

83/74  
9-6-74  
N88AK

UCRL-52049

# CPS: A CONTINUOUS-POINT-SOURCE COMPUTER CODE FOR PLUME DISPERSION AND DEPOSITION CALCULATIONS

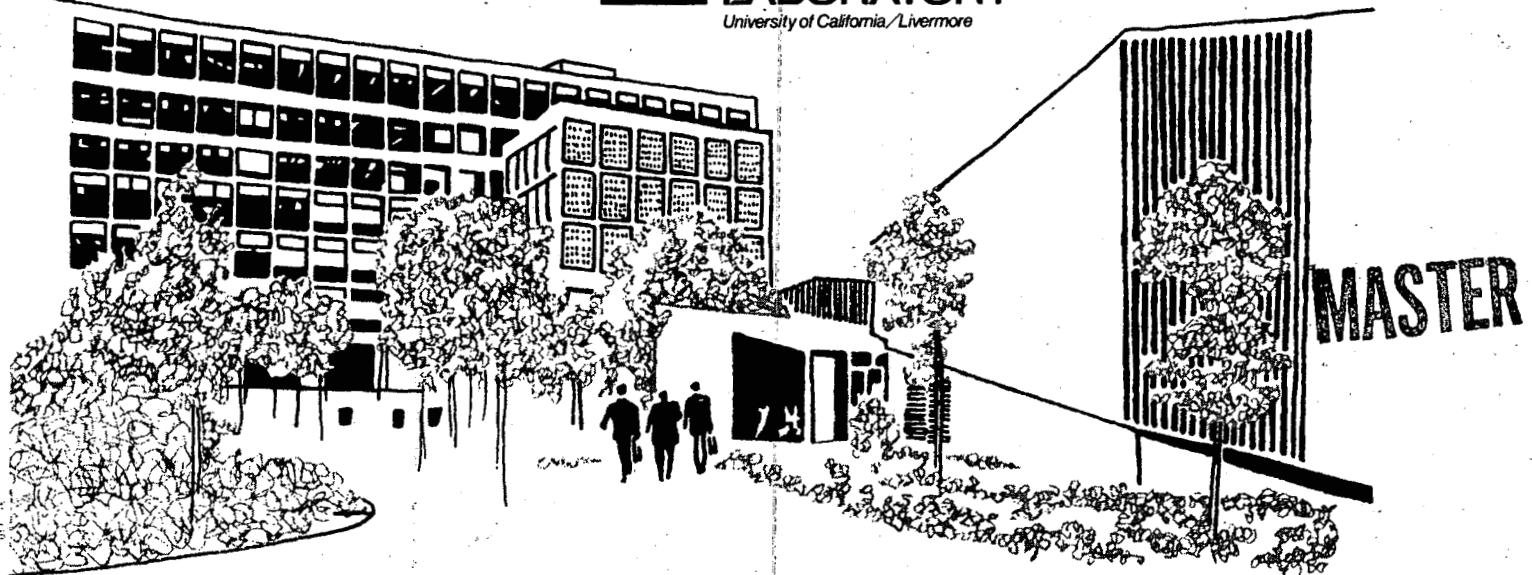
Kendall R. Peterson

Todd V. Crawford

Leonard A. Lawson

May 21, 1976

Prepared for U.S. Energy Research & Development  
Administration under contract No. W-7405-Eng-48



DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

## **DISCLAIMER**

**This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.**

## **DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

NOTICE

"This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research & Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately-owned rights."

Printed in the United States of America

Available from

National Technical Information Service

U.S. Department of Commerce

5285 Port Royal Road

Springfield, VA 22161

Price: Printed Copy \$ ; Microfiche \$2.25

<u>Page Range</u>	<u>Domestic Price</u>	<u>Page Range</u>	<u>Domestic Price</u>
001-025	\$ 3.50	326-350	10.00
026-050	4.00	351-375	10.50
051-075	4.50	376-400	10.75
076-100	5.00	401-425	11.00
101-125	5.25	426-450	11.75
126-150	5.50	451-475	12.00
151-175	6.00	476-500	12.50
176-200	7.50	501-525	12.75
201-225	7.75	526-550	13.00
226-250	8.00	551-575	13.50
251-275	9.00	576-600	13.75
276-300	9.25	601-up	*
301-325	9.75		

\* Add \$2.50 for each additional 100 page increment from 601 to 1,000 pages;  
add \$4.50 for each additional 100 page increment over 1,000 pages.



**LAWRENCE LIVERMORE LABORATORY**

*University of California, Livermore, California, 94550*

UCRL-52049

**CPS: A CONTINUOUS-POINT-SOURCE  
COMPUTER CODE FOR PLUME DISPERSION  
AND DEPOSITION CALCULATIONS**

Kendall R. Peterson

Todd V. Crawford

Leonard A. Lawson

MS. date: May 21, 1976

—NOTICE—

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

**MASTER**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

## Contents

Preface . . . . .	iv
Abstract . . . . .	1
Introduction . . . . .	1
User-Level Instructions . . . . .	3
Input . . . . .	3
Output . . . . .	6
Error Halts . . . . .	7
Availability . . . . .	8
Sample Problems . . . . .	8
Theory . . . . .	8
Basic Equations . . . . .	8
Wind Speed . . . . .	9
Standard Deviations . . . . .	9
Plume Height . . . . .	9
Dry Deposition . . . . .	10
Wet Deposition . . . . .	11
Radioactive Decay . . . . .	11
Background . . . . .	11
Vertical Integral . . . . .	11
Total Deposition . . . . .	11
Modes of Operation . . . . .	11
Program Description . . . . .	12
Appendix A CPS Code Listing and Computer-Prepared Flowchart . . . . .	17
Appendix B Sample CPS Problems . . . . .	71

## Preface

T. V. Crawford, presently associated with E. I. du Pont de Nemours & Co., Inc., at the Savannah River Laboratory, set up the basic framework of the continuous-point-source code before leaving the Lawrence Livermore Laboratory.

