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A COMPUTER MODEL FOR SIZING RAPID TRANSIT TUNNEL DIAMETERS

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FINAL REPORT

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16. Abstract

A computer program was developed to assist the determination of minimum tunnel diameters for electrified rapid transit systems. Inputs include vehicle shape, walkway location, clearances, and track geometrics. The program written in FORTRAN IV calculates the locations of six critical points with respect to the top of the low rail. Twenty triplets of points are considered, each triplet defining a possible circle. Circles not containing all six points are discarded and the minimum-diameter circle is selected. An additional plotting option is available to provide a visual presentation of tunnel, vehicle envelope, and walkway envelope.

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PREFACE

This report contains a computer program developed to assist the determination of minimum tunnel diameters for rapid transit systems. It is the result of a work item performed under contract DOT-TSC-601 for the Transportation Systems Center. The overall results of this contract have been published in a final technical report, A.J. Birkmyer and D.L. Richardson, "Systems Analysis of Rapid Transit Underground Construction," 2 Vols., U.S. Dept. of Transportation, Office of the Secretary and Urban Mass Transportation Administration, Washington, DC, December 1974, DOT-TST-75-72. I-II, UMTA-MA-06-0025-74-11.I-II.

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1. INTRODUCTION

In the design of rapid transit tunnels, one of the most important specifications is the diameter of the tunnel. Establishing the tunnel diameter is not a trivial task, since the geometry of several lateral and vertical train movements must be considered under differing locations of walkway, conditions of superrelevation, and values of track-curve radius.* Minimization of the tunnel diameter is important, since the volume of earth material to be moved varies directly with the cross-sectional area of the tunnel face.

A computer program has been developed to simplify the process of calculating tunnel diameters. This program can be used to reduce substantially the time required for tunnel diameter determination and should greatly assist the development of standards for tunnel. Moreover, it would be possible to use the rapid response of the computer to evaluate several alternative vehicle designs to help develop standard tunnel/vehicle designs.

1.1 SCOPE OF MODEL

With the program, it is possible to evaluate tunnel diameters over a range of track-curve radii under four distinct conditions:

1. Walkway on inside of curve; zero superelevation
2. Walkway on inside of curve; maximum superelevation
3. Walkway on outside of curve; zero superelevation
4. Walkway on outside of curve; maximum superelevation

1.2 ENVELOPE PARAMETERIZATION

The size and shape of the car directly affects the tunnel diameter. The computer program allows for two different ways to input car size and shape, but in both cases the same general shape is assumed.

*Gerald Saulnier, "Rapid Transit Tunnel Dimensions in the United States: A Brief Summary," U.S. Dept. of Transportation, Office of the Secretary, Washington DC, June 1975, DOT-TSC-OST-75-24.

The program assumes a vehicle envelope that has a flat bottom with distinct corner points. The sides of the vehicle envelope can be flat or bowed out. The upper corners of the envelope are approximated as circles, and the top must slope up to a point at the centerline of the vehicle. A further elaboration on the envelope parameterization appears in the user's manual, Section 2.

1.3 CRITICAL POINTS WITHIN THE TUNNEL

Six special points coincident with the critical car dimensions potentially affect the tunnel diameter. These points are identified on the accompanying geometric layout drawings of circular BART tunnels as indicated in Figures 1-1 and 1-2. The points are defined as follows:

A. Clearance Point for Contract Rail

This is the point of the contact rail which is normally opposite the walkway. This point constrains in the "bottom" of the circle.

B. Walkway Tread Clearance

The service walkway tread in tunnels must be a certain distance above the rail which is adjacent to the walkway. Clearance must be provided between the transit car and the walkway tread. Further, this walkway tread has a certain minimum width. The intersection point of tread and tunnel may become an extreme point constraining the tunnel diameter.

C. Walkway Head-Room Clearance

Clearance must be provided between the transit car and the top of the walkway envelope. The walkway envelope has a specific minimum width at its top. With superelevation the combination of these factors produces a point that may constrain the width of the tunnel.

D.}
E.} Corner of Envelope Interference Points

Contact of one (or even both) of the upper vehicle corners with the tunnel may be critical points, constraining the tunnel diameter. (See Figure 1-3.)

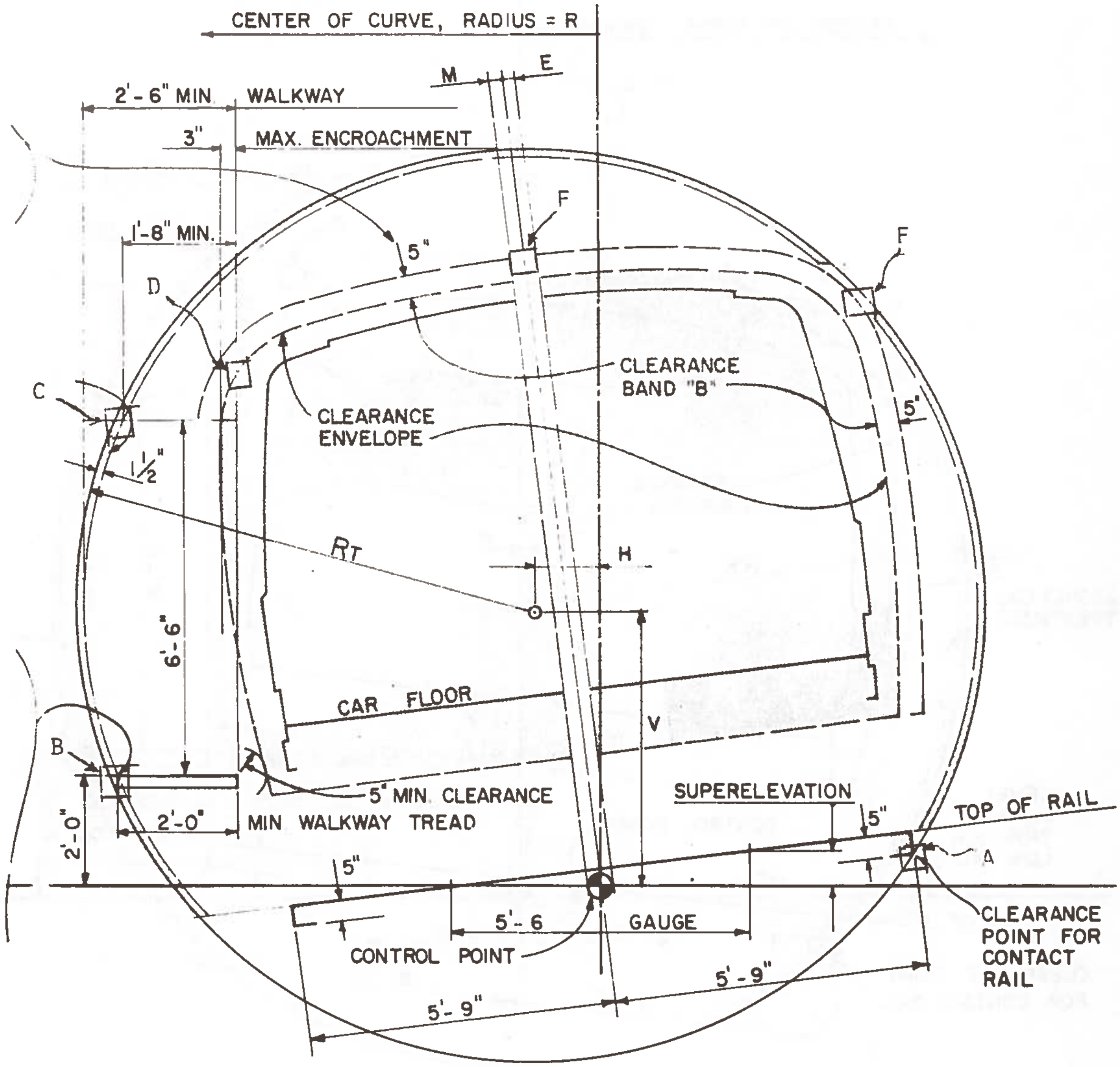


Figure 1-1. Walkway on Same Side as Center of Curve

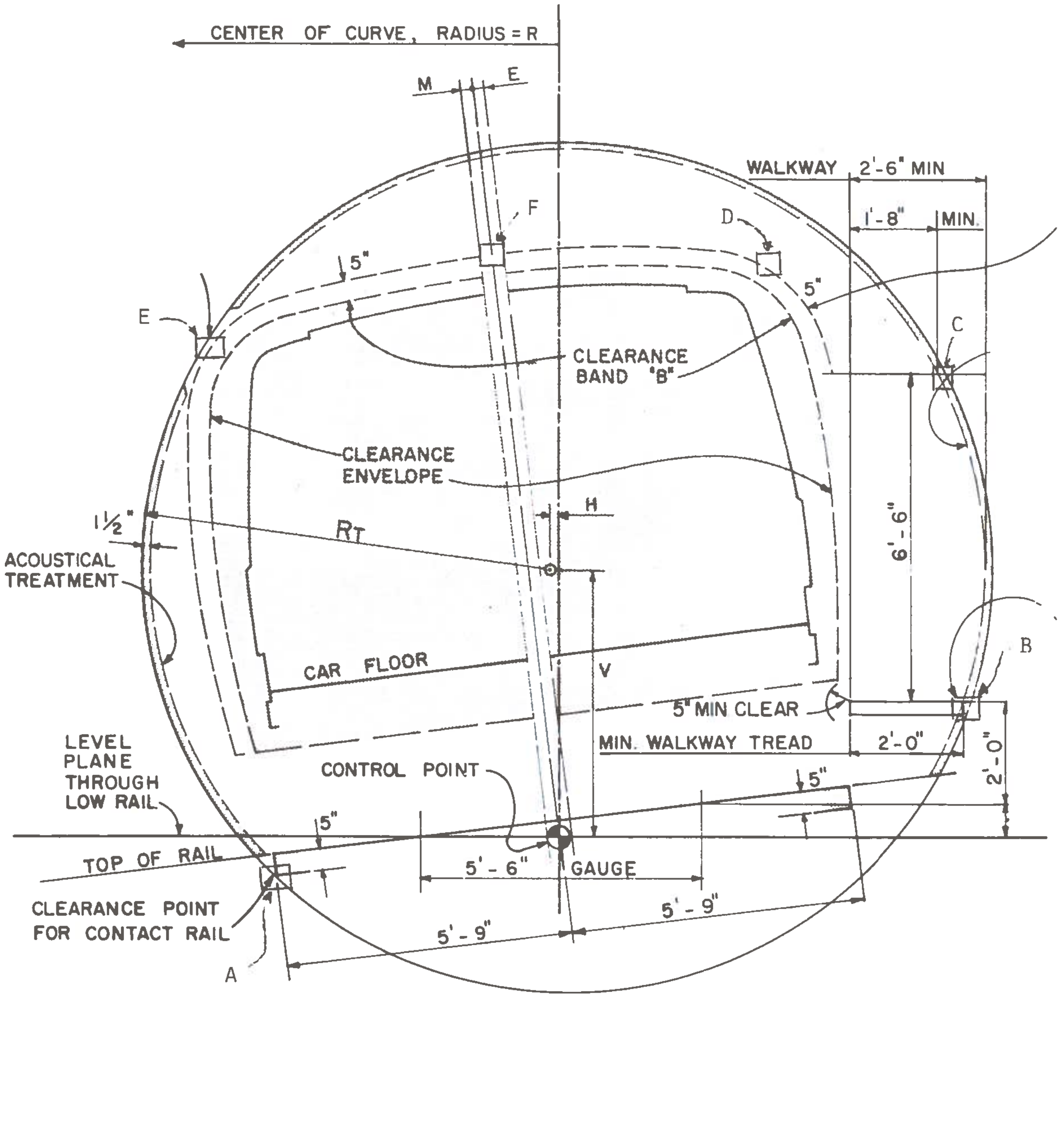


Figure 1-2. Walkway on Opposite Side to Center of Curve

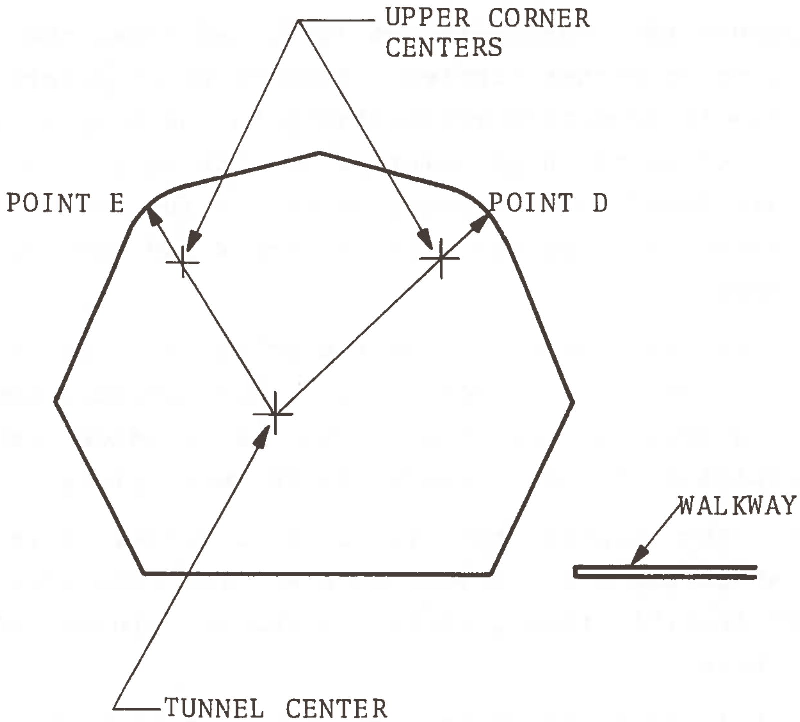


Figure 1-3. Vehicle Envelope

F. Top Point of Car

The intersection of the centerline of the car and the roof of the car may be a critical point, if, for instance, the car has a pyramidal shape or carries air-conditioning equipment on the vehicle-roof.

1.4 DIAMETER CALCULATIONS

The tunnel diameter can be calculated for all the conditions implied above in Section 1.1, "Scope of Model." These calculations reflect combinations of three parameters:

1. Location of the walkway
2. Zero or maximum superelevation
3. Radius of the curvature of the track

For each combination of these parameters, a tunnel diameter can be calculated using the following procedure:

1. Compute the coordinates of A, B, and F and the centers of the upper corner circles. Each of these points has a definite geometric relationship to the origin, which is defined as the high point of the low rail. Points D and E are found using a computer search for the points of tangency between the vehicle-corner and the edge of the tunnel.
2. In general, only three of the points will be on the actual perimeter of the circle. It is not obvious, however, which three are critical. Thus, we consider each possible triplet of points. There are 20 such triplets.
3. For each triplet, the circle is discarded if it does not contain the six critical points. The remaining circles are feasible tunnel diameters and the minimum of these is selected.

While it is possible to perform by hand all of the calculations that the computer executes in finding the center and diameter of the tunnel, a cursory glance at the equations will show that the calculations involved are extremely laborious. For instance, the process of finding a circle with a D or E point entails solving an equation with over 100 terms; the likelihood of error is quite large in solving an equation of this size. On the other hand, the trial and error method using a draftsman is slow and very laborious. These calculations are described in the following section.

1.5 CALCULATIONS FOR POINTS D AND E

Points D and E are defined as those points on the upper vehicle corners furthest from the center of the tunnel. Point D is on the side of the car next to the walkway. Points D or E will be found at the intersection of the upper vehicle corner curve and a line drawn through the center of the tunnel and the center of the upper corner surve (see Figure 1-3). Unfortunately, since the center of the tunnel is exactly what is being sought, points D and E are not known. All that is known about these points is their definition.

Finding the center and radius of a circle passing through three of the points A, B, C, and F is fairly straightforward. The center of a circle passing through three of these points must be equidistant from each point, by the definition of a circle. To find the center of the circle we set up expressions for the distance from each point to the center point (x,y). Since the distances are equal, each distance expression is equal. Thus, two equations with two unknowns are derived and can be solved for x and y, the coordinates of the center of the circle.

Finding the center and radius of a circle passing through two of the points A, B, C, and F and either D or E is not a trivial problem, since the actual locations of the vehicle corner points D and E are not known. Given two of the points A, B, C, or F plus one of the vehicle's upper corners (D or E) as the tunnel constraints, it is inconvenient to use two equations with two unknowns, since the equation involving the vehicle corner point turns out to be a fourth-order polynominal when fully expanded:

$$\left(x_5 - x\right)^2 + \left(y_5 - y\right)^2 + R_1 = \left(x_1 - x\right)^2 + \left(y_1 - y\right)^2$$

where

$\left(x_5, y_5\right)$ = coordinates of vehicle corner circle center

R_1 = radius of vehicle corner circle

$\left(x_1, y\right)$ = coordinates of one of the points A, B, C, or F

(x,y) = the location of the center of the circle

The difficulties of solving this fourth order polynominal encourage the search for another method of finding the center of the circle. The modern high speed digital computer provides a means to solve the problem, using a technique called binary search.

The two known points will be equidistant from the center of the circle passing through them. Thus the center must lie on the perpendicular bisector of the line segment connecting the known points. The binary search is begun by establishing upper and lower limits on the perpendicular bisector to the line segment and a point is found midway between the two limits. (See Figure 1-4.)

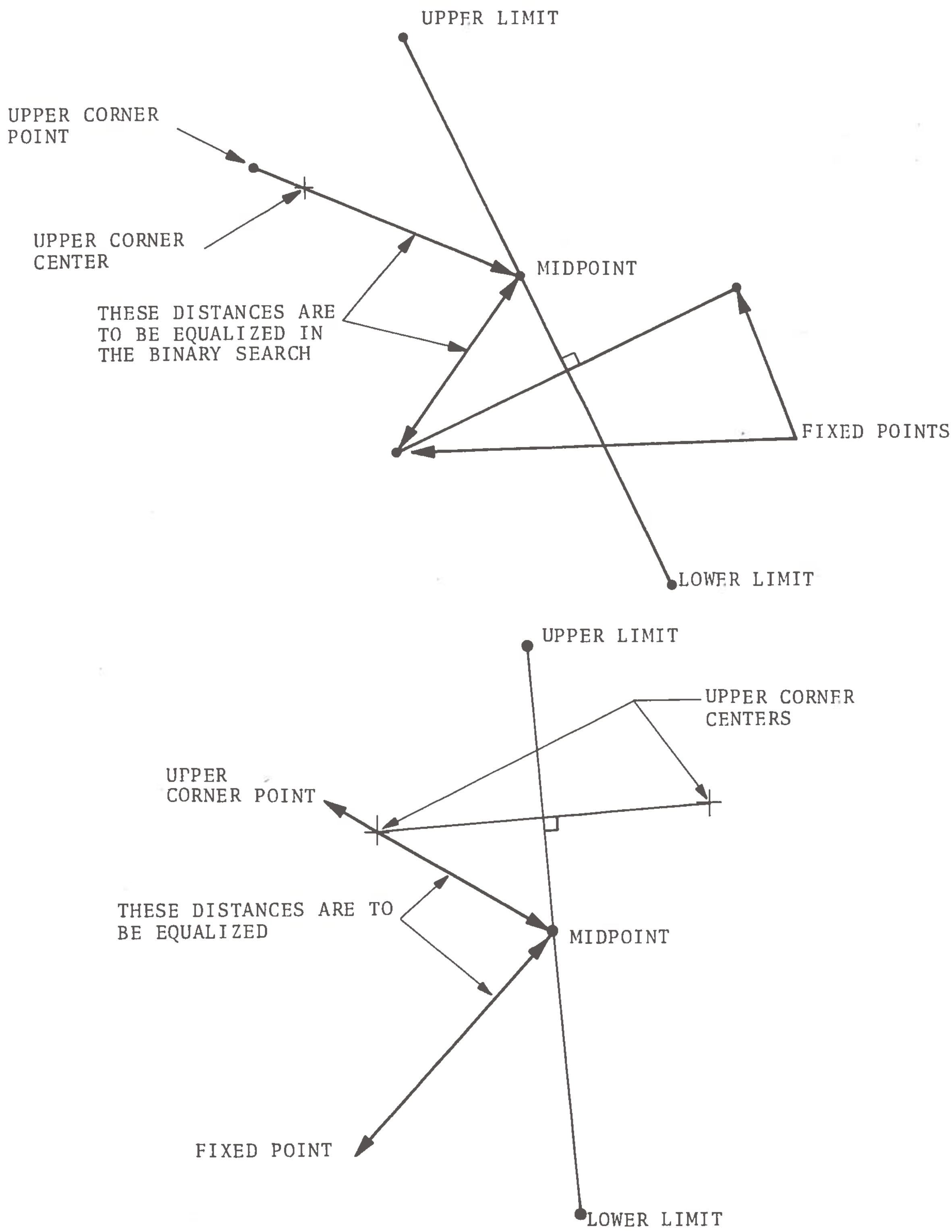


Figure 1-4. Binary Search

If the distance from this point to one of the fixed points is less than the distance to the upper vehicle corner point under consideration, the lower limit is raised. If the reverse is true, the upper limit is lowered. A new point, midway between the two limits is found and tested the same way as the first. This process is repeated until the center point is found.

The center of a circle involving both points D and E can be found in the same manner. The bisector is constructed perpendicular to the line sigment connecting the centers of the upper vehicle corners. The upper and lower limits are established and the binary search system is conducted. (See Figure 1-4.)

This system converges fairly rapidly; 40 iterations are sufficient to find the location of the center of a 17-foot diameter circle, when the initial upper and lower limits are within 1000 feet of each other. Forty iterations produce an answer accurate to within 0.01 inches.

2. USER'S MANUAL

2.1 INTRODUCTION

A computer program has been developed to determine the minimum tunnel diameter consistent with geometric constraints of tunnel design. The program was written in standard FORTRAN IV and compiles under IBM 360 65 WATFIV and FORTRAN G compilers. Finding the smallest diameter is not a simple problem, since the geometry of several lateral and vertical train movements must be considered under differing locations of walkway, conditions of superelevation, and values of track curve radius. Development of the Bay Area Transit tunnel specifications required several man-months. With this computer program, the task of finding the center and size of the smallest tunnel should take but a few hours. The user establishes the value of the controlling support systems and car dimensions, and the machine does the rest. The program considers six, and only six, critical points. The size and location of the contact rail determine one critical point, the walkway determines two more, and the car accounts for the remaining three.

In order for the program to be valid, certain constraints must be met. With regard to the contact rail point, the third rail must be below the bottom of the car, and cannot lie between the two other rails. With regard to the car itself, two of the critical points are associated with the upper corners of the car. In the process of finding the locations of these points, symmetry is assumed about an axis through the center of the profile of the car. The final critical point is the maximum top point of the car. There can be only one such point on the car and this top point must be on the axis of symmetry of the car. For a further discussion of this point, see the discussion of the input MAXHT, Section 2.2.18 below.

2.2 PREPARATION OF DATA

Following is a description of all of the data inputs describing the tunnel, walkway, and vehicle geometrics. These data are also listed in the Definition of Variables, Section 3. All inputs must be given in inches except where noted. All the values must be in decimal format except for the choice of the corner-circle option.

2.2.1 Gauge

The first input to consider is the gauge of the track. The gauge is the distance between the inner edges of the rails. (See Figure 2-1.)

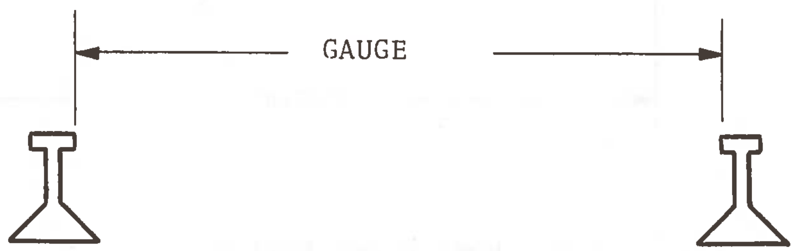


Figure 2-1. Gauge

2.2.2 SE

The superelevation is the distance that one rail is raised above the other on curves. (See Figure 2-2.)

