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Project Report

The Complex Terrain Dispersion Model

Terrain Preprocessor System

User's Guide and Program Descriptions

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THE COMPLEX TERRAIN DISPERSION MODEL (CTDM) TERRAIN PREPROCESSOR SYSTEM - USER GUIDE AND PROGRAM DESCRIPTION

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ABSTRACT

This report describes the operation of a terrain preprocessor which approximates actual terrain features with mathematical functions. The best-fit parameters for these functions are used by the Complex Terrain Dispersion Model (CTDM) in the calculation of lateral and vertical streamline displacement, an important step in the calculation of concentrations at hill receptor locations.

The CTDM Terrain Preprocessor is a series of 3 programs which process digitized contour data to provide hill shape parameters in a format suitable for direct input to CTDM. The first program, FITCON, accepts as input a user-defined hill in terms of its maximum elevation and the x,y coordinates of the hill center. The elevation and point coordinates of individual contours are then input from a master file. After evaluation and editing, each contour is processed by numerical integration to determine the following parameters for an equivalent ellipse: semi-major and semi-minor axis lengths; contour centroid coordinates; and the orientation of the ellipse. These parameters are input to the second preprocessor program, HCRIT, which determines, for the portion of the hill above a given critical elevation, the best-fit inverse polynomial profiles along the hill's major and minor axes. The center coordinates of the fitted hill are calculated as the mean of the ellipse center coordinates for those contours above a given critical elevation. The orientation of the fitted hill is calculated as a vector average of the ellipse orientations weighted by the ellipse eccentricity. HCRIT provides an input file for CTDM which contains the following information for each critical elevation:

- Ellipse parameters corresponding to contours at user-specified elevations
- Coordinates of the center of the fitted hill
- Orientation of the major axis of the fitted hill with respect to north
- The length scale and exponents for the inverse polynominal fits along the hill major and minor axes.

The third program, PLOTCON, generates the following screen displays to aid in the evaluation of the hill fitting process:

- Map of input contours
- Map of digitized contours which have been qualified and edited
- Map of the digitized contours and their associated fitted ellipses

- For each critical cut-off elevation, a map showing the digitized contours and the contours of the fitted hill at elevations corresponding to the elevations of those digitized contours above the critical elevation.

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LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOL	
A	Area enclosed by a polygon formed by the straight lines connecting digitized contour points
A_k	Area of trapezoidal element k
a	Length of an ellipse semi-major axis
abs(A)	Absolute value of A
a_j	Calculated semi-major axis length for contour j
b	Length of an ellipse semi-minor axis
b_j	Calculated semi-minor axis length for contour j
χ^2	Quantity minimized to determine best fit values of L and P
D_k	Perpendicular distance from contour point k to an axis line, which lies within the contour plane and passes through the contour centroid
E	Elevation used in the interpolation of ellipse parameters
ECC	Ellipse eccentricity
ECC_j	Calculated eccentricity for the elliptical representation of contour j
h	Elevation of a point on the hill surface
H_c	Critical dividing streamline height
h_j	Elevation of contour j
h_o	Critical cutoff elevation
h_W	Elevation of the uppermost contour on the hill
h_T	Elevation of hill top
HC_i	ith critical height
L	Inverse polynominal length scale
M_{xk}	The x-component of the first moment of trapezoidal element k

M2	Second moment of an ellipse about its minor axis
$M2_k$	Second moment for trapezoidal segment k about a line passing through the contour centroid
N_c	Number of contours for a hill above the critical cutoff elevation
N_{HC}	Number of critical elevations
N_p	Number of digitized points for a contour
π	3.14159265 ...
P	Inverse polynominal exponent
P_c	Interpolated ellipse parameter (not including the orientation)
r	Calculated radius of a contour determined to be circular
R_g	Maximum value of R_{gm} for $m = 1,18$
R_{gm}	Radius of gyration of the digitized contour about a line passing through the contour centroid and making an angle θ_m with respect to the positive x-axis
SM_m	Second moment of the digitized contour about a line passing through the contour centroid and making an angle θ_m with respect to the positive x-axis
σ_a	Standard deviation parameter for the Gaussian terrain distribution shape along the major axis
σ_b	Standard deviation parameter for the Gaussian terrain distribution shape along the minor axis
θ	Orientation angle for the minor axis of the fitted hill
θ_c	Orientation angle obtained for a critical elevation by vector interpolation.
θ_j	Value of θ_m associated with the maximum value of R_{gm} for the contour j
θ_m	Angle with respect to the x-axis of the m th line through the centroid of the contour in the plane of the contour ($m = 1,18$)
W_k	Distance along an axis line, within the contour plane and passing through the contour centroid, between the intersection of perpendiculars from adjacent contour points (k and k+1)
x	Distance from a specified origin toward the east
x'	Distance measured along the hill major axis
X_c	Calculated x-coordinate for the contour centroid

X_{cj}	x-coordinate of the centroid of digitized contour j
X_H	x-coordinate of the centroid of a fitted inverse polynomial hill
x_j	Major or minor axis length for contour j
x_k	x-coordinate for contour point k
y	Distance from a specified origin toward the north
y'	Distance measured along the hill minor axis
Y_c	Calculated y-coordinate for the contour centroid
Y_{cj}	y-coordinate of the centroid of digitized contour j
Y_H	y-coordinate of the centroid of a fitted inverse polynomial hill
y_k	y-coordinate for contour point k

ABBREVIATIONS

ASRL	Atmospheric Sciences Research Laboratory
CCB	Cinder Cone Butte
CTMD	Complex Terrain Model Development
CTDM	Complex Terrain Dispersion Model
DOS	Disk Operating System
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FSPS	Full Scale Plume Study
HBR	Hogback Ridge
SHIS	Small Hill Impaction Study
TPP	Tracy Power Plant
USGS	United States Geological Survey

SECTION 1

INTRODUCTION

1.1 Development of the Complex Terrain Dispersion Model (CTDM)

CTDM is a model designed to estimate ground level concentrations on elevated terrain during periods in which the atmosphere is stably stratified. The model provides concentration estimates for receptors on a single isolated hill for a single averaging period. The model can accept multiple terrain features; however, the flow is only influenced by one hill at a time.

The central feature of CTDM is its use of a critical dividing-streamline height (H_c) to separate the flow into two discrete layers. This basic concept was suggested by theoretical arguments of Drazin (1961) and Sheppard (1956) and was demonstrated through laboratory experiments by Riley et al. (1976), Brighton (1978), Hunt and Snyder (1980), Snyder et al. (1980) and Snyder and Hunt (1984). The flow below H_c is restricted to lie in a nearly horizontal plane, allowing little motion in the vertical. Consequently, plume material below H_c travels along and around the terrain, rather than up and over the terrain. The flow above H_c is allowed to rise up and over the terrain. Two separate components of CTDM compute ground-level concentrations resulting from material in each of these flows.

An important step in the calculation of concentrations at receptors above H_c is the determination of lateral and vertical streamline displacements. The calculation of these displacements for a hill of arbitrary shape would require the use of an elaborate numerical model and significant computing resources, neither of which can be justified on the basis of increased accuracy of the concentration predictions. The current version of the model is designed to run on a microcomputer.

If one assumes that the portion of the hill above H_c can be fit to a simple mathematical surface, then the lateral and vertical streamline displacements can be estimated from analytical expressions which can be rapidly evaluated. For CTDM to make use of this idealized terrain, the model must have access to hill fit parameters for a range of H_c values.

1.2 Requirements for a CTDM Terrain Preprocessor

CTDM requires much more information about hills than other screening models. CTDM needs a 3-dimensional representation of each hill. Therefore, the Terrain Preprocessor produces an analytical description of the hill shape. Although CTDM will accept several distinct hills, the Terrain Preprocessor will process only one hill at a time. Hence, the Terrain Preprocessor must be run for each hill and the resulting files may be appended to one large terrain file for input to CTDM. One constraint of CTDM is that in the calculations only one isolated hill is considered at a time. A discussion whose purpose is to aid the user in selecting distinct terrain features is included in Appendix A.

Since CTDM is designed for regulatory applications, an objective method is needed to characterize actual terrain in terms of a mathematical shape. In the absence of such a method, two users analyzing the same hill (with the same contours) could arrive at significantly different representations for the fitted hill. The preprocessor provides a display of the actual and fitted hill to enable the user to determine whether the fit is reasonable from a physical standpoint, or whether a subfeature of the digitized terrain should be isolated for analysis.

1.3 Summary of Preprocessor Operation

Two programs must be run to generate terrain input parameters to CTDM for a given hill. A third program allows the user to display the contours for the actual and fitted hills. The first program, FITCON, asks the user to define a hill in terms of its name, identification number, maximum elevation and x,y coordinates of the hill center. The user then specifies the name of a master file of digitized contour data and a file to be used for diagnostic output during the fitting process. In the master file, the following data is provided for each contour:

- Contour identification number,
- Contour elevation,
- Number of digitized points,
- A code indicating whether a contour is input as complete or incomplete,
- x,y coordinates of the digitized contour points.

The user chooses one of the following 3 methods for selection of contours from the master file: (1) all contours selected, (2) contours selected based upon a range of user-specified contour identification numbers, or (3) the specification of a file containing the contour identification numbers for the hill in question. Before a contour is accepted for processing, it must pass a number of tests. Incomplete contours are closed by a reflection of points through the hill center or contour centroid. The program provides special processing for those contours which are found to be a series of multiple contours at the same elevation. After qualification and editing (described in Section 2.1.2), the area and centroid coordinates of each contour are determined by numerical integration. Each contour is then fit to an ellipse by first finding the slope of the line through the centroid in the plane of the contour which gives the largest second moment for the area within the contour. In the determination of this maximum second moment for a contour to 10° resolution, eighteen lines having equal angular spacing are used. The line associated with the maximum second moment is assumed to define the orientation of the minor axis of the ellipse representing the contour. The lengths of the semi-major and semi-minor axes for this ellipse are calculated from the analytical expressions for the area and second moment of an ellipse.

These fitted ellipse parameters for each contour are input to the second preprocessor program, HCRIT, which determines, for the portion of the hill above a given critical elevation, the best-fit inverse polynomial profiles along the hill major and minor axes. The center coordinates of the fitted hill are calculated as the mean of the ellipse center coordinates for those contours above a given critical elevation. The orientation of the fitted hill is calculated as a vector average of the ellipse orientations, weighted by the ellipse eccentricity. The user can specify the critical elevations to be used by HCRIT in two ways. The first option is to have each contour elevation, with the exception of the uppermost, serve as a critical elevation. Alternatively, the user can specify a number of equally spaced critical elevations between the lowest and uppermost contour. The lowest critical elevation must be at or below the lowest stack or tower base elevation for model input. Sometimes it may be necessary to extrapolate imaginary heights from the hill base down to below the stack base elevation. In the inverse polynomial fit to the hill profile, a critical elevation is treated as an effective hill base. HCRIT provides an input file for CTDM which contains the following information for each critical elevation:

- Ellipse parameters corresponding to the contour at the critical elevation* (these parameters are interpolated in the case where a critical elevation does not correspond to a contour elevation),

- Coordinates of the center of the fitted hill,

- Orientation of the major axis of the fitted hill with respect to north,

- The length scales and exponents for the inverse polynomial fits along the hill major and minor axes.

The third preprocessor program, PLOTCON, uses plot files from FITCON and HCRIT to generate the following screen displays which aid in the evaluation of the hill-fitting process:

* It should be noted that the term "critical elevation" is only used here to indicate that the same elevations are used in the specification of ellipse parameters and cutoff hills within CTDM. CTDM uses these parameters to determine the characteristics of the ellipse at plume height if the plume is below the computed critical dividing-streamline height for a given hour.

- Map of digitized contours either as they were input or after they have been qualified and edited,

- Map of the digitized contours and their associated fitted ellipses,

- For each critical cutoff elevation, a map showing the digitized contours and the contours of the fitted hill at elevations corresponding to the elevations of those digitized contours above the critical elevation.

1.4 Organization of the Manual

This manual is designed for users requiring different levels of detail regarding system operation. Users wishing to simply run the Terrain Preprocessor System should consult Section 4, which gives detailed input requirements for the system. For each of the inputs, references are made to those portions of the manual giving more detailed information. These cross references are also provided for the output items described in Section 5. New users of the system should also read Section 3, which covers the operation of the system. Finally, those users requiring a more detailed discussion of the terrain-fitting process should consult Section 2.

SECTION 2

RULES FOR TERRAIN FITTING

This section describes in detail the rules followed by the Terrain Preprocessor System in the fitting of terrain features to mathematical shapes. Also given in this section are the rules which must be followed by the system user in the preparation of input data. Throughout this discussion, a clear distinction is made between the rules which must be followed by the user and the rules followed by the system during the process of terrain data qualification, editing and fitting. These different types of rules are discussed in the same section because it is important for the user to understand how decisions made by the system depend upon user inputs. The user rules discussed in this section are, however, restated in the listing of input requirements given in Section 4.

2.1 Fitting of Ellipses to Digitized Contours

For an isolated hill, the selection of contours for the fitting of the hill is relatively straightforward. For more complex terrain, the user must decide which features are to be included in the description of a "hill". For example, if the contours for 2 adjacent peaks are input to the program, it will attempt to fit the peaks with a single inverse polynomial hill. Although this may be appropriate for peaks very close together in comparison to the distance to the source, the user may need to fit each of these terrain features in the absence of the other for some receptors (see discussion in Appendix A).

The user must first identify, from an examination of topographic maps, those features which represent individual hills to be used in the modeling. Each of these hills should be assigned a name, identification number, and a maximum elevation. The user must also specify the x,y coordinates of the hill center. This center does not have to coincide with the location of the point of maximum elevation of the hill. Since it is only used in the completion of incomplete contours (see Section 2.1.2.1), the hill center should correspond roughly to the mean center of the hill contours which have been input as complete. All contours in the study area must be assigned identification numbers and the correspondence between hills and contours determined. For each hill, a file of contour identification numbers must be prepared with one contour identification number on each line of the file. As mentioned earlier, the same contour may be assigned to more than one hill.

2.1.1 Rules for Contour Digitization

Since a given contour may be assigned to more than one hill, the contour parameters must be placed by the user in a master file, which is read during each run of the FITCON program for a given hill. Each hill is then characterized by the user in terms of a set of contour identification numbers, which is also input to FITCON.

In the master file prepared by the user, each contour is described first by a record giving the contour identification number, the elevation of the contour, the number of digitized points on the contour, and an indicator (CFLAG) which specifies whether the contour is being input as open (CFLAG=0) or closed (CFLAG=1). Following this record are a number of records, each giving the x,y coordinates of the digitized contour points. For the convenience of the user, all master file parameters are input in free format. An example of a digitized contour is given in Figure 1. In the subsequent fitting of this contour to an ellipse, the FITCON program assumes that the contour is a polygon in the horizontal (x,y) plane with the sides of the polygon formed by straight lines connecting adjacent points input by the user. A sufficient number of points should be selected by the user to define the basic shape of the contour. An unnecessarily large number of contour points will slow down the process by which a contour is fitted to an ellipse. A maximum of 1000 digitized points are allowed for each contour. This number could be increased by changing the value of the parameter NPCMAX and modifying the appropriate DIMENSION STATEMENTS in the FITCON main program and associated subroutines.

The contour points for a given contour must be input by the user in a consecutive order, either clockwise or counter-clockwise. All contour elevations given in the master file must have the same units and origin as the hill-top elevation (which is specified interactively by the user during each run of FITCON) and the stack base elevation (which is input to CTDM). All contour x,y point coordinates must have the same units and zero reference point as the hill center x,y coordinate, which is also specified interactively by the user. Obviously, the same scale should be used for both x and y. The positive x-axis must point to the true east and the positive y-axis must point to true north. The receptor locations, which are input directly to CTDM separately, must be specified according to the same x,y coordinate system as the digitized contour points. As long as the consistency requirements mentioned above are met, the user is free to use any coordinate system for specifying the contour elevation and digitized point coordinates. For a CTDM run, the user will be required to furnish the factors needed to convert elevations and distances to meters.

There may be cases in which it is not practical or desirable to digitize the full length of a contour. In this case, the program FITCON will complete the contour according to a procedure described in Section 2.1.2.1. There is the requirement that the digitized incomplete contour input by the user be continuous from the first to the last point. The program is not designed to complete contours which have been digitized in a piecewise fashion. The user may also find it necessary to specify multiple contours at the same elevation as a single contour for the purpose of determining an equivalent elliptical contour at that elevation. The rules for input of multiple contours at the same elevation are given in Section 2.1.2.2.

2.1.2 Contour Qualification and Editing

The program FITCON will retrieve data from the master file for contours specified by the user for the hill in question. Before a contour is accepted for processing, it must be subjected to a number of tests. On the basis of these tests, the contour is either accepted or rejected. Before a contour is accepted, however, it may require editing by the program, as in the case of an incomplete contour or a contour which represents multiple contours at the same elevation.

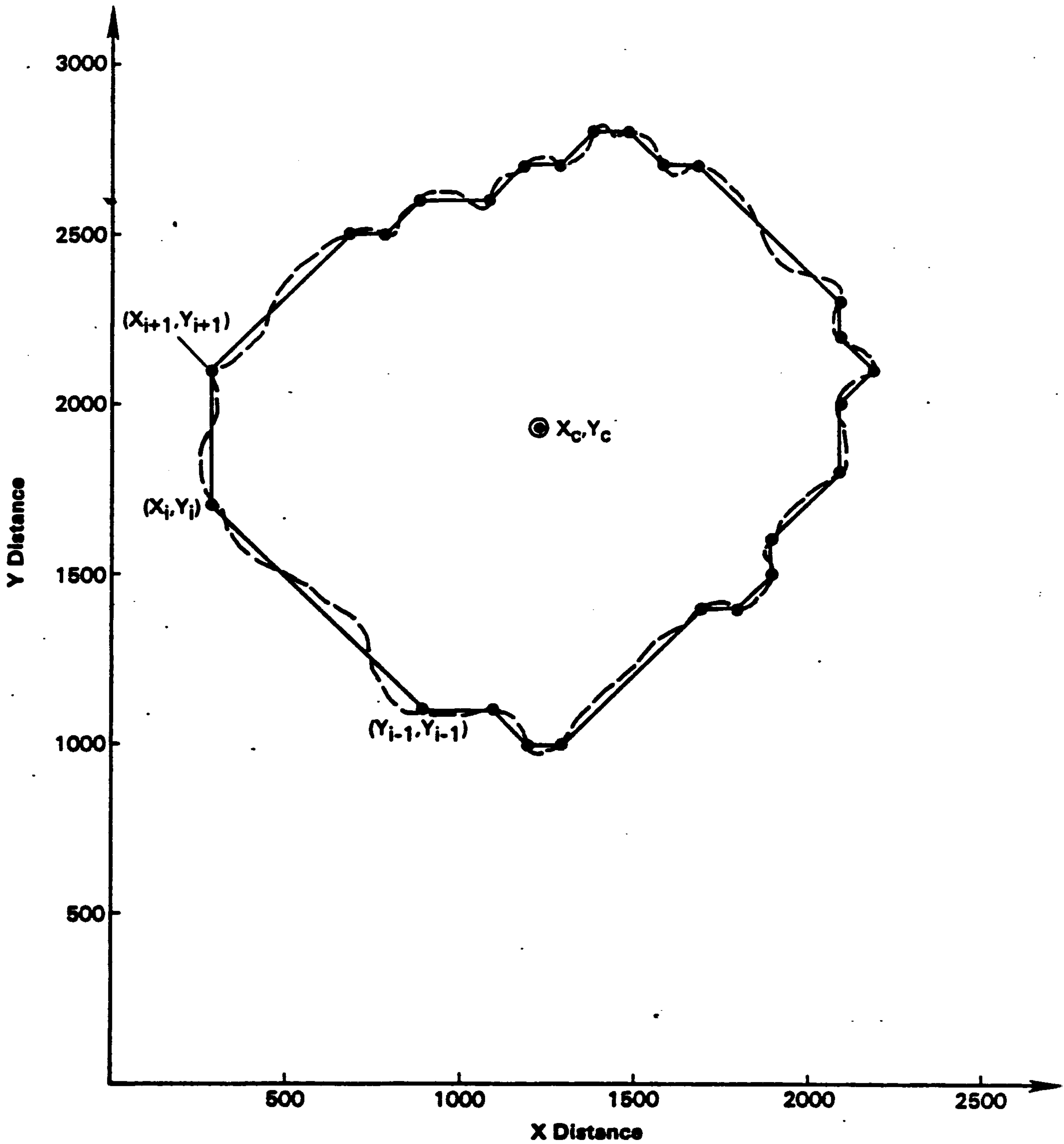


Figure 1. Example digitized contour.

The program first determines whether the contour elevation is greater than the hill top elevation input by the user. If so, the contour is rejected. Contours having less than 3 points or more points than the maximum allowed are also rejected.

Due to errors in the digitization process, a contour may actually cross itself. This problem can lead to computed values of the contour area and second moment having opposite signs. If this is found to be the case, then the contour is rejected. Even if the signs of the area and second moment are the same, the problem of the contour crossing itself will be revealed from the display of input contours generated by program PLOTCON.

If the input of an additional contour from the master file would cause the maximum number of contours (200) to be exceeded, then the input of contours is halted and a warning message is written to the diagnostic output file. The ellipse fitting procedure is then carried out using the 200 contours input up to that point. The maximum number of allowed contours can be increased by changing the value of the variable NCMAX and the appropriate array dimensions in the FITCON main program.

2.1.2.1 Contour Completion

A common situation which arises in the association of terrain contours with individual hills is shown in Figure 2. Both HILL 1 and HILL 2 are enclosed by a common contour which eventually closes at a rather large distance from the centers of both hills. To obtain a mathematical description of the surface of HILL 1, it is necessary to digitize the 3 component contours associated with the hill. If, however, the lowest of these contours were digitized over its full extent (not shown in Figure 2), it would strongly bias the computed parameters (center location, orientation and shape) for the fitted hill, which would bear little resemblance to HILL 1 as shown in Figure 2. In this case the user should only digitize that portion of the contour which is associated with HILL 1, allowing the program FITCON to complete the partially digitized contour as shown in Figure 2. The procedures followed by the program in this contour completion are described below.

A contour completion code (CFLAG) must be specified in the first record for each contour in the master file. A complete contour is one for which the coordinates of the first and last digitized points are identical. If it is determined that the first and last digitized contour points have identical coordinates and the contour completion code has a value of 1, then the contour is accepted for processing as it stands. If the first and last points are identical and the completion code has a value other than 1, then a warning message is written to the diagnostic output file and the contour is accepted for processing as it stands. If the first and last points are not identical and the completion code is equal to 1, then the program FITCON assumes that the user intended to complete the contour, but, in fact, did not. In this case, a warning message is written to the diagnostic output file and a point, having the same coordinates as the initial point, is added to the contour. If the addition of this point causes an exceedance of the allowed maximum number of digitized contour points, then the contour is rejected. If not, then the contour is accepted for processing. If the first and last contour points are not identical and the contour completion code is not equal to 1, then the program FITCON will complete the contour by the selective removal and addition of contour points.

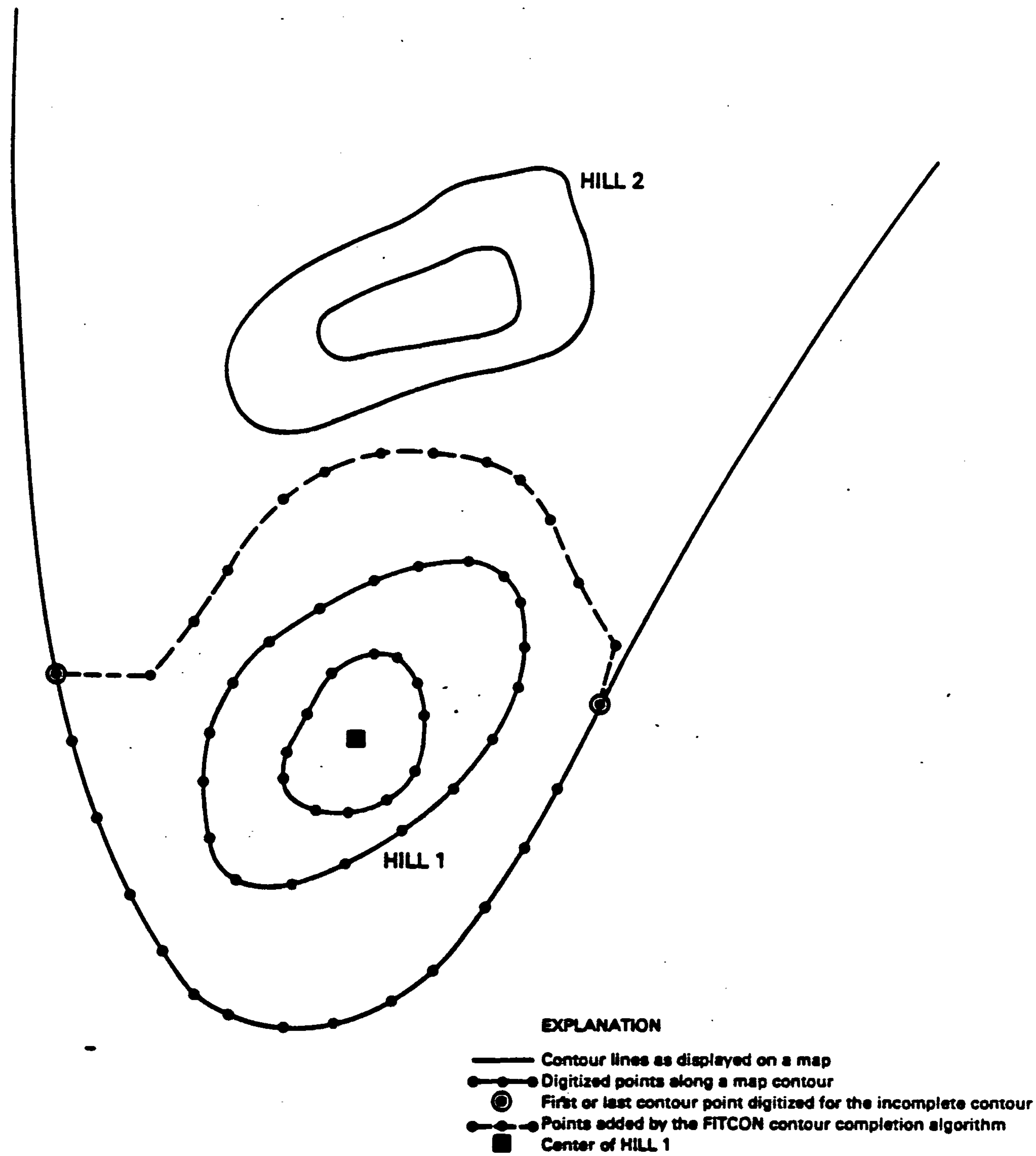


Figure 2. The closing of an incomplete contour as performed by program FITCON.

To minimize the probability that the completed contour will cross itself, the incomplete contour can be edited by FITCON (if this option is selected by the user) prior to the addition of points to complete the contour. The objective of this editing is to obtain a sequence of points whose order is consistently clockwise or counter-clockwise as viewed from the hill center location, whose x,y coordinates were specified interactively by the user. The resulting series of points is a subset of the original set of points. The parameter used in this editing process is the filtering angle, which is input interactively by the user during program FITCON execution. This filtering angle must be no smaller than 1 degree and no larger than 22.5 degrees. Until additional experience has been gained in the application of FITCON to a wider range of complex terrain settings, this filtering angle should be set to 1 degree by the user. This filtering angle is divided into 360 degrees and the result rounded to the nearest integer to obtain the value for the total number of angular sectors to be used in the filtering process. Moving in order from point to point, the program calculates the heading and distance from the hill center x,y position to the x,y position of the contour point. The angular sector which contains this heading is then determined. If another contour point was previously found to occupy this sector and its distance to the hill center is smaller than the distance from the current point, then the current point is discarded. If, in moving from one point to the next, the change in sector number is more than 1, the program assigns a "pseudopoint" to each of the intermediate sectors. The distance to each pseudopoint is determined through simple interpolation by angular sector between the distances to the current and preceeding points. If the sector associated with a pseudopoint corresponds to a sector occupied by a previously evaluated (and subsequently retained) actual point (or pseudopoint) located at a greater distance than the current pseudopoint, then the previous point (or pseudopoint) is discarded and the current pseudopoint retained for future comparisons. If its distance to the hill center is smaller than that of the pseudopoint, the previous point (or pseudopoint) is retained and the current pseudopoint is discarded. The pseudopoints are only used for making decisions regarding the retention or elimination of actual points during the filtering process. Once the filtering process has been completed these pseudopoints are discarded. The point filtering process is illustrated in Figure 3.

If two actual points are sufficiently close together, the filtration process will cause an unwarranted removal of one of the points simply because the points occupy the same sector. This problem is reduced by choosing a relatively small filtration angle in comparison to the angular separation between adjacent contour points as viewed from the hill center. The selection of a very small filtration angle, however, can needlessly slow down the filtering process. For this reason, the minimum filtration angle in the program is currently set at 1 degree.

After the contour points have been filtered, the contour is completed through the addition of points (see Figure 3). The locations of these points are determined by a reflection of existing points through the hill center or incomplete contour centroid. The first step in this process is to determine the angle formed by the lines from the hill center to the first and last digitized contour points. As shown in Figure 4, the

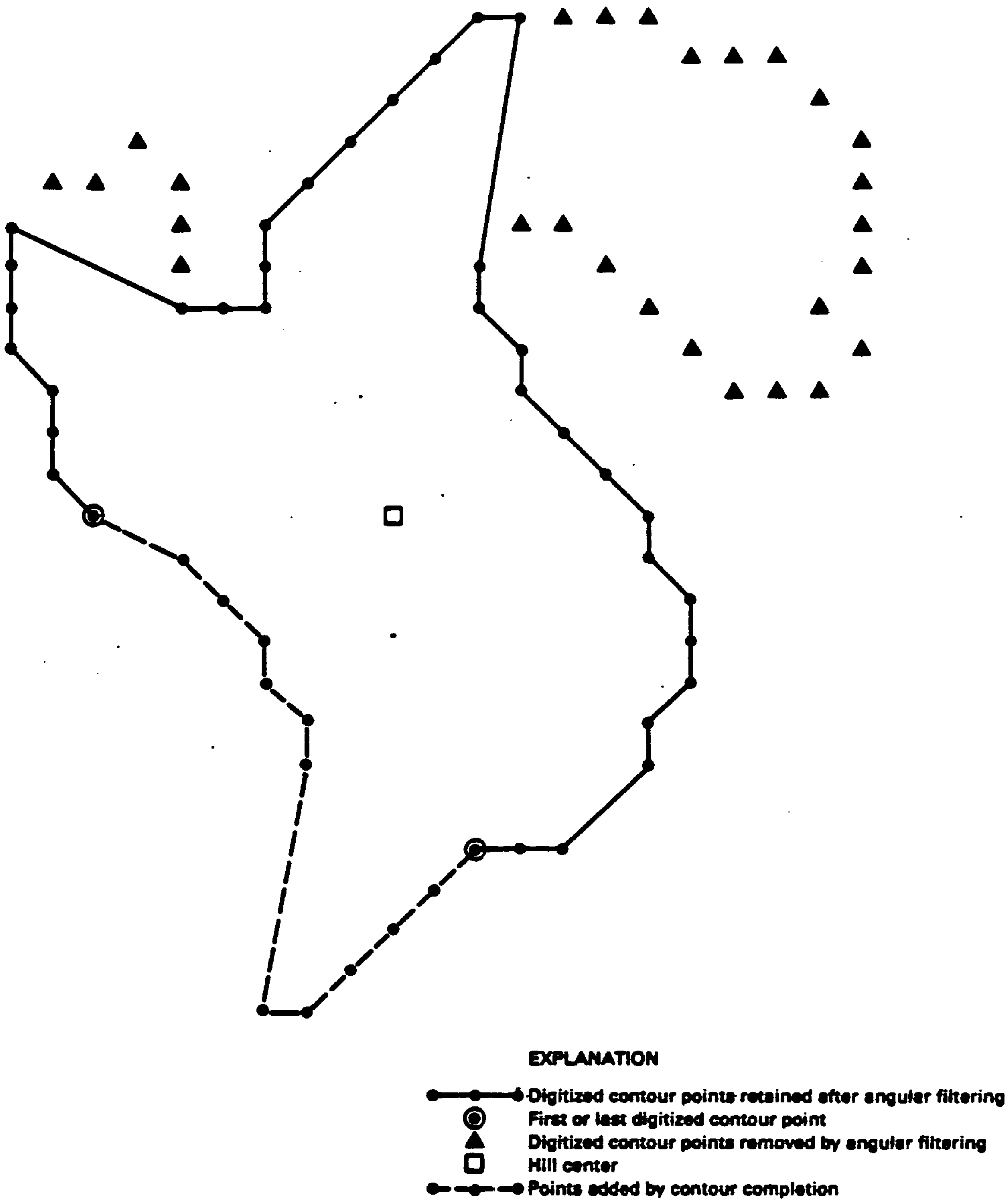


Figure 3. Illustration of point filtering and contour completion.

Case 1
Points Input Counter Clockwise

$\sphericalangle F = 360 - \sphericalangle FL$

Case 2
Points Input Clockwise

$\sphericalangle F = 360 + \sphericalangle FL$

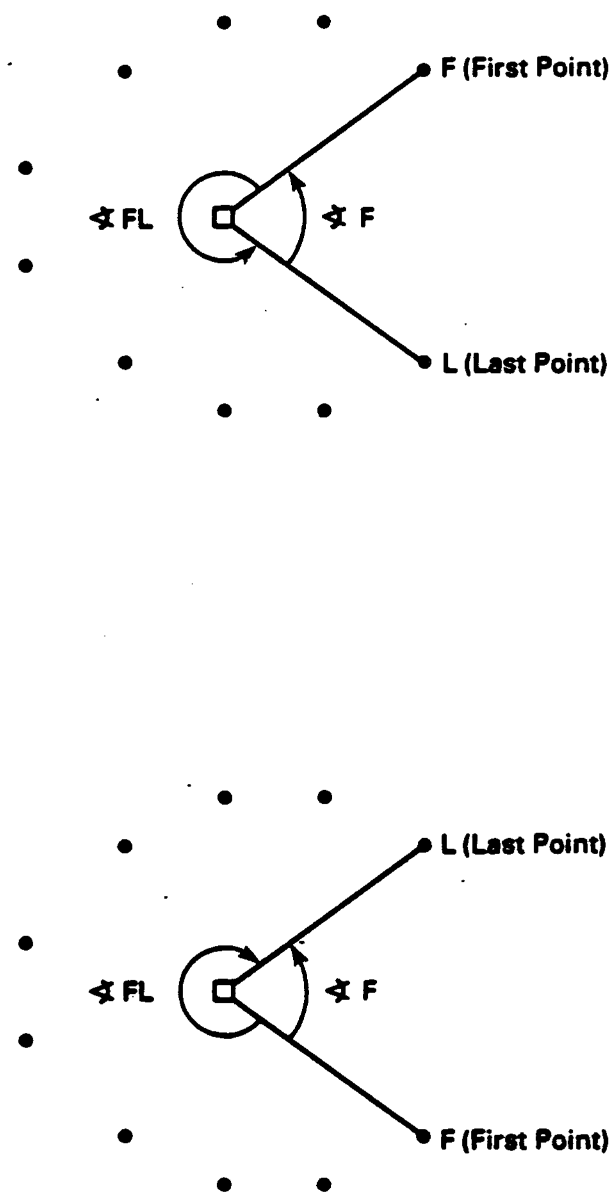


Figure 4. Selection of acceptance angle for contour completion.

computation of this positive acceptance angle depends upon the sense in which the contour points have been input (clockwise or counter clockwise). An incomplete contour is considered to have its points input in a clockwise sense if the area of this contour is found to be positive after it has been completed through the addition of a point corresponding to the hill center. Otherwise, the order of input for the incomplete contour points is assumed to be counter clockwise.

If the angle (shown as ∢ F in Figure 4) is found to be less than 90 degrees, then the point reflection is performed using the incomplete contour centroid (determined without the addition of the hill center point), rather than the hill center. The rationale for this decision can be understood by examining Figures 5 through 7. The contour completion shown in Figure 5 is reasonable from a physical standpoint. In this case the hill center was used as the reflection point, since the angle formed by joining the hill center to the first and last contour points is greater than 90 degrees. In Figure 6, however, the hill center is shown to be relatively close to one segment of the incomplete contour, giving an acceptance angle of less than 90 degrees. If, in this case, the hill center were used as the reflection point, then the completed contour would have the unrealistic shape shown in Figure 6. The shape of the completed contour becomes more realistic when the centroid of the uncompleted contour is used for reflection instead of the hill center (see Figure 7). Nevertheless, the user should exercise care in the choice of the hill center (see Appendix A).

No matter which of the two points is used in the point reflection, the rule for the addition of points is the same. Moving from the first digitized point to the last, a new point is located along a line joining the contour point and the reflection point (hill center or incomplete contour centroid) at a distance from the contour point which is equal to twice the distance from the point to the reflection point. If this new point falls within the acceptance angle, then the point is retained. Otherwise, the point is discarded. If the addition of a point will cause the maximum number of allowable points to be reached, then this point is set equal to the initial point, thereby prematurely ending the contour completion process.

2.1.2.2 Dealing with Multiple Contours at the Same Elevation

In a complex terrain situation, there may be more than one contour at the same elevation (see Figure 2). If each of these contours is associated with a well-defined terrain feature, then contours should be input to the program in conjunction with separate hills. If this is not the case, the program will accept the input of more than one contour at the same elevation. The user must input the points as if they lay on a single contour. If two separate contours having the same elevation are input from the master file, the second contour will be discarded. Consider the three contours shown in Figure 8, which fall inside a single contour. The user must input the coordinates of the beginning point of each contour twice (i.e. the contour must be closed by the user). The acceptable input sequence is shown in Figure 8(a). For the calculation of the area, centroid coordinates, and second moments for this generalized contour (actually containing 3 contours), the program renumbers the contour points as shown in Figure 8(b). The two zero area segments connecting the three contours effectively transform the three contours into a single contour.

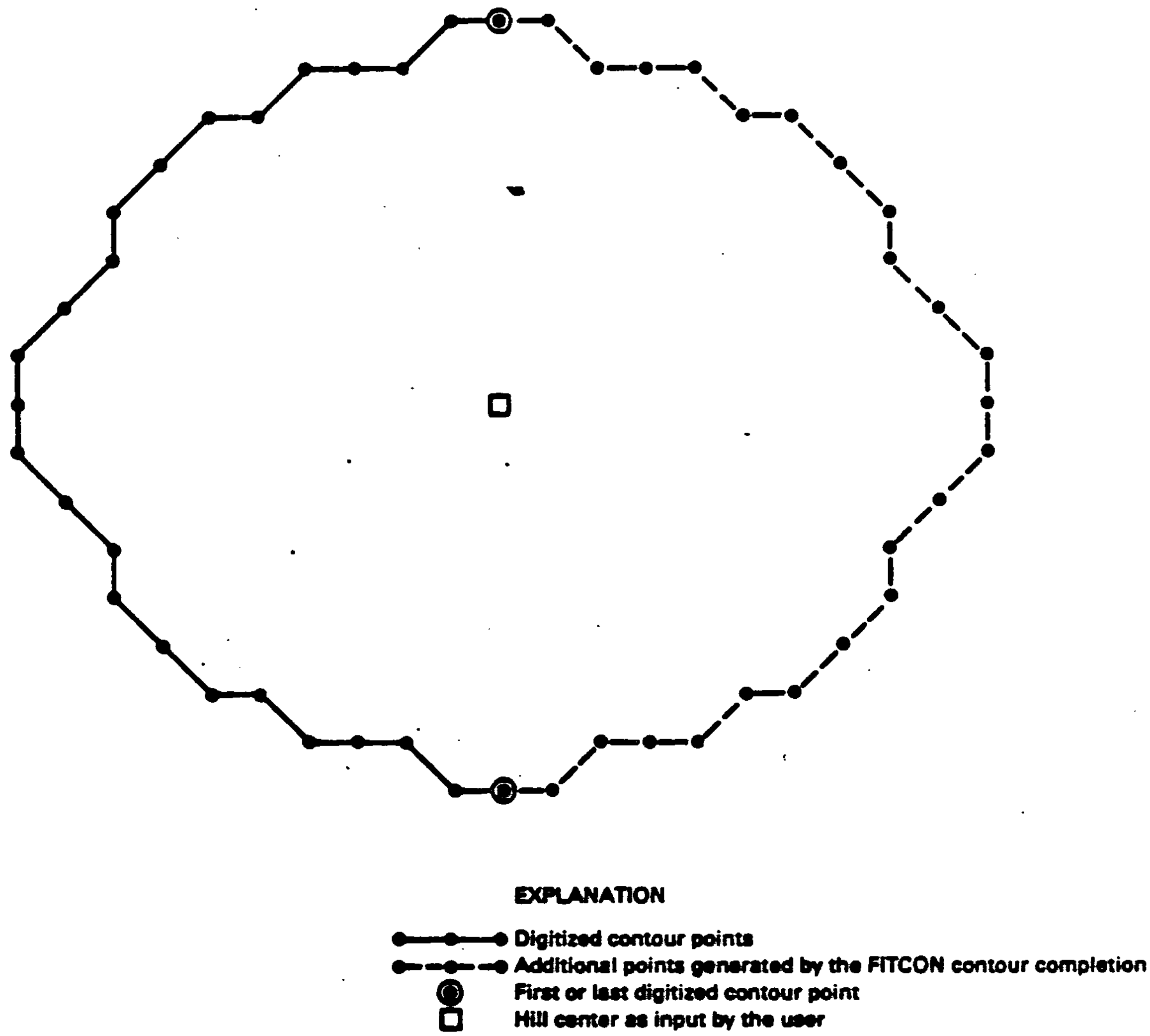


Figure 5. Contour completion with the hill center used as the reflection point - acceptance angle equals 180 degrees.

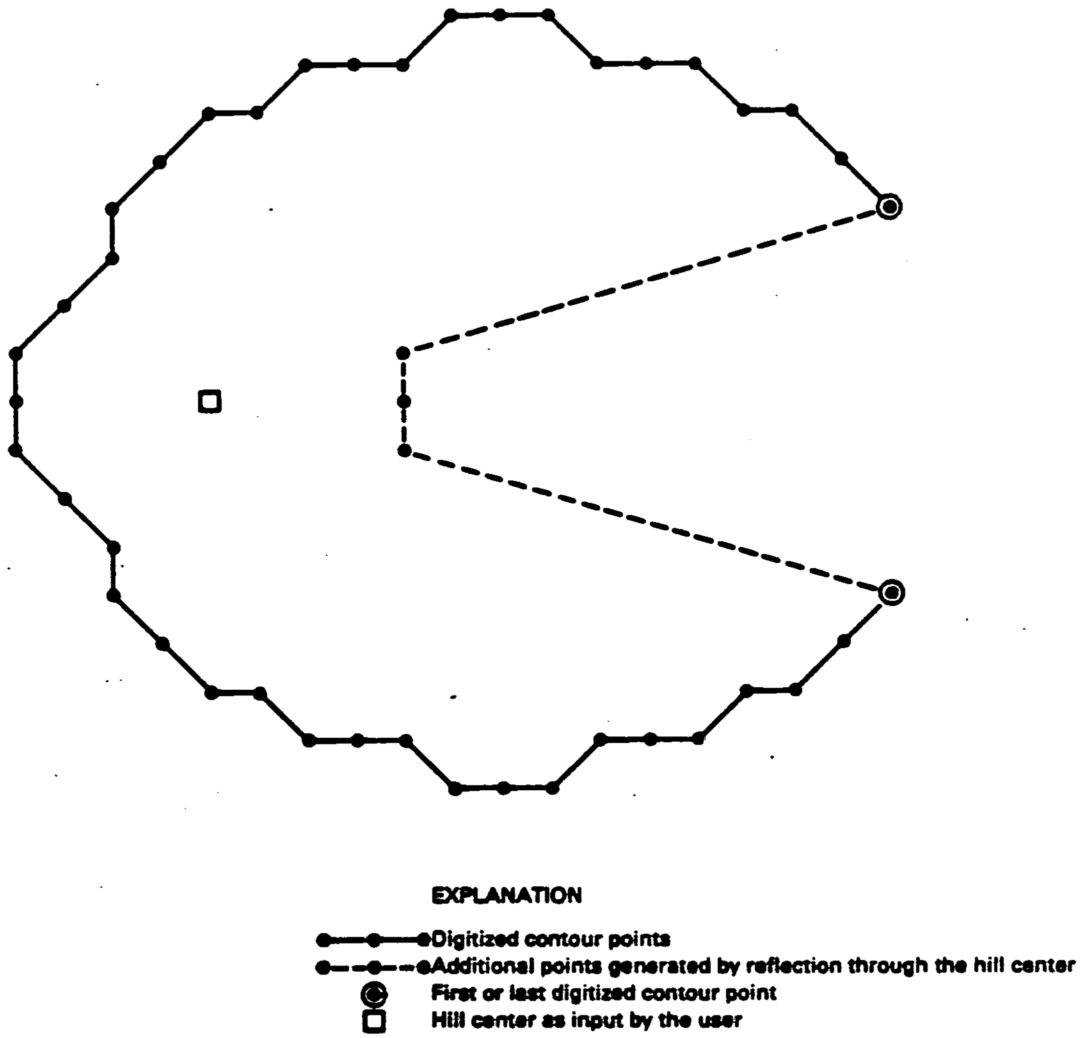


Figure 6. Contour completion with the hill center used as the reflection point - acceptance angle equals 31.9 degrees.