L. A. Lawson initially programmed the code and has made numerous programming changes to arrive at its present form.

K. R. Peterson has extensively modified the code and has introduced a number of improvements to extend its versatility and usefulness.

"Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Energy Research & Development Administration to the exclusion of others that may be suitable."

# CPS: A CONTINUOUS-POINT-SOURCE COMPUTER CODE FOR PLUME DISPERSION AND DEPOSITION CALCULATIONS

## Abstract

The continuous-point-source computer code calculates concentrations and surface deposition at distances from 0.1 to 100 km, assuming a Gaussian plume. The basic input is atmospheric stability category and wind speed, but a number of refinements are included:

1. Wind speed as a function of height.
2. Enhanced dilution from building wakes close to the source.
3. Calculation of plume-center trajectory as a function of effluent heat flux and wind speed.
4. Physical stack height.
5. Topography as a function of distance from the source.
6. Dry deposition resulting from turbulent processes.
7. Wet deposition resulting from precipitation.

8. Radioactive decay.
9. Nonzero background for the particular effluent involved.
10. Whether a release is routine or accidental.

Two kinds of output can be obtained:

1. The concentration as a function of distance, calculated from one set of meteorological data.
2. Contour plots of concentrations as a function of azimuth and distance, at different probability levels, calculated from many stored meteorological data sets.

This report describes the code in detail. It presents the equations used as well as input/output variables and format, internal variables, a code flowchart, a FORTRAN listing, three sample problems, and user-level instructions.

## Introduction

The continuous-point-source (CPS) code uses the commonly accepted methods discussed at length by Slade et al. in Meteorology and Atomic

Energy, 1968<sup>1</sup> to calculate the

<sup>1</sup>D. H. Slade, Ed., Meteorology and Atomic Energy, 1968 (U.S. Atomic Energy Commission, 1968).

concentrations in a continuously emitted plume. Calculations are made for distances of 0.1 to 100 km downwind. The Gaussian plume-diffusion equation is used; the vertical and horizontal standard deviations of the distributions are functions of the distance downwind and of the atmospheric stability category. These functions are a part of the code, but the user must input the Pasquill-Gifford stability category.

Wind speed is input for the above-ground height of the anemometer but is adjusted to the height of the plume centerline by the use of a stability-dependent power-law profile equation.

The code will handle topography as a function of distance from the source by changing the vertical distance between the plume centerline and the ground.

The continuous point source can be located at any height between the ground surface and the top of a stack. If a significant heat flux is associated with the emitted effluent, the code calculates the trajectory of the buoyant plume, using the heat flux rate and the mean wind speed between the physical stack top and the elevation above the ground of the plume (the code calculates this average wind speed and final plume height in an iterative procedure) as a function of distance downwind.

For near-surface sources the ef-

fects of cavity dilution resulting from building-wake effects can be included in the calculation. The user must provide the cross-sectional area of the building normal to the wind direction.

The mass of emitted material in the plume flowing past a particular point downwind can be depleted by turbulent dry deposition (a deposition velocity is specified) or precipitation (a washout/rainout coefficient is specified). Airborne concentrations are appropriately reduced, and the cumulative amount deposited on the ground is calculated as a function of distance downwind. Similarly, if the emitted material is radioactive, a half-life can be specified and radioactive decay will be included in the calculations.

There are two types of output. With one meteorological data set (wind speed, stability category, wind direction, and occurrence of precipitation) plume-centerline concentrations, ground-level under-plume-concentration, and ground-level sector-averaged airborne concentration are output as a function of distance. Also the sector-averaged deposition on the ground (via dry and wet processes) and the value of the vertical integral through the plume centerline are output as a function of distance.

With a large amount of meteorological input--say hourly data for a

year--the code calculates concentrations and deposition as a function of azimuth and distance. Running sums are stored. At the end of the data set, contours of concentrations (plume centerline, ground-level under-cloud centerline, and sector-averaged at ground level) for different probability levels are prepared. By assuming a log-normal distribution of concentrations at points downwind, probability-level contours are also prepared. These contours will be exceeded 10, 5, 1, and 0.5% of the time. Also output are contour plots of the arithmetic and geometric average concentrations and

of the total accumulated deposition, allowing for radioactive decay if present.

For this second type of output, an input parameter is used to specify whether the release is routine or accidental. For routine emissions, the contours resemble a type of dispersion "wind rose." For an accidental release, the contours can be used for planning purposes and give concentrations that might be expected from a release lasting tens of minutes to days when the wind direction is not known prior to the accident.

### User-Level Instructions

#### INPUT

A sample input sheet for use with the CPS code is shown in Fig. 1. The

definitions of the variables are given in Table 1. When preparing the input, the equals sign must follow immediately after the variable name; the number

#### Line

1	Title (any length up to 50 spaces)			
2	Q=	H=	VDEP=	NORM=
3	GZHT=	ZSFC=	UMIN=	THALF=
4	ITOP=	ITDI=	SDZMX=	CA=
5	ISTACK=	SQ=	IPF=	PP=
6	BKG=	INPT=	SIZE=	KEPLOT=
7	TSTEP=	NPLETH=		
8	PLETH=			
9	DIST=			
24				
25	HGT=			
40				
41	ZZZZ			
42	DIR=	USFC=	ISCAT=	PRECP= ZZZZ

Fig. 1. Input sheet for the CPS code (filename: CPSIN).

Table 1. Input for the CPS code.