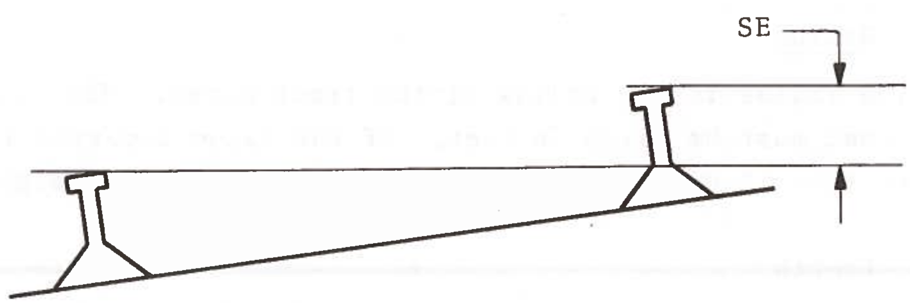


Figure 2-2. SE

2.2.3 HORLOC

The horizontal location of the contact rail is the distance from the centerline of the track to the outer edge of the contact rail. This distance is needed to find the first critical point. (See Figure 2-3.)

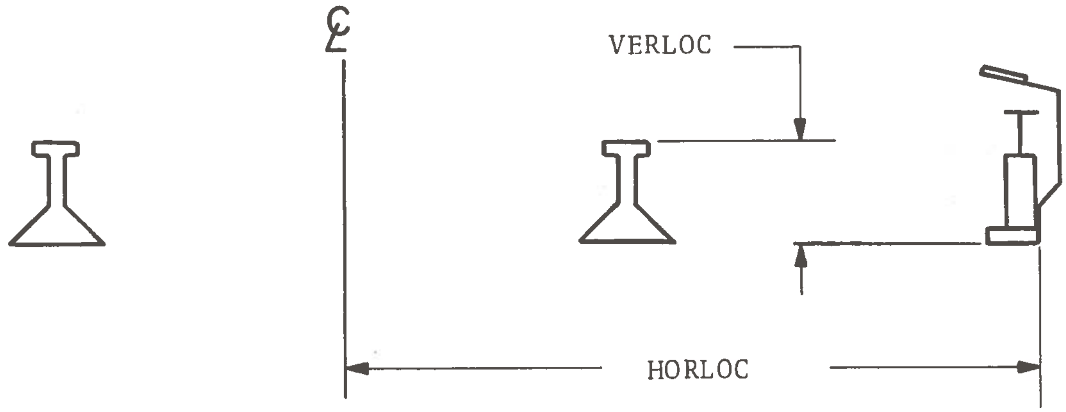


Figure 2-3. HORLOC and VERLOC

2.2.4 VERLOC

The vertical location of the contact rail is the vertical distance from the top of the rails to the bottom of the contact rail. This distance is required for finding the first critical point. (See Figure 2-3.)

2.2.5 Radius

The radius is the radius of the track curve. This is the only input that must be given in feet. If the value inputted is greater than 10,000 ft, the track is assumed to be straight.

2.2.6 Length

Length is the overall car length. (See Figure 2-4.)

2.2.7 AXDIST

AXDIST is the distance between the axles of the trucks of each car. (See Figure 2-4.)

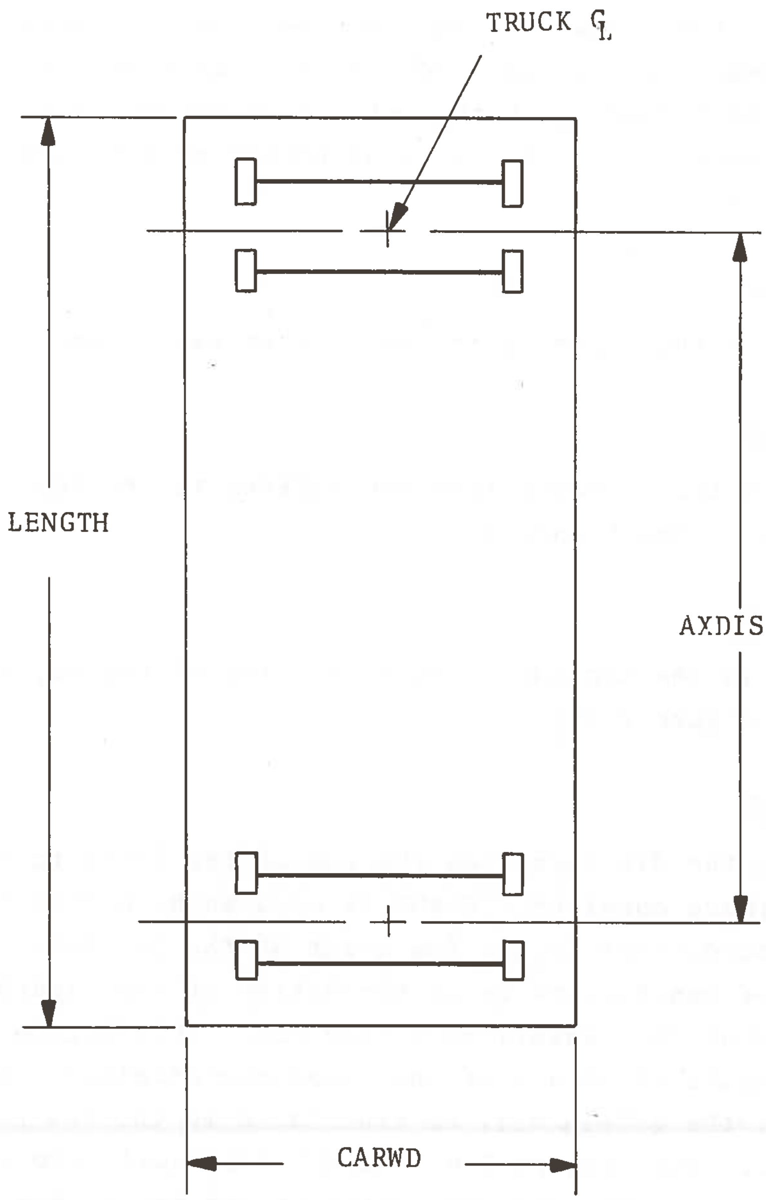


Figure 2-4. AXDIST and CARWD

2.2.8 WALKHT

In order to find the second and third critical points, it is necessary to know the distance from the top of the adjacent rail to the top of the walkway. Two cases must be considered: first, with the walkway on the same side as the center of the curve of the track, and second, with the walkway on the opposite side. However, in both cases, the value of WALKHT must be the same. (See Figure 2-5.)

2.2.9 FOOTWD

FOOTWD is the width of the service walkway. (See Figure 2-5.)

2.2.10 STAND

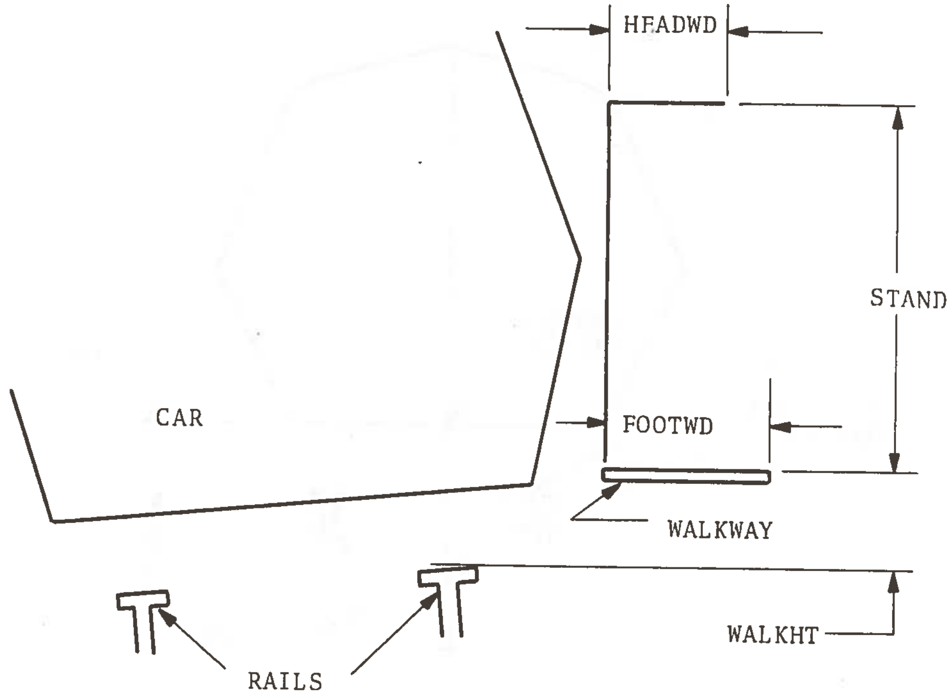
STAND is the distance from the walkway to the top of the walkway envelope. (See Figure 2-5.)

2.2.11 HEADWD

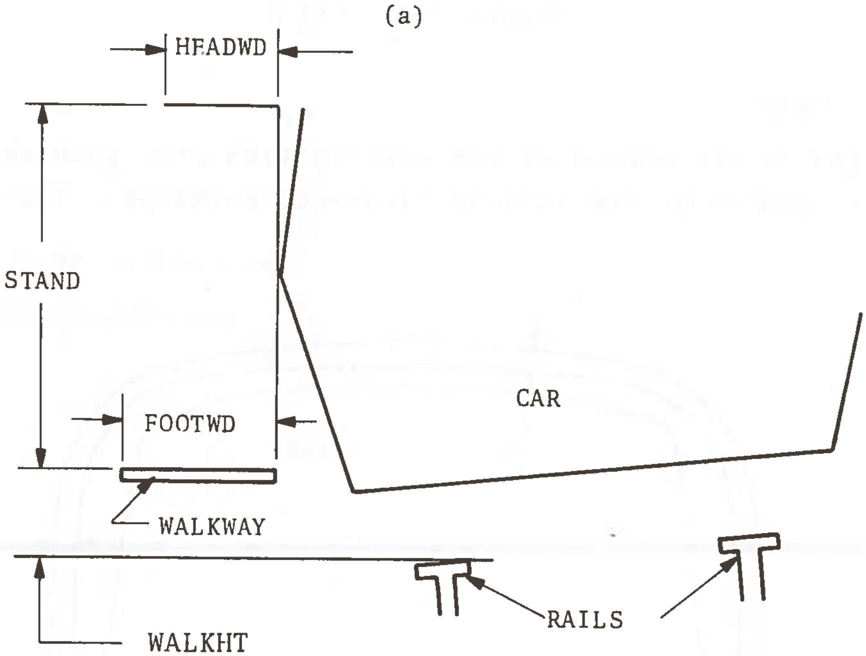
HEADWD is the minimum width of the top of the walkway envelope. (See Figure 2-5.)

2.2.12 CARHT

This is the distance from the top of the rails to the bottom of the clearance envelope. CARHT is used to help translate the origin of coordinates to the low point of the low rail. Initially, the origin of coordinates is at the bottom of the clearance envelope and at the centerline of the car. This origin is used to locate the critical points of the clearance envelope. Later in the program, the origin will be translated to the low point of the low rail. (See Figure 2-6.) CARHT may equal zero if, for instance, the clearance envelope begins at the top of the rails.



(a)



(b)

Figure 2-5. WALKHT, FOOTWD, STAND, and HEADWD
(a) Walkway on Opposite Side of Curve Center
(b) Walkway on Same Side of Curve Center

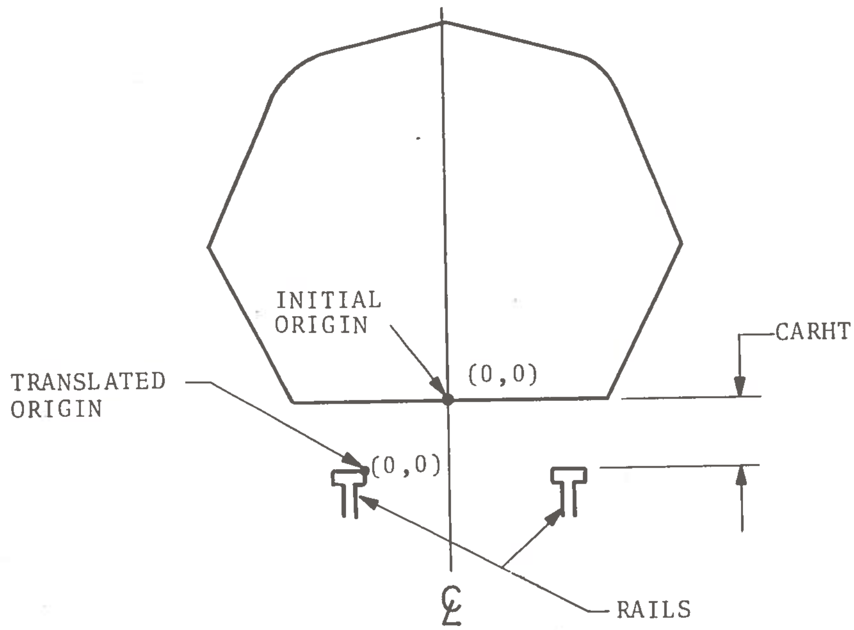


Figure 2-6. CARHT

2.2.13 CLEAR

CLEAR is the amount of the construction plus running clearances allowed about the vehicle clearance envelope. (See Figure 2-7.)

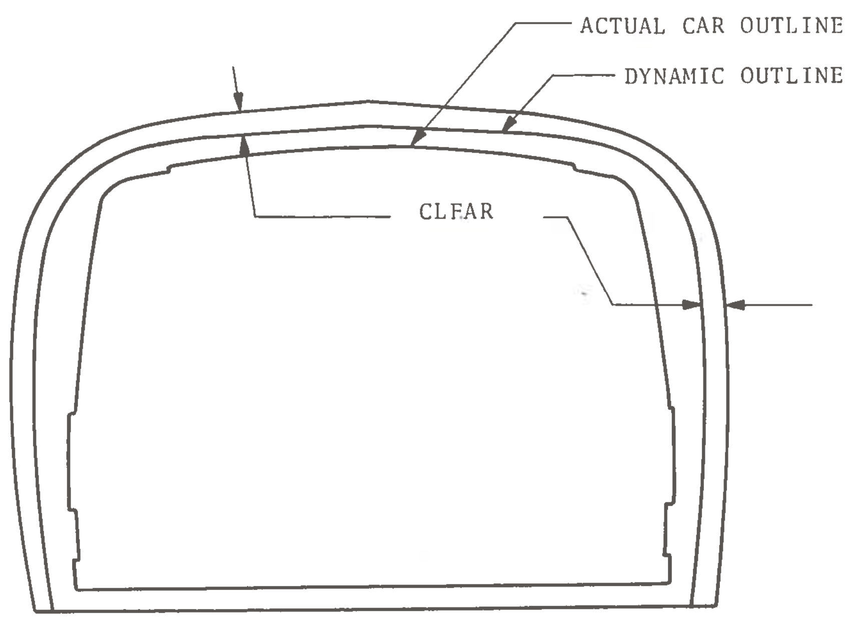


Figure 2-7. CLEAR

2.2.14 WLKCLR

Walkway envelope clearance is the maximum distance that the clearance envelope can come to the edge of the walkway when the walkway is on the opposite side of the car as the center of the curve. (See Figure 2-8.)

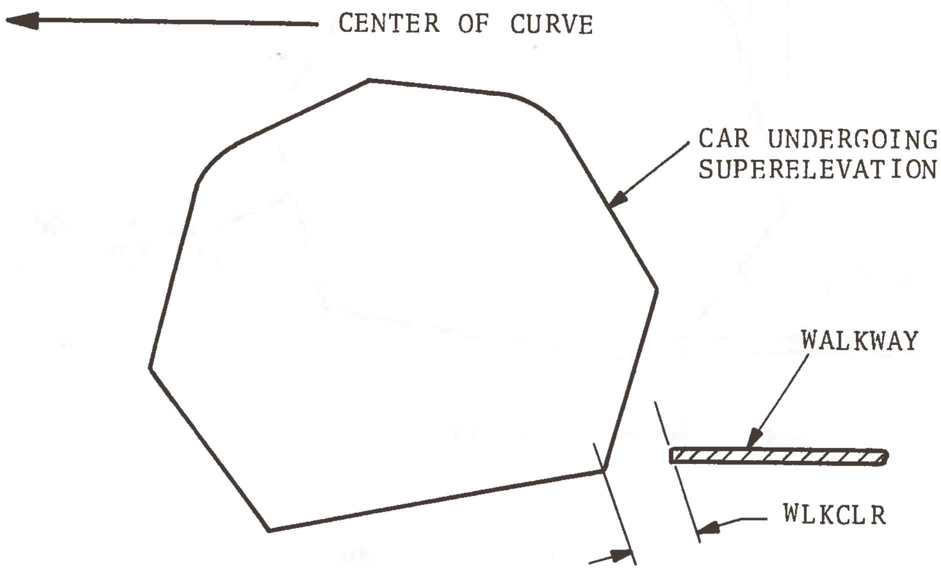


Figure 2-8. WLKCLR

2.2.15 ENCRCH

The maximum walkway envelope encroachment is the maximum distance that the clearance envelope of the car may encroach upon the walkway envelope. ENCRCH may equal zero or have a negative value. (See Figure 2-9.)

2.2.16 TRDCLR

The service walkway tread clearance is essnetially the same as WLKCLR. The only difference is that TRDCLR refers to the walkway on the same side of the car as the center of the curve. (See Figure 2-9.)

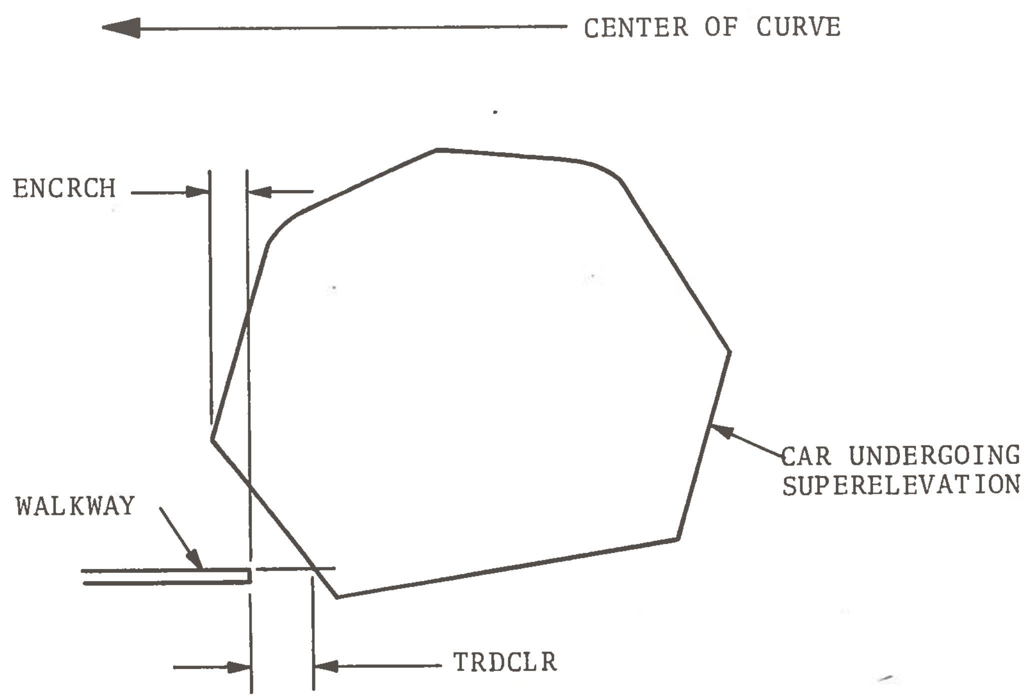


Figure 2-9. ENCRCH and TRDCLR

2.2.17 ACOUST

If the tunnel under consideration is to be treated with an acoustical material, ACOUST is its thickness in inches. (See Figure 2-10.)

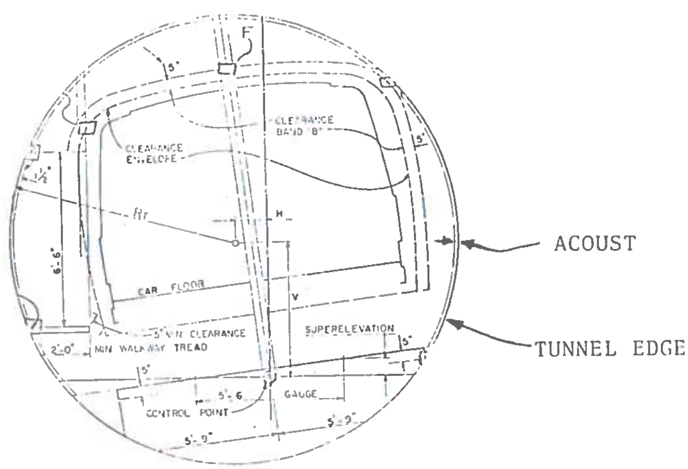


Figure 2-10. ACOUST

2.2.18 MAXHT

The maximum height of the top of the car is the distance from the bottom of the clearance envelope to the top of the car. The value of MAXHT must be taken at the axis of symmetry of the car. (See Figure 2-11.) The program cannot allow the point of MAXHT to be off center. In addition, there must be only one point that has the value MAXHT; that is, the roof cannot have a flat spot. For instance, the cars shown in Figure 2-11a and b are not acceptable, but that of c is.

2.2.19 CARWD

CARWD is the maximum width of the car. (See Figure 2-4.)

2.2.20 J

J determines the option in use for finding the centers of the circles describing the upper corners of the car and for determining the shape of the clearance envelope of the car. The choice is between option one and option two.

Numeral one or two must be typed in the second column of the data card and must be in integer format.

2.2.20.1 Option One Data - Option one uses five data points to describe the clearance envelope of the car: the bottom left corner point, the extreme left side point, and three points on the upper corner curve. Note that the origin of coordinates is at the bottom of the clearance envelope and at the centerline of the car. The input data should be given as cartesian coordinates. (See Figure 2-11.) The top point of the car has already been specified by MAXHT. Note that the side and top are not necessarily tangent to the corner circle. It may be advisable to magnify the corner portion of the envelope and drawing to increase the accuracy of the coordinate values of the three corner points.

