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**Wireframe Analysis of Driver Leg-Movement Space:
Determination of Nth-Percentile Maximum Excursion Histograms**

Project Report

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16. Abstract <p>This document describes the function and use of two computer programs used with the WIREFRAM program (see UMTRI-92-24) for determining driver leg-movement Maximum Excursion Histograms. The programs are called MXMXEX and PRCNTILE. These programs are run after WIREFRAM runs, which determines the "package-maximum excursion histogram" for each subject in the study. A package-maximum excursion histogram represents the maximum extent envelope in a particular direction for all repetitions of all movements for the subject for a particular vehicle seating package.</p> <p>Beginning with a set of WIREFRAM package-maximum excursion histogram files (one file for each subject), MXMXEX and PRCNTILE allow determination of Nth-percentile maximum excursion histograms for any selected population. Maximum excursion histogram files can be obtained from the PRCNTILE program for any seating package used in the study, any histogram type, and any percentile, N, for the total driving population. Total driving population is normally defined from 10 different stature groups of adult male and female subjects who performed pedal actuation tasks and generated leg-movement space-time contours.</p> <p>Maximum excursion files produced by PRCNTILE are Nth percentile in the sense that for each histogram cell in the leg-movement space, N percent of the (weighted) population does not have excursions that exceed the maximum excursion value.</p> <p>This manual discusses program input data and also program output and the method of their calculation. Illustrative examples are given.</p>					
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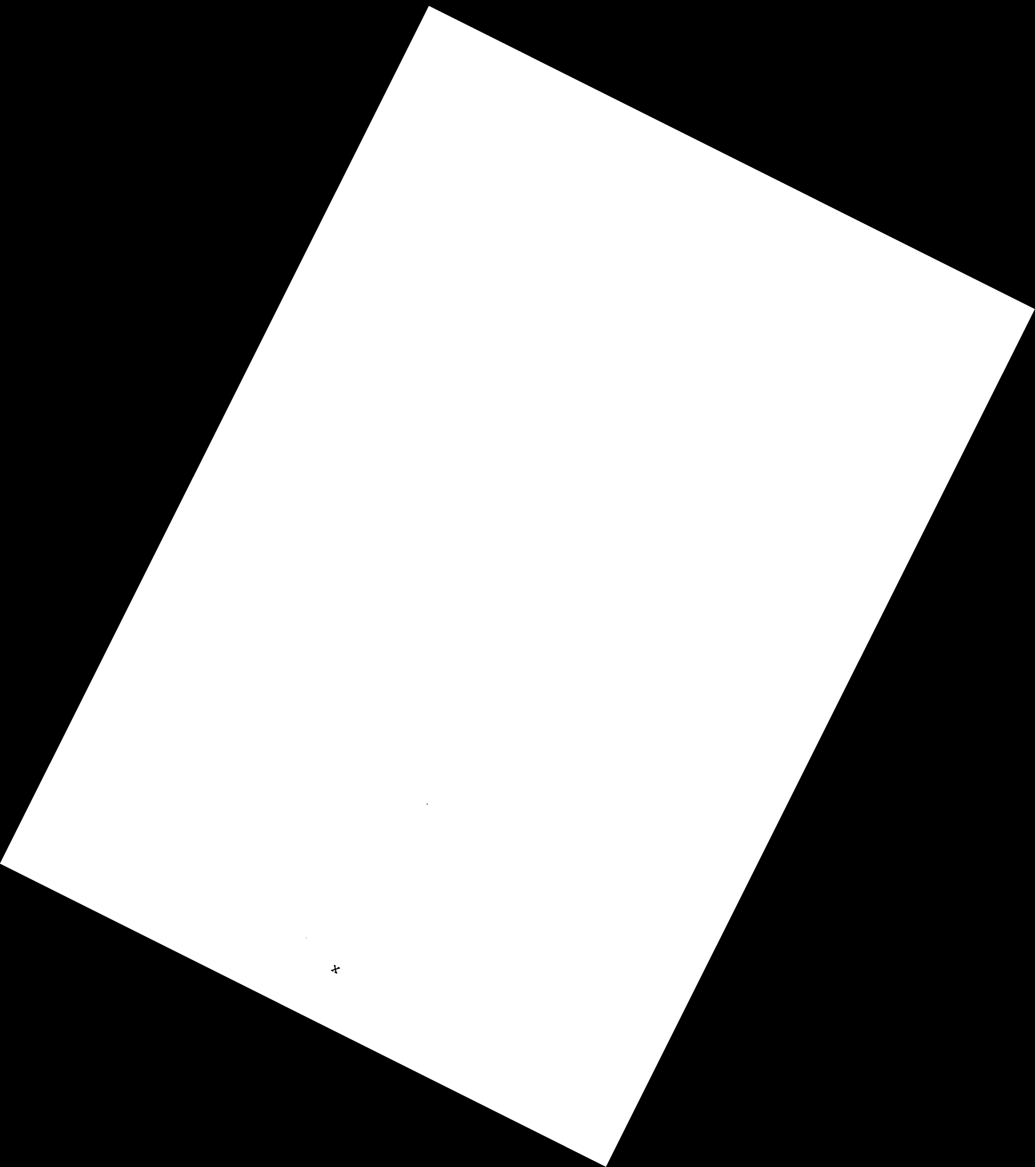
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MXMXEX and PRCNTILE Programs

Determination of Nth-Percentile Maximum Excursion Histograms

1.0 Introduction

This document describes the function and use of two computer programs used with the WIREFRAM program for determining driver leg-movement maximum excursion histograms. The programs are called MXMXEX (MaXimum-MaXimum EXcursion) and PRCNTILE. These programs are run after WIREFRAM runs, which determine the "package-maximum excursion histogram" for each subject in the study. The package-maximum excursion histogram represents the maximum extent envelope for all repetitions of all movements for the subject for a particular vehicle package geometry (i.e., seat height, etc.). (See WIREFRAM User and Programmer Guides.)

Beginning with a set of WIREFRAM package-maximum excursion histogram files (one file for each subject), MXMXEX and PRCNTILE allow determination of Nth-percentile maximum excursion histograms for any selected population. MXMXEX determines a distribution file of maximum excursion values for any specified group of subjects. After MXMXEX has been run for one or more groups selected for defining a particular population, PRCNTILE can be run to determine a maximum excursion histogram file for any requested percentile, N, for the defined population. A maximum excursion histogram, whether produced by WIREFRAM or PRCNTILE, is a set of values of a user-specified maximum excursion coordinate (normally +Z, -X, +Y, or -Y) as a function of the other two coordinates. A maximum excursion value may be any integer number (in millimeters). The other two coordinates are defined over an n-by-m grid in a plane that cuts through the wireframe; thus, the other two coordinates take on values that are a constant plus a multiple of the grid spacing (i.e., "cell" size). Maximum excursion files produced by PRCNTILE are Nth percentile in the sense that for each histogram cell in the leg-movement space, N percent of the (weighted) population do not have excursions that exceed the maximum excursion value.

Section 2.0 of this manual describes the MXMXEX program. Section 3.0 describes the PRCNTILE program.

For more detailed information about wireframes, cutting planes, and maximum excursion histograms, see WIREFRAM User and Programmer Guides.

2.0 MXMXEX -- Maximum-Maximum Excursion Program

The program MXMXEX (Maximum-Maximum Excursion) determines the cell-by-cell distribution of maximum histogram values from any specified group of subjects. The program requires about 6 MB of memory on an MS-DOS 386 computer.