870406

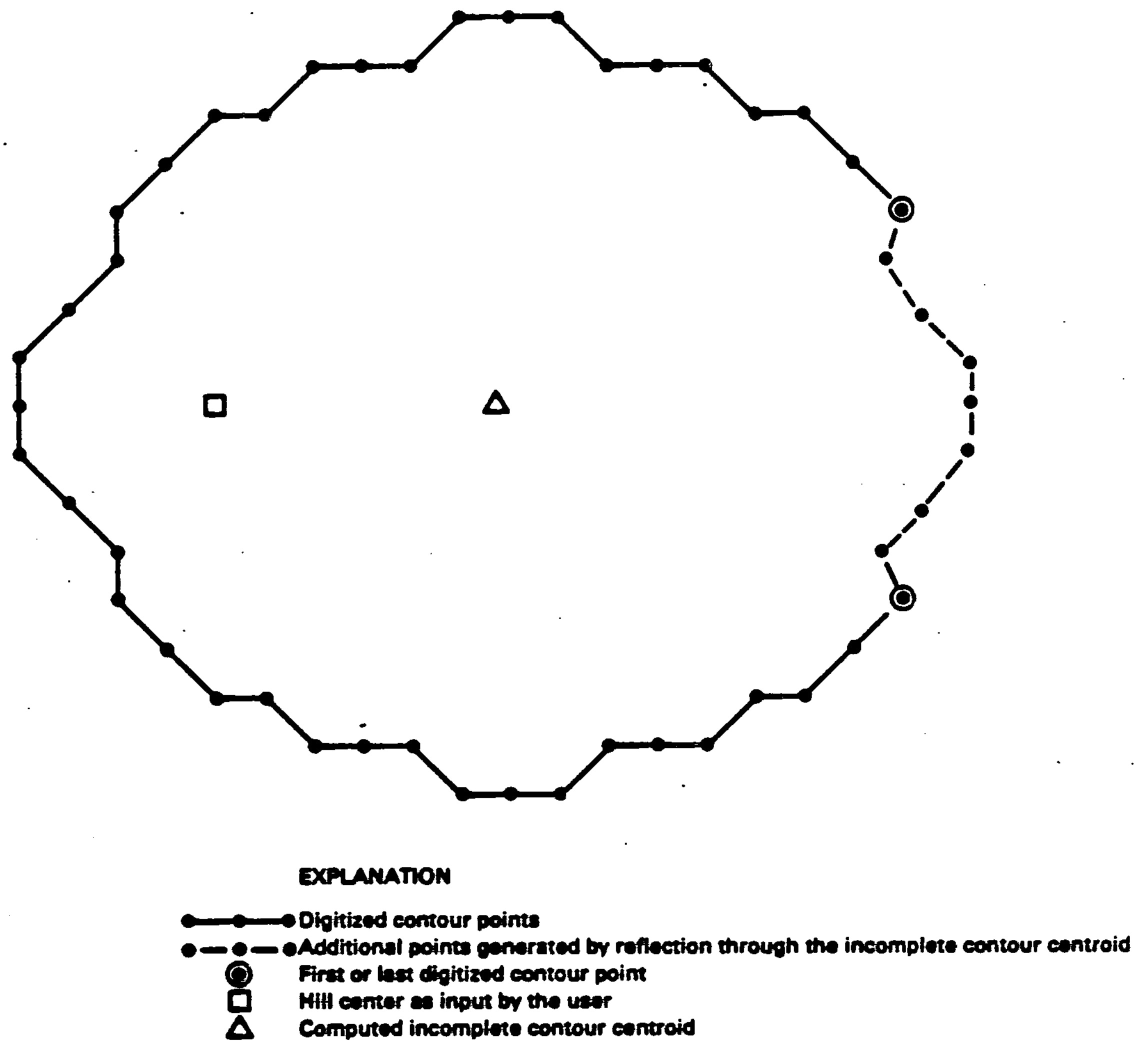
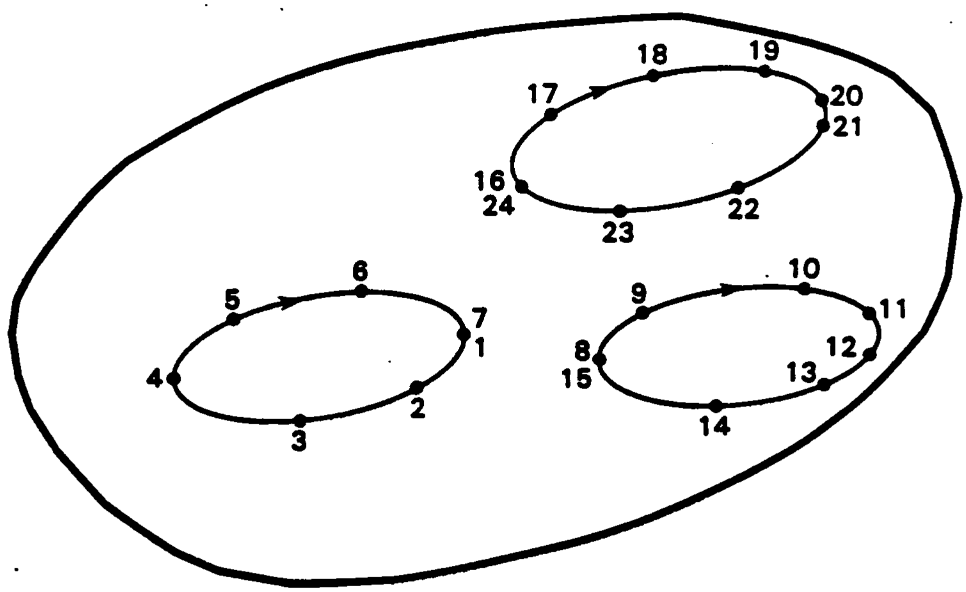
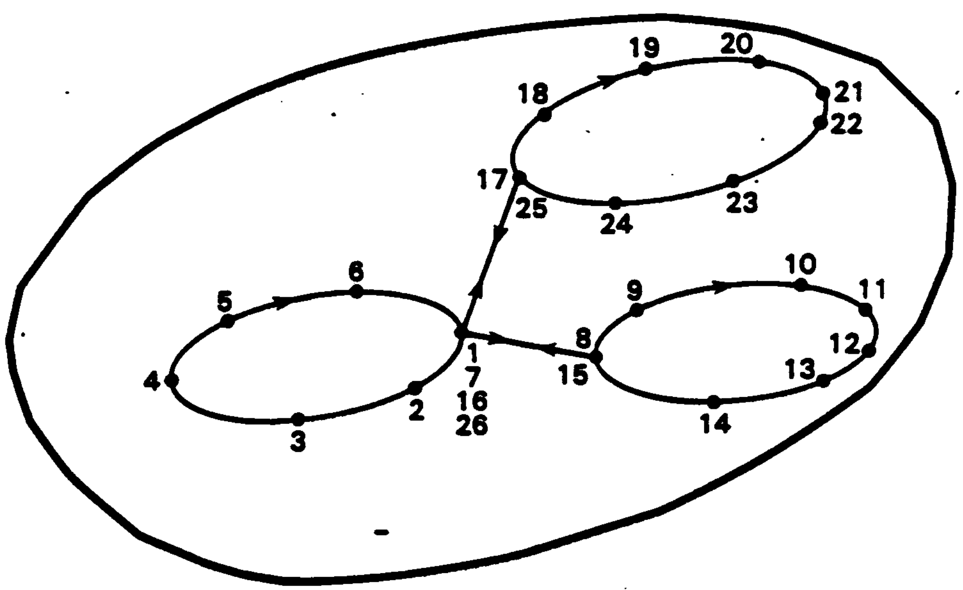


Figure 7. Contour completion with the incomplete contour centroid used as the reflection point - acceptance angle equals 51.5 degrees.

8704069



a) User input sequence of points.



b) Modified point sequence used by the program.

Figure 8. Analysis of multiple contours at the same elevation.

860063

2.1.3 Calculation of the Area and Centroid of Each Digitized Contour

The area, A, of the polygon formed by the N_p digitized contour points (after editing) is given by

$$A = \sum_{k=1}^{N_p} (y_k + y_{k+1})(x_{k+1} - x_k)/2 \quad . \tag{1}$$

See Section B.1 for the derivation of Equation (1).

The value for A will be positive if the points are input in a clockwise sense and negative if the points are input in a counter-clockwise sense. The value reported in the diagnostic output file for the contour area is the absolute value of A. The contour centroid coordinates X_c, Y_c are given by

$$X_c = \left(\sum_{k=1}^{N_p} (x_{k+1}y_k - x_k y_{k+1})(x_{k+1} + x_k)/2 + \right. \tag{2a}$$

$$\left. \sum_{k=1}^{N_p} (y_{k+1} - y_k)(x_{k+1}^2 + x_k x_{k+1} + x_k^2)/3 \right) /A \quad . \tag{2b}$$

$$Y_c = - \left(\sum_{k=1}^{N_p} (y_{k+1} x_k - y_k x_{k+1})(y_{k+1} + y_k)/2 \right.$$

$$\left. + \sum_{k=1}^{N_p} (x_{k+1} - x_k)(y_{k+1}^2 + y_k y_{k+1} + y_k^2)/3 \right) /A \quad .$$

The calculated values for X_c and Y_c will be the same if the contour points are input in the clockwise or counter-clockwise sense. See Section B.2 for a derivation of Equations (2a) and (2b).

2.1.4 Determination of Contour Orientation

The next step in the contour fitting is to assume that each digitized contour can be approximated by an ellipse having the same centroid and area as the contour. The orientation of this ellipse is determined by first taking the second moment of the contour area about each of eighteen axes passing through the centroid of the contour in the plane of the contour (see Figure 9). The second moment, SM_m, of the digitized contour polygon about a line passing through the contour centroid and making an angle θ_m with respect to the positive x-axis is given by:

$$SM_m = \sum_{k=1}^{N_p} \frac{W_k}{12}(D_{k+1}^3 + D_k^3 + D_k D_{k+1}^2 + D_{k+1} D_k^2) \tag{3}$$

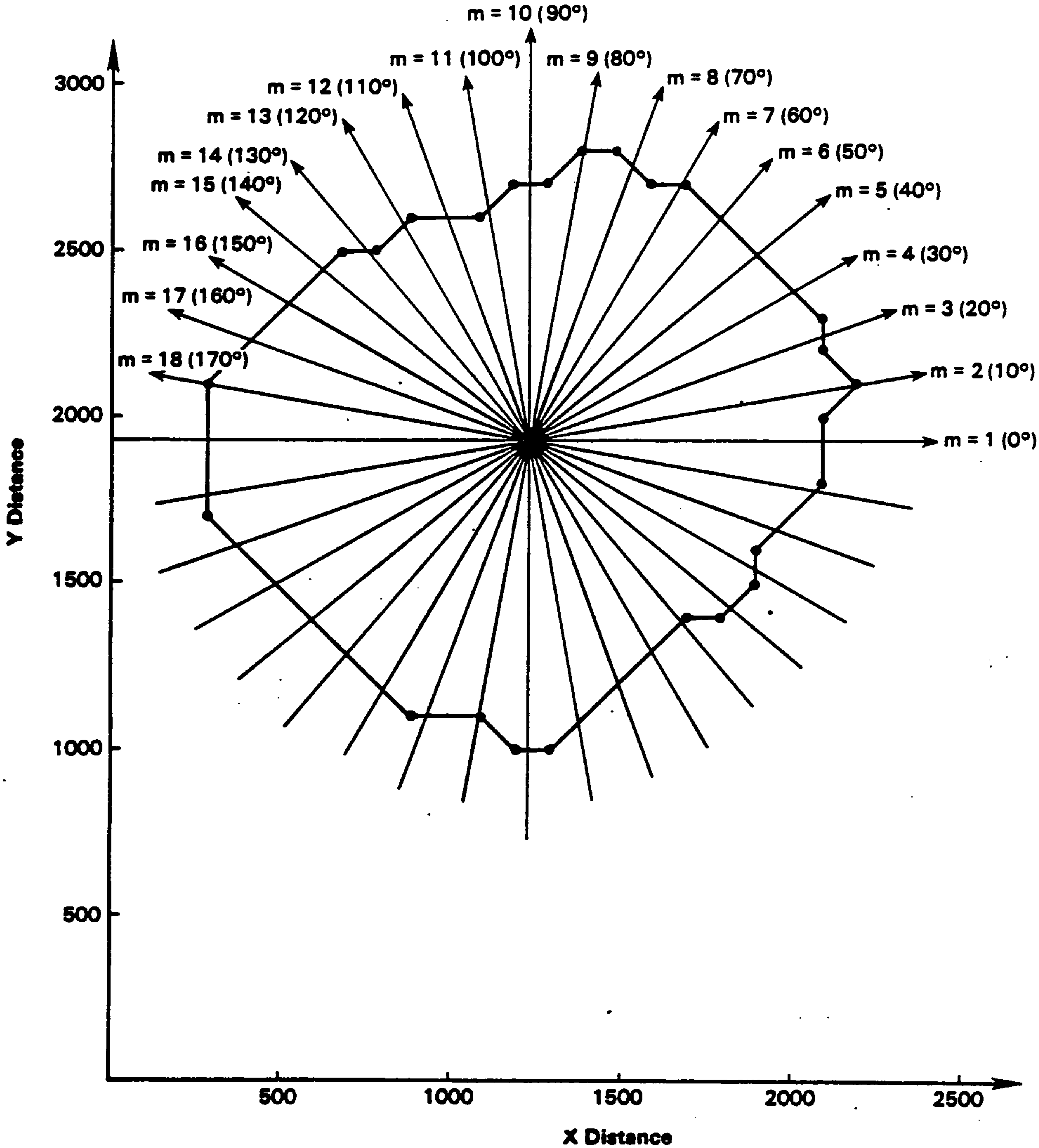


Figure 9. Axes for the calculation of second moments.

where

$$W_k = (x_{k+1}-x_k) \cos \theta_m + (y_{k+1} - y_k) \sin \theta_m$$

$$D_k = -(x_k-X_c) \sin \theta_m + (y_k-Y_c) \cos \theta_m$$

$$m = 1,18 \quad .$$

For contour points input in a clockwise sense, the value of SM_m will be positive. It will be negative for points input in a counter clockwise sense. In determining the axis having the greatest second moment, the parameter actually used by the program is the "radius of gyration", R_{gm}, given by

$$R_{gm} = \left(\frac{SM_m}{A}\right)^{1/2} \quad . \tag{4}$$

The value R_{gm} will be positive no matter which direction the contour points are input. The axis having the greatest value of R_{gm}, R_g, is assumed to define the orientation, θ, of the minor axis of the ellipse. See Section B.3 for a derivation of equations (3) and (4).

2.1.5 Calculation of the Semi-Major and Semi-Minor Axis Lengths for the Contour Elliptical Representation

In determining the length, a, of the semi-major axis of the fitted ellipse, the following property of an ellipse is used:

$$a = 2R_g \quad . \tag{5}$$

The length, b, of the semi-minor axis of the ellipse is calculated from the formula for the area of an ellipse as follows:

$$b = \frac{\text{abs}(A)}{\pi a} \quad . \tag{6}$$

where abs(A) = absolute value of A .

Once a and b are known, then the eccentricity of the ellipse, ECC, can be calculated as follows:

$$ECC = \frac{(a^2 - b^2)^{1/2}}{a} \quad . \tag{7}$$

If the range of values of R_{gm} for $m = 1,18$ is less than 1 percent of the maximum value of R_g, then the contour is assumed to be circular with a radius, r, given by

$$r = \left(\frac{\text{abs}(A)}{\pi}\right)^{1/2} \quad . \tag{8}$$

The same assumption of a circular contour is also made if, for some reason, the computed value for b is found to be greater than a. In the tests of the program to date, this condition (b > a) has not been observed.

2.2 Mathematical Representation of a Cut-Off Hill

The first preprocessor program, FITCON, determines an elliptical representation for each digitized contour associated with a given hill. Each contour can then be specified in terms of an elevation, centroid coordinates, semi-major and semi-minor axis lengths, and the orientation of the minor axis with respect to the positive x-axis. To calculate concentrations at hill receptors under stable conditions, the CTDM requires the following information for each of a series of critical cutoff elevations:

- The characteristics of the ellipse corresponding to the cut-off elevation. If this cutoff elevation coincides with a contour elevation, then the ellipse parameters are those determined by FITCON for the contour. Otherwise, the ellipse parameters are obtained by interpolation using parameters for the contours above and below the critical elevation.

- The center x,y coordinates and the orientation of the fitted hill corresponding to the portion of the actual hill above the critical elevation.

- The parameters which give the best inverse polynomial fit to the cut-off hill profile along the cutoff hill major and minor axes.

These parameters are calculated by HCRIT, the second of the 3 preprocessor programs, and are passed in a file to CTDM. The assumptions used in the calculation of these parameters are described in this section.

2.2.1 Best-Fit Ellipse at a Critical Elevation

The file written by program FITCON for input to program HCRIT contains the following parameters for each digitized contour processed:

- Contour elevation

- x,y coordinates of the fitted ellipse centroid

- Lengths of the semi-major and semi-minor axes for the fitted ellipse

- Eccentricity of the fitted ellipse

- Orientation of the fitted ellipse semi-minor axis with respect to the positive x-axis

The same assumption of a circular contour is also made if, for some reason, the computed value for b is found to be greater than a. In the tests of the program to date, this condition (b > a) has not been observed.

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- The characteristics of the ellipse corresponding to the cut-off elevation. If this cutoff elevation coincides with a contour elevation, then the ellipse parameters are those determined by FITCON for the contour. Otherwise, the ellipse parameters are obtained by interpolation using parameters for the contours above and below the critical elevation.

- The center x,y coordinates and the orientation of the fitted hill corresponding to the portion of the actual hill above the critical elevation.

- The parameters which give the best inverse polynomial fit to the cut-off hill profile along the cutoff hill major and minor axes.

These parameters are calculated by HCRIT, the second of the 3 preprocessor programs, and are passed in a file to CTDM. The assumptions used in the calculation of these parameters are described in this section.

2.2.1 Best-Fit Ellipse at a Critical Elevation

The file written by program FITCON for input to program HCRIT contains the following parameters for each digitized contour processed:

- Contour elevation

- x,y coordinates of the fitted ellipse centroid

- Lengths of the semi-major and semi-minor axes for the fitted ellipse

- Eccentricity of the fitted ellipse

- Orientation of the fitted ellipse semi-minor axis with respect to the positive x-axis

If there is only one contour, then the values for the ellipse centroid coordinates are set equal to the values for the single contour. The semi-major and semi-minor axis lengths for the critical elevation contour are extrapolated by assuming a zero-area contour at the hill-top elevation. Also, if the extrapolated value for the major axis is less than the extrapolated value for the minor axis, then both axes are set equal to the square root of their product. Finally, if the interpolated or extrapolated axis lengths are less than the corresponding axis lengths for the first contour above this critical elevation, then the axis lengths are set equal to the corresponding values for the first contour above this critical elevation.

The orientation of the ellipse at the critical elevation, θ_c, is computed by vector interpolation of contour orientations weighted by the contour eccentricities. The equations for the interpolation (extrapolation) of the value for the ellipse orientation at the critical elevation are given below:

$$\theta_c = \tan^{-1} (SUMY/SUMX) \qquad (10)$$

where

$$SUMX = ECC_L \cos \theta_L + \left(\frac{E - E_L}{E_H - E_L}\right) (ECC_H \cos \theta_H - ECC_L \cos \theta_L) \qquad (11(a))$$

$$SUMY = ECC_L \sin \theta_L + \left(\frac{E - E_L}{E_H - E_L}\right) (ECC_H \sin \theta_H - ECC_L \sin \theta_L) \qquad (11(b))$$

ECC_L = eccentricity at E_L

ECC_H = eccentricity at E_H

θ_L = orientation at E_L

θ_H = orientation at E_H .

If the critical elevation, E, is lower than the lowest contour elevation, then Equations (10) through (11) still apply except that E_L and E_H are defined as follows:

E_L = elevation of the lower digitized contour

E_H = elevation of the contour immediately above E_L

If there is only one contour, then the value for the ellipse orientation at the critical elevation is set equal to the orientation for the single contour. The parameters for the ellipse at the critical elevation are written by program HCRIT to a file which is input directly to CTDM. These ellipse parameter records are written to the file in the order of increasing critical elevation. Before they are written to this file, the ellipse orientations are modified so that they are expressed in terms of degrees clockwise from north for the contour major axis.

2.2.2 The Inverse Polynomial Profile

In addition to the ellipse parameters at the critical elevation, the CTDM requires that, for each critical elevation, the hill be fit along its major and minor axes in the vertical plane with an inverse polynomial profile. In this fit, the critical elevation is considered as the base of the cut-off hill. The location, shape and orientation of this fitted hill depend upon the ellipse parameters for the contours above the critical elevation. In the following discussion, the procedure for fitting an inverse polynomial profile to a cutoff hill will be described. First, however, the mathematical properties of the inverse polynomial profile will be investigated.

2.2.2.1 Mathematical Properties

A hill having an inverse polynomial profile along the x-direction can be characterized by the following expression:

$$h = \frac{\Delta H}{1 + (\frac{x}{L})^P} + h_o \quad (12)$$

where

- h = elevation of the hill surface at a horizontal distance x from the hill center along the x-direction
- h_o = base elevation of the hill which would correspond to a particular critical cut-off elevation
- ΔH = $h_T - h_o$
- h_T = hill top elevation
- P = profile exponent
- L = half-height length scale

An example of this profile is shown in Figure 10 for a range of exponent values.

To determine the best fit values of P and L for a series of actual terrain points along the x-direction, it is necessary to express Equation (12) in the following form:

$$\ln x - \ln L = \frac{1}{P} \ln \left(\frac{\Delta H}{h - h_o} - 1 \right) \quad (13)$$

Consider a collection of N_c terrain points with coordinates (x_j, h_j) with $h_o < h_j < h_T$ and $x_j > 0$. The best-fit values for P and L can be obtained by minimizing the following expression, χ^2, with respect to 1/P and ln L:

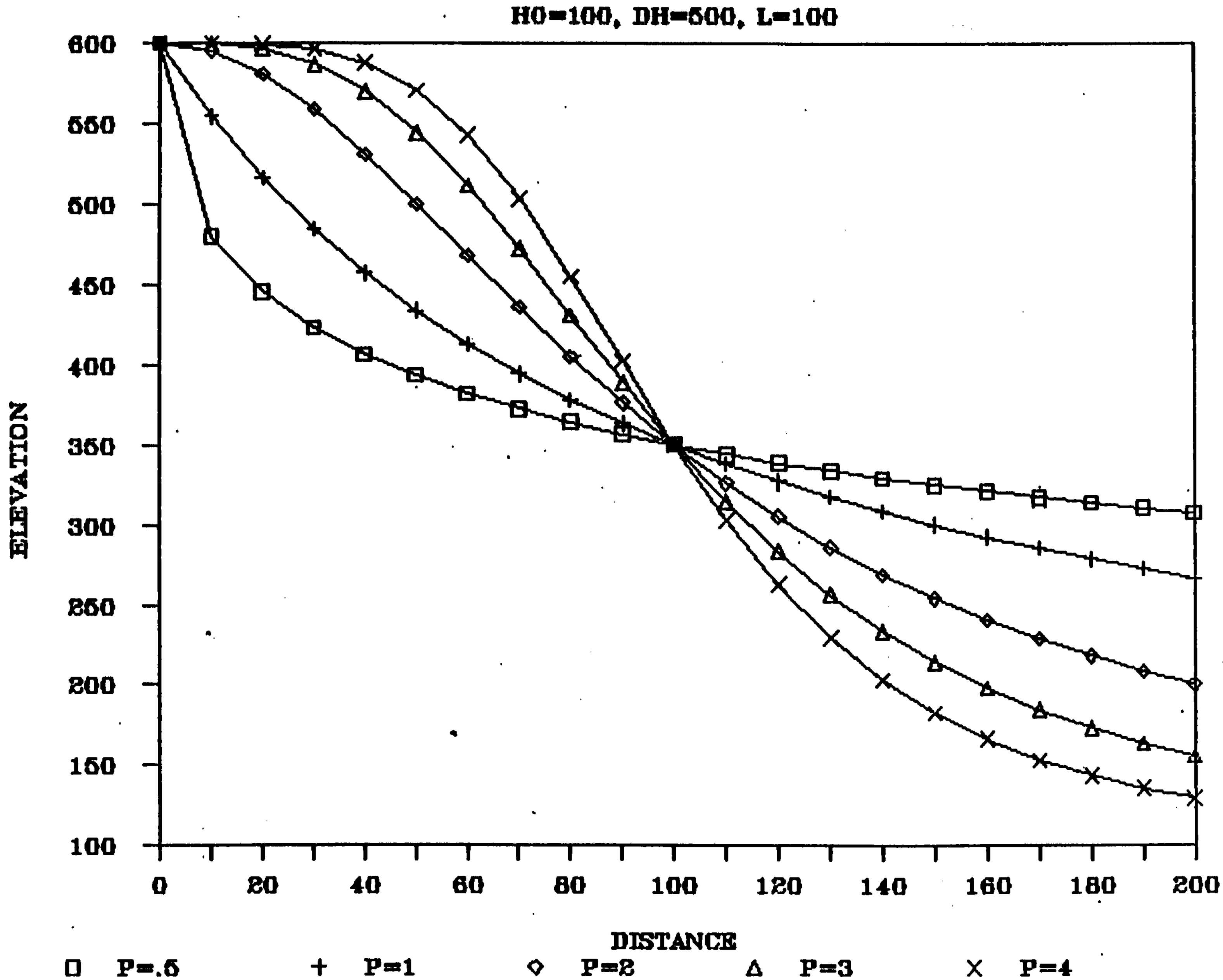

Figure 10. Inverse polynomial hill profile for five different exponent values.

$$\chi^2 = \sum_{j=1}^{N_c} \left[\ln x_j - \ln L - \frac{1}{P} \ln \left(\frac{\Delta H}{h_j - h_o} - 1 \right) \right]^2 \tag{14}$$

$$\frac{\partial \chi^2}{\partial \left(\frac{1}{P}\right)} = 0 \tag{15a}$$

$$\frac{\partial \chi^2}{\partial (\ln L)} = 0 \tag{15b}$$

Solving Equations 15(a) and (b), the following results are obtained for P and L:

$$P = \frac{N_c*SUM3 - SUM1**2}{N_c*SUM4 - SUM1*SUM2} \tag{16}$$

$$L = \exp\left(\frac{SUM2*SUM3 - SUM1*SUM4}{N_c*SUM3 - SUM1**2}\right) \tag{17}$$

where

$*$ = multiplication

$**$ = exponentiation

$$SUM1 = \sum_{j=1}^{N_c} \ln \left(\frac{\Delta H}{h_j - h_o} - 1 \right)$$

$$SUM2 = \sum_{j=1}^{N_c} \ln x_j$$

$$SUM3 = \sum_{j=1}^{N_c} \left(\ln \frac{\Delta H}{h_j - h_o} - 1 \right)^2$$

$$SUM4 = \sum_{j=1}^{N_c} \ln x_j \ln \left(\frac{\Delta H}{h_j - h_o} - 1 \right)$$

2.2.2.2 Procedure for Fitting the Profile to a Cutoff Hill

The center coordinates of the fitted hill (X_H, Y_H) are calculated as the arithmetic mean of the centroid coordinates (X_{cj}, Y_{cj}) of the N_c individual contours above the critical cutoff elevation:

$$X_H = \left(\sum_{j=1}^{N_c} X_{cj} \right) / N_c \tag{18a}$$

$$Y_H = \left(\sum_{j=1}^{N_c} Y_{cj} \right) / N_c \tag{18b}$$

No weighting with respect to contour area is performed since this would minimize the influence of the higher elevation contours in the determination of the fitted hill centroid. The orientation angle, θ, for the minor axis of the fitted hill is assumed to be a vector average of the individual contour minor axis orientations, weighted by the contour eccentricities;

$$\theta = \tan^{-1} \left(\frac{\sum_{j=1}^{N_c} ECC_j \sin \theta_j}{\sum_{j=1}^{N_c} ECC_j \cos \theta_j} \right) \tag{19}$$

where

θ_j = orientation angle for the ellipse representing contour j

ECC_j = eccentricity for the ellipse representing contour j

The eccentricity is used as a weighting factor since the orientation of a nearly circular contour (ECC~0) should not be considered when determining the orientation of the fitted cutoff hill.

At this point, all the ellipses above the cutoff elevation have been assigned a common center (X_H, Y_H) and a common orientation (θ) of the semi-minor axis with respect to the positive x-axis. What remains to be determined are the best-fit inverse polynomial parameters (P and L) for the hill major and minor axes. The best-fit parameters for the cutoff hill major axis (P_a and L_a) are calculated using Equations (16) and (17) with $x_j = a_j$ (the semi-major axis length for the ellipse representing contour j). The number of terms in the summation is equal to N_c, the number of contours above the critical cutoff elevation. The best-fit parameters for the cutoff hill minor axis (P_b and L_b) are calculated using Equations (16) and (17) with $x_j = b_j$ (the semi-minor axis length for the ellipse representing contour j).

If the best-fit values of either P_a and P_b are found to be negative (implying an increase of contour axis length with height), then this negative value is set equal to its absolute value.

Once the fitted hill parameters have been determined, they are written by program HCRIT to the CTDM input file with the parameter records in the order of increasing hill cut-off elevation. The cut-off hill orientations, written to the CTDM input file, are expressed in terms of degrees clockwise from north for the fitted hill major axis.

It should be noted that CTDM actually fits the inverse polynomial profiles along the major and minor axes of the cut-off hill to the following Gaussian shapes:

$$h = \Delta H \exp\left(\frac{-x^2}{2\sigma_a^2}\right) + h_o \tag{20a}$$

$$h = \Delta H \exp\left(\frac{-y^2}{2\sigma_b^2}\right) + h_o \tag{20b}$$

where

σ_a = standard deviation parameter for the Gaussian terrain distribution shape along the major axis,
σ_b = standard deviation parameter for the Gaussian terrain distribution shape along the minor axis.

The assumption is then made within CTDM that the hill terrain shape in 2 dimensions is given by the following expression:

$$h = \Delta H \exp\left(\frac{-x^2}{2\sigma_a^2} \cdot \frac{-y^2}{2\sigma_b^2}\right) + h_o \tag{21}$$

where

x = distance along the major axis,
y = distance along the minor axis.

This 2-dimensional Gaussian hill will have elliptical contours and will have a Gaussian profile along an arbitrary direction, θ, with respect to the major axis with the standard deviation parameter, σ_r, given by

$$\sigma_r = \frac{\sigma_a \sigma_b}{(\sigma_a^2 \sin^2 \theta + \sigma_b^2 \cos^2 \theta)^{1/2}} \tag{22}$$

SECTION 3

SYSTEM OPERATION

The CTDM Terrain Preprocessor described in this manual is designed to run on IBM-PC compatible microcomputers for which a FORTRAN compiler and BASICA interpreter (or compiler) are available. It is recommended that the microcomputer contain the appropriate math coprocessor for faster program execution.

The Terrain Preprocessor actually consists of 3 programs which are executed consecutively. The first program, written in FORTRAN, is named FITCON. It determines the best-fit ellipse for each input digitized contour. These ellipse parameters are used by the second FORTRAN program, HCRIT, to calculate, for each of a number of elevations, the ellipse parameters at that elevation and the best fit inverse polynomial hill shape for the portion of the hill above that elevation. Since both FITCON and HCRIT are written in FORTRAN 77, their use is not restricted to microcomputers. These programs can be run on any mini or mainframe computer for which a FORTRAN 77 compiler is available. The computer system must also allow for interactive input and output. The third program, PLOTCON, displays the input digitized contours, the fitted ellipse for each contour, and the contours of the fitted inverse polynomial hills. The operational characteristics of FITCON, HCRIT, and PLOTCON are described in the following 3 sections. Program listings are given in Appendix D of this manual.

3.1 FITCON

The program FITCON is written in the FORTRAN 77 language. The $LARGE metacommand must precede the FITCON main program if the MicroSoft™ compiler is used to compile the program. The comments section of the main program is extensive. The first portion of this section is devoted to a summary of program operation. This is followed by a detailed alphabetical glossary of every variable used in the program. The same level of detail of commenting is followed in the FITCON subroutines.

The main program comments section is followed by a number of TYPE, DIMENSION and DATA statements. Following these statements, several program constants are set. These include file unit numbers and maximum array dimensions.

The program first asks the user to specify the name of the master file containing the digitized contour information for the hill in question. The format for this file, is given in Section 4 of this manual. For each digitized contour in the master file, there is a record giving the contour identification number, contour elevation, number of digitized contour points, and a variable which indicates whether the contour is to be considered open or closed. The contour elevations must have the same units as the other elevations input to CTDM. This record is followed by the x,y coordinates of each digitized point on the contour. These coordinates must have the same units as the source and receptor coordinates used in CTDM. This master file of digitized contours may be generated by an automated contour digitization procedure or prepared by use of the DOS editor EDLIN or some other text editing program.

The user is then asked to input the name of the file to be used for program diagnostic output. If the name CON is specified for the output file, then the output is routed directly to the terminal. If the name PRN is specified for the output file, then the output will be routed directly to the line printer. If the name NUL is used for the output file, then no output file will be generated. By specifying a name for the file such as OUTPUT, the output file can be examined following program execution by use of the TYPE or PRINT commands or by inputting the output file to a file editing program. A detailed description of this output file is given in Section 5 of this manual. The file contains the following information:

- An echo of inputs specified by the user;
- Listings of input contour data;
- Listings of modified contour point coordinates;
- Messages generated during the contour editing and qualification process;
- The area, centroid coordinates, orientation and semi-axes lengths for the elliptical representation of each input digitized contour.

The user must then specify an identification number and a name for the hill in question. These two parameters are used by the plot program to ensure that plot files generated by programs FITCON and HCRIT correspond to the same hill. These identification parameters are also used by the CTDM itself. The user is also asked for the hill-top elevation and x,y coordinates of the hill center. The hill-top elevation is passed to program HCRIT to be used in the calculation of best-fit inverse polynomial parameters for cut-off hills. This elevation must have the same units as other elevations input to CTDM. The hill center x,y coordinates are used by FITCON only for the completion of incomplete contours. They must have the same units as the contour point coordinates input from the master file. Even if contours are input as complete, however, these coordinates should have realistic values since the plot of input digitized contours will be scaled to include this hill center location. The user is then asked whether point filtering is to be used prior to the completion of an incomplete contour. The point filtering process was described in detail in Section 2.1.2.1. If the answer is yes, the user is asked to input a filtering angle between 1 and 22.5 degrees. A value of 1 degree is currently recommended.

There are 3 ways provided by FITCON for selection of hill contours from the contour master file:

- All contours selected from the file,
- All contours having identification numbers falling within a user specified range,
- A file containing contour identification numbers for the hill in question.

If the third of these options is selected by the user, then the file of hill contour identification numbers is sorted using subroutine ISORT to facilitate the retrieval of contour data from the master file.

The user is then asked whether a plot containing the digitized and fitted contours is to be generated. If so, then the user must specify a name for the plot file. It must have a different name than the plot file specified by the user during the subsequent execution of the program HCRIT. After opening this plot file, FITCON also opens a scratch file which will temporarily hold some of the plot parameters. In the first record of the plot file, the character expression "FITCON" is written to indicate that the plot file is being written by program FITCON. The hill identification number and hill name are then written to the second record of the plot file. The hill center coordinates are written to the third plot file record.

FITCON then begins reading the digitized contour parameters from the master file and subjecting these contours to a qualification and editing process. The first qualification step is to determine whether the contour identification number matches the user-specified selection criteria. If not, the x,y coordinates for the contour are bypassed using subroutine SKIPCN and the next contour is input from the master file. If the contour identification number does meet the selection criteria, the contour is then subjected to the following additional tests:

- The contour elevation must be less than the hill-top elevation,
- The contour must not have an elevation equal to that of a contour which has been previously accepted from the master file,
- The contour must have at least 3 points,
- The contour must have no more than the maximum allowed number of digitized points (currently set at 1000).

If the contour passes the tests listed above, the program FITCON subroutine MULTC determines whether the contour is actually a set of multiple contours at the same elevation. If so, subroutine MULTC carries out the point reassignment procedure described in Section 2.1.2.2. The contour is rejected during this process if the number of maximum points is exceeded or if the last in a series of multiple contours is found not be be closed. If the contour is found to be a single contour (i.e. no contour closure before the final contour point), then this contour is subjected to the contour completion process described in Section 2.1.2.1.

This procedure is performed within subroutine CONCOMP and its associated subroutine VECTOR. Before the contour is finally accepted for processing, however, it must pass the following final two tests:

- The absolute value of the contour area obtained by numerical integration, using subroutine ARCM, must be greater than zero.

- The area and maximum second moment (calculated by subroutine SMOMNT) for the contour must have the same sign so that a real value for the radius of gyration may be calculated. A contour can fail this test if it crosses itself.

Once the contour has been accepted and if a plot has been requested, then both the unedited and edited contour point x,y coordinates are written to the plot scratch file. The plot boundaries for the display of unedited and edited contours are then updated to reflect the extent of this newly accepted contour. The centroid coordinates, orientation and semi-axes lengths for the elliptical representation of this edited contour are calculated, according to the methods described in Sections 2.1.3 through 2.1.5, and stored in the appropriate arrays. The next contour is then read from the master file and the qualification, editing and fitting process is repeated.

The input of digitized contours is halted when the end of the master file is reached or when the input of an additional contour would exceed the maximum number of contours allowed for a hill (currently set at 200). If the third contour selection mode was used, the user is informed, through a message written to the diagnostic output file, whether or not all the contours requested were found in the master file. If no contours were selected, an error message is written both to the screen and the diagnostic output file and program execution is terminated. In addition to the messages written to the diagnostic output file during the contour qualification and editing process, the user is kept informed by screen messages as to the disposition of contours input from the master file.

Once all contours have been processed, the master file is closed and the following information is written to the plot file:

- The number of contours processed,

- The identification numbers of the processed contours sorted in ascending order,

- The plot boundary limits for both unedited and edited contours.

The scratch plot file containing the coordinates of the unedited and edited contours is then rewound and the contour coordinates transferred to the plot file. Once this is completed, the scratch plot file is closed and deleted. The ellipse parameters for each processed contour are then written to the plot file.

The user is then asked for the name of the file which will be input to the program HCRIT. The following information is then written to this file:

format for this file is given in Table 4. The second is a file of parameters required by CTDM for the calculation of plume transport parameters for a number of critical elevations. The format for this file is given in Table 5.

5.3 PLOTCON

The program PLOTCON generates output in the form of screen displays and screen diagnostics. The program first displays actual contours in either unedited or edited format. This display is then overlayed with a display of fitted ellipses corresponding to the actual contours. Finally, a set of inverse polynomial contours is displayed for the fitted hill corresponding to each of a series of cut-off elevations. The following screen error mesages are generated by PLOTCON:

- FITCON plot file not found,
- HCRIT plot file not found,
- FITCON and HCRIT hill identification numbers do not match,
- FITCON and HCRIT hill names do not match,
- FITCON and HCRIT number of contours do not match,
- FITCON and HCRIT contour identification numbers do not match.

TABLE 4

FC MAT FOR THE PLOT FILE GENERATED BY HCRIT

Record Group	Parameter Name	Columns	Format	Description
1	-	1-6	A6	"HCRIT"
2	IDHILL	1-2	I2	Hill identification number
2	HNAME	4-18	A15	Hill name
3	NC	10	I10	Number of contours
4*	IDC(J), J=1, NC	10	I10	Sorted contour ID numbers
5	HTOP	15	E15.4	Hill-top elevation
6*	HCON	15	E15.4	Sorted contour elevations
7	NCR	10	I10	Number of critical elevations
8**	HC	15	E15.4	Critical elevation
8	XHTOPF, YHTOPF	16-45	2E15.4	x,y coordinates for the fitted cut-off hill centroid
8	ORENF	46-60	E15.4	Orientation (degrees) of the fitted cut-off hill minor axis with respect to the positive x-axis (east)
8	PA, PB	61-90	2E15.4	Inverse polynominal exponent parameters for the major and minor fitted hill axes.
8	LA, LB	91-120	2E15.4	Inverse polynominal length scale parameters for the major and minor fitted hill axes

*Repeated for each contour
**Repeated for each critical elevation

TABLE 5

FORMAT FOR THE FILE GENERATED BY HCRIT FOR INPUT TO CTDM

Record Group	Parameter Name	Columns	Format	Description
1	IDHILL	6-7	I2	Hill identification number
1	NCR	9-10	I2	Number of critical elevations
1	HTOP	21-30	E10.4	Hill-top elevation
1	HNAME	31-45	A15	Hill name
2*	HC	1-10	F10.3	Critical elevation
2	XCM, YCM	11-30	2E10.4	x,y-coordinates of the ellipse centroid for the critical elevation
2	ONOR	31-40	F10.3	Orientation (degrees) of the ellipse major axis with respect to north
2	A, B	41-60	2F10.3	Semi-major and semi-minor axes lengths for the ellipse at the critical elevation
3*	HC	1-10	F10.3	Critical elevation
3	XHTOPF, YHTOPF	10-30	2E10.4	x,y coodinates for the fitted cut-off hill centroid
3	ONOR**	31-40	F10.3	Orientation of the fitted cut-off hill major axis with respect to north (degrees)
3	PA, PB	41-60	2F10.3	Inverse polynominal exponent parameters for the major and minor fitted hill axes
3	LA, LB	61-80	2F10.3	Inverse polynominal length scale parameters for the major and minor fitted hill axes

* There are NCR group 2 records followed by NCR group 3 records

** Same as the variable name used for the third parameter of record group 2, the value is, however, different.

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APPENDIX A
SELECTION OF TERRAIN FEATURES
FOR CTDM

APPENDIX A

SELECTION OF TERRAIN FEATURES FOR CTDM

The CTDM user is required to assign a terrain element (hill number) to each model receptor near a terrain feature. (For receptors away from terrain features (hill number 0), a flat terrain calculation is performed.)

CTDM considers flow around isolated hills and is not designed to account for complex interactions among several terrain features adjacent to one another. Therefore, CTDM operates under the assumption that the meteorological input represents local flows with the steering of very large terrain features already accounted for. It is recommended that the most local terrain element be defined as a hill for each receptor.

In areas where hills are not isolated, the user faces a decision as to which portion of a large hill complex should be chosen for use in CTDM. In such cases, an incomplete hill (with some contours not closed) is often the most appropriate choice. Such incomplete hills are typically portions of a more complex hill that are on the side facing the source in question.

An example of how an incomplete hill is defined is shown in Figure A-1. In this figure, the monitor locations labeled 1, 3, 4, and 6 reside on a portion of the much larger Piedmont Mountain complex that also encompasses monitors 5, 7, 8, and 9. In general, it is appropriate to isolate a portion of a hill from a larger complex if the receptor points in question are at or above a closed contour on the hill portion. This is the case (although marginally so) for monitors 1, 3, 4, and 6. In this example, the data points for contours that are not closed on this hill are stopped during the digitization process at the hill portion boundary as defined by the user (e.g., see Figure A-1). The Terrain Preprocessor will then complete these contours through the use of symmetry about a hill center specified by the user. In this way, the isolated hills required by CTDM are created from non-isolated hill input. The local hill shape for monitor locations 1, 3, 4, and 6 is retained by using the smallest hill portion possible. The part of the isolated hill that is "made up" from the non-isolated hill for use in CTDM is generally to the lee of the monitor locations, and is therefore not a significant factor in the model calculations.

A sample terrain configuration featuring a complex of two local hills as part of a larger hill system is shown in Figure A-2. For plumes from stack A, receptors 1 and 2 can be considered to be on two separate local hills (divided by the dashed line in the figure). For stack B, however, the influence of Hill A as well as Hill B must be considered for receptor 2 (the Terrain Preprocessor would consider a multi-peak hill for this

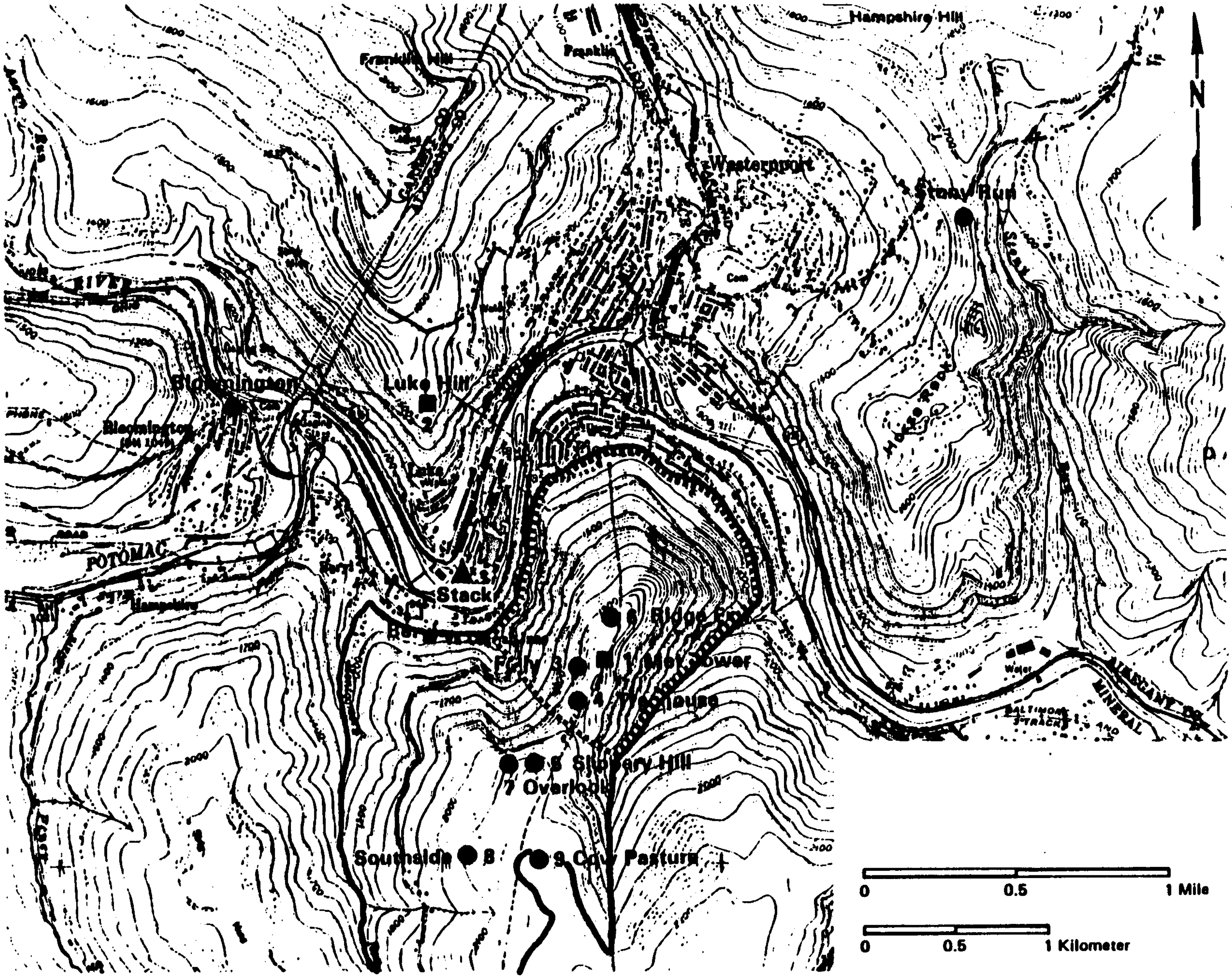

Figure A-1. Map of Luke Mill area showing isolated terrain features south of the source.

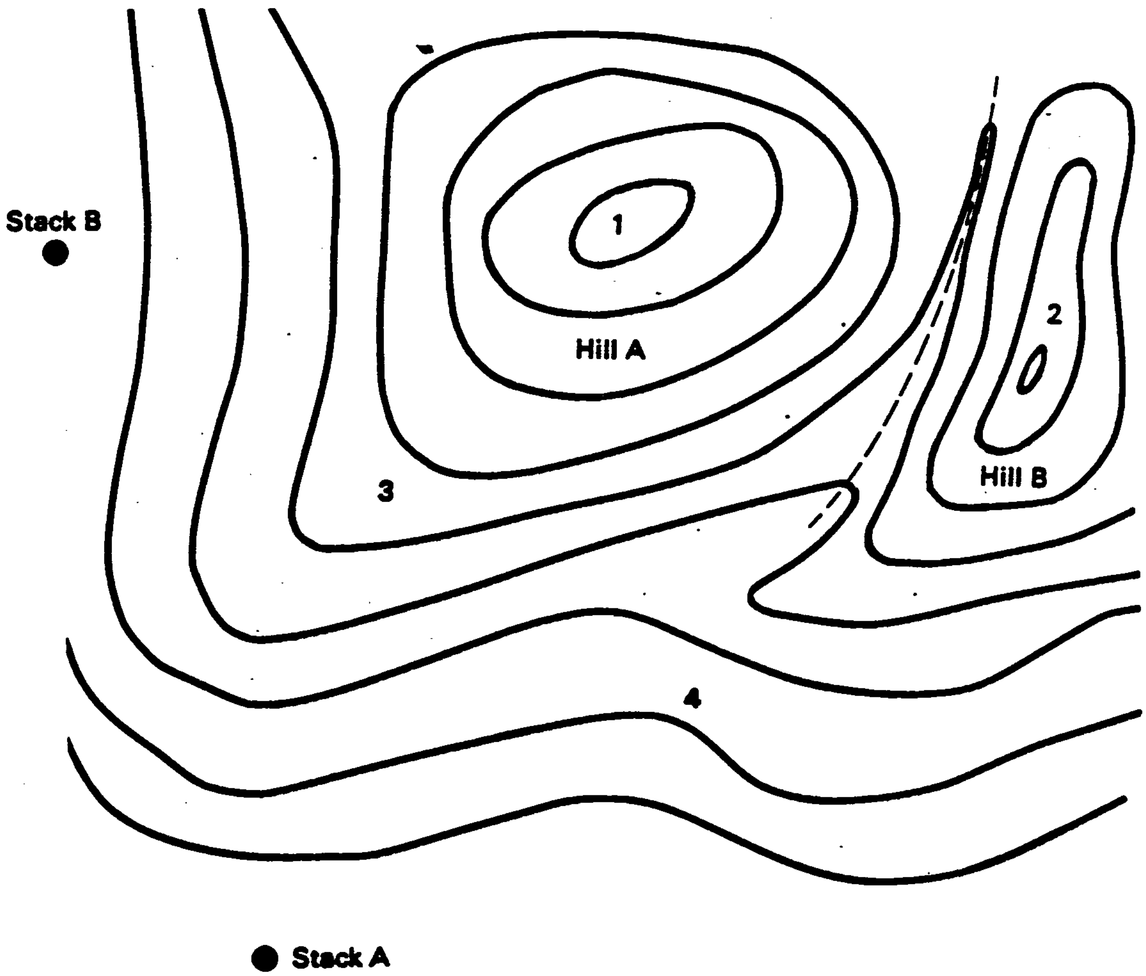

Figure A-2. Example illustrating how to select terrain features for various CTDM receptor locations. Receptors 1 and 2 should be associated with local hills A and B, respectively, for stack A (these hills are separated by the dashed line). For stack B, receptor 2 must consider hill A and B together. Receptor 3 can be associated with local hill A for both stacks. For receptor 4, a combined terrain feature including both hills must be used for both stacks.