Name	Dimension	Units	Definition
BCD	6		Title of the current problem
BKG		units/m <sup>3</sup>	Background concentration of an emitted material
CA		m <sup>2</sup>	Building-wake factor
DIR		degrees	Direction from which the wind is blowing, relative to true north
DIST	10, 16	m	Distance of HGT values downwind (maximum number of distances is 10, and last value must be >105; for 16 different azimuths (22.5° sectors) starting toward the north (N = #1) and going through east to south to west; last entry is toward the north-northwest
GZHT		m	Height of ground zero above mean sea level
H		m	Physical height of release above GZHT
HGT	10, 16	m	Height of terrain above mean sea level at the corresponding distances and azimuths of DIST
INPT			Determines printout; if $\leq 0$ , will not print DIR and USFC input
IPF			An input flag for washout; if $\leq 0$ , it is not necessary to check for precipitation
ISCAT			Stability categories 1 through 6, corresponding to Pasquill-Gifford categories A through F
ISTACK			If ISTACK > 0, the effective plume rise must be calculated
ITDI			A flag for the number of sets of meteorological data that are to be processed; if $\leq 0$ code will expect large number of data sets and will do probability plots
ITOP			If ITOP > 0, use the topographical input; otherwise all topography is considered to be at sea level (GZHT must also be zero if ITOP $\leq 0$ )
KEPLOT			If KEPLOT > 0, the DD80 output is held for viewing on the TMDS; otherwise the DD80 file is automatically sent to the plotter

Table 1. Input for the CPS code (continued).

Name	Dimension	Units	Definition
NORM			Flag for type of release (normal release, $\leq 0$ ; accidental release, $> 0$ )
NPLETH	1 to 6		Optional entry to draw fewer than six contours
PLETH	1 to 6	units/m <sup>3</sup>	Optional entry to draw to contours specified instead of contours automatically selected by the code
PP		sec <sup>-1</sup>	Washout coefficient; not used if IPF $\leq 0$ or if PRECP $\leq 0$
PRECP			A flag for occurrence of precipitation; if no precipitation occurred, IPF $\leq 0$
Q		units	Source term
SDZMX		m	The maximum depth of mixed layer; if the input is $\leq 0$ , the maximum value of $\sigma_z$ is 2000
SIZE		m	Determines length of square plotting grid; maximum is $2 \times 10^5$ m
SQ		cal/sec	Stack heat flux
THALF		sec	Half-life of radionuclide; if THALF $\leq 0$ , the decay option is skipped
TSTEP		sec	Time interval between meteorological observations
UMIN		m/sec	Minimum wind speed allowed
USFC		m/sec	Wind speed at height ZSFC
VDEP		m/sec	Deposition velocity
ZSFC		m	Height of surface wind-measuring system aboveground

for a given variable may go any place after the equals sign. However, there must be no spaces in the number (e.g., 4.3E03, not 4.3E 03). The numbers are read into the computer in the format specified on the input sheet. If a decimal point is used,

the number will be read as a floating-point number; otherwise the number will be read as a fixed-point number. Any variable whose name starts with the letters I through N should be entered as a fixed-point variable. All others are floating-point variables.

NPLETH and PLETH are optional entries.

Special attention should be paid to the variables DIST and HGT. These are two-dimensional arrays that may have up to 10 distances or heights for each set of meteorological data. If there is more than one set, each set must have exactly 10 entries. The first line corresponds to topography toward the north (for a wind from the south), the second set to the north-northeast, the third set to the northeast, through the sixteenth, which is to the north-northwest. If there are less than 10 real values, an appropriate number of zeros must be put in to make 10 entries before starting with the next set. The last real value of DIST in any azimuth must have a value greater than  $10^5$  m. A space must be put in between each variable in an array; commas are not used.

The first line of the input form has been left blank. For the code to run, the title of the problem must be entered on this line. Between the title (first line) and DIST entries, the variables may be entered in any order, with several entries on each line, as long as the input does not go past column 72.

#### OUTPUT

Two different sets of output are available, depending on input. If

ITDI > 0, the output is provided for each set of meteorological data that is input. If ITDI = 0, the code makes calculations for many sets of meteorological data and then produces a set of average and probability outputs.

The variables that are printed out when using one set of data at a time are the following:

XDIST	Distance from the originating source, m
XCP	Plume-center line concentration, units/m <sup>3</sup>
XSFC	Ground-surface concentration under the plume centerline, units/m <sup>3</sup>
XI	Sector-averaged concentration at ground, units/m <sup>2</sup>
VI	Vertical integral through the plume centerline, units/m <sup>2</sup>
DEP	Wet and dry deposition on ground, units/m <sup>2</sup>
GHT	Ground height at distances described by XDIST, m
U	Wind speed at cloud-center altitude for each XDIST value, m/sec
UA	Average wind speed out to XDIST, m/sec

Two plots accompany this printed output. The first shows concentration in units per cubic metre versus distance downwind in metres; three curves are plotted: plume-centerline concentration, ground-level concentration on centerline, and sector-averaged ground-level concentration. The second plot

is the vertical integral through the plume centerline and total deposition, both in units per square metre, versus distance downwind in metres.

When the probability option is run, three types of output are presented. The first and second types are the arithmetic and geometric averages. The third type is for four levels of percentage probability: 10, 5, 1, and 0.5%. The calculations for each of these percentages represent the values that will be exceeded that percentage of the time. Variable names in the printout are

DIST	Distance downwind from the originating source, m
CP	Plume-center concentration, units/m <sup>3</sup>
SFC	Ground-level concentration under the plume center, units/m <sup>3</sup>
XI	Sector-averaged concentration at ground level, units/m <sup>3</sup>
TDEP	Total deposition (this is not an average, but the total wet and dry deposition for the whole time; if radioactive decay is present, the plot gives the amount remaining at the end of the total time, units/m <sup>2</sup> )

A contour plot is provided for each of the three types of concentration at each of the four percentage levels. Following these probability plots are

three concentration plots for the arithmetic average and three for the geometric average. The scale for all plots is determined by SIZE; for each plot, the smallest contour is selected that will most nearly fill the grid without having two adjacent points off the grid. The plots are always square.

Provision is made in the code to prepare countour plots for normal or accidental releases. The variable name NORM identifies the type of release. While the code is running, each of the concentrations is accumulated. For a normal release, these accumulated values are divided by the total number of observations, while for an accidental release the values within each sector are divided by the number of observations within that sector.

#### ERROR HALTS

Two error halts are included in the code. Both are caused by illegal input data and cause the code to terminate. If DIR exceeds 360° or if ISCAT exceeds 6 (stability category F), a message is sent to the teletype and the printout file. In both instances the code will terminate. The card in error will be the last one printed on the printout file if INPT > 0. In order to restart the program, the input must be corrected.