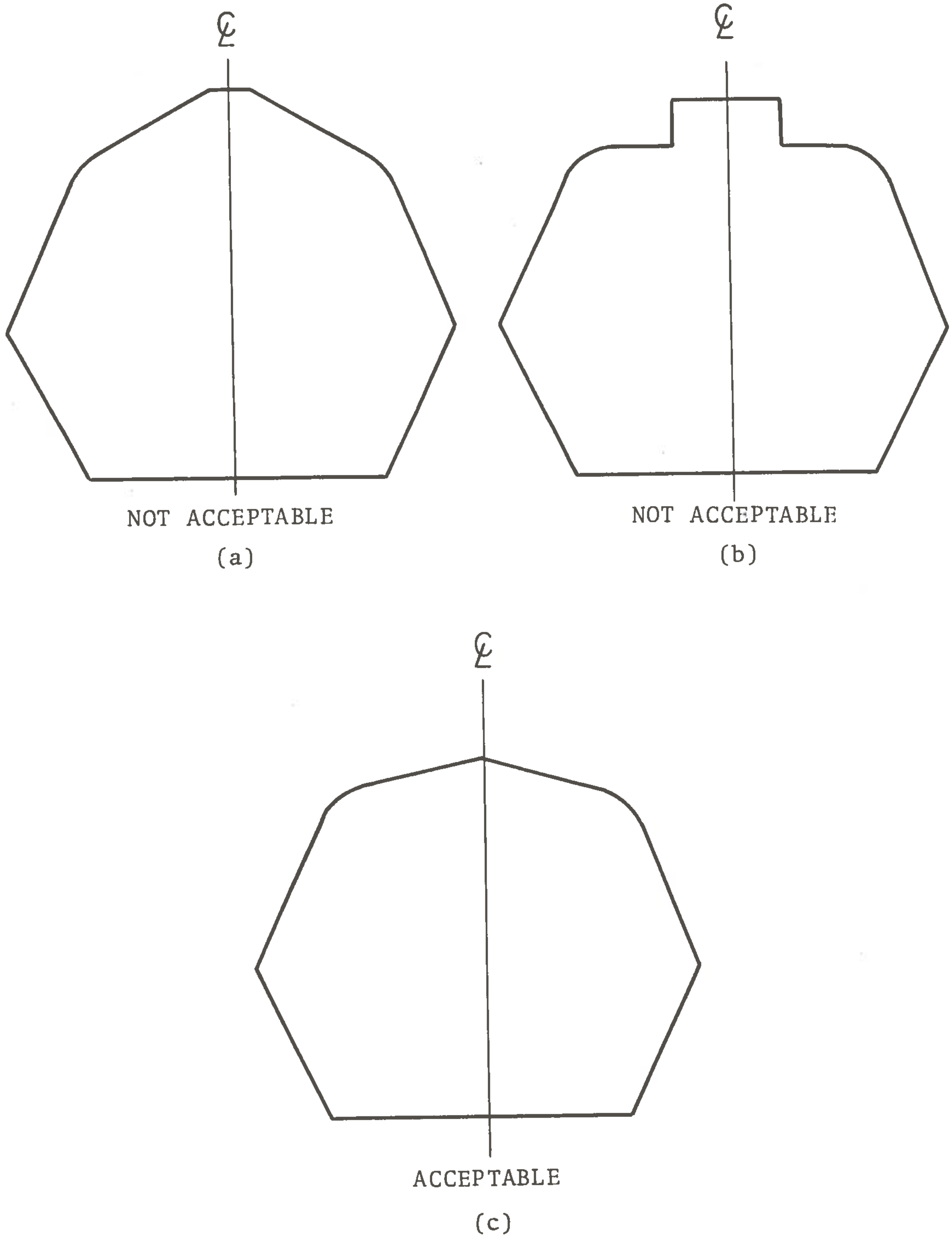


Figure 2-11. MAXHT and J

2.2.20.2 Option Two Data - Option two uses six dimensions in defining the clearance envelope of the car. These dimensions are: the width of the envelope at the bottom (WEB), width of the envelope at the extreme side (WEES), the height of the envelope at the extreme side (HEES), the slope of the side of the car (SIDSLP), the slope of the top of the car (TOPSLP), and the radius of curvature of the upper corner curve (CORRAD). Note that the upper corners are approximated as circles. (See Figure 2-12.)

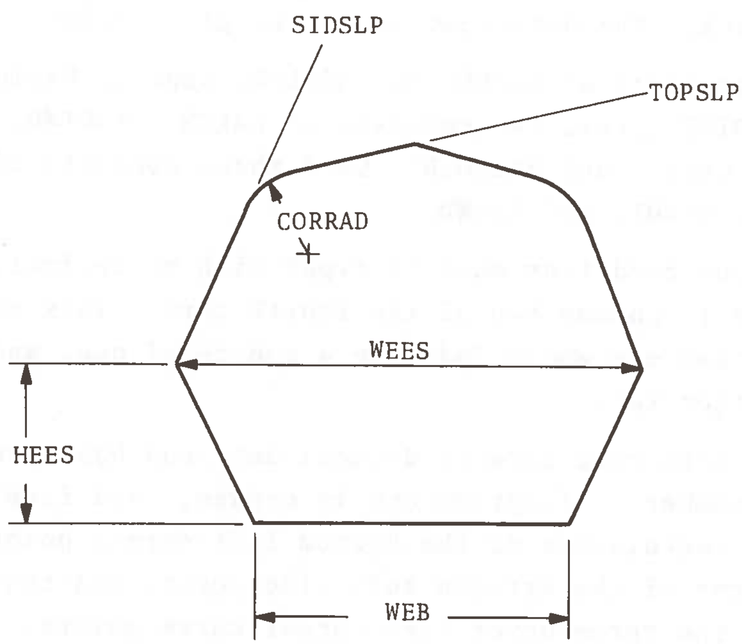


Figure 2-12. J — Option Two Data

These circles will automatically be tangent to the top and sides of the envelope. CORRAD may be estimated by finding the intersection of lines perpendicular to the top and side which pass through the apparent tangency points. The intersection will be the center of the corner circle.

2.2.21 L

The final input operates a continuation option. If '99' is typed in the first two columns of a data card, the program will return to the beginning to accept more data for another run. Any other numbers will cause the program to terminate execution.

The data are divided into six sections. Each section has its own data card. It is important that each piece of data be typed in the proper order and in the proper position. Failure to enter the data correctly will result in numerous error messages.

The data for the first three cards must be typed in real format; that is, each piece of data must have a decimal point (e.g., 3.1, 70., .12). Each variable has been allocated seven places on the data card and each place must be filled with a number or a blank. The data must be in the given order.

Card one consists of GAUGE, SE, HORLOC, VERLOC, RADIUS, LENGTH, and AXDIST. Card two consists of WALKHT, FOOTWD, STAND, HEADWD, CARHT, CLEAR, and WALKCLR. Card three consists of TRDCLR, ENCRCH, ACOUST, MAXHT, and CARWD.

The data for card four must be typed with no decimal. A one or two is typed in column two of the fourth card. This card gives a value to J; thus one would indicate a choice of one, and two, a choice of option two.

The fifth data card accepts decimal data and has seven columns for each number. If option one is chosen, card five consists of the x and y coordinates of the bottom left corner point, the x and y coordinates of the extreme left side point, and the x and y coordinates of the three upper left corner curve points.

If, on the other hand, option two is selected, card five should consist of WES, WEES, HEES, SIDSLP, TOPSLP, and CORRAD.

The sixth card is used to return to the beginning of the program if an additional run is desired. If another run is needed, card six will have a nine typed in columns one and two. Any other number will result in the termination of the execution of the program.

If card six has nines typed in columns one and two, each data element must again be inputted, and thus there will be six more cards after the card with the nines.

If card six has something besides nines in column one, no more data is required.

An example of the data input appears in Figure 2-13.

```
CARD NO.

    GAUGE    SE    HOFLOC VERLOC RADIUS LENGTH  AXDIST
    66.0    8.25   69.0   5.0    500.0  840.0   600.0

    WALKHT FOOTWD  STAND HEADWD CARHT  CLEAR WLKCLR
2   24.0   24.0    78.0  20.0   25.0   5.0   2.0

    TRDCLR ENCRCH ACOUST MAXHT  CARWD
3    5.0   3.0     1.5   105.0  140.0

    OPTION NUMBER ONE
4    1

    OPTION ONE DATA
5   -67.0  0.0   -70.0  43.0   -67.25  83.0  -60.0  95.0  -48.0   100.5

    RETURN OPTION-RETURN
6   99

    GAUGE    SE    HOFLOC VERLOC RADIUS LENGTH  AXDIST
1   66.0    0.0    69.0   5.0    500.0  840.0   600.0

    WALKHT FOOTWD  STAND HEADWD CARHT  CLEAR WLKCLR
2   24.0   24.0    78.0  20.0   25.0   5.0   2.0

    TRDCLR ENCRCH ACOUST MAXHT  CARWD
3    5.0   3.0     1.5   105.0  140.0

    OPTION NUMBER TWO
4    2

     WEB   WEEB   HEES   SIDSLP TOPSLP CORRAD
5   134.0  140.0  43.0   21.0   0.11   24.0

    RETURN OPTION-END
6   00
```

Figure 2-13. Data Input

2.3 OUTPUTS

The program will first print out all the input data. Then, the values calculated through the program will be listed.

In the output of the calculated values, an H and a V will be listed. These are the horizontal and vertical distances from the control point to the center of the circle defining the tunnel. The control point is defined as the intersection of the axis of symmetry of the car and the horizontal line tangent to the top of the low rail. (See Figure 2-14.)

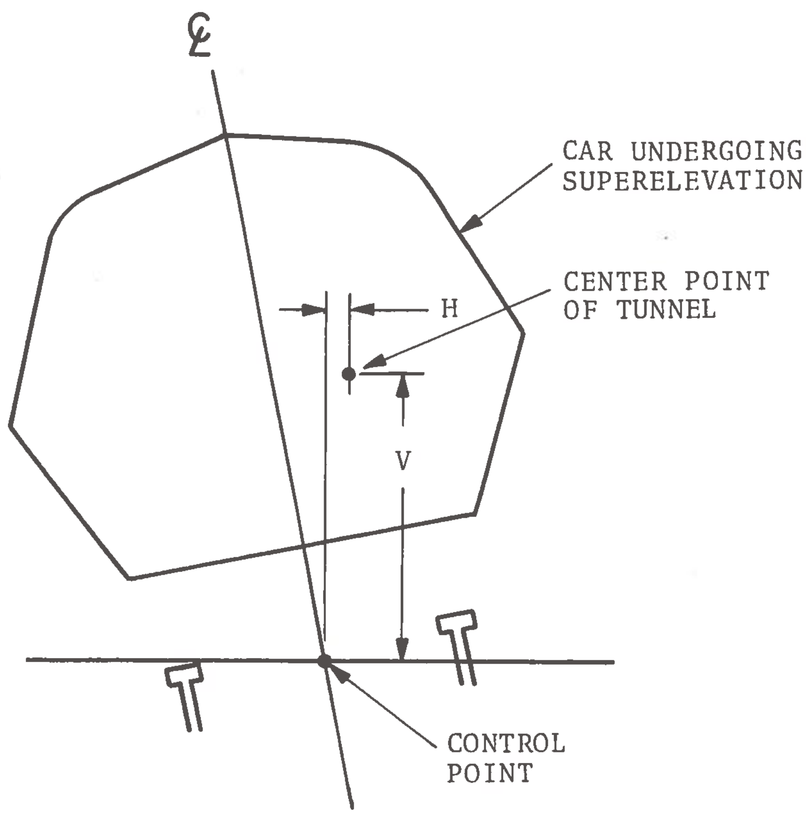


Figure 2-14. Outputs

3. DEFINITION OF VARIABLES

This section, in conjunction with the flowcharts (Section 4) and the Program Listing (Section 5), is intended as documentation for computer programmers. A list of definitions of the variables used in the tunnel diameter computer program is presented in Tables 3-1 to 3-4. References are given to figures in Section 2 (the User's Manual) which illustrates the input variables. Certain variables used in the body of the program are illustrated by additional figures. (See Figures 3-1 to 3-7.) Special reference numbers are also given which indicate the statement sequence number in the computer program where each variable is initially used. These reference numbers appear under the column "REF" in the list of variables. A brief definition accompanies each variable.

TABLE 3-1. DEFINITION OF VARIABLES, MAIN PROGRAM

SYMBOL	FIGURE NO.	REFERENCE	DEFINITION
GAUGE	2-1	1	Gauge of railway
SE	2-2	1	Superelevation
HORLOC	2-3	1	Horizontal location of contact rail
VERLOC	2-3	1	Vertical location of contact rail
RADIUS		1	Radius of track curve, in feet.
LENGTH	2-4	1	Overall car length
AXDIST	2-4	1	Distance between center of tracks
WALKHT	2-5	2	Height of walkway above adjacent rail
FOOTWD	2-5	2	Minimum width of walkway
STAND	2-5	2	Height of walkway envelope
HEADWD	2-5	2	Width of top of clearance envelope
CARHT	2-6	2	Height of clearance envelope above rails
CLEAR	2-7	2	Amount of construction clearance
WLKCLR	2-8	2	Walkway envelope clearance
TRDCLR	2-9	3	Walkway tread clearance
ENCRCH	2-9	3	Max.walkway envelope encroachment
ACOUST	2-10	3	Acoustical thickness
MAXHT	2-11	3	Maximum height of top of car
CARWD	2-4	5	Maximum width of car
J	2-11, 2-12		Determines option in use: J = 1-option 1 J = 2-option 2
PI	-	7	3.141593
WEB		10	Width at the bottom of the clearance envelope
WEES		10	Width of clearance envelope at extreme side
HEES		10	Height of WEES
SIDSLP		10	Slope of upper left side of the car
TOPSLP		10	Slope of the left top side of the car
CORRAD		10	Upper corner radius. (See Fig. 3-1)
XLC,YLC XLS,YLS SLCNR,YLCNR XRC,YRC XRS,YRS XRCNR,YRCNR		15-20	The symbols XLC, YLC, etc. are used in reference to the clearance envelope of the car. The X and Y refer to the X&Y coordinates of a point; L is left sice of the car, R is the right side. C refers to the lower corner, S to the extreme side, CNR to the center of the circles defining the upper corner circles. This convention will be used throughout the program. T is center top point. (See Fig. 3-2)

TABLE 3-1. DEFINITION OF VARIABLES, MAIN PROGRAM (Continued)

SYMBOL	REF.	DEFINITION
Q1,Q2	21,23	Q's are used to denote the slope of various lines used throughout the program
B1,B2	22,28,32	B's are used in the program to denote the Y intercepts of various lines. Thus lines will be defined by Y=QXX+B
Q1	21	Slope of the upper left side of the car
B1	22	Y intercept of the line describing the upper left side of the car
Q2	24	Slope of the left top side of the car
B2	24	Y-intercept of the line describing the left top side of the car
X1	25	X-coordinate of the point of intersection of the upper left side and the left top side lines
Y1	26	Y-coordinate of the point of intersection of the upper left side and left top side lines
Q3	27	Slope of the line that bisects the angle between side & top lines
B3	28	Y-intercept of the bisector line
R	29	Corner Radius
X2,Y2	30,31	Intersection point of the side line and the X-axis. This is the starting point for the binary search. (See Fig. 3-3)
B4	32	Y intercept of a line perpendicular to the side line through the point X2,Y2
X4,Y4	33,34	Point of intersection of the bisector line and the perpendicular line
D	35	Distance between (X2,Y2) and (X4,Y4).

TABLE 3-1 . DEFINITION OF VARIABLES, MAIN PROGRAM (Continued)

SYMBOL	REF.	DEFINITION
X2,X2	38,39	New starting point
X3,Y3	42,43	The point midway between (X1,Y1) and (X2,Y2)
B4	44	Y intercept of the line perpendicular to the side line through the point (X3,Y3)
X4,Y4	45,46	Point of intersection of the bisector line and the perpendicular line
D	47	Distance between (X3,Y3) & (X4,Y4)
	(See Fig. 3-3)	
XLCI,YLCI	62,623	Storage for XLC and YLC
XRCI,YRCI	626,629	Storage for XRC and YRC
A,B,C	74-76	Used for the calculation of END and ID
RD	77	Radius of Curve in inches
ID	78	Overhang of the middle of the car
END	79	Overhang of the end of the car
TXLC,etc.	91-1019	The translated coordinates of the various points of the clearance envelope. The origin of coordinates is moved to the low point of the low rail.
K	102	Variable used to which side of curve the walkway is on: K=1-walkway on same side as center of curve K=2-walkway on opposite side
PHI	108	Angle of superelevation
BVL	125,130	Boolean variable BVL=1 when K=1 BVL=-when K=2
U	126	length from low point of low rail to end of contact rail opposite walkway
AX,AY	127,128	(X,Y) coordinates of point A
BX,BY	134,1354,1358,137,145	X,Y coordinates of point B
CX,CY	146,147	X,Y coordinates of point C
DX,DY	152,153,157,158	X,Y coordinates of point D
EX,EY	154,155,159,160	X,Y coordinates of point E
FX,FY	148,149	X,Y coordinates of point F
TEMP	135	The distance from the corner of the car to the edge of the walkway. Used to find point B when walkway is on opposite side

TABLE 3-1 . DEFINITION OF VARIABLES, MAIN PROGRAM (Continued)

SYMBOL	REF.	DEFINITION
Q	138	Slope of the botton left side line
B	139	Y intercept of the botton left side line
X1	140	X coordinate of the point on the bottom left side line whose Y valve is the height of the walkway above the adjacent rail (WALKHT).
XA	141	One of the extreme points that will determine the valve of BX. This one is located at the bottom of the walkway
XB	142	Another extreme point for determining point BX. This one is the extreme side point of the car.
	(See Fig. 3-4)	
G	1421	Distance between the left side point and the center of the upper left corner.
PSI	1422	The angle between the upper left side line of the clearance envelope and the line connecting the left side point and the upper left corner
THETA	1423	The angle between the X axis and the line connecting the upper left corner and the left side point.
V1	1424	The slope of the upper left side line.
V2	1425	The slope of the line perpendicular to the upper left side line.
BT	1426	Y intercept of the upper left side line of the clearance envelope
BR	1427	Y intercept of the line perpendicular to the upper left side line through the center of the upper corner.
XLT,YLT	1428,1429	The coordinates of the point of intersection of the upper side line and a line perpendicular to it through the center of the upper circle.
XC		The last critical point used in finding BX when the walkway is on the same side. This one is located at the extreme upper side point.
	(See Fig. 3-5)	

TABLE 3-1 . DEFINITION OF VARIABLES, MAIN PROGRAM (Concluded)

SYMBOL	REF.	DEFINITION
P	1643,1663,1683 1703	Temporary location of the Smallest feasible tunnel radius found.
XO,YO	1646,1649,1666,1669 1686,1689,1706,1709	The temporary location of the Coordinates of the center of the smallest feasible tunnel radius found.
D	1753 4 others	Temporary storage location of the smallest feasible tunnel radius found.
DR(K)	1955	Smallest feasible tunnel radius given in feet, as found under the Kth trial
DA(K),DB(K),	197-202	Distance from the center of the tunnel to each of the points A through F, as found under the Kth trial given in feet.
H(K)	206	Horizontal distance from control point to the center of the tunnel found
V(K)	207	Vertical distance from control point to the center of the tunnel found. Given in feet.

TABLE 3-2. DEFINITION OF VARIABLES – SUBROUTINE PCHK
TUNNEL – JOB NO. 10520-001

SYMBOL	REF.	DEFINITION
Q1	304	Slope of the line connecting (DX,DY) and (EX,EY)
B1	305	Y intercept of the line connecting (DX,DY) and (EX,EY)
X1,Y1	307,308	Midpoint of the line y=Q1X+B1
R	314,3163	Maximum distance along the perpendicular to the line y=Q1X+B1 that will be considered.
B2	316	Y intercept of the line perpendicular to y=Q1X+B1 at the point (X1,Y1)
X3,Y3	3164,3165,322,323	One of the starting points along the perpendicular. This point is at a distance R from (X1,Y1).
X4,Y4	3166,3167 326,323	The other starting point on the perpendicular. This point is at a distance R from (X1,Y1), but in the opposite direction from (X3,Y3)
A,B,C	319-321	Coefficient used to find the point (X3,Y3) and (X4,Y4)
X,Y	325,326	The first point considered for the center of the tunnel. eventually it will be the location of the center when the binary search has ended
D1	329	Distance from (X,Y) to the perimeter of the upper edge of the clearance envelope on the D side
D2	330	Distance from (X,Y) to the point (XA,YA). Note that (XA,YA) can be any of A,B,C or F.
	(See Fig. 3-6)	
D3	339,341,343	Distance from (X,Y) to the remaining points
DT	347,350	Storage location of the smallest tunnel radius found to this point.
XT,YT	348,349 352,353	Storage location of the Center of the smallest tunnel found to this point

TABLE 3-3. DEFINITION OF VARIABLES — SUBROUTINE CIRCLE & COMP — JOB NO. 10520-001

SYMBOL	REF.	DEFINITION
A,B,C,D,E,F	402-407	Coefficients used to determine the center and radius of the circle described by three points
X,Y	408,409	Coordinates of the center of the circle
R	410	radius of the circle determined by the three points
D	421	Distance from the center of the inputed circle to one of A,B,C, or F.
D	424,426	Distance from the center to the perimeter of the upper edge of the clearance envelope on the D and E side
TRAD	429,433	Temporary location of the smallest tunnel radius found to this point
XTEMP,YTEMP	430,431 434,435	Temporary location of the center of the smallest tunnel radius found to this point

TABLE 3-4. DEFINITION OF VARIABLES — SUBROUTINE CHECK — JOB NO. 10520-001

SYMBOL	REF.	DEFINITION
Q1	503	Slope of the line connecting (XA,YA) and (XB,YB). These points can be from the set of A,B,C,F .
B1	504	Y intercept of the line connecting (XA,YA) and (XB,YB)
X1,Y1	506,507	Midpoint of the line Y=Q1X+B1= 1
R	513	Maximum distance to be considered, taken on a perpendicular to 1 through (X1,Y1)
A,B,C	518-520	Coefficients used to find the points that are at a distance R from (X1,Y1)
(X3,Y3),(X4,Y4)	521-5227	The points that are at a distance R from (X1,Y1)
X,Y	524,524	The point half way from (X3,Y3) and (X4,Y4) that is the starting point of the binary search. When the search is ended, it will be the center point of the circle
D1	528	Distance from (X,Y) to the perimeter of the upper edge of the clearance envelope on either the D or E side
D2	529	Distance from (X,Y) to the point (XA,YA). Note that (XA,YA) can be any of A,B,C or F.
	(See Fig. 3-7)	
D3	538,541 543	Distance from (X,Y) to the remaining points
D4	539	Distance from (X,Y) to the point (XA,YA)
DTEM	547,561	Storage location of the smallest tunnel radius found to this point
XTEM,YTEM	548,549, 562,563	Storage location of the center of the smallest tunnel found to this point