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instance). The complication for receptor 2 makes it necessary to consider separate CTDM runs for stacks A and B. In order to use receptor 2 for Stacks A and B in a single run, a user has to create two coincident receptors for that position and assign different hill numbers for each, depending on the stack. Afterward, the results for the inappropriate receptor for each stack must be ignored.

The user must input a hill center for each CTDM hill. This center is used only in the contour completion algorithm of the terrain preprocessor; it does not affect closed contours. The hill center does not necessarily have to be at the physical center of the hill. There is no program input restriction on where incomplete contours end, since the terrain preprocessor will accept incomplete contours and complete them through a reflection algorithm about the specified hill center. However, it is advisable to define hill such that contours extend at least halfway around the specified hill center. The center should be chosen to minimize crossover of completed ("edited") contours onto any existing closed contours. The graphical display of the edited contours will aid the user in determining if the contour completion looks reasonable or if the hill center position should be adjusted. Fortunately, the arbitrary positioning of the hill center appears to have a minor effect upon the maximum concentrations on the hill if an adequate receptor coverage is provided (Strimaitis et al., 1987).

If a receptor does not appear to be associated with any hill (i.e., is in "simple" or flat terrain, with the plume height far above the terrain features), the user may still model this receptor with CTDM by specifying hill number '0' in the receptor input file.

- Hill identification number and name;
- Hill-top elevation;
- Processed contour identification numbers sorted in ascending order;
- The elevation, centroid coordinates, semi-axes lengths, eccentricity and orientation of the ellipse associated with each processed contour.

The contour identification numbers are sorted and passed to HCRIT only for subsequent consistency checks within the plot program PLOTCON. These checks will be discussed in Section 3.3.

3.2 HCRIT

The HCRIT program is used to calculate (1) ellipse parameters for a series of elevations and (2) the inverse polynomial fit parameters for the portion of the hill above each of these elevations, which is assumed to act effectively as the base of a cutoff hill. When HCRIT is executed, the user is first asked to specify the name of the file generated by FITCON for input to HCRIT. The program then asks the user for the name of the file to be passed to CTDM. The user must then specify whether or not a plot showing the fitted contours is to be generated for each critical elevation. If a plot is required, then the user must specify the name of the plot file, which must have a name different from the plot file generated by FITCON.

HCRIT then reads the following information from the file passed from FITCON:

- The hill identification number and name;
- Hill-top elevation;
- Number of fitted contours;
- Sorted identification numbers for the fitted contours;
- Elevations, centroid coordinates, semi-axes lengths, eccentricities and orientations of the fitted contours.

The following information is then transferred to the HCRIT plot file:

- The character expression "HCRIT" to identify the plot file as one generated by the HCRIT program,
- The hill identification number and name,
- Number of fitted contours,

- Sorted identification numbers for fitted contours,

- Hill-top elevation.

The FITCON file is then closed and the fitted contour parameters are sorted in ascending order with respect to contour elevation. This pointer sort is carried out by subroutine PSORTR. These sorted contour elevations are written to the HCRIT plot file.

Two options are available for specifying critical elevations in the HCRIT program. The user may specify that each contour level (with the exception of the uppermost contour) is to be used as a critical elevation. This mode can be used only if there is more than one contour. The other option is to ask for up to 20 critical elevations to be evenly spaced between a user-supplied lower elevation and the uppermost contour elevation. If the second option is selected and N_{HC} critical elevations are requested with the first elevation beginning at HC_1, the remaining $N_{HC}-1$ critical elevations are determined as follows:

$$HC_i = (h_N - HC_1)/N_{HC} + HC_1$$

where

HC_i = elevation of the ith critical elevation

h_N = elevation of the uppermost contour of the N fitted contours

$i = 2, N_{HC}$.

The value of HC_1 specified by the user must be at least one elevation unit below h_N.

Note: CTDM requires that the lowest critical elevation be at or below stack base elevation. If there are no actual terrain contours near this elevation, the HCRIT program calculates best-fit ellipses and cut-off hill shapes at the required heights by extrapolation from the lower part of the hill for which contour input is available.

Once the critical elevations have been specified, then the number of these elevations is written to the HCRIT plot file. Also, the hill identification number, number of critical elevations, hill-top elevation and hill name are written to the CTDM input file. The program then determines the best-fit ellipse at each critical elevation according to the methods described in Section 2.2.1. N_{HC} records are written to the CTDM input file, each containing the critical elevation, ellipse centroid coordinates, orientation of the ellipse major axis with respect to north, and the lengths of the ellipse semi-major and semi-minor axes.

Using the methods described in Section 2.2.2.2., the program then calculates the following parameters for the cut-off hill corresponding to each critical elevation:

- Critical elevation,

- x,y coordinates of the cut-off hill center,

- Orientation of the major axis of the fitted cut-off hill with respect to north,

- Inverse polynomial best-fit exponents for the major and minor axes of the fitted cut-off hill,

- Inverse polynomial best-fit length scales for the fitted cut-off hill major and minor axes.

In fitting the inverse polynomial profile parameters for the cut-off hill, only contour elevations greater than one elevation unit above the critical elevations are used in the fit. These parameters are written to both the HCRIT plot file and the CTDM input file.

3.3 PLOTCON

The PLOTCON program is used to display the output from the FITCON and HCRIT programs. The user must have an Advanced BASIC(BASICA) interpreter or compiler to run PLOTCON. A special version of PLOTCON(HPLTCON) has been written in HBASIC for users of the Hercules™ Graphics Board with an IBM PC, XT or AT. PLOTCON will not run, however, on non-IBM personal computers with a Hercules™ Graphics Board. The interpretive version of PLOTCON is run by typing the command BASICA PLOTCON.

The first statement of PLOTCON erases the function key display from the 25th line of the display, making that line available for program use. The user is then asked to input the name of the plot file generated by program FITCON. This file is opened and the first record is read to determine whether the expression "FITCON" is present. If not, an error message is written to the screen and the user is asked again to input the file name. If the file is accepted, the following information is input from the plot file:

- Hill identification number,

- Hill name,

- Hill center coordinates,

- Number of fitted contours,

- Contour identification numbers,

- Maximum and minimum x and y coordinates for the unedited and edited contours.

The user is then asked whether the plot is to be low resolution (320 points horizontal by 200 points vertical) color or high resolution (640 points horizontal by 200 points vertical) black and white. For the low resolution color display, the text and actual contours (unedited or edited) are given in white, the fitted contours in magenta, and the background in light blue. If the Hercules™ version of PLOTCON

(HPLTCON) is used, only one type of display (720 points horizontal by 348 points vertical - black and white) is available. For each type of display, the scale parameters are assigned values which ensure that each plot, when output to a graphics printer, will have the same vertical and horizontal scale and will occupy the maximum area when viewed on the display terminal. For the low resolution (320 x 200) color option, the vertical and horizontal scales for the plots on the display terminal are virtually equal. To obtain the same vertical and horizontal scale for the hardcopy in high resolution (640 x 200), however, the horizontal scale for the terminal display had to be made slightly larger than the vertical scale. Plots obtained with the Hercules™ Graphics Board have the same horizontal and vertical resolution on both the screen display and printout. Once the type of display has been selected, the user must specify whether the actual hill contours are to be plotted as unedited or edited. As discussed in Section 2.1.2.1, the edited contours represent contours which were input as open, but have been closed, in some cases by the point reflection process (either with or without angular filtering).

After these inputs have been completed, PLOTCON sets a number of plot boundaries, scale factors and colors. The actual contours are then plotted with special logic designed to handle the case of multiple contours at the same elevation. Since coordinates for both unedited and edited contours are contained in the same file, logic is provided for skipping the unwanted point sets (unedited or edited). Once the actual contours have been plotted on the screen, the program plots a square (3 points by 3 points) in white corresponding to the user-supplied location for the hill center. This plot of actual contours and the hill center is stored in an array for later display. The program then displays the hill name and the text "INPUT CONTOURS" at the top of the screen. The program pauses until the user strikes any key. If the "ESC" (escape) key is pressed, then execution of the program is terminated. During this and subsequent pauses in program execution, the user has the option of printing out the plot by holding down the "Shift" key and pressing the "PrtSc" key*. Hercules™ Graphics Board users must also press the 0 (zero) key following the "Shift PrtSc" command.

PLOTCON then displays the elliptical representation of each contour, overlayed on the plot of actual contours. For each fitted contour, the following parameters are input from the FITCON plot file: x,y coordinates of the ellipse centroid, lengths of the ellipse semi-major and semi-minor axes, and the orientation of the ellipse minor axis with respect to the positive x-axis. Starting at the end of the semi-major axis and moving counter-clockwise from the ellipse centroid, ellipse points are generated

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*The user must have one of the commonly available 9-pin graphics printers to exercise this option. Also, for displays with a resolution of 320 x 200 (color) and 640 x 200 (black and white), the user must have run the program GRAPHICS.COM prior to PLOTCON execution. Hercules™ Graphics Board users must run the program HGC.COM before HPLTCON execution using the command HGC PRINT.

at 3 degree intervals, transformed to the x,y coordinate system, and then connected with straight lines. After the fitted contours have been plotted, the hill name and text "FITTED CONTOURS" are written to the top line of the display. The program execution then pauses until the user presses any key. If the ESC key is pressed, program execution is terminated.

Once a key is pressed, the program returns to text mode and the user is asked whether a display of fitted cutoff hill contours is to be generated. If the answer is yes, the user is asked to input the name of the plot file generated by program HCRIT. If the first record in this file does not contain the character expression "HCRIT", then the user is asked again to specify the plot file name. If the file is accepted, PLOTCON checks whether there is agreement between the FITCON and HCRIT plot files with respect to the hill identification number, hill name, number of contours, and contour identification numbers. If any of these parameters do not agree, then an error message is given and program execution is terminated. If agreement is found, then the program returns to graphics mode and the elevations of the hill top and individual contours are input from the HCRIT plot file. The program also reads the number of critical elevations and begins a loop over these elevations. For each critical elevation, the following parameters are input from the HCRIT plot file:

- Critical elevation,
- x,y coordinates of the fitted hill centroid,
- Orientation of the fitted hill minor axis with respect to the positive x-axis,
- Inverse polynomial parameters (exponent and length scale) for the fitted hill major and minor axes.

The program then determines the orientation of the cutoff hill major axis with respect to the positive x-axis and retrieves the background plot of digitized actual contours, which was previously generated and stored in an array. The program then plots the contours of the fitted cutoff hill at those elevations which are at least one elevation unit above the critical cutoff elevation. For display of these contours, the following generalized version of the inverse polynomial profile (Equation 12) is used:

$$h_j = \frac{\Delta H}{1 + \left(\frac{x'}{L_a}\right)^{P_a} + \left(\frac{y'}{L_b}\right)^{P_b}} + h_o \qquad (23)$$

where

h_j = contour elevation

h_o = hill cutoff elevation

$\Delta H = h_T - h_o$

h_T = hill top elevation

P_a, P_b = best-fit inverse polynomial exponent parameters for the fitted hill major and minor axes obtained from Equation (16)

L_a, L_b = best-fit inverse polynomial length scale parameters for the fitted hill major and minor axes obtained from Equation (17)

x', y' = coordinates of a point on the inverse polynomial contour at elevation h_j with x' measured along the fitted hill major axis and y' measured along the fitted hill minor axis.

Equation (23) may be rewritten as follows:

$$\left(\frac{x'}{AFIT}\right)^{P_a} + \left(\frac{y'}{BFIT}\right)^{P_b} = 1 \qquad (24)$$

where

$$AFIT = L_a \left(\frac{\Delta H}{h_j - h_o} - 1\right)^{\frac{1}{P_a}}$$

$$BFIT = L_b \left(\frac{\Delta H}{h_j - h_o} - 1\right)^{\frac{1}{P_b}}$$

If P_a and P_b are equal to 2, then Equation (24) represents an ellipse. For values of P_a and P_b less than 2, the contour shape at the axis points becomes sharper with the contour acquiring a diamond shape for $P_a = P_b = 1$. For P_a and P_b values less than 1, the contour acquires a concave appearance. For values of P_a and P_b larger than 2, the contour acquires a rectangular shape with rounded corners. Due to the wide variation in shapes possible with Equation (24), the fitted contour is not plotted in a parametric fashion (r, θ) as was done in the case of the fitted ellipses. Instead, 400 evenly spaced x' values along the major axis from - AFIT to + AFIT are selected and the corresponding y' values determined. Also, 400 evenly spaced y' values along the minor axis from - BFIT to + BFIT are selected and the corresponding x' values determined. After transformation to the x,y coordinate system, these 800 contour points are simply plotted and not connected.

After all the fitted hill contours for a given critical cut-off elevation have been plotted, the program displays the calculated centroid of the fitted hill as a 3 x 3 array of points. The hill name and critical elevation value are then displayed on the top line of the screen. The program execution then pauses until the user presses any key. Program execution terminates if the ESC key is pressed. Once a key is pressed, fitted hill contours are plotted for the next highest critical elevation. This process is repeated until all critical elevations have been analyzed.

It is important to note that with respect to the cut-off hill, the only parameters used by the CTDM "LIFT" calculation are the cut-off hill center, orientation and inverse polynomial profile coefficients for the major and minor axes. The fitted hill contours are only displayed to determine whether their size and location correspond to the actual contour locations, which in many cases they will not. In this regard, the use of Equation (24) to represent the shape of these contours is arbitrary. In fact, CTDM fits the inverse polynomial profile along the major and minor cutoff hill axes to Gaussian shapes. The resulting Gaussian-shaped hill will have contours which are elliptical. In the CTDM "WRAP" calculation, the individual fitted ellipses constructed by program FITCON are used.

SECTION 4

INPUT REQUIREMENTS

In this section, the requirements for interactive and batch inputs will be described for the programs FITCON, HCRIT and PLOTCON. References are provided to discussions in Sections 2 and 3. Some of the inputs required by the programs HCRIT and PLOTCON are given in output files generated by FITCON and HCRIT. These files will be described in Section 5, which deals with program output.

4.1 FITCON

The first program of the Terrain Preprocessor System to be run for a given hill is program FITCON. The following interactive inputs must be specified by the user when running program FITCON for a given hill:

- Contour master file name (maximum of 14 characters)*.
  (See Section 2.1.1, paragraph 1 and Section 3.1, paragraph 3.)

- Diagnostic output file name (maximum of 14 characters)*.
  (See Section 3.1, paragraph 4.)

- Hill identification number (1-99).
  (See Section 2.1; Section 3.1, paragraph 5; and Appendix A.)

- Hill name (1 to 15 characters).
  (See Section 3.1, paragraph 5.)

- Hill-top elevation in user units (maximum of 10 digits including the decimal point).
  (See Section 3.1, paragraph 5 and Section 2.2.2.1.)

- Hill center x-coordinate in user units (maximum of 10 digits including the decimal point).
  (See Section 3.1, paragraph 5 and Section 2.1.2.1.)

- Hill center y-coordinate in user units (maximum of 10 digits including the decimal point).
  (See Section 3.1, paragraph 5 and Section 2.1.2.1.)

- A yes (Y) or no (N) answer as to whether angular filtering is to be used in the contour completion process.
  (See Section 3.1, paragraph 5 and Section 2.1.2.1.)

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*A maximum of 2 characters for the drive specifier and 8 characters for the file name followed by a period and a maximum of 3 characters for the file name extension.

- Angular filter size (1-22.5 degrees) to be used in the contour completion analysis (maximum of 10 digits including the decimal point). Required only if the answer to the previous question is yes. Recommended value is 1. (See Section 3.1, paragraph 5 and Section 2.1.2.1.)

- Mode for selection of contours from the master file (1-3)
  - Mode 1 - all contours in master file selected for the hill.
  - Mode 2 - range of identification numbers used in the selection of contour numbers for the hill.
  - Mode 3 - identification numbers for the hill contours specified in a separate file.
    (See Section 3.1, paragraphs 6 and 7.)

- Lower bound for the contour identification number range for contour selection (1-9999). Required only if the contour selection mode is 2. (See Section 3.1, paragraphs 6 and 7.)

- Upper bound for the contour identification range for contour selection (1-9999). Required only if the contour selection mode is 2. (See Section 3.1, paragraphs 6 and 7.)

- Name of the file holding the identification numbers of the contours to be selected from the master file (maximum of 11 characters). Required only if the contour selection mode is 3. (See Section 3.1, paragraphs 6 and 7.)

- A yes (Y) or no (N) answer as to whether a plot of the actual and fitted contours is to be generated. (See Section 3.1, paragraph 8.)

- Name of the FITCON plot file (maximum of 14 characters). Required only if the answer to the previous question is yes. (See Section 3.1, paragraph 8.)

- Name of the file containing fitted contour output to be passed to program HCRIT (maximum of 14 characters). (See last 2 paragraphs of Section 3.1.)

The first batch file required by FITCON is the master file containing digitized contour parameters. The input format for this file is specified in Table 1. For more information related to the preparation of this file, see Sections 2.1.1 and 2.1.2. A second batch input file is required only if contour selection Mode 3 is specified. This file contains the contour identification numbers for the selected contours for the hill in question. These identification numbers (1-9999) must be given one integer number per record in free format.

4.2 HCRIT

Following the successful completion of the FITCON run, program HCRIT is then run for the hill in question. Aside from the file of fitted contour parameters passed to it by program FITCON, program HCRIT requires only the user-supplied interactive inputs given below:

TABLE 1

FORMAT FOR THE CONTOUR MASTER FILE

Record Group	Parameter Name	Format	Description
1*	IDC	Free	Contour identification number (integer)
	HCON	Free	Contour elevation (user units)
	NPC	Free	Number of input points for contour (integer)
	CFLAG	Free	Contour flag (integer) 0 = Open 1 = Closed
2*	XCON, YCON**	Free	x, y coordinates of the NPC contour points (user units)

*Record group repeated for each contour

**Values may span more than one record. A convenient format for file review and editing is to specify x and y for a single contour point on one record.

- Name of the file containing fitted contour parameters generated by program FITCON (maximum of 14 characters) must be the same as the last file name input to program FITCON. Also see Section 3.2, paragraphs 1 and 2.)

- Name of the output file to be passed to CTDM (maximum of 14 characters). (See Section 3.2, paragraphs 1 and 6.)

- A yes (Y) or no (N) answer as to whether plots of fitted hill contours are to be generated for each critical elevation. (See Section 3.2, paragraph 1.)

- HCRIT plot file name (maximum of 14 characters). Required only if the answer to the previous question is yes. (See Section 3.2, paragraph 1.)

- Selection mode for critical elevations (1-2).
  - Mode 1 - critical elevations at all contour elevations except uppermost
  - Mode 2 - critical elevations at all evenly spaced levels between a user-supplied elevation and the uppermost contour elevation (see Section 3.2, paragraphs 4 through 6.)

- Number of critical elevations (1-200). Required only if critical elevation selection mode 2 is used. (See Section 3.2, paragraphs 4 through 6.)

- Lowest critical elevation (maximum of 10 digits including the decimal point). Must be at least one elevation unit below the highest contour elevation. CTDM requires this elevation to be at or below stack base elevation. (See Section 3.2, paragraphs 4 through 6.)

4.3 PLOTCON

With the exception of the plot files generated by FITCON and HCRIT, the only inputs to PLOTCON are specified interactively by the user. These input parameters are listed below:

- Name of the plot file from program FITCON (maximum of 14 characters) must be the same file name as that specified interactively during program FITCON execution. (See Section 4.1.)

- Display selection option (1 or 2).
  - Option 1 - low resolution with color
  - Option 2 - high resolution black and white. Not required if the Hercules™ version of the program is used. (See Section 3.3, paragraph 3.)

- Contour type selection option (1 or 2)
  - Option 1 - Unedited contours
  - Option 2 - Edited contours.
  (See Section 3.3, paragraph 3.)

- A yes (Y) or no (N) answer as to whether a plot of fitted contours is to be generated for each critical elevation. (See Section 3.3, paragraph 6.)

- Name of the plot file from program HCRIT (maximum of 14 characters). Required only if the answer to the previous question is yes. Must be the same file name as that specified interactively during program HCRIT execution. (See Section 4.2.)

SECTION 5

OUTPUT DESCRIPTION

In this section, the output of the 3 terrain preprocessor programs FITCON, HCRIT and PLOTCON is described. There are 4 types of output generated by the 3 programs which constitute the Terrain Preprocessor:

- Screen diagnostics,
- Diagnostic information written to an output file or printer,
- Files passed from one program to the next,
- Graphical output.

Program FITCON utilizes the first 3 types of output, while HCRIT only passes files to PLOTCON and CTDM. Program PLOTCON generates both graphical output and screen diagnostics.

5.1 FITCON

The following screen diagnostic outputs are provided by program FITCON:

- A message that a particular contour (identified by its ID number) has been rejected. User is directed to consult the diagnostic output file after program completion. The diagnostic output file is described below.
- A message that a particular contour (identified by its ID number) has been accepted.
- A message that no contours were requested (i.e. the contour ID file is empty). Applies only if contour selection mode 3 is used.
- A message that no contours were selected from the master file.

The following information is written by program FITCON to the diagnostic output file:

- Hill identification number and name. (See Section 3.1, paragraph 5.)
- Angular filter size specified by the user (only if angular filtering has been requested by the user). (See Section 2.1.2.1.)
- Angular filter size after it has been modified to divide evenly into 360 degrees (only if angular filtering has been requested by the user). (See Section 2.1.2.1.)

- Hill-top elevation and hill center coordinates. (See Section 3.1, paragraph 5.)

- A message that all contours in the master file are to be selected (only if contour selection mode 1 is used). (See Section 3.1, paragraphs 6 and 7.)

- Lower and upper identification number limits for selection of contours from the master file (only if contour selection mode 2 is used). (See Section 3.1, paragraphs 6 and 7.)

- List of sorted identification numbers for contours to be selected from the master file (only if contour selection mode 3 is used). (See Section 3.1, paragraphs 6 and 7.)

- Contour identification number and elevation. (See Section 2.1.1.)

- x,y coordinates input for a contour. (See Section 2.1.1.)

- Modified x,y coordinates for a contour. (See Section 2.1.2.)

- Contour area and centroid coordinates (See Section 2.1.3.)

- Semi-axis lengths, eccentricity, and orientation for the ellipse representing a contour. (See Section 2.1.4.)

In addition to the items of information listed above, the following messages are written by FITCON to the diagnostic output file if errors are found:

- Maximum number of contours reached. (See Section 2.1.2, paragraph 4.).

- Contour elevation greater than the hilltop elevation - contour rejected. (See Section 2.1.2, paragraph 2.)

- Previously accepted contour has the same elevation as the current contour - current contour rejected. Multiple contours at the same elevation must be input as a single contour. (See Section 2.1.2.2.)

- Contour has fewer than 3 points - contour rejected. (See Section 2.1.2, paragraph 2.)

- Contour has more than the maximum number of allowable points - contour rejected. (See Section 2.1.1, paragraph 2.)

- Maximum number of points exceeded in the contour point reassignment process for multiple contours at the same elevation - contour rejected. (See Section 2.1.2.2.)

- The last in a series of multiple contours was found not to be closed - contour rejected. (See Section 2.1.2.2.)

- Contour found to be a single contour (i.e. no contour closure was found before the final contour point). (See Section 2.1.2.2.)

- Point reassignment for the multiple contour successfully completed. (See Section 2.1.2.2.)

- Point reassignment for the multiple contour successfully completed after the point input order of one or more component contours was reversed to make the order of point input for each component contour the same as the first component contour. (See Section 2.1.2.2.)

- Contour completion halted due to exceedance of the maximum number of allowable contour points. The final contour point will have coordinates equal to those of the initial point. (See Section 2.1.2.1.)

- Contour specified as closed was found to be open. Added final point assumed to be the same as the initial point. (See Section 2.1.2.1.)

- Maximum number of contour points exceeded in the closing operation. Final point is replaced by the initial point. (See Section 2.1.2.1.)

- Contour specified as open was found to be closed. (See Section 2.1.2.1.)

- Contour area found to be zero - contour rejected. (See Section 2.1.2 paragraph 2.)

- A real value for the radius of gyration could not be computed - contour rejected. (See Section 2.1.2, paragraph 3.)

- The relative difference between the maximum and minimum radii of gyration for the contour was found to be less than 1 percent. Contour assumed to be circular. (See Section 2.1.5.)

- No contour identification numbers were found in the contour ID file (only applies if contour selection mode 2 is used). (See Section 3.1, paragraphs 6 and 7.)

- No contours were selected from the master file.

Program FITCON constructs 2 output files which are subsequently read by the HCRIT and PLOTCON programs. The file passed to the PLOTCON program contains information required to plot actual and fitted contours for the hill in question. The format for this file is given in Table 2. The second file, which is passed to program HCRIT, contains the parameters for the fitted ellipses, along with the elevations of the hill top and contours. The format for this file is given in Table 3.

5.2 HCRIT

The only output from program HCRIT consists of two files. The first is a plot file containing parameters required by PLOTCON for the display of contours on cut-off hills for a number of cut-off elevations. The

TABLE 2

FORMAT FOR THE PLOT FILE GENERATED BY FITCON

Record Group	Parameter Name	Columns	Format	Description
1	-	1-6	A6	"FITCON"
2	IDHILL	1-2	I2	Hill identification number
2	HNAME	4-18	A15	Hill name
3	XHTOP	1-15	E15.4	Hill center x-coordinate
3	YHTOP	16-30	E15.4	Hill center y-coordinate
4	NC	1-10	I10	Number of contours accepted
5*	IDC(J), J=1, NC	1-10	I10	Sorted contour ID numbers
6	XMIN1, XMAX1, YMIN1, YMAX1	1-60	4E15.4	Boundary limits for unedited contours
7	XMIN2, XMAX2, YMIN2, YMAX2	1-60	4E15.4	Boundary limits for edited contours
8**	NPCSV	1-10	I10	Number of contour points for an unedited coutour
8	HCON(J)	11-25	E15.4	Elevation of contour J
9	XCONSV(K), YCONSV(K), K=1, NPCSV	1-30	2E15.4	x,y coordinates for an unedited contour
10	NPC	1-10	I10	Number of contour points for an edited contour
10	HCON(J)	11-25	E15.4	Elevation of contour J
11	XCON(K), YCON(K), K=1, NPC	1-30	2E15.4	x,y coordinates for an edited contour
12*	XCM	1-15	E15.4	x-coordinate for a contour centroid
12	YCM	16-30	E15.4	y-coordinate for a contour centroid
12	A	31-45	E15.4	Semi-major axis length for the elliptical representation of the contour

TABLE 2 (Continued)

Record Group	Parameter Name	Columns	Format	Description
12	B	46-60	E15.4	Semi-minor axis length for the elliptical representation of the contour
12	OREN	61-75	E15.4	Orientation (degrees) of the semi-minor axis of the ellipse with respect to the positive x-axis (east)

*Repeat for each contour

**Groups 8 through 11 repeated for each contour

TABLE 3

FORMAT FOR THE FILE GENERATED BY FITCON FOR INPUT TO HCRIT

Record Group	Parameter Name	Columns	Format	Description
1	IDHILL	1-2	I2	Hill identification number
1	HNAME	4-18	A15	Hill name
2	HTOP	15	E15.4	Hill-top elevation
3	NC	10	I10	Number of accepted contours
4*	HCON	1-15	E15.4	Contour elevation
4	XCM	16-30	E15.4	x-coordinate of contour centroid
4	YCM	31-45	E15.4	y-coordinate of contour centroid
4	A	46-60	E15.4	Ellipse semi-major axis length
4	B	61-75	E15.4	Ellipse semi-minor axis length
4	ECC	76-90	E15.4	Eccentricity of the ellipse
4	OREN	91-105	E15.4	Orientation (degrees) of the ellipse semi-minor axis with respect to the positive x-axis (east)

*Repeat for each contour

APPENDIX B
DERIVATION OF EQUATIONS FOR THE AREA, CENTROID COORDINATES, AND SECOND MOMENT OF A DIGITIZED CONTOUR

APPENDIX B

DERIVATION OF EQUATIONS FOR THE AREA, CENTROID COORDINATES, AND SECOND MOMENT OF A DIGITIZED CONTOUR

B.1 Derivation of Equation (1) for the Area of a Digitized Contour

An example digitized contour is shown in Figure B-1. The N_p individual digitized points (x_k, y_k) have been connected by straight lines. Consider the trapezoid formed by connecting the following points in order (x_k, y_k), (x_{k+1}, y_{k+1}), $(x_{k+1}, 0)$ and $(x_k, 0)$. The area, A_k, of this trapezoid is given by

$$A_k = (y_k + y_{k+1})(x_{k+1} - x_k)/2 \quad . \tag{B-1}$$

As the running sum over the trapezoids is accumulated, the area total will first increase and then decrease as the x coordinate begins to decrease. The net area, following the summation of trapezoidal areas over the N_p contour points, will be the area enclosed by the contour formed by the straight-line connection of digitized contour points. In the example shown in Figure B-1, the calculated area will be positive since the points are input in a clockwise order. The area would be negative if the order of point input were counter-clockwise.

B.2 Derivation of Equations (2a) and (2b) for the Centroid Coordinates of a Digitized Contour

Consider again the trapezoidal element shown in Figure B-1. The x-component of the first moment, Mx_k, of this trapezoidal element is given by

$$Mx_k = \int_{x_i}^{x_{(i+1)}} xy \, dx \tag{B-2}$$

where

$$y = y_i + \left(1 - \frac{x_{i+1} - x}{x_{i+1} - x_i}\right)(y_{i+1} - y_i) \tag{B-3}$$

$$= \frac{x_{i+1}y_i - x_i y_{i+1}}{x_{i+1} - x_i} + \frac{(y_{i+1} - y_i)\,x}{x_{i+1} - x_i} \quad . \tag{B-3}$$

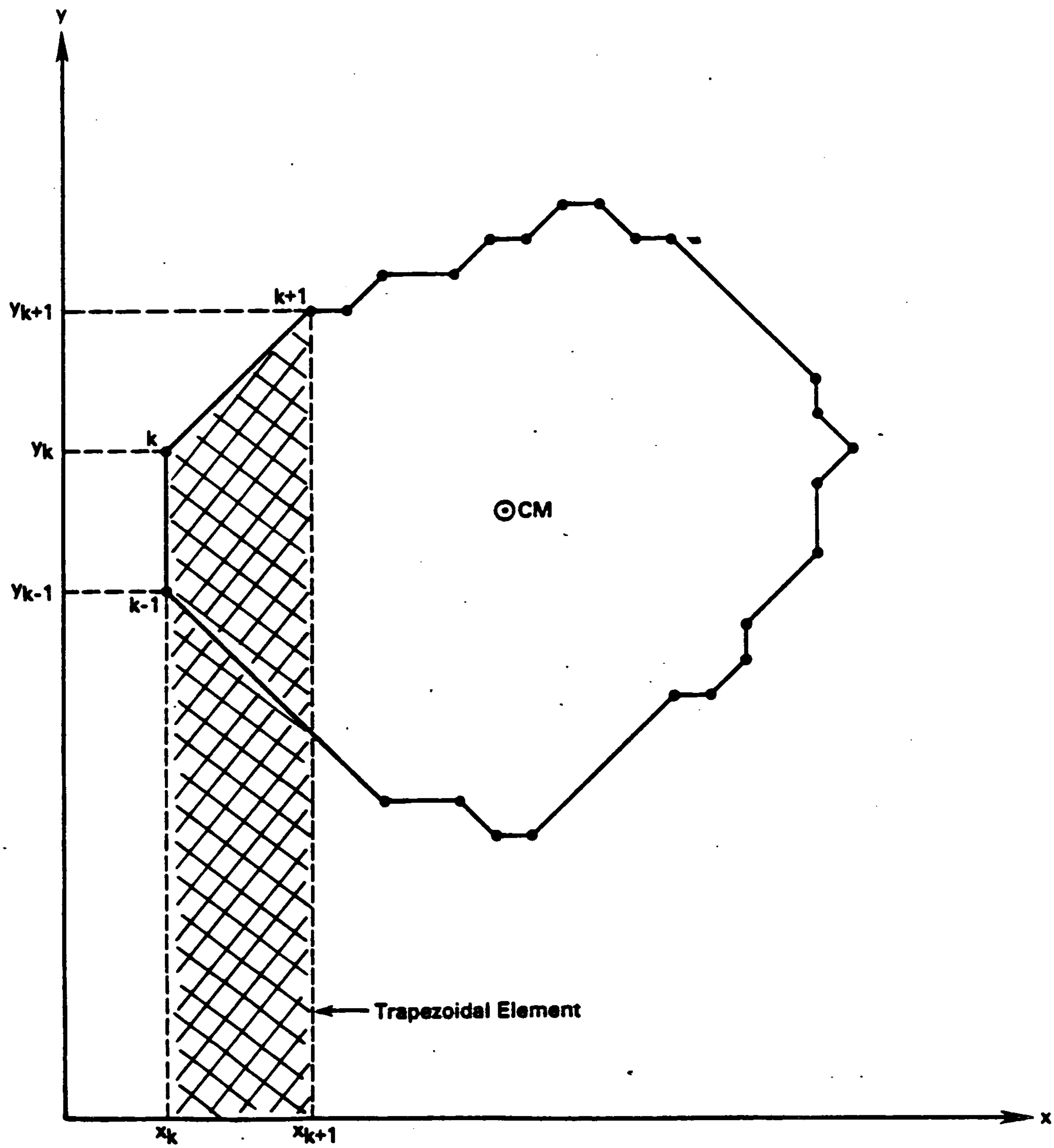

Figure B-1. Example Digitized Contour.

An evaluation of Equation (B-2) gives

$$Mx_k = \frac{1}{2} \left(\frac{x_{i+1}y_i - x_i y_{i+1}}{x_{i+1} - x_i}\right) (x_{i+1}^2 - x_i^2) + \frac{1}{3} \left(\frac{y_{i+1} - y_i}{x_{i+1} - x_i}\right) (x_{i+1}^3 - x_i^3) \tag{B-4}$$

$$= \frac{1}{2} (x_{i+1}y_i - x_i y_{i+1}) (x_{i+1} + x_i) + \frac{1}{3} (y_{i+1} - y_i) (x_{i+1}^2 + x_i x_{i+1} + x_i^2) \quad .$$

A summation of the Mx_k terms over k will give the total x-component of the first moment. Dividing this sum by the contour area (positive or negative) gives the x-coordinate of the centroid (See Equation (2a)). The y-coordinate of the centroid is obtained by interchanging x and y in the formula for the centroid x-coordinate and multiplying by -1 to correct for the fact that the contour area was computed by integration in the x,y coordinate system.

B.3 Derivation of Equation (3) for the Second Moment of a Digitized Contour About a Line Passing Through the Contour Centroid

The calculation of a contour second moment about a line passing through the contour centroid is performed by calculating the second moments of individual trapezoidal sections and summing up the contributions. One such trapezoidal section is shown in Figure B-2. It is constructed by dropping perpendiculars from the points (x_k, y_k) and (x_{k+1}, y_{k+1}) to the line passing through the contour centroid and making an angle θ with respect to the x-axis. The value of D_k can be calculated by use of the identity that the magnitude of the cross product of two vectors is equal to the product of the magnitudes of the vectors times the sine of the angle between the vectors. Both of these vectors lie in the plane of the contour. The first is the unit vector along the line passing through the contour centroid. The second vector is formed by connecting the centroid and the point (x_k, y_k). The cross product of these vectors is given by

$$(\cos\theta\,\hat{i} + \sin\theta\,\hat{j}) \cdot [(x_k - X_c)\hat{i} + (Y_k - y_c)\hat{j}] = \hat{k}\,D_k \tag{B-5}$$

where

$\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors in the x,y and z directions.

Equation (B-5) can be rewritten as

$$D_k = -(x_k - X_c)\sin\theta + (y_k - Y_c)\cos\theta \quad . \tag{B-6}$$

Note that D_k will be positive for points lying to the left of the line passing through the centroid and negative for points lying to the right of the line.

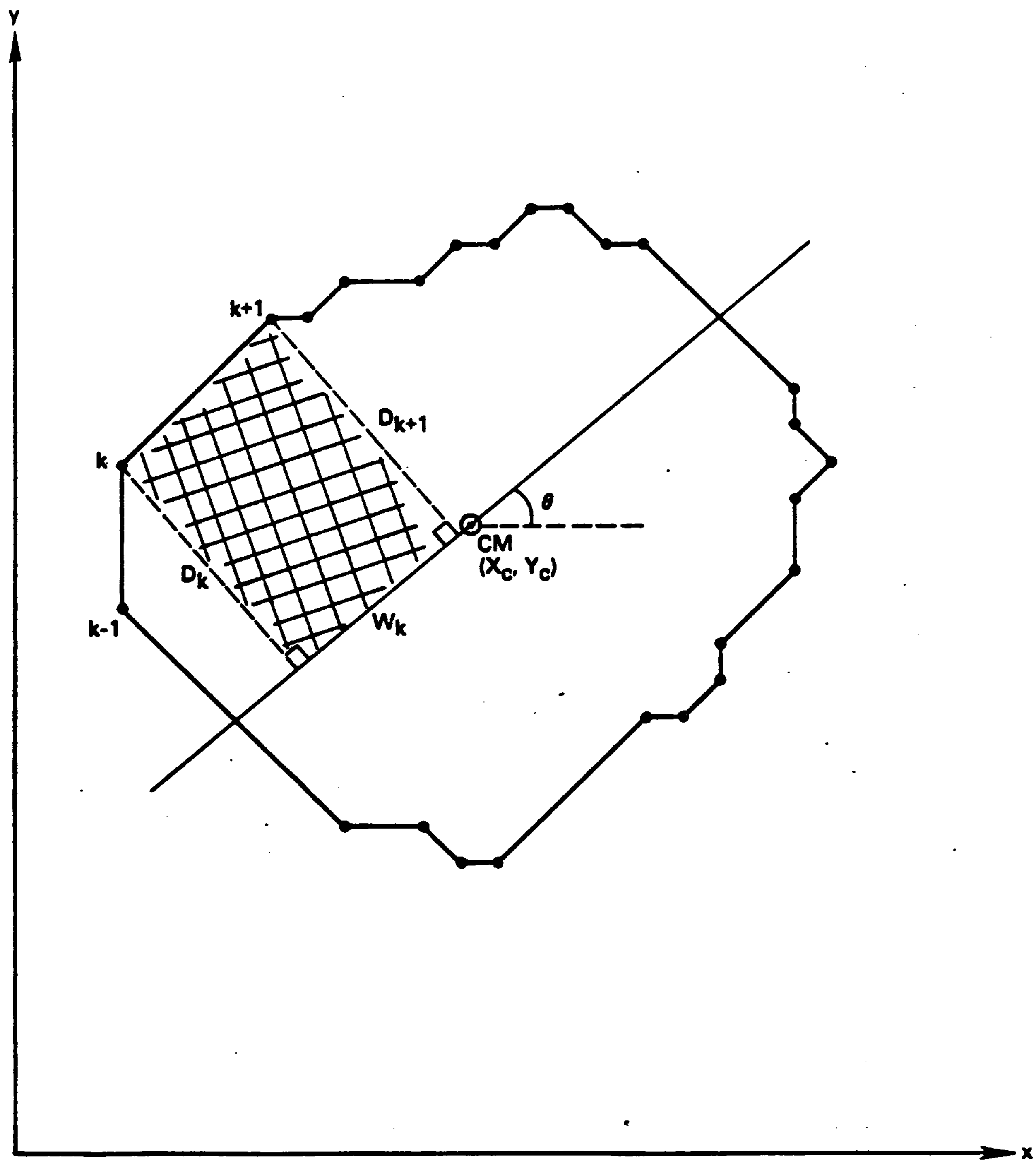

Figure B-2. Digitized Contour Illustrating the Second Moment Calculation.

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The final side of the trapezoidal section has a length W_k (see Figure B-2). It connects the foot of the perpendicular D_k to the foot of perpendicular D_{k+1}. The length of W_k, which may be either positive or negative, is calculated by use of the identity that the scalar product of two vectors is equal to the product of the magnitude of the two vectors times the cosine of the angle between the vectors. Both of these vectors lie in the plane of the contour. The first is the unit vector along the line passing through the contour centroid. The second vector is formed by connecting the centroid and the point (x_k, y_k). The dot product of these vectors is the distance from the centroid to the foot of perpendicular D_k and is given by

$$(\cos\theta\,\hat{i} + \sin\theta\,\hat{j}) \cdot [(x_k - X_c)\hat{i} + (y_k - Y_c)\hat{j}]$$

$$= (x_k - X_c)\cos\theta + (y_k - Y_c)\sin\theta \quad . \tag{B-7}$$

The distance from the centroid to the foot of perpendicular D_{k+1} is given by

$$(x_{k+1} - X_c)\cos\theta + (y_{k+1} - Y_c)\sin\theta \quad . \tag{B-8}$$

The distance, W_k, from the foot of perpendicular D_k to the foot of perpendicular D_{k+1} is calculated by subtracting Equation (B-7) from Equation (B-8):

$$W_k = (x_{k+1} - x_k)\cos\theta + (y_{k+1} - y_k)\sin\theta \quad . \tag{B-9}$$

The second moment, $M2_k$, about the β-axis for the trapezoidal segment shown in Figure B-3 is given by

$$M2_k = \int_o^{D_k} W_k \alpha^2 d\alpha + \int_{D_k}^{D_{k+1}} W_k \left(1 - \frac{\alpha - D_k}{D_{k+1} - D_k}\right)\alpha^2 \, d\alpha \tag{B-10}$$

$$= \frac{W_k}{12}\left(D_{k+1}^3 + D_k D_{k+1}^2 + D_k^2 D_{k+1} + D_{k+1}^3\right) \tag{B-11}$$

For points input in a clockwise order, the trapezoidal segments lying to the left of the axis (see Figure B-2) will have positive values of W_k, D_k, and D_{k+1}, so that the second moment contribution, $M2_k$, will be positive. Segments lying to the right of the axis will also have a positive second moment since W_k, D_k and D_{k+1} will also be negative. For points input in a counter-clockwise order, second moment contributions for segments lying to the left and right of the axis will be negative. This does not present a problem since the total second moment will be normalized by the contour area which, in the case of a counter-clockwise order of point input, will also be negative. As shown in Figure B-4,

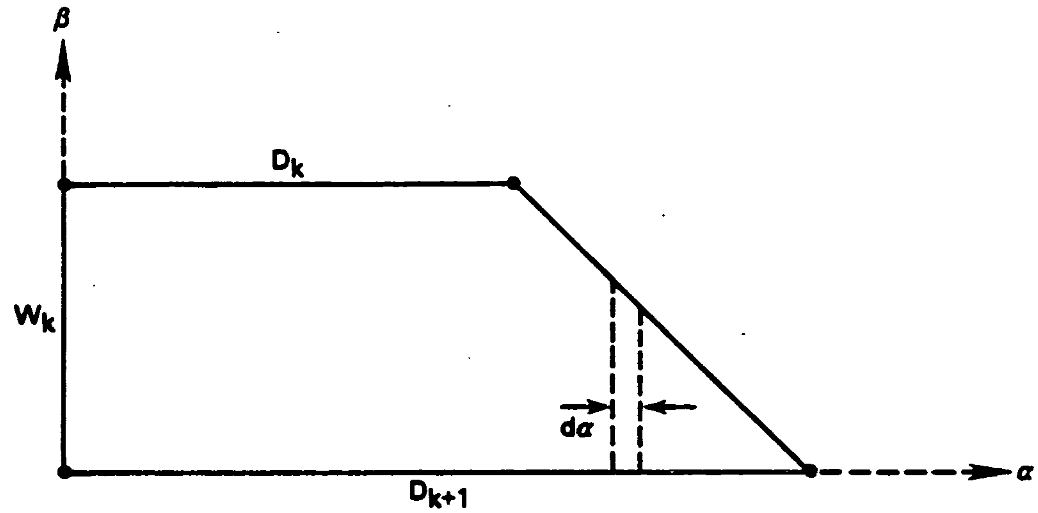

Figure B-3. Trapezoidal Segment for Second Moment Calculation.

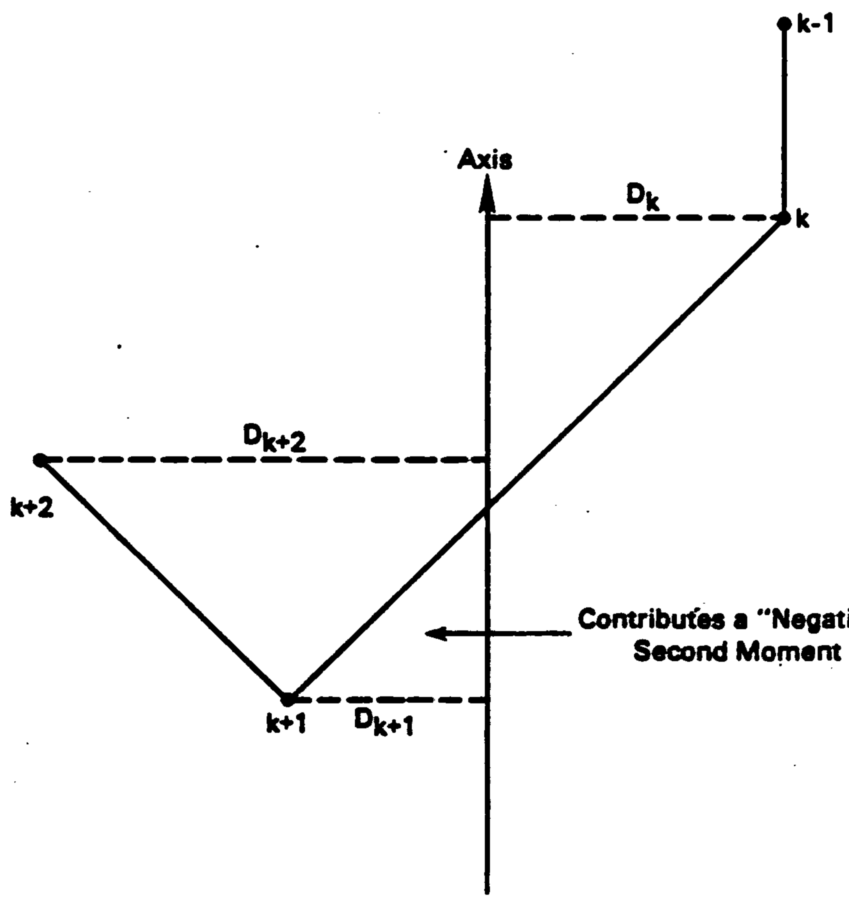

Figure B-4. Non-Trapezoidal Segments for Contours Crossing the Axis.