## AVAILABILITY

The CPS code has been written for, and run on, a CDC 7600 computer. An abbreviated version (without topography) has been programmed for a programmable desk calculator and plotter.

This latter program cannot handle more than one case at a time.

## SAMPLE PROBLEMS

Sample problems for both modes of operation have been prepared and are included in Appendix B.

## Theory

### BASIC EQUATIONS

The theory used in the CPS code is taken largely from Meteorology and Atomic Energy, 1968. The basic plume diffusion equation used is

$$X = \frac{Q}{2\pi[\sigma_y\sigma_z + (cA/\pi)]u} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \\ \times \left\{ \exp\left[-\frac{(z-h)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z+h)^2}{2\sigma_z^2}\right] \right\}, \quad (1)$$

where

$X$  = concentration, units/m<sup>3</sup>

$Q$  = source strength, units/sec

$\sigma_y$  = horizontal standard deviation (SGY) in cross-wind direction,

m

$\sigma_z$  = vertical standard deviation (SGZ), m

$u$  = wind speed (UA), m/sec

$h$  = height of plume centerline

above ground (SMH), m

$cA$  = cavity dilution term, where

$c$  is between 0.5 and 1 and  $A$  is the cross-sectional area of the building, m<sup>2</sup>

$y$  = cross-wind distance, m

$z$  = vertical distance, m

The code uses variations of Eq. (1) to calculate concentrations along the axis of the plume centerline ( $y = 0$  and  $z = h$ ), at the ground under the plume centerline ( $y = 0$  and  $z = 0$ ), and sector-averaged (over a 22.5° sector) at ground level. The equations for these three concentrations are

$$X_{CP} = \frac{Q}{2\pi(\sigma_y\sigma_z + (cA/\pi)u)}$$

$$\times \left[ 1 + \exp\left(-2 \frac{h^2}{\sigma_z^2}\right) \right], \quad (2)$$

$$XSFC = \frac{Q}{\pi[\sigma_y\sigma_z + (cA/\pi)]u} \times \exp\left(-0.5 \frac{h^2}{\sigma_z^2}\right), \quad (3)$$

and

$$XI = XSFC \left(\frac{2}{\pi}\right)^{\frac{1}{2}} \frac{8\sigma_y}{x}. \quad (4)$$

Equation (4) for the sector-averaged concentration can be made equivalent to the equation in Ref. 1 by substituting XSFC from Eq. (3). The symbol  $\times$  in Eq. (4) is distance downwind and is XDIST in the code.

#### WIND SPEED

The wind speed in the above equations is for the height of the plume center and is the average wind speed between the source and the distance downwind for which the calculation is being done. The wind speed at each point downwind is calculated from

$$U = USFC \left(\frac{SMH}{ZSFC}\right)^{XN(ISCAT)}, \quad (5)$$

where USFC is the wind speed (m/sec) measured at height ZSFC and XN(ISCAT) is an array of exponents as a function of stability category. The actual value used in Eqs. (2) and (3) is an average of the U values between the source and the distance of concern

(this average U is called UA in the code).

#### STANDARD DEVIATIONS

The standard deviations ( $\sigma_y$  and  $\sigma_z$ ) were extracted from the Pasquill-Gifford curves in Meteorology and Atomic Energy, 1968. The vertical standard deviations have been entered in the code as a two-dimensional table that uses stability category and distance. The maximum value allowed is 2000 m. The cross-wind horizontal standard deviations have been approximated by straight lines on log-log paper. The regression equation used is

$$SGY = SIGY(ISCAT)(XDIST)^{0.917}, \quad (6)$$

where SIGY(ISCAT) is an input array for six stability categories (1 through 6) corresponding to Pasquill-Gifford stability categories A through F.

#### PLUME HEIGHT

The height of the plume centerline above the ground (SMH) at any distance downwind is calculated from the difference between plume centerline altitude and the altitude of the ground; both can be functions of distance downwind. The height of release (H) is input. This can be ground level (H = 0) or an elevated

source. If the effluent has a significant heat flux ( $SQ$ ), the trajectory of the plume centerline ( $H + DH$ ) above the emission altitude is calculated with the following formulas, based on work by Montgomery et al.<sup>2</sup>:

For stability categories 1 through 4,

$$DH = 2.50(XDIST)^{0.56} F^{0.33} (UBAR)^{-1}. \quad (7)$$

For stability category 5,

$$DH = 3.75(XDIST)^{0.49} F^{0.33} (UBAR)^{-1}. \quad (8)$$

For stability category 6,

$$DH = 13.8(XDIST)^{0.26} F^{0.33} (UBAR)^{-1}. \quad (9)$$

The maximum values of  $XDIST$  allowed are 4000 m in Eq. (7), 4000 m in Eq. (8), and 2000 m in Eq. (9). Plume rise due to heat flux is assumed to cease at these distances. The parameter  $F$  in these three equations is a heat-flux parameter from Briggs<sup>3</sup> and

<sup>2</sup>T. L. Montgomery, S. B. Carpenter, W. C. Colbaugh, and F. W. Thomas, "Results of Recent TVA Investigations of Plume Rise," paper presented at the 64th Annual Meeting of the Air Pollution Control Association, Atlantic City, New Jersey, June 27-July 2, 1971.

<sup>3</sup>G. A. Briggs, Plume Rise (U.S. Atomic Energy Commission, Division of Technical Information, November 1969).

is equal to  $3.75 \times 10^{-5} SQ$ , where  $SQ$  is the heat flux in calories per second. The wind speed  $UBAR$  is the average speed between the ground and plume center and is obtained by integrating Eq. (5) between these limits and dividing by  $DH$ . This solution for  $DH$  and  $UBAR$  is done in an iterative manner until the last iteration changes  $DH$  by less than 10% from the previously calculated value of  $DH$ .

The stack height  $H$  is added to  $DH$  as a function of distance downwind to obtain the total height  $TH$  of the plume centerline above the ground.