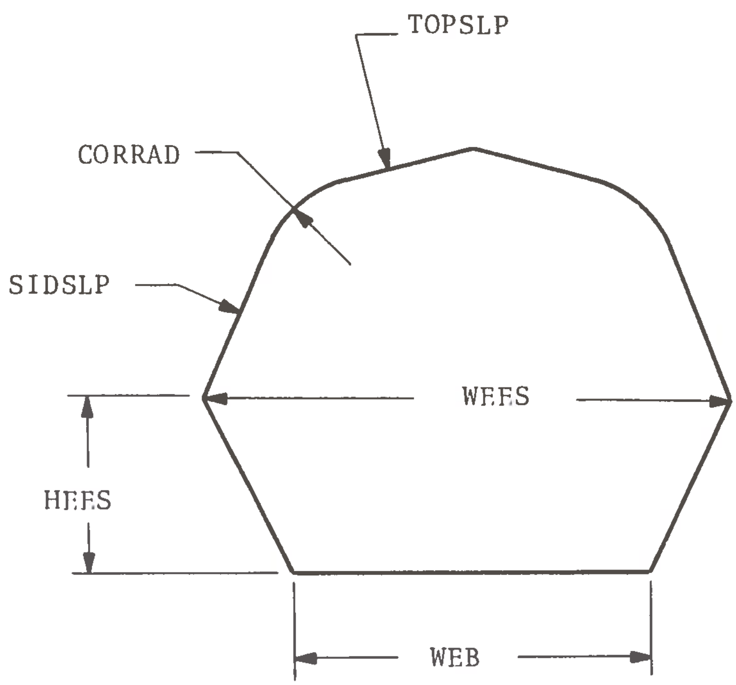


Figure 3-1. Input Data for Option Two

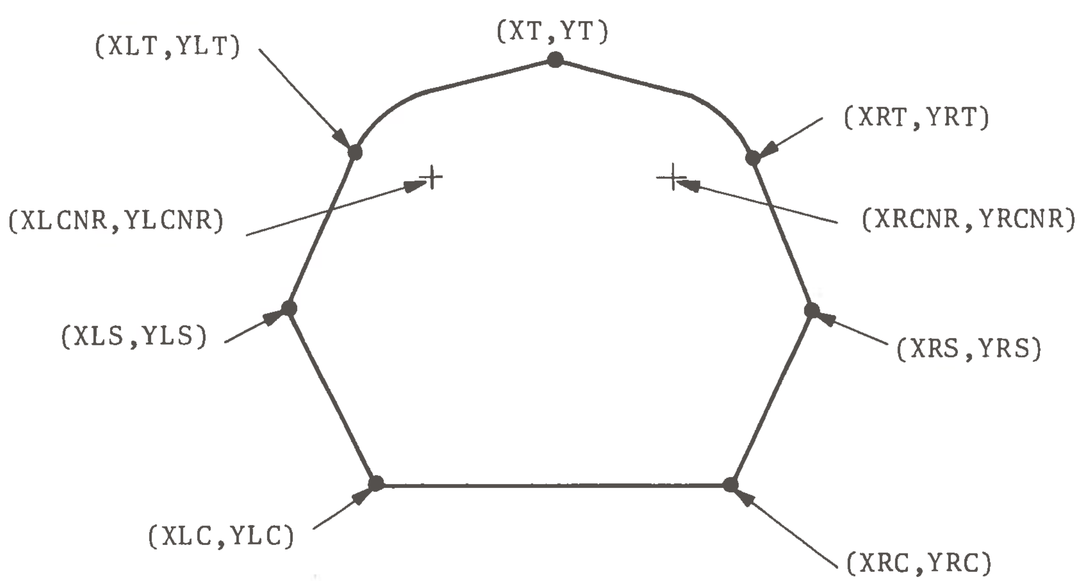


Figure 3-2. Reference Points of the Clearance Envelope on the Car

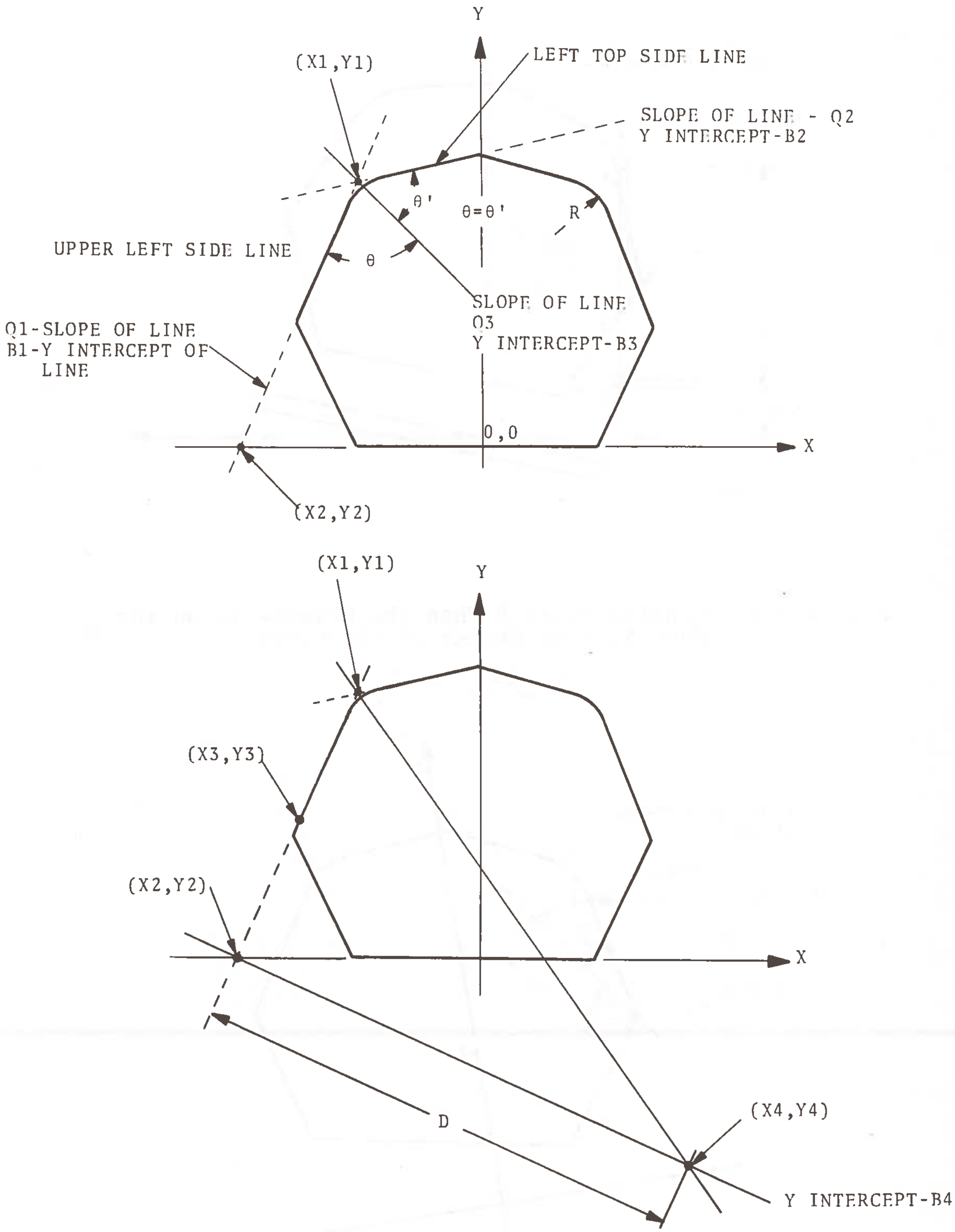


Figure 3-3. Finding (XLCNR, YLCNR) On Option Two

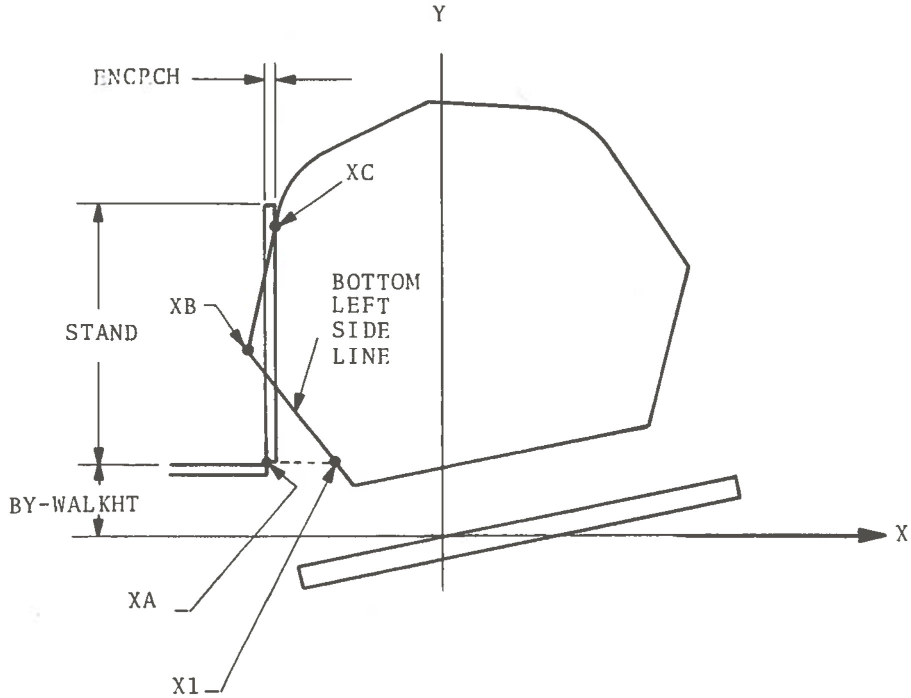


Figure 3-4. Finding Point B When the Walkway Is on the Same Side as Center of the Curve

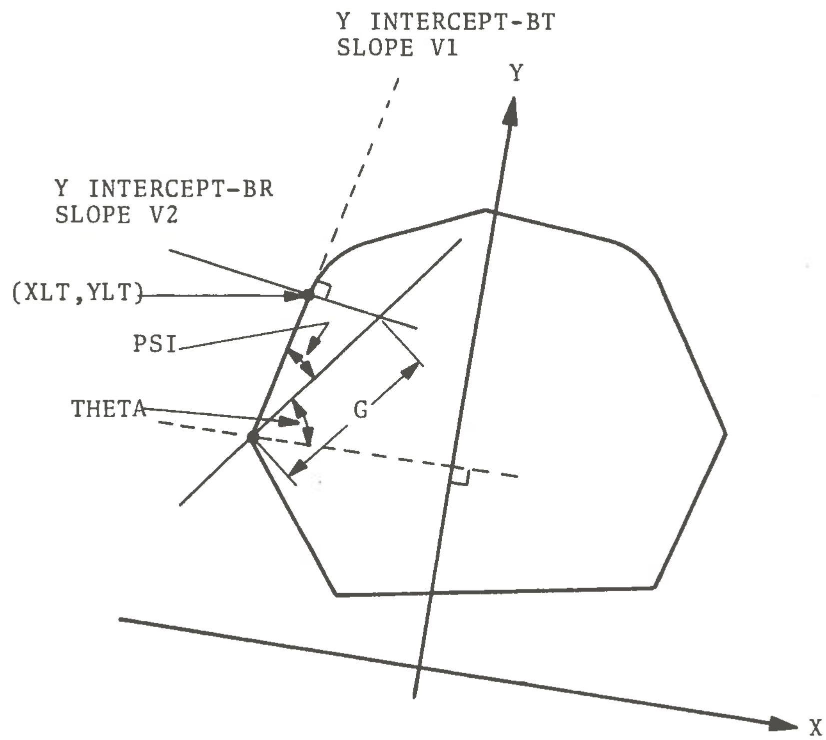


Figure 3-5. Finding Point XC

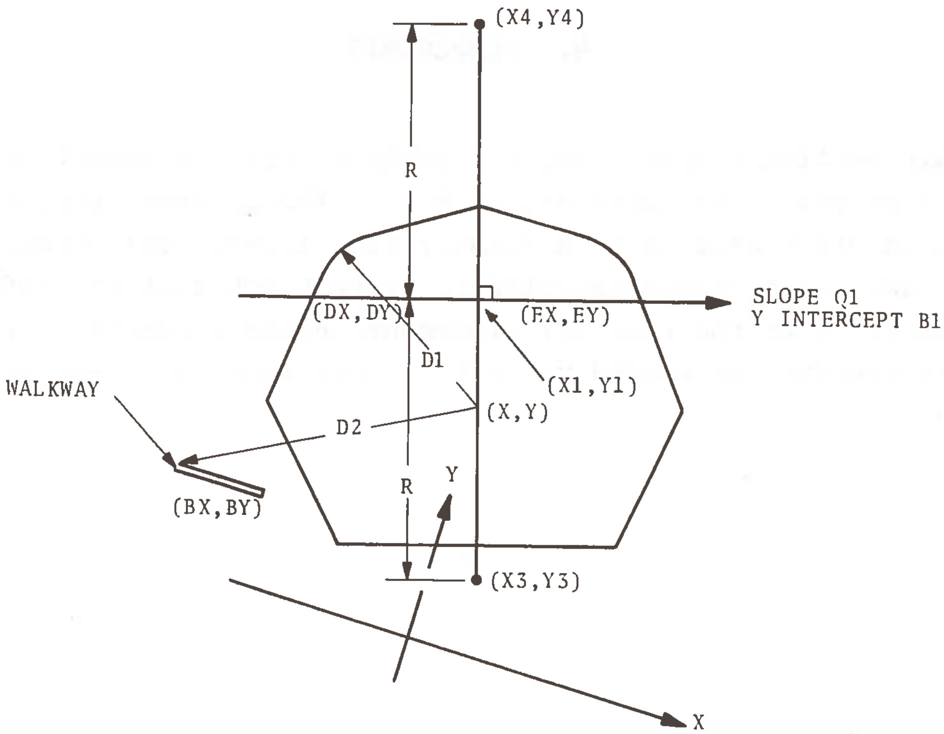


Figure 3-6. Finding Tunnel Center Using Subroutine PCHK

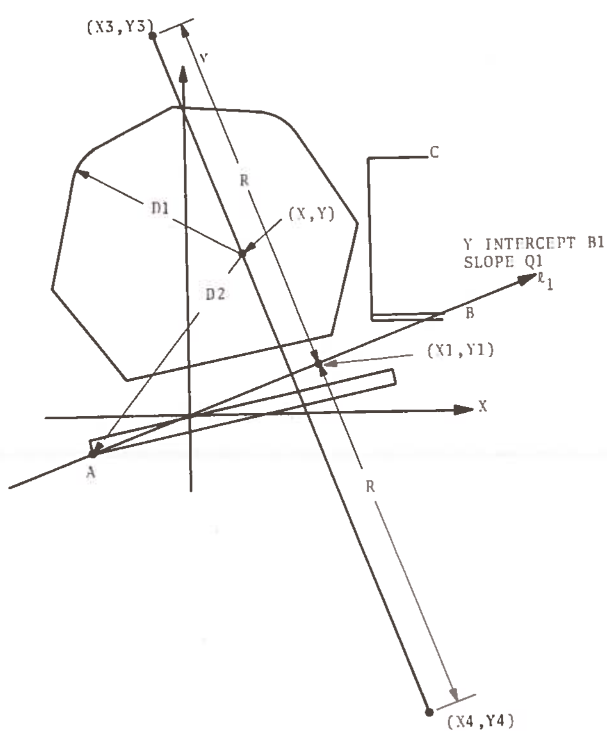


Figure 3-7. Finding Tunnel Center Using Subroutine CHECK

4. FLOWCHARTS

This section presents logic flowcharts for the tunnel diameter computer program (Figures 4-1 to 4-3). The program steps are defined in block diagram form illustrating loops, logic branch points, and input/output operations. Each block contains reference number(s) to the relevant statement sequence number(s) in the computer program corresponding to the operations described in the flowchart.

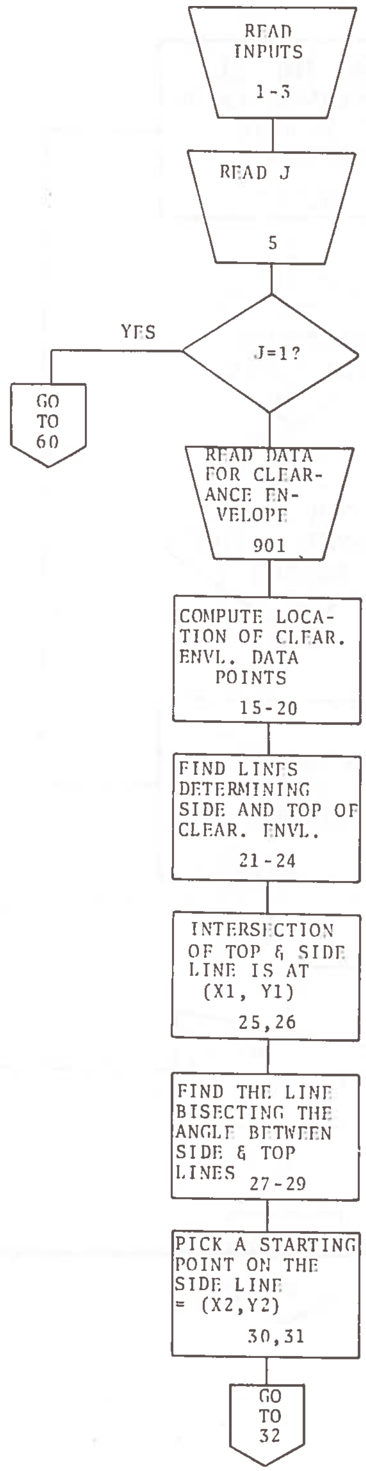


Figure 4-1. Tunnel Diameter Project Flowchart — Main Program

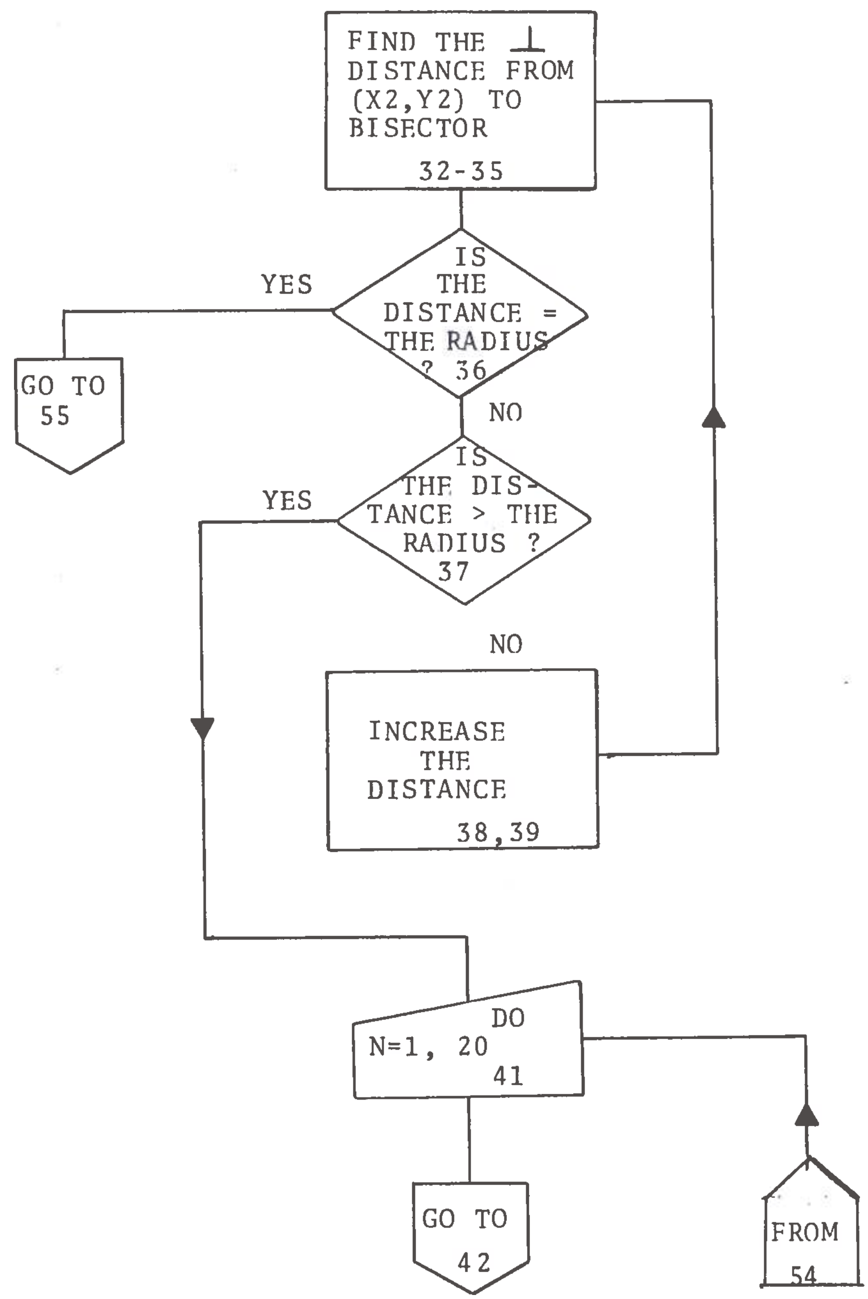


Figure 4-1. Tunnel Diameter Project Flowchart – Main Program (Continued)

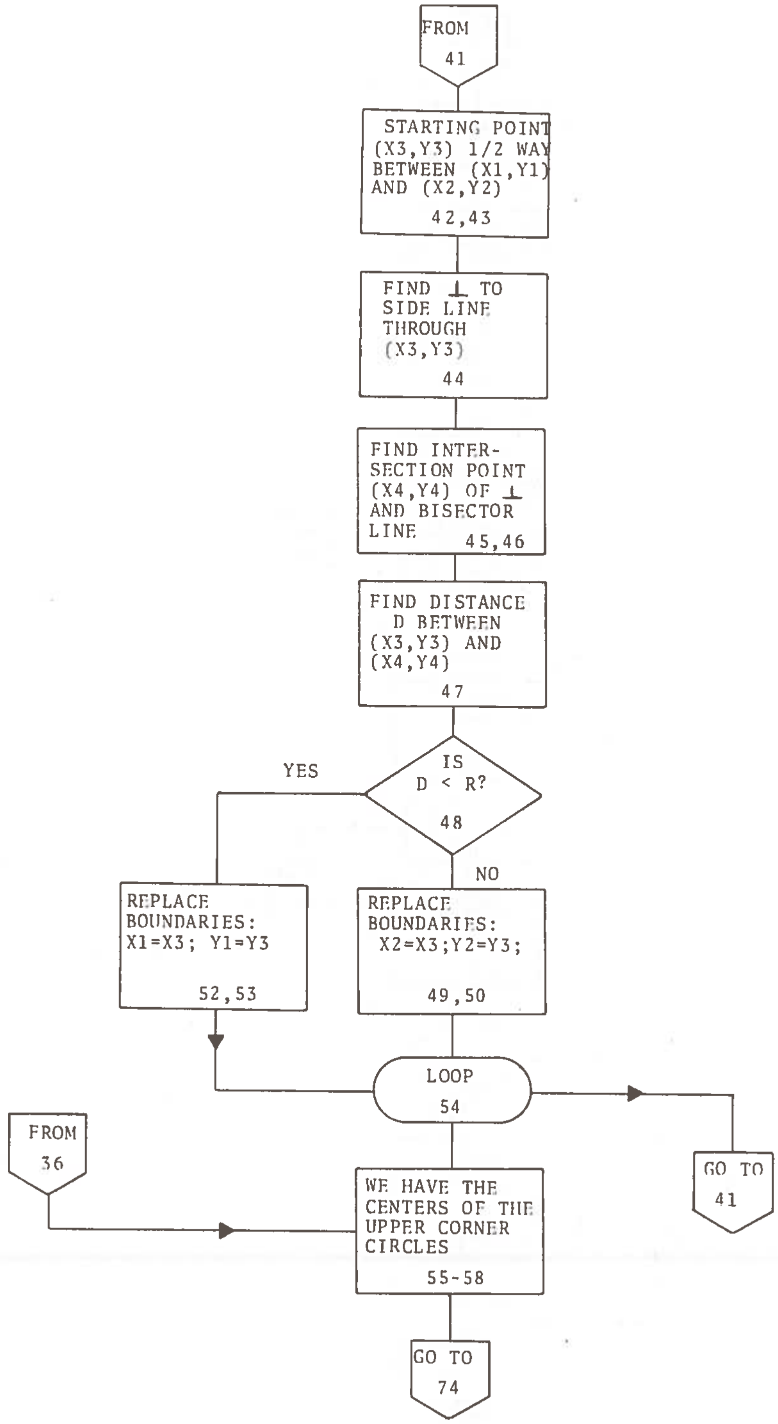


Figure 4-1. Tunnel Diameter Project Flowchart – Main Program (Continued)