The program writes two output files. For the purpose of discussing these files, a specific type of maximum histogram will be used for illustration, viz., an XPZ maximum excursion histogram. It is called an XPZ histogram because an $X = \text{constant}$ family of cutting planes (6 mm apart) is used in WIREFRAM processing and maximum excursion in the Plus-Z direction is determined--in each 6 mm x 6 mm cell of an X-Y grid. The other types of histograms for which processing was conducted in the study are ZMX, XPY, and XMY (M=minus). Any CSH histogram can be determined, however, where C (cutting plane coordinate) is X, Y, or Z, S (sign for H) is P(+) or M(-), and H (histogram coordinate) is X, Y, or Z and not equal to C. The four types of maximum excursion histograms are described in Table 1.

Table 1. Maximum Excursion Histogram Types

MAXIMUM EXCURSION HISTOGRAM TYPES USED IN STUDY		
Type	Maximum Excursion in	Cutting Planes (6 mm apart)
XPZ	+ Z	X = constant (vertical, transverse)
ZMX	- X	Z = constant (horizontal)
XPY	+ Y	X = constant (vertical, transverse)
XMY	- Y	X = constant (vertical, transverse)

Notes:

1. +X is rearward
2. +Y is to the left
3. +Z is upward
4. transverse: left-right, across the legs

2.1 MXMXEX Output Files

This section describes and illustrates output files from a run of the MXMXEX program. Input data for the run are not shown here. Complete input and output for runs of both MXMXEX and PRCNTILE for a simpler example are included in Section 3.2.

2.1.1 Group Maximum Excursion Histogram File

The WIREFRAM program determines up to 21 maximum excursion histogram files, including one--the "nnnnnV00.CSH" file--for which all repetitions and all movements are examined for a particular seat V (T, E, or C for Taurus, Econoline, or Camaro¹) and subject "nnnnn" to obtain maximum excursion values, cell by cell. This is the "package-maximum excursion histogram." Just as WIREFRAM determines a *global* histogram file for a particular subject and vehicle seating package, MXMXEX determines a *group* global histogram file for a particular vehicle seating package for a group of subjects. That is, WIREFRAM reads any specified set of "nnnnnV00.CSH" files, one for each subject in the group, and produces a single, global maximum excursion histogram file, which is called "GROUPxxx.xxx", where xxx.xxx is V00.CSH, regardless of the population group specified. The file should be renamed, identifying the group--usually 01, 02, ..., 10--so that it is not written over when an MXMXEX run is made for another group. An appropriate name for a Taurus seating package run for group 01 and maximum excursion histogram type XPZ would be GRP01TAU.XPZ, for example.

2.1.2 Maximum Excursion Distribution File

Leg-movement data will be of greatest benefit to automotive design engineers if it can be presented in terms of population percentiles. That is, while global maximum excursion data are still of interest, it is important to determine also the cell-by-cell distributions of maximum excursion values over all subjects in specified groups, such as 201xx, 202xx, ..., 205xx, 106xx, 107xx, ..., 110xx. This is the primary function of MXMXEX. Regardless of the population group for which the MXMXEX run is made, the output file containing distribution data is called "DISTRxxx.xxx", where xxx.xxx is V00.CSH. As for the GROUPxxx.xxx files, a DISTRxxx.xxx must be renamed before an MXMXEX run is made for another group.

2.2 Example Output

Example output files for the Taurus seating package and XPZ maximum excursion histograms are illustrated by extracted sections in Figures 1 and 2. These are from the final test run of the program, which was for the full group of 20xxx subjects. The global maximum excursion histogram file, GROUPT00.XPZ, is 133676 bytes in size and 16515 bytes when

¹ The seat identified in this manual and in data sets as a "Camaro" seat was actually from a Firebird.

ZIP'd. The maximum excursion distribution file, DISTRT00.XPZ, is 570659 bytes in size and 173202 bytes when ZIP'd. The MXMXEX program took 5 to 10 minutes to run for the 20xxx group. Both output files are sequential and in ASCII.

2.2.1 GROUPT00.XPZ

This file has exactly the same layout and size as the 50 20???T00.XPZ files read by MXMXEX to produce it and is illustrated in Figure 1. Values for all X-Y cells are the maximum excursions in the plus-Z direction over all reps and movements and all 20??? subjects for the Taurus seat. A "-9999" value indicates that no subject's wireframe encloses the associated X-Y cell for any value of Z; i.e., no part of the occupant compartment located within a column along Z at this cell location would be interfered with by any leg movement made by any of the 20xxx-group of subjects.

2.2.2 DISTRT00.XPZ

The Maximum Excursion Distribution file is illustrated in Figure 2. The file is completely described in the file header section, which is included with the numeric data. (That description is not repeated here; see Figure 2.)

The data record " 47/ 143 152 159" in Figure 2 is used to illustrate content of the GROUPT00.XPZ and DISTRT00.XPZ files. The " 47/" indicates that 47 (of the 50) subjects do not have a non-9999 Z-value in the X-Y cell corresponding to this record, i.e., their wireframes do not enclose this part of the laboratory leg-movement space. The numbers 143, 152, and 159 are the ascendingly ordered maximum +Z excursion values for this cell for the three subjects that reach this X-Z in at least one of their leg movements. The largest +Z reached was 159, so 159 is the value that will be found in the GROUPT00.XPZ file (Figure 1) for the 20xxx group of subjects.

The " 47/ 143 152 159" record is line number 1807 in the DISTRT00.XPZ file. The instructions printed in the header indicate that 50 should be subtracted from 1807 to get the numeric data record number, $K = 1807 - 50 = 1757$. Equations included in the header then indicate that the *inner loop index* (for X) is $KI = 1757 \text{ mod } 134 = \underline{15}$. The *outer loop index* (for Y) is $KO = (1757 - 15)/134 + 1 = \underline{14}$. Then, $X(KI) = -288 + 6*(15-1) = \underline{-204}$ and $Y(KO) = 100 + 6*(14-1) = \underline{178}$.

The numbers underlined above all relate to identification of the cell corresponding to a particular record. Other equations in the file header allow the inverse calculation to be made if needed (i.e., to get numeric data record number for given cell identifiers).

Note that if more than one subject has the same maximum excursion value for a cell, that value is repeated. This is seen in the 1st, 5th, and 6th "44/" cells in Figure 2.