#### DRY DEPOSITION

The depletion of mass resulting from dry deposition is calculated for each distance downwind by calculating the ratio  $R$  of the mass actually passing a point downwind to the mass that would have been passing the same point without any depletion. This ratio, from Ref. 1, is

$$R = \left\{ \exp \left[ \int_0^x \frac{dx}{\sigma_z \exp(h^2/2\sigma_z^2)} \right] \right\} - \left( \frac{2}{\pi} \right)^{\frac{1}{2}} \frac{v_d}{u} \quad (10)$$

This equation is evaluated for each distance downwind using  $UA$  and an input deposition velocity ( $v_d = VDEP$ ). The products of  $R$  and concentration

values without deposition yield concentrations that include depletion resulting from deposition.

#### WET DEPOSITION

If precipitation occurs, it is assumed to occur over the distance from the source to 100 km. The corrected concentrations at a particular point are obtained by multiplying by

$$\exp \left[ - \frac{(PP)(XDIST)}{UA} \right], \quad (11)$$

where PP is a washout coefficient.

#### RADIOACTIVE DECAY

If the emitted material is radioactive, the code uses an input radioactive half-life (THALF) to calculate the decrease in concentrations at distances downwind by en route decay. The corrected concentrations are obtained by multiplying by

$$\exp \left[ - \frac{0.693 XDIST}{(THALF)(UA)} \right]. \quad (12)$$

#### BACKGROUND

At the completion of the calculations for XCP, XSFC, and XI, an input background (BKG) value is added. The background value can be set to zero if desired.

#### VERTICAL INTEGRAL

After these final values of concentrations are obtained, the vertical integral upward through the plume center is calculated with the following equation that makes use of the already evaluated values of XCP:

$$VI = \frac{XCP(2\pi)^{\frac{1}{2}} [\sigma_z + (cA/\pi)^{\frac{1}{2}}]}{1 + \exp(-2h^2/\sigma_z^2)}. \quad (13)$$

#### TOTAL DEPOSITION

Total deposition (dry and wet) is calculated by means of the following equation:

$$\begin{aligned} DEP = & TSTEP[(XI - BKG)(VDEP) \\ & + (PP)(VI)(A)]. \end{aligned} \quad (14)$$

The sector-averaged concentration (XI) minus background (BKG) times the deposition velocity (VDEP), all integrated over the time TSTEP, gives the dry-deposition component. The product of the washout coefficient (PP), the vertical integral (VI), the ratio of sector-averaged to non-sector-averaged concentrations, both minus the background (A), and TSTEP gives the wet-deposition component.

#### MODES OF OPERATION

When the input consists of only one meteorological data set, Eqs. (1)

through (14) are used and the primary output consists of XCP, XSFC, XI, DEP, and VI as a function of distance downwind.

When a large number of meteorological data sets are input, wind direction is used to place observations into the 16 wind sectors. For each data set a check is made to determine whether the value exceeds background at each distance downwind; if so, running sums of the concentration, the logarithm of the concentration, and the square of the logarithm of the concentration are continued. Counters keep track of the number of times each radial grid point is increased. All previous depositions are decayed over TSTEP, and the deposition from this particular data set is added to that already deposited along that azimuth.

After all data sets have been processed, the arithmetic and geometric average concentrations--as well as the geometric mean and the standard

deviation during those times when the concentrations were greater than background--are calculated. The fraction of time that a particular point (for 16 azimuths and 28 points along each azimuth) is above background is also available. These calculations are used to prepare contour plots, in an azimuth-distance sense, of arithmetic and geometric average concentrations and contour plots of concentrations that will be exceeded at specified probability levels (10, 5, 1, and 0.5% of the time). For the latter plots, a log-normal probability distribution of concentrations is assumed for the fraction of the time that the concentrations exceeded background.

Contour plots are also prepared for the total deposition existing at the end of the last meteorological data set. This is the integrated deposition over the time period of the meteorological data, appropriately decayed if a radionuclide is released.

### Program Description

The variables used in the CPS code are listed and defined in Table 2.

The values that are entered as data statements in the CPS code are listed in Table 3. Table 4 gives the array used to determine the vertical standard deviation (SIGZ).

A FORTRAN listing of the CPS code is given in Appendix A. Insofar as possible, variable names in the code are consistent with those in the text. In addition Appendix A contains a computer-prepared flowchart of the code.

Table 2. CPS variables.

Name	Dimension	Units	Definition
AXCP	16, 28	units/m <sup>3</sup>	Running sum and arithmetic average for plume centerline concentration
AXI	16, 28	units/m <sup>3</sup>	Running sum and arithmetic average for ground-level sector-averaged concentration
AXSFC	16, 28	units/m <sup>3</sup>	Running sum and arithmetic average for ground-level under-plume-centerline concentration.
BETA			Intermediate parameter used in calculating the effect of dry deposition between 0 and 100 m downwind
CON	4		Standard deviation associated with the probability levels desired in a log-normal probability distribution
CP	16, 28	units/m <sup>3</sup>	Temporary storage for plume-centerline concentrations at different probability levels
CS	16		The cosines of the angles formed by the 16 direction lines
DEP	28	units/m <sup>2</sup>	Wet and dry deposition
DH		m	Height of plume centerline above height of emission
EXI	16, 28		Temporary storage for ground-level sector-averaged concentrations at different probability levels
F		m <sup>4</sup> /sec <sup>3</sup>	Buoyancy flux parameter = $3.7 \times 10^{-5}$ SQ
GHT	16, 28	m	Ground height at distances described by XDIST
ITOT		hours	Total number of meteorological observations; the code assumes them to be at 1-hr intervals only for purposes of writing on CRTs
NN	16		Number of meteorological observations by direction
NNN			Total number of meteorological observations
ODH			Previous value of DH
OSGZ		m	Value of SGZ for J - 1

Table 2. CPS variables (continued).