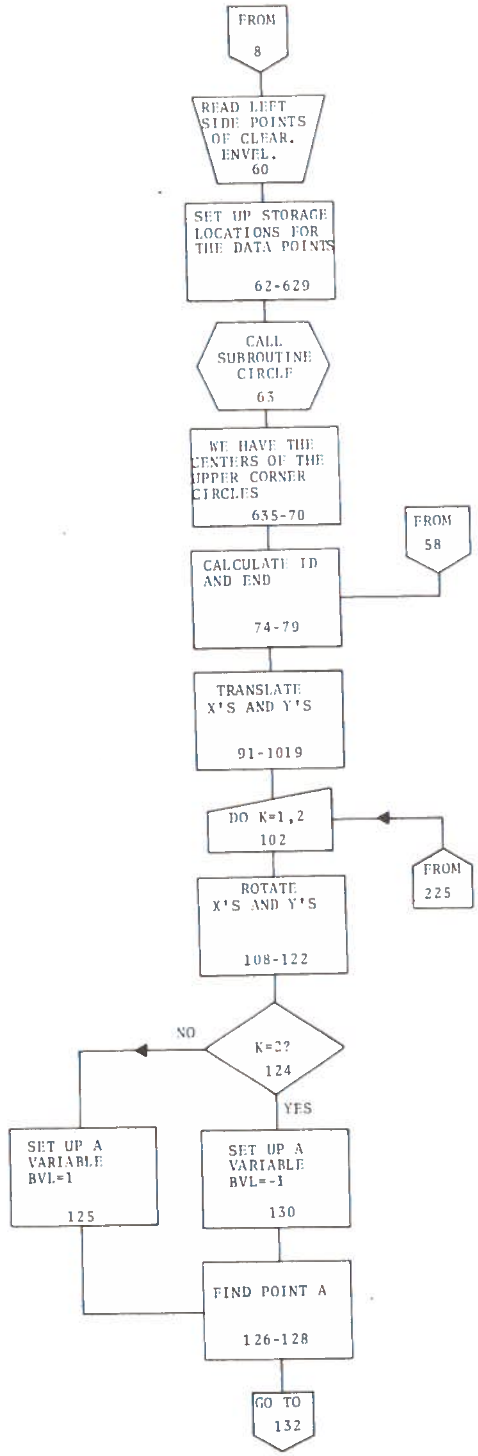


Figure 4-1. Tunnel Diameter Project Flowchart — Main Program (Continued)

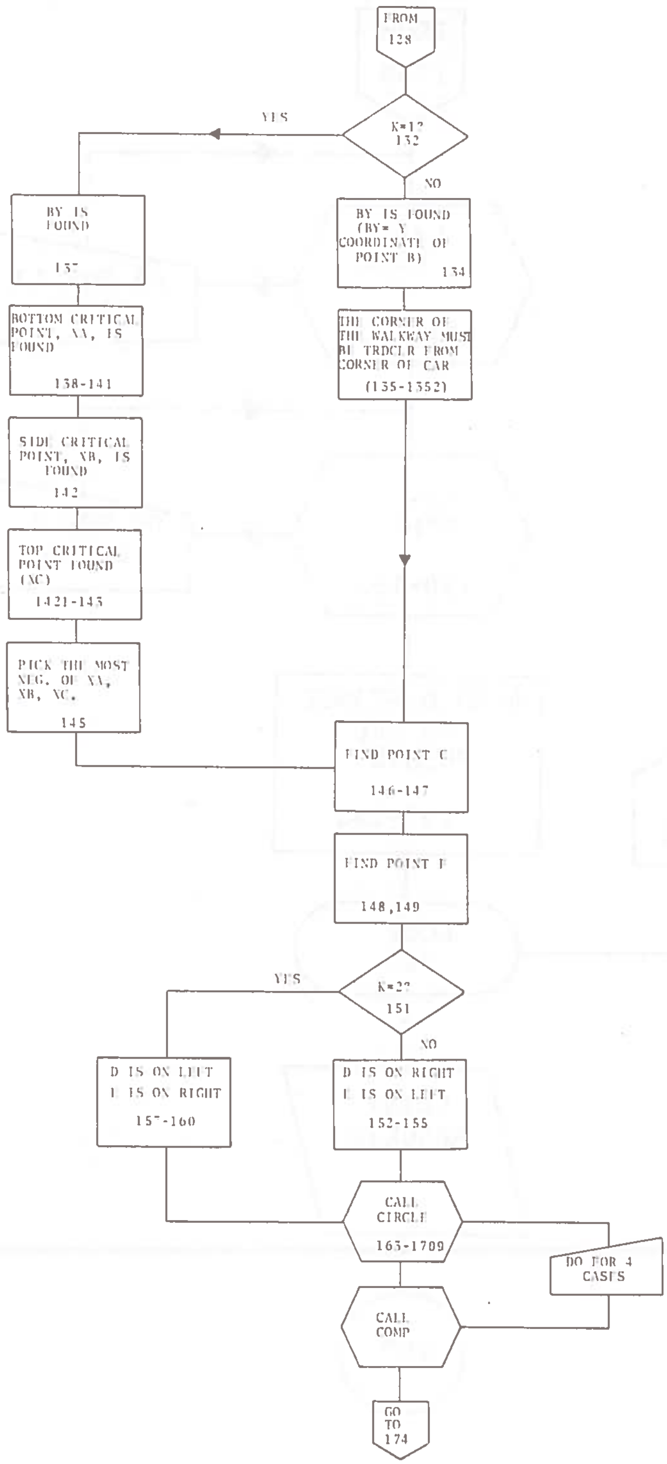


Figure 4-1. Tunnel Diameter Project Flowchart — Main Program (Continued)

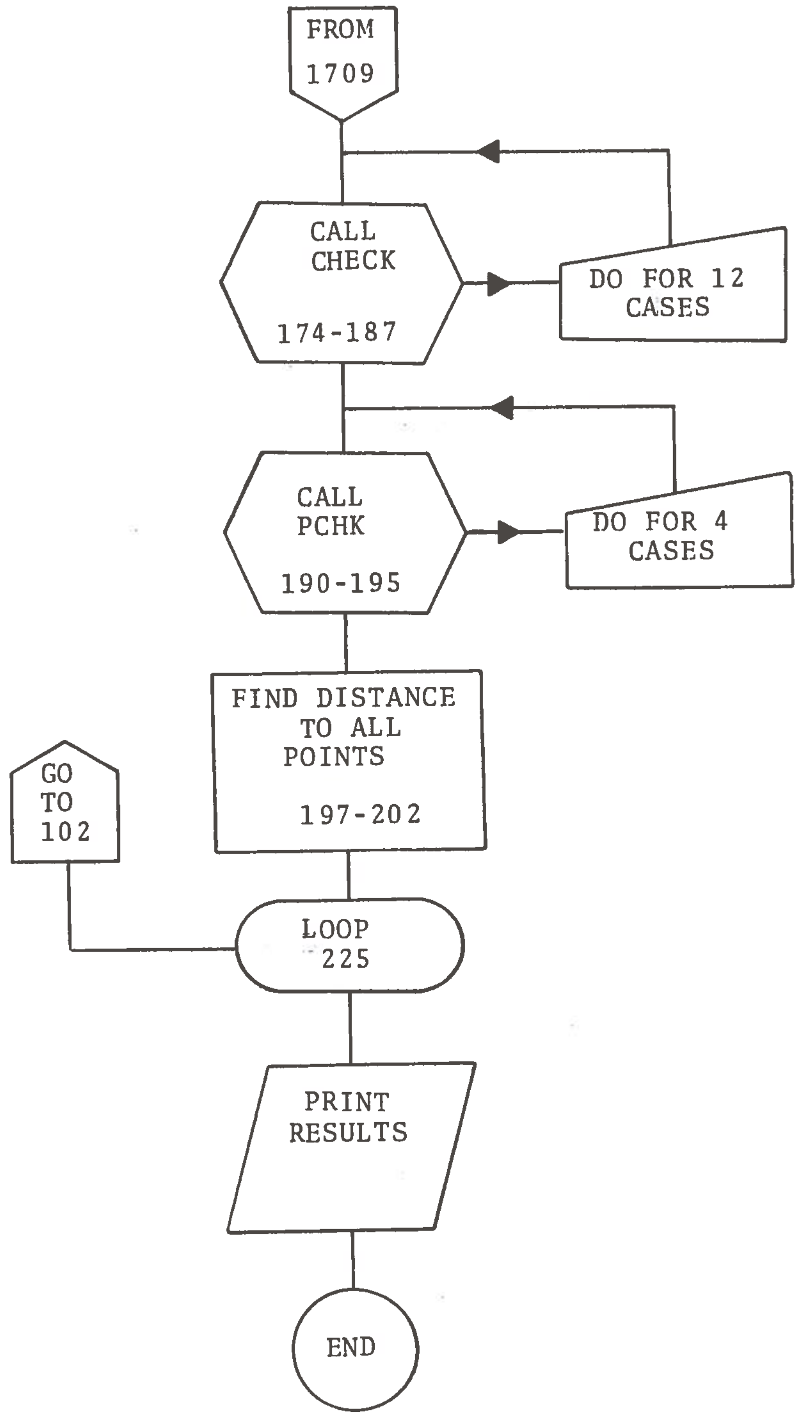


Figure 4-1. Tunnel Diameter Project Flowchart — Main Program (Concluded)

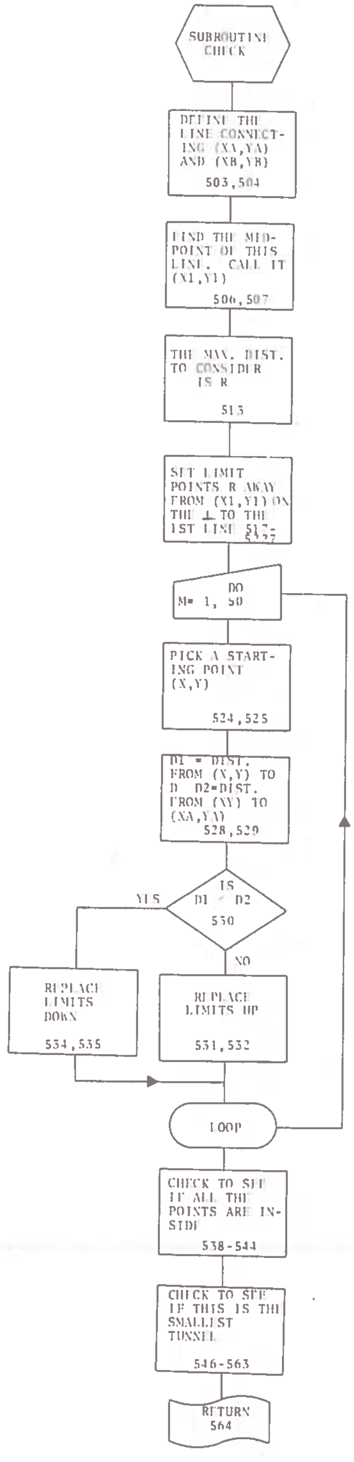


Figure 4-2. Tunnel Diameter Project Flowchart — Subroutine CHECK

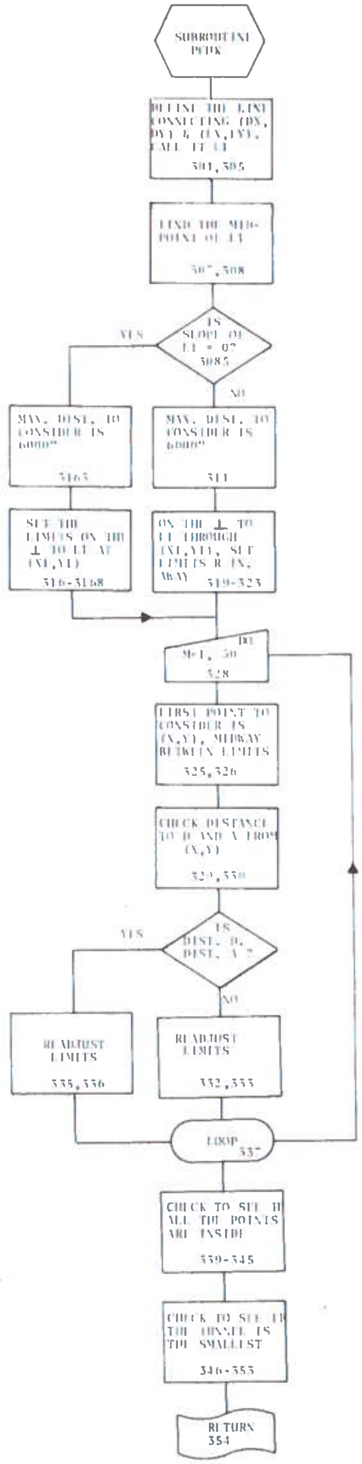


Figure 4-3. Tunnel Diameter Project Flowchart — Subroutine PCHK

5. PROGRAM AND OUTPUT

This is the complete program listing, including comments. This program has been run on an IBM 360/65 under both the Fortran G and WAT V compilers, and is expected to run on any machine with the WAT V (i.e., Univac, Honeywell, CDC) with few, if any, modifications.

The computer outputs are also shown in this section following the program listing. Three cases are presented corresponding to the BART specifications for track curvatures of 500 feet, 1500 feet, and tangent all with superelevation of zero and 8.25 inches.