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there can be cases in which D_k and D_{k+1} have opposite signs. In this case, there is no longer a trapezoidal segment, but two right similar triangles with opposite sides equal to D_k and D_{k+1}. If one uses Equation (B-11) to calculate the second moment contribution of this segment, the result will correspond to the difference between the second moment of the triangle with side D_k and the triangle with side D_{k+1}. As shown in Figure B-4, this negative contribution of the triangle with side D_{k+1} is needed to properly offset a portion of the second moment associated with the trapezoidal segment having sides D_{k+1} and D_{k+2}. The computation of the total second moment of the contour (about the axis) obtained through a summation of Equation (B-11) over k is therefore exact.

B.4 Calculation of the Radius of Gyration of an Ellipse about its Minor Axis

Consider an ellipse with a semi-minor axis of length, b, and a semi-major axis of length, a. The equation of this ellipse, with its major axis along the x-axis and its centroid at the origin, is given by

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \quad . \tag{B-12}$$

The second moment, M2, about the minor axis is then given by

$$M2 = 4\int_0^a x^2 y \, dx \tag{B-13}$$

$$= 4b\int_0^a x^2 \left(1-\frac{x^2}{a^2}\right)^{1/2} dx$$

$$= \frac{\pi a^3 b}{4} \quad . \tag{B-14)}$$

The radius of gyration, R_g, is therefore given by

$$R_g = \left(\frac{M2}{\text{area of the ellipse}}\right)^{1/2} \tag{B-15}$$

$$= \left[\left(\frac{\pi a^3 b}{4}\right)/(\pi ab)\right]^{1/2}$$

$$= \frac{a}{2} \quad . \tag{B-16}$$

APPENDIX C
PROGRAM TEST CASE

APPENDIX C

PROGRAM TEST CASE

For the purpose of illustrating the operation of the Terrain Preprocessor, a single "gullied hill" having 7 closed contours is used. This example does not exercise the contour completion or multiple contour (at a single elevation) processing capabilities of program FITCON. These were tested, however, by the cases run for the CTDM model evaluation studies.

The file names chosen for this test case (DATCON, OUTPUT, PLOT1, CONOUT, PLOT2 and CTDMIN) are arbitrary. Different names could be selected by the user. To obtain higher resolution plots for this report, the Hercules™ version of PLOTCON (HPLTCON) has been used.

CONTOUR MASTER FILE (DATCON)

1	.1000E+02	35	1
.0000E+00	.4000E+01		
.0000E+00	.2400E+02		
.1000E+01	.2800E+02		
.2000E+01	.2900E+02		
.4000E+01	.3000E+02		
.5000E+01	.3000E+02		
.8000E+01	.2800E+02		
.1000E+02	.2400E+02		
.1300E+02	.2300E+02		
.1500E+02	.2400E+02		
.1700E+02	.2700E+02		
.1900E+02	.2900E+02		
.2200E+02	.3000E+02		
.2400E+02	.3000E+02		
.2600E+02	.2900E+02		
.2800E+02	.2700E+02		
.3000E+02	.2300E+02		
.2900E+02	.2200E+02		
.2600E+02	.2100E+02		
.2100E+02	.1900E+02		
.2000E+02	.1700E+02		
.2000E+02	.1600E+02		
.2100E+02	.1400E+02		
.2200E+02	.1300E+02		
.2600E+02	.1000E+02		
.2800E+02	.8000E+01		
.3000E+02	.4000E+01		
.3000E+02	.3000E+01		
.2800E+02	.2000E+01		
.2400E+02	.2000E+01		
.1700E+02	.3000E+01		
.1100E+02	.2000E+01		
.5000E+01	.0000E+00		
.2000E+01	.1000E+01		
.0000E+00	.4000E+01		
2	.2000E+02	32	1
.1000E+01	.7000E+01		
.1000E+01	.2100E+02		
.2000E+01	.2500E+02		
.3000E+01	.2800E+02		
.5000E+01	.2900E+02		
.7000E+01	.2700E+02		
.9000E+01	.2300E+02		
.1200E+02	.2100E+02		
.1300E+02	.2100E+02		
.1600E+02	.2300E+02		
.2100E+02	.2800E+02		
.2300E+02	.2900E+02		
.2700E+02	.2600E+02		
.2800E+02	.2500E+02		
.2800E+02	.2400E+02		
.2300E+02	.2400E+02		
.2000E+02	.2300E+02		
.1900E+02	.2200E+02		
.1800E+02	.1800E+02		
.1800E+02	.1600E+02		
.1900E+02	.1300E+02		
.2300E+02	.9000E+01		

.2600E+02	.6000E+01		
.2600E+02	.5000E+01		
.2400E+02	.5000E+01		
.2100E+02	.6000E+01		
.1700E+02	.7000E+01		
.1300E+02	.6000E+01		
.1000E+02	.5000E+01		
.5000E+01	.4000E+01		
.3000E+01	.4000E+01		
.1000E+01	.7000E+01		
3	.3000E+02	27	1
.2000E+01	.9000E+01		
.2000E+01	.2100E+02		
.3000E+01	.2500E+02		
.5000E+01	.2700E+02		
.7000E+01	.2500E+02		
.9000E+01	.2100E+02		
.1100E+02	.1900E+02		
.1300E+02	.1900E+02		
.1800E+02	.2400E+02		
.2200E+02	.2700E+02		
.2500E+02	.2700E+02		
.2600E+02	.2500E+02		
.2300E+02	.2500E+02		
.2000E+02	.2400E+02		
.1800E+02	.2200E+02		
.1700E+02	.2000E+02		
.1600E+02	.1700E+02		
.1700E+02	.1300E+02		
.2000E+02	.1000E+02		
.2300E+02	.7000E+01		
.2200E+02	.7000E+01		
.1900E+02	.8000E+01		
.1600E+02	.9000E+01		
.1300E+02	.9000E+01		
.7000E+01	.7000E+01		
.3000E+01	.7000E+01		
.2000E+01	.9000E+01		
4	.4000E+02	18	1
.3000E+01	.1000E+02		
.3000E+01	.2100E+02		
.4000E+01	.2400E+02		
.5000E+01	.2500E+02		
.6000E+01	.2400E+02		
.8000E+01	.2000E+02		
.1000E+02	.1800E+02		
.1300E+02	.1700E+02		
.1400E+02	.1600E+02		
.1500E+02	.1300E+02		
.1700E+02	.1100E+02		
.1800E+02	.1000E+02		
.1700E+02	.1000E+02		
.1400E+02	.1100E+02		
.1300E+02	.1100E+02		
.8000E+01	.1000E+02		
.5000E+01	.9000E+01		
.3000E+01	.1000E+02		
5	.5000E+02	11	1
.4000E+01	.1200E+02		
.4000E+01	.2100E+02		

.5000E+01	.2300E+02		
.6000E+01	.2200E+02		
.8000E+01	.1800E+02		
.1000E+02	.1600E+02		
.1100E+02	.1400E+02		
.1000E+02	.1200E+02		
.8000E+01	.1100E+02		
.5000E+01	.1100E+02		
.4000E+01	.1200E+02		
6	.6000E+02	10	1
.5000E+01	.1300E+02		
.5000E+01	.2100E+02		
.6000E+01	.2100E+02		
.6000E+01	.1900E+02		
.8000E+01	.1600E+02		
.9000E+01	.1500E+02		
.9000E+01	.1300E+02		
.8000E+01	.1200E+02		
.6000E+01	.1200E+02		
.5000E+01	.1300E+02		
7	.7000E+02	6	1
.6000E+01	.1400E+02		
.6000E+01	.1700E+02		
.8000E+01	.1500E+02		
.8000E+01	.1400E+02		
.7000E+01	.1300E+02		
.6000E+01	.1400E+02		

FITCON EXECUTION WITH INTERACTIVE INPUT

```
FITCON

ENTER CONTOUR MASTER FILE NAME -> DATCON

ENTER DIAGNOSTIC OUTPUT FILE NAME -> OUTPUT

ENTER HILL ID NUMBER(1-99) -> 2

ENTER HILL NAME(1-15CHAR.) -> GULLIED HILL

INPUT HILL TOP ELEVATION -> 80

INPUT HILL CENTER X-COORDINATE -> 7

INPUT HILL CENTER Y-COORDINATE -> 14.5

ANGULAR FILTERING?(Y/N) -> N

                    SPECIFY CONTOUR SELECTION MODE
                    1.) ALL CONTOURS SELECTED
                    2.) SELECT RANGE OF CONTOUR IDs
                    3.) INPUT FILE WITH CONTOUR IDs
                        CHOICE?(1,2,OR 3) -> 1

PLOT REQUESTED?(Y/N) -> Y

ENTER PLOT FILE NAME -> PLOT1

Please wait...Contour data being processed


Contour ID    1 has been accepted

Contour ID    2 has been accepted

Contour ID    3 has been accepted

Contour ID    4 has been accepted

Contour ID    5 has been accepted

Contour ID    6 has been accepted

Contour ID    7 has been accepted

ENTER FILE NAME FOR FITTED CONTOUR OUTPUT -> CONOUT
Stop - Program terminated.

D:\>
```

FITCON DIAGNOSTIC OUTPUT FILE (OUTPUT)

HILL NUMBER 2 IS GULLIED HILL

HILL TOP ELEVATION= .8000E+02
HILL CENTER X-COORDINATE= .7000E+01
HILL CENTER Y-COORDINATE= .1450E+02

ALL CONTOURS IN FILE DATCON SELECTED FOR INPUT

CONTOUR ELEVATION FOR CONTOUR ID 1 = .1000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID 1

.0000E+00	.4000E+01
.0000E+00	.2400E+02
.1000E+01	.2800E+02
.2000E+01	.2900E+02
.4000E+01	.3000E+02
.5000E+01	.3000E+02
.8000E+01	.2800E+02
.1000E+02	.2400E+02
.1300E+02	.2300E+02
.1500E+02	.2400E+02
.1700E+02	.2700E+02
.1900E+02	.2900E+02
.2200E+02	.3000E+02
.2400E+02	.3000E+02
.2600E+02	.2900E+02
.2800E+02	.2700E+02
.3000E+02	.2300E+02
.2900E+02	.2200E+02
.2600E+02	.2100E+02
.2100E+02	.1900E+02
.2000E+02	.1700E+02
.2000E+02	.1600E+02
.2100E+02	.1400E+02
.2200E+02	.1300E+02
.2600E+02	.1000E+02
.2800E+02	.8000E+01
.3000E+02	.4000E+01
.3000E+02	.3000E+01
.2800E+02	.2000E+01
.2400E+02	.2000E+01
.1700E+02	.3000E+01
.1100E+02	.2000E+01
.5000E+01	.0000E+00
.2000E+01	.1000E+01
.0000E+00	.4000E+01

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID 1 = 35

X-Y COORDINATES(EDITED) FOR CONTOUR ID 1

.0000E+00	.4000E+01
.0000E+00	.2400E+02
.1000E+01	.2800E+02
.2000E+01	.2900E+02

```
    .4000E+01   .3000E+02
    .5000E+01   .3000E+02
    .8000E+01   .2800E+02
    .1000E+02   .2400E+02
    .1300E+02   .2300E+02
    .1500E+02   .2400E+02
    .1700E+02   .2700E+02
    .1900E+02   .2900E+02
    .2200E+02   .3000E+02
    .2400E+02   .3000E+02
    .2600E+02   .2900E+02
    .2800E+02   .2700E+02
    .3000E+02   .2300E+02
    .2900E+02   .2200E+02
    .2600E+02   .2100E+02
    .2100E+02   .1900E+02
    .2000E+02   .1700E+02
    .2000E+02   .1600E+02
    .2100E+02   .1400E+02
    .2200E+02   .1300E+02
    .2600E+02   .1000E+02
    .2800E+02   .8000E+01
    .3000E+02   .4000E+01
    .3000E+02   .3000E+01
    .2800E+02   .2000E+01
    .2400E+02   .2000E+01
    .1700E+02   .3000E+01
    .1100E+02   .2000E+01
    .5000E+01   .0000E+00
    .2000E+01   .1000E+01
    .0000E+00   .4000E+01

CONTOUR AREA=    .6620E+03
X-COORDINATE OF CONTOUR CENTROID=    .1315E+02
Y-COORDINATE OF CONTOUR CENTROID=    .1468E+02

ELLIPSE PARAMETERS FOR CONTOUR ID     1

SEMI-MAJOR AXIS LENGTH=    .1632E+02
SEMI-MINOR AXIS LENGTH=    .1291E+02
ELLIPSE ECCENTRICITY=    .6113E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE
POSITIVE X-AXIS=120.00 DEGREES

CONTOUR ELEVATION FOR CONTOUR ID    2 =    .2000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID    2

    .1000E+01   .7000E+01
    .1000E+01   .2100E+02
    .2000E+01   .2500E+02
    .3000E+01   .2800E+02
    .5000E+01   .2900E+02
    .7000E+01   .2700E+02
    .9000E+01   .2300E+02
    .1200E+02   .2100E+02
    .1300E+02   .2100E+02
    .1600E+02   .2300E+02
    .2100E+02   .2800E+02
    .2300E+02   .2900E+02
```

.2700E+02	.2600E+02
.2800E+02	.2500E+02
.2800E+02	.2400E+02
.2300E+02	.2400E+02
.2000E+02	.2300E+02
.1900E+02	.2200E+02
.1800E+02	.1800E+02
.1800E+02	.1600E+02
.1900E+02	.1300E+02
.2300E+02	.9000E+01
.2600E+02	.6000E+01
.2600E+02	.5000E+01
.2400E+02	.5000E+01
.2100E+02	.6000E+01
.1700E+02	.7000E+01
.1300E+02	.6000E+01
.1000E+02	.5000E+01
.5000E+01	.4000E+01
.3000E+01	.4000E+01
.1000E+01	.7000E+01

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID 2 = 32

X-Y COORDINATES(EDITED) FOR CONTOUR ID 2

.1000E+01	.7000E+01
.1000E+01	.2100E+02
.2000E+01	.2500E+02
.3000E+01	.2800E+02
.5000E+01	.2900E+02
.7000E+01	.2700E+02
.9000E+01	.2300E+02
.1200E+02	.2100E+02
.1300E+02	.2100E+02
.1600E+02	.2300E+02
.2100E+02	.2800E+02
.2300E+02	.2900E+02
.2700E+02	.2600E+02
.2800E+02	.2500E+02
.2800E+02	.2400E+02
.2300E+02	.2400E+02
.2000E+02	.2300E+02
.1900E+02	.2200E+02
.1800E+02	.1800E+02
.1800E+02	.1600E+02
.1900E+02	.1300E+02
.2300E+02	.9000E+01
.2600E+02	.6000E+01
.2600E+02	.5000E+01
.2400E+02	.5000E+01
.2100E+02	.6000E+01
.1700E+02	.7000E+01
.1300E+02	.6000E+01
.1000E+02	.5000E+01
.5000E+01	.4000E+01
.3000E+01	.4000E+01
.1000E+01	.7000E+01

CONTOUR AREA= .3970E+03
X-COORDINATE OF CONTOUR CENTROID= .1128E+02
Y-COORDINATE OF CONTOUR CENTROID= .1543E+02

ELLIPSE PARAMETERS FOR CONTOUR ID 2

SEMI-MAJOR AXIS LENGTH= .1377E+02
SEMI-MINOR AXIS LENGTH= .9175E+01
ELLIPSE ECCENTRICITY= .7458E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE
POSITIVE X-AXIS=120.00 DEGREES

CONTOUR ELEVATION FOR CONTOUR ID 3 = .3000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID 3

.2000E+01	.9000E+01
.2000E+01	.2100E+02
.3000E+01	.2500E+02
.5000E+01	.2700E+02
.7000E+01	.2500E+02
.9000E+01	.2100E+02
.1100E+02	.1900E+02
.1300E+02	.1900E+02
.1800E+02	.2400E+02
.2200E+02	.2700E+02
.2500E+02	.2700E+02
.2600E+02	.2500E+02
.2300E+02	.2500E+02
.2000E+02	.2400E+02
.1800E+02	.2200E+02
.1700E+02	.2000E+02
.1600E+02	.1700E+02
.1700E+02	.1300E+02
.2000E+02	.1000E+02
.2300E+02	.7000E+01
.2200E+02	.7000E+01
.1900E+02	.8000E+01
.1600E+02	.9000E+01
.1300E+02	.9000E+01
.7000E+01	.7000E+01
.3000E+01	.7000E+01
.2000E+01	.9000E+01

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID 3 = 27

X-Y COORDINATES(EDITED) FOR CONTOUR ID 3

.2000E+01	.9000E+01
.2000E+01	.2100E+02
.3000E+01	.2500E+02
.5000E+01	.2700E+02
.7000E+01	.2500E+02
.9000E+01	.2100E+02
.1100E+02	.1900E+02
.1300E+02	.1900E+02

```
    .1800E+02   .2400E+02
    .2200E+02   .2700E+02
    .2500E+02   .2700E+02
    .2600E+02   .2500E+02
    .2300E+02   .2500E+02
    .2000E+02   .2400E+02
    .1800E+02   .2200E+02
    .1700E+02   .2000E+02
    .1600E+02   .1700E+02
    .1700E+02   .1300E+02
    .2000E+02   .1000E+02
    .2300E+02   .7000E+01
    .2200E+02   .7000E+01
    .1900E+02   .8000E+01
    .1600E+02   .9000E+01
    .1300E+02   .9000E+01
    .7000E+01   .7000E+01
    .3000E+01   .7000E+01
    .2000E+01   .9000E+01

CONTOUR AREA=    .2425E+03
X-COORDINATE OF CONTOUR CENTROID=    .1010E+02
Y-COORDINATE OF CONTOUR CENTROID=    .1569E+02

ELLIPSE PARAMETERS FOR CONTOUR ID    3

SEMI-MAJOR AXIS LENGTH=    .1138E+02
SEMI-MINOR AXIS LENGTH=    .6782E+01
ELLIPSE ECCENTRICITY=    .8030E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE
POSITIVE X-AXIS=110.00 DEGREES

CONTOUR ELEVATION FOR CONTOUR ID    4 =    .4000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID    4

    .3000E+01   .1000E+02
    .3000E+01   .2100E+02
    .4000E+01   .2400E+02
    .5000E+01   .2500E+02
    .6000E+01   .2400E+02
    .8000E+01   .2000E+02
    .1000E+02   .1800E+02
    .1300E+02   .1700E+02
    .1400E+02   .1600E+02
    .1500E+02   .1300E+02
    .1700E+02   .1100E+02
    .1800E+02   .1000E+02
    .1700E+02   .1000E+02
    .1400E+02   .1100E+02
    .1300E+02   .1100E+02
    .8000E+01   .1000E+02
    .5000E+01   .9000E+01
    .3000E+01   .1000E+02

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID    4 =    18
```

X-Y COORDINATES(EDITED) FOR CONTOUR ID 4

.3000E+01	.1000E+02
.3000E+01	.2100E+02
.4000E+01	.2400E+02
.5000E+01	.2500E+02
.6000E+01	.2400E+02
.8000E+01	.2000E+02
.1000E+02	.1800E+02
.1300E+02	.1700E+02
.1400E+02	.1600E+02
.1500E+02	.1300E+02
.1700E+02	.1100E+02
.1800E+02	.1000E+02
.1700E+02	.1000E+02
.1400E+02	.1100E+02
.1300E+02	.1100E+02
.8000E+01	.1000E+02
.5000E+01	.9000E+01
.3000E+01	.1000E+02

CONTOUR AREA= .1190E+03
X-COORDINATE OF CONTOUR CENTROID= .7972E+01
Y-COORDINATE OF CONTOUR CENTROID= .1532E+02

ELLIPSE PARAMETERS FOR CONTOUR ID 4

SEMI-MAJOR AXIS LENGTH= .8283E+01
SEMI-MINOR AXIS LENGTH= .4573E+01
ELLIPSE ECCENTRICITY= .8337E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE POSITIVE X-AXIS= 40.00 DEGREES

CONTOUR ELEVATION FOR CONTOUR ID 5 = .5000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID 5

.4000E+01	.1200E+02
.4000E+01	.2100E+02
.5000E+01	.2300E+02
.6000E+01	.2200E+02
.8000E+01	.1800E+02
.1000E+02	.1600E+02
.1100E+02	.1400E+02
.1000E+02	.1200E+02
.8000E+01	.1100E+02
.5000E+01	.1100E+02
.4000E+01	.1200E+02

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID 5 = 11

X-Y COORDINATES(EDITED) FOR CONTOUR ID 5

.4000E+01	.1200E+02
.4000E+01	.2100E+02
.5000E+01	.2300E+02
.6000E+01	.2200E+02

.8000E+01	.1800E+02
.1000E+02	.1600E+02
.1100E+02	.1400E+02
.1000E+02	.1200E+02
.8000E+01	.1100E+02
.5000E+01	.1100E+02
.4000E+01	.1200E+02

CONTOUR AREA= .5300E+02
X-COORDINATE OF CONTOUR CENTROID= .6679E+01
Y-COORDINATE OF CONTOUR CENTROID= .1574E+02

ELLIPSE PARAMETERS FOR CONTOUR ID 5

SEMI-MAJOR AXIS LENGTH= .5957E+01
SEMI-MINOR AXIS LENGTH= .2832E+01
ELLIPSE ECCENTRICITY= .8798E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE POSITIVE X-AXIS= 20.00 DEGREES

CONTOUR ELEVATION FOR CONTOUR ID 6 = .6000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID 6

.5000E+01	.1300E+02
.5000E+01	.2100E+02
.6000E+01	.2100E+02
.6000E+01	.1900E+02
.8000E+01	.1600E+02
.9000E+01	.1500E+02
.9000E+01	.1300E+02
.8000E+01	.1200E+02
.6000E+01	.1200E+02
.5000E+01	.1300E+02

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID 6 = 10

X-Y COORDINATES(EDITED) FOR CONTOUR ID 6

.5000E+01	.1300E+02
.5000E+01	.2100E+02
.6000E+01	.2100E+02
.6000E+01	.1900E+02
.8000E+01	.1600E+02
.9000E+01	.1500E+02
.9000E+01	.1300E+02
.8000E+01	.1200E+02
.6000E+01	.1200E+02
.5000E+01	.1300E+02

CONTOUR AREA= .2250E+02
X-COORDINATE OF CONTOUR CENTROID= .6585E+01
Y-COORDINATE OF CONTOUR CENTROID= .1544E+02

ELLIPSE PARAMETERS FOR CONTOUR ID 6

SEMI-MAJOR AXIS LENGTH= .4562E+01

SEMI-MINOR AXIS LENGTH= .1570E+01
ELLIPSE ECCENTRICITY= .9389E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE
POSITIVE X-AXIS= 20.00 DEGREES

CONTOUR ELEVATION FOR CONTOUR ID 7 = .7000E+02

X-Y COORDINATES INPUT FOR CONTOUR ID 7

.6000E+01	.1400E+02
.6000E+01	.1700E+02
.8000E+01	.1500E+02
.8000E+01	.1400E+02
.7000E+01	.1300E+02
.6000E+01	.1400E+02

CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.
(I.E. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)

MODIFIED NUMBER OF POINTS FOR CONTOUR ID 7 = 6

X-Y COORDINATES(EDITED) FOR CONTOUR ID 7

.6000E+01	.1400E+02
.6000E+01	.1700E+02
.8000E+01	.1500E+02
.8000E+01	.1400E+02
.7000E+01	.1300E+02
.6000E+01	.1400E+02

CONTOUR AREA= .5000E+01
X-COORDINATE OF CONTOUR CENTROID= .6867E+01
Y-COORDINATE OF CONTOUR CENTROID= .1480E+02

ELLIPSE PARAMETERS FOR CONTOUR ID 7

SEMI-MAJOR AXIS LENGTH= .1764E+01
SEMI-MINOR AXIS LENGTH= .9025E+00
ELLIPSE ECCENTRICITY= .8591E+00
ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE
POSITIVE X-AXIS= 20.00 DEGREES

FITCON PLOT FILE (PLOT 1)

```
FITCON
 2 GULLIED HILL
     .7000E+01       .1450E+02
        7
        1
        2
        3
        4
        5
        6
        7
     .0000E+00       .3000E+02       .0000E+00       .3000E+02
     .0000E+00       .3000E+02       .0000E+00       .3000E+02
       35        .1000E+02
     .0000E+00       .4000E+01
     .0000E+00       .2400E+02
     .1000E+01       .2800E+02
     .2000E+01       .2900E+02
     .4000E+01       .3000E+02
     .5000E+01       .3000E+02
     .8000E+01       .2800E+02
     .1000E+02       .2400E+02
     .1300E+02       .2300E+02
     .1500E+02       .2400E+02
     .1700E+02       .2700E+02
     .1900E+02       .2900E+02
     .2200E+02       .3000E+02
     .2400E+02       .3000E+02
     .2600E+02       .2900E+02
     .2800E+02       .2700E+02
     .3000E+02       .2300E+02
     .2900E+02       .2200E+02
     .2600E+02       .2100E+02
     .2100E+02       .1900E+02
     .2000E+02       .1700E+02
     .2000E+02       .1600E+02
     .2100E+02       .1400E+02
     .2200E+02       .1300E+02
     .2600E+02       .1000E+02
     .2800E+02       .8000E+01
     .3000E+02       .4000E+01
     .3000E+02       .3000E+01
     .2800E+02       .2000E+01
     .2400E+02       .2000E+01
     .1700E+02       .3000E+01
     .1100E+02       .2000E+01
     .5000E+01       .0000E+00
     .2000E+01       .1000E+01
     .0000E+00       .4000E+01
       35        .1000E+02
     .0000E+00       .4000E+01
     .0000E+00       .2400E+02
     .1000E+01       .2800E+02
     .2000E+01       .2900E+02
     .4000E+01       .3000E+02
     .5000E+01       .3000E+02
     .8000E+01       .2800E+02
     .1000E+02       .2400E+02
     .1300E+02       .2300E+02
```

.1500E+02	.2400E+02
.1700E+02	.2700E+02
.1900E+02	.2900E+02
.2200E+02	.3000E+02
.2400E+02	.3000E+02
.2600E+02	.2900E+02
.2800E+02	.2700E+02
.3000E+02	.2300E+02
.2900E+02	.2200E+02
.2600E+02	.2100E+02
.2100E+02	.1900E+02
.2000E+02	.1700E+02
.2000E+02	.1600E+02
.2100E+02	.1400E+02
.2200E+02	.1300E+02
.2600E+02	.1000E+02
.2800E+02	.8000E+01
.3000E+02	.4000E+01
.3000E+02	.3000E+01
.2800E+02	.2000E+01
.2400E+02	.2000E+01
.1700E+02	.3000E+01
.1100E+02	.2000E+01
.5000E+01	.0000E+00
.2000E+01	.1000E+01
.0000E+00	.4000E+01
32	.2000E+02
.1000E+01	.7000E+01
.1000E+01	.2100E+02
.2000E+01	.2500E+02
.3000E+01	.2800E+02
.5000E+01	.2900E+02
.7000E+01	.2700E+02
.9000E+01	.2300E+02
.1200E+02	.2100E+02
.1300E+02	.2100E+02
.1600E+02	.2300E+02
.2100E+02	.2800E+02
.2300E+02	.2900E+02
.2700E+02	.2600E+02
.2800E+02	.2500E+02
.2800E+02	.2400E+02
.2300E+02	.2400E+02
.2000E+02	.2300E+02
.1900E+02	.2200E+02
.1800E+02	.1800E+02
.1800E+02	.1600E+02
.1900E+02	.1300E+02
.2300E+02	.9000E+01
.2600E+02	.6000E+01
.2600E+02	.5000E+01
.2400E+02	.5000E+01
.2100E+02	.6000E+01
.1700E+02	.7000E+01
.1300E+02	.6000E+01
.1000E+02	.5000E+01
.5000E+01	.4000E+01
.3000E+01	.4000E+01
.1000E+01	.7000E+01
32	.2000E+02

.1000E+01	.7000E+01
.1000E+01	.2100E+02
.2000E+01	.2500E+02
.3000E+01	.2800E+02
.5000E+01	.2900E+02
.7000E+01	.2700E+02
.9000E+01	.2300E+02
.1200E+02	.2100E+02
.1300E+02	.2100E+02
.1600E+02	.2300E+02
.2100E+02	.2800E+02
.2300E+02	.2900E+02
.2700E+02	.2600E+02
.2800E+02	.2500E+02
.2800E+02	.2400E+02
.2300E+02	.2400E+02
.2000E+02	.2300E+02
.1900E+02	.2200E+02
.1800E+02	.1800E+02
.1800E+02	.1600E+02
.1900E+02	.1300E+02
.2300E+02	.9000E+01
.2600E+02	.6000E+01
.2600E+02	.5000E+01
.2400E+02	.5000E+01
.2100E+02	.6000E+01
.1700E+02	.7000E+01
.1300E+02	.6000E+01
.1000E+02	.5000E+01
.5000E+01	.4000E+01
.3000E+01	.4000E+01
.1000E+01	.7000E+01
27	.3000E+02
.2000E+01	.9000E+01
.2000E+01	.2100E+02
.3000E+01	.2500E+02
.5000E+01	.2700E+02
.7000E+01	.2500E+02
.9000E+01	.2100E+02
.1100E+02	.1900E+02
.1300E+02	.1900E+02
.1800E+02	.2400E+02
.2200E+02	.2700E+02
.2500E+02	.2700E+02
.2600E+02	.2500E+02
.2300E+02	.2500E+02
.2000E+02	.2400E+02
.1800E+02	.2200E+02
.1700E+02	.2000E+02
.1600E+02	.1700E+02
.1700E+02	.1300E+02
.2000E+02	.1000E+02
.2300E+02	.7000E+01
.2200E+02	.7000E+01
.1900E+02	.8000E+01
.1600E+02	.9000E+01
.1300E+02	.9000E+01
.7000E+01	.7000E+01
.3000E+01	.7000E+01
.2000E+01	.9000E+01

27	.3000E+02
.2000E+01	.9000E+01
.2000E+01	.2100E+02
.3000E+01	.2500E+02
.5000E+01	.2700E+02
.7000E+01	.2500E+02
.9000E+01	.2100E+02
.1100E+02	.1900E+02
.1300E+02	.1900E+02
.1800E+02	.2400E+02
.2200E+02	.2700E+02
.2500E+02	.2700E+02
.2600E+02	.2500E+02
.2300E+02	.2500E+02
.2000E+02	.2400E+02
.1800E+02	.2200E+02
.1700E+02	.2000E+02
.1600E+02	.1700E+02
.1700E+02	.1300E+02
.2000E+02	.1000E+02
.2300E+02	.7000E+01
.2200E+02	.7000E+01
.1900E+02	.8000E+01
.1600E+02	.9000E+01
.1300E+02	.9000E+01
.7000E+01	.7000E+01
.3000E+01	.7000E+01
.2000E+01	.9000E+01
18	.4000E+02
.3000E+01	.1000E+02
.3000E+01	.2100E+02
.4000E+01	.2400E+02
.5000E+01	.2500E+02
.6000E+01	.2400E+02
.8000E+01	.2000E+02
.1000E+02	.1800E+02
.1300E+02	.1700E+02
.1400E+02	.1600E+02
.1500E+02	.1300E+02
.1700E+02	.1100E+02
.1800E+02	.1000E+02
.1700E+02	.1000E+02
.1400E+02	.1100E+02
.1300E+02	.1100E+02
.8000E+01	.1000E+02
.5000E+01	.9000E+01
.3000E+01	.1000E+02
18	.4000E+02
.3000E+01	.1000E+02
.3000E+01	.2100E+02
.4000E+01	.2400E+02
.5000E+01	.2500E+02
.6000E+01	.2400E+02
.8000E+01	.2000E+02
.1000E+02	.1800E+02
.1300E+02	.1700E+02
.1400E+02	.1600E+02
.1500E+02	.1300E+02
.1700E+02	.1100E+02
.1800E+02	.1000E+02

.1700E+02	.1000E+02
.1400E+02	.1100E+02
.1300E+02	.1100E+02
.8000E+01	.1000E+02
.5000E+01	.9000E+01
.3000E+01	.1000E+02
11	.5000E+02
.4000E+01	.1200E+02
.4000E+01	.2100E+02
.5000E+01	.2300E+02
.6000E+01	.2200E+02
.8000E+01	.1800E+02
.1000E+02	.1600E+02
.1100E+02	.1400E+02
.1000E+02	.1200E+02
.8000E+01	.1100E+02
.5000E+01	.1100E+02
.4000E+01	.1200E+02
11	.5000E+02
.4000E+01	.1200E+02
.4000E+01	.2100E+02
.5000E+01	.2300E+02
.6000E+01	.2200E+02
.8000E+01	.1800E+02
.1000E+02	.1600E+02
.1100E+02	.1400E+02
.1000E+02	.1200E+02
.8000E+01	.1100E+02
.5000E+01	.1100E+02
.4000E+01	.1200E+02
10	.6000E+02
.5000E+01	.1300E+02
.5000E+01	.2100E+02
.6000E+01	.2100E+02
.6000E+01	.1900E+02
.8000E+01	.1600E+02
.9000E+01	.1500E+02
.9000E+01	.1300E+02
.8000E+01	.1200E+02
.6000E+01	.1200E+02
.5000E+01	.1300E+02
10	.6000E+02
.5000E+01	.1300E+02
.5000E+01	.2100E+02
.6000E+01	.2100E+02
.6000E+01	.1900E+02
.8000E+01	.1600E+02
.9000E+01	.1500E+02
.9000E+01	.1300E+02
.8000E+01	.1200E+02
.6000E+01	.1200E+02
.5000E+01	.1300E+02
6	.7000E+02
.6000E+01	.1400E+02
.6000E+01	.1700E+02
.8000E+01	.1500E+02
.8000E+01	.1400E+02
.7000E+01	.1300E+02
.6000E+01	.1400E+02
6	.7000E+02

.6000E+01	.1400E+02			
.6000E+01	.1700E+02			
.8000E+01	.1500E+02			
.8000E+01	.1400E+02			
.7000E+01	.1300E+02			
.6000E+01	.1400E+02			
.1315E+02	.1468E+02	.1632E+02	.1291E+02	.1200E+03
.1128E+02	.1543E+02	.1377E+02	.9175E+01	.1200E+03
.1010E+02	.1569E+02	.1138E+02	.6782E+01	.1100E+03
.7972E+01	.1532E+02	.8283E+01	.4573E+01	.4000E+02
.6679E+01	.1574E+02	.5957E+01	.2832E+01	.2000E+02
.6585E+01	.1544E+02	.4562E+01	.1570E+01	.2000E+02
.6867E+01	.1480E+02	.1764E+01	.9025E+00	.2000E+02

FITCON OUTPUT FILE FOR HCRIT INPUT (CONOUT)

2 GULLIED HILL

.8000E+02

7

1

2

3

4

5

6

7

.1000E+02	.1315E+02	.1468E+02	.1632E+02	.1291E+02	.6113E+00	.1200E+03
.2000E+02	.1128E+02	.1543E+02	.1377E+02	.9175E+01	.7458E+00	.1200E+03
.3000E+02	.1010E+02	.1569E+02	.1138E+02	.6782E+01	.8030E+00	.1100E+03
.4000E+02	.7972E+01	.1532E+02	.8283E+01	.4573E+01	.8337E+00	.4000E+02
.5000E+02	.6679E+01	.1574E+02	.5957E+01	.2832E+01	.8798E+00	.2000E+02
.6000E+02	.6585E+01	.1544E+02	.4562E+01	.1570E+01	.9389E+00	.2000E+02
.7000E+02	.6867E+01	.1480E+02	.1764E+01	.9025E+00	.8591E+00	.2000E+02

HCRIT EXECUTION WITH INTERACTIVE INPUT

```
A:\TERRAIN>HCRIT

 ENTER INPUT FILE NAME(FROM FITCON) -> CONOUT

 ENTER OUTPUT FILE NAME(FOR CTDM) ->TERRAIN

 PLOT REQUESTED?(Y/N) -> Y

 ENTER PLOT FILE NAME -> PLOT2

                    SPECIFY CRITICAL HEIGHT SELECTION MODE
                    1.) AT ALL CONTOUR ELEVATIONS EXCEPT UPPERMOST
                    2.) EVENLY SPACED BETWEEN A USER SUPPLIED ELEVATION
                        AND THE UPPERMOST CONTOUR ELEVATION
      CHOICE?(1 OR 2) -> 1

A:\TERRAIN>
```

HCRIT PLOT FILE (Plot 2)

```
HCRIT
 2 GULLIED HILL
         7
         1
         2
         3
         4
         5
         6
         7
     .8000E+02
     .1000E+02
     .2000E+02
     .3000E+02
     .4000E+02
     .5000E+02
     .6000E+02
     .7000E+02
         6
     .1000E+02    .8247E+01    .1540E+02    .4868E+02    .1791E+01    .1467E+01    .6295E+01    .3233E+01
     .2000E+02    .7641E+01    .1540E+02    .3745E+02    .1799E+01    .1540E+01    .5383E+01    .2624E+01
     .3000E+02    .7026E+01    .1532E+02    .2471E+02    .1853E+01    .1676E+01    .4464E+01    .2070E+01
     .4000E+02    .6710E+01    .1533E+02    .2000E+02    .1805E+01    .1921E+01    .3633E+01    .1589E+01
     .5000E+02    .6726E+01    .1512E+02    .2000E+02    .1459E+01    .2504E+01    .2837E+01    .1190E+01
     .6000E+02    .6867E+01    .1480E+02    .2000E+02    .2000E+01    .2000E+01    .1764E+01    .9025E+00
```

HCRIT OUTPUT FILE FOR INPUT TO CTDM (TERRAIN)

2 6		.8000E+02		GULLIED HILL			
10.000	.1315E+02	.1468E+02	60.000	16.320	12.910		
20.000	.1128E+02	.1543E+02	60.000	13.770	9.175		
30.000	.1010E+02	.1569E+02	70.000	11.380	6.782		
40.000	.7972E+01	.1532E+02	140.000	8.283	4.573		
50.000	.6679E+01	.1574E+02	160.000	5.957	2.832		
60.000	.6585E+01	.1544E+02	160.000	4.562	1.570		
10.000	.8247E+01	.1540E+02	131.319	1.791	1.467	6.295	3.233
20.000	.7641E+01	.1540E+02	142.548	1.799	1.540	5.383	2.624
30.000	.7026E+01	.1532E+02	155.290	1.853	1.676	4.464	2.070
40.000	.6710E+01	.1533E+02	160.000	1.805	1.921	3.633	1.589
50.000	.6726E+01	.1512E+02	160.000	1.459	2.504	2.837	1.190
60.000	.6867E+01	.1480E+02	160.000	2.000	2.000	1.764	.902

PLOTCON (HPLTCON) EXECUTION WITH INTERACTIVE INPUT

```
D:\>PLOTCON

        INPUT NAME OF PLOTFILE FROM PROGRAM FITCON-->? PLOT1

        SELECT TYPE OF DISPLAY

        1.) Low resolution with color
        2.) High resolution black and white

        Choice?(1 or 2)-->? 2

        SELECT THE CONTOUR TYPE FOR DISPLAY

        1.) Unedited Contours
        2.) Edited Contours

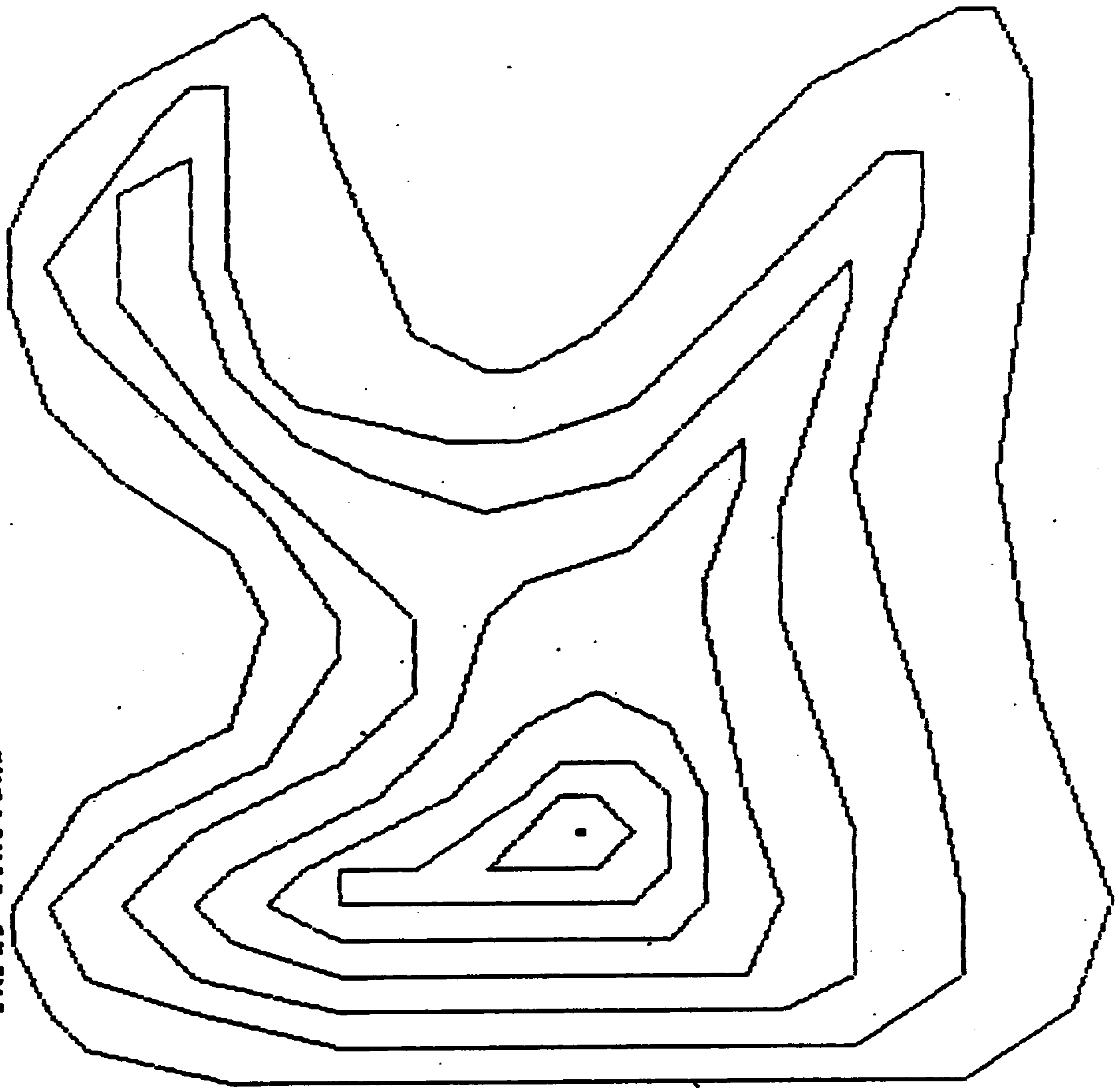
        Choice?(1 or 2)-->? 2

        DISPLAY FITTED CUTOFF HILL CONTOURS?(Y/N)->? Y

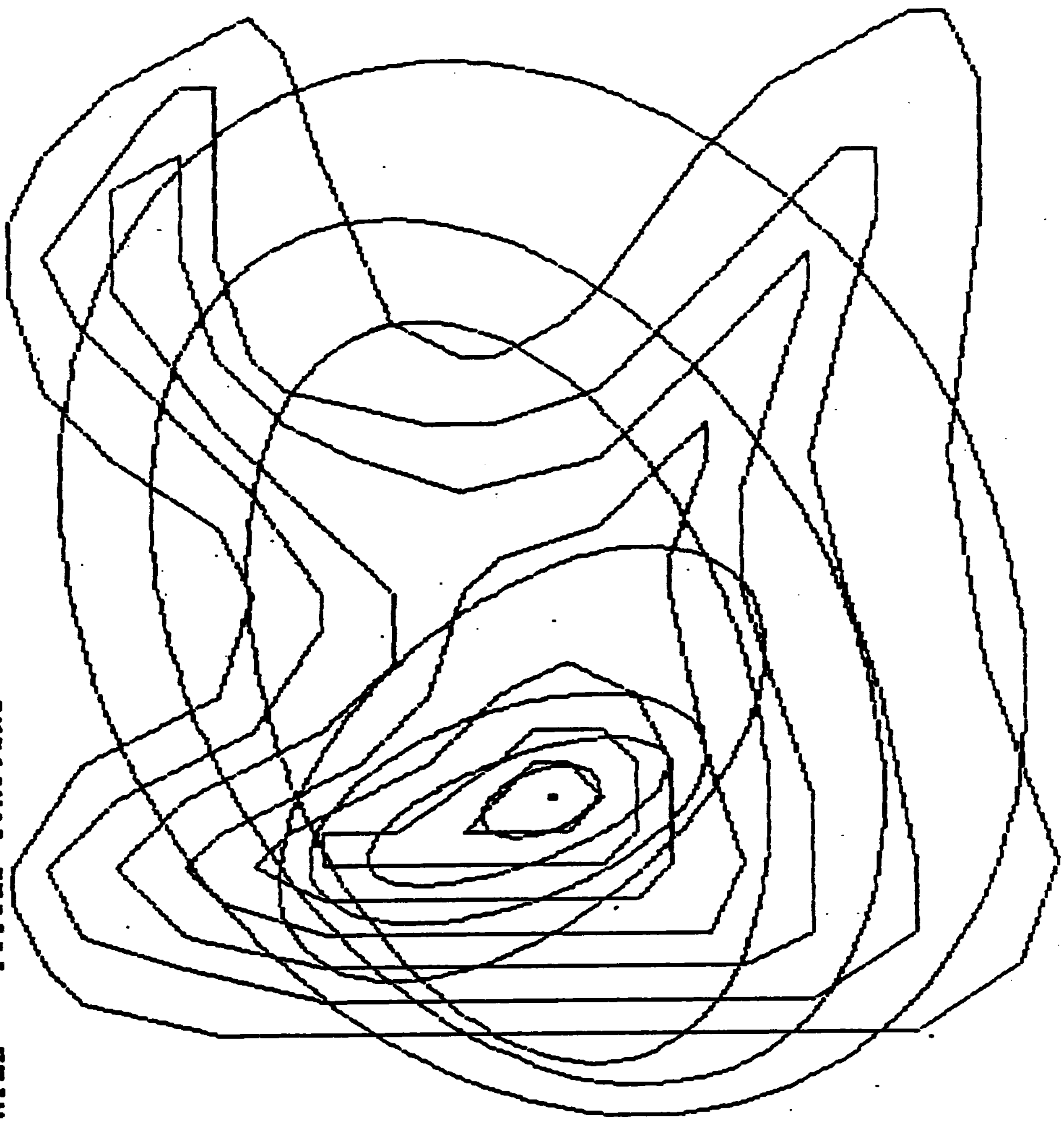
    INPUT NAME OF PLOTFILE FROM PROGRAM HCRIT? PLOT2
```