Maximum Maximum Excursion: Subject set 20XXX
 Seat= Taurus, Movement= 0, Repetition= 0, No. Samples= 1
 Cutting Plane Family No. 1 ("X = const cuts "): plane no. 1, X= -288.0
 Cutting Plane Family No. 1 ("X = const cuts "): plane no. 2, X= -282.0

 Cutting Plane Family No. 1 ("X = const cuts "): plane no. 15, X= -204.0

 Cutting Plane Family No. 1 ("X = const cuts "): plane no.134, X= 510.0
 Cutting Plane Family No. 1 ("X = const cuts "): plane no.135, X= 516.0

Beg X- box No	X-box values									
1	-288	-282	-276	-270	-264	-258	-252	-246	-240	-234
11	-228	-222	-216	-210	-204	-198	-192	-186	-180	-174
21	-168	-162	-156	-150	-144	-138	-132	-126	-120	-114
31	-108	-102	-96	-90	-84	-78	-72	-66	-60	-54
41	-48	-42	-36	-30	-24	-18	-12	-6	0	6
51	12	18	24	30	36	42	48	54	60	66
61	72	78	84	90	96	102	108	114	120	126
.....										
.....										
121	432	438	444	450	456	462	468	474	480	486
131	492	498	504	510						

Y-box No.	Y-box Value	Beg X- box No	Maximum excursion in Z direction											
1	100	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
.....														
.....														
		81	497	497	497	496	496	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		91	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		101	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		111	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		121	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		131	-9999	-9999	-9999	-9999								
14	178	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	-9999	147	159	164	198	201	204	208		
		21	211	214	218	221	224	227	235	243	251	258		
		31	266	275	275	254	259	264	269	274	279	284		
		41	290	295	302	308	315	321	328	335	342	348		
		51	356	362	368	375	381	388	394	402	409	417		
		61	424	429	435	440	445	451	458	465	471	479		
		71	486	493	499	503	509	514	519	524	531	536		
		81	542	546	546	546	546	547	547	547	547	546		
		91	481	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		101	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		111	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		121	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		131	-9999	-9999	-9999	-9999								
15	184	1	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
		11	-9999	-9999	150	157	164	176	178	200	203	206		
		21	211	214	217	221	224	228	231	235	243	252		

Figure 1. Maximum Excursion Histogram File GROUPT00.XPZ

CELLWISE DISTRIBUTION OF MAXIMUM EXCURSION VALUES FOR A SUBJECT GROUP

Maximum Histogram Type: XPZ
 Subject Group File Name: 20XXX

20101	20102	20103	20104	20105	20106	20107	20108	20109	20111
20201	20202	20204	20205	20207	20208	20209	20210	20211	20301
20302	20303	20304	20306	20307	20308	20309	20310	20311	20312
20401	20402	20403	20404	20406	20407	20408	20410	20411	20412
20413	20501	20503	20504	20505	20506	20507	20508	20511	20512

 Number of cells: 14606

Cells are indexed as in "reading" across and down through the maximum excursion file; i.e., the "inner loop" is on X and the "outer loop" is on Y .

Inner loop coordinate (V): X = -288 to 510 by step 6 (count = 134)
 Outer loop coordinate (U): Y = 100 to 748 by step 6 (count = 109)

K = linear cell index
 KI = inner loop index = K mod 134 (134 if mod is zero)
 KO = outer loop index = (K - KI) / 134 + 1

$X(KI) = -288 + (6) * (KI - 1)$
 $Y(KO) = 100 + (6) * (KO - 1)$

 X = inner loop coordinate
 Y = outer loop coordinate

$KI = (X - -288) / (6) + 1$
 $KO = (Y - 100) / (6) + 1$
 $K = (KO - 1) * 134 + KI$

 Cell values are maximum excursion in Z.

The records below are for cell index K = 1 to 14606 and have the format:
 I3, '/', 10I4 -- i.e., each record has the form 'nnn/aaaabbbbccccddd...'.
 Here, nnn is the number of -9999 values for this cell among all histogram files
 for the subjects listed in file 20XXX . The values aaaa, bbbb, cccc, ...
 are ascendingly ordered non-9999 values of Z that occur in all histogram files.
 This file can be used to generate a scratch, formatted direct access file if
 desired for postprocessing operations.

 THIS IS LINE 50. SUBTRACT 50 FROM DATA RECORD NUMBER TO GET CELL INDEX, K.
 50/
 50/

.....
 Figure 2. Maximum Excursion Distribution File DISTRT00.XPZ
 (Page 1 of 2)

```

50/
50/
.....
.....
50/
50/
49/ 147
47/ 143 152 159
47/ 154 158 164
45/ 146 154 161 168 198
46/ 157 165 173 201
45/ 162 166 168 178 204
45/ 170 171 175 183 208
45/ 171 178 184 189 211
44/ 170 181 185 194 194 214
44/ 170 185 190 199 201 218
44/ 173 187 196 203 210 221
44/ 173 187 201 208 220 224
44/ 147 172 206 213 227 227
42/ 125 151 174 194 211 218 231 235
42/ 129 153 177 199 211 224 231 243
43/ 132 158 177 203 229 234 251
44/ 135 161 207 234 234 258
45/ 139 166 207 239 266
45/ 142 169 181 244 275
46/ 146 174 249 275
47/ 146 178 254
.....
.....

```

Figure 2. Maximum Excursion Distribution File DISTRT00.XPZ
(cont.) (Page 2 of 2)

3.0 PRCNTILE -- Nth-Percentile Maximum Histogram Program

The PRCNTILE program calculates information related to percentiles for maximum excursion histograms. It has two primary functions, viz., to calculate A) a "total-population" probability distribution file given maximum excursion histogram data for different (weighted) population groups and B) an Nth-percentile maximum excursion histogram given a probability distribution file and a desired percentile, N in [0,100]. Outputs A and B are from Options 2 and 1, described in Table 3. The PRCNTILE program requires about 9 MB of memory on an MS-DOS 386 computer.

Maximum excursion histogram files can be obtained from the PRCNTILE program for any seating package (Taurus, Econoline, Camaro), any histogram type, and any percentile, N, for the total driving population. Here, *total driving population* is normally defined by 10 groups of subjects as defined in Table 2. The population may be defined as desired, however--e.g., all males, groups 6 through 10 weighted 15.0, 25.0, 20.0, 25.0, and 15.0; or a 4 to 1 female to male mix, groups 1 through 10 weighted 12.0, 20.0, 16.0, 20.0, 12.0, 3.0, 5.0, 4.0, 5.0, 3.0.

Table 2. Definition of Total Driving Population

DEFINITION OF THE TOTAL DRIVING POPULATION
IN THE FORD STUDY

Group No.	File Names	Sex	Number of Subjects	Group Weight in Driving Population (%)
1	201xx	F	10	7.5
2	202xx	F	9	12.5
3	203xx	F	11	10.0
4	204xx	F	11	12.5
5	205xx	F	9	7.5
6	106xx	M	10	7.5
7	107xx	M	11	12.5
8	108xx	M	10	10.0
9	109xx	M	9	12.5
10	110xx	M	11	7.5

3.1 PRCNTILE Program Summary

Table 3 summarizes the options, inputs, and outputs of the PRCNTILE program. The user selects from two different options when running the program. They are 1) to calculate a maximum excursion histogram for some percentile N from a probability distribution file specified for a particular population (generated by Option 2), and 2) to generate a file that, for each cell, gives the population probability distribution $p(x)$ for maximum excursions less than or equal to x , from maximum excursion "DISTR"ibution files produced by MXMXEX.

Table 3. PRCNTILE Program Summary (Page 1 of 2)

Option

1 = calculate a maximum excursion histogram for some percentile N from a probability distribution file specified for a particular population (generated by Option 2)

Inputs:

- a) the probability distribution file, PROBxxxx.xxx, specific to a population and to a maximum excursion type, which has previously been generated by Option 2
- b) a value N in [0, 100] to request a desired percentile

Outputs:

- a) a maximum excursion histogram file (cell by cell format), PRCNTxxx.xxx, for the requested percentile

Option

2 = generate a population probability distribution file $p(x)$, for maximum excursion less than or equal to x , from "DISTR"ibution files

Inputs:

- a) a set of M DISTRxxxx.xxx files representing in total a specific population [files generated by MXMXEX, containing cell by cell distribution data for maximum excursion for subjects in the M population groups]
- b) weighting factors for the M different population groups within the total population

-- continued on next page --

Table 3. PRCNTILE Program Summary (Page 2 of 2)

Outputs:

- a) a probability distribution file, PROBxxxx.xxx, specific to the population and to the maximum excursion type

Method:

1. input weighting factor W_i for population groups, $i=1, \dots, M$
2. determine the number of subjects in each population group, S_i , $i=1, \dots, L$
3. calculate the weight per subject in each population group, $w_i = W_i / S_i$
4. for each cell, i.e., record "K":
 - a. determine an ordered set of unique integer maximum excursion values, V_j , $J=0, \dots, JJ$, over all population groups, where $j=0$ is for the -9999 (no value for cell)
 - b. determine the count $C_{j,i}$ of occurrences of each unique value, for each population group
 - c. determine the weighted number of occurrences of each value over all population groups to model the total driving population: $\beta_j = \sum C_{j,i} \cdot w_i$
 - d. normalize the β 's by $B = \sum \beta_j$ and calculate the probability distribution function of the JJ maximum excursion values:

$$\theta_0 = \beta_0 / B$$

$$\theta_j = \beta_j / B + \theta_{j-1}$$

β_j is a weighted probability density function for occurrence in the total population of all of the maximum excursion values. θ_j is the normalized partial sums of the β 's; it is the probability distribution for the probability that a subject selected randomly from the total population will have a maximum excursion less than or equal to the j th unique value for this cell.

- e. for a requested percentile N in $[0, 100]$, calculate the maximum excursion value V as a linearly interpolated value in the θ table for argument $x = N/100$

3.2 Example Input and Output for MXMXEX and PRCNTILE

Figures 4 and 5 illustrate output from PRCNTILE options 1 and 2, respectively. Associated cellwise maximum excursion distribution files, MXMXEX output, are shown in Figures 3-A and 3-B. The example illustrated by Figures 3, 4, and 5 is for full, 14606-cell, maximum histogram files for XPZ for the Taurus seating package but for a simple total population defined by two groups as follows:

Population Group A: the first six of the 201xx subjects,
group weight = 0.50 (subjects 20101,
20102, 20103, 20104, 20105, 20106)

Population Group B: the last four of the 201xx subjects,
group weight = 0.50 (subjects 20107,
20108, 20109, 20111)

For purpose of illustration attention is focused on a particular cell--specifically, cell number K = 2432, i.e., X = -174, Y = 208. Values for this cell are marked in Figures 3, 4, and 5.

Required input to MXMXEX includes specification of a file that contains a list of the subjects that make up the group as well as a path for finding the "nnnnnV00.CSH" maximum excursion histograms from WIREFRAM runs. The list files for the two MXMXEX runs for this example (GROUP-A and GROUP-B) are shown in Figures 6-A and 6-B. Similarly, required input to PRCNTILE (for Option 2) includes specification of a file that contains a list of the maximum excursion distribution files to be read as input as well as values for the weight factors to be used for the designated groups. The weight factors must add to either 1.000 or to 100.0. The list file for PRCNTILE (Option 2) for this example is shown in Figure 7. Interactive (or batch) inputs are required also by both the MXMXEX and PRCNTILE programs. Listings of the complete interactive input and output for the two runs of MXMXEX (for group A and group B) are in Figures 8-A and 8-B. Listings for the two runs of PRCNTILE (for Option 2 and Option 1) are in Figures 9 and 10.

3.2.1 Description of Procedure: MXMXEX

MXMXEX was first run for each of the two population groups, A and B. The cellwise maximum excursion distribution files obtained as output were next used as input to PRCNTILE for the purpose of generating a probability distribution file. This is done by selecting Option 2 in the PRCNTILE run. Portions of the MXMXEX output files DISATAU.XPZ and DISBTAU.XPZ (PRCNTILE input files) are shown in Figures 3-A and 3-B, and portions of the total-population probability distribution file obtained from the run of PRCNTILE for Option 2 are shown in Figure 4. (Also see Section 3.2 and Figures 6-A, 6-B, 7, 8-A, 8-B, 9, and 10.)

3.2.2 Description of Procedure: PRCNTILE

Finally, with the Figure 4 data as input, the 85th-percentile maximum excursion histogram file was generated by running PRCNTILE with Option 1. A portion of the output file is shown in Figure 5. The 85th-percentile value for each cell in Figure 5 is obtained from a linear interpolation between values in the probability distribution file for the weighted population, shown in Figure 4. Note that the maximum excursion histogram data are in a *cellwise* format, i.e., they are ordered sequentially, one value per record. This is different from the format of the maximum excursion histogram files produced by the WIREFRAM program and (for group-maximums) the MXMEX program, as illustrated by Figure 1. The X and Y values for any cellwise Z-excursion value in Figure 5 must be calculated from the line number of the excursion value. The calculation is simple and is illustrated in the figure. Calculation formulas are printed in the header section of the file (page 1 of Figure 5).

Side, front, and top views of the 85th-percentile maximum excursion histogram envelope for the "Group A / Group B" example are shown in the plots of Figures 11 to 14. The contours in each plot are for the entire family of vertical, transverse cutting planes (i.e., parallel planes at X = constant for XPZ histograms). The cutting planes are 6 mm apart. The plots are for data that have been transformed from laboratory buck coordinates to H-point coordinates by first converting to vehicle coordinates. For the Taurus seating package the transformation relations¹ are:

$$\begin{aligned} X_{\text{H-point}} &= X + (2398 - 3046) = X - 648 \\ Y_{\text{H-point}} &= -Y + (40 + 370) = -Y + 410 \\ Z_{\text{H-point}} &= Z + (385 - 655) = Z - 270 \end{aligned}$$

where X, Y, and Z are unadjusted maximum excursion histogram data such as in Figure 5.

PRCNTILE (Option 1) can be rerun to obtain as many different Nth-percentile maximum excursion histograms as desired. It is necessary to rerun MXEXEX and Option 2 of PRCNTILE only if it is desired to determine Nth-percentile histograms for a different population.

(Also see Section 3.2 and Figures 6-A, 6-B, 7, 8-A, 8-B, 9, and 10.)

¹ Transformation relations for the Econoline and Camaro (Firebird) are:

$$\begin{aligned} \text{Econoline:} \quad X_{\text{H-point}} &= X + (2586 - 3181) = X - 595 \\ Y_{\text{H-point}} &= -Y + (92 + 502) = -Y + 594 \\ Z_{\text{H-point}} &= Z + (718 - 1130) = Z - 412 \end{aligned}$$

$$\begin{aligned} \text{Camaro:} \quad X_{\text{H-point}} &= X + (2410 - 3050) = X - 640 \\ Y_{\text{H-point}} &= -Y + (40 + 370) = -Y + 410 \\ Z_{\text{H-point}} &= Z + (428 - 609) = Z - 181 \end{aligned}$$

```

...
...
6/
6/
5/ 137
5/ 142
4/ 148 229
4/ 153 231
3/ 159 170 233      <-- K = (line number in file) - 50 = 2432
2/ 164 169 170 236      KI = K mod 134 (134 if mod is zero) = 20
2/ 169 169 170 238      KO = (K - KI) / 134 + 1 = 19
2/ 165 171 179 241
2/ 147 175 185 243
3/ 175 191 247      where 134 is the "V count" from line 23
3/ 174 197 250
4/ 202 254      X(KI) = -288 + ( 6) * (KI - 1) = -174
4/ 208 257      Y(KO) = 100 + ( 6) * (KO - 1) = 208
4/ 214 261
4/ 220 264      where the values -288, 100, and 6
4/ 227 268      are from lines 23 and 24
4/ 233 270
...
...