The computer results fall within the BART specifications: tunnel radii of 8.50 feet and 8.25 feet for the cases 500' and 1500' track curvature radius, respectively. A slight discrepancy (0.19") may be noted in the computer outputs between option one and option two results, which reflects roundoff error as well as slight differences in estimating the corner circle shapes for option one versus option two.

```
      COMMON CORRAD,CLEAR,DA,DY,EX,EY
      DIMENSION [illegible](3),DB(3),DC(3),DD(3),[illegible](3),[illegible](3),[illegible](3),[illegible](3),V(3)
      DIMENSION Y(360),Z(360),AXF(180),AYF(180),[illegible](180),ANE(180)
      INTEGER*2 [illegible],ANGL2
      READ [illegible] [illegible],AXHI,LENGTH
C READ LIST OF INPUTS
    2 READ(5,7) GAUGE,SF,HORLOC,VERLOC,RADIUS,LENGTH,AXDIST
      READ(5,7) WALKHT,FOOTRD,STAND,HEADRM,[illegible],CLEAR,ALKCLR
      READ(5,7) TROCLR,ENDRCH,ACOUST,MAXHT,CARAD
    7 FORMAT(7F7.2)
      READ(5,9)J
    9 FORMAT(I2)
      PI=3.141593
      IF(J.EQ.1)GOTO  13
C OR OPTION 2,UPPER CORNER COMPUTED FOR LEFT SIDE DATA
C READ DATA FOR CLEARANCE ENVELOPE,OPTION 2
      READ(5,7) WED,WEES,HEES,SIDSLP,TOPSLP,CORRAD
C NOTE THAT THE ORIGIN IS LOCATED AT BOTTOM OF CLEAR. ENVL.&AT CENT.
C LINE OF CAR
C THIS PART FINDS THE CENTER OF THE CORNER CIRCLE FOR THE LEFT SIDE
C COMPUTE LOCATION OF DATA POINTS FOR CLEAR. ENVL.
      YLC=0
      YRC=0
      XLC=-1*WED/2
      XRC=WED/2
      XLS=-1*WEES/2
      YLS=HEES
      YRS=HEES
      XRS=-1*XLS
      IF (XLS.[illegible].XLC) GOTO 21
C FIND LINES DETERMINING SIDE AND TOP OF CLEAR. ENVL.
      Q1=SIDSLP
      B1=YLS-Q1*XLS
      Q2=TOPSLP
      B2=[illegible]
C FIND INTERSECTION POINT OF SIDE & TOP LINES
C THE INTERSECTION POINT IS (X1,Y1)
      X1=(B2-B1)/(Q1-Q2)
      Y1=Q1*X1+B1
C FIND THE LINE BISECTING THE ANGLE BETWEEN SIDE&TOP LINES
      Q3=TAN(PI-(PI+ATAN(Q2)-ATAN(Q1))/2+ATAN(Q2))
      B3=Y1-Q3*X1
      R=CORRAD
C PICK A STARTING POINT ON THE SIDE LINE:(X2,Y2)
      X2=-B1/Q1
      Y2=0
C FIND THE PERPENDICULAR DISTANCE FROM (X2,Y2) TO THE BISECTOR LINE
   10 B4=Y2+(1/Q1)*X2
      X4=(B4-B3)/(Q3+1/Q1)
      Y4=Q3*X4+B3
      D=SQRT((X4-X2)*(X4-X2)+(Y4-Y2)*(Y4-Y2))
      IF (D.EQ.R)GOTO 20
      IF (D.GT.R) GOTO 12
      X2=X2-2*[illegible]
```

```
      Y2=(Q1*(X2)+B1)
      GOTO 10
C THE DO LOOP FINDS THE CENTER OF THE CORNER CIRCLE BY BISECTION
   12 DO 17 N=1,20
      X3=(X2+X1)/2
      Y3=Q1*X3+B1
      B4=Y3+(1/Q1)*X3
      X4=(B4-B3)/(Q3+1/Q1)
      Y4=Q3*X4+B3
      D=SQRT((X3-X4)*(X3-X4)+(Y3-Y4)*(Y3-Y4))
      IF(D.LT.R) GOTO 15
      X2=X3
      Y2=Y3
      GOTO 17
   15 X1=X3
      Y1=Y3
   17 CONTINUE
      GOTO 20
   21 Q2=TOPSLP
      B2=MAXHT
      Y1=Q2*XLS+B2
      X1=XLS
      Q3=TAN(PI/4+ATAN(TOPSLP)/2)
      B3=Y1-Q3*X1
      R=CORRAD
      X2=XLS
      Y2=0
   22 X4=-B3/Q3
      Y4=Q3*X4+B3
      D=SQRT((X4-X2)*(X4-X2)+(Y4-Y2)*(Y4-Y2))
      IF (D.EQ.R) GOTO 20
      IF (D.GT.R) GOTO 23
      X2=XLS
      Y2=Y2-2*R
      GOTO 22
   23 DO 25 N=1,20
      X3=XLS
      Y3=(Y2+Y1)/2
      Y4=Y3
      X4=(Y4-B3)/Q3
      D=SQRT((X3-X4)*(X3-X4)+(Y3-Y4)*(Y3-Y4))
      IF (D.LT.R) GOTO 27
      X2=X3
      Y2=Y3
      GOTO 25
   27 X1=X3
      Y1=Y3
   25 CONTINUE
   20 XLCNR=X4
      YLCNR=Y4
      XRCNR=-X4
      YRCNR=Y4
      GOTO 30
   13 READ(5,14)XLC,YLC,XLS,YLS,X1,[illegible],X2,Y2,X3,Y3
```

```
0095          14 FORMAT(11F7.2)                                          61
0096             XLCI=XLC                                                62
0097             YLCI=YLC                                                623
0098             XLSI=XLS                                                626
0099             YLSI=YLS                                                629
      C ON OPTION 1,UPPER CORNERS COMPUTED FOR LEFT SIDE DATA           5980
0100             CALL CIRCLF(X1,Y1,X2,Y2,X3,Y3,R,X,Y)                    63
0101             XLCNR=X                                                 635
0102             XRCNR=-X                                                64
0103             YLCNR=Y                                                 65
0104             YRCNR=Y                                                 66
0105             YRC=YLC                                                 67
0106             YRS=YLS                                                 68
0107             XRC=-1*XLC                                              69
0108             XRS=-1*XLS                                              70
0109          30 CORRAD=R                                                71
      C CALCULATE M & E                                                  73
0110             IF (RADIUS.LT.10000.) GOTO 32                           732
0111             ID=0.0                                                  734
0112             END=0.0                                                 736
0113             GOTO 34                                                 738
0114          32 A=LENGTH                                                74
0115             B=AXLIST                                                75
0116             C=CARHD                                                 76
0117             RD=RADIUS*12                                            77
0118             ID=RD-SQRT(RD*RD-B*B/4)                                 78
0119             END=SQRT((RD-ID+C)*(RD-ID+C)+A*A/4)-RD-C                79
      C TRANSLATE X*S&Y*S                                                90
0120          34 TXT=GAUGE/2                                             91
0121             TYT=RAXHT+CARHT                                         92
0122             TXLCNR=XLCNR-ID+GAUGE/2                                 93
0123             TXLS=XLS-ID+GAUGE/2                                     94
0124             TXLC=XLC-ID+GAUGE/2                                     95
0125             TXRCNR=XRCNR+END+GAUGE/2                                96
0126             TXRS=XRS+END+GAUGE/2                                    97
0127             TXRC=XRC+END+GAUGE/2                                    98
0128             TYLCNR=YLCNR+CARHT                                      99
0129             TYRCNR=YRCNR+CARHT                                      100
0130             TYRS=YRS+CARHT                                          101
0131             TYLS=YLS+CARHT                                          1013
0132             TYLC=YLC+CARHT                                          1016
0133             TYRC=YRC+CARHT                                          1019
      C ROTATE ALL THE POINTS                                            10780
0134          44 PHI=ATAN(SE/GAUGE)                                      108
0135             XLCNR=TXLCNR*COS(PHI)-TYLCNR*SIN(PHI)                   109
0136             XRCNR=TXRCNR*COS(PHI)-TYRCNR*SIN(PHI)                   110
0137             XLS=TXLS*COS(PHI)-TYLS*SIN(PHI)                         111
0138             XRS=TXRS*COS(PHI)-TYRS*SIN(PHI)                         112
0139             XLC=TXLC*COS(PHI)-TYLC*SIN(PHI)                         113
0140             XRC=TXRC*COS(PHI)-TYRC*SIN(PHI)                         114
0141             XT=TXT*COS(PHI)-TYT*SIN(PHI)                            115
0142             YLCNR=TYLCNR*COS(PHI)+TXLCNR*SIN(PHI)                   116
0143             YRCNR=TYRCNR*COS(PHI)+TXRCNR*SIN(PHI)                   117
0144             YLS=TYLS*COS(PHI)+TXLS*SIN(PHI)                         118
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0145          YRS=TYRS*COS(PHI)+TXRS*SIN(PHI)                                119
0146          YLC=TYLC*COS(PHI)+TXLC*SIN(PHI)                                120
0147          YRC=TYRC*COS(PHI)+TXRC*SIN(PHI)                                121
0148          YT=TYT*COS(PHI)+TXT*SIN(PHI)                                   122
0149          DO 100 K=1,2                                                   102
      C CASE1:WALKWAY SAME SIDE,CASE 2:WALKWAY OPP. SIDE                     103
      C SET UP A VARIABLE B THAT WILL TELL WHICH SIDE THE WALKWAY IS ON      12380
0150          IF(K.EQ.2)GOTO 48                                              124
0151          BVL=1                                                          125
      C FIND POINT A                                                         12580
0152       47 U=(2*HORLOC+BVL*GAUGE)/2                                       126
0153          AX=VERLOC*SIN(PHI)+BVL*U*COS(PHI)                              127
0154          AY=-VERLOC*COS(PHI)+BVL*U*SIN(PHI)                             128
0155          GOTO50                                                         129
0156       48 BVL=-1                                                         130
0157          GOTO 47                                                        131
0158       50 IF(K.EQ.1)GOTO 52                                              132
      C FIND POINT B                                                         13280
0159          BY=SE+WALKHT                                                   134
0160          TEMP=WLKCLR*WLKCLR-(BY-YRC)*(BY-YRC)                           135
0161          IF (TEMP.LT.0) GOTO 60                                         1352
0162          BX=SQRT(TEMP)+XRC+FOOTWD                                       135
0163          GOTO 61                                                        1356
0164       60 BX=XRC+FOOTWD                                                  1358
0165       61 GOTO 53                                                        136
0166       52 BY=WALKHT                                                      137
0167          Q=(YLC-YLS)/(XLC-XLS)                                          138
0168          B=YLC-Q*XLC                                                    139
0169          XI=(BY-B)/Q                                                    140
0170          XA=XI-WLKCLR                                                   141
0171          XB=XLS+ENCRCH                                                  142
0172          G=SQRT((XLS-XLCNR)*(XLS-XLCNR)+(YLS-YLCNR)*(YLS-YLCNR))        1421
0173          PSI=ARSIN(CORRAD/G)                                            1422
0174          THETA=ATAN((YLCNR-YLS)/(XLCNR-XLS))                            1423
0175          V1=TAN(PSI+THETA)                                              1424
0176          V2=-1/V1                                                       1425
0177          BT=YLS-V1*XLS                                                  1426
0178          BR=YLCNR-V2*XLCNR                                              1427
0179          XLT=(BT-BR)/(V2-V1)                                            1428
0180          YLT=V1*XLT+BT                                                  1429
0181          XC=(BY+STAND-YLS+((YLS-YLT)/(XLS-XLT))*XLS)*(XLS-XLT)/(YLS-YLT)+   143
             XENCRCH                                                         144
0182          BX=AMIN1(XA,XB,XC)-FOOTWD-ACOUST                               145
      C FIND POINT C                                                         14580
0183       53 CY=BY+STAND                                                    146
0184          CX=BX+BVL*(FOOTWD-HEADWD)                                      147
      C FIND POINT F                                                         14780
0185          FX=XI                                                          148
0186          FY=YT                                                          149
      C LOCATE THE CENTER OF THE 2 TOP CIRCLES.CALL ONE D,THE OTHER E        14980
      C ADJUST D SO IT IS ON SAME SIDE AS WALKWAY,E SO IT IS OPPOSITE D      150
0187          IF(K.EQ.2) GOTO 55                                             151
0188          DX=XLCNR                                                       152
0189          DY=YLCNR                                                       153
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0190          EX=XRCNR                                                          154
0191          EY=YRCNR                                                          155
0192          GOTO 56                                                           156
0193       55 DX=XRCNR                                                          157
0194          DY=YRCNR                                                          158
0195          EX=XLCNR                                                          159
0196          EY=YLCNR                                                          160
      C WE NOW HAVE ALL THE POINTS LOCATED.WE BEGIN TO EXAMINE CIRCLES FORMED   161
      C BY THE DEFINITE POINTS A.B.C.F.                                         162
0197       56 CALL CIRCLE(AX,AY,BX,BY,CX,CY,R,X,Y)                              163
0198          CALL COMP(R,999.9,FX,FY,X,Y,0.0,0.0,TRAD,XTEMP,YTEMP)             164
0199          P=TRAD
0200          XO=XTEMP
0201          YO=YTEMP
0202          CALL CIRCLE(AX,AY,BX,BY,FX,FY,R,X,Y)                              165
0203          CALL COMP(R,P,CX,CY,X,Y,XO,YO,TRAD,XTEMP,YTEMP)                   166
0204          P=TRAD
0205          XO=XTEMP
0206          YO=YTEMP
0207          CALL CIRCLE(AX,AY,CX,CY,FX,FY,R,X,Y)                              167
0208          CALL COMP(R,P,BX,BY,X,Y,XO,YO,TRAD,XTEMP,YTEMP)                   168
0209          P=TRAD
0210          XO=XTEMP
0211          YO=YTEMP
0212          CALL CIRCLE(FX,FY,CX,CY,BX,BY,R,X,Y)                              169
0213          CALL COMP(R,P,AX,AY,X,Y,XO,YO,TRAD,XTEMP,YTEMP)                   170
0214          P=TRAD
0215          XO=XTEMP
0216          YO=YTEMP
      C WE NOW HAVE THE SMALLEST CIRCLE CONSIDERING A.B.C.F.CENTER AT XO.YO     171
      C AND RADIUS P.                                                           172
      C NEXT CONSIDER ALL CIRCLES WITH ONE D OR E POINT                         173
0217          CALL CHECK(AX,AY,BX,BY,DX,DY,CX,CY,FX,FY,EX,EY,P,XO,YO,           175
             XDTEM,XTEM,YTEM)
0218          D=DTEM
0219          XO=XTEM
0220          YO=YTEM
0221          CALL CHECK(AX,AY,BX,BY,EX,EY,CX,CY,FX,FY,DX,DY,D,XO,YO,           176
             XDTEM,XTEM,YTEM)
0222          D=DTEM
0223          XO=XTEM
0224          YO=YTEM
0225          CALL CHECK(AX,AY,CX,CY,DX,DY,BX,BY,FX,FY,EX,EY,D,XO,YO,           177
             XDTEM,XTEM,YTEM)
0226          D=DTEM
0227          XO=XTEM
0228          YO=YTEM
0229          CALL CHECK(AX,AY,CX,CY,EX,EY,BX,BY,FX,FY,DX,DY,D,XO,YO,           178
             XDTEM,XTEM,YTEM)
0230          D=DTEM
0231          XO=XTEM
0232          YO=YTEM
0233          CALL CHECK(AX,AY,FX,FY,DX,DY,BX,BY,CX,CY,EX,EY,D,XO,YO,           179
             XDTEM,XTEM,YTEM)
```

```
0234        D=DTEM
0235        XO=XTEM
0236        YO=YTEM
0237        CALL CHECK(AX,AY,FX,FY,EX,EY,BX,BY,CX,CY,DX,DY,D,XO,YO,                180
           XDTEM,XTEM,YTEM)
0238        D=DTEM
0239        XO=XTEM
0240        YO=YTEM
0241        CALL CHECK(BX,BY,CX,CY,DX,DY,AX,AY,FX,FY,EX,EY,D,XO,YO,                181
           XDTEM,XTEM,YTEM)
0242        D=DTEM
0243        XO=XTEM
0244        YO=YTEM
0245        CALL CHECK(BX,BY,CX,CY,EX,EY,AX,AY,FX,FY,DX,DY,D,XO,YO,                182
           XDTEM,XTEM,YTEM)
0246        D=DTEM
0247        XO=XTEM
0248        YO=YTEM
0249        CALL CHECK(BX,BY,FX,FY,DX,DY,AX,AY,CX,CY,EX,EY,D,XO,YO,                183
           XDTEM,XTEM,YTEM)
0250        D=DTEM
0251        XO=XTEM
0252        YO=YTEM
0253        CALL CHECK(BX,BY,FX,FY,EX,EY,AX,AY,CX,CY,DX,DY,D,XO,YO,                184
           XDTEM,XTEM,YTEM)
0254        D=DTEM
0255        XO=XTEM
0256        YO=YTEM
0257        CALL CHECK(CX,CY,FX,FY,DX,DY,AX,AY,BX,BY,EX,EY,D,XO,YO,                185
           XDTEM,XTEM,YTEM)
0258        D=DTEM
0259        XO=XTEM
0260        YO=YTEM
0261        CALL CHECK(CX,CY,FX,FY,EX,EY,AX,AY,BX,BY,DX,DY,D,XO,YO,                186
           XDTEM,XTEM,YTEM)
0262        D=DTEM
0263        XO=XTEM
0264        YO=YTEM
      C THE SMALLEST TUNNEL IS OF RADIUS D,CENTER AT (XO,YO)                       187
      C NEXT LOOK AT 3 POINTS,TWO OF WHICH ARE D AND E                             188
0265        CALL PCHK(AX,AY,BX,BY,CX,CY,FX,FY,D,XO,YO,DT,XTE,YTE)                 190
0266        D=DT
0267        XO=XTE
0268        YO=YTE
0269        CALL PCHK(BX,BY,AX,AY,CX,CY,FX,FY,D,XO,YO,DT,XTE,YTE)
0270        D=DT
0271        XO=XTE
0272        YO=YTE
0273        CALL PCHK(CX,CY,AX,AY,BX,BY,FX,FY,D,XO,YO,DT,XTE,YTE)
0274        D=DT
0275        XO=XTE
0276        YO=YTE
0277        CALL PCHK(FX,FY,AX,AY,BX,BY,CX,CY,D,XO,YO,DT,XTE,YTE)                 193
0278        D=DT
```

```
      XO=XTE
      YO=YTE
C WE HAVE THE SMALLEST TUNNEL,RADIUS D,CENTER AT (XO,YO)              195
      DR(K)=D/12
C FIND DISTANCE TO ALL POINTS                                       196
      DA(K)=SQRT((AX-XO)*(AX-XO)+(AY-YO)*(AY-YO))/12
      DB(K)=SQRT((BX-XO)*(BX-XO)+(BY-YO)*(BY-YO))/12
      DC(K)=SQRT((CX-XO)*(CX-XO)+(CY-YO)*(CY-YO))/12
      DD(K)=(SQRT((DX-XO)*(DX-XO)+(DY-YO)*(DY-YO))+CORRAD+CLEAR)/12
      DE(K)=(SQRT((EX-XO)*(EX-XO)+(EY-YO)*(EY-YO))+CORRAD+CLEAR)/12
      DF(K)=SQRT((FX-XO)*(FX-XO)+(FY-YO)*(FY-YO))/12
C  COMPUTE LOCATION OF TUNNEL CENTER TO CONTROL POINT                205
      H(K)=XO-((GAUGE*COS(PHI))/2+(SE*TAN(PHI))/2)                  206
      V(K)=YO/12
  100 CONTINUE                                                      225
      READ 9,L
      IF (L.EQ.33) GOTO 700
C PRINT THE RESULTS                                                 211
      PRINT 301
      PRINT 302
      PRINT 304
      PRINT 305
      PRINT 306,GAUGE
      PRINT 307,SE
      PRINT 308,HORLOC
      PRINT 309
      PRINT 310,VERLOC
      PRINT 311
      R=RADIUS*12
      PRINT 312,R
      PRINT 313,LENGTH
      PRINT 314,AXDIST
      PRINT 315,WALKHT
      PRINT 316
      PRINT 317,FOOTWD
      PRINT 318
      PRINT 430,STAND
      PRINT 319,HEADWD
      PRINT 320
      PRINT 321,CARHT
      PRINT 322
      PRINT 323,CLEAR
      PRINT 324,WLKCLR
      PRINT 325
      PRINT 326,TRUCLR
      PRINT 327,ENCRCH
      PRINT 328
      PRINT 401,ACOUST
      PRINT 402
      PRINT 403,MAXHT
      PRINT 415
      PRINT 414,CARWD
      PRINT 440,IO
      PRINT 441,END
```

```
      IF(J.EQ.2) GOTO 102
      PRINT 404
      PRINT 405
      PRINT 407
      PRINT 408
      PRINT 409,XLCI,YLCI
      PRINT 410,XLSI,YLSI
      PRINT 411,X1,Y1
      PRINT 412,X2,Y2
      PRINT 413,X3,Y3
      GOTO 101
  102 PRINT 416
      PRINT 417
      PRINT 419
      PRINT 420
      PRINT 421,WEB
      PRINT 422
      PRINT 423,WEES
      PRINT 424
      PRINT 425,HEES
      PRINT 426
      PRINT 427,SIDSLP
      PRINT 428,TOPSLP
      PRINT 429,CORRAD
  101 PRINT 500
      PRINT 501
      PRINT 502
      PRINT 503
      PRINT 504,RADIUS,RADIUS
      PRINT 517
      PRINT 514,SE,SE
      PRINT 505,DR(1),DR(2)
      PRINT 506
      PRINT 507,DA(1),DA(2)
      PRINT 508,DB(1),DB(2)
      PRINT 509,DC(1),DC(2)
      PRINT 510,DD(1),DD(2)
      PRINT 511,DE(1),DE(2)
      PRINT 512,DF(1),DF(2)
      PRINT 513
      PRINT 514
      PRINT 515,H(1),H(2)
      PRINT 516, V(1),V(2)
      PRINT 520
      PRINT 521
      PRINT 522
      PRINT 523
  301 FORMAT('1',T26,'INPUT DATA')
  302 FORMAT(T26,'----- ----',//)
  304 FORMAT(T6,'ITEM',T31,'SYMBOL',T56,'VALUE,IN.')
  305 FORMAT(T6,'----',T31,'------',T56,'---------',/)
  306 FORMAT(' GAUGE OF TRACK',T31,'GAUGE',T58,F7.2)
  307 FORMAT(' SUPERELEVATION',T31,'SE',T58,F7.2)
  308 FORMAT(' HORIZONTAL LOCATION OF',T31,'HORLOC',T58,F7.2)
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0383      309 FORMAT(T6,'CONTACT RAIL')
0384      310 FORMAT(' VERTICAL LOCATION OF',T31,'VERLOC',T58,F7.2)
0385      311 FORMAT(T6,'CONTACT RAIL')
0386      312 FORMAT(' RADIUS OF CURVATURE',T31,'RADIUS',T58,F10.2)
0387      313 FORMAT(' LENGTH OF CAR',T31,'LENGTH',T58,F7.2)
0388      314 FORMAT(' DISTANCE BETWEEN AXLES',T31,'AXDIST',T58,F7.2)
0389      315 FORMAT(' HEIGHT OF WALKWAY ABOVE',T31,'WALKHT',T58,F7.2)
0390      316 FORMAT(T6,'ADJACENT RAIL')
0391      317 FORMAT(' MINIMUM WIDTH OF WALK-',T31,'FOOTWD',T58,F7.2)
0392      318 FORMAT(T6,'WAY TREAD')
0393      319 FORMAT(' WIDTH OF TOP OF WALK-',T31,'HEADWD',T58,F7.2)
0394      320 FORMAT(T6,'WAY ENVELOPE (MIN)')
0395      321 FORMAT(' HEIGHT OF CLEARANCE EN-',T31,'CARHT',T58,F7.2)
0396      322 FORMAT(T6,'VELOPE ABOVE RAILS')
0397      323 FORMAT(' CONSTRUCTION CLEARANCE',T31,'CLEAR',T58,F7.2)
0398      324 FORMAT(' WALKWAY ENVELOPE CLEAR-' ,T31,'WLKCLR',T58,F7.2)
0399      325 FORMAT(T6,'ANCE')
0400      326 FORMAT(' WALKWAY TREAD CLEARANCE',T31,'TRDCLR',T58,F7.2)
0401      327 FORMAT(' MAX. WALKWAY ENVELOPE',T31,'ENCRCH',T58,F7.2)
0402      328 FORMAT(T6,'ENCROACHMENT')
0403      401 FORMAT(' ACOUSTICAL TREATMENT',T31,'ACOUST',T58,F7.2)
0404      402 FORMAT(T6,'THICKNESS')
0405      403 FORMAT(' MAXIMUM HEIGHT OF TOP',T31,'MAXHT',T58,F7.2)
0406      404 FORMAT(//,T24,'OPTION ONE DATA')
0407      405 FORMAT(T2,'------- --- ----',/)
0408      407 FORMAT(T6,'ITEM',T31,'COORDINATES (X,Y)')
0409      408 FORMAT(T6,'----',T31,'----------- -----')
0410      409 FORMAT(' BOTTOM CORNER POINT',T31,F7.2,',',F7.2)
0411      410 FORMAT(' EXTREME SIDE POINT',T31,F7.2,',',F7.2)
0412      411 FORMAT(' CORNER CURVE POINT ONE',T31,F7.2,',',F7.2)
0413      412 FORMAT(' CORNER CURVE POINT TWO',T31,F7.2,',',F7.2)
0414      413 FORMAT(' CORNER CURVE POINT THREE',T31,F7.2,',',F7.2)
0415      414 FORMAT(  ' CAR WIDTH',T31,'CARWD',T58,F7.2)
0416      415 FORMAT(T6,'OF CAR')
0417      416 FORMAT(//,T25,'OPTION TWO DATA')
0418      417 FORMAT(T26,'------- --- ----',/)
0419      419 FORMAT(T6,'ITEM',T31,'SYMBOL',T60,'VALUE')
0420      420 FORMAT(T6,'----',T31,'------',T60,'-----')
0421      421 FORMAT(' WIDTH OF ENVELOPE AT',T31,'WEB',T58,F7.2)
0422      422 FORMAT(T6,'BOTTOM')
0423      423 FORMAT(' WIDTH OF ENVELOPE AT',T31,'WEES',T58,F7.2)
0424      424 FORMAT(T6,'EXTREME SIDE')
0425      425 FORMAT(' HEIGHT OF ENVELOPE AT',T31,'HEES',T58,F7.2)
0426      426 FORMAT(T6,'EXTREME SIDE')
0427      427 FORMAT(' SLOPE OF SIDE OF CAR',T31,'SIDSLP',T58,F7.2)
0428      428 FORMAT(' SLOPE OF TOP OF CAR',T31,'TOPSLP',T58,F7.2)
0429      429 FORMAT(' RADIUS OF CURVATURE',T31,'CORRAD',T58,F7.2)
0430      430 FORMAT(' HEIGHT OF WALK ENVELOPE',T31,'STAND',T58,F7.2)
0431      440 FORMAT(' MIDDLE OVERHANG',T31,'ID',T58,F7.2)
0432      441 FORMAT(' END OVERHANG',T31,'END',T58,F7.2)
0433      500 FORMAT('1',/,T36,'COMPUTATION OF TUNNEL RADIUS',//)
0434      501 FORMAT(1H ,T31,'WALKWAY ON SAME SIDE',T71,'WALKWAY ON OPPOSITE')
0435      502 FORMAT(T32,'AS CENTER OF CURVE',T70,'SIDE AS CENTER OF CURVE')
0436      503 FORMAT(1H ,T35,'RADIUS',T75,'RADIUS')
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504 FORMAT(T34,F6.0,' FT',T74,F6.0,' FT')
505 FORMAT(' TUNNEL RADIUS (FT)',T34,F6.2,T74,F6.2,/)
506 FORMAT(1H ,' DISTANCE TO POINTS (FT)')
507 FORMAT(T6,'A-CONTACT RAIL',T34,F6.2,T74,F6.2)
508 FORMAT(T6,'B-TREAD OF WALKWAY',T34,F6.2,T74,F6.2)
509 FORMAT(T6,'C-HEAD OF WALKWAY',T34,F6.2,T74,F6.2)
510 FORMAT(T6,'D-TOP CORNER WALKWAY',T34,F6.2,T74,F6.2)
511 FORMAT(T6,'E-OPPOSITE TOP CORNER',T34,F6.2,T74,F6.2)
512 FORMAT(T6,'F-TOP OF VEHICLE',T34,F6.2,T74,F6.2,/)
513 FORMAT(1H ,' TUNNEL CENTER WITH ')
514 FORMAT(' RESPECT TO CONTROL POINT',/)
515 FORMAT(1H ,T14,'H(IN)',T34,F6.2,T74,F6.2)
516 FORMAT(T14,'V(FT)',T34,F6.2,T74,F6.2)
517 FORMAT(T34,'----------',T74,'----------',/)
518 FORMAT(' SUPERELEVATION (IN.)',T34,F6.2,T74,F6.2,/)
520 FORMAT(/,T6,'NO SIGN INDICATES CENTER')
521 FORMAT(T6,'TO RIGHT OF CONTROL POINT')
522 FORMAT(/,T6,'- SIGN INDICATES CENTER')
523 FORMAT(T6,'TO LEFT OF CONTROL POINT',////////)
    IF(L.EQ.99) GOTO 2
    IF (L.EQ.66) GOTO 800
700 DO 1000 N=1,360
    W(N)=D*SIN((N*PI)/180)
    Z(N)=D*COS((N*PI)/180)
1000 CONTINUE
    G1=SQRT((XT-XLCNR)*(XT-XLCNR)+(YT-YLCNR)*(YT-YLCNR))
    P2=ARSIN((CORRAD)/G1)
    Q5=(YT-YLCNR)/(XT-XLCNR)
    P3=ATAN(Q5)
    Q6=TAN(P3-P2)
    H6=YT-Q6*XT
    Q7=-1/Q6
    B7=YLCNR-Q7*XLCNR
    XTL=(H6-B7)/(Q7-Q6)
    YTL=Q6*XTL+H6
    ANGL1=INT((-P2*180)/PI+90)
    DO 1050 N=1,ANGL1
    AXE(N)=-CORRAD*SIN(((ANGL1-N)*PI)/180)+XLCNR
    AYE(N)=CORRAD*COS(((ANGL1-N)*PI)/180)+YLCNR
1050 CONTINUE
    G2=SQRT((XT-XRCNR)*(XT-XRCNR)+(YT-YRCNR)*(YT-YRCNR))
    P4=ARSIN(CORRAD/G2)
    P5=ATAN((YT-YRCNR)/(XT-XRCNR))
    SLOP1=TAN(P5-P4)
    YINT1=YT-SLOP1*XT
    SLOP2=-1/SLOP1
    YINT2=YRCNR-SLOP2*XRCNR
    XTR=(YINT1-YINT2)/(SLOP2-SLOP1)
    YTR=SLOP1*XTR+YINT1
    G3=SQRT((XRS-XRCNR)*(XRS-XRCNR)+(YRS-YRCNR)*(YRS-YRCNR))
    P6=ARSIN(CORRAD/G3)
    P7=ATAN((YRS-YRCNR)/(XRS-XRCNR))
    SLOP3=TAN(P7-P6)
    ALOP4=PI/2-ATAN(-1/SLOP3)
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      ANGL2=INT((ALOP4*180)/PI)
      DO 1100 N=1,ANGL2
      AME(N)=CORRAD*SIN((N*PI)/180)+XRCNR
      ANE(N)=CORRAD*COS((N*PI)/180)+YRCNR
 1100 CONTINUE
      TRCX=-(HORLOC-GAUGE/2)*COS(PHI)
      TRCY=-(HORLOC-GAUGE/2)*SIN(PHI)
      TRDX=VERLOC*SIN(PHI)+TRCX
      TRDY=-VERLOC*COS(PHI)+TRCY
      TREX=(2*HORLOC)*COS(PHI)+TRDX
      TREY=(2*HORLOC)*SIN(PHI)+TRDY
      TRFX=-VERLOC*SIN(PHI)+TREX
      TRFY=VERLOC*COS(PHI)+TREY
      CALL PLOTF(30,8)
      CALL OFFSET(0.,36.,0.,36.)
      CALL PLOT(4.5,7.,-3)
      CALL LINE(W(1),Z(1),360,1,0,+12)
      CALL SYMBOL(0.,0.,.1,3,0.,-1)
      CALL PLOT(-X0,-Y0,-13)
      CALL SYMBOL(0.,0.,.1,3,0.,-1)
      CALL SLINE
      CALL PLOT(XLC,YLC,+13)
      CALL PLOT(XLS,YLS,+12)
      CALL PLOT(XLT,YLT,+12)
      CALL CLINE
      CALL PLOT(AXE(1),AYE(1),+12)
      CALL LINE(AXE(1),AYE(1),ANGL1,1,0,+12)
      CALL SLINE
      CALL PLOT(XT,YT,+12)
      CALL PLOT(AME(1),ANE(1),+12)
      CALL CLINE
      CALL LINE(AME(1),ANE(1),ANGL2,1,0,+12)
      CALL SLINE
      CALL PLOT(XRS,YRS,+12)
      CALL PLOT(XRC,YRC,+12)
      CALL PLOT(XLC,YLC,+12)
      CALL PLOT(BX,BY,+13)
      FOOTX=BX+FOOTWD*HVL
      CALL PLOT(FOOTX,BY,+12)
      STANY=BY+STAND
      CALL PLOT(FOOTX,STANY,+12)
      HEDX=FOOTX-HEADWD*HVL
      CALL PLOT(HEDX,STANY,+12)
      CALL PLOT(0,0,+13)
      CALL PLOT(TRCX,TRCY,+12)
      CALL PLOT(TRDX,TRDY,+12)
      CALL PLOT(TREX,TREY,+12)
      CALL PLOT(TRFX,TRFY,+12)
      CALL PLOT(0,0,+12)
      CALL SYMBOL(-2.,-2.,.1,15HSUPERELEVATION=,0.,15)
      CALL NUMBER(999.,999.,.1,SE,0.,2)
      CALL SYMBOL(999.,999.,.1,3HIN.,0.,3)
      CALL SYMBOL(1.3,999.,.1,13HTRACK RADIUS=,0.,13)
      CALL NUMBER(999.,999.,.1,RADIUS,0.,0)
```

```
      CALL SYMBOL(999.,999.,.1,3HFT.,0.,3)
      CALL SYMBOL(-2.,-2.5,.1,12HTUNNEL DIA.=,0.,12)
      DIAM=2*DR(K)
      CALL NUMBER(999.,999.,.1,DIAM,0.,2)
      CALL SYMBOL(999.,999.,.1,3HFT.,0.,3)
      CALL SYMBOL(-2.,-3.,.1,26HDISTANCE TO POINTS IN FEET,0.,26)
      CALL SYMBOL(-2.,-3.25,.1,2HA-,0.,2)
      CALL NUMBER(999.,999.,.1,DA(K),0.,2)
      CALL SYMBOL(-2.,-3.50,.1,2HB-,0.,2)
      CALL NUMBER(999.,999.,.1,DB(K),0.,2)
      CALL SYMBOL(-2.,-3.75,.1,2HC-,0.,2)
      CALL NUMBER(999.,999.,.1,DC(K),0.,2)
      CALL SYMBOL(-2.,-4.00,.1,2HD-,0.,2)
      CALL NUMBER(999.,999.,.1,DD(K),0.,2)
      CALL SYMBOL(-2.,-4.25,.1,2HE-,0.,2)
      CALL NUMBER(999.,999.,.1,DE(K),0.,2)
      CALL SYMBOL(-2.,-4.50,.1,2HF-,0.,2)
      CALL NUMBER(999.,999.,.1,DF(K),0.,2)
      CALL POFF
      CALL EXIT
  800 STOP
      END
```