PLOT OF ACTUAL INPUT CONTOURS

GULLIED HILL INPUT CONTOURS

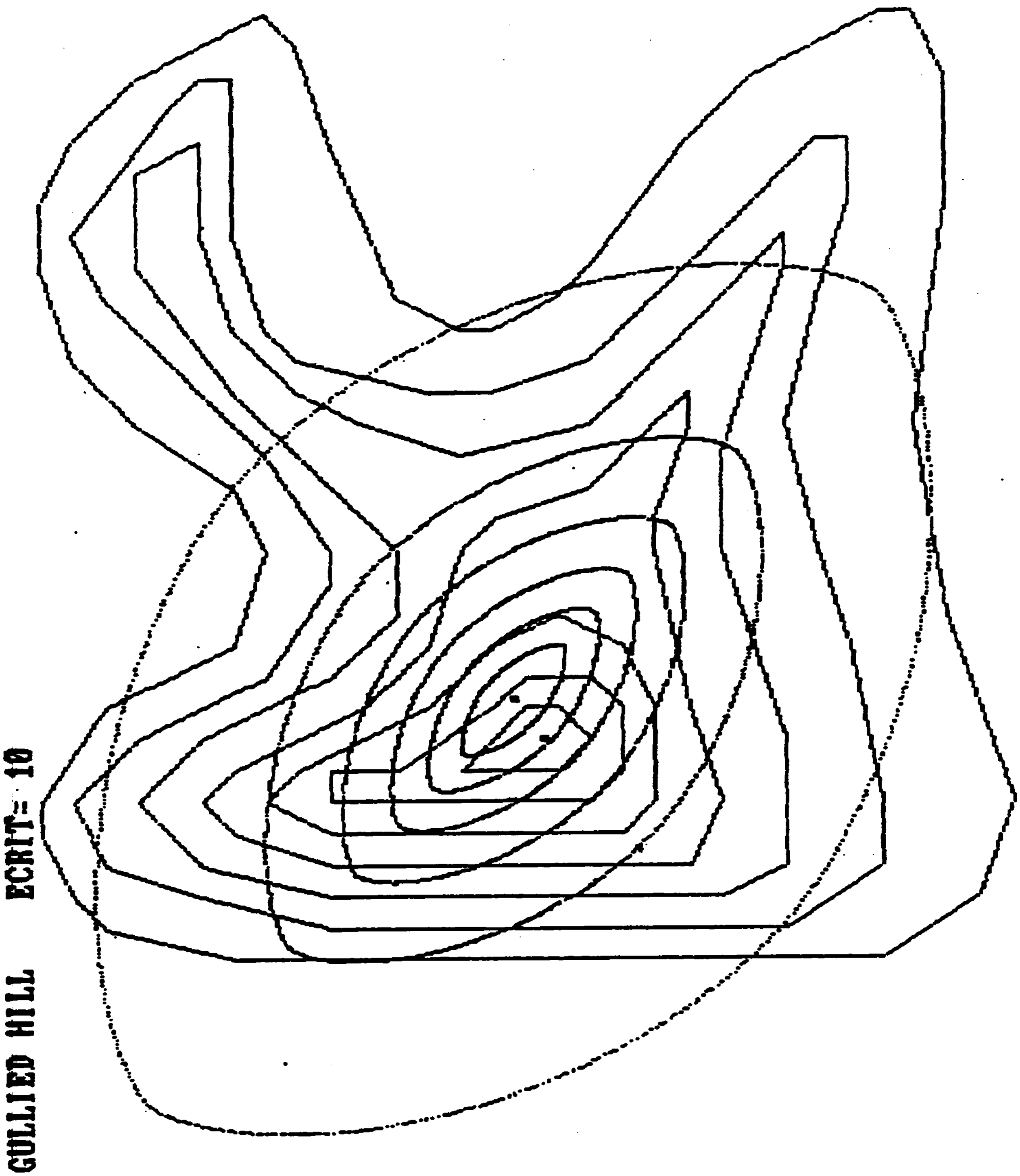


PLOT OF ACTUAL CONTOURS AND FITTED ELLIPSES



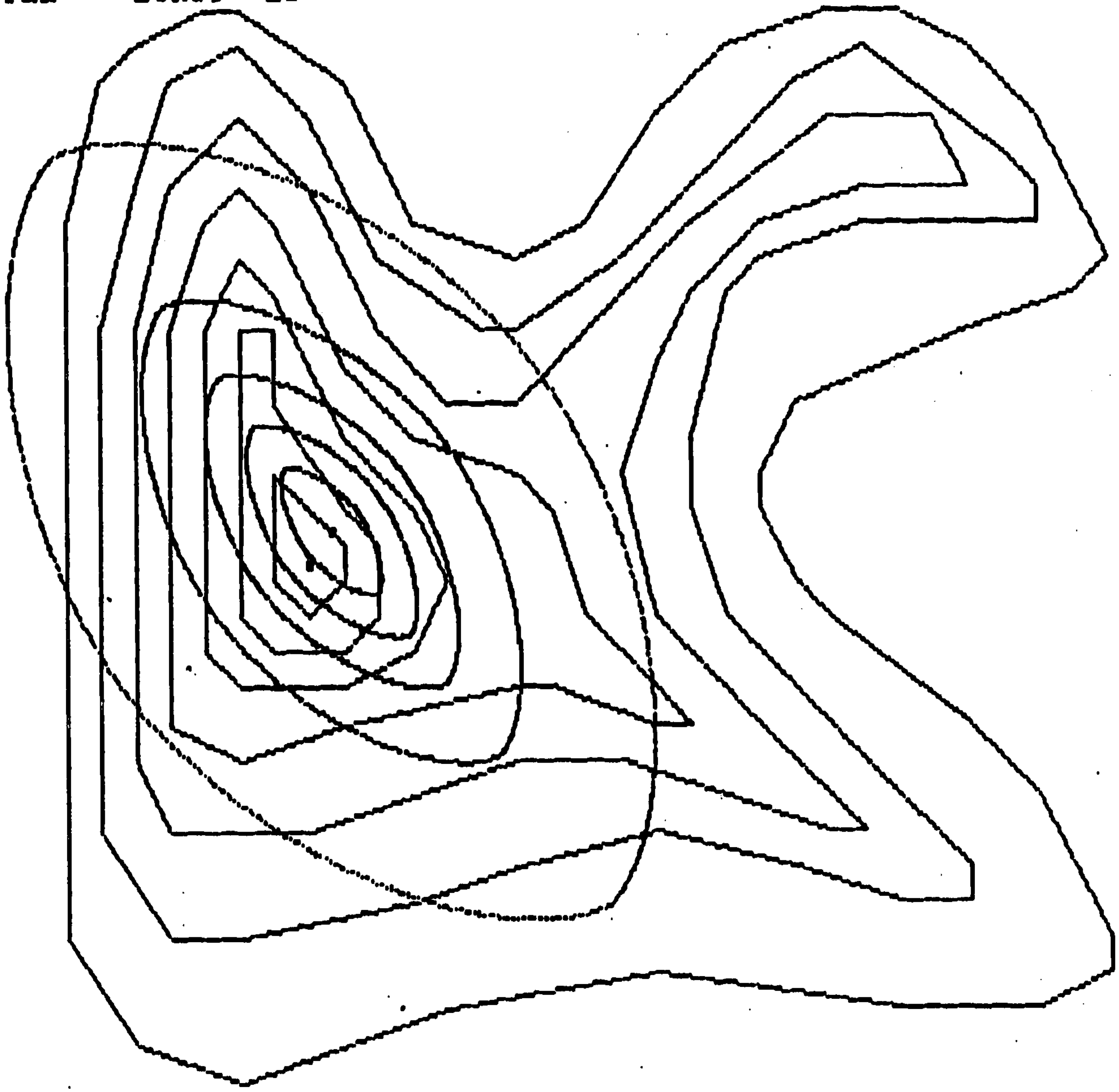
GULLIED HILL FITTED CONTOURS

PLOT OF ACTUAL CONTOURS AND INVERSE POLYNOMIAL CONTOURS AT ACTUAL CONTOUR ELEVATIONS ABOVE THE CRITICAL CUTOFF ELEVATION



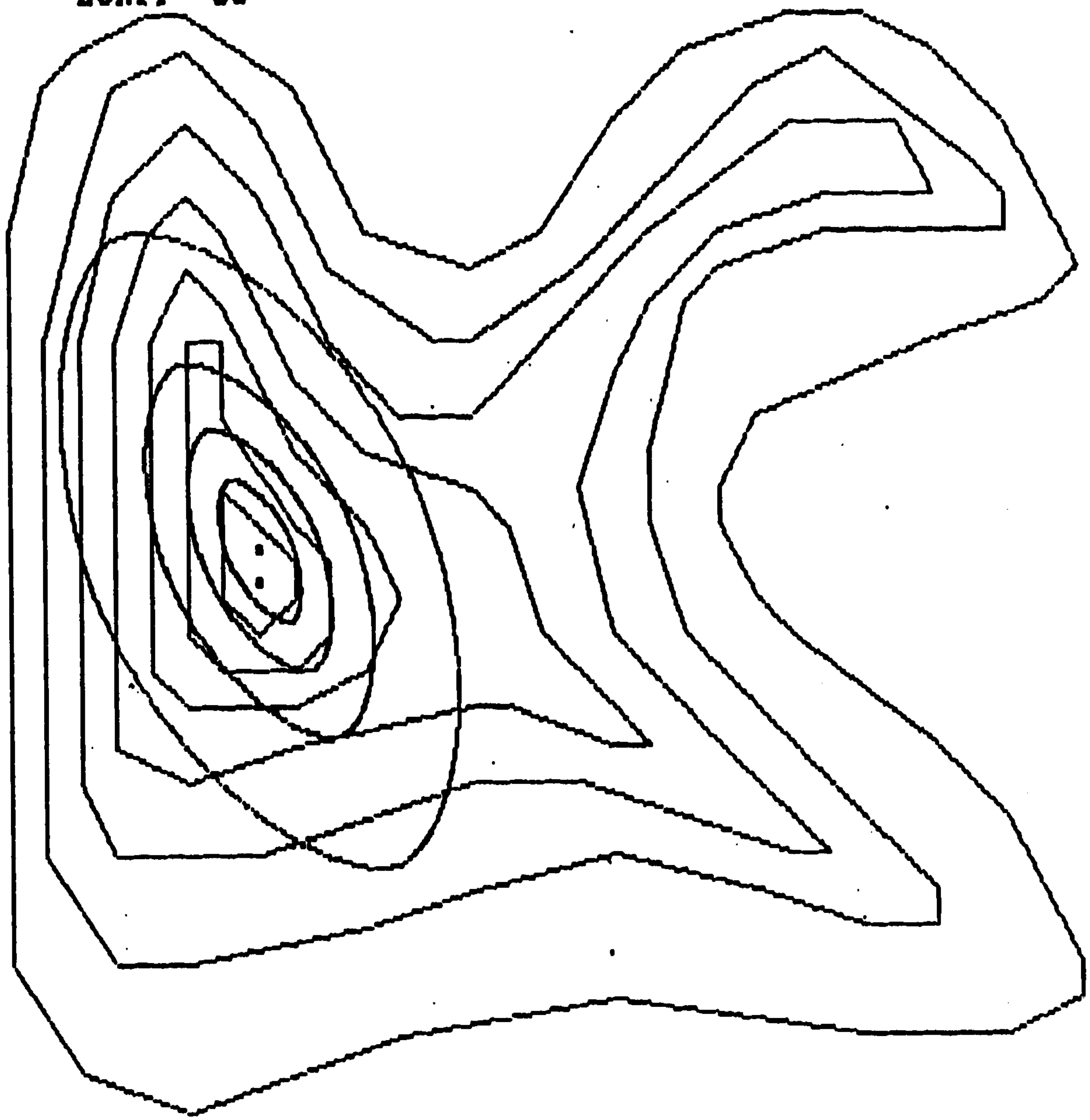
Critical Elevation (HC) = 10

GULLIED HILL ECRIT= 20



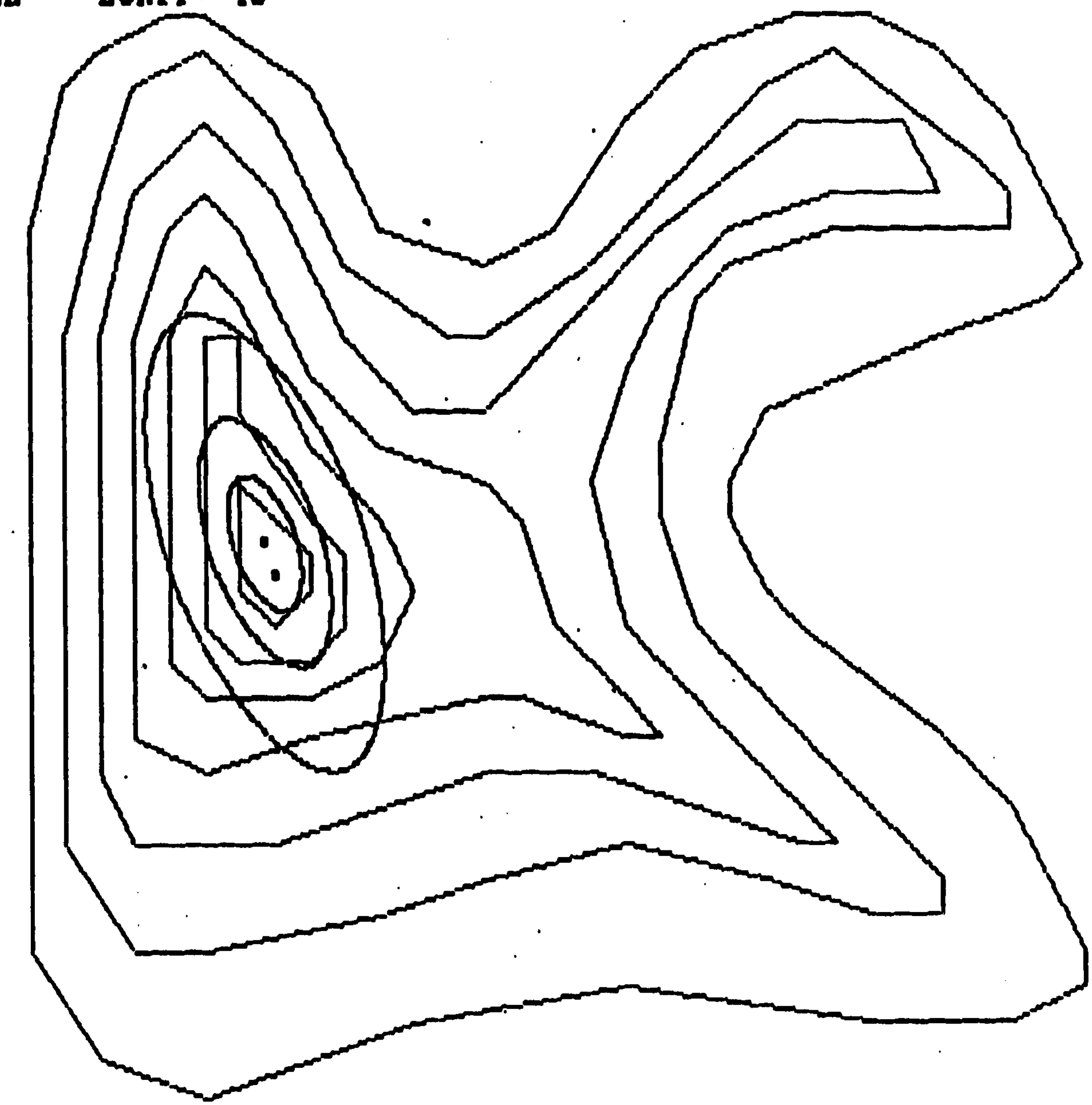
Critical Elevation (HC) = 20

GULLIED HILL   ECRIT= 30



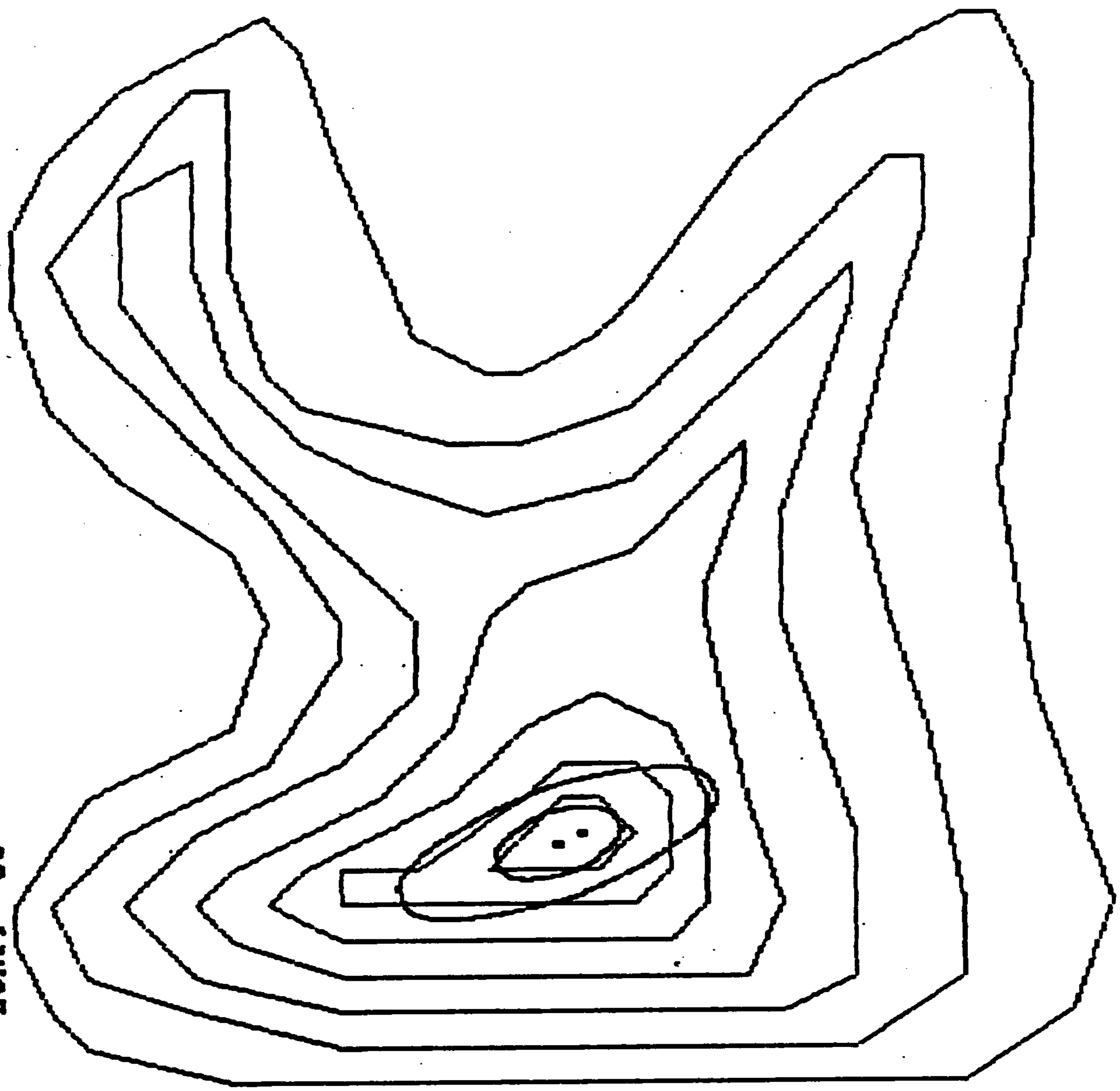
Critical Elevation (HC) = 30

GULLIED HILL   ECRIT= 40

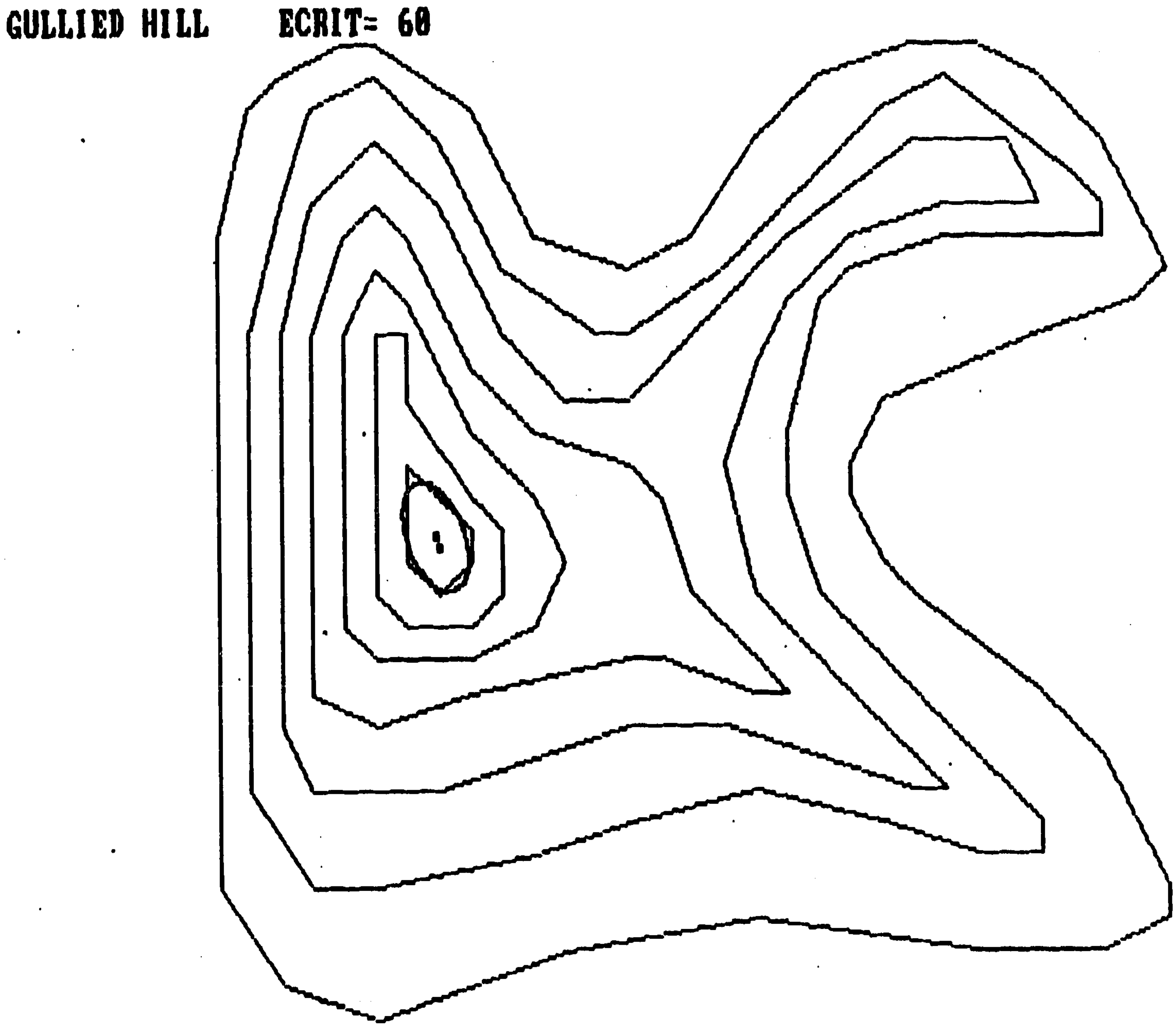


Critical Elevation (HC) = 40

GULLIED HILL ECRIT= 50



Critical Elevation (HC) = 50



Critical Elevation (HC) = 60

APPENDIX D
PROGRAM LISTINGS

FITCON MAIN PROGRAM AND SUBROUTINES

```
      PROGRAM FITCON
C***PROGRAM TO FIT DIGITIZED CONTOURS TO ELLIPTICAL SHAPES. PROGRAM
C***GENERATES A FILE OF ELLIPTICAL CONTOUR PARAMETERS TO BE USED BY
C***PROGRAM HCRIT TO PERFORM THE CRITICAL HEIGHT ANALYSIS FOR THE
C***HILL IN QUESTION. A PLOT FILE IS ALSO GENERATED FOR SUBSEQUENT
C***DISPLAY OF DIGITIZED AND FITTED CONTOURS.
C***
C***
C   GLOSSARY OF TERMS
C***
C***
C   A(J)=CALCULATED SEMI-MAJOR AXIS LENGTH(USER COORDINATES) FOR THE
C        ELLIPTICAL REPRESENTATION OF CONTOUR J
C   AFIL=ANGULAR FILTER SIZE(1 TO 22.5 DEGREES) INPUT BY THE USER
C        FOR THE CONTOUR COMPLETION ANALYSIS. MODIFIED AFTER INPUT
C        SO THAT IT DIVIDES EVENLY INTO 360 DEGREES.
C   ANGLE(M)=(M-1)*10.0 WHERE M=1,18
C   ANS=CHARACTER*1 VARIABLE HOLDING THE ANSWER TO A YES(Y) OR NO(N)
C      QUESTION
C   AR=VALUE OF THE AREA RETURNED BY A CALL TO SUBROUTINE ARCM.
C      AR WILL BE POSITIVE IF THE CONTOUR POINTS ARE GIVEN IN A
C      CLOCKWISE FASHION AND NEGATIVE IF THE CONTOUR POINTS ARE GIVEN
C      IN A COUNTER-CLOCKWISE FASHION
C   ARCM=SUBROUTINE TO CALCULATE THE CONTOUR AREA AND CENTROID
C        COORDINATES
C   AREA=AREA OF A GIVEN CONTOUR(=ABS(AR))
C   B(J)=CALCULATED SEMI-MINOR AXIS LENGTH(USER COORDINATES) FOR THE
C        ELLIPTICAL REPRESENTATION OF CONTOUR J
C   CFLAG=CONTOUR CLOSURE INDICATOR
C        =0(CONTOUR OPEN)
C        =1(CONTOUR CLOSED)
C   CN(M)=COS(PI*(M-1)*10.0/180.) WHERE M=1,18
C   CONIN=UNIT NUMBER FOR FILE CONTAINING CONTOUR IDs FOR THE HILL
C         IN QUESTION
C   CONFILE=CHARACTER*15 VARIABLE GIVING THE NAME OF THE FILE
C           CONTAINING CONTOUR IDs FOR THE HILL IN QUESTION
C   CONCOMP=SUBROUTINE WHICH ADDS POINTS TO COMPLETE A CONTOUR
C   COUT=UNIT NUMBER FOR OUTPUT FILE COUTFILE WHICH WILL BE INPUT TO
C        THE CRITICAL HEIGHT ANALYSIS PROGRAM
C   COUTFILE=CHARACTER*15 VARIABLE GIVING THE NAME OF THE OUTPUT FILE
C            CONTAINING THE FITTED HILL PARAMETERS WHICH WILL BE INPUT
C            TO THE CRITICAL HEIGHT ANALYSIS PROGRAM(HCRIT)
C   DFTOL=DISTANCE FROM FIRST TO LAST CONTOUR POINT(USER COORDINATES)
C   DOUT=UNIT NUMBER FOR FILE CONTAINING DIAGNOSTIC OUTPUT
C   DOUTFILE=CHARACTER*15 VARIABLE GIVING THE NAME OF THE FILE
C            CONTAINING DIAGNOSTIC OUTPUT FOR THE HILL IN QUESTION
C   ECC(J)=ECCENTRICITY OF THE ELLIPSE REPRESENTING CONTOUR J
C        =SQRT(A(J)**2-B(J)**2)/A(J)
C   HCON(J)=ELEVATION OF HILL CONTOUR J(USER COORDINATES)
C   HCONT=VALUE OF HCON(J) FOR A PARTICULAR CONTOUR J
C   HNAME=CHARACTER*15 VARIABLE GIVING THE HILL NAME
C   HTOP=HILL TOP ELEVATION(USER COORDINATES)
C   ICL=SMALLEST ID(1-9999) NUMBER FOR THE CONTOUR GROUP(INPUT ONLY FOR
C       ICMODE=2)
C   ICMODE=CONTOUR INPUT MODE FOR THE HILL IN QUESTION
C        =1(ALL CONTOURS IN THE MASTER FILE SELECTED FOR INPUT)
C        =2(CONTOUR ID RANGE SPECIFIED FOR INPUT)
C        =3(INPUT FILE WITH CONTOUR IDs SPECIFIED)
C   ICU=LARGEST ID NUMBER(1-9999) FOR THE CONTOUR GROUP(INPUT ONLY FOR
C       ICMODE=2)
```

```
C     IDC(J)=ID NUMBER FOR CONTOUR J WHICH HAS BEEN SELECTED FROM THE        FIT00610
C            CONTOUR MASTER FILE                                             FIT00620
C     IDCPK(I)=ID NUMBER FOR THE Ith CONTOUR SPECIFIED IN FILE CONFILE       FIT00630
C     IDHILL=HILL ID NUMBER(1-999) SPECIFIED BY THE USER                     FIT00640
C     IN=UNIT NUMBER FOR CONTOUR MASTER FILE                                 FIT00650
C     ISMFLG=COMPLETION CODE RETURNED BY SUBROUTINE SMOMNT                   FIT00660
C           =0(RADIUS OF GYRATION WAS CALCULATED)                            FIT00670
C           =1(RADIUS OF GYRATION COULD NOT BE CALCULATED)                   FIT00680
C     J=CURRENT NUMBER OF CONTOURS INPUT FROM THE MASTER FILE FOR THE        FIT00690
C       HILL IN QUESTION(AFTER QUALIFICATION AND EDITING)                    FIT00700
C     LTPR=WORKING ARRAY USED BY SUBROUTINE ISORT                            FIT00710
C     MASTER=CHARACTER*15 VARIABLE GIVING THE NAME OF THE MASTER FILE        FIT00720
C            CONTAINING THE CONTOUR ELEVATIONS AND POINT COORDINATES         FIT00730
C     MCFLAG=MULTIPLE CONTOUR SUBROUTINE COMPLETION CODE RETURNED FROM       FIT00740
C            SUBROUTINE MULTC                                                FIT00750
C           =0(MAXIMUM NUMBER OF POINTS EXCEEDED IN THE CONTOUR POINT        FIT00760
C              REASSIGNMENT PROCESS--CONTOUR REJECTED)                       FIT00770
C           =1(THE LAST IN A SERIES OF MULTIPLE CONTOURS WAS FOUND NOT       FIT00780
C              TO BE CLOSED--CONTOUR REJECTED)                               FIT00790
C           =2(CONTOUR WAS FOUND TO BE A SINGLE CONTOUR(I.E. NO CONTOUR      FIT00800
C              CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT))            FIT00810
C           =3(POINT REASSIGNMENT FOR THE MULTIPLE CONTOUR WAS               FIT00820
C              SUCCESSFULLY COMPLETED)                                       FIT00830
C     NC=TOTAL NUMBER OF CONTOURS SELECTED FROM THE MASTER FILE FOR THE      FIT00840
C        HILL IN QUESTION                                                    FIT00850
C     NCID=NUMBER OF REQUESTED CONTOUR IDs CONTAINED IN CONFILE              FIT00860
C     NCMAX=MAXIMUM NUMBER OF CONTOURS ALLOWED                               FIT00870
C     NCT2=2*NC                                                              FIT00880
C     NFIL=INT(360./AFIL)                                                    FIT00890
C     NPC=NUMBER OF POINTS ON A CONTOUR                                      FIT00900
C     NPCMAX=MAXIMUM NUMBER OF POINTS PER CONTOUR ALLOWED                    FIT00910
C     NPCSV=NUMBER OF POINTS ON A CONTOUR PRIOR TO CONTOUR COMPLETION        FIT00920
C     NSLOPE=NUMBER OF LINES USED IN THE DETERMINATION OF THE LINE,          FIT00930
C            PASSING THROUGH THE CONTOUR CENTROID, WHICH GIVES THE           FIT00940
C            MAXIMUM RADIUS OF GYRATION FOR THE DIGITIZED CONTOUR            FIT00950
C     OREN(J)=ANGLE CORRESPONDING TO THE ORIENTATION OF THE SEMI-            FIT00960
C            MINOR AXIS OF CONTOUR J. THE POSSIBLE ORIENTATIONS REPRESENTFIT00970
C            THE FOLLOWING DIRECTIONS WITH RESPECT TO THE POSITIVE           FIT00980
C            X-AXIS:0,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150,FIT00990
C            160,AND 170 DEGREES                                             FIT01000
C     ORENT=CONTOUR MINOR AXIS ORIENTATION CORRESPONDING TO THE MAXIMUM      FIT01010
C           RADIUS OF GYRATION RETURNED BY SUBROUTINE SMOMNT. ORENT IS       FIT01020
C           SIMPLY A TEMPORARY HOLDING VARIABLE FOR OREN(J)                  FIT01030
C     PI=3.14159265                                                          FIT01040
C     PFILE=CHARACTER*15 VARIABLE GIVING THE NAME OF THE PLOT FILE           FIT01050
C     PFLAG=PLOT GENERATON INDICATOR                                         FIT01060
C          =0(NO PLOT GENERATED)                                             FIT01070
C          =1(PLOT GENERATED)                                                FIT01080
C     RAD=RADIUS OF THE EQUIVALENT CIRCULAR CONTOUR(USER COORDINATES)        FIT01090
C     RG=MAXIMUM RADIUS OF GYRATION CONSIDERING THE 18 ORIENTATIONS OF       FIT01100
C        AXES PASSING THROUGH THE CONTOUR CENTROID IN THE PLANE OF           FIT01110
C        THE CONTOUR(USER COORDINATES)                                       FIT01120
C     RGRAT=THE RATIO OF THE DIFFERENCE BETWEEN THE MAXIMUM AND MINIMUM      FIT01130
C           RADII OF GYRATION(CONSIDERING THE 18 ORIENTATIONS OF AXES        FIT01140
C           PASSING THROUGH THE CONTOUR CENTROID) TO THE MAXIMUM RADIUS      FIT01150
C           OF GYRATION. USED TO DETERMINE WHETHER AN INPUT CONTOUR SHOULDFIT01160
C           BE REPRESENTED BY A CIRCLE                                       FIT01170
C     SKIPCN=SUBROUTINE TO SKIP OVER CONTOUR POINTS FOR CONTOURS WHICH AREFIT01180
C            NOT PROCESSED                                                   FIT01190
C     SMOMNT=SUBROUTINE WHICH CALCULATES THE MAXIMUM RADIUS OF GYRATION      FIT01200
```

```
C          FOR AN INPUT CONTOUR BY CONSIDERING THE CALCULATED RADII OF
C          GYRATION FOR 18 LINES OF EQUAL ANGULAR SPACING WHICH PASS
C          THROUGH THE CONTOUR CENTROID IN THE PLANE OF THE CONTOUR
C   SN(M)=SIN(PI*(M-1)*10.0/180.) WHERE M=1,18
C   ISORT=SUBROUTINE TO CARRY OUT A SIMPLE PARAMETER SORT
C   UPL=UNIT NUMBER FOR THE FILE PFILE
C   UPSCR=UNIT NUMBER FOR THE SCRATCH FILE "PSCRAT"
C   XC=CONTOUR CENTROID X-COORDINATE RETURNED BY A CALL TO ARCM.
C      XC IS SIMPLY A TEMPORARY HOLDING VARIABLE FOR XCM(J)
C   XCM(J)=CALCULATED X-COORDINATE(USER COORDINATES) OF THE CENTER OF
C          MASS OF CONTOUR J
C   XCON(K)=X-COORDINATE(USER COORDINATES) OF A POINT K ON A CONTOUR
C   XCONSV(K)=HOLDING ARRAY FOR THE VALUE OF XCON(K) PRIOR TO CONTOUR
C             COMPLETION
C   XHTOP=INPUT VALUE FOR THE HILL CENTER X-COORDINATE(USER COORDINATES)
C   XMAX1=VARIABLE CONTAINING THE CURRENT MAXIMUM CONTOUR X-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE UNEDITED CONTOURS
C   XMAX2=VARIABLE CONTAINING THE CURRENT MAXIMUM CONTOUR X-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE EDITED CONTOURS
C   XMIN1=VARIABLE CONTAINING THE CURRENT MINIMUM CONTOUR X-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE UNEDITED CONTOURS
C   XMIN2=VARIABLE CONTAINING THE CURRENT MINIMUM CONTOUR X-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE EDITED CONTOURS
C   YC=CONTOUR CENTROID Y-COORDINATE RETURNED BY A CALL TO ARCM.
C      YC IS SIMPLY A TEMPORARY HOLDING VARIABLE FOR YCM(J)
C   YCM(J)=CALCULATED Y-COORDINATE(USER COORDINATES) OF THE CENTER OF
C          MASS OF CONTOUR J
C   YCON(K)=Y-COORDINATE(USER COORDINATES) OF A POINT K ON A CONTOUR
C   YCONSV(K)=HOLDING ARRAY FOR THE VALUE OF YCON(K) PRIOR TO CONTOUR
C             COMPLETION
C   YHTOP=INPUT VALUE FOR THE HILL CENTER Y-COORDINATE(USER COORDINATES)
C   YMAX1=VARIABLE CONTAINING THE CURRENT MAXIMUM CONTOUR Y-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE UNEDITED CONTOURS
C   YMAX2=VARIABLE CONTAINING THE CURRENT MAXIMUM CONTOUR Y-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE EDITED CONTOURS
C   YMIN1=VARIABLE CONTAINING THE CURRENT MINIMUM CONTOUR Y-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE UNEDITED CONTOURS
C   YMIN2=VARIABLE CONTAINING THE CURRENT MINIMUM CONTOUR Y-COORDINATE
C        FOR ALL INPUT CONTOURS. USED IN THE DETERMINATION OF PLOT
C        BOUNDARIES FOR THE EDITED CONTOURS
C***
C***
      INTEGER CFLAG,CONIN,DOUT,PFLAG,UPL,UPSCR,COUT
      CHARACTER*1 ANS
      CHARACTER*15 CONFILE,DOUTFILE,MASTER,COUTFILE,HNAME,PFILE
      DIMENSION XCON(1000),YCON(1000),HCON(200),A(200),B(200),
     &XCM(200),YCM(200),ECC(200),OREN(200),IDC(200),IDCPK(200),
     &LPTR(200),NPTR(200),XCONSV(1000),YCONSV(1000)
      DIMENSION SN(18),CN(18),ANGLE(18)
C***
C***
C   INITIALIZATION OF VARIABLES
C***
```

```
C***
C***INITIALIZE THE ANGLE ARRAY TO BE USED FOR THE CONTOUR
C***ORIENTATION ANALYSIS.
      DATA ANGLE/0.,10.,20.,30.,40.,50.,60.,70.,80.,90.,100.,110.,
     &120.,130.,140.,150.,160.,170./
C***INITIALIZE SINE AND COSINE ARRAYS TO BE USED FOR THE CONTOUR
C***ORIENTATION ANALYSIS.
      DATA SN/0.,0.1736,0.3420,0.5,0.6428,0.7660,0.8660,0.9397,
     &0.9848,1.0,0.9848,0.9397,0.8660,0.7660,0.6428,0.5,0.3420,0.1736/
      DATA CN/1.0,0.9848,0.9397,0.8660,0.7660,0.6428,0.5,0.3420,0.1736,
     &0.0,-0.1736,-0.3420,-0.5,-0.6428,-0.7660,-0.8660,-0.9397,-0.9848/
C***SPECIFY FILE UNIT NUMBERS.
      CONIN=14
      IN=15
      DOUT=16
      COUT=17
      UPL=18
      UPSCR=19
C***SPECIFY CONSTANTS.
      PI=3.14159265
      NCMAX=200
      NPCMAX=1000
      NSLOPE=18
C***
C***
C   INPUT FILE NAMES(MASTER FILE AND DIAGNOSTIC OUTPUT FILE) AND
C   HILL IDENTIFICATION INFORMATION.
C***
C***
C***INPUT NAMES FOR THE CONTOUR MASTER FILE AND THE DIAGNOSTIC
C***OUTPUT FILE.
    5 WRITE(*,10)
   10 FORMAT(/,1X,'ENTER CONTOUR MASTER FILE NAME -> '\)
      READ(*,'(A)') MASTER
      IF(MASTER.EQ.' ') GO TO 5
   15 WRITE(*,20)
   20 FORMAT(/,1X,'ENTER DIAGNOSTIC OUTPUT FILE NAME -> '\)
      READ(*,'(A)') DOUTFILE
      IF(DOUTFILE.EQ.' ') GO TO 15
C***OPEN THE CONTOUR MASTER FILE AND THE DIAGNOSTIC OUTPUT FILE.
      OPEN(IN,FILE=MASTER,STATUS='OLD')
      OPEN(DOUT,FILE=DOUTFILE,STATUS='NEW')
C***INPUT HILL IDENTIFIER NUMBER AND HILL NAME.
   25 WRITE(*,30)
   30 FORMAT(/,1X,'ENTER HILL ID NUMBER(1-99) -> '\)
      READ(*,'(BN,I2)',ERR=25) IDHILL
      IF(IDHILL.EQ.0) GO TO 25
   35 WRITE(*,40)
   40 FORMAT(/,1X,'ENTER HILL NAME(1-15CHAR.) -> '\)
      READ(*,'(A)') HNAME
      IF(HNAME.EQ.' ') GO TO 35
      WRITE(DOUT,50) IDHILL,HNAME
   50 FORMAT(/,1X,'HILL NUMBER',I4,1X,'IS',1X,A15)
C***
C***
C   INPUT THE HILL TOP ELEVATION AND THE COORDINATES OF THE
C   HILL CENTER.
C***
C***
C***INPUT THE HILL TOP ELEVATION.
```

```
   60 CONTINUE                                                          FIT02410
      WRITE(*,70)                                                       FIT02420
   70 FORMAT(/,1X,'INPUT HILL TOP ELEVATION -> '\)                      FIT02430
      READ(*,'(BN,F10.0)',ERR=60) HTOP                                  FIT02440
C***INPUT THE HILL CENTER X AND Y COORDINATES.                          FIT02450
   80 WRITE(*,110)                                                      FIT02460
  110 FORMAT(/,1X,'INPUT HILL CENTER X-COORDINATE -> '\)                FIT02470
      READ(*,'(BN,F10.0)',ERR=80) XHTOP                                 FIT02480
  115 WRITE(*,120)                                                      FIT02490
  120 FORMAT(/,1X,'INPUT HILL CENTER Y-COORDINATE -> '\)                FIT02500
      READ(*,'(BN,F10.0)',ERR=115) YHTOP                                FIT02510
C***DETERMINE WHETHER ANGULAR FILTERING IS TO BE USED.                  FIT02520
      WRITE(*,1201)                                                     FIT02530
 1201 FORMAT(/,1X,'ANGULAR FILTERING?(Y/N) -> '\)                       FIT02540
      READ(*,'(A)') ANS                                                 FIT02550
      IF(ANS.EQ.'Y'.OR.ANS.EQ.'y') GO TO 1202                           FIT02560
      NFIL=0                                                            FIT02570
      GO TO 1261                                                        FIT02580
 1202 CONTINUE                                                          FIT02590
C***INPUT ANGULAR FILTER SIZE FOR USE IN THE CONTOUR COMPLETION ANALYSISFIT02600
  121 WRITE(*,122)                                                      FIT02610
  122 FORMAT(/,1X,'INPUT ANGULAR FILTER SIZE FOR CONTOUR COMPLETION(1-22FIT02620
     &.5 DEG.) -> '\)                                                   FIT02630
      READ(*,'(BN,F10.0)',ERR=121) AFIL                                 FIT02640
      IF(AFIL.GE.1.0.AND.AFIL.LE.22.5) GO TO 124                        FIT02650
      WRITE(*,123)                                                      FIT02660
  123 FORMAT(/,1X,'***ERROR*** SPECIFIED FILTER SIZE OUT OF RANGE--TRY AFIT02670
     &GAIN')                                                            FIT02680
      GO TO 121                                                         FIT02690
C***WRITE SPECIFIED ANGULAR FILTER SIZE TO THE DIAGNOSTIC OUTPUT FILE.  FIT02700
  124 WRITE(DOUT,125) AFIL                                              FIT02710
  125 FORMAT(/,1X,'SPECIFIED ANGULAR FILTER SIZE FOR CONTOUR COMPLETION=FIT02720
     &',F10.3,1X,'DEGREES')                                             FIT02730
C***MODIFY FILTER SIZE SO THAT IT DIVIDES EVENLY INTO 360 DEGREES.      FIT02740
      NFIL=INT(360./AFIL)                                               FIT02750
C***WRITE MODIFIED ANGULAR FILTER SIZE TO THE DIAGNOSTIC OUTPUT FILE.   FIT02760
      WRITE(DOUT,126) AFIL                                              FIT02770
  126 FORMAT(/,1X,'MODIFIED ANGULAR FILTER SIZE=',F10.3,1X,'DEGREES')   FIT02780
 1261 CONTINUE                                                          FIT02790
C***MAKE SURE THAT MAP BOUNDARIES INCLUDE HILL CENTER COORDINATES.      FIT02800
      XMIN1=XHTOP                                                       FIT02810
      YMIN1=YHTOP                                                       FIT02820
      XMAX1=XHTOP                                                       FIT02830
      YMAX1=YHTOP                                                       FIT02840
      XMIN2=XHTOP                                                       FIT02850
      YMIN2=YHTOP                                                       FIT02860
      XMAX2=XHTOP                                                       FIT02870
      YMAX2=YHTOP                                                       FIT02880
C***WRITE THE HILL TOP ELEVATION AND HILL CENTER COORDINATES TO THE     FIT02890
C***DIAGNOSTIC OUTPUT FILE.                                             FIT02900
      WRITE(DOUT,130) HTOP,XHTOP,YHTOP                                  FIT02910
  130 FORMAT(/,1X,'HILL TOP ELEVATION=',E12.4,/,                        FIT02920
     &1X,'HILL CENTER X-COORDINATE=',E12.4,/,                           FIT02930
     &1X,'HILL CENTER Y-COORDINATE=',E12.4)                             FIT02940
C***                                                                    FIT02950
C***                                                                    FIT02960
C   SPECIFICATION OF CONTOURS TO BE INPUT FROM THE MASTER FILE USING    FIT02970
C   ONE OF 3 METHODS                                                    FIT02980
C***                                                                    FIT02990
C***                                                                    FIT03000
```

```
C***ASK THE USER TO SPECIFY THE MODE OF CONTOUR SELECTION FROM
C***THE CONTOUR MASTER FILE.
  135 WRITE(*,140)
      WRITE(*,142)
  140 FORMAT(//,22X,'SPECIFY CONTOUR SELECTION MODE',/,
     &22X,'1.) ALL CONTOURS SELECTED',/,
     &22X,'2.) SELECT RANGE OF CONTOUR IDs',/,
     &22X,'3.) INPUT FILE WITH CONTOUR IDs')
  142 FORMAT(/,26X,'CHOICE?(1,2,OR 3) -> '\)
      READ(*,'(BN,I3)',ERR=135) ICMODE
      IF(ICMODE.EQ.1) GO TO 150
      IF(ICMODE.EQ.2) GO TO 170
      IF(ICMODE.EQ.3) GO TO 210
      WRITE(*,146)
  146 FORMAT(/,1X,'***ERROR***  MODE SELECTION OUT OF RANGE--TRY AGAIN')
      GO TO 135
C***USE ALL CONTOURS IN THE MASTER FILE(CONTOUR SELECTION MODE 1).
  150 WRITE(DOUT,160) MASTER
  160 FORMAT(/,1X,'ALL CONTOURS IN FILE  ',A15,1X,'SELECTED FOR INPUT')
      GO TO 300
C***INPUT THE SMALLEST AND LARGEST ID NUMBERS FOR THE GROUP OF
C***CONTOURS(CONTOUR SELECTION MODE NUMBER 2).
  170 WRITE(*,180)
  180 FORMAT(/,1X,'INPUT SMALLEST ID NUMBER(1-9999) FOR CONTOUR GROUP ->
     & '\)
      READ(*,'(BN,I4)',ERR=170) ICL
      IF(ICL.EQ.0) GO TO 170
  185 WRITE(*,190)
  190 FORMAT(/,1X,'INPUT LARGEST ID NUMBER(1-9999) FOR CONTOUR GROUP ->
     &'\)
      READ(*,'(BN,I4)',ERR=185) ICU
      IF(ICU.EQ.0) GO TO 185
      IF(ICU.GE.ICL) GO TO 195
      WRITE(*,191)
  191 FORMAT(/,1X,'***ERROR***  LOWER SERIAL NUMBER GREATER THAN UPPER--
     &TRY AGAIN')
      GO TO 170
  195 CONTINUE
C***WRITE ID RANGE FOR CONTOUR SELECTION TO THE DIAGNOSTIC OUTPUT FILE.
      WRITE(DOUT,200) MASTER,ICL,ICU
  200 FORMAT(/,1X,'CONTOURS SELECTED FROM MASTER FILE ',A15,/,
     &1X,'HAVE ID NUMBERS BETWEEN',I5,1X,'AND',I5)
      GO TO 300
C***INPUT THE NAME OF THE FILE CONTAINING THE CONTOUR ID NUMBERS FOR
C***THE HILL IN QUESTION(CONTOUR SELECTION MODE NUMBER 3).
  210 WRITE(*,220)
  220 FORMAT(/,1X,'ENTER CONTOUR ID FILE NAME ->.'\)
      READ(*,'(A)') CONFILE
      IF(CONFILE.EQ.' ') GO TO 210
C***OPEN CONTOUR ID FILE.
      OPEN(CONIN,FILE=CONFILE,STATUS='OLD')
C***INPUT ID NUMBERS FROM THE CONTOUR ID FILE.
C***SET COUNTER FOR CONTOUR IDs.
      NCID=1
  230 CONTINUE
C***READ THE NEXT ID NUMBER.
      READ(CONIN,*,END=270) IDCPK(NCID)
      NCID=NCID+1
C***CHECK TO SEE IF THE NUMBER OF CONTOURS IS GREATER THAN THE MAXIMUM
C***AMOUNT.
```

```
      IF(NCID.GT.NCMAX) GO TO 250
      GO TO 230
  250 WRITE(DOUT,260) NCMAX
  260 FORMAT(/,1X,'***WARNING***MAXIMUM NUMBER OF CONTOURS(',I4,') REAC
     &HED')
C***DETERMINE WHETHER ANY CONTOURS HAVE BEEN REQUESTED. IF NOT, WRITE
C***AN ERROR MESSAGE TO BOTH THE DIAGNOSTIC OUTPUT FILE AND THE SCREEN
C***AND THEN EXIT THE PROGRAM.
  270 NCID=NCID-1
      IF(NCID.EQ.0) GO TO 1000
      WRITE(DOUT,280) NCID,MASTER,IDHILL,HNAME
  280 FORMAT(/,1X,I4,1X,'CONTOURS TO BE SELECTED FROM MASTER FILE ',
     &A15,/,1X,'FOR HILL',I4,'(',A15,')',//,1X,'IDs REQUESTED:')
C***SORT LIST OF CONTOUR IDs IN ASCENDING ORDER.
      CALL ISORT(IDCPK,NCID,LPTR)
      WRITE(DOUT,290) (IDCPK(I),I=1,NCID)
  290 FORMAT(1X,I5)
C***CLOSE THE CONTOUR ID FILE.
      CLOSE(CONIN,STATUS='KEEP')
  300 CONTINUE
C***
C***
C   DETERMINE WHETHER A PLOT IS TO BE GENERATED, INPUT PLOT FILE NAME,
C   AND OPEN THE PLOT FILE. IF PLOT IS REQUESTED, ALSO OPEN A SCRATCH
C   FILE "PSCRAT".
C***
C***
C***ASK WHETHER A PLOT IS TO BE GENERATED. FIRST, INITIALIZE THE PLOT
C***FLAG INDICATOR TO CORRESPOND TO A "NO" ANSWER.
      PFLAG=0
      WRITE(*,310)
  310 FORMAT(/,1X,'PLOT REQUESTED?(Y/N) -> '\)
      READ(*,'(A)') ANS
      IF(ANS.EQ.'Y'.OR.ANS.EQ.'y') PFLAG=1
      IF(PFLAG.EQ.0) GO TO 315
C***ASK USER TO INPUT THE NAME OF THE PLOT FILE.
 3101 WRITE(*,311)
  311 FORMAT(/,1X,'ENTER PLOT FILE NAME -> '\)
      READ(*,'(A)') PFILE
      IF(PFILE.EQ.' ') GO TO 3101
C***OPEN THE PLOT FILE AND THE SCRATCH FILE.
      OPEN(UPL,FILE=PFILE,STATUS='NEW')
      OPEN(UPSCR,FILE='PSCRAT',STATUS='NEW')
      IF(PFLAG.NE.1) GO TO 315
C***WRITE "FITCON" TO THE FIRST RECORD OF THIS PLOT FILE TO INDICATE
C***THAT THE PLOT FILE IS BEING GENERATED BY PROGRAM FITCON.
      WRITE(UPL,3111)
 3111 FORMAT('FITCON')
C***WRITE THE HILL ID NUMBER AND NAME TO THE PLOT FILE.
      WRITE(UPL,312) IDHILL,HNAME
  312 FORMAT(I2,1X,A15)
C***WRITE THE HILL CENTER COORDINATES TO THE PLOT FILE.
      WRITE(UPL,313) XHTOP,YHTOP
  313 FORMAT(2E15.4)
  315 CONTINUE
      WRITE(*,316)
  316 FORMAT(/,1X,'Please wait...Contour data being processed',/)
C***
C***
C   INPUT AND EDIT CONTOUR DATA.
```

```
C***
C***
C***SET CONTOUR COUNTER.
      J=1
  320 CONTINUE
C***CHECK WHETHER THE MAXIMUM NUMBER OF CONTOURS HAVE BEEN INPUT.
      IF(J.GT.NCMAX) GO TO 670
C***INPUT THE ID NUMBER, ELEVATION, NUMBER OF POINTS, AND CONTOUR
C***CLOSURE INDICATOR FOR THE NEXT CONTOUR.
      READ(IN,*,END=700) IDC(J),HCON(J),NPC,CFLAG
      IF(ICMODE.NE.2) GO TO 340
C***CONTOUR SELECTION MODE 2
C***DETERMINE WHETHER THE CONTOUR ID NUMBER FALLS WITHIN THE BOUNDS
C***SPECIFIED BY THE USER. IF NOT, READ DATA FOR ANOTHER CONTOUR FROM
C***THE MASTER FILE.
      IF(IDC(J).LT.ICL.OR.IDC(J).GT.ICU) GO TO 355
      GO TO 360
  340 IF(ICMODE.NE.3) GO TO 360
C***CONTOUR SELECTION MODE 3
C***DETERMINE WHETHER THE ID NUMBER FOR THE CONTOUR INPUT FROM THE
C***MASTER FILE MATCHES ONE OF THE SORTED ID NUMBERS INPUT FROM CONFILE.
C***IF NOT, READ DATA FOR ANOTHER CONTOUR FROM THE MASTER FILE.
      DO 350 I=1,NCID
C***SINCE IDCPK ARRAY VALUES HAVE BEEN SORTED IN ASCENDING ORDER, THE
C***CURRENT ID NUMBER FROM THE MASTER FILE CAN SOMETIMES BE ELIMINATED
C***WITHOUT HAVING TO GO THROUGH THE ENTIRE LIST OF IDCPK ARRAY VALUES.
      IF(IDC(J).LT.IDCPK(I)) GO TO 355
      IF(IDC(J).EQ.IDCPK(I)) GO TO 360
  350 CONTINUE
  355 CALL SKIPCN(IN,NPC)
      GO TO 320
  360 CONTINUE
C***CHECK WHETHER THE CONTOUR ELEVATION IS GREATER THAN THE HILL TOP
C***ELEVATION. IF SO, WRITE AN ERROR MESSAGE AND DISCONTINUE PROCESSING
C***THE CONTOUR.
      IF(HCON(J).LT.HTOP) GO TO 375
      WRITE(*,365) IDC(J)
  365 FORMAT(/,1X,'Contour ID ',I4,1X,'has been rejected',/,1X,
     &'--See diagnostic output file after program completion')
      WRITE(DOUT,370) IDC(J),HCON(J),HTOP
  370 FORMAT(/,1X,'***ERROR***  CONTOUR ID',I5 ,1X,'DOES NOT HAVE AN ELE
     &VATION LESS THEN THE HILL TOP',/,1X,'CONTOUR ELEVATION=',E12.4,
     &/,1X,'HILL TOP ELEVATION=',E12.4,/,1X,'CONTOUR WILL NOT BE PROCESS
     &ED',/)
      CALL SKIPCN(IN,NPC)
      GO TO 320
C***FIND WHETHER THE CONTOUR HAS AN ELEVATION WHICH IS THE SAME AS A
C***CONTOUR WHICH HAS BEEN PREVIOUSLY ACCEPTED. IF SO, WRITE AN ERROR
C***MESSAGE AND DISCONTINUE PROCESSING THE CONTOUR. MULTIPLE CONTOURS
C***AT THE SAME ELEVATION MUST BE INPUT AS A SINGLE CONTOUR.
  375 IF(J.EQ.1) GO TO 380
      JM1=J-1
      DO 376 JJ=1,JM1
      JJK=JJ
      IF(ABS(HCON(J)-HCON(JJ)).LE.1.0E-15) GO TO 377
  376 CONTINUE
      GO TO 380
  377 WRITE(DOUT,378) IDC(JJK),HCON(J)
  378 FORMAT(/,1X,'***ERROR***  PREVIOUSLY ACCEPTED CONTOUR ID',I5,1X,
     &'ALSO HAS',/,1X,'AN ELEVATION OF',E15.4,1X,'--CONTOUR REJECTED',
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     &/,1X,'MULTIPLE CONTOURS AT THE SAME ELEVATION MUST BE INPUT AS A SFIT04810
     &INGLE CONTOUR')                                                   FIT04820
      WRITE(*,365) IDC(J)                                               FIT04830
      CALL SKIPCN(IN,NPC)                                               FIT04840
      GO TO 320                                                         FIT04850
C***CHECK WHETHER THE CONTOUR HAS FEWER THAN 3 POINTS. IF SO, WRITE AN  FIT04860
C***ERROR MESSAGE AND DISCONTINUE PROCESSING THE CONTOUR.               FIT04870
  380 IF(NPC.GT.2) GO TO 400                                            FIT04880
      WRITE(*,365) IDC(J)                                               FIT04890
      WRITE(DOUT,390) IDC(J),NPC                                        FIT04900
  390 FORMAT(/,1X,'***ERROR***  CONTOUR ID', I5,1X,'HAS FEWER THAN 3 POIFIT04910
     &NTS.',/,14X,'CONTOUR WILL NOT BE PROCESSED',/)                    FIT04920
      CALL SKIPCN(IN,NPC)                                               FIT04930
      GO TO 320                                                         FIT04940
C***CHECK WHETHER THE MAXIMUM NUMBER OF CONTOUR POINTS HAS BEEN EXCEEDEDFIT04950
C***IF SO, WRITE AN ERROR MESSAGE AND DISCONTINUE PROCESSING THE CONTOURFIT04960
  400 IF(NPC.LT.NPCMAX) GO TO 420                                       FIT04970
      WRITE(*,365) IDC(J)                                               FIT04980
      WRITE(DOUT,410) IDC(J),NPC,NPCMAX                                 FIT04990
  410 FORMAT(/,1X,'***ERROR***  CONTOUR ID',I5,1X,'HAS',I5,1X,'POINTS.',FIT05000
     &/,14X,'MAXIMUM ALLOWED IS',I5,'. CONTOUR WILL NOT BE PROCESSED.') FIT05010
      CALL SKIPCN(IN,NPC)                                               FIT05020
      GO TO 320                                                         FIT05030
C***WRITE THE CONTOUR ELEVATION TO THE DIAGNOSTIC OUTPUT FILE.          FIT05040
  420 WRITE(DOUT,425) IDC(J),HCON(J)                                    FIT05050
  425 FORMAT(/,1X,'CONTOUR ELEVATION FOR CONTOUR ID', I5,1X,'=',E12.4)  FIT05060
C***INPUT X,Y COORDINATES OF CONTOUR POINTS.                            FIT05070
      READ(IN,*) (XCON(K),YCON(K),K=1,NPC)                              FIT05080
C***WRITE THE CONTOUR POINT COORDINATES TO THE DIAGNOSTIC OUTPUT FILE.  FIT05090
      WRITE(DOUT,440) IDC(J)                                            FIT05100
  440 FORMAT(/,1X,'X-Y COORDINATES INPUT FOR CONTOUR ID',I5,/)          FIT05110
      WRITE(DOUT,450) (XCON(K),YCON(K),K=1,NPC)                         FIT05120
  450 FORMAT(1X,2E12.4)                                                 FIT05130
C***DETERMINE WHETHER THIS CONTOUR IS ACTUALLY A SET OF MULTIPLE        FIT05140
C***CONTOURS AT THE SAME ELEVATION.                                     FIT05150
      CALL MULTC(XCON,YCON,NPC,NPCMAX,MCFLAG)                           FIT05160
      IF(MCFLAG.EQ.0) WRITE(DOUT,451)                                   FIT05170
  451 FORMAT(/,1X,'MAXIMUM NUMBER OF POINTS EXCEEDED IN THE CONTOUR',   FIT05180
     &1X,'POINT REASSIGNMENT PROCESS.',/,1X,'--CONTOUR REJECTED')       FIT05190
      IF(MCFLAG.EQ.1) WRITE(DOUT,452)                                   FIT05200
  452 FORMAT(/,1X,'THE LAST IN A SERIES OF MULTIPLE CONTOURS WAS FOUND',FIT05210
     &1X,'NOT TO BE CLOSED.',/,1X,'--CONTOUR REJECTED')                 FIT05220
      IF(MCFLAG.EQ.2) WRITE(DOUT,453)                                   FIT05230
  453 FORMAT(/,1X,'CONTOUR WAS FOUND TO BE A SINGLE CONTOUR.',/,1X,'(I.EFIT05240
     &. NO CONTOUR CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT.)') FIT05250
      IF(MCFLAG.EQ.3) WRITE(DOUT,454)                                   FIT05260
  454 FORMAT(/,1X,'POINT REASSIGNMENT FOR THE MULTIPLE CONTOUR WAS',    FIT05270
     &1X,'SUCCESSFULLY COMPLETED')                                      FIT05280
      IF(MCFLAG.EQ.4) WRITE(DOUT,455)                                   FIT05290
  455 FORMAT(/,1X,'POINT REASSIGNMENT FOR THE MULTIPLE CONTOUR WAS SUCCEFIT05300
     &SSFULLY COMPLETED',/,1X,'AFTER THE POINT INPUT ORDER OF ONE OR MORFIT05310
     &E COMPONENT CONTOURS WAS',/,1X,'REVERSED TO MAKE THE ORDER OF EACHFIT05320
     & COMPONENT CONTOUR THE SAME AS THE',/,1X,'FIRST COMPONENT CONTOUR'FIT05330
     &)                                                                 FIT05340
      IF(MCFLAG.LT.2) WRITE(*,365) IDC(J)                               FIT05350
      IF(MCFLAG.LT.2) GO TO 320                                         FIT05360
C***BEFORE ANY ADDITIONAL EDITING, SAVE THE CONTOUR POINT COORDINATES   FIT05370
C***FOR LATER WRITING TO THE PLOT FILE                                  FIT05380
      NPCSV=NPC                                                         FIT05390
      DO 460 K=1,NPCSV                                                  FIT05400
```