Name	Dimension	Units	Definition
OSMH		m	Value of SMH for J = 1
PPP			If PRECP > 0, PPP = PP; if PRECP $\leq$ 0, PPP = 0
R			Plume depletion fraction from dry deposition
RK			Parameter used in calculating the effect of dry deposition
SFC	16, 28	units/m <sup>3</sup>	Temporary storage for ground-level concentrations, under the plume centerline, at different probability levels
SGY		m	Standard deviation in cross-wind direction of the plume Gaussian distribution
SGZ		m	Standard deviation in vertical direction of the plume Gaussian distribution
SIGY	6		An array of constants used to calculate SIGY for the six different stability categories
SIGZ	6, 28	m	Vertical standard deviation as a function of stability category
SMH		m	Difference between the ground height and the plume height
SN	16		The sines of the angles formed by the 16 azimuths
SUM			Used to calculate UA
SUMI			Parameter used in calculating the effect of dry deposition
SQ		cal/sec	Heat flux into buoyant plume
SXCP	16, 28	units/m <sup>3</sup>	Geometric average for XCP
SXCP2	16, 28		Running sum of the squares of the logarithms and the geometric standard deviation for XCP
SXI	16, 28		Running sum of the logarithms and the geometric average for XI
SXI2	16, 28		Running sum of the squares of the logarithms and the geometric standard deviation for XI
SXSFC	16, 28		Running sum of the logarithms and the geometric mean for XSFC

Table 2. CPS variables (continued)

Name	Dimension	Units	Definition
SXSFC2	16, 28		Running sum of the squares of the logarithms and the geometric standard deviation for XSFC
TDEP	16, 28	units/m <sup>2</sup>	Total deposition
TH	28	m	Total plume height above the ground
U	28	m/sec	Wind speed for the current interval from XDIST(J - 1) to XDIST(J)
UA	28	m/sec	Average wind speed at plume centerline height out to XDIST(J)
UBAR		m/sec	Average wind speed between height of source (H) and TH at the source
VI	28	units/m <sup>2</sup>	Vertical integral through plume centerline
XCP	28	units/m <sup>3</sup>	Plume-centerline concentration
XDIST	28	m	Distance from source
XI	28	units/m <sup>3</sup>	Sector-average concentration at ground level
XN	6		Array of constants used in the power-law wind profile as a function of stability
XSFC	28	units/m <sup>3</sup>	Ground surface concentration under plume centerline

Table 3. Values entered as data statements in the CPS code.

Parameter	Stability category <sup>a</sup>					
	1	2	3	4	5	6
XN	0.14	0.17	0.21	0.25	0.33	0.45
SIGY	0.34	0.24	0.19	0.12	0.09	0.06
CON	0.9	0.95	0.99	0.995		
XDIST <sup>b</sup>	1.0E2	1.3E2	1.7E2	2.2E2	2.8E2	
	3.6E2	4.6E2	6.0E2	7.7E2		
	1.0E3	1.3E3	1.7E3	2.2E3	2.8E3	
	3.6E3	4.6E3	6.0E3	7.7E3		
	1.0E4	1.3E4	1.7E4	2.2E4	2.8E4	
	3.6E4	4.6E4	6.0E4	7.7E4	1.0E5	

<sup>a</sup> Corresponding to Pasquill-Gifford stability categories A through F.<sup>b</sup> XDIST values are scaled as a geometric progression so that eight points lie between decades.

Table 4. Values of  $\sigma_z$  (SIGZ) used in the CPS code.<sup>a</sup>

Distance (km)	Stability category, <sup>b</sup> ISCAT					6
	1	2	3	4	5	
0.10	17	10.5	7.7	5	3	1.5
0.13	21	15	10	6.3	4	2
0.17	27	18	13	7.7	5	2.6
0.22	38	23	17	9.5	6.4	3.4
0.28	56	30	21	12	8.2	4.6
0.36	83	40	28	15	10.5	5.9
0.46	150	55	34	18	13	7.5
0.60	200	71	42	22	16	9.1
0.77	360	97	52	27	19	11
1.0	740	150	66	34	23	14
1.3	1700	200	82	40	28	18
1.7	2000	320	110	50	34	20
2.2	2000	500	150	59	40	24
2.8	2000	890	180	69	47	28
3.6	2000	1700	200	80	53	31
4.6	2000	2000	260	91	60	35
6.0	2000	2000	300	110	68	39
7.7	2000	2000	380	130	77	44
10.	2000	2000	460	150	84	49
13.	2000	2000	580	170	94	53
17.	2000	2000	700	190	100	60
22.	2000	2000	850	210	110	65
28.	2000	2000	1000	250	120	70
36.	2000	2000	1200	280	140	74
46.	2000	2000	1500	310	160	79
60.	2000	2000	1800	360	170	84
77.	2000	2000	2000	400	175	89
100.	2000	2000	2000	450	180	94

<sup>a</sup>Units are in metres.

<sup>b</sup>Corresponding to Pasquill-Gifford categories A through F.