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FORTRAN IV G LEVEL 21 PCHK DATE = 74214 10/27/35 PAGE 0001

```
      SUBROUTINE PCHK(XA,YA,XB,YB,XC,YC,XF,YF,DN,XN,YN,DT,XT,YT)
      COMMON CORRAD,CLEAR,DX,DY,EX,EY
C FIRST DEFINE THE LINE CONNECTING D AND E. CALL IT L1.
      G1=(EY-DY)/(EX-DX)
      B1=EY-G1*EX
C X1,Y1 IS THE MIDPOINT OF THE LINE
      X1=(EX+DX)/2
      Y1=G1*X1+B1
      IF (G1.EQ.0) GOTO 120
C THE SLOPE OF THE PERPENDICULAR LINE IS 1/G1.CALL THIS LINE P
      R=6000
C THE MAXIMUM DISTANCE WE HAVE TO CONSIDER IS R
      B2=Y1+(1/G1)*X1
  110 GOTO 130
  120 R=6000
      X3=X1
      Y3=Y1-R
      X4=X1
      Y4=Y1+R
      GOTO 131
C WE HAVE A LINE L3 PERPENDICULAR TO L1 THROUGH (X1,Y1).ON THIS LINE
C PICK POINT(X3,Y3) AT A DISTANCE R FROM (X1,Y1) AND A POINT (X4,Y4)
C ALSO A DISTANCE R FROM (X1,Y1) BUT IN THE OPPOSITE DIRECTION
  130 A=G1*G1+1
      B=2*X1*G1-2*G1*G1*B2-2*Y1
      C=G1*B2*G1*B2-2*X1*G1*B2+X1*X1+Y1*Y1-R*R
      Y3=((-B-SQRT(B*B-4*A*C))/(2*A))*10
      X3=-G1*(Y3-B2)
      Y4=((-B+SQRT(B*B-4*A*C))/(2*A))*10
      X4=-G1*(Y4-B2)
C THE DO LOOP ZEROES IN ON THE CENTER OF THE CIRCLE
  131 DO140 M=1,50
C THE FIRST POINT TO CONSIDER IS MIDWAY BETWEEN (X4,Y4) AND (X3,Y3)
      X=(X3+X4)/2
      Y=(Y3+Y4)/2
      D1=SQRT((DX-X)*(DX-X)+(DY-Y)*(DY-Y))+CORRAD+CLEAR
      D2=SQRT((XA-X)*(XA-X)+(YA-Y)*(YA-Y))
      IF(D2.LT.D1) GOTO 135
      X4=X
      Y4=Y
      GOTO 140
  135 X3=X
      Y3=Y
  140 CONTINUE
C CHECK TO SEE IF ALL THE POINTS ARE INSIDE THE TUNNEL
      D3=SQRT((XB-X)*(XB-X)+(YB-Y)*(YB-Y))
      IF(D3.GT.D2) GOTO 143
      D3=SQRT((XC-X)*(XC-X)+(YC-Y)*(YC-Y))
      IF(D3.GT.D2) GOTO 143
      D3=SQRT((XF-X)*(XF-X)+(YF-Y)*(YF-Y))
      IF(D3.GT.D2)GOTO 143
C CHECK TO SEE IF THE TUNNEL IS THE SMALLEST
      IF(D2.GE.DT)GOTO 143
      DT=D2
```

```
          XT=X2
          YT=Y2
          GOTO 144
      143 DT=DN
          XT=XN
          YT=YN
      144 RETURN
          END
```

```
FORTRAN IV G LEVEL  21              CIRCLE             DATE = 74214           10/27/39               PAGE 0001

 0001              SUBROUTINE CIRCLE(X1,Y1,X2,Y2,X3,Y3,R,X,Y)                                    401
              C THIS SUBROUTINE FITS A CIRCLE TO THE 3 POINTS INPUTED                            40110
 0002              A=(2*X2-2*X1)                                                                 402
 0003              B=(2*Y2-2*Y1)                                                                 403
 0004              C=(X2*X2-X1*X1+Y2*Y2-Y1*Y1)                                                   404
 0005              D=2*X3-2*X1                                                                   405
 0006              E=2*Y3-2*Y1                                                                   406
 0007              F=X3*X3-X1*X1+Y3*Y3-Y1*Y1                                                     407
 0008              Y=(F-(D*C)/A)/(E-(D*B)/A)                                                     408
 0009              X=(C-B*Y)/A                                                                   409
 0010              R=SQRT((X1-X)*(X1-X)+(Y1-Y)*(Y1-Y))                                           410
 0011              RETURN                                                                        411
 0012              END                                                                           412
```

```
FORTRAN IV G LEVEL  21              COMP               DATE = 74214          10/27/75              PAGE 0001

 0001               SUBROUTINE COMP(R,OR,XF,YF,X,Y,XN,YN,TRAD,XTEMP,YTEMP)                  419
 0002               COMMON CORRAD,CLEAR,DX,DY,EX,EY                                         420
              C AFTER COMPUTING A CIRCLE FROM 3 OF A,B,C,F, WE LOOK AT D AND E AND         42010
              C THE REMAINING POINT                                                         42011
 0003               D=SQRT((XF-X)*(XF-X)+(YF-Y)*(YF-Y))                                     421
              C CHECKING TO SEE IF ALL THE POINTS ARE INSIDE THE TUNNEL                     42012
 0004               IF(D.GT.R) GOTO 149                                                     423
 0005               D=SQRT((DX-X)*(DX-X)+(DY-Y)*(DY-Y))+CORRAD+CLEAR                        424
 0006               IF(D.GT.R) GOTO 149                                                     425
 0007               D=SQRT((EX-X)*(EX-X)+(EY-Y)*(EY-Y))+CORRAD+CLEAR                        426
 0008               IF(D.GT.R) GOTO 149                                                     427
              C CHECK TO SEE IF THIS IS THE SMALLEST CIRCLE                                 42701
 0009               IF(R.GT.OR) GOTO 149                                                    428
 0010               TRAD=R                                                                  429
 0011               XTEMP=X                                                                 430
 0012               YTEMP=Y                                                                 431
 0013               GOTO 150                                                                432
 0014           149 TRAD=OR                                                                 433
 0015               XTEMP=XN                                                                434
 0016               YTEMP=YN                                                                435
 0017           150 RETURN                                                                  436
 0018               END                                                                     437
```

```
      SUBROUTINE CHECK(XA,YA,XB,YB,XR,YR,X7,Y7,X8,Y8,X9,Y9,DN,XN,YN,
     XDTEM,XTEM,YTEM)
      COMMON CORRAD,CLEAR,DX,DY,EX,EY
      IF (XB.EQ.XA) GOTO 170
      Q1=(YB-YA)/(XB-XA)
      B1=YA-Q1*XA
C WE HAVE A LINE Y=Q1X+B1 CONNECTING A AND B.X1,Y1 IS THE MIDPOINT
      X1=(XA+XB)/2
      Y1=Q1*X1+B1
      R=6000
C THE MAX. DISTANCE WE HAVE TO CONSIDER IS R
      B2=Y1+(1/Q1)*X1
C WE HAVE A LINE THROUGH X1,Y1 PERPENDICULAR TO THE FIRST LINE.ON THIS
C LINE,WE PICK POINT X3,Y3 AT A DISTANCE R FROM X1,Y1
      A=Q1*Q1+1
      B=2*X1*Q1-2*Q1*Q1*B2-2*Y1
      C=Q1*B2*Q1*B2-2*X1*Q1*B2+X1*X1+Y1*Y1-R*R
      Y3=(-1*B+SQRT(B*B-4*A*C))/(2*A)
      X3=-1*Q1*(Y3-B2)
      Y4=((-B-SQRT(B*B-4*A*C))/(2*A))
      X4=-Q1*(Y4-B2)
      GOTO 175
  170 X1=XA
      Y1=(YA+YB)/2
      X3=XA-6000
      Y3=Y1
      X4=XA+6000
      Y4=Y1
C THE FIRST POINT ON THIS LINE IS HALF WAY BETWEEN X3,Y3 AND X4,Y4
C THE DO LOOP ZOOMS IN ON THE CENTER OF THE CIRCLE
  175 DO 190 N=1,50
      X=(X3+X4)/2
      Y=(Y4+Y3)/2
      D1=SQRT((X-XR)*(X-XR)+(Y-YR)*(Y-YR))+CORRAD+CLEAR
      D2=SQRT((X-XA)*(X-XA)+(Y-YA)*(Y-YA))
      IF(D1.LT.D2)GOTO 185
      X4=X
      Y4=Y
      GOTO 190
  185 X3=X
      Y3=Y
  190 CONTINUE
C WE CHECK TO SEE IF ALL THE POINTS ARE INSIDE THE TUNNEL
      D3=SQRT((X7-X)*(X7-X)+(Y7-Y)*(Y7-Y))
      D4=SQRT((XA-X)*(XA-X)+(YA-Y)*(YA-Y))
      IF(D3.GT.D4) GOTO 193
      D3=SQRT((XB-X)*(XB-X)+(YB-Y)*(YB-Y))
      IF(D3.GT.D4) GOTO 193
      D3=SQRT((X9-X)*(X9-X)+(Y9-Y)*(Y9-Y))+CORRAD+CLEAR
      IF(D3.GT.D4) GOTO 193
C WE CHECK TO SEE IF THE TUNNEL IS THE SMALLEST ONE
      IF(D4.GE.DN) GOTO 193
      DTEM=D4
      XTEM=X
```

```
0046            YTEM=Y                                              559
0047            GOTO 194                                            560
0048        193 DTEM=DN
0049            XTEM=XN                                             562
0050            YTEM=YN                                             563
0051        194 RETURN                                              564
0052            END                                                 565
```

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	0.00
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	6000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	7.51
END OVERHANG	END	6.86

OPTION ONE DATA

ITEM	COORDINATES (X,Y)
BOTTOM CORNER POINT	-67.00, 0.00
EXTREME SIDE POINT	-70.00, 43.00
CORNER CURVE POINT ONE	-41.44, 83.00
CORNER CURVE POINT TWO	-60.00, 95.00
CORNER CURVE POINT THREE	-48.00, 100.50

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 500. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 500. FT
SUPERELEVATION (IN.)	0.00	0.00
TUNNEL RADIUS (FT)	8.41	8.35
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.41	8.35
B-TREAD OF WALKWAY	8.41	8.35
C-HEAD OF WALKWAY	8.27	8.18
D-TOP CORNER WALKWAY	7.45	7.47
E-OPPOSITE TOP CORNER	8.41	8.35
F-TOP OF VEHICLE	5.83	5.79
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-7.82	6.46
V(FT)	5.04	5.07

NO SIGN INDICATES CENTER TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	0.00
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	6000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	7.51
END OVERHANG	END	6.86

OPTION TWO DATA

ITEM	SYMBOL	VALUE
WIDTH OF ENVELOPE AT BOTTOM	WEB	134.00
WIDTH OF ENVELOPE AT EXTREME SIDE	WEES	140.00
HEIGHT OF ENVELOPE AT EXTREME SIDE	HEES	43.00
SLOPE OF SIDE OF CAR	SIDSLP	21.00
SLOPE OF TOP OF CAR	TOPSLP	0.11
RADIUS OF CURVATURE	CORRAD	23.12

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 500. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 500. FT
SUPERELEVATION (IN.)	0.00	0.00
TUNNEL RADIUS (FT)	8.41	8.34
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.41	8.34
B-TREAD OF WALKWAY	8.41	8.34
C-HEAD OF WALKWAY	8.27	8.18
D-TOP CORNER WALKWAY	7.43	7.45
E-OPPOSITE TOP CORNER	8.41	8.34
F-TOP OF VEHICLE	5.83	5.79
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-7.83	6.47
V(FT)	5.04	5.07

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE,IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	8.25
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	6000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	7.51
END OVERHANG	END	6.86

OPTION ONE DATA

ITEM	COORDINATES (X,Y)
BOTTOM CORNER POINT	-67.00, 0.00
EXTREME SIDE POINT	-70.00, 43.00
CORNER CURVE POINT ONE	-45.14, 83.00
CORNER CURVE POINT TWO	-60.00, 95.00
CORNER CURVE POINT THREE	-46.00, 100.50

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 500. FT	WALKWAY ON OPPOSITE SIDF AS CENTER OF CURVE RADIUS 500. FT
SUPERELEVATION (IN.)	8.25	8.25
TUNNEL RADIUS (FT)	8.49	8.41
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.49	8.41
B-TREAD OF WALKWAY	8.49	8.34
C-HEAD OF WALKWAY	8.18	8.41
D-TOP CORNER WALKWAY	7.38	7.41
E-OPPOSITE TOP CORNER	8.49	8.41
F-TOP OF VEHICLE	5.83	5.79
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-16.90	-0.74
V(FT)	5.26	5.46

NO SIGN INDICATES CENTER TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE,IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	8.25
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VEPLOC	5.00
RADIUS OF CURVATURE	RADIUS	6000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	7.51
END OVERHANG	END	6.86

OPTION TWO DATA

ITEM	SYMBOL	VALUE
WIDTH OF ENVELOPE AT BOTTOM	WEB	134.00
WIDTH OF ENVELOPE AT EXTREME SIDE	WEES	140.00
HEIGHT OF ENVELOPE AT EXTREME SIDE	HEES	43.00
SLOPE OF SIDE OF CAR	SIDSLP	21.00
SLOPE OF TOP OF CAR	TOPSLP	0.11
RADIUS OF CURVATURE	CORRAD	23.12

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 500. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 500. FT
SUPERELEVATION (IN.)	8.25	8.25
TUNNEL RADIUS (FT)	8.50	8.41
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.50	8.41
B-TREAD OF WALKWAY	8.50	8.34
C-HEAD OF WALKWAY	8.20	8.41
D-TOP CORNER WALKWAY	7.34	7.39
E-OPPOSITE TOP CORNER	8.50	8.41
F-TOP OF VEHICLE	5.84	5.79
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-17.16	-0.70
V(FT)	5.25	5.45

NO SIGN INDICATES CENTER TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	0.00
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	18000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	2.50
END OVERHANG	END	2.36

OPTION ONE DATA

ITEM	COORDINATES (X,Y)
BOTTOM CORNER POINT	-67.00, 0.00
EXTREME SIDE POINT	-70.00, 43.00
CORNER CURVE POINT ONE	-36.43, 83.00
CORNER CURVE POINT TWO	-60.00, 95.00
CORNER CURVE POINT THREE	-48.00, 100.50

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 1500. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 1500. FT
SUPERELEVATION (IN.)	0.00	0.00
TUNNEL RADIUS (FT)	8.14	8.08
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.14	8.08
B-TREAD OF WALKWAY	8.09	8.03
C-HEAD OF WALKWAY	8.14	8.08
D-TOP CORNER WALKWAY	7.43	7.48
E-OPPOSITE TOP CORNER	8.14	8.08
F-TOP OF VEHICLE	6.05	6.04
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-5.93	4.87
V(FT)	4.80	4.81

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE,IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	0.00
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	18000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALKWAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALKWAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE ENVELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEARANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	IO	2.50
END OVERHANG	END	2.36

OPTION TWO DATA

ITEM	SYMBOL	VALUE
WIDTH OF ENVELOPE AT BOTTOM	WEB	134.00
WIDTH OF ENVELOPE AT EXTREME SIDE	WEES	140.00
HEIGHT OF ENVELOPE AT EXTREME SIDE	HEES	43.00
SLOPE OF SIDE OF CAR	SIDSLP	21.00
SLOPE OF TOP OF CAR	TOPSLP	0.11
RADIUS OF CURVATURE	CORRAD	23.12

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 1500. FT	WALKWAY ON OPPOSITE SIDF AS CENTER OF CURVE RADIUS 1500. FT
SUPERELEVATION (IN.)	0.00	0.00
TUNNEL RADIUS (FT)	8.14	8.07
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.14	8.07
B-TREAD OF WALKWAY	8.07	8.01
C-HEAD OF WALKWAY	8.14	8.07
D-TOP CORNER WALKWAY	7.41	7.46
E-OPPOSITE TOP CORNER	8.14	8.07
F-TOP OF VEHICLE	6.06	6.05
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-6.02	4.97
V(FT)	4.79	4.80

NO SIGN INDICATES CENTER TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	56.00
SUPERELEVATION	SE	8.25
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	18000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALKWAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALKWAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE ENVELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEARANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	2.50
END OVERHANG	END	2.36

OPTION ONE DATA

ITEM	COORDINATES (X,Y)
BOTTOM CORNER POINT	-67.00, 0.00
EXTREME SIDE POINT	-70.00, 43.00
CORNER CURVE POINT ONE	-40.05, 83.00
CORNER CURVE POINT TWO	-60.00, 95.00
CORNER CURVE POINT THREE	-45.00, 100.50

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 1500. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 1500. FT
SUPERELEVATION (IN.)	8.25	8.25
TUNNEL RADIUS (FT)	8.20	8.21
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.20	8.21
B-TREAD OF WALKWAY	8.20	7.91
C-HEAD OF WALKWAY	8.07	8.21
D-TOP CORNER WALKWAY	7.38	7.36
E-OPPOSITE TOP CORNER	8.20	8.21
F-TOP OF VEHICLE	6.05	6.05
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-14.52	-0.79
V(FT)	5.04	5.19

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

CORE USAGE OBJECT CODE= 31584 BYTES,ARRAY AREA= 5892 BYTES,TOTAL AREA AVAILABLE= 39008 BYTES

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0, NUMBER OF EXTENSIONS= 0

COMPILE TIME= 2.14 SEC,EXECUTION TIME= 1.62 SEC, WATFIV - VERSION 1 LEVEL 3 MARCH 1971 DATE= 74/228

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	8.25
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	13000.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	2.50
END OVERHANG	END	2.36

OPTION TWO DATA

ITEM	SYMBOL	VALUE
WIDTH OF ENVELOPE AT BOTTOM	WEB	134.00
WIDTH OF ENVELOPE AT EXTREME SIDE	WEES	140.00
HEIGHT OF ENVELOPE AT EXTREME SIDE	HEES	43.00
SLOPE OF SIDE OF CAR	SIDSLP	21.00
SLOPE OF TOP OF CAR	TOPSLP	0.11
RADIUS OF CURVATURE	CORRAD	23.12

```
                              COMPUTATION OF TUNNEL RADIUS

                         WALKWAY ON SAME SIDE              WALKWAY ON OPPOSITE
                          AS CENTER OF CURVE             SIDE AS CENTER OF CURVE
                               RADIUS                           RADIUS
                              1500. FT                         1500. FT
                             ---------                        ---------

SUPERELEVATION (IN.)            8.25                             8.25

TUNNEL RADIUS (FT)              8.21                             8.21

 DISTANCE TO POINTS (FT)
    A-CONTACT RAIL              8.21                             8.21
    B-THREAD OF WALKWAY         8.21                             7.69
    C-HEAD OF WALKWAY           8.09                             8.21
    D-TOP CORNER WALKWAY        7.35                             7.34
    E-OPPOSITE TOP CORNER       8.21                             8.21
    F-TOP OF VEHICLE            6.07                             6.06

 TUNNEL CENTER WITH
RESPECT TO CONTROL POINT

            H(IN)             -14.79                            -0.70
            V(FT)               5.02                             5.18

    NO SIGN INDICATES CENTER
    TO RIGHT OF CONTROL POINT

    - SIGN INDICATES CENTER
    TO LEFT OF CONTROL POINT


CORE USAGE      OBJECT CODE=   31584 BYTES,ARRAY AREA=    5892 BYTES,TOTAL AREA AVAILABLE=   39008  BYTES

DIAGNOSTICS       NUMBER OF ERRORS=      0, NUMBER OF WARNINGS=      0, NUMBER OF EXTENSIONS=      0

COMPILE TIME=    2.29 SEC,EXECUTION TIME=    1.59 SEC,  WATFIV - VERSION 1 LEVEL 3 MARCH  1971     DATE=  74/228
```

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SF	0.00
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	120012.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	0.00
END OVERHANG	END	0.00

OPTION ONE DATA

ITEM	COORDINATES (X,Y)
BOTTOM CORNER POINT	-67.00, 0.00
EXTREME SIDE POINT	-70.00, 43.00
CORNER CURVE POINT ONE	-33.93, 83.00
CORNER CURVE POINT TWO	-60.00, 95.00
CORNER CURVE POINT THREE	-48.00, 100.50

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 10001. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 10001. FT
SUPERELEVATION (IN.)	0.00	0.00
TUNNEL RADIUS (FT)	8.04	7.98
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.04	7.98
B-TREAD OF WALKWAY	7.89	7.83
C-HEAD OF WALKWAY	8.04	7.98
D-TOP CORNER WALKWAY	7.40	7.45
E-OPPOSITE TOP CORNER	8.04	7.98
F-TOP OF VEHICLE	6.16	6.15
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-5.49	4.56
V(FT)	4.69	4.69

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	0.00
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	120012.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	0.00
END OVERHANG	END	0.00

OPTION TWO DATA

ITEM	SYMBOL	VALUE
WIDTH OF ENVELOPE AT BOTTOM	WEB	134.00
WIDTH OF ENVELOPE AT EXTREME SIDE	WEES	140.00
HEIGHT OF ENVELOPE AT EXTREME SIDE	HEES	43.00
SLOPE OF SIDE OF CAR	SIDSLP	21.00
SLOPE OF TOP OF CAR	TOPSLP	0.11
RADIUS OF CURVATURE	CORRAD	23.12

COMPUTATION OF TUNNEL RADIUS

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 10001. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 10001. FT
SUPERELEVATION (IN.)	0.00	0.00
TUNNEL RADIUS (FT)	8.04	7.98
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.04	7.98
B-TREAD OF WALKWAY	7.87	7.81
C-HEAD OF WALKWAY	8.04	7.98
D-TOP CORNER WALKWAY	7.38	7.43
E-OPPOSITE TOP CORNER	8.04	7.98
F-TOP OF VEHICLE	6.17	6.17
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-5.60	4.68
V(FT)	4.68	4.68

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

CORE USAGE OBJECT CODE= 31584 BYTES,ARRAY AREA= 5892 BYTES,TOTAL AREA AVAILABLE= 39008 BYTES

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0, NUMBER OF EXTENSIONS= 0

COMPILE TIME= 2.36 SEC,EXECUTION TIME= 6.71 SEC, WATFIV - VERSION 1 LEVEL 3 MARCH 1971 DATE= 74/228

INPUT DATA

ITEM	SYMBOL	VALUE,IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	8.25
HORIZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	120012.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	ID	0.00
END OVERHANG	END	0.00

OPTION ONE DATA

ITEM	COORDINATES (X,Y)
BOTTOM CORNER POINT	-67.00, 0.00
EXTREME SIDE POINT	-70.00, 43.00
CORNER CURVE POINT ONE	-37.51, 83.00
CORNER CURVE POINT TWO	-60.00, 95.00
CORNER CURVE POINT THREE	-48.00, 100.50

COMPUTATION OF TUNNEL RADIU.