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      XCONSV(K)=XCON(K)
      YCONSV(K)=YCON(K)
  460 CONTINUE
      IF(MCFLAG.GE.3) GO TO 530
C***PERFORM EDIT CHECKING FOR A SINGLE CONTOUR.
C***FIND THE DISTANCE(DFTOL) FROM THE FIRST TO THE LAST CONTOUR.
      DFTOL=SQRT((XCON(NPC)-XCON(1))**2+(YCON(NPC)-YCON(1))**2)
C***IF THIS DISTANCE IS EFFECTIVELY ZERO AND THE CONTOUR HAS BEEN
C***SPECIFIED AS CLOSED, THEN CONTINUE PROCESSING THE CONTOUR.
      IF(DFTOL.LT.1.0E-15.AND.CFLAG.EQ.1) GO TO 530
C***IF THIS DISTANCE IS EFFECTIVELY ZERO AND THE CONTOUR HAS BEEN
C***SPECIFIED AS OPEN, THEN WRITE A WARNING TO THE DIAGNOSTIC OUTPUT
C***FILE AND CONTINUE PROCESSING THE CONTOUR AS IF IT WERE CLOSED.
      IF(DFTOL.LT.1.0E-15.AND.CFLAG.NE.1) GO TO 510
C***IF THIS DISTANCE IS SIGNIFICANTLY GREATER THAN ZERO AND THE CONTOUR
C***HAS BEEN SPECIFIED AS CLOSED, THEN ADD TO THE CONTOUR A FINAL POINT
C***WHICH HAS THE SAME COORDINATES AS THE FIRST POINT. IF THE ADDITION
C***OF THIS POINT CAUSES THE NUMBER OF CONTOUR POINTS TO EXCEED THE
C***MAXIMUM ALLOWABLE, THEN SUBSTITUTE THE FIRST CONTOUR POINT FOR THE
C***LAST CONTOUR POINT AND CONTINUE PROCESSING THE CONTOUR AS IF IT WERE
C***CLOSED. THE APPROPRIATE WARNINGS ARE WRITTEN TO THE DIAGNOSTIC
C***OUTPUT FILE.
      IF(DFTOL.GE.1.0E-15.AND.CFLAG.EQ.1) GO TO 470
C***IF THIS DISTANCE IS SIGNIFICANTLY GREATER THAN ZERO AND THE CONTOUR
C***HAS BEEN SPECIFIED AS OPEN, THEN CALL SUBROUTINE CONCOMP TO ADD
C***POINTS TO COMPLETE THE CONTOUR.
      CALL CONCOMP(XCON,YCON,NPC,NPCMAX,XHTOP,YHTOP,AFIL,NFIL,DOUT)
      GO TO 530
  470 IF(NPC.EQ.NPCMAX) GO TO 490
      NPC=NPC+1
      XCON(NPC)=XCON(1)
      YCON(NPC)=YCON(1)
      WRITE(DOUT,480)
  480 FORMAT(/,1X,'***WARNING***CONTOUR SPECIFIED AS CLOSED WAS FOUND TO
     & BE OPEN.',/,14X,'ADDED FINAL POINT IS ASSUMED TO BE THE SAME AS T
     &HE INITIAL POINT.')
      GO TO 530
  490 XCON(NPC)=XCON(1)
      YCON(NPC)=YCON(1)
      WRITE(DOUT,500)
  500 FORMAT(/,1X,'***WARNING***CONTOUR SPECIFIED AS CLOSED WAS FOUND TO
     & BE OPEN.',/,14X,'ADDED FINAL POINT IS ASSUMED TO BE THE SAME AS T
     &HE INITIAL POINT',//,1X,'***WARNING***MAXIMUM NUMBER OF CONTOUR PO
     &INTS EXCEEDED IN THE CLOSING OPERATION.',/,14X,'FINAL POINT IS REP
     &LACED BY THE INITIAL POINT.')
      GO TO 530
  510 WRITE(DOUT,520)
  520 FORMAT(/,1X,'***WARNING***CONTOUR SPECIFIED AS OPEN WAS FOUND TO B
     &E CLOSED')
  530 CONTINUE
C***WRITE THE EDITED NUMBER OF CONTOUR POINTS TO THE DIAGNOSTIC OUTPUT
C***FILE.
      WRITE(DOUT,531) IDC(J),NPC
  531 FORMAT(/,1X,'MODIFIED NUMBER OF POINTS FOR CONTOUR ID',I5,1X,'=',
     &I5)
C***WRITE THE EDITED CONTOUR POINT COORDINATES TO THE DIAGNOSTIC OUTPUT
C***FILE.
      WRITE(DOUT,532) IDC(J)
  532 FORMAT(/,1X,'X-Y COORDINATES(EDITED) FOR CONTOUR ID',I5,/)
      WRITE(DOUT,450) (XCON(K),YCON(K),K=1,NPC)
```

```
C***
C***
C   CALCULATE THE AREA AND CENTER OF MASS FOR THE INPUT CONTOUR.
C***
C***
      CALL ARCM(XCON,YCON,AR,XC,YC,NPC)
      AREA=ABS(AR)
C***DETERMINE WHETHER THE CALCULATED AREA OF THE CONTOUR IS EFFECTIVELY
C***ZERO. IF SO, WRITE AN ERROR MESSAGE AND DISCONTINUE PROCESSING THE
C***CONTOUR.
      IF(AREA.GT.1.0E-15) GO TO 550
      WRITE(*,365) IDC(J)
      WRITE(DOUT,540)
  540 FORMAT(/,1X,'AREA FOUND TO BE EFFECTIVELY ZERO--CONTOUR REJECTED')
      GO TO 320
  550 CONTINUE
C***CALCULATE THE MAXIMUM RADIUS OF GYRATION AND THE ASSOCIATED MINOR
C***AXIS ORIENTATION FOR THE CONTOUR.
      CALL SMOMNT(XCON,YCON,AR,NSLOPE,SN,CN,ANGLE,NPC,
     &XC,YC,RG,RGRAT,ORENT,ISMFLG)
C***DETERMINE WHETHER A REAL VALUE FOR THE RADIUS OF GYRATION HAS BEEN
C***CALCULATED FOR THE CONTOUR. IF NOT, WRITE AN ERROR MESSAGE AND
C***DISCONTINUE PROCESSING THE CONTOUR.
      IF(ISMFLG.EQ.0) GO TO 555
      WRITE(*,365) IDC(J)
      WRITE(DOUT,551)
  551 FORMAT(/,1X,'CONTOUR REJECTED--A REAL VALUE FOR THE RADIUS OF GYRA
     &TION COULD NOT BE',/,1X,'COMPUTED. THIS CAN OCCUR IF THE CONTOUR I
     &S VERY TORTUOUS AND TOO FEW POINTS WERE',/,1X,' USED IN ITS DIGITI
     &ZATION OR IF A VERY TORTUOUS CONTOUR HAS BEEN INPUT AS',/,1X,'INCO
     &MPLETE EVEN IF A SUFFICIENT NUMBER OF POINTS HAVE BEEN USED IN THE
     &',/,1X,'DIGITIZATION PROCESS.',//,1X,'SOLUTION--MANUALLY COMPLETE 
     &AND/OR REDIGITIZE THE CONTOUR')
      GO TO 320
  555 CONTINUE
      XCM(J)=XC
      YCM(J)=YC
C***WRITE THE CALCULATED CONTOUR AREA AND CENTROID COORDINATES TO THE
C***DIAGNOSTIC OUTPUT FILE.
      WRITE(DOUT,560) AREA,XCM(J),YCM(J)
  560 FORMAT(/,1X,'CONTOUR AREA=',E12.4,/,
     &1X,'X-COORDINATE OF CONTOUR CENTROID=',E12.4,/,
     &1X,'Y-COORDINATE OF CONTOUR CENTROID=',E12.4)
C***EDIT CHECKS HAVE BEEN COMPLETED. CONTOUR HAS BEEN ACCEPTED FOR
C***PROCESSING.
C***
C***
C     IF A PLOT HAS BEEN REQUESTED, WRITE THE CONTOUR COORDINATES(BOTH
C     UNEDITED AND EDITED) TO THE SCRATCH FILE "PSCRAT" AND UPDATE THE
C     PLOT BOUNDARIES TO REFLECT THE BOUNDARIES OF THE NEWLY INPUT
C     CONTOUR.
C***
C***
      IF(PFLAG.EQ.0) GO TO 575
      WRITE(UPSCR,570) NPCSV,HCON(J)
  570 FORMAT(I10,E15.4)
      DO 572 K=1,NPCSV
      WRITE(UPSCR,571) XCONSV(K),YCONSV(K)
  571 FORMAT(2E15.4)
      IF(XCONSV(K).GT.XMAX1) XMAX1=XCONSV(K)
```

```
      IF(XCONSV(K).LT.XMIN1) XMIN1=XCONSV(K)
      IF(YCONSV(K).GT.YMAX1) YMAX1=YCONSV(K)
      IF(YCONSV(K).LT.YMIN1) YMIN1=YCONSV(K)
  572 CONTINUE
      WRITE(UPSCR,570) NPC,HCON(J)
      DO 574 K=1,NPC
      WRITE(UPSCR,571) XCON(K),YCON(K)
      IF(XCON(K).GT.XMAX2) XMAX2=XCON(K)
      IF(XCON(K).LT.XMIN2) XMIN2=XCON(K)
      IF(YCON(K).GT.YMAX2) YMAX2=YCON(K)
      IF(YCON(K).LT.YMIN2) YMIN2=YCON(K)
  574 CONTINUE
  575 CONTINUE
C***
C***
C   COMPUTE THE PARAMETERS FOR THE ELLIPTICAL REPRESENTATION OF THE
C   CONTOUR.
C***
C***
      OREN(J)=ORENT
C***CALCULATE THE SEMI-MAJOR AXIS LENGTH FOR THE EQUIVALENT ELLIPSE
C***USING THE RELATIONSHIP, FOR AN ACTUAL ELLIPSE, BETWEEN THE
C***SEMI-MAJOR AXIS LENGTH AND THE RADIUS OF GYRATION ABOUT AN AXIS
C***WHICH COINCIDES WITH THE SEMI-MINOR AXIS OF THE ELLIPSE.
      A(J)=2.*RG
C***CALCULATE THE SEMI-MINOR AXIS LENGTH FOR THE EQUIVALENT ELLIPSE
C***USING THE FORMULA FOR THE AREA OF AN ELLIPSE AND THE PREVIOUSLY
C***DETERMINED VALUE FOR THE SEMI-MAJOR AXIS LENGTH.
      B(J)=AREA/(PI*A(J))
C***DETERMINE WHETHER THE CONTOUR SHOULD BE CONSIDERED CIRCULAR
C***FIRST TEST FOR CIRCULAR CONTOUR--CALCULATED SEMI-MINOR AXIS
C***LENGTH GREATER THAN OR EQUAL TO SEMI-MAJOR AXIS LENGTH.
      IF(A(J).GT.B(J)) GO TO 590
      WRITE(DOUT,580)
  580 FORMAT(/,1X,'CALCULATED ELLIPSE SEMI-MINOR AXIS LENGTH WAS FOUND',
     &' TO BE GREATER THAN',/,1X,'OR EQUAL TO THE CALCULATED SEMI-MAJOR'
     &,' AXIS LENGTH--CONTOUR ASSUMED TO BE CIRCULAR')
      GO TO 610
C***SECOND TEST FOR CIRCULAR CONTOUR--DETERMINE WHETHER THE RELATIVE
C***DIFFERENCE BETWEEN THE MAXIMUM AND MINIMUM RADII OF GYRATION FOR
C***THE CONTOUR IS LESS THAN 1 PERCENT.
  590 IF(RGRAT.GT.0.01) GO TO 620
      WRITE(DOUT,600)
  600 FORMAT(/,1X,'THE RELATIVE DIFFERENCE BETWEEN THE MAXIMUM AND',
     &' MINIMUM RADII OF GYRATION',/,1X,'FOR THE CONTOUR IS LESS THAN',
     &' 1 PERCENT--CONTOUR ASSUMED TO BE CIRCULAR')
C***SET BOTH THE SEMI-MAJOR AND SEMI-MINOR AXIS LENGTHS EQUAL TO THE
C***RADIUS OF A CIRCLE WITH AREA EQUAL TO AREA.
  610 RAD=SQRT(AREA/PI)
C***THE ECCENTRICITY OF A CIRCLE IS ZERO.
      ECC(J)=0.
      A(J)=RAD
      B(J)=RAD
      GO TO 630
C***CALCULATE THE ECCENTRICITY OF THE ELLIPSE REPRESENTING THE CONTOUR.
  620 ECC(J)=SQRT(A(J)**2-B(J)**2)/A(J)
C***WRITE ELLIPSE FIT PARAMETERS TO THE DIAGNOSTIC OUTPUT FILE.
  630 WRITE(DOUT,640) IDC(J)
  640 FORMAT(/,1X,'ELLIPSE PARAMETERS FOR CONTOUR ID',I5,/)
      WRITE(DOUT,650) A(J),B(J),ECC(J),OREN(J)
```

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  650 FORMAT(1X,'SEMI-MAJOR AXIS LENGTH=',E12.4,/,
     &1X,'SEMI-MINOR AXIS LENGTH=',E12.4,/,
     &1X,'ELLIPSE ECCENTRICITY=',E12.4,/,
     &1X,'ORIENTATION OF SEMI-MINOR AXIS WITH RESPECT TO THE',
     &/,1X,'POSITIVE X-AXIS=',F6.2,1X,'DEGREES')
C***UPDATE THE CONTOUR COUNTER AND READ DATA FOR A NEW CONTOUR FROM THE
C***MASTER FILE.
      WRITE(*,660) IDC(J)
  660 FORMAT(/,1X,'Contour ID ',I4,1X,'has been accepted')
      J=J+1
      GO TO 320
  670 WRITE(DOUT,260)
C***END OF CONTOUR MASTER FILE REACHED
  700 NC=J-1
C***CLOSE THE MASTER FILE.
      CLOSE(IN,STATUS='KEEP')
C***IF THE CONTOUR ID NUMBERS(FOR CONTOUR SELECTION FROM THE MASTER
C***FILE) WERE INPUT FROM CONFILE, CHECK WHETHER THE NUMBER OF CONTOURS
C***REQUESTED MATCHES THE NUMBER ACTUALLY SELECTED FROM THE MASTER FILE.
C***IF NOT, WRITE A WARNING MESSAGE TO THE DIAGNOSTIC OUTPUT FILE.
      IF(ICMODE.EQ.3.AND.NC.NE.NCID) WRITE(DOUT,710)
  710 FORMAT(/,1X,'***WARNING***NUMBER OF CONTOURS SELECTED FROM THE',
     &' MASTER FILE DOES NOT',/,14X,'MATCH THE NUMBER REQUESTED')
C***CHECK WHETHER ANY CONTOURS HAVE BEEN SELECTED FROM THE MASTER FILE.
C***IF NOT, WRITE AN ERROR MESSAGE BOTH TO THE DIAGNOSTIC OUTPUT FILE
C***AND THE SCREEN AND THEN EXIT THE PROGRAM.
      IF(NC.EQ.0) GO TO 1010
C***
C***
C***WRITE THE OUTPUT FILES FOR SUBSEQUENT PROCESSING BY THE PLOT PROGRAM
C***AND THE CRITICAL HEIGHT ANALYSIS PROGRAM(HCRIT).
C***
C***
C***SORT THE ID NUMBERS FOR THE CONTOURS WHICH WERE FINALLY SELECTED.
      CALL ISORT(IDC,NC,LPTR)
C***CHECK WHETHER PLOT HAS BEEN REQUESTED. IF SO, WRITE TO THE PLOT
C***FILE THE INFORMATION NECESSARY TO SUBSEQUENTLY PLOT THE INPUT
C***DIGITIZED CONTOURS.
      IF(PFLAG.EQ.0) GO TO 770
C***REWIND THE SCRATCH FILE.
      REWIND UPSCR
C***WRITE THE NUMBER OF CONTOURS TO THE PLOT FILE.
      WRITE(UPL,720) NC
  720 FORMAT(I10)
C***WRITE THE SORTED CONTOUR ID NUMBERS TO THE PLOT FILE.
C***NOTE: THE CONTOUR IDs ARE SORTED ONLY FOR SUBSEQUENT ID CHECKS IN
C***THE PLOT PROGRAM. THE DIGITIZED CONTOURS INPUT TO THE PLOT PROGRAM
C***DO NOT HAVE TO BE SORTED.
      WRITE(UPL,730) (IDC(J),J=1,NC)
  730 FORMAT(I10)
C***WRITE THE PLOT BOUNDARY LIMITS FOR BOTH UNEDITED AND EDITED
C***CONTOURS TO THE PLOT FILE.
      WRITE(UPL,740) XMIN1,XMAX1,YMIN1,YMAX1
  740 FORMAT(4E15.4)
      WRITE(UPL,740) XMIN2,XMAX2,YMIN2,YMAX2
C***TRANSFER THE DIGITIZED CONTOUR COORDINATES FROM THE SCRATCH FILE
C***TO THE PLOT FILE.
      NCT2=2*NC
      DO 760 J=1,NCT2
      READ(UPSCR,570) NPC,HCONT
```

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      WRITE(UPL,570) NPC,HCONT
      DO 750 K=1,NPC
      READ(UPSCR,571) XCON(K),YCON(K)
      WRITE(UPL,571) XCON(K),YCON(K)
  750 CONTINUE
  760 CONTINUE
C***CLOSE AND DELETE THE SCRATCH FILE.
      CLOSE(UPSCR,STATUS='DELETE')
C***OPEN THE OUTPUT FILE FOR THE CRITICAL HEIGHT ANALYSIS PROGRAM.
  770 CONTINUE
  775 WRITE(*,780)
  780 FORMAT(/,1X,'ENTER FILE NAME FOR FITTED CONTOUR OUTPUT -> '\)
      READ(*,'(A)') COUTFILE
      IF(COUTFILE.EQ.' ') GO TO 775
      OPEN(COUT,FILE=COUTFILE,STATUS='NEW')
C***WRITE THE HILL ID NUMBER AND NAME TO THE FITTED CONTOUR OUTPUT
C***FILE.
      WRITE(COUT,312) IDHILL,HNAME
C***WRITE THE ACTUAL HILL TOP ELEVATION TO THE FITTED CONTOUR OUTPUT
C***FILE.
      WRITE(COUT,790) HTOP
  790 FORMAT(E15.4)
C***WRITE THE NUMBER OF CONTOURS TO THE FITTED CONTOUR OUTPUT FILE.
      WRITE(COUT,720) NC
C***WRITE THE SORTED CONTOUR IDs TO THE FITTED CONTOUR OUTPUT FILE.
C***NOTE: CONTOUR IDs ARE SORTED ONLY FOR SUBSEQUENT ID CHECKS IN
C***THE PLOT PROGRAM. FITTED CONTOUR PARAMETERS DO NOT HAVE TO BE
C***SORTED FOR INPUT TO THE CRITICAL HEIGHT ANALYSIS PROGRAM.
      WRITE(COUT,730) (IDC(J),J=1,NC)
C***WRITE THE CONTOUR FIT PARAMETERS TO THE FITTED CONTOUR OUTPUT
C***FILE.
      DO 810 J=1,NC
      WRITE(COUT,800) HCON(J),XCM(J),YCM(J),A(J),B(J),ECC(J),OREN(J)
  800 FORMAT(7E15.4)
  810 CONTINUE
      IF(PFLAG.EQ.0) GO TO 840
C***WRITE THE CONTOUR FIT PARAMETERS TO THE PLOT FILE.
      DO 830 J=1,NC
      WRITE(UPL,820) XCM(J),YCM(J),A(J),B(J),OREN(J)
  820 FORMAT(5E15.4)
  830 CONTINUE
  840 CONTINUE
C***ANALYSIS COMPLETED--EXIT PROGRAM.
      GO TO 2000
 1000 WRITE(DOUT,1005)
 1005 FORMAT(/,1X,'***ERROR***  NO CONTOURS WERE REQUESTED--EXIT PROGRAM
     &')
      WRITE(*,1005)
      GO TO 2000
 1010 WRITE(DOUT,1015)
 1015 FORMAT(/,1X,'***ERROR***  NO CONTOURS SELECTED FROM MASTER FILE--E
     &XIT PROGRAM')
      WRITE(*,1015)
C***DELETE SCRATCH FILE AND PLOT FILE.
      CLOSE(UPSCR,STATUS='DELETE')
      CLOSE(UPL,STATUS='DELETE')
 2000 CONTINUE
      STOP
      END
```

```
      SUBROUTINE ARCM(XCON,YCON,AR,XC,YC,NPC)
C***SUBROUTINE TO CALCULATE THE AREA AND CENTROID X-Y COORDINATES
C***FOR AN INPUT CONTOUR
      DIMENSION XCON(1),YCON(1)
      AR=0.
      XC=0.
      YC=0.
      NPCM1=NPC-1
      DO 100 K=1,NPCM1
      AR=AR+(YCON(K+1)+YCON(K))*(XCON(K+1)-XCON(K))/2.
      XC=XC+0.5*(XCON(K+1)*YCON(K)-XCON(K)*YCON(K+1))*
     &(XCON(K+1)+XCON(K))+(YCON(K+1)-YCON(K))*
     &(XCON(K+1)**2+XCON(K)*XCON(K+1)+XCON(K)**2)/3.
      YC=YC+0.5*(YCON(K+1)*XCON(K)-YCON(K)*XCON(K+1))*
     &(YCON(K+1)+YCON(K))+(XCON(K+1)-XCON(K))*
     &(YCON(K+1)**2+YCON(K)*YCON(K+1)+YCON(K)**2)/3.
  100 CONTINUE
C***CLOSE CONTOUR FOR PURPOSES OF CALCULATING THE AREA AND CENTROID.
C***THIS IS REQUIRED FOR USE OF THE SUBROUTINE BY SUBROUTINE CONCOMP,
C***THE CONTOUR COMPLETION SUBROUTINE.
      AR=AR+(YCON(1)+YCON(NPC))*(XCON(1)-XCON(NPC))/2.
      XC=XC+0.5*(XCON(1)*YCON(NPC)-XCON(NPC)*YCON(1))*
     &(XCON(1)+XCON(NPC))+(YCON(1)-YCON(NPC))*
     &(XCON(1)**2+XCON(NPC)*XCON(1)+XCON(NPC)**2)/3.
      YC=YC+0.5*(YCON(1)*XCON(NPC)-YCON(NPC)*XCON(1))*
     &(YCON(1)+YCON(NPC))+(XCON(1)-XCON(NPC))*
     &(YCON(1)**2+YCON(NPC)*YCON(1)+YCON(NPC)**2)/3.
C***CHECK FOR ZERO AREA CONTOUR
      IF(ABS(AR).LT.1.0E-15) RETURN
      XC=XC/AR
      YC=-YC/AR
      RETURN
      END
```

```
      SUBROUTINE CONCOMP(XCON,YCON,NPC,NPCMAX,XHTOP,YHTOP,AFIL,NFIL,
     &DOUT)
C***THIS SUBROUTINE COMPLETES A CONTOUR WHICH HAS BEEN INPUT FROM THE
C***CONTOUR MASTER FILE AS AN INCOMPLETE CONTOUR. THE FIRST STEP IN THIS
C***COMPLETION PROCESS IS THE ELIMINATION OF THOSE POINTS WHICH LIE IN
C***THE SAME SECTOR AS (1)AN ACTUAL CONTOUR POINT WHICH IS CLOSER TO
C***THE HILL CENTER OR (2)A SEGMENT OF A LINE CONNECTING ADJACENT POINTS
C***WHICH IS CONTAINED WITHIN THE SECTOR AND WHOSE APPROXIMATE MIDPOINT
C***IS CLOSER TO THE HILL CENTER THAN THE POINT IN QUESTION.
C***
C***
C   GLOSSARY OF TERMS
C***
C***
C   AFIL=ANGULAR WIDTH OF EACH OF THE NFIL SECTORS
C   COUNT=COUNTER USED IN THE INTERPOLATION OF DISTANCES FOR "PSEUDO-
C         POINTS"
C   DIF=NUMBER OF ANGULAR SECTORS COVERED IN MOVING FROM THE PREVIOUS
C       TO THE CURRENT CONTOUR POINT
C   DIST=DISTANCE FROM THE HILL CENTER TO THE CURRENT CONTOUR POINT
C   DISTM(ISEC)=CURRENT MINIMUM DISTANCE FROM THE HILL CENTER TO THE
C               CLOSEST CONTOUR POINT OR SEGMENT FOR THE SECTOR ISEC
C   DOLD=DISTANCE FROM THE HILL CENTER TO THE PREVIOUS CONTOUR POINT
C   DTEST=VARIABLE USED IN THE TEST FOR MINIMUM DISTANCE FOR PSEUDO-
C         POINTS
C   IR(ISEC)=CONTOUR POINT, WITHIN SECTOR ISEC, WHICH LIES CLOSEST TO
C            THE HILL CENTER
C           =0 IF NO CONTOUR POINT HAS YET BEEN JUDGED TO LIE CLOSEST
C              TO THE CENTER
C           =9999 IF A CONTOUR SEGMENT LIES CLOSER
C   IROLD=PREVIOUS VALUE FOR IR(ISEC)
C   ISEC=NUMBER OF THE ANGULAR SECTOR FOR THE CURRENT POINT
C   ISOLD=SECTOR OCCUPIED BY THE PREVIOUS CONTOUR POINT
C   ITEST=VARIABLE USED IN DETERMINING WHETHER MORE THAN ONE SECTOR
C         HAS BEEN CROSSED IN MOVING FROM THE PREVIOUS TO THE CURRENT
C         CONTOUR POINT
C   METH=CONTOUR POINT REFLECTION FLAG
C       =0(HILL CENTER USED FOR REFLECTION)
C       =1(CONTOUR CENTROID USED FOR REFLECTION)
C   NCOUNT=RUNNING TOTAL OF THE SET OF CONTOUR POINTS AFTER MODIFICATION
C          BY ANGULAR FILTRATION
C   NFIL=NUMBER OF SECTORS OF EQUAL WIDTH USED IN THE ANGULAR FILTRATION
C        PROCESS
C   NFILM=HALF THE NUMBER OF TOTAL ANGULAR SECTORS ROUNDED UP TO THE
C         NEAREST SECTOR NUMBER. USED TO DETERMINE WHICH SECTORS ARE
C         CROSSED BY A LINE CONNECTING TWO ADJACENT POINTS
C   NPC=INITIAL AND THEN THE FINAL NUMBER OF CONTOUR POINTS
C   NPCO=INITIAL NUMBER OF CONTOUR POINTS
C   XCONS,YCONS=TEMPORARY CONTOUR POINT STORAGE ARRAYS USED IN THE
C               ELIMINATION OF POINTS BY ANGULAR FILTERING
C   XHTOP,YHTOP=X-Y COORDINATES OF THE HILL CENTER(INPUT BY THE USER
C               IN PROGRAM FITCON)
C   XREF,YREF=X-Y COORDINATES OF THE POINT TO BE USED FOR CONTOUR POINT
C             REFLECTION. THIS POINT IS THE HILL CENTER FOR METH=0 AND
C             THE CONTOUR CENTROID FOR METH=1.
C***
C***
      INTEGER DOUT
      DIMENSION XCON(1),YCON(1),XCONS(1000),YCONS(1000),DISTM(360),
     &IR(360)
C***BEFORE CARRYING OUT THE CONTOUR COMPLETION PROCESS, ELIMINATE
C***THROUGH ANGULAR FILTERING, THOSE POINTS WHICH MAY CAUSE THE CLOSED
C***CONTOUR TO BE UNREALISTIC FROM A PHYSICAL STANDPOINT.
C***ZERO OUT THE FILTERING ARRAYS.
C***FIRST, DETERMINE WHETHER ANGULAR FILTERING WILL BE REQUIRED.
      IF(NFIL.EQ.0) GO TO 45
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      DO 1 ISEC=1,NFIL
      DISTM(ISEC)=0.
      IR(ISEC)=0
    1 CONTINUE
      NCOUNT=0
      NFILM=FLOAT(NFIL)/2.+0.500001
      XP=XCON(1)
      YP=YCON(1)
C***CALCULATE THE SECTOR AND DISTANCE FROM THE HILL CENTER FOR THE FIRST
C***CONTOUR POINT.
      CALL VECTOR(XHTOP,YHTOP,XP,YP,ANGLE,DX,DY)
      ISOLD=ANGLE/AFIL
      IF(ISOLD.LT.1) ISOLD=1
      IF(ISOLD.GT.NFIL) ISOLD=NFIL
      DOLD=SQRT((XP-XHTOP)**2+(YP-YHTOP)**2)
C***CHOOSE THE CLOSEST POINT TO THE HILL CENTER LOCATION FOR EACH
C***SECTOR OF ANGULAR WIDTH AFIL.
      DO 3 K=1,NPC
      XP=XCON(K)
      YP=YCON(K)
      DIST=SQRT((XP-XHTOP)**2+(YP-YHTOP)**2)
      CALL VECTOR(XHTOP,YHTOP,XP,YP,ANGLE,DX,DY)
      ISEC=ANGLE/AFIL
      IF(ISEC.LT.1) ISEC=1
      IF(ISEC.GT.NFIL) ISEC=NFIL
C***DETERMINE WHETHER A CONTOUR POINT OR SEGMENT HAS ALREADY APPEARED IN
C***THIS ANGULAR SECTOR.
      IF(IR(ISEC).NE.0) GO TO 2
      NCOUNT=NCOUNT+1
C***ACCEPT THE POINT(XCON(K),YCON(K)) AND INITIALIZE THE ARRAYS IR AND
C***DISTM.
      XCONS(NCOUNT)=XP
      YCONS(NCOUNT)=YP
      IR(ISEC)=NCOUNT
      DISTM(ISEC)=SQRT((XP-XHTOP)**2+(YP-YHTOP)**2)
      GO TO 1000
C***DETERMINE WHETHER THE DISTANCE FROM THE HILL CENTER TO THE POINT IS
C***LESS THAN THE CURRENT MINIMUM DISTANCE FOR THIS SECTOR.
    2 CONTINUE
      IF(DIST.GE.DISTM(ISEC)) GO TO 1000
C***REINITIALIZE DISTM(ISEC) TO CORRESPOND TO THE DISTANCE FROM THE
C***HILL CENTER FOR THE CONTOUR POINT IN QUESTION.
      DISTM(ISEC)=DIST
C***TEMPORARILY SAVE THE PREVIOUS VALUE OF IR(SEC).
      IROLD=IR(ISEC)
      IF(IROLD.EQ.9999) GO TO 201
C***FLAG THE X-COORDINATE OF THE PREVIOUSLY CLOSEST CONTOUR POINT
C***(IROLD) FOR LATER ELIMINATION OF THE POINT.
      XCONS(IROLD)=1.0E+15
  201 NCOUNT=NCOUNT+1
C***REINITIALIZE THE IR ARRAY TO CORRESPOND TO THE NUMBER OF THE CONTOUR
C***POINT IN QUESTION.
      IR(ISEC)=NCOUNT
C***ACCEPT THE CONTOUR POINT NCOUNT.
      XCONS(NCOUNT)=XP
      YCONS(NCOUNT)=YP
C***HANDLE SECTORS BETWEEN THOSE SECTORS OCCUPIED BY THE CURRENT AND
C***PREVIOUS CONTOUR POINTS.
C***DETERMINE HOW MANY SECTORS HAVE BEEN CROSSED. IF MORE THAN ONE HAS
C***BEEN CROSSED, THEN DEAL WITH "PSEUDOPOINTS" WHICH OCCUPY SECTORS
C***BETWEEN THE CURRENT AND PREVIOUS CONTOUR POINTS.
 1000 ITEST=IABS(ISEC-ISOLD)
C***DETERMINE WHETHER MORE THAN ONE SECTOR HAS BEEN CROSSED.
      IF(ITEST.LE.1.OR.ITEST.EQ.NFIL-1) GO TO 1400
C***FOUR CASES:
C***(1) ISEC>ISOLD; ISEC-ISOLD>=NFILM
```

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C***(2) ISEC>ISOLD; ISEC-ISOLD<NFILM
C***(3) ISOLD>ISEC; ISOLD-ISEC>=NFILM
C***(4) ISOLD>ISEC; ISOLD-ISEC<NFILM
      IF(ISEC.GT.ISOLD) GO TO 1200
      IF((ISOLD-ISEC).GE.NFILM) GO TO 1100
      DIF=FLOAT(ISOLD-ISEC)
      COUNT=1.
C***CASE #4
      DO 1010 I=ISOLD-1,ISEC+1,-1
C***ESTIMATE THE DISTANCE, DTEST, TO THE PSEUDOPOINT BY SIMPLE INTER-
C***POLATION WITH RESPECT TO THE SECTOR NUMBER.
      DTEST=DOLD+(COUNT/DIF)*(DIST-DOLD)
      IF(DTEST.GT.DISTM(I).AND.IR(I).NE.0) GO TO 1010
      IF(IR(I).EQ.0) GO TO 1001
C***IF THE PREVIOUSLY CLOSEST POINT WAS AN ACTUAL CONTOUR POINT RATHER
C***THAN A "PSEUDOPOINT", THEN FLAG THE PREVIOUSLY CLOSEST POINT FOR
C***LATER REMOVAL.
      IF(IR(I).EQ.9999) GO TO 1002
      IROLD=IR(I)
      XCONS(IROLD)=1.0E+15
C***THE VALUE "9999" FOR IR(I) INDICATES THAT THE CLOSEST CONTOUR POINT
C***FOR SECTOR I IS A "PSEUDOPOINT".
 1001 IR(I)=9999
C***ESTIMATE THE DISTANCE, DISTM(I), TO THE PSEUDOPOINT BY SIMPLE INTER-
C***POLATION WITH RESPECT TO THE SECTOR NUMBER.
 1002 DISTM(I)=DTEST
      COUNT=COUNT+1.
 1010 CONTINUE
      GO TO 1400
C***CASE #3
 1100 DIF=FLOAT(NFIL-(ISOLD-ISEC))
      COUNT=1.
C***LOOP MUST BE BROKEN INTO 2 PARTS.
C***PART ONE
      DO 1150 I=ISOLD+1,NFIL,1
      DTEST=DOLD+(COUNT/DIF)*(DIST-DOLD)
      IF(DTEST.GT.DISTM(I).AND.IR(I).NE.0) GO TO 1150
      IF(IR(I).EQ.0) GO TO 1111
      IF(IR(I).EQ.9999) GO TO 1112
      IROLD=IR(I)
      XCONS(IROLD)=1.0E+15
 1111 IR(I)=9999
 1112 DISTM(I)=DTEST
      COUNT=COUNT+1.
 1150 CONTINUE
C***PART TWO
      DO 1160 I=1,ISEC-1,1
      DTEST=DOLD+(COUNT/DIF)*(DIST-DOLD)
      IF(DTEST.GT.DISTM(I).AND.IR(I).NE.0) GO TO 1160
      IF(IR(I).EQ.0) GO TO 1151
      IF(IR(I).EQ.9999) GO TO 1152
      IROLD=IR(I)
      XCONS(IROLD)=1.0E+15
 1151 IR(I)=9999
 1152 DISTM(I)=DTEST
      COUNT=COUNT+1.
 1160 CONTINUE
      GO TO 1400
 1200 IF((ISEC-ISOLD).GE.NFILM) GO TO 1300
C***CASE #2
      DIF=FLOAT(ISEC-ISOLD)
      COUNT=1.
      DO 1210 I=ISOLD+1,ISEC-1,1
      DTEST=DOLD+(COUNT/DIF)*(DIST-DOLD)
      IF(DTEST.GT.DISTM(I).AND.IR(I).NE.0) GO TO 1210
      IF(IR(I).EQ.0) GO TO 1201
```

