MERIDIAN. LAT OF ARBITRARY ORIGIN IS P1. X=DIST FROM CM     00134600
C     ALONG LAT P2. Y=DIST FROM P1 TO P2. X,Y IN METERS.                  00134700
C     P1,P2,AND IL IN SECONDS.                                            00134800
      REAL IL,LA,IP,IPR                                                   00134900
      DATA ARCONE,ESQ,LA,A0,A2,A4,A6,A8/4.8481369E-6,6.7686580E-3,        00135000
     *     6378206.4,6367399.7,32433.888,34.4187,.0454,6.0E-5/            00135100
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      IP=P2-P1                                                          00135200
      SINP2=SIN(P2*ARCONE)                                              00135300
      COSP2=COS(P2*ARCONE)                                              00135400
      THETA=IL*SINP2                                                    00135500
      A=SQRT(1.0-(ESQ*(2.*SINP2)))/(LA*ARCONE)                          00135600
      COT=COSP2/SINP2                                                   00135700
      X=(COT*SIN(THETA*ARCONE))/(A*ARCONE)                              00135800
      IPR=IP*ARCONE                                                     00135900
      PR=((P2+P1)/2.)*ARCONE                                            00136000
      Y= A0*IPR-(A2*COS(2.*PR)*SIN(IPR))+(A4*COS(4.*PR)*SIN(2.*IPR))-   00136100
     * (A6*COS(6.*PR)*SIN(3.*IPR))+A8*COS(8.*PR)*SIN(4.*IPR)            00136200
      RETURN                                                            00136300
      END                                                               00136400
      SUBROUTINE GEDINV(ISPHER,ALAT,ALONG,AZ,CLVL,BACAZ,BLAT,BLONG)     00136500
C     INVERSE COMPUTATION, ROBBINS FORMULA,BOMFORD,P,109                00136600
      IMPLICIT REAL*8(A-E,O-Z)                                          00136700
      DMETR=3.2808333333333D0                                           00136800
      PI=3.141592653589793     D0                                       00136900
      GO TO (20,21,22,23),ISPHER                                        00137000
      AFT=6378206.4                                                     00137100
      ESQ=6.768657997291 D-3                                            00137200
      GO TO 25                                                          00137300
   20 AFT=6378249.0                                                     00137400
      ESQ=6.803425359830 D-3                                            00137500
      GO TO 25                                                          00137600
   21 AFT=6377397.0                                                     00137700
      ESQ=6.674312325543 D-3                                            00137800
      GO TO 25                                                          00137900
   22 AFT=6377276.0                                                     00138000
      ESQ=6.637868287356 D-3                                            00138100
      GO TO 25                                                          00138200
   23 AFT=6378388.0                                                     00138300
      ESQ=6.722670022333 D-3                                            00138400
   25 AFT=AFT*DMETR                                                     00138500
      IF(ALONG.GT.0.)ALONG=2.*PI-ALONG                                  00138600
      IF(ALONG.LT.0.)ALONG=-ALONG                                       00138700
      IF(BLONG.GT.0.)BLONG=2.*PI-BLONG                                  00138800
      IF(BLONG.LT.0.)BLONG=-BLONG                                       00138900
C     ENNU=RADIUS OF CURVATURE IN PRIME VERTICAL                        00139000
      ENNUA=AFT/DSQRT(1.-(ESQ*DSIN(ALAT)*DSIN(ALAT)))                   00139100
      ENNUB=AFT/DSQRT(1.-(ESQ*DSIN(BLAT)*DSIN(BLAT)))                   00139200
C     FORMULA I                                                         00139300
      TANSIB=(1.-ESQ+ESQ*(ENNUA*DSIN(ALAT))/(ENNUB*DSIN(BLAT)))*DSIN    00139400
     X(BLAT)/DCOS(BLAT)                                                 00139500
      PSIB=DATAN(TANSIB)                                                00139600
      DAPHIR=BLAT-PSIB                                                  00139700
      DLBDR=BLONG-ALONG                                                 00139800
C     FORMULA II                                                        00139900
      IF(DABS(DLBDR).GT.1.D-11) GO TO 302                               00140000
      AZ=0.0D0                                                          00140100
      GO TO 303                                                         00140200
  302 COTAZ=(DCOS(ALAT)*TANSIB-DSIN(ALAT)*DCOS(DLBDR))/DSIN(DLBDR)      00140300
      IF(DABS(COTAZ).GT..1D-11) GO TO 320                               00140400
      AZ=PI/2.D0                                                        00140500
      GO TO 303                                                         00140600
  320 TAN=1./COTAZ                                                      00140700
      AZ=DATAN(TAN)                                                     00140800
  303 IF(AZ)13,18,18                                                    00140900
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   13 AZ=AZ+PI                                                                  00141000
   18 CALL LOCAZ(AZ,ALAT,ALONG,BLAT,BLONG)                                      00141100
C     FORMULA III                                                               00141200
      DPHIR=BLAT-ALAT                                                           00141300
      IF(DABS(DLBDR).GT.1.D-12)GO TO 399                                        00141400
      BACAZ=AZ                                                                  00141500
      GO TO 398                                                                 00141600
C     BACK AZIMUTH USING DALBYS THEOREM, SEE PAGE 104, BOMFORDS GEODESY         00141700
  399 DR=2.*DATAN(DCOS(DLBDR/2.)*DCOS(DPHIR/2.)/(DSIN((ALAT+BLAT)/2.)          00141800
     X*DSIN(DLBDR/2.)))                                                         00141900
      BACAZ=AZ-DR-ESQ**2*DLBDR*DPHIR**2*DCOS(ALAT)**4*DSIN(ALAT)/4.D0           00142000