## **Appendix A**

**CPS Code Listing**

**and**

**Computer-Prepared Flowchart**

## CPS Code Listing

```

1 * ID 166GAR          CPSF           KEN           BXW75000001
2 * CONTROLLEE(0,CPS)
3 * DUMP (OCT,DEC)
4 * XEQ CPS
5 * CARDS DEBUG ~
6 * LOG ~
7 * LOG 70000;
8 * PRINT C
9 * LIST8
10 * FORTRAN          CPSF

11 C DATE AND NATURE OF LAST CHANGE
12 C 10/17/73 ADDED PRINT OUTS OF GEOMETRIC MEAN VALUES
13 C 8/1/73 CORRECTIONS MADE TO BOUNDARY OF CONTOUR PLOTS
14 C 2/20/76 PROVISION MADE FOR NORMAL VS. ACCID. RELEASE (NORM)
15 C PROGRAM CPS (HSP, TAPE2)
16 COMMON /A/ XDIST(28), SN(17), CS(17), SIZE, TNLG, PLETH(6), PLSET, NPLETH
17 DIMENSION C0N(4), SIGZ(6,28), SIGY(6), U(28),
18 1 DIST(10,16), HGT(10,16), UA(28), SDZ(28)
19 1 DIMENSION NN(16), TDEP(16,28), SXI2(16,28), SXCP(16,28), AXI(16,28)
20 1 AXSFC(16,28), SXSFC(16,28),
21 2 SXI(16,28), XN(6), GHT(16,28), BCD(6)
22 2 DIMENSION CP(17,28), SFC(16,28), EXI(16,28), PRNT(4),
23 1 NXSCP(16,28), XNSFC(16,28), XNXI(16,28)
24 2 DIMENSION TH(28), XCP(28), XSFC(28), XI(28), DEP(28), VI(28),
25 1 AXCP(16,28), SXCP2(16,28), SXSFC2(16,28)
26 2 DIMENSION HM(3), CM(3), CMA(3), XB(5), YB(5)
27 2 DATA (XN = .14, .17, .21, .25, .33, .45)
28 2 DATA (PRNT= 10., 5., 1., .5)
29 2 DATA (C0N= .9, .95, .99, .995)
30 2 DATA (SIGZ = 17., 10., 5., 7., 7., 5., 3., 1., 5., 21., 15., 10., 6., 3., 4., 2., 27., 18.,
31 1 13., 7., 7., 5., 2., 6., 38., 23., 17., 9., 5., 6., 4., 3., 4., 56., 30., 21., 12., 8., 2., 4., 6.,
32 2 83., 40., 28., 15., 10., 5., 5., 9., 150., 55., 34., 18., 13., 7., 5., 2E2, 71., 42.,
33 3 22., 16., 9., 1., 360., 97., 52., 27., 19., 11., 740., 150., 66., 34., 23., 14.,
34 4 1., 7E3, 2E2, 82., 40., 28., 18., 2E3, 320., 110., 50., 34., 20., 2E3, 5E2, 150.,
35 5 59., 40., 24., 2E3, 890., 180., 69., 47., 28., 2E3, 1., 7E3, 2E2, 80., 53., 31.)
36 6 DATA (SIGZ(1,16) = 2(2E3), 260., 91., 60., 35., 2(2E3), 3E2, 110., 68., 39., 2(2E3), 380., 130.,
37 7 77., 44., 2(2E3), 460., 150., 84., 49., 2(2E3), 580., 170., 94., 53.)
38 8 DATA (SIGZ(1,21) = 2(2E3))
39 9 7E2, 190., 1E2, 60., 2(2E3), 850., 210., 110., 65., 2(2E3), 1E3, 250., 120.,
40 10 70., 2(2E3), 1200., 280., 140., 74., 2(2E3), 1500., 310., 160., 79.)
41 11 DATA (SIGZ(1,26) = 2(2E3), 1800., 360., 170., 84., 3(2E3), 400., 175.,
42 12 89., 3(2E3), 450., 180., 94.)
43 13 DATA (SIGY = .34, .24, .19, .12, .09, .06)
44 14 DATA (XDIST= 1.0E2, 1.3E2, 1.7E2, 2.2E2, 2.8E2, 3.6E2, 4.6E2, 6.0E2, 7.7E2,
45 1.1.0E3, 1.3E3, 1.7E3, 2.2E3, 2.8E3, 3.6E3, 4.6E3, 6.0E3, 7.7E3, 1.0E4,
46 2.1.3E4, 1.7E4, 2.2E4, 2.8E4, 3.6E4, 4.6E4, 6.0E4, 7.7E4, 1.0E5)
47 15 NAMELIST /B/ IPF, Q, CA, VDEP, PP, H, NORM, SQ, UMIN, ZSFC, HGT,
48 16 1 THALF, BKG, SDZMX, DIST, GZHT, ITOP, ITDI, TSTEP, KEPLGT, ISTACK
49 2 TRACE, SIZE, PLETH, NPLETH, INPT
50 3 NAMELIST /D/ USFC, ISCAT, PRECP, DIR
51 4 CALL ASSIGN (2, 0, 5RCPSIN, 0)
52 5 PI = 3.141592654
53 6 NPLETH = 6
54 7 TNLG = LOGF(10.)
55 8 TOP1 = 6.283185307
56 9 CALL ASSIGN (3,15)
57 10 RIT 2, W13, (BCD(1), I = 1, 6)
58 11 W0T 3, W13, (BCD(1), I = 1, 6)
59 12 INPUT DATA B, 2, 3
60 13 IF (INPT) A01, A01,
61 14 INPT= 3
62 15 A01 INPUT DATA D, 2, INPT
63 16 CALL KEEP80 (3RDX0)
64 17 IF (PLETH(1)) A02, A02,
65 18 PLSET = 1.
66 19 A02 IF (H - 1.) , A03, A03
67 20 H = 1.
68 21 A03 PPP = 0.
69 22 IF (PRECP) A05, A05,
70 23 PPP = PP
71 24 A05 I = 1
72 25 IF (SDZMX) , , A07
73 26 SDZMX = 2000.
74 27 C CONVERT INPUT HEIGHT OF GROUND (HGT) AT THE VARIABLE DISTANCES (GHT)
75 28 C TO GROUND HEIGHTS (GHT) AT FIXED DISTANCE INTERVALS(XDIST)
76 29 A07 IF (ITOP) , , A20
77 30 D0 A10, J = 1, 448
78 31 A10 GHT(J) = 0.
79 32 G0 TO A51
80 33 A20 D0 A50, I = 1, 16
81 34
82 35