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      IF(IR(I).EQ.9999) GO TO 1202
      IROLD=IR(I)
      XCONS(IROLD)=1.0E+15
 1201 IR(I)=9999
 1202 DISTM(I)=DTEST
      COUNT=COUNT+1.
 1210 CONTINUE
      GO TO 1400
C***CASE #1
 1300 DIF=FLOAT(NFIL-(ISEC-ISOLD))
      COUNT=1.
C***LOOP MUST BE BROKEN INTO 2 PARTS.
C***PART ONE
      DO 1350 I=ISOLD-1,1,-1
      DTEST=DOLD+(COUNT/DIF)*(DIST-DOLD)
      IF(DTEST.GT.DISTM(I).AND.IR(I).NE.0) GO TO 1350
      IF(IR(I).EQ.0) GO TO 1311
      IF(IR(I).EQ.9999) GO TO 1312
      IROLD=IR(I)
      XCONS(IROLD)=1.0E+15
 1311 IR(I)=9999
 1312 DISTM(I)=DTEST
      COUNT=COUNT+1.
 1350 CONTINUE
C***PART TWO
      DO 1360 I=NFIL,ISEC+1,-1
      DTEST=DOLD+(COUNT/DIF)*(DIST-DOLD)
      IF(DTEST.GT.DISTM(I).AND.IR(I).NE.0) GO TO 1360
      IF(IR(I).EQ.0) GO TO 1351
      IF(IR(I).EQ.9999) GO TO 1352
      IROLD=IR(I)
      XCONS(IROLD)=1.0E+15
 1351 IR(I)=9999
 1352 DISTM(I)=DTEST
      COUNT=COUNT+1.
 1360 CONTINUE
C***SAVE THE SECTOR NUMBER AND DISTANCE FOR COMPARISON WITH THE NEXT
C***POINT.
 1400 ISOLD=ISEC
      DOLD=DIST
    3 CONTINUE
      NPC=1
      DO 4 K=1,NCOUNT
      IF(XCONS(K).GT.1.0E+14) GO TO 4
      XCON(NPC)=XCONS(K)
      YCON(NPC)=YCONS(K)
      NPC=NPC+1
    4 CONTINUE
      NPC=NPC-1
   45 CONTINUE
C***CALL SUBROUTINE ARCM TO DETERMINE THE AREA OF THE INCOMPLETE
C***CONTOUR. IF THE AREA IS NEGATIVE, THEN THE CONTOUR POINTS HAVE
C***BEEN INPUT IN A COUNTERCLOCKWISE SENSE. IF THE AREA IS POSITIVE,
C***THEN THE CONTOUR POINTS HAVE BEEN INPUT IN A CLOCKWISE SENSE.
C***THIS INFORMATION IS REQUIRED BY THE CONTOUR COMPLETION ALGORITHM.
C***THE X AND Y COORDINATES OF THE INCOMPLETE CONTOUR CENTER OF
C***MASS(XCM,YCM) ARE NOT USED BY THE CONTOUR COMPLETION ALGORITHM.
C***FIRST ADD THE POINT (XHTOP,YHTOP) TO THE CONTOUR ONLY FOR THE
C***PURPOSE OF THIS DIRECTION DETERMINATION.
      METH=0
      XREF=XHTOP
      YREF=YHTOP
      NPCP1=NPC+1
C***CHECK WHETHER CONTOUR COMPLETION WILL CAUSE THE NUMBER OF CONTOUR
C***POINTS TO EXCEED THE MAXIMUM. IF SO, SET THE COORDINATES OF THE
C***FINAL POINT EQUAL TO THOSE OF THE INITIAL POINT AND PRINT A WARNING
```

```
C***MESSAGE.
      IF(NPCP1.LT.NPCMAX) GO TO 5
      XCON(NPC)=XCON(1)
      YCON(NPC)=YCON(1)
      WRITE(DOUT,20) NPCMAX
      RETURN
    5 XCON(NPCP1)=XHTOP
      YCON(NPCP1)=YHTOP
      CALL ARCM(XCON,YCON,AREA,XCM,YCM,NPCP1)
    6 XP=XCON(1)
      YP=YCON(1)
C***FIND THE HEADING AND X,Y COMPONENTS OF THE VECTOR FROM THE HILL
C***TOP X,Y POINT TO THE FIRST CONTOUR POINT.
      CALL VECTOR(XREF,YREF,XP,YP,ANGLE,DX,DY)
      IF(AREA.LT.0.) ANG2=ANGLE
      IF(AREA.GE.0.) ANG1=ANGLE
      XP=XCON(NPC)
      YP=YCON(NPC)
C***FIND THE HEADING AND X,Y COMPONENTS OF THE VECTOR FROM THE HILL
C***TOP X,Y POINT TO THE LAST CONTOUR POINT.
      CALL VECTOR(XREF,YREF,XP,YP,ANGLE,DX,DY)
      IF(AREA.LT.0.) ANG1=ANGLE
      IF(AREA.GE.0.) ANG2=ANGLE
      IF(METH.EQ.1) GO TO 7
      ADIF=ANG2-ANG1
      IF(ADIF.LT.0.) ADIF=360.+ADIF
C***IF THE ANGULAR DIFFERENCE BETWEEN THE VECTORS IS LESS THAN
C***90 DEGREES, USE THE CENTROID OF THE CONTOUR FOR THE REFLECTION
C***POINT INSTEAD OF THE HILL CENTER.
      IF(ADIF.GT.90.) GO TO 7
      CALL ARCM(XCON,YCON,AREA,XCM,YCM,NPC)
      XREF=XCM
      YREF=YCM
      METH=1
      GO TO 6
    7 CONTINUE
C***SAVE THE NUMBER OF ORIGINAL CONTOUR POINTS.
      NPCO=NPC
C***IN THE CASE OF POSITIVE(NEGATIVE) CONTOUR AREA, DETERMINE, FOR EACH
C***CONTOUR POINT, WHETHER THE HEADING OF THE VECTOR FROM THE CONTOUR
C***POINT TO THE HILL TOP X,Y POINT LIES BETWEEN THE HEADINGS OF THE
C***VECTORS FROM THE HILL TOP X,Y POINT TO THE FIRST(LAST) CONTOUR POINT
C***AND FROM THE HILL TOP X,Y POINT TO THE LAST(FIRST) CONTOUR POINT.
C***IF THIS IS SO, THEN ASSIGN AN ADDITIONAL CONTOUR POINT AT THE
C***TERMINATION OF THE VECTOR HAVING A HEADING EQUAL TO THAT OF THE
C***VECTOR FROM THE ORIGINAL CONTOUR POINT TO THE HILL TOP X,Y POINT
C***AND HAVING A LENGTH EQUAL TO TWICE THE LENGTH OF THIS VECTOR. IF
C***THE ADDITION OF A CONTOUR POINT WOULD CAUSE THE MAXIMUM NUMBER OF
C***CONTOUR POINTS TO BE EQUALED, THEN THE COORDINATES OF THIS CONTOUR
C***POINT ARE SET EQUAL TO THE COORDINATES OF THE FIRST CONTOUR POINT
C***AND THE CONTOUR COMPLETION PROCESS IS HALTED.
      DO 100 K=1,NPCO
      XP=XCON(K)
      YP=YCON(K)
      CALL VECTOR(XP,YP,XREF,YREF,ANGLE,DX,DY)
      IF(ANG1.GT.ANG2) GO TO 40
      IF(ANGLE.GT.ANG1.AND.ANGLE.LT.ANG2) GO TO 10
      GO TO 100
   10 NPC=NPC+1
      IF(NPC.LT.NPCMAX) GO TO 30
      XCON(NPC)=XCON(1)
      YCON(NPC)=YCON(1)
      WRITE(DOUT,20) NPCMAX
   20 FORMAT(/,1X,'***WARNING***CONTOUR COMPLETION HALTED DUE TO EXCEEDA
     &NCE OF',/,1X,'MAXIMUM NUMBER(',I3,1X,') OF CONTOUR POINTS',/,
     &1X,'THE FINAL CONTOUR POINT WILL HAVE COORDINATES EQUAL TO THOSE O
```

```
     &F THE INITIAL POINT')
      RETURN
   30 XCON(NPC)=XREF+DX
      YCON(NPC)=YREF+DY
      GO TO 100
   40 IF(ANGLE.LT.ANG1.AND.ANGLE.GT.ANG2) GO TO 100
      NPC=NPC+1
      IF(NPC.LT.NPCMAX) GO TO 50
      XCON(NPC)=XCON(1)
      YCON(NPC)=YCON(1)
      WRITE(DOUT,20) NPCMAX
      RETURN
   50 XCON(NPC)=XREF+DX
      YCON(NPC)=YREF+DY
  100 CONTINUE
C***CLOSE OUT THE CONTOUR BY ADDING A FINAL POINT WITH COORDINATES
C***EQUAL TO THOSE OF THE INITIAL POINT.
      NPC=NPC+1
      XCON(NPC)=XCON(1)
      YCON(NPC)=YCON(1)
      RETURN
      END
```

```
      SUBROUTINE ISORT(LIST,NDL,LPTR)
C***MERGE EXCHANGE SORT
C***NUMBER OF COMPARISONS=N*LOG(N)/LOG(2)
C***LIST=ARRAY TO BE SORTED
C***NDL=NUMBER OF ARRAY ELEMENTS TO BE SORTED
C***LPTR=WORKING ARRAY
      DIMENSION LIST(1),LPTR(1)
C***CHECK INITIAL ORDER
      IF(NDL.LE.1) RETURN
      DO 10 I=2,NDL
         IF(LIST(I-1).GT.LIST(I)) GO TO 20
   10    CONTINUE
      RETURN
C***BEGIN SORT
   20 L2I=1
      DO 100 I=1,20
         M=1
         L2IH=L2I
         L2I=2*L2I
         IF(L2IH.GT.NDL) GO TO 110
         JUP=NDL/L2I+1
         DO 90 J=1,JUP
            N=M+L2IH
            IF(N.GT.NDL) GO TO 90
            KLO=M
            KUP=MIN0(KLO+L2I-1,NDL)
            MUP=KLO+L2IH-1
            DO 60 K=KLO,KUP
               IF(N.GT.NDL) GO TO 30
               IF(N.GT.KUP) GO TO 30
               IF(M.GT.MUP) GO TO 40
               IF(LIST(M).GT.LIST(N)) GO TO 40
   30          NL=M
               M=M+1
               GO TO 50
   40          NL=N
               N=N+1
   50          LPTR(K)=LIST(NL)
   60          CONTINUE
   70       DO 80 K=KLO,KUP
               LIST(K)=LPTR(K)
   80          CONTINUE
               M=KLO+L2I
   90          CONTINUE
  100       CONTINUE
  110    RETURN
         END
```

```
      SUBROUTINE MULTC(XCON,YCON,NPC,NPCMAX,MCFLAG)
C***THIS SUBROUTINE DETERMINES WHETHER A CONTOUR IS REALLY A SERIES
C***OF MULTIPLE CONTOURS. IF THIS IS FOUND TO BE THE CASE, THEN THE
C***CONTOUR POINT NUMBERING SCHEME IS MODIFIED TO SHOW A SERIES OF
C***CONTOURS CONNECTED TO THE FIRST CONTOUR IN THE SERIES BY INFINITELY
C***THIN STRIPS FOR THE PURPOSE OF CALCULATING THE AREA, CONTROID
C***COORDINATES, AND SECOND MOMENTS OF THE COMPONENT CONTOURS TAKEN
C***AS A GROUP.
C***
C***
C   GLOSSARY OF TERMS
C***
C***
C   ISO=SIGN(+ OR -) OF THE AREA OF THE FIRST COMPONENT CONTOUR
C   ISN=SIGN(+ OR -) OF THE AREA OF THE Nth COMPONENT CONTOUR(NOT
C       INCLUDING THE FIRST COMPONENT CONTOUR)
C   K=COUNTER FOR THE INPUT SET OF CONTOUR POINTS
C   KCOUNT=COUNTER FOR THE FINAL SET OF CONTOUR POINTS
C   KFIN(N)=ENDING VALUE OF KCOUNT FOR THE Nth COMPONENT CONTOUR
C           (NOT COUNTING THE FIRST COMPONENT CONTOUR)
C   KSTART(N)=STARTING VALUE OF KCOUNT FOR THE Nth COMPONENT CONTOUR
C             (NOT COUNTING THE FIRST COMPONENT CONTOUR)
C   MCFLAG=SUBROUTINE COMPLETION CODE
C         =0(MAXIMUM NUMBER OF POINTS EXCEEDED IN THE CONTOUR POINT
C            REASSIGNMENT PROCESS--CONTOUR REJECTED)
C         =1(THE LAST IN A SERIES OF MULTIPLE CONTOURS WAS FOUND
C            NOT TO BE CLOSED--CONTOUR REJECTED)
C         =2(CONTOUR WAS FOUND TO BE A SINGLE CONTOUR(I.E. NO CONTOUR
C            CLOSURE WAS FOUND BEFORE THE FINAL CONTOUR POINT))
C         =3(POINT REASSIGNMENT FOR THE MULTIPLE CONTOUR WAS
C            SUCCESSFULLY COMPLETED)
C         =4(ALL COMPONENT CONTOURS NOT INPUT WITH POINTS IN THE SAME
C            ORDER. THE ORDER OF POINT INPUT FOR THE COMPONENT CONTOURS
C            HAS BEEN MADE THE SAME AS THE FIRST COMPONENT CONTOUR.
C            FOLLOWING THIS ACTION, THE POINT REASSIGNMENT FOR THE
C            MULTIPLE CONTOUR WAS SUCCESSFULLY COMPLETED.)
C   NCON=NUMBER OF COMPONENT CONTOURS NOT INCLUDING THE FIRST
C        (INCREMENTED DURING THE COURSE OF THE ANALYSIS)
C   NN=POINT COUNTER(1 TO (KFIN(N)-KSTART(N))+1) WITHIN COMPONENT
C      CONTOUR N
C   XCON=ARRAY CONTAINING X COORDINATES OF THE INITIAL AND FINAL SET
C        OF CONTOUR POINTS
C   YCON=ARRAY CONTAINING Y COORDINATES OF THE INITIAL AND FINAL SET
C        OF CONTOUR POINTS
C   XCONS,YCONS=WORKING ARRAYS FOR CONTOUR POINT REASSIGNMENT
C***
C***
      DIMENSION XCON(1000),YCON(1000),XCONS(1000),YCONS(1000)
      DIMENSION KSTART(500),KFIN(500)
      NCON=1
      XCONS(1)=XCON(1)
      YCONS(1)=YCON(1)
      DO 100 K=2,NPC
      KSAVE=K
      XCONS(K)=XCON(K)
      YCONS(K)=YCON(K)
C***DETERMINE WHETHER THE CONTOUR CLOSES BEFORE THE LAST CONTOUR POINT
C***HAS BEEN REACHED. IF SO, ASSUME THE CONTOUR IS COMPOSED OF MULTIPLE
C***CONTOURS AT THE SAME ELEVATION. CONTINUE WITH THE ANALYSIS. IF NOT,
C***THEN RETURN TO THE MAIN PROGRAM WITH A COMPLETION CODE OF 2.
      IF(ABS(XCON(K)-XCON(1)).LT.1.0E-15.AND.ABS(YCON(K)-YCON(1)).LT.
     &1.0E-15.AND.K.NE.NPC) GO TO 110
  100 CONTINUE
      MCFLAG=2
      GO TO 400
  110 CONTINUE
```

```
C***DETERMINE THE AREA OF THE FIRST COMPONENT CONTOUR AND ITS SIGN FOR
C***LATER USE.
      CALL ARCM(XCON,YCON,AREA,XCM,YCM,KSAVE)
      ISO=1
      IF(AREA.LT.0.) ISO=-1
      KSP1=KSAVE+1
      KSTART(1)=KSP1
C***STORE THE COORDINATES OF THE FIRST POINT OF THE SECOND COMPONENT
C***CONTOUR IN THE TEMPORARY STORAGE ARRAYS.
      XCONS(KSP1)=XCON(KSP1)
      YCONS(KSP1)=YCON(KSP1)
      KSP2=KSAVE+2
C***IF ONLY ONE ADDITIONAL POINT HAS BEEN SPECIFIED AFTER THE FIRST
C***CONTOUR CLOSURE, THEN RETURN TO THE MAIN PROGRAM WITH A COMPLETION
C***CODE OF 1.
      IF(KSP2.LE.NPC) GO TO 150
      MCFLAG=1
      GO TO 400
  150 CONTINUE
C***SPECIFY THE BEGINNING POINT OF THE SECOND COMPONENT CONTOUR AS
C***(XCOMP,YCOMP).
      XCOMP=XCON(KSP1)
      YCOMP=YCON(KSP1)
      KCOUNT=KSP2
      K=KCOUNT
C***UP TO THIS POINT THE NUMBER OF THE INPUT AND MODIFIED CONTOUR POINTS
C***IS STILL THE SAME. NOW ENTER THE LOOP WHICH CARRIES OUT THE POINT
C***REASSIGNMENT PROCESS.
  200 CONTINUE
      XCONS(KCOUNT)=XCON(K)
      YCONS(KCOUNT)=YCON(K)
C***HAS THE NEXT CLOSURE BEEN REACHED? IF SO, RETURN TO THE POINT
C***OF FIRST CLOSURE(XCON(1),YCON(1)) BEFORE CONTINUING.
      IF(ABS(XCON(K)-XCOMP).GT.1.0E-15.OR.ABS(YCON(K)-YCOMP).GT.1.0E-15)
     &GO TO 210
C***SPECIFY THE END POINT FOR COMPONENT CONTOUR NCON.
      KFIN(NCON)=KCOUNT
C***INCREMENT COUNTER FOR THE SET OF MODIFIED CONTOUR POINTS.
      KCOUNT=KCOUNT+1
C***CHECK WHETHER THE MAXIMUM NUMBER OF CONTOUR POINTS HAS BEEN EXCEEDED
      IF(KCOUNT.LE.NPCMAX) GO TO 205
      MCFLAG=0
      GO TO 400
  205 CONTINUE
C***RETURN TO CLOSURE POINT FOR FIRST COMPONENT CONTOUR.
      XCONS(KCOUNT)=XCON(1)
      YCONS(KCOUNT)=YCON(1)
C***INCREMENT COUNTER FOR THE ORIGINAL SET OF POINTS.
      K=K+1
C***DETERMINE WHETHER THE NUMBER OF INPUT CONTOUR POINTS HAS BEEN
C***EXHAUSTED.
      IF(K.GT.NPC) GO TO 300
      KCOUNT=KCOUNT+1
C***CHECK WHETHER THE MAXIMUM NUMBER OF CONTOUR POINTS HAS BEEN EXCEEDED
      IF(KCOUNT.LE.NPCMAX) GO TO 206
      MCFLAG=0
      GO TO 400
  206 CONTINUE
C***INCREMENT THE NUMBER OF COMPONENT CONTOURS(EXCLUDING THE FIRST) BY 1
      NCON=NCON+1
C***SPECIFY THE STARTING POINT FOR COMPONENT CONTOUR N.
      KSTART(NCON)=KCOUNT
      XCONS(KCOUNT)=XCON(K)
      YCONS(KCOUNT)=YCON(K)
C***SPECIFY THE BEGINNING POINT OF THE NEW COMPONENT CONTOUR AS
C***(XCOMP,YCOMP) FOR USE IN THE DETERMINATION OF COMPONENT CONTOUR
```

```
C***CLOSURE.
      XCOMP=XCON(K)
      YCOMP=YCON(K)
C***INCREMENT THE COUNTER FOR THE INPUT SET OF CONTOUR POINTS.
  210 K=K+1
C***DETERMINE WHETHER THE NUMBER OF INPUT CONTOUR POINTS HAS BEEN
C***EXHAUSTED.
      IF(K.LE.NPC) GO TO 250
      MCFLAG=1
      GO TO 400
  250 CONTINUE
C***INCREMENT THE COUNTER FOR THE MODIFIED SET OF CONTOUR POINTS.
      KCOUNT=KCOUNT+1
C***CHECK WHETHER THE NUMBER OF CONTOUR POINTS HAS BEEN EXCEEDED.
      IF(KCOUNT.LE.NPCMAX) GO TO 200
      MCFLAG=0
      GO TO 400
  300 CONTINUE
      NPC=KCOUNT
C***TRANSFER THE POINT COORDINATES FROM THE TEMPORARY HOLDING ARRAYS
C***TO THE INITIAL POINT COORDINATE ARRAYS.
      DO 350 K=1,KCOUNT
      XCON(K)=XCONS(K)
      YCON(K)=YCONS(K)
  350 CONTINUE
      MCFLAG=3
C***DETERMINE WHETHER ALL COMPONENT CONTOURS HAVE THEIR POINTS INPUT
C***IN THE SAME SENSE(CLOCKWISE OR COUNTER-CLOCKWISE). IF NOT, MODIFY
C***THE INPUT SEQUENCES TO REFLECT THE SEQUENCE USED FOR THE FIRST
C***COMPONENT CONTOUR.
      DO 390 N=1,NCON
      NN=0
      DO 370 K=KSTART(N),KFIN(N),1
      NN=NN+1
      XCONS(NN)=XCON(K)
      YCONS(NN)=YCON(K)
  370 CONTINUE
C***FIND THE AREA OF THE COMPONENT CONTOUR AND ITS SIGN. IF THE SIGN
C***OF THE AREA IS DIFFERENT FROM THE SIGN OF THE AREA OF THE INITIAL
C***COMPONENT CONTOUR, THEN REVERSE THE INPUT ORDER OF THE COMPONENT
C***CONTOUR POINTS.
      CALL ARCM(XCONS,YCONS,AREA,XCM,YCM,NN)
      ISN=1
      IF(AREA.LT.0.) ISN=-1
      IF(ISN.EQ.ISO) GO TO 390
      MCFLAG=4
      DO 380 K=KSTART(N),KFIN(N),1
      XCON(K)=XCONS(NN)
      YCON(K)=YCONS(NN)
      NN=NN-1
  380 CONTINUE
  390 CONTINUE
  400 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE SKIPCN(IN,NPC)
C***SUBROUTINE TO SKIP CONTOUR POINTS FOR CONTOURS WHICH ARE NOT
C***TO BE PROCESSED
      READ(IN,*) (XDUM,YDUM,K=1,NPC)
      RETURN
      END
```

```
      SUBROUTINE SMOMNT(XCON,YCON,AR,NSLOPE,SN,CN,ANGLE,NPC,
     &XC,YC,RG,RGRAT,ORENT,ISMFLG)
C***SUBROUTINE TO CALCULATE THE SECOND MOMENTS AND RADII OF GYRATION
C***FOR THE INPUT CONTOUR ABOUT AXES OF EQUAL ANGULAR SPACING AND
C***WHICH PASS THROUGH THE CENTROID OF THE CONTOUR IN THE PLANE OF THE
C***CONTOUR
C***INITIALIZE VALUES FOR THE MAXIMUM AND MINIMUM RADII OF GYRATION
      DIMENSION SN(1),CN(1),XCON(1),YCON(1),ANGLE(1)
      ISMFLG=0
      RGMAX=0.
      RGMIN=1.0E+15
C***BEGIN LOOP OVER AXIS ORIENTATION VALUES
      DO 200 M=1,NSLOPE
C***INITIALIZE THE SECOND MOMENT FOR THIS AXIS TO ZERO
      SMOM=0.
C***BEGIN LOOP OVER CONTOUR POINTS
C***D1=PERPENDICULAR DISTANCE TO THE AXIS LINE FROM CONTOUR POINT K
C***D2=PERPENDICULAR DISTANCE TO THE AXIS FROM CONTOUR POINT K+1
C***W=DISTANCE ALONG THE AXIS LINE BETWEEN THE INTERSECTION OF
C***   PERPENDICULARS FROM ADJACENT CONTOUR POINTS(K AND K+1)
      NPCM1=NPC-1
      D1=-(XCON(1)-XC)*SN(M)+(YCON(1)-YC)*CN(M)
      DO 100 K=1,NPCM1
      D2=-(XCON(K+1)-XC)*SN(M)+(YCON(K+1)-YC)*CN(M)
      W=(XCON(K+1)-XCON(K))*CN(M)+(YCON(K+1)-YCON(K))*SN(M)
      SMOM=SMOM+(W/12.)*(D2**3+D1**3+D1*D2**2+D2*D1**2)
      D1=D2
  100 CONTINUE
      IF(SMOM/AR.LT.0.0) ISMFLG=1
      IF(ISMFLG.EQ.1) RETURN
C***CALCULATE THE RADIUS OF GYRATION OF THE CONTOUR ABOUT THIS AXIS
      RG=SQRT(SMOM/AR)
C***UPDATE THE VALUES FOR THE MAXIMUM AND MINIMUM RADII OF GYRATION
C***AND SAVE THE ORIENTATION INDEX FOR THE AXIS HAVING THE CURRENT
C***LARGEST RADIUS OF GYRATION
      IF(RG.LT.RGMAX) GO TO 150
      RGMAX=RG
      MMAX=M
  150 IF(RG.GT.RGMIN) GO TO 200
      RGMIN=RG
  200 CONTINUE
      RG=RGMAX
      RGRAT=(RGMAX-RGMIN)/RGMAX
      ORENT=ANGLE(MMAX)
      RETURN
      END
```

```
      SUBROUTINE VECTOR(XBEG,YBEG,XEND,YEND,ANGLE,DX,DY)
C***SUBROUTINE CALCULATES THE DIRECTION(DEGREES) AND X,Y COMPONENTS
C***FOR A VECTOR FROM (XBEG,YBEG) TO (XEND,YEND). THE COMPUTED
C***DIRECTIONS RANGE FROM 0 TO 360 DEGREES
      PI=3.14159265
      DX=XEND-XBEG
      DY=YEND-YBEG
      IF(ABS(DX).LT.1.0E-15.AND.ABS(DY).LT.1.0E-15) GO TO 10
      ANGLE=(180./PI)*ATAN2(DY,DX)
      GO TO 20
   10 ANGLE=0.
   20 IF(ANGLE.LT.0.) ANGLE=360.+ANGLE
      RETURN
      END
```

HCRIT MAIN PROGRAM AND SUBROUTINE PSORTR

```
      PROGRAM HCRIT
C***PROGRAM TO FIT ELLIPTICAL CONTOURS TO AN INVERSE POLYNOMIAL HILL
C***SHAPE FOR A RANGE OF USER SPECIFIED CRITICAL CUTOFF ELEVATIONS.
C***THE PROGRAM PROVIDES CRITICAL ELEVATION HILL PARAMETERS FOR
C***INPUT TO THE COMPLEX TERRAIN DISPERSION MODEL(CTDM).
C***
C***
C   GLOSSARY OF TERMS
C***
C***
C   A(J)=SEMI-MAJOR AXIS LENGTH FOR CONTOUR J(USER COORDINATES)
C   AI=INTERPOLATED VALUE OF A(J) TO A GIVEN CRITICAL ELEVATION
C   AS(J)=TEMPORARY A(J) STORAGE ARRAY USED IN SORTING
C   ANS=CHARACTER*1 VARIABLE HOLDING THE ANSWER TO A YES(Y) OR NO(N)
C       QUESTION
C   B(J)=SEMI-MINOR AXIS LENGTH FOR CONTOUR J(USER COORDINATES)
C   BI=INTERPOLATED VALUE OF B(J) TO A GIVEN CRITICAL ELEVATION
C   BS(J)=TEMPORARY B(J) STORAGE ARRAY USED IN SORTING
C   ECC(J)=ECCENTRICITY OF CONTOUR J
C   ECCS(J)=TEMPORARY ECC(J) STORAGE ARRAY USED IN SORTING
C   FCONFILE=CHARACTER*15 VARIABLE CONTAINING THE INPUT FILE NAME FOR
C             THE FITTED CONTOUR PARAMETERS GENERATED BY PROGRAM FITCON
C   FEXT=EXTRAPOLATION FACTOR USED TO ASSIGN THE SEMI-MAJOR AND
C         SEMI-MINOR AXIS LENGTHS FOR THE CASE OF ONE CONTOUR AND
C         A CRITICAL ELEVATION BELOW THAT SINGLE CONTOUR
C   FRACT=FRACTIONAL DIFFERENCE OF THE CRITICAL ELEVATION BETWEEN
C          ADJACENT CONTOUR ELEVATIONS
C   HC(I)=ARRAY OF CRITICAL ELEVATIONS
C   HCLOW=THE LOWEST CRITICAL ELEVATION(INPUT FOR CRITICAL ELEVATION
C          SELECTION MODE 2)
C   HCON(J)=ELEVATION OF CONTOUR J(USER COORDINATES)
C   HCONM1=HCON(NC)-1.
C   HCONS(J)=TEMPORARY HCON(J) STORAGE ARRAY USED IN SORTING
C   HHILL=HEIGHT OF THE HILL TOP ABOVE A GIVEN CRITICAL ELEVATION
C   HNAME=CHARACTER*15 VARIABLE GIVING THE HILL NAME
C   HTOP=HILL TOP ELEVATION(USER COORDINATES)
C   ICHMOD=CRITICAL ELEVATION INPUT MODE FOR THE HILL IN QUESTION
C          =1(CRITICAL ELEVATIONS WILL BE AT CONTOUR ELEVATIONS WITH
C             THE EXCEPTION OF THE UPPERMOST CONTOUR)
C          =2(CRITICAL ELEVATIONS EVENLY SPACED BETWEEN A USER SUPPLIED
C             LOWER ELEVATION AND THE ELEVATION OF THE UPPERMOST CONTOUR)
C   IDC(J)=ID NUMBER FOR CONTOUR J
C   IDHILL=HILL ID NUMBER(1-999)
C   IN=UNIT NUMBER FOR THE FITTED HILL INPUT FILE FROM PROGRAM FITCON
C   LA=LENGTH PARAMETER FOR AN INVERSE POLYNOMIAL FIT ALONG THE HILL
C      MAJOR AXIS(USER COORDINATES)
C   LB=LENGTH PARAMETER FOR AN INVERSE POLYNOMIAL FIT ALONG THE HILL
C      MINOR AXIS(USER COORDINATES)
C   LPTR=WORKING ARRAY USED IN THE POINTER SORT(PSORTR)
C   MOUT=UNIT NUMBER FOR THE FILE(MOUTFILE) CONTAINING TERRAIN
C         PARAMETERS WHICH ARE PASSED TO CTDM
C   MOUTFILE=CHARACTER*15 VARIABLE CONTAINING THE OUTPUT FILE NAME FOR
C             THE PARAMETERS TO BE PASSED TO CTDM
C   NC=NUMBER OF FITTED CONTOURS INPUT FROM FCONFILE
C   NCHMAX=MAXIMUM NUMBER OF CRITICAL ELEVATIONS WHICH CAN BE ANALYZED
C   NCON=NUMBER OF CONTOURS USED IN FITTING A HILL FOR A GIVEN CRITICAL
C         ELEVATION
C   NCR=NUMBER OF CRITICAL ELEVATIONS USED
C   NPTR=ARRAY CONTAINING THE SORTED POINTERS RETURNED FROM SUBROUTINE
C         PSORTR
C   ONOR=MAJOR AXIS ORIENTATION IN DEGREES CLOCKWISE FROM NORTH(FOR A
C         CONTOUR OR A FITTED HILL)(BETWEEN 0 AND 180 DEGREES)
C   OREN(J)=ORIENTATION ANGLE OF THE CONTOUR J SEMI-MINOR AXIS WITH
C          RESPECT TO THE POSITIVE X-AXIS
C   ORENF=ORIENTATON OF THE MINOR AXIS OF A FITTED HILL AS MEASURED
C          COUNTER CLOCKWISE FROM THE POSITIVE X-AXIS(EAST)
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C   ORENI=INTERPOLATED VALUE OF OREN(J) TO A GIVEN CRITICAL ELEVATION
C   ORENS(J)=TEMPORARY OREN(J) STORAGE ARRAY USED IN SORTING
C   PA=EXPONENT FOR AN INVERSE POLYNOMIAL FIT ALONG THE HILL MAJOR AXIS
C   PB=EXPONENT FOR AN INVERSE POLYNOMIAL FIT ALONG THE HILL MINOR AXIS
C   PFILE=CHARACTER*15 VARIABLE GIVING THE NAME OF THE CRITICAL
C         ELEVATION PLOT FILE. THIS NAME MUST BE DIFFERENT THAN THE NAME
C         OF THE PLOT FILE GENERATED BY PROGRAM FITCON. BOTH PLOT FILES
C         ARE EVENTUALLY BE INPUT TO THE PLOT PROGRAM.
C   PFLAG=PLOT GENERATION INDICATOR
C        =0(NO PLOT GENERATED)
C        =1(PLOT GENERATED)
C   PSORTR=SUBROUTINE FOR SORTING POINTERS(CALLED TO SORT CONTOUR
C          FIT PARAMETERS BY CONTOUR ELEVATION(ASCENDING ORDER))
C   SUM1,SUM2A,SUM2B,SUM3,SUM4A,SUM4B=SUMMATION VARIABLES USED IN THE
C          CALCULATION OF BEST FIT INVERSE POLYNOMIAL HILL PROFILES
C   SUMX,SUMY=INTERMEDIATE VARIABLES USED IN THE DETERMINATION OF THE
C          ORIENTATIONS OF INTERPOLATED CONTOURS AND FITTED HILLS
C   UPL=UNIT NUMBER FOR THE CRITICAL ELEVATION PLOT FILE
C   XCM(J)=X-COORDINATE OF THE CONTOUR J CENTROID(USER COORDINATES)
C   XCMI=INTERPOLATED VALUE OF XCM(J) TO A GIVEN CRITICAL ELEVATION
C   XCMS(J)=TEMPORARY XCM(J) STORAGE ARRAY USED IN SORTING
C   XHTOPF=AVERAGE OF THE X-COORDINATES OF CONTOUR CENTROIDS ABOVE
C          A GIVEN CRITICAL ELEVATION
C   YCM(J)=Y-COORDINATE OF THE CONTOUR J CENTROID(USER COORDINATES)
C   YCMI=INTERPOLATED VALUE OF YCM(J) TO A GIVEN CRITICAL ELEVATION
C   YCMS(J)=TEMPORARY YCM(J) STORAGE ARRAY USED IN SORTING
C   YHTOPF=AVERAGE OF THE Y-COORDINATES OF CONTOUR CENTROIDS ABOVE
C          A GIVEN CRITICAL ELEVATION
C***
C***
      DIMENSION A(200),AS(200),B(200),BS(200),ECC(200),ECCS(200),
     &HCON(200),HCONS(200),IDC(200),OREN(200),ORENS(200),XCM(200),
     &XCMS(200),YCM(200),YCMS(200),LPTR(200),NPTR(200),HC(200)
      REAL*4 LA,LB
      INTEGER UPL
      CHARACTER*1 ANS
      CHARACTER*15 FCONFILE,MOUTFILE,PFILE,HNAME
C***
C***
C   INITIALIZATION OF VARIABLES
C***
C***
C***SPECIFY FILE UNIT NUMBERS.
      IN=14
      MOUT=15
      UPL=16
C***SPECIFY CONSTANTS.
      PI=3.14159265
      NCHMAX=200
C***
C***
C   INPUT FILE NAMES.
C***
C***
C***ENTER THE NAME OF THE INPUT FILE CONTAINING THE CONTOUR FIT
C***PARAMETERS GENERATED BY PROGRAM FITCON.
    5 WRITE(*,10)
   10 FORMAT(/,1X,'ENTER INPUT FILE NAME(FROM FITCON) -> '\)
      READ(*,'(A)') FCONFILE
      IF(FCONFILE.EQ.' ') GO TO 5
C***OPEN THE INPUT FILE.
      OPEN(IN,FILE=FCONFILE,STATUS='OLD')
C***ENTER THE NAME OF THE OUTPUT FILE WHICH WILL BE PASSED DIRECTLY
C***TO CTDM.
   15 WRITE(*,20)
   20 FORMAT(/,1X,'ENTER OUTPUT FILE NAME(FOR CTDM) ->'\)
```

```
      READ(*,'(A)') MOUTFILE
      IF(MOUTFILE.EQ.' ') GO TO 15
C***OPEN THE OUTPUT FILE.
      OPEN(MOUT,FILE=MOUTFILE,STATUS='NEW')
C***
C***
C   DETERMINE WHETHER A PLOT IS TO BE GENERATED.
C***
C***
C***FIRST, INITIALIZE THE PLOT FLAG INDICATOR TO CORRESPOND TO A
C***"NO" ANSWER.
      PFLAG=0
      WRITE(*,30)
   30 FORMAT(/,1X,'PLOT REQUESTED?(Y/N) -> '\)
      READ(*,'(A)') ANS
      IF(ANS.EQ.'Y'.OR.ANS.EQ.'y') PFLAG=1
      IF(PFLAG.EQ.0) GO TO 50
C***INPUT THE NAME OF THE PLOT FILE.
   35 WRITE(*,40)
   40 FORMAT(/,1X,'ENTER PLOT FILE NAME -> '\)
      READ(*,'(A)') PFILE
      IF(PFILE.EQ.' ') GO TO 35
C***OPEN THE PLOT FILE.
      OPEN(UPL,FILE=PFILE,STATUS='NEW')
C***WRITE "HCRIT" TO THE FIRST RECORD OF THIS PLOT FILE TO INDICATE
C***THAT THIS PLOT FILE IS GENERATED BY PROGRAM HCRIT.
      WRITE(UPL,45)
   45 FORMAT('HCRIT')
   50 CONTINUE
C***
C***
C   READ DATA FROM THE FITTED CONTOUR FILE.
C***
C***
C***INPUT THE HILL ID NUMBER AND NAME.
      READ(IN,60) IDHILL,HNAME
   60 FORMAT(I2,1X,A15)
C***INPUT THE HILL TOP ELEVATION.
      READ(IN,70) HTOP
   70 FORMAT(E15.4)
C***INPUT THE NUMBER OF FITTED CONTOURS.
      READ(IN,80) NC
   80 FORMAT(I10)
C***INPUT THE SORTED CONTOUR IDs. THESE IDs ARE WRITTEN TO THE
C***PLOT FILE AND COMPARED WITH THE SORTED IDs WRITTEN TO THE
C***PLOT FILE WRITTEN BY FITCON. THIS CHECK PREVENTS THE COMPARISON
C***OF AN ACTUAL AND A FITTED CONTOUR WHICH IN FACT REPRESENT DIFFERENT
C***CONTOURS.
      READ(IN,80) (IDC(J),J=1,NC)
      IF(PFLAG.EQ.0) GO TO 85
C***WRITE TO THE PLOT FILE THE HILL ID NUMBER, HILL NAME, NUMBER
C***OF FITTED CONTOURS, THE SORTED CONTOUR IDs, AND THE HILL TOP
C***ELEVATION.
      WRITE(UPL,60) IDHILL,HNAME
      WRITE(UPL,80) NC
      WRITE(UPL,80) (IDC(J),J=1,NC)
      WRITE(UPL,70) HTOP
   85 CONTINUE
C***INPUT THE CONTOUR FIT PARAMETERS FOR THE HILL IN QUESTION.
      DO 100 J=1,NC
      READ(IN,90) HCON(J),XCM(J),YCM(J),A(J),B(J),ECC(J),OREN(J)
   90 FORMAT(7E15.4)
  100 CONTINUE
C***CLOSE THE FITTED CONTOUR INPUT FILE.
      CLOSE(IN,STATUS='KEEP')
C***
```

```
C***
C   SORT THE CONTOUR PARAMETERS BY CONTOUR ELEVATION(IN ASCENDING ORDER)
C   BY USE OF A POINTER SORT.
C***
C***
      CALL PSORTR(HCON,NC,NPTR,LPTR)
C***REORDER THE CONTOUR FIT PARAMETERS BASED UPON THE RESULTS OF THE
C***POINTER SORT.
      DO 110 J=1,NC
      HCONS(J)=HCON(NPTR(J))
      AS(J)=A(NPTR(J))
      BS(J)=B(NPTR(J))
      ECCS(J)=ECC(NPTR(J))
      ORENS(J)=OREN(NPTR(J))
      XCMS(J)=XCM(NPTR(J))
      YCMS(J)=YCM(NPTR(J))
  110 CONTINUE
      DO 120 J=1,NC
      HCON(J)=HCONS(J)
      A(J)=AS(J)
      B(J)=BS(J)
      ECC(J)=ECCS(J)
      OREN(J)=ORENS(J)
      XCM(J)=XCMS(J)
      YCM(J)=YCMS(J)
  120 CONTINUE
      IF(PFLAG.EQ.0) GO TO 123
C***WRITE THE SORTED CONTOUR ELEVATIONS TO THE PLOT FILE.
      DO 122 J=1,NC
      WRITE(UPL,121) HCON(J)
  121 FORMAT(E15.4)
  122 CONTINUE
  123 CONTINUE
C***
C***
C   DETERMINE CRITICAL ELEVATIONS TO BE USED FOR FITTING CUTOFF
C   HILLS.
C***
C***
C***TWO MODES ARE AVAILABLE FOR THE INPUT OF CRITICAL ELEVATIONS.
C***THE USER MAY SPECIFY THAT EACH CONTOUR LEVEL(WITH THE EXCEPTION
C***OF THE UPPERMOST CONTOUR) IS TO BE SPECIFIED AS A CRITICAL
C***ELEVATION, OR THE USER MAY ASK FOR UP TO A MAXIMUM OF NHCMAX
C***CRITICAL ELEVATIONS EVENLY SPACED BETWEEN A USER SPECIFIED LOWER
C***ELEVATION AND THE UPPER MOST CONTOUR OF THE HILL.
  125 WRITE(*,130)
  130 FORMAT(//,22X,'SPECIFY CRITICAL HEIGHT SELECTION MODE',/,
     &22X,'1.) AT ALL CONTOUR ELEVATIONS EXCEPT UPPERMOST',/,
     &22X,'2.) EVENLY SPACED BETWEEN A USER SUPPLIED ELEVATION',/,
     &26X,'AND THE UPPERMOST CONTOUR ELEVATION',/,
     &26X,'CHOICE?(1 OR 2) -> '\)
      READ(*,'(BN,I1)',ERR=125) ICHMOD
      IF(ICHMOD.EQ.1) GO TO 150
      IF(ICHMOD.EQ.2) GO TO 170
      WRITE(*,140)
  140 FORMAT(/,1X,'***ERROR***  SELECTION MODE OUT OF RANGE--TRY AGAIN')
      GO TO 125
C***CRITICAL ELEVATION SELECTION MODE 1
C***THE NUMBER OF CRITICAL ELEVATIONS WILL BE ONE LESS THAN THE NUMBER
C***OF CONTOURS.
  150 NCR=NC-1
      IF(NCR.GT.0) GO TO 155
      WRITE(*,151)
  151 FORMAT(/,1X,'SINCE THERE IS ONLY ONE CONTOUR, THE CONTOUR SELECTIO
     &N MODE 1 CANNOT BE USED.',/,1X,'MODE 2 WILL BE USED INSTEAD.')
C***RESET THE CRITICAL ELEVATION SELECTION MODE.
```