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 10001. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 10001. FT
SUPERELEVATION (IN.)	8.25	8.25
TUNNEL RADIUS (FT)	8.06	8.11
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.06	8.11
B-TREAD OF WALKWAY	8.06	7.69
C-HEAD OF WALKWAY	8.01	8.11
D-TOP CORNER WALKWAY	7.38	7.35
E-OPPOSITE TOP CORNER	8.06	8.11
F-TOP OF VEHICLE	6.16	6.17
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-13.32	-0.92
V(FT)	4.93	5.06

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

INPUT DATA

ITEM	SYMBOL	VALUE, IN.
GAUGE OF TRACK	GAUGE	66.00
SUPERELEVATION	SE	8.25
HOROZONTAL LOCATION OF CONTACT RAIL	HORLOC	69.00
VERTICAL LOCATION OF CONTACT RAIL	VERLOC	5.00
RADIUS OF CURVATURE	RADIUS	120012.00
LENGTH OF CAR	LENGTH	840.00
DISTANCE BETWEEN AXLES	AXDIST	600.00
HEIGHT OF WALKWAY ABOVE ADJACENT RAIL	WALKHT	24.00
MINIMUM WIDTH OF WALK-WAY TREAD	FOOTWD	24.00
HEIGHT OF WALK ENVELOPE	STAND	78.00
WIDTH OF TOP OF WALK-WAY ENVELOPE (MIN)	HEADWD	20.00
HEIGHT OF CLEARANCE EN-VELOPE ABOVE RAILS	CARHT	25.00
CONSTRUCTION CLEARANCE	CLEAR	5.00
WALKWAY ENVELOPE CLEAR-ANCE	WLKCLR	2.00
WALKWAY TREAD CLEARANCE	TRDCLR	5.00
MAX. WALKWAY ENVELOPE ENCROACHMENT	ENCRCH	3.00
ACOUSTICAL TREATMENT THICKNESS	ACOUST	1.50
MAXIMUM HEIGHT OF TOP OF CAR	MAXHT	105.00
CAR WIDTH	CARWD	140.00
MIDDLE OVERHANG	IO	0.00
END OVERHANG	END	0.00

OPTION TWO DATA

ITEM	SYMBOL	VALUE
WIDTH OF ENVELOPE AT BOTTOM	WEB	134.00
WIDTH OF ENVELOPE AT EXTREME SIDE	WEES	140.00
HEIGHT OF ENVELOPE AT EXTREME SIDE	HEES	43.00
SLOPE OF SIDE OF CAR	SIDSLP	21.00
SLOPE OF TOP. OF CAR	TOPSLP	0.11
RADIUS OF CURVATURE	CORRAD	23.12

COMPUTATION OF TUNNEL RADII

	WALKWAY ON SAME SIDE AS CENTER OF CURVE RADIUS 10001. FT	WALKWAY ON OPPOSITE SIDE AS CENTER OF CURVE RADIUS 10001. FT
SUPERELEVATION (IN.)	8.25	8.25
TUNNEL RADIUS (FT)	8.07	8.11
DISTANCE TO POINTS (FT)		
A-CONTACT RAIL	8.07	8.11
B-TREAD OF WALKWAY	8.07	7.68
C-HEAD OF WALKWAY	8.04	8.11
D-TOP CORNER WALKWAY	7.35	7.32
E-OPPOSITE TOP CORNER	8.07	8.11
F-TOP OF VEHICLE	6.18	6.18
TUNNEL CENTER WITH RESPECT TO CONTROL POINT		
H(IN)	-13.59	-0.81
V(FT)	4.92	5.05

NO SIGN INDICATES CENTER
TO RIGHT OF CONTROL POINT

- SIGN INDICATES CENTER
TO LEFT OF CONTROL POINT

CORE USAGE   OBJECT CODE= 31496 BYTES,ARRAY AREA=   5892 BYTES,TOTAL AREA AVAILABLE= 39008 BYTES

DIAGNOSTICS   NUMBER OF ERRORS=   0, NUMBER OF WARNINGS=   0, NUMBER OF EXTENSIONS=   0

COMPILE TIME=   2.34 SEC,EXECUTION TIME=   9.10 SEC, WATFIV - VERSION 1 LEVEL 3 MARCH 1971   DATE= 74/232

6. PLOTTING ROUTINE

This section gives a listing of statements which can be added to the MAIN routine to produce a computer-generated plot of the tunnel shape, center point, top of low-rail, vehicle envelope, and the walkway envelope. These figures can be used to give rapid visualization of the computer printouts and to reduce drafting costs. The routine is designed using software for a ZETA plotter on the IBM 360/65. A special output file must be defined to hold the data to be plotted. If the end card equals '66' instead of '99' the computer-plot is generated. In order to visualize location of the critical points, refer back to Figures 1-1 and 1-2. The scale in these plots is 1 inch equals 1 yard (3 feet).

```
      414 FORMAT(   ' CAR WIDTH',T31,'CARWD',T58,F7.2)
      415 FORMAT(T6,'OF CAR')
      416 FORMAT(//,T26,'OPTION TWO DATA')
      417 FORMAT(T26,'------ --- ----',/)
      419 FORMAT(T6,'ITEM',T31,'SYMBOL',T60,'VALUE')
      420 FORMAT(T6,'----',T31,'------',T60,'-----')
      421 FORMAT(' WIDTH OF ENVELOPE AT',T31,'WEB',T58,F7.2)
      422 FORMAT(T6,'BOTTOM')
      423 FORMAT(' WIDTH OF ENVELOPE AT',T31,'WEES',T58,F7.2)
      424 FORMAT(T6,'EXTREME SIDE')
      425 FORMAT(' HEIGHT OF ENVELOPE AT',T31,'HEES',T58,F7.2)
      426 FORMAT(T6,'EXTREME SIDE')
      427 FORMAT(' SLOPE OF SIDE OF CAR',T31,'SIDSLP',T58,F7.2)
      428 FORMAT(' SLOPE OF TOP OF CAR',T31,'TOPSLP',T58,F7.2)
      429 FORMAT(' RADIUS OF CURVATURE',T31,'CORRAD',T58,F7.2)
      430 FORMAT(' HEIGHT OF WALK ENVELOPE',T31,'STAND',T58,F7.2)
      440 FORMAT(' MIDDLE OVERHANG',T31,'ID',T58,F7.2)
      441 FORMAT(' END OVERHANG',T31,'END',T58,F7.2)
      500 FORMAT('1',/,T36,'COMPUTATION OF TUNNEL RADIUS',//)
      501 FORMAT(1H ,T31,'WALKWAY ON SAME SIDE',T71,'WALKWAY ON OPPOSITE')
      502 FORMAT(T32,'AS CENTER OF CURVE',T70,'SIDE AS CENTER OF CURVE')
      503 FORMAT(1H ,T35,'RADIUS',T75,'RADIUS')
      504 FORMAT(T34,F6.0,' FT',T74,F6.0,' FT')
      505 FORMAT(' TUNNEL RADIUS (FT)',T34,F6.2,T74,F6.2,/)
      506 FORMAT(1H ,' DISTANCE TO POINTS (FT)')
      507 FORMAT(T6,'A-CONTACT RAIL',T34,F6.2,T74,F6.2)
      508 FORMAT(T6,'B-TREAD OF WALKWAY',T34,F6.2,T74,F6.2)
      509 FORMAT(T6,'C-HEAD OF WALKWAY',T34,F6.2,T74,F6.2)
      510 FORMAT(T6,'D-TOP CORNER WALKWAY',T34,F6.2,T74,F6.2)
      511 FORMAT(T6,'E-OPPOSITE TOP CORNER',T34,F6.2,T74,F6.2)
      512 FORMAT(T6,'F-TOP OF VEHICLE',T34,F6.2,T74,F6.2,/)
      513 FORMAT(1H ,' TUNNEL CENTER WITH ')
      514 FORMAT(' RESPECT TO CONTROL POINT',/)
      515 FORMAT(1H ,T14,'H(IN)',T34,F6.2,T74,F6.2)
      516 FORMAT(T14,'V(FT)',T34,F6.2,T74,F6.2)
      517 FORMAT(T34,'---------',T74,'---------',/)
      518 FORMAT(' SUPERELEVATION (IN.)',T34,F6.2,T74,F6.2,/)
      520 FORMAT(/,T6,'NO SIGN INDICATES CENTER')
      521 FORMAT(T6,'TO RIGHT OF CONTROL POINT')
      522 FORMAT(/,T6,'- SIGN INDICATES CENTER')
      523 FORMAT(T6,'TO LEFT OF CONTROL POINT',////////)
          IF(L.EQ.99) GOTO 2
          IF (L.EQ.66) GOTO 800
PLOTTING ROUTINE
      700 DO 1000 N=1,360
          W(N)=D*SIN((N*PI)/180)    } TUNNEL CIRCLE
          Z(N)=D*COS((N*PI)/180)
     1000 CONTINUE
          G1=SQRT((XT-XLCNR)*(XT-XLCNR)+(YT-YLCNR)*(YT-YLCNR))
          P2=ARSIN((CORRAD)/G1)
          Q5=(YT-YLCNR)/(XT-XLCNR)
          P3=ATAN(Q5)
          Q6=TAN(P3-P2)
          B6=YT-Q6*XT
          Q7=-1/Q6
```

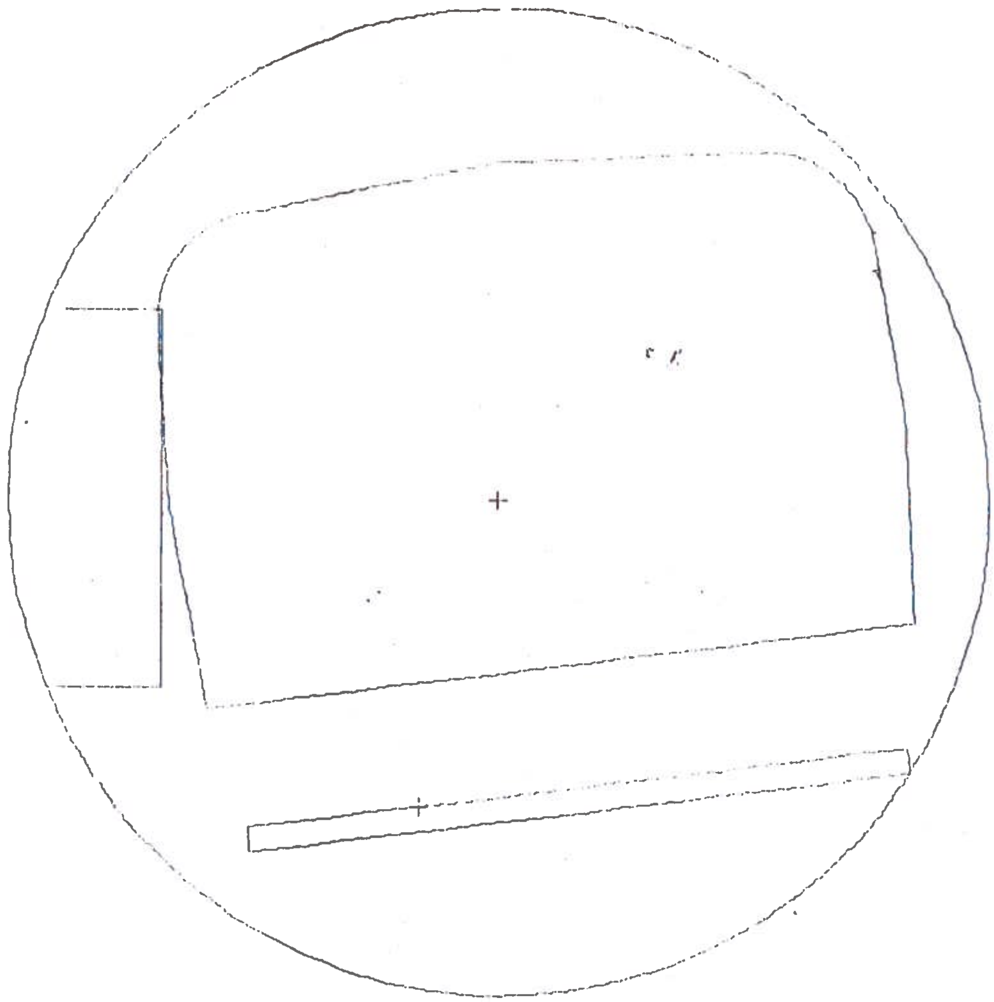
```
      B7=YLCNR-Q7*XLCNR
      XTL=(B6-B7)/(Q7-Q6)
      YTL=Q6*XTL+B6
      ANGL1=INT((-V2*180)/PI+90)
      DO 1050 N=1,ANGL1
      AXE(N)=-CORRAD*SIN(((ANGL1-N)*PI)/180)+XLCNR  } LEFT UPPER
      AYE(N)=CORRAD*COS(((ANGL1-N)*PI)/180)+YLCNR   } CORNER
 1050 CONTINUE                                      } CIRCLE
      G2=SQRT((XT-XRCNR)*(XT-XRCNR)+(YT-YRCNR)*(YT-YRCNR))
      P4=ARSIN(CORRAD/G2)
      P5=ATAN((YT-YRCNR)/(XT-XRCNR))
      SLOP1=TAN(P5-P4)
      YINT1=YT-SLOP1*XT
      SLOP2=-1/SLOP1
      YINT2=YRCNR-SLOP2*XRCNR
      XTR=(YINT1-YINT2)/(SLOP2-SLOP1)
      YTR=SLOP1*XTR+YINT1
      G3=SQRT((XRS-XRCNR)*(XRS-XRCNR)+(YRS-YRCNR)*(YRS-YRCNR))
      P6=ARSIN(CORRAD/G3)
      P7=ATAN((YRS-YRCNR)/(XRS-XRCNR))
      SLOP3=TAN(P7-P6)
      ALOP4=PI/2-ATAN(-1/SLOP3)
      ANGL2=INT((ALOP4*180)/PI)
      DO 1100 N=1,ANGL2
      AME(N)=CORRAD*SIN((N*PI)/180)+XRCNR  } RIGHT UPPER
      ANE(N)=CORRAD*COS((N*PI)/180)+YRCNR  } CORNER
 1100 CONTINUE                             } CIRCLE
      TRCX=-(HORLOC-GAUGE/2)*COS(PHI)  ]
      TRCY=-(HORLOC-GAUGE/2)*SIN(PHI)  ]
      TRDX=VERLOC*SIN(PHI)+TRCX        ]
      TRDY=-VERLOC*COS(PHI)+TRCY       ]
      TREX=(2*HORLOC)*COS(PHI)+TRDX    ]  RAIL
      TREY=(2*HORLOC)*SIN(PHI)+TRDY    ]
      TRFX=-VERLOC*SIN(PHI)+TREX       ]
      TRFY=VERLOC*COS(PHI)+TREY        ]
      CALL PLOTF(30,8)
      CALL OFFSET(0.,36.,0.,36.)
      CALL PLOT(4.6,7.,-3)
      CALL LINE(W(1),Z(1),360,1,0,+12)   DRAW TUNNEL
      CALL SYMBOL(0.,0.,.1,3,0.,-1)  PUT + AT CENTER
      CALL PLOT(-X0,-Y0,-13)
      CALL SYMBOL(0.,0.,.1,3,0.,-1) PUT + AT ORIGIN
      CALL SLINE
      CALL PLOT(XLC,YLC,+13)  }
      CALL PLOT(XLS,YLS,+12)  } DRAW LEFT SIDE OF CAR
      CALL PLOT(XLT,YLT,+12)  }
      CALL CLINE
      CALL PLOT(AXE(1),AYE(1),+12)                }  DRAW LEFT
      CALL LINE(AXE(1),AYE(1),ANGL1,1,0,+12)      }  CORNER OF CAR
      CALL SLINE
      CALL PLOT(XT,YT,+12)              }
      CALL PLOT(AME(1),ANE(1),+12)      } DRAW TOP OF CAR
      CALL CLINE
      CALL LINE(AME(1),ANE(1),ANGL2,1,0,+12) } DRAW RIGHT CORNER
                                             } OF CAR
```

```
      CALL SLINE
      CALL PLOT(XRS,YRS,+12)          } COMPLETE CAR
      CALL PLOT(XRC,YRC,+12)          }
      CALL PLOT(XLC,YLC,+12)          }
      CALL PLOT(BX,BY,+13)            ]
      FOOTX=BX+FOOTWD*BVL             ]
      CALL PLOT(FOOTX,BY,+12)         ]
      STANY=BY+STAND                  ] DRAW WALKWAY
      CALL PLOT(FOOTX,STANY,+12)      ]
      HEDX=FOOTX-HEADWD*BVL           ]
      CALL PLOT(HEDX,STANY,+12)       ]
      CALL PLOT(0,0,+13)
      CALL PLOT(TRCX,TRCY,+12)        } DRAW RAIL
      CALL PLOT(TRDX,TRDY,+12)        }
      CALL PLOT(TREX,TREY,+12)        }
      CALL PLOT(TRFX,TRFY,+12)        }
      CALL PLOT(0,0,+12)
      CALL SYMBOL(-2.,-2.,.1,15HSUPERELEVATION=,0.,15)
      CALL NUMBER(999.,999.,.1,SE,0.,2)
      CALL SYMBOL(999.,999.,.1,3HIN.,0.,3)
      CALL SYMBOL(1.3,999.,.1,13HTRACK RADIUS=,0.,13)
      CALL NUMBER(999.,999.,.1,RADIUS,0.,0)
      CALL SYMBOL(999.,999.,.1,3HFT.,0.,3)
      CALL SYMBOL(-2.,-2.5,.1,12HTUNNEL DIA.=,0.,12)
      DIAM=2*DR(K)
      CALL NUMBER(999.,999.,.1,DIAM,0.,2)
      CALL SYMBOL(999.,999.,.1,3HFT.,0.,3)
      CALL SYMBOL(-2.,-3.,.1,26HDISTANCE TO POINTS IN FEET,0.,26)
      CALL SYMBOL(-2.,-3.25,.1,2HA-,0.,2)
      CALL NUMBER(999.,999.,.1,DA(K),0.,2)
      CALL SYMBOL(-2.,-3.50,.1,2HB-,0.,2)
      CALL NUMBER(999.,999.,.1,DB(K),0.,2)
      CALL SYMBOL(-2.,-3.75,.1,2HC-,0.,2)
      CALL NUMBER(999.,999.,.1,DC(K),0.,2)
      CALL SYMBOL(-2.,-4.00,.1,2HD-,0.,2)
      CALL NUMBER(999.,999.,.1,DD(K),0.,2)
      CALL SYMBOL(-2.,-4.25,.1,2HE-,0.,2)
      CALL NUMBER(999.,999.,.1,DE(K),0.,2)
      CALL SYMBOL(-2.,-4.50,.1,2HF-,0.,2)
      CALL NUMBER(999.,999.,.1,DF(K),0.,2)
      CALL NOBF
      CALL EXIT
  800 STOP
      END
```

PLOTTING (statements 0491–0532)

PRINTING (statements 0508–0530)

SEE FIGURE 1-1



SUPERELEVATION=8.25IN. TRACK RADIUS=500.FT.

TUNNEL DIA.=16.97FT.

DISTANCE TO POINTS IN FEET

A-8.49

B-8.49

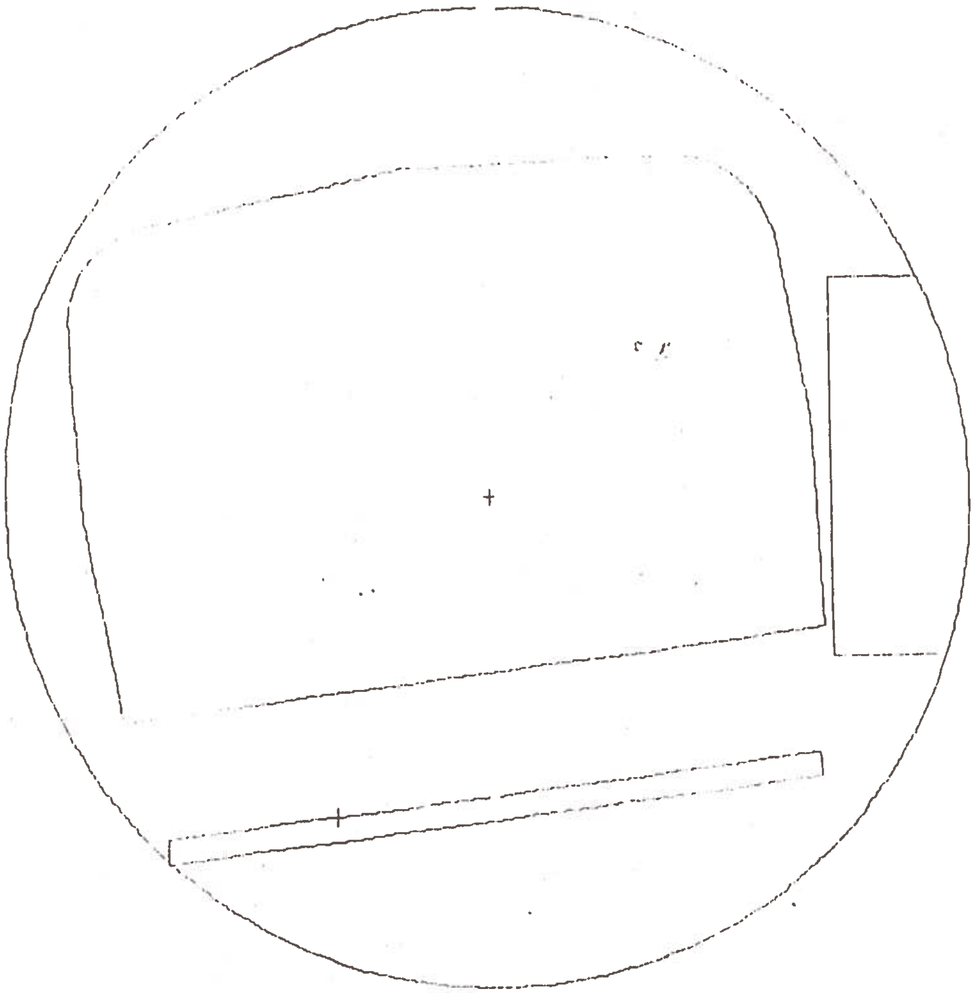
C-8.17

D-7.37

E-8.49

F-5.83

SEE FIGURE 1-2



SUPERELEVATION=6.25IN TRACK RADIUS-500.FT.

TUNNEL DIA =16.62FT.

DISTANCE TO POINTS IN FEET

A-6 41

B-6.34

C-6.41

D-7.41

E-6.41

F-5 79