```

```

83      K = 1
84      DO A50, J = 1, 28
85      A25 IF (DIST(K,I) - XDIST(J)) , , A30
86      K = K + 1
87      GO TO A25
88      A30 IF (K = 1) A40
89      GHT(I,J) = (HGT(K,I)-GZHT) / DIST(K,I) * XDIST(J)
90      GO TO A50
91      A40 GHT(I,J) = HGT(K-1,I) + (HGT(K,I) - HGT(K-1,I)) / (DIST(K,I) -
92      1 DIST(K-1,I)) * (XDIST(J) - DIST(K-1,I)) - GZHT
93      A50 CONTINUE
94      A51 IF (USFC - UMIN) , A52, A52
95      USFC = UMIN
96      A52 I = 1
97      DO A53, J = 1, 28
98      SDZ(J) = .465 * SDZMX
99      A53 TH(J) = H
100     IF (ITDI) A70
101     C COMPUTE I WHICH IS THE INDEX OF THE DIRECTION DIR. THIS IS ONLY USED
102     WHEN SUMMARIZING THE RESULTS OF MANY OBSERVATIONS.
103     IF (DIR = 360.) A58, A58,
104     WOT 3, WR14
105     WOT 59, WR14
106     CALL EXIT
107     A58 IF (DIR = 168.75) , A60, A60
108     DIR = DIR + 360.
109     A60 I = ((DIR - 168.75) / 22.5) + 1.
110     A70 IF (ISCAT = 6) A80, A80,
111     WOT 3, WR15
112     WOT 59, WR15
113     CALL EXIT
114     WR14 FORMAT (23HDIR EXCEEDS 360 DEGREES)
115     WR15 FORMAT (15HISCAT EXCEEDS 6)
116     A80 IF (ISTACK) B100, B100,
117     C COMPUTE THE RISE OF THE PLUME AS IT TRAVELS DOWNWIND.
118     F = 3.75E-5 * SQ
119     UBAR = USFC * (H / ZSFC)**XN(ISCAT)
120     IF (ISCAT = 5) B20, B30
121     A = 2.5 * 4000.**.56 * F**(.1/3.)
122     B = 2.5
123     C = .56
124     X = XN(ISCAT)
125     GO TO B40
126     B20 A = 3.75 * 4000.**.49 * F**(.1/3.)
127     B = 3.75
128     C = .49
129     X = XN(ISCAT)
130     GO TO B40
131     B30 A = 13.8 * 2000.**.26 * F**(.1/3.)
132     B = 13.8
133     C = .26
134     X = XN(ISCAT)
135     B40 ODH = A / UBAR
136     DH = ODH
137     B50 UBAR = USFC / (ZSFC**X * (X+1) * DH) * ((DH+H)**(X+1) - H**(X+1))
138     DH = A / UBAR
139     IF (ABSF(ODH-DH) / ODH = .1) B60,
140     ODH = DH
141     GO TO B80
142     B60 DO B70, J = 1, 13
143     TH(J) = H + B * XDIST(J)**C * F**(.1/3.) / UBAR
144     IF (TH(J) = SDZMX) B65, B65,
145     IF (TH(J) = 1.7 * SDZMX) B63,
146     SDZ(J) = TH(J) - SDZMX
147     GO TO B70
148     B63 TH(J) = SDZMX
149     B65 SDZ(J) = .465 * SDZMX
150     B70 CONTINUE
151     II = 14
152     IF (ISCAT = 5) B80,
153     II = 12
154     B80 DO B90, J = II, 28
155     TH(J) = H + DH
156     IF (TH(J) = SDZMX) B87, B87,
157     IF (TH(J) = 1.7 * SDZMX) B85,
158     SDZ(J) = TH(J) - SDZMX
159     GO TO B90
160     B85 TH(J) = SDZMX
161     B87 SDZ(J) = .465 * SDZMX
162     B90 CONTINUE
163     C COMPUTE CENTER CONCENTRATION, GROUND LEVEL CONCENTRATION, INTEGRATED
164     GROUND LEVEL CONCENTRATION AND VERTICAL INTEGRAL.
165     B100 U(1) = USFC * ((TH(1) - GHT(1,1)) / ZSFC)**XN(ISCAT)
166     UA(1) = U(1)
167     SUM = U(1) * XDIST(1)
168     SUM1 = 0.
169     DO C60, J = 1, 28
170     SMH = TH(J) - GHT(1,J)
171     IF (SMH) , , COS
172     SMH = 1.
173     CO5 SGZ = SIGZ(ISCAT,J)

```

```

174      IF (SGZ - SDZ(J)) C10, C10,
175      SGZ = SDZ(J)
176      C10 SGY = SIGY(ISCAT) * XDIST(J)**.917
177      IF (J - 1) C15, C15,
178      U(J) = USFC * (SMH / ZSFC)**XN(ISCAT)
179      SUM = SUM + (U(J) + U(J-1)) / 2. * (XDIST(J) - XDIST(J-1))
180      UA(J) = SUM / XDIST(J)
181      CONST = Q / (TOP1 * (SGY * SGZ + CA/PI) * UA(J))
182      CONA = EXPF(-.5* (SMH / SGZ)**2)
183      CONAA = EXPF(-2. * (SMH / SGZ)**2)
184      XCP(J) = CONST * (1. + CONAA)
185      XSFC(J) = CONST * 2. * CONA
186      IF (VDEP) C30, C30,
187  C DEPOSITION OPTION
188      RK = - SQRTF(2. / PI) * VDEP / UA(J)
189      IF ((SMH / SGZ) - 37.) , , C25
190      IF (J - 1) C20,
191      BETA = 2. * XDIST(J) / (SGZ * EXPF(SMH**2/(2.* SGZ**2)))
192      GO TO C25
193      C20 IF (OSMH / OSGZ - 37.) C25
194      SUM1 = SUM1 + (XDIST(J) - XDIST(J-1)) * 2. / (OSGZ * EXPF(OSMH**2 /
195      1 (2. * OSGZ**2)) + SGZ * EXPF(SMH**2 / (2. * SGZ**2)))
196      C25 Z = SUM1 + BETA
197      IF (Z - 740.) C27, C27,
198      Z = 740.
199      C27 R = EXPF(Z)**RK
200      OSMH = SMH
201      OSGZ = SGZ
202      XCP(J) = XCP(J) * R
203      XSFC(J) = XSFC(J) * R
204      C30 IF (IPF) C40, C40,
205      IF (PRECP) C40, C40,
206  C PRECIPITATION OPTION
207      CONB = EXPF(- PP * XDIST(J) / UA(J))
208      XCP(J) = XCP(J) * CONB
209      XSFC(J) = XSFC(J) * CONB
210      C40 IF (THALF) C50, C50,
211  C DECAY OPTION
212      CONC = EXPF((- 693 * XDIST(J) / UA(J)) / (3600. * THALF))