398   CONTINUE                                                                  00142100
      IF(BACAZ.LT.0.)BACAZ=BACAZ+2.*PI                                          00142200
      IF(DABS(BACAZ-AZ).LT.PI/2.)BACAZ=BACAZ+PI                                 00142300
      IF(BACAZ.GT.2.*PI)BACAZ=BACAZ-2.*PI                                       00142400
C     FORMULA IV                                                                00142500
      IF(DABS(AZ).GT.1.D-11.AND.DABS(AZ-PI).GT.1.D-11.AND.DABS(AZ-2.*PI)        00142600
     X.GT.1.D-11)GO TO 306                                                      00142700
      SINSIG=DCOS(PSIB)*(DCOS(ALAT)*DSIN(PSIB)/DCOS(PSIB)-DSIN(ALAT)*           00142800
     XDCOS(DLBDR))/DCOS(AZ)                                                     00142900
      GO TO 307                                                                 00143000
  306 SINSIG=DSIN(DLBDR)*DCOS(PSIB)/DSIN(AZ)                                    00143100
307   IF(DABS(SINSIG).GT..1D-10) GO TO 310                                      00143200
      SIG=0.000                                                                 00143300
      GO TO 309                                                                 00143400
310   IF(DABS(SINSIG).LT..999999999D0) GO TO 308                                00143500
      SIG=PI/2.D0                                                               00143600
      GO TO  309                                                                00143700
308   TANSIG=SINSIG/DSQRT(1.-(SINSIG*SINSIG))                                   00143800
      SIG=DATAN(TANSIG)                                                         00143900
C     FORMULA VI                                                                00144000
  309 EGESQ=(ESQ/(1.-ESQ))*DSIN(ALAT)*DSIN(ALAT)                                00144100
      ACHSQ=ESQ/(1.-ESQ)*DCOS(ALAT)*DCOS(ALAT)*DCOS(AZ)*DCOS(AZ)                00144200
      EGE=DSQRT(EGESQ)                                                          00144300
      ACH=DSQRT(ACHSQ)                                                          00144400
      CLVL=ENNUA*SIG*(1.-(SIG*SIG*ACHSQ/6.)*(1.-ACHSQ)+SIG**3*EGE*ACH*          00144500
     X(1.-2.*ACHSQ)/8.+(SIG**4/120.)*(ACHSQ*(4.-7.*ACHSQ)-3.*EGESQ*(1.          00144600
     X-7.*ACHSQ))-SIG**5*EGE*ACH/48.)                                           00144700
      CLVL=DABS(CLVL)                                                           00144800
      AZ=AZ+PI                                                                  00144900
      BACAZ=BACAZ+PI                                                            00145000
      IF(AZ.GT.2.*PI)AZ=AZ-2.*PI                                                00145100
      IF(BACAZ.GT.2.*PI)BACAZ=BACAZ-2.*PI                                       00145200
      IF(ALONG.LT.PI)ALONG=-ALONG                                               00145300
      IF(ALONG.GT.PI)ALONG=2.*PI-ALONG                                          00145400
      IF(BLONG.LT.PI)BLONG=-BLONG                                               00145500
      IF(BLONG.GT.PI)BLONG=2.*PI-BLONG                                          00145600
      RETURN                                                                    00145700
      END                                                                       00145800
      SUBROUTINE LOCAZ(AZM,APHIR,ALBDR,BPHIR,BLBDR)                             00145900
C     BRITISH AZIMUTH IS NORTH=ZERO, BRITISH LONGITUDE IS EAST FROM             00146000
C     GREENWICH, INPUT AZIMUTH AND LONGITUDE ARE BRITISH, OUTPUT                00146100
C     AZIMUTH IS BRITISH                                                        00146200
      IMPLICIT REAL*8(A-E,O-Z)                                                  00146300
      PI=3.14159265358979 3                                                     00146400
      IF(BPHIR-APHIR)13,14,16                                                   00146500
13    IF(ALBDR-BLBDR)27,18,20                                                   00146600
C     AZIMUTH IN SE QUADRANT                                                    00146700
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      C     AZIMUTH IS SOUTH                                          00146800
   18 AZM=PI                                                          00146900
      GO TO 27                                                        00147000
      C     AZIMUTH IN SW QUADRANT                                    00147100
   20 AZM=AZM+PI                                                      00147200
      GO TO 27                                                        00147300
   14 IF(ALBDR-BLBDR)30,29,23                                         00147400
      C     AZIMUTH IS EAST                                           00147500
   30 CONTINUE                                                        00147600
      GO TO 27                                                        00147700
      C     POINT ONLY, NOT A LINE                                    00147800
   29 GO TO 27                                                        00147900
      C     AZIMUTH IS WEST                                           00148000
   23 AZM=AZM+PI                                                      00148100
      GO TO 27                                                        00148200
   16 IF(ALBDR-BLBDR)27,28,24                                         00148300
      C     AZM IS NE                                                 00148400
      C     AZIMUTH IS NORTH                                          00148500
   28 AZM=0.0                                                         00148600
      GO TO 27                                                        00148700
      C     AZM IS NW                                                 00148800
   24 AZM=AZM+PI                                                      00148900
   27 CONTINUE                                                        00149000
      RETURN                                                          00149100
      END                                                             00149200
```