```

Figure 3-A. The Cellwise Maximum Excursion DISTRibution File from MXMXEX for Population Group A (Six Subjects)

```

...
...
3/ 195
3/ 198
1/ 174 201 208
1/ 177 203 210
1/ 180 206 212
1/ 183 206 214
1/ 187 196 217      <-- K = (line number in file) - 50 = 2432
1/ 190 197 217      KI = K mod 134 (134 if mod is zero) = 20
2/ 193 200      KO = (K - KI) / 134 + 1 = 19
2/ 196 203
2/ 199 206
2/ 200 209      where 134 is the "V count" from line 23
2/ 200 212
2/ 197 215      X(KI) = -288 + ( 6) * (KI - 1) = -174
2/ 201 218      Y(KO) = 100 + ( 6) * (KO - 1) = 208
2/ 208 222
2/ 213 225      where the values -288, 100, and 6
2/ 218 229      are from lines 23 and 24
2/ 221 232
...
...

```

Figure 3-B. The Cellwise Maximum Excursion DISTRibution File from MXMXEX for Population Group B (Four Subjects)

CELLWISE TOTAL POPULATION PROBABILITY DISTRIBUTION FOR MAXIMUM EXCURSION

Maximum Histogram Type: XPZ
List of DISTRxxx.xxx files: DEMOLIST

Header of the probability distribution file PROBxxxx.XPZ from a run of PRCNTILE (Option 2) with group A and group B maximum excursion distribution files as input and group weights of 0.50 and 0.50

Number of cells: 14606

Cells are indexed as in "reading" across and down through the maximum excursion file; i.e., the "inner loop" is on X and the "outer loop" is on Y .

Inner loop coordinate (V): X = -288 to 510 by step 6 (count = 134)
Outer loop coordinate (U): Y = 100 to 748 by step 6 (count = 109)

K = linear cell index
KI = inner loop index = K mod 134 (134 if mod is zero)
KO = outer loop index = (K - KI) / 134 + 1

X(KI) = -288 + (6) * (KI - 1)
Y(KO) = 100 + (6) * (KO - 1)

X = inner loop coordinate
Y = outer loop coordinate

KI = (X - -288) / (6) + 1
KO = (Y - 100) / (6) + 1
K = (KO - 1) * 134 + KI

Cell values are maximum excursion in %.

The records below are for cell index K = 1 to 14606 and have the format:
1st record, blank. 2nd record of form '///aaaabbbbccccddd...'.
3rd record, 102F4.3, where the first value is the part of the total population with -9999 and the other values are the part of the population with maximum excursion less than or equal to the value above in the 2nd record. The values aaaa, bbbb, cccc, ..., are ordered, unique non-9999 values that occur for cell K in all DISTRxxx files.

THIS IS RECORD #50. CALCULATE CELL INDEX AS K = (REC#(blank) - (51-3)) / 3 .

///
1.00

Figure 4. Option 2 Output from a Run of PRCNTILE
(Probability Distribution File) (Page 1 of 2)

```
//// 195
.875 1.0
```

```
//// 198
.875 1.0
```

```
//// 137 174 201 208
.542.625.750.875 1.0
```

```
//// 142 177 203 210
.542.625.750.875 1.0
```

```
//// 148 180 206 212 229
.458.542.667.792.917 1.0
```

```
//// 153 183 206 214 231
.458.542.667.792.917 1.0
```

```
//// 159 170 187 196 217 233
.375.458.542.667.792.917 1.0
```

Portion of the probability distribution file PROBxxxx.XPZ from a run of PRCNTILE (Option 2) with group A and group B maximum excursion distribution files as input and group weights of 0.50 and 0.50

```
<-- K = (line number in file - 48) / 3
      = 2432
      line number = 3 * K + 48 = 7344
```

```
//// 164 169 170 190 197 217 236
.292.375.458.542.667.792.917 1.0
```

Figure 4. Option 2 Output from a Run of PRCNTILE
(cont.) (Probability Distribution File) (Page 2 of 2)

CELLWISE MAXIMUM EXCURSION HISTOGRAM (TOTAL POPULATION) FOR 85th PERCENTILE

Maximum Histogram Type: XPZ
Probability Distribution File Name: \PROB-AB.XPZ

Portion of the 85th-percentile maximum excursion file from a run of PRCNTILE (Option 1) with the probability distribution file for groups A and B as input

Number of cells: 14606

Cells are indexed as in "reading" across and down through the maximum excursion file; i.e., the "inner loop" is on X and the "outer loop" is on Y .

Inner loop coordinate (V): X = -288 to 510 by step 6 (count = 134)
Outer loop coordinate (U): Y = 100 to 748 by step 6 (count = 109)

K = linear cell index
KI = inner loop index = K mod 134 (134 if mod is zero)
KO = outer loop index = (K - KI) / 134 + 1

X(KI) = -288 + (6) * (KI - 1)
Y(KO) = 100 + (6) * (KO - 1)

X = inner loop coordinate
Y = outer loop coordinate

KI = (X - -288) / (6) + 1
KO = (Y - 100) / (6) + 1
K = (KO - 1) * 134 + KI

Cell values are maximum excursion in Z.

The records below are for cell index K = 1 to 14606 and have the format: A4, where the value is the nearest integer to the interpolated floating point maximum excursion, Z = W, for the 85th percentile or ' ---' if all groups have -9999 for cell (assume -9999), ' -+-' if within -9999 range, or ' +++' if between -9999 and first non-9999 value (assume -9999). A 85th percentile value W for maximum excursion in Z means that 85 per cent of the values for the weighted population are less than or equal to W.

THIS IS LINE 50. SUBTRACT 50 FROM DATA RECORD NUMBER TO GET CELL INDEX, K.

Figure 5. Option 1 Output from a Run of PRCNTILE (Nth-Percentile Maximum Excursion Histogram File) (Page 1 of 2)

```

.....
.....
-+-
-+-
196
198
209
210
206
206
196
199
202
204
206
208
213
218
222
228
232
236
241
245
250
.....
.....

```

Portion of the 85th-percentile maximum excursion file from a run of PRCNTILE (Option 1) with the probability distribution file for groups A and B as input

```

<-- K = (line number in file) minus 50 = 2432

      KI = K mod 134 (134 if mod is zero) = 20
      KO = (K - KI) / 134 + 1 = 19

      where 134 is the "V count" from line 23

      X(KI) = -288 + ( 6 ) * (KI - 1) = -174
      Y(KO) = 100 + ( 6 ) * (KO - 1) = 208

      where the values -288, 100, and 6
      are from lines 23 and 24

```

Interpolation using values from Figure 4:

$$Z = 196 + (217 - 196) * (.85 - .792) / (.917 - .792)$$

$$= 205.77 \approx 206 \text{ mm}$$

Figure 5. Option 1 Output from a Run of PRCNTILE (Nth-Percentile Maximum Excursion Histogram File) (Page 2 of 2)

```
c:\wire\20101
c:\wire\20102
c:\wire\20103
c:\wire\20104
c:\wire\20105
c:\wire\20106
```

Figure 6-A. MXMXEX Input "List" File GROUP-A for Two Group Example

```
c:\wire\20107
c:\wire\20108
c:\wire\20109
c:\wire\20111
```

Figure 6-B. MXMXEX Input "List" File GROUP-B for Two Group Example

```
c:\wire\disatau.xpz
50
c:\wire\disbtau.xpz
50
```

Figure 7. PRCNTILE (Option 2) Input "List" File for Two Group Example

C:\WIRE>UP MXMXEX
Copyright (c) 1987, 1988 A. I. Architects, Inc. (OS 1.9.16; CP 5.9a)

Enter file name which contains list of subject numbers prefixed by
paths for location of the Maximum Excursion Files (40 characters):
GROUP-A

Enter Seat/Mvt/Rep Indicator, or END to quit (3 char; e.g., E00):
T00

Enter the extension for the desired Maximum Excursion Files
for specified subjects (3 char -- viz., ZMX, XPZ, XPY, XMY, etc.):
XPZ

Specify path z:\...\ to write max-maximum excursion file (28 chars):
C:\WIRE\

Specify path z:\...\ to write distribution file (28 chars), or "skip":
C:\WIRE\

Analyzing	c:\wire\20101T00.XPZ
Analyzing	c:\wire\20102T00.XPZ
Analyzing	c:\wire\20103T00.XPZ
Analyzing	c:\wire\20104T00.XPZ
Analyzing	c:\wire\20105T00.XPZ
Analyzing	c:\wire\20106T00.XPZ

The Maximum Maximum Excursion File has been written.
File = C:\WIRE\GROUPT00.XPZ

Generating the Distribution File...
File = C:\WIRE\DISTRT00.XPZ

** PROCESSING COMPLETED **

Enter Seat/Mvt/Rep Indicator, or END to quit (3 char; e.g., E00):
END

Normal Termination

C:\WIRE>RENAME GROUPT00.XPZ GRPATAU.XPZ

C:\WIRE>RENAME DISTRT00.XPZ DISATAU.XPZ

C:\WIRE>DIR ???ATAU.XPZ

Volume in drive C has no label
Directory of C:\WIRE

GRPATAU	XPZ	133676	4-17-91	10:42a
DISATAU	XPZ	145003	4-17-91	10:42a

Figure 8-A. Interactive Input and Output for Group A Run
of MXMXEX

C:\WIRE>UP MXMXEX
Copyright (c) 1987, 1988 A. I. Architects, Inc. (OS 1.9.16; CP 5.9a)

Enter file name which contains list of subject numbers prefixed by
paths for location of the Maximum Excursion Files (40 characters):
GROUP-B

Enter Seat/Mvt/Rep Indicator, or END to quit (3 char; e.g., E00):
T00

Enter the extension for the desired Maximum Excursion Files
for specified subjects (3 char -- viz., ZMX, XPZ, XPY, XMY, etc.):
XPZ

Specify path z:\...\ to write max-maximum excursion file (28 chars):
C:\WIRE\

Specify path z:\...\ to write distribution file (28 chars), or "skip":
C:\WIRE\

Analyzing	c:\wire\20107T00.XPZ
Analyzing	c:\wire\20108T00.XPZ
Analyzing	c:\wire\20109T00.XPZ
Analyzing	c:\wire\20111T00.XPZ

The Maximum Maximum Excursion File has been written.
File = C:\WIRE\GROUPT00.XPZ

Generating the Distribution File...
File = C:\WIRE\DISTRT00.XPZ

** PROCESSING COMPLETED **

Enter Seat/Mvt/Rep Indicator, or END to quit (3 char; e.g., E00):
END

Normal Termination

C:\WIRE>RENAME GROUPT00.XPZ GRPBTAU.XPZ

C:\WIRE>RENAME DISTRT00.XPZ DISBTAU.XPZ

C:\WIRE>DIR ???BTAU.XPZ

Volume in drive C has no label
Directory of C:\WIRE

GRPBTAU	XPZ	133676	4-17-91	10:44a
DISBTAU	XPZ	122841	4-17-91	10:45a

Figure 8-B. Interactive Input and Output for Group B Run
of MXMXEX

```
C:\WIRE>UP PRCNTILE
Copyright (c) 1987, 1988 A. I. Architects, Inc. (OS 1.9.16; CP 5.9a)
```

```
Select option 1 or 2:
```

- 1 = calculate a maximum excursion histogram for percentile P
- 2 = generate a population probability distribution file (p(x),
for maximum excursion less than or equal to x)
- 3 = quit

```
2
```

```
Initializing...
```

```
Enter name of file which contains list of DISTRxxx.xxx files  
(prefixed by paths) and weights for all subject groups (40 char):  
DEMOLIST
```

```
Analyzing C:\WIRE\DISATAU.XPZ
```

```
Analyzing C:\WIRE\DISBTAU.XPZ
```

```
Generating probability distribution file...
```

```
Output file is PROBDIST.XPZ
```

```
C:\WIRE>RENAME PROBDIST.XPZ PROB-AB.XPZ
```

```
C:\WIRE>DIR PROB-AB.XPZ
```

```
Volume in drive C has no label  
Directory of C:\WIRE
```

```
PROB-AB XPZ 379035 4-17-91 11:02a
```

```
C:\WIRE>
```

Figure 9. Interactive Input and Output for Run of PRCNTILE, Option 2, for Two Group Example


```
C:\WIRE>UP PRCNTILE
Copyright (c) 1987, 1988 A. I. Architects, Inc. (OS 1.9.16; CP 5.9a)
```

```
Select option 1 or 2:
```

- 1 = calculate a maximum excursion histogram for percentile P
- 2 = generate a population probability distribution file (p(x),
for maximum excursion less than or equal to x)
- 3 = quit

```
1
```

```
Enter a percentile value, P in [0, 100]:
```

```
85
```

```
Enter name of the PROBxxxx.xxx file for probability distribution  
data, prefixed by path (40 char):
```

```
PROB-AB.XPZ
```

```
Generating output data...
```

```
Output file is PRCNTILE.XPZ
```

```
C:\WIRE>RENAME PRCNTILE.XPZ PCT85-AB.XPZ
```

```
C:\WIRE>DIR PCT85-AB.XPZ
```

```
Volume in drive C has no label
```

```
Directory of C:\WIRE
```

```
PCT85-AB XPZ      89475    4-17-91  11:04a
```

```
C:\WIRE>
```

Figure 10. Interactive Input and Output for Run of PRCNTILE,
Option 1, for Two Group Example

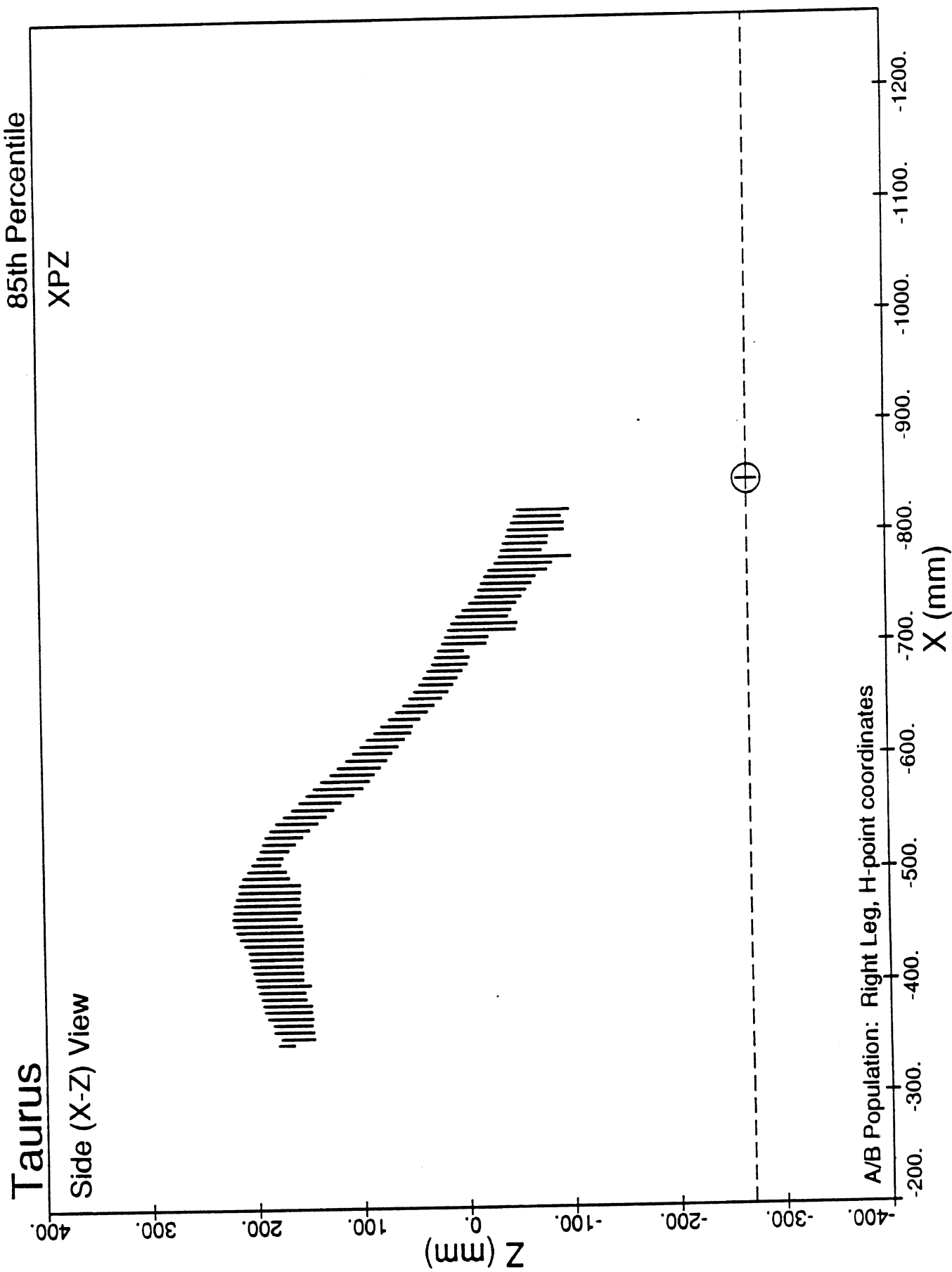


Figure 11. Side View (Right Leg) of 85th-Percentile Histogram

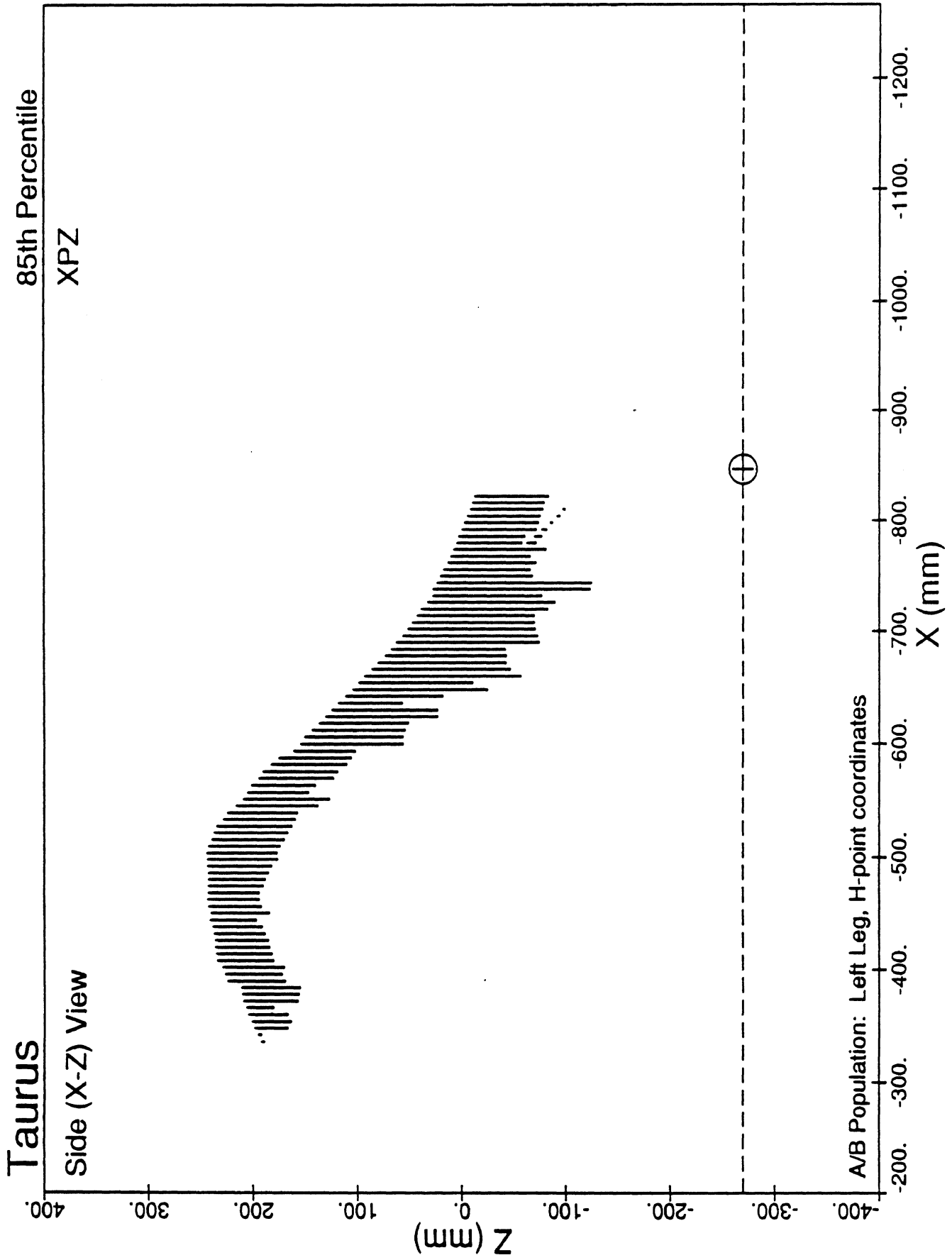


Figure 12. Side View (Left Leg) of 85th-Percentile Histogram

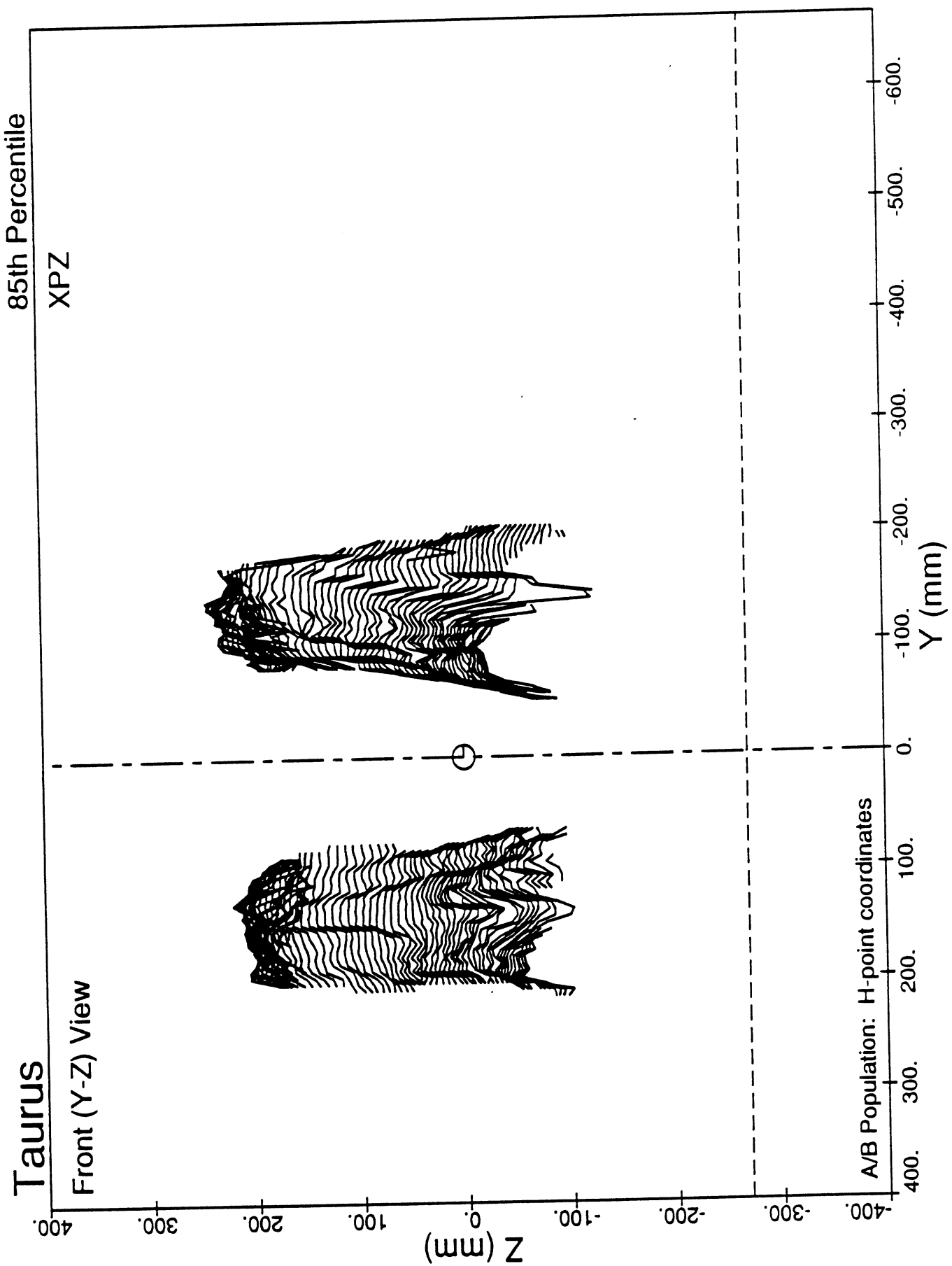


Figure 13. Front View of 85th-Percentile XPZ Histogram

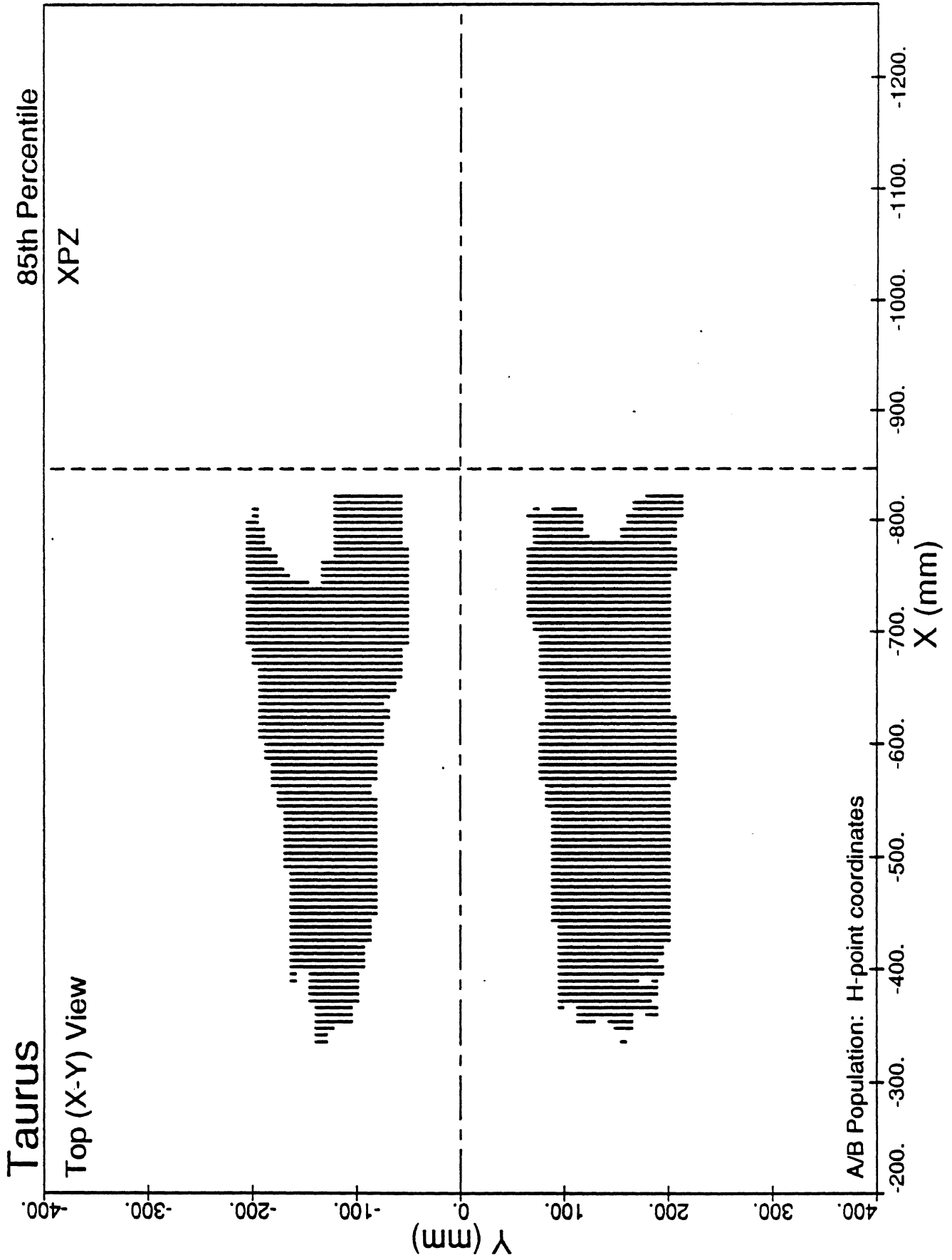


Figure 14. Top View of 85th-Percentile XPZ Histogram