```
      ICHMOD=2
      GO TO 170
  155 DO 160 I=1,NCR
      HC(I)=HCON(I)
  160 CONTINUE
      GO TO 250
C***CRITICAL ELEVATION SELECTION MODE 2
C***READ IN NUMBER OF CRITICAL ELEVATIONS.
  170 WRITE(*,180)
  180 FORMAT(/,1X,'INPUT THE NUMBER OF CRITICAL ELEVATIONS(1-200) -> '\)
      READ(*,'(BN,I3)',ERR=170) NCR
      IF(NCR.LE.NCHMAX.AND.NCR.NE.0) GO TO 200
      WRITE(*,190)
  190 FORMAT(/,1X,'***ERROR***  NUMBER OF CRITICAL ELEVATIONS OUT OF RAN
     &E--TRY AGAIN')
      GO TO 170
C***INPUT THE LOWEST CRITICAL ELEVATION.
  200 WRITE(*,210)
  210 FORMAT(/,1X,'INPUT THE LOWEST CRITICAL ELEVATION -> '\)
  215 READ(*,'(BN,F10.0))',ERR=200) HCLOW
C***CHECK WHETHER THE LOWEST CRITICAL ELEVATION IS OVER 1 ELEVATION UNIT
C***ABOVE THE HIGHEST CONTOUR ELEVATION. IF SO, ASK THE USER TO INPUT
C***ANOTHER VALUE FOR THE LOWEST CRITICAL ELEVATON.
      HCONM1=HCON(NC)-1.
      IF(HCLOW.LT.HCONM1) GO TO 230
      WRITE(*,220) HCONM1
  220 FORMAT(/,1X,'LOWEST CRITICAL ELEVATION MUST BE LESS THAN',E15.4
     &,/,1X,'TRY AGAIN')
      GO TO 215
C***ASSIGN THE CRITICAL ELEVATIONS.
C***HCLOW WILL BE THE FIRST ELEVATION. THERE WILL BE NCR-1 ADDITIONAL
C***CRITICAL ELEVATIONS ABOVE HCLOW HAVING A SPACING EQUAL TO DELC,
C***WHERE DELC=(HCON(NC)-HLOW)/NCR. THE HIGHEST CRITICAL ELEVATION
C***WILL BE A DISTANCE OF DELC BELOW THE UPPERMOST CONTOUR LEVEL.
  230 DELC=(HCON(NC)-HCLOW)/FLOAT(NCR)
      DO 240 I=1,NCR
      HC(I)=HCLOW+(I-1)*DELC
  240 CONTINUE
  250 CONTINUE
      IF(PFLAG.EQ.0) GO TO 251
C***WRITE THE NUMBER OF CRITICAL ELEVATIONS TO THE PLOT FILE.
      WRITE(UPL,80) NCR
  251 CONTINUE
C***ASSIGNMENT OF CRITICAL ELEVATIONS COMPLETED.
C***
C***
C   WRITE THE HILL ID, THE NUMBER OF CRITICAL ELEVATIONS, THE HILL
C   TOP ELEVATION, AND THE HILL NAME TO THE CTDM INPUT FILE.
C***
C***
      WRITE(MOUT,260) IDHILL,NCR,HTOP,HNAME
  260 FORMAT(5X,I2,1X,I2,10X,E10.4,10X,A15)
C***
C***
C   FOR EACH CRITICAL ELEVATION, DETERMINE THE PARAMETERS WHICH BEST
C   DESCRIBE THE ELLIPTICAL TERRAIN CONTOUR AT THAT ELEVATION. THESE
C   PARAMETERS ARE WRITTEN TO THE CTDM INPUT FILE FOR USE IN THE "WRAP"
C   PLUME CALCULATION IN CTDM. IF THE CRITICAL ELEVATION DOES NOT CO-
C   INCIDE WITH AN INPUT CONTOUR(I.E. ICHMOD=2), THEN THE PARAMETERS
C   MUST BE DETERMINED BY A SIMPLE INTERPOLATION OF FITTED CONTOUR
C   PARAMETERS BASED ON ELEVATION. THE INTERPOLATION OF THE OREN-
C   TATION VALUES IS A VECTOR INTERPOLATION WITH THE VECTORS WEIGHTED
C   WITH THE ECCENTRICITY OF THE CONTOUR.
C***
C***
      IF(ICHMOD.EQ.2) GO TO 290
```

```
C***CASE 1--CRITICAL ELEVATIONS COINCIDE WITH CONTOUR ELEVATIONS.
      DO 280 J=1,NCR
C***FIND THE ORIENTATION OF THE MAJOR AXIS MEASURED CLOCKWISE FROM
C***NORTH(BETWEEN 0 AND 180 DEGREES).
      ONOR=180.-OREN(J)
      IF(ONOR.LT.0.) ONOR=360.+ONOR
      IF(ONOR.GT.180.) ONOR=ONOR-180.
      WRITE(MOUT,270) HC(J),XCM(J),YCM(J),ONOR,A(J),B(J)
  270 FORMAT(F10.3,2E10.4,3F10.3)
  280 CONTINUE
      GO TO 360
C***CASE 2--CRITICAL ELEVATIONS EVENLY SPACED BETWEEN HCLOW AND THE
C***UPPERMOST CONTOUR
  290 DO 350 I=1,NCR
      DO 300 J=1,NC
      JK=J
      IF(HCON(J).GT.HC(I)) GO TO 310
  300 CONTINUE
  310 IF(JK.GT.1) GO TO 320
C***IF THE CRITICAL ELEVATION IS BELOW THE LOWEST CONTOUR, THEN
C***EXTRAPOLATE THE VALUES FOR THE CONTOUR ORIENTATION, CENTROID
C***COORDINATES, AND SEMI-MAJOR AND SEMI-MINOR AXIS LENGTHS USING THE
C***VALUES OF THESE PARAMETERS FOR THE LOWEST TWO CONTOURS. IF THERE
C***IS ONLY ONE CONTOUR, THEN THE VALUES FOR THE ORIENTATION AND
C***CENTROID COORDINATES OF THE CRITICAL ELEVATION CONTOUR ARE SET
C***EQUAL TO THE CORRESPONDING VALUES FOR THE SINGLE CONTOUR. THE
C***SEMI-MAJOR AND SEMI-MINOR AXIS LENGTHS FOR THE CRITICAL ELEVATION
C***CONTOUR ARE EXTRAPOLATED BY ASSUMING A ZERO AREA CONTOUR AT THE
C***HILL TOP ELEVATION.
      IF(NC.EQ.1) GO TO 315
      JK=2
      GO TO 320
  315 XCMI=XCM(1)
      YCMI=YCM(1)
      ORENI=OREN(1)
      FEXT=(HTOP-HC(I))/(HTOP-HCON(1))
      AI=A(1)*FEXT
      BI=B(1)*FEXT
      GO TO 340
C***INTERPOLATE TO FIND CONTOUR PARAMETERS AT THE Ith CRITICAL
C***ELEVATION.
  320 FRACT=(HC(I)-HCON(JK-1))/(HCON(JK)-HCON(JK-1))
      XCMI=XCM(JK-1)+FRACT*(XCM(JK)-XCM(JK-1))
      YCMI=YCM(JK-1)+FRACT*(YCM(JK)-YCM(JK-1))
      AI=A(JK-1)+FRACT*(A(JK)-A(JK-1))
      BI=B(JK-1)+FRACT*(B(JK)-B(JK-1))
C***DO NOT ALLOW AI AND BI TO DECREASE WITH ELEVATION.
      IF(AI.LT.A(JK-1)) AI=A(JK-1)
      IF(BI.LT.B(JK-1)) BI=B(JK-1)
C***INTERPOLATE THE ORIENTATION VECTORIALLY WITH THE ELLIPSE
C***ECCENTRICITY USED AS A WEIGHTING FACTOR.
      SUMX=ECC(JK-1)*COS(PI*OREN(JK-1)/180.)+FRACT*(ECC(JK)*
     &COS(PI*OREN(JK)/180.)-ECC(JK-1)*COS(PI*OREN(JK-1)/180.))
      SUMY=ECC(JK-1)*SIN(PI*OREN(JK-1)/180.)+FRACT*(ECC(JK)*
     &SIN(PI*OREN(JK)/180.)-ECC(JK-1)*SIN(PI*OREN(JK-1)/180.))
C***AVOID CALLING THE ATAN2 FUNCTION WITH BOTH ARGUMENTS BEING
C***EFFECTIVELY ZERO.
      IF(ABS(SUMX).LT.1.0E-8.AND.ABS(SUMY).LT.1.0E-8) GO TO 330
      ORENI=(180./PI)*ATAN2(SUMY,SUMX)
      GO TO 340
  330 ORENI=0.
C***IF THE EXTRAPOLATION PROCESS GIVES AN ELLIPSE WITH A MINOR AXIS
C***GREATER THAN A MAJOR AXIS, THEN ASSUME THAT THE AXES ARE EQUAL
C***AND THAT THE ELLIPSE HAS THE SAME AREA.
  340 IF(AI.GE.BI) GO TO 345
      AI=SQRT(AI*BI)
```

```
      BI=AI
  345 CONTINUE
C***FIND THE ORIENTATION OF THE INTERPOLATED CONTOUR MAJOR AXIS AS
C***MEASURED CLOCKWISE FROM NORTH(BETWEEN 0 AND 180 DEGREES).
      ONOR=180.-ORENI
      IF(ONOR.LT.0.) ONOR=360.+ONOR
      IF(ONOR.GT.180.) ONOR=ONOR-180.
      WRITE(MOUT,270) HC(I),XCMI,YCMI,ONOR,AI,BI
  350 CONTINUE
  360 CONTINUE
C***THE WRITING OF BEST FIT CONTOUR ELLIPSE PARAMETERS FOR CUTOFF
C***ELEVATIONS TO THE CTDM INPUT FILE HAS BEEN COMPLETED.
C***
C***
C   DETERMINE THE FITTED HILL PARAMETERS FOR EACH CRITICAL CUTOFF
C   ELEVATION AND WRITE THESE PARAMETERS TO BOTH THE PLOT FILE AND
C   THE CTDM INPUT FILE.
C***
C***
      DO 500 I=1,NCR
C***ZERO OUT SUMMATION VARIABLES.
      SUM1=0.
      SUM2A=0.
      SUM2B=0.
      SUM3=0.
      SUM4A=0.
      SUM4B=0.
      SUMX=0.
      SUMY=0.
      XHTOPF=0.
      YHTOPF=0.
      NCON=0
C***CALCULATE THE HILL HEIGHT ABOVE THE CRITICAL HEIGHT.
      HHILL=HTOP-HC(I)
      DO 400 J=1,NC
C***CONTOUR ELEVATIONS USED IN FITTING THE PORTION OF THE HILL ABOVE
C***THE CRITICAL ELEVATION MUST BE AT LEAST ONE UNIT ABOVE THE CRITICAL
C***ELEVATION.
      IF(HCON(J).LE.HC(I)+1.) GO TO 400
      NCON=NCON+1
      FJ=ALOG(HHILL/(HCON(J)-HC(I))-1.)
      SUM1=SUM1+FJ
      SUM3=SUM3+FJ**2
      SUM2A=SUM2A+ALOG(A(J))
      SUM2B=SUM2B+ALOG(B(J))
      SUM4A=SUM4A+ALOG(A(J))*FJ
      SUM4B=SUM4B+ALOG(B(J))*FJ
      SUMX=SUMX+ECC(J)*COS(PI*OREN(J)/180.)
      SUMY=SUMY+ECC(J)*SIN(PI*OREN(J)/180.)
      XHTOPF=XHTOPF+XCM(J)
      YHTOPF=YHTOPF+YCM(J)
  400 CONTINUE
      IF(NCON.EQ.1) GO TO 410
      LA=EXP((SUM2A*SUM3-SUM4A*SUM1)/(NCON*SUM3-SUM1**2))
      LB=EXP((SUM2B*SUM3-SUM4B*SUM1)/(NCON*SUM3-SUM1**2))
      PA=(NCON*SUM3-SUM1**2)/(NCON*SUM4A-SUM1*SUM2A)
      PB=(NCON*SUM3-SUM1**2)/(NCON*SUM4B-SUM1*SUM2B)
C***NEGATIVE EXPONENTS NOT ALLOWED
      PA=ABS(PA)
      PB=ABS(PB)
      GO TO 420
C***IF ONLY ONE CONTOUR IS USED IN THE HILL FIT, ONE MUST ASSUME
C***THAT THE EXPONENTS IN THE INVERSE POLYNOMIAL FIT ARE BOTH 2.
  410 CONTINUE
      PA=2.
      PB=2.
```

```
      LA=A(NC)/(HHILL/(HCON(NC)-HC(I))-1.)**(1./PA)
      LB=B(NC)/(HHILL/(HCON(NC)-HC(I))-1.)**(1./PB)
C***AVOID CALLING THE ATAN2 FUNCTION WITH BOTH ARGUMENTS BEING
C***EFFECTIVELY ZERO.
  420 IF(ABS(SUMX).LT.1.0E-8.AND.ABS(SUMY).LT.1.0E-8) GO TO 430
      ORENF=(180./PI)*ATAN2(SUMY,SUMX)
      GO TO 440
  430 ORENF=0.
C***FIND THE ORIENTATION OF THE MAJOR AXIS AS MEASURED CLOCKWISE FROM
C***NORTH(BETWEEN 0 AND 180 DEGREES).
  440 ONOR=180.-ORENF
      IF(ONOR.LT.0.) ONOR=360.+ONOR
      IF(ONOR.GT.180.) ONOR=ONOR-180.
      XHTOPF=XHTOPF/FLOAT(NCON)
      YHTOPF=YHTOPF/FLOAT(NCON)
      IF(PFLAG.EQ.0) GO TO 455
C***WRITE THE FITTED HILL PARAMETERS TO THE PLOT FILE.
      WRITE(UPL,450) HC(I),XHTOPF,YHTOPF,ORENF,PA,PB,LA,LB
  450 FORMAT(8E15.4)
  455 CONTINUE
C***WRITE THE FITTED HILL PARAMETERS TO THE CTDM INPUT FILE.
      WRITE(MOUT,460) HC(I),XHTOPF,YHTOPF,ONOR,PA,PB,LA,LB
  460 FORMAT(F10.3,2E10.4,5F10.3)
  500 CONTINUE
      STOP
      END
```

```
      SUBROUTINE PSORTR(ARRAY,NDL,NPTR,LPTR)
C***POINTER SORT USING THE MERGE EXCHANGE METHOD
C***NUMBER OF COMPARISONS=N*LOG(N)/LOG(2)
C***ARRAY=REAL ARRAY TO BE SORTED
C***NDL=NUMBER OF ELEMENTS OF ARRAY TO BE SORTED
C***NPTR=POINTER ARRAY
C***LPTR=WORKING ARRAY
      DIMENSION ARRAY(1),NPTR(1),LPTR(1)
C***CHECK INITIAL ORDER
      I1=NPTR(1)
      IF(NDL.LE.1.AND.I1.EQ.1) RETURN
      IF(I1.LT.1.OR.I1.GT.NDL) GO TO 30
      DO 20 I=2,NDL
         I2=NPTR(I)
         IF(I1.EQ.I2) GO TO 30
         IF(I2.LT.1.OR.I2.GT.NDL) GO TO 30
         IF(ARRAY(I1).GT.ARRAY(I2)) GO TO 30
         I1=I2
   20    CONTINUE
      RETURN
C***SET UP POINTER ARRAY
   30 DO 40 I=1,NDL
         NPTR(I)=I
   40    CONTINUE
C***BEGIN THE SORT
      IF(NDL.LE.1) RETURN
      L2I=1
      DO 120 I=1,20
         M=1
         L2IH=L2I
         L2I=2*L2I
         IF(L2IH.GT.NDL) GO TO 130
         JUP=NDL/L2I+1
         DO 110 J=1,JUP
            N=M+L2IH
            IF(N.GT.NDL) GO TO 110
            KLO=M
            KUP=MIN0(KLO+L2I-1,NDL)
            MUP=KLO+L2IH-1
            DO 80 K=KLO,KUP
               IF(N.GT.NDL) GO TO 50
               IF(N.GT.KUP) GO TO 50
               IF(M.GT.MUP) GO TO 60
               IF(ARRAY(NPTR(M)).GT.ARRAY(NPTR(N))) GO TO 60
   50.         NL=M
               M=M+1
               GO TO 70
   60          NL=N
               N=N+1
   70          LPTR(K)=NPTR(NL)
   80          CONTINUE
   90       DO 100 K=KLO,KUP
               NPTR(K)=LPTR(K)
  100          CONTINUE
            M=KLO+L2I
  110       CONTINUE
         IF(L2I.GE.NDL) GO TO 130
  120    CONTINUE
  130 RETURN
      END
```

PLOTCON

```
10 'Program to plot contours for actual and fitted hills on a display
20 'terminal with 320(horizontal)x200(vertical) resolution in color
30 'or 640(horizontal)x200(vertical) resolution in black and white
40 'Clear the screen.
50 CLS
60 'Disable the display of function keys to allow more space for
70 'plotting.
80 KEY OFF
90 DEFINT I-N
100 'Dimension the arrays for contour elevations, contour identification
110 'numbers(from both FITCON and HCRIT), and the array for storing the
120 'plot of digitized contours(unedited or edited).
130 DIM HCON(200),IDC1(200),IDC2(200),IAR(8002)
140 LOCATE 12,15
150 'Input the name of the plot file from program FITCON.
160 INPUT " INPUT NAME OF PLOTFILE FROM PROGRAM FITCON-->";PLOT1$
170 ON ERROR GOTO 3190
180 OPEN PLOT1$ FOR INPUT AS #1
190 ON ERROR GOTO 0
200 'Make sure that this plot file was generated by program FITCON.
210 INPUT#1, PF1$
220 IF PF1$="FITCON" THEN GOTO 280
230 CLS
240 LOCATE 10,15
250 PRINT PLOT1$ " IS NOT A FILE GENERATED BY PROGRAM FITCON-TRY AGAIN"
260 CLOSE #1
270 GOTO 140
280 CLS
290 'Input the hill identification number, hill name, hill center
300 'coordinates, number of fitted contours, and the identification
310 'numbers for the fitted contours.
320 INPUT#1, IDH1,HNAME1$
330 INPUT#1, XHTOP,YHTOP
340 INPUT#1, NC1
350 FOR J=1 TO NC1
360 INPUT#1,IDC1(J)
370 NEXT J
380 'Input the plot boundaries for the unedited contours.
390 INPUT#1, XMIN1,XMAX1,YMIN1,YMAX1
400 'Input the plot boundaries for the edited contours.
410 INPUT#1, XMIN2,XMAX2,YMIN2,YMAX2
420 LOCATE 10,22
430 'Select the type of display.
440 PRINT "SELECT TYPE OF DISPLAY"
450 PRINT
460 PRINT TAB(22) "1.) Low resolution with color"
470 PRINT TAB(22) "2.) High resolution black and white"
480 PRINT
490 INPUT "                        Choice?(1 or 2)-->";RFLAG%
500 CLS
510 LOCATE 10,22
520 'Select the type of contours to be displayed.
530 PRINT "SELECT THE CONTOUR TYPE FOR DISPLAY"
540 PRINT
550 PRINT TAB(22) "1.) Unedited Contours"
560 PRINT TAB(22) "2.) Edited Contours"
570 PRINT
580 INPUT "                        Choice?(1 or 2)-->";DFLAG%
590 CLS
600 'Set plot boundaries, scale factors, and colors.
```

```
610 SCRCX=320!:DSCRX=468!:SCRCY=104!:DSCRY=190!:RATIO=1.3574
620 IF RFLAG%=1 THEN SCRCX=160!:DSCRX=205!:RATIO=1.5437
630 IF DFLAG%=2 THEN GOTO 690
640 XC=(XMIN1+XMAX1)/2!
650 YC=(YMIN1+YMAX1)/2!
660 DX=XMAX1-XMIN1
670 DY=YMAX1-YMIN1
680 GOTO 730
690 XC=(XMIN2+XMAX2)/2!
700 YC=(YMIN2+YMAX2)/2!
710 DX=XMAX2-XMIN2
720 DY=YMAX2-YMIN2
730 IF DX/DY<RATIO THEN DD=DY ELSE DD=DX/RATIO
740 DSCRXDDD=DSCRX/DD
750 DSCRYDDD=DSCRY/DD
760 'For the medium resolution mode, set the background color to light
770 'blue and the digitized contour color to white.
780 IF RFLAG%=1 THEN SCREEN 1:IC=3 ELSE SCREEN 2:IC=1
790 IF RFLAG%=1 THEN COLOR 9,1
800 'Begin loop over contours.
810 FOR J=1 TO NC1
820 'Input the number of points on the unedited contour.
830 INPUT#1, NPC
840 IF DFLAG%=1 THEN GOTO 920
850 'Skip over unedited contour coordinates if edited contours are desired.
860 FOR K=1 TO NPC
870 INPUT#1, DUMX,DUMY
880 NEXT K
890 'Input the number of points on the edited contour.
900 INPUT#1, NPC
910 'Input the coordinates of the first contour point.
920 INPUT#1, X1,Y1
930 XOLD=X1
940 YOLD=Y1
950 'Set contour closure indicator to zero. The parameters DUPFLG% and IFR
960 'are used to allow the plotting of multiple contours at the same
970 'elevation(see Users Manual for details)
980 DUPFLG%=0
990 'Scale first contour point for plotting.
1000 XS1=SCRCX+(X1-XC)*DSCRXDDD
1010 YS1=SCRCY-(Y1-YC)*DSCRYDDD
1020 'Plot the first contour point.
1030 PSET(XS1,YS1),IC
1040 'Set contour closure counter to zero.
1050 IFR=0
1060 'Begin loop over the remainder of the contour points.
1070 FOR K=2 TO NPC
1080 INPUT#1, X,Y
1090 'If 2 or more contour closures have been reached and the point has
1100 'the same coordinates as the initial point, then skip over the point.
1110 IF IFR>=2 AND ABS(X-X1)<1E-15 AND ABS(Y-Y1)<1E-15 THEN GOTO 1310
1120 'Scale the point X,Y for plotting.
1130 XS=SCRCX+(X-XC)*DSCRXDDD
1140 YS=SCRCY-(Y-YC)*DSCRYDDD
1150 IF DUPFLG%=0 GOTO 1270
1160 'One of the multiple contours has been closed. Move to the new point
1170 'without drawing a line. Substitute the current point for the
1180 'previous individual contour beginning point.
1190 XOLD=X
1200 YOLD=Y
```

```
1210 DUPFLG%=0
1220 PSET(XS,YS),IC
1230 GOTO 1310
1240 'Determine whether one of the individual multiple contours has been
1250 'closed. If so, set the closure indicator DUPFLG% to 1 and
1260 'increment the contour closure counter IFR by 1.
1270 IF ABS(X-XOLD)<1E-15 AND ABS(Y-YOLD)<1E-15 THEN DUPFLG%=1:IFR=IFR+1
1280 'Draw a line from the previous point to the current point.
1290 LINE -(XS,YS),IC
1300 'End loop over contour points.
1310 NEXT K
1320 IF DFLAG%<> 1 THEN GOTO 1390
1330 'Skip over edited contours.
1340 INPUT#1, NPC
1350 FOR K=1 TO NPC
1360 INPUT#1,DUMX,DUMY
1370 NEXT K
1380 'End loop over contours.
1390 NEXT J
1400 'Scale hill center coordinates.
1410 XSHC=SCRCX+(XHTOP-XC)*DSCRXDDD
1420 YSHC=SCRCY-(YHTOP-YC)*DSCRYDDD
1430 XUL=XSHC-1
1440 XLR=XSHC+1
1450 YUL=YSHC-1
1460 YLR=YSHC+1
1470 'Plot a 3x3 box of points centered at the hill center.
1480 LINE(XUL,YUL)-(XLR,YLR),IC,BF
1490 IF RFLAG%=1 THEN GXMX%=319 ELSE GXMX%=639
1500 'Store the plot of digitized contours in array IAR.
1510 GET (0,0)-(GXMX%,199),IAR
1520 PRINT HNAME1$ " INPUT CONTOURS"
1530 'Pause until user presses any key. Program will terminate if the
1540 'user presses the ESC key.
1550 GOSUB 3410
1560 CLS
1570 'Change color to magenta for plotting fitted contours.
1580 IF RFLAG%=1 THEN IC=2
1590 'Restore the plot of digitized contours.
1600 PUT (0,0),IAR,PSET
1610 'Begin loop over contours.
1620 FOR J=1 TO NC1
1630 'Input ellipse parameters for each contour: ellipse centroid
1640 'coordinates, semi-axes lengths, and the orientation of the minor
1650 'axis with respect to the positive x-axis.
1660 INPUT#1, XCM,YCM,A,B;OREN
1670 'Determine the orientation of the major axis with respect to the
1680 'positive x-axis
1690 OREN=OREN-90!
1700 CSE=COS(.017453*OREN)
1710 SNE=SIN(.017453*OREN)
1720 XP=A
1730 XFIT=XCM+XP*CSE
1740 YFIT=YCM+XP*SNE
1750 XS=SCRCX+(XFIT-XC)*DSCRXDDD
1760 YS=SCRCY-(YFIT-YC)*DSCRYDDD
1770 'Move to a point at the end of the ellipse semi-major axis.
1780 PSET(XS,YS)
1790 A2=A^2
1800 B2=B^2
```

```
1810 'Draw an ellipse with 120 points.
1820 FOR L=1 TO 120
1830 THC=-L*.05276
1840 R=SQR(1!/(COS(THC)^2/A2+SIN(THC)^2/B2))
1850 XP=R*COS(THC)
1860 YP=R*SIN(THC)
1870 XFIT=XCM+XP*CSE-YP*SNE
1880 YFIT=YCM+XP*SNE+YP*CSE
1890 XS=SCRCX+(XFIT-XC)*DSCRXDDD
1900 YS=SCRCY-(YFIT-YC)*DSCRYDDD
1910 LINE -(XS,YS),IC
1920 NEXT L
1930 'End loop over contours.
1940 NEXT J
1950 PRINT HNAME1$ " FITTED CONTOURS"
1960 'Pause until the user presses any key. If the user presses the ESC
1970 'key, then program execution will terminate.
1980 GOSUB 3410
1990 CLS
2000 'Begin plotting contours for fitted cutoff hills.
2010 'Go to text mode for user input.
2020 SCREEN 2:SCREEN 0
2030 LOCATE 12,19
2040 'Determine whether fitted hill contours are to be displayed.
2050 INPUT " DISPLAY FITTED CUTOFF HILL CONTOURS?(Y/N)->";ANS$
2060 IF ANS$="N" THEN SYSTEM
2070 IF ANS$="n" THEN SYSTEM
2080 CLOSE #1
2090 LOCATE 14,15
2100 'Input the name of the plot file from program HCRIT.
2110 INPUT " INPUT NAME OF PLOTFILE FROM PROGRAM HCRIT";PLOT2$
2120 ON ERROR GOTO 3220
2130 OPEN PLOT2$ FOR INPUT AS #1
2140 ON ERROR GOTO 0
2150 'Make sure the plot file was generated by program HCRIT.
2160 INPUT#1, PF2$
2170 IF PF2$="HCRIT" THEN GOTO 2230
2180 CLS
2190 LOCATE 12,20
2200 PRINT PLOT2$ " IS NOT A FILE GENERATED BY PROGRAM HCRIT-TRY AGAIN"
2210 CLOSE #1
2220 GOTO 2090
2230 CLS
2240 'Check whether the hill identification number, hill name, number
2250 'of fitted contours, and contour identification numbers match
2260 'those from the FITCON plot file.
2270 INPUT#1, IDH2,HNAME2$
2280 IF IDH2<>IDH1 THEN GOTO 3250
2290 IF HNAME1$<>HNAME2$ THEN GOTO 3280
2300 INPUT#1, NC2
2310 IF NC1<>NC2 THEN GOTO 3310
2320 FOR J=1 TO NC2
2330 INPUT#1, IDC2(J)
2340 IF IDC1(J)<>IDC2(J) THEN GOTO 3340
2350 NEXT J
2360 'Return to graphics mode.
2370 IF RFLAG%=1 THEN SCREEN 1:IC=2 ELSE SCREEN 2:IC=1
2380 IF RFLAG%=1 THEN COLOR 9,1
2390 'Input hill top elevation and contour elevations.
2400 INPUT#1, HTOP
```

```
2410 FOR J=1 TO NC2
2420 INPUT#1, HCON(J)
2430 NEXT J
2440 'Input number of critical elevations.
2450 INPUT#1, NCR
2460 'Begin loop over critical elevations.
2470 FOR I=1 TO NCR
2480 'For each critical elevation, input the critical elevation, cutoff
2490 'hill centroid coordinates, orientation of the hill minor axis
2500 'with respect to the positive x-axis, and the inverse polynomial
2510 'fit parameters for each hill axis.
2520 INPUT#1, HC,XHTOPF,YHTOPF,ORENF,PA,PB,RLA,RLB
2530 'Determine the orientation of the major axis with respect to the
2540 'positive x-axis.
2550 ORENF=ORENF-90!
2560 CSE=COS(.017453*ORENF)
2570 SNE=SIN(.017453*ORENF)
2580 'Retrieve background plot of digitized contours(unedited or edited).
2590 PUT (0,0),IAR,PSET
2600 'Begin loop over contours.
2610 FOR J=1 TO NC2
2620 'Contours must be at least one elevation unit higher than the
2630 'critical elevation if their elevations are to be used for the display
2640 'of contours on the cutoff hill.
2650 IF HCON(J)<=HC+1! THEN GOTO 3020
2660 FLOG=LOG((HTOP-HC)/(HCON(J)-HC)-1!)
2670 AFIT=RLA*EXP((1!/PA)*FLOG)
2680 BFIT=RLB*EXP((1!/PB)*FLOG)
2690 'The equation for the inverse polynomial contour is
2700 '    (XP/AFIT)**PA+(YP/BFIT)**PB=1
2710 'in the coordinate system in which the x and y primed axes
2720 'coincide with the major and minor axes of the hill respectively.
2730 'Begin loop to calculate 800 contour point coordinates.
2740 FOR L=1 TO 200
2750 IF L>99 GOTO 2810
2760 'Let x primed be the independent variable.
2770 XPOL=L*.01*AFIT
2780 YPOL=BFIT*(1!-(XPOL/AFIT)^PA)^(1!/PB)
2790 GOTO 2840
2800 'Let y primed be the independent variable.
2810 YPOL=(L-100)*.01*BFIT
2820 XPOL=AFIT*(1!-(YPOL/BFIT)^PB)^(1!/PA)
2830 'First quadrant(x primed=+,y primed=+)
2840 XP=XPOL
2850 YP=YPOL
2860 GOSUB 3460
2870 'Second quadrant(x primed=+,y primed=-)--moving clockwise.
2880 XP=XPOL
2890 YP=-YPOL
2900 GOSUB 3460
2910 'Third quadrant(x primed=-,y primed=-)
2920 XP=-XPOL
2930 YP=-YPOL
2940 GOSUB 3460
2950 'Fourth quadrant(x primed=-,y primed=+)
2960 XP=-XPOL
2970 YP=YPOL
2980 GOSUB 3460
2990 'End contour point loop.
3000 NEXT L
```

```
3010 'End contour loop.
3020 NEXT J
3030 XSHCF=SCRCX+(XHTOPF-XC)*DSCRXDDD
3040 YSHCF=SCRCY-(YHTOPF-YC)*DSCRYDDD
3050 XUL=XSHCF-1
3060 XLR=XSHCF+1
3070 YUL=YSHCF-1
3080 YLR=YSHCF+1
3090 'Plot a 3x3 box of points centered about the cutoff hill centroid.
3100 LINE (XUL,YUL)-(XLR,YLR),IC,BF
3110 PRINT HNAME2$ " ECRIT=" HC
3120 'Pause until user strikes a key. If the ESC key is pressed, then
3130 'execution of the program is terminated.
3140 GOSUB 3410
3150 CLS
3160 'End loop on critical elevations.
3170 NEXT I
3180 SYSTEM
3190 IF ERR=53 THEN PRINT "FITCON PLOT FILE NOT FOUND-Press any key"
3200 GOSUB 3410
3210 SYSTEM
3220 IF ERR=53 THEN PRINT "HCRIT PLOT FILE NOT FOUND-Press any key"
3230 GOSUB 3410
3240 SYSTEM
3250 PRINT "FITCON AND HCRIT HILL IDs DO NOT MATCH-Press any key"
3260 GOSUB 3410
3270 SYSTEM
3280 PRINT "FITCON AND HCRIT HILL NAMES DO NOT MATCH-Press any key"
3290 GOSUB 3410
3300 SYSTEM
3310 PRINT "FITCON AND HCRIT NUMBER OF CONTOURS DO NOT MATCH-Press any key"
3320 GOSUB 3410
3330 SYSTEM
3340 PRINT "FITCON AND HCRIT CONTOUR IDs DO NOT MATCH-Press any key"
3350 GOSUB 3410
3360 SYSTEM
3370 END
3380 'Subroutine which causes program execution to pause until a key
3390 'is struck. If the ESC key is pressed, then program execution
3400 'will be terminated.
3410 A$=INKEY$: IF A$="" THEN 3410
3420 IF A$=CHR$(27) THEN SYSTEM
3430 RETURN
3440 'Subroutine to rotate points into the x,y coordinate system before
3450 'plotting
3460 XFIT=XHTOPF+XP*CSE-YP*SNE
3470 YFIT=YHTOPF+XP*SNE+YP*CSE
3480 XS=SCRCX+(XFIT-XC)*DSCRXDDD
3490 YS=SCRCY-(YFIT-YC)*DSCRYDDD
3500 PSET(XS,YS),IC
3510 RETURN
```

HPLTCON

```
10 'Program to plot contours for actual and fitted hills on a display
20 'terminal with 720(horizontal)x348(vertical) resolution(black and
30 'white) driven by a Hercules Graphics Board
40 'Clear the screen.
50 CLS
60 'Disable the display of function keys to allow more space for
70 'plotting.
80 KEY OFF
90 DEFINT I-N
100 'Dimension the arrays for contour elevations, contour identification
110 'numbers(from both FITCON and HCRIT), and the array for storing the
120 'plot of digitized contours(unedited or edited).
130 DIM HCON(200),IDC1(200),IDC2(200),IAR(15662)
140 LOCATE 12,15
150 'Input the name of the plotfile from program FITCON
160 INPUT " INPUT NAME OF PLOTFILE FROM PROGRAM FITCON-->";PLOT1$
170 ON ERROR GOTO 2940
180 OPEN PLOT1$ FOR INPUT AS #1
190 ON ERROR GOTO 0
200 INPUT#1, PF1$
210 IF PF1$="FITCON" THEN GOTO 270
220 CLS
230 LOCATE 10,15
240 PRINT PLOT1$ " IS NOT A FILE GENERATED BY PROGRAM FITCON-TRY AGAIN"
250 CLOSE #1
260 GOTO 140
270 CLS
280 'Input the hill identification number, hill name, hill center
290 'coordinates, number of fitted contours, and the identification
300 'for the fitted contours.
310 INPUT#1, IDH1,HNAME1$
320 INPUT#1, XHTOP,YHTOP
330 INPUT#1, NC1
340 FOR J=1 TO NC1
350 INPUT#1,IDC1(J)
360 NEXT J
370 'Input the plot boundaries for the unedited contours.
380 INPUT#1, XMIN1,XMAX1,YMIN1,YMAX1
390 'Input the plot boundaries for the edited contours.
400 INPUT#1, XMIN2,XMAX2,YMIN2,YMAX2
410 'Set plot boundaries and scale factors.
420 SCRCX=360!:DSCRX=499!:SCRCY=180!:DSCRY=333!:RATIO=1.4286
430 CLS
440 LOCATE 10,22
450 'Select the type of contours to be displayed.
460 PRINT "SELECT THE CONTOUR TYPE FOR DISPLAY"
470 PRINT
480 PRINT TAB(22) "1.) Unedited Contours"
490 PRINT TAB(22) "2.) Edited Contours"
500 PRINT
510 INPUT "                         Choice?(1 or 2)-->";DFLAG%
520 CLS
530 IF DFLAG%=2 THEN GOTO 590
540 XC=(XMIN1+XMAX1)/2!
550 YC=(YMIN1+YMAX1)/2!
560 DX=XMAX1-XMIN1
570 DY=YMAX1-YMIN1
580 GOTO 630
590 XC=(XMIN2+XMAX2)/2!
600 YC=(YMIN2+YMAX2)/2!
```

```
610 DX=XMAX2-XMIN2
620 DY=YMAX2-YMIN2
630 IF DX/DY<RATIO THEN DD=DY ELSE DD=DX/RATIO
640 DSCRXDDD=DSCRX/DD
650 DSCRYDDD=DSCRY/DD
660 'Begin loop over contours.
670 FOR J=1 TO NC1
680 'Input the number of points on the unedited contour.
690 INPUT#1, NPC
700 IF DFLAG%=1 THEN GOTO 780
710 'Skip over unedited contour coordinates if edited contours are used.
720 FOR K=1 TO NPC
730 INPUT#1, DUMX,DUMY
740 NEXT K
750 'Input the number of points on the edited contour.
760 INPUT#1,NPC
770 'Input the coordinates of the first contour point.
780 INPUT#1, X1,Y1
790 XOLD=X1
800 YOLD=Y1
810 'Set contour closure indicator to zero. The parameters DUPFLG% and IFR
820 'are used to allow the plotting of multiple contours at the same
830 'elevation(see Users Manual for details).
840 DUPFLG%=0
850 'Scale first contour point for plotting.
860 XS1=SCRCX+(X1-XC)*DSCRXDDD
870 YS1=SCRCY-(Y1-YC)*DSCRYDDD
880 'Plot the first contour point.
890 PSET (XS1,YS1)
900 'Set contour closure indicator to zero.
910 IFR=0
920 'Begin loop over the remaining contour points.
930 FOR K=2 TO NPC
940 INPUT#1, X,Y
950 'If two or more contour closures have been reached and the point has
960 'the same coordinates as the initial point, then skip over the point.
970 IF IFR>=2 AND ABS(X-X1)<1E-15 AND ABS(Y-Y1)<1E-15 THEN GOTO 1170
980 'Scale the point x,y for plotting.
990 XS=SCRCX+(X-XC)*DSCRXDDD
1000 YS=SCRCY-(Y-YC)*DSCRYDDD
1010 IF DUPFLG%=0 GOTO 1130
1020 'One of the multiple contours has been closed. Move to the new point
1030 'without drawing a line. Substitute the current point for the
1040 'previous individual contour beginning point.
1050 XOLD=X
1060 YOLD=Y
1070 DUPFLG%=0
1080 PSET(XS,YS)
1090 GOTO 1170
1100 'Determine whether one of the individual multiple contours has been
1110 'closed. If so, set the closure indicator DUPFLG% to 1 and
1120 'increment the contour closure counter IFR by 1.
1130 IF ABS(X-XOLD)<1E-15 AND ABS(Y-YOLD)<1E-15 THEN DUPFLG%=1:IFR=IFR+1
1140 'Draw a line from the previous point to the current point.
1150 LINE -(XS,YS)
1160 'End loop over contour points.
1170 NEXT K
1180 IF DFLAG%<>1 THEN GOTO 1250
1190 'Skip over edited contours.
1200 INPUT#1,NPC
```

```
1210 FOR K=1 TO NPC
1220 INPUT#1, DUMX,DUMY
1230 NEXT K
1240 'End loop over contours.
1250 NEXT J
1260 'Scale hill center coordinates.
1270 XSHC=SCRCX+(XHTOP-XC)*DSCRXDDD
1280 YSHC=SCRCY-(YHTOP-YC)*DSCRYDDD
1290 XUL=XSHC-1
1300 XLR=XSHC+1
1310 YUL=YSHC-1
1320 YLR=YSHC+1
1330 'Plot a 3x3 box of points centered at the hill center.
1340 LINE(XUL,YUL)-(XLR,YLR),,BF
1350 'Store the plot of digitized contours in array IAR.
1360 GET (0,0)-(719,347),IAR
1370 PRINT HNAME1$ " INPUT CONTOURS"
1380 'Pause until user presses a key. Program will terminate if the
1390 'user presses the ESC key.
1400 GOSUB 3160
1410 CLS
1420 'Restore the plot of digitized contours.
1430 PUT (0,0),IAR,PSET
1440 'Begin loop over contours.
1450 FOR J=1 TO NC1
1460 'Input ellipse parameters for each contour: ellipse centroid
1470 'coordinates, semi-axes lengths, and the orientation of the minor
1480 'axis with respect to the positive x-axis.
1490 INPUT#1, XCM,YCM,A,B,OREN
1500 'Determine the orientation of the ellipse major axis with respect
1510 'to the positive x-axis.
1520 OREN=OREN-90!
1530 CSE=COS(.017453*OREN)
1540 SNE=SIN(.017453*OREN)
1550 XP=A
1560 XFIT=XCM+XP*CSE
1570 YFIT=YCM+XP*SNE
1580 XS=SCRCX+(XFIT-XC)*DSCRXDDD
1590 YS=SCRCY-(YFIT-YC)*DSCRYDDD
1600 'Move to a point at the end of the ellipse semi-major axis.
1610 PSET(XS,YS)
1620 A2=A^2
1630 B2=B^2
1640 'Draw an ellipse with 120 points.
1650 FOR L=1 TO 120
1660 THC=-L*.05276
1670 R=SQR(1!/(COS(THC)^2/A2+SIN(THC)^2/B2))
1680 XP=R*COS(THC)
1690 YP=R*SIN(THC)
1700 XFIT=XCM+XP*CSE-YP*SNE
1710 YFIT=YCM+XP*SNE+YP*CSE
1720 XS=SCRCX+(XFIT-XC)*DSCRXDDD
1730 YS=SCRCY-(YFIT-YC)*DSCRYDDD
1740 LINE -(XS,YS)
1750 NEXT L
1760 'End loop over contours.
1770 NEXT J
1780 PRINT HNAME1$ " FITTED CONTOURS"
1790 'Pause until the user presses a key. If the user presses the ESC
1800 'key, then program execution will terminate.
```

```
1810 GOSUB 3160
1820 CLS
1830 'Begin plotting contours for fitted cutoff hills.
1840 LOCATE 12,19
1850 'Determine whether fitted hill contours are to be displayed.
1860 INPUT " DISPLAY FITTED CUTOFF HILL CONTOURS?(Y/N)->";ANS$
1870 IF ANS$="N" THEN SYSTEM
1880 IF ANS$="n" THEN SYSTEM
1890 CLOSE #1
1900 LOCATE 14,20
1910 'Input the name of the plot file from program HCRIT.
1920 INPUT " INPUT NAME OF PLOTFILE FROM PROGRAM HCRIT";PLOT2$
1930 ON ERROR GOTO 2970
1940 OPEN PLOT2$ FOR INPUT AS #1
1950 ON ERROR GOTO 0
1960 'Make sure that the plot file was generated by program HCRIT.
1970 INPUT#1, PF2$
1980 IF PF2$="HCRIT" THEN GOTO 2040
1990 CLS
2000 LOCATE 12,15
2010 PRINT PLOT2$ " IS NOT A FILE GENERATED BY PROGRAM HCRIT-TRY AGAIN"
2020 CLOSE #1
2030 GOTO 1900
2040 CLS
2050 'Check whether the hill identification number, hill name, number
2060 'of fitted contours, and contour identification numbers match.
2070 INPUT#1, IDH2,HNAME2$
2080 IF IDH2<>IDH1 THEN GOTO 3000
2090 IF HNAME1$<>HNAME2$ THEN GOTO 3030
2100 INPUT#1, NC2
2110 IF NC1<>NC2 THEN GOTO 3060
2120 FOR J=1 TO NC2
2130 INPUT#1, IDC2(J)
2140 IF IDC1(J)<>IDC2(J) THEN GOTO 3090
2150 NEXT J
2160 'Input hill top elevation and contour elevations.
2170 INPUT#1, HTOP
2180 FOR J=1 TO NC2
2190 INPUT#1, HCON(J)
2200 NEXT J
2210 'Input the number of critical elevations.
2220 INPUT#1, NCR
2230 'Begin loop for critical elevations.
2240 FOR I=1 TO NCR
2250 'For each critical elevation, input the critical elevation, cutoff
2260 'hill centroid coordinates, orientation of the hill minor axis
2270 'with respect to the positive x-axis, and the inverse polynomial
2280 'fit parameters for each hill axis.
2290 INPUT#1, HC,XHTOPF,YHTOPF,ORENF,PA,PB,RLA,RLB
2300 'Determine the orientation of the major axis with respect to the
2310 'positive x-axis.
2320 ORENF=ORENF-90!
2330 CSE=COS(.017453*ORENF)
2340 SNE=SIN(.017453*ORENF)
2350 'Retrieve the background plot of digitized contours(unedited or edited)
2360 PUT (0,0),IAR,PSET
2370 'Begin loop over contours.
2380 FOR J=1 TO NC2
2390 'Contours must be at least one elevation unit higher than the
2400 'critical elevation if their elevations are to be used for the display
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2410 'of contours on the cutoff hill.
2420 IF HCON(J)<=HC+1! THEN GOTO 2770
2430 FLOG=LOG((HTOP-HC)/(HCON(J)-HC)-1!)
2440 AFIT=RLA*EXP((1!/PA)*FLOG)
2450 BFIT=RLB*EXP((1!/PB)*FLOG)
2460 'The equation for the inverse polynomial contour is
2470 '      (XP/AFIT)**PA+(YP/BFIT)**PB=1
2480 'in the coordinate system in which the x and y primed axes
2490 'coincide with the major and minor axes of the hill respectively.
2500 'Begin loop to calculate 800 contour point coordinates.
2510 FOR L=1 TO 200
2520 IF L>99 GOTO 2580
2530 'Let x primed be the independent variable.
2540 XPOL=L*.01*AFIT
2550 YPOL=BFIT*(1!-(XPOL/AFIT)^PA)^(1!/PB)
2560 GOTO 2610
2570 'Let y primed be the independent variable.
2580 YPOL=(L-100)*.01*BFIT
2590 XPOL=AFIT*(1!-(YPOL/BFIT)^PB)^(1!/PA)
2600 'First quadrant(x primed=+,y primed=+)
2610 XP=XPOL
2620 YP=YPOL
2630 GOSUB 3210
2640 'Second quadrant(x primed=+,y primed=-)--moving clockwise
2650 XP=XPOL
2660 YP=-YPOL
2670 GOSUB 3210
2680 'Third quadrant(x primed=-,y primed=-)
2690 XP=-XPOL
2700 YP=-YPOL
2710 GOSUB 3210
2720 'Fourth quadrant(x primed=-,y primed=+)
2730 XP=-XPOL
2740 YP=YPOL
2750 GOSUB 3210
2760 NEXT L
2770 NEXT J
2780 XSHCF=SCRCX+(XHTOPF-XC)*DSCRXDDD
2790 YSHCF=SCRCY-(YHTOPF-YC)*DSCRYDDD
2800 XUL=XSHCF-1
2810 XLR=XSHCF+1
2820 YUL=YSHCF-1
2830 YLR=YSHCF+1
2840 'Plot a 3x3 box of points centered about the cutoff hill centroid.
2850 LINE (XUL,YUL)-(XLR,YLR),,BF
2860 PRINT HNAME2$ " ECRIT=" HC
2870 'Pause until the user strikes a key. If the ESC key is pressed, then
2880 'execution of the program is terminated.
2890 GOSUB 3160
2900 CLS
2910 'End loop on critical elevations.
2920 NEXT I
2930 SYSTEM
2940 IF ERR=53 THEN PRINT "FITCON PLOT FILE NOT FOUND-Press any key"
2950 GOSUB 3160
2960 SYSTEM
2970 IF ERR=53 THEN PRINT "HCRIT PLOT FILE NOT FOUND-Press any key"
2980 GOSUB 3160
2990 SYSTEM
3000 PRINT "FITCON AND HCRIT HILL IDs DO NOT MATCH-Press any key"
```

```
3010 GOSUB 3160
3020 SYSTEM
3030 PRINT "FITCON AND HCRIT HILL NAMES DO NOT MATCH-Press any key"
3040 GOSUB 3160
3050 SYSTEM
3060 PRINT "FITCON AND HCRIT NUMBER OF CONTOURS DO NOT MATCH-Press any key"
3070 GOSUB 3160
3080 SYSTEM
3090 PRINT "FITCON AND HCRIT CONTOUR IDs DO NOT MATCH-Press any key"
3100 GOSUB 3160
3110 SYSTEM
3120 END
3130 'Subroutine which causes program execution to pause until a key
3140 'is struck. If the ESC key is pressed, then program execution
3150 'will be terminated.
3160 A$=INKEY$: IF A$="" THEN 3160
3170 IF A$=CHR$(27) THEN SYSTEM
3180 RETURN
3190 'Subroutine to rotate points into the x,y coordinate system before
3200 'plotting
3210 XFIT=XHTOPF+XP*CSE-YP*SNE
3220 YFIT=YHTOPF+XP*SNE+YP*CSE
3230 XS=SCRCX+(XFIT-XC)*DSCRXDDD
3240 YS=SCRCY-(YFIT-YC)*DSCRYDDD
3250 PSET(XS,YS)
3260 RETURN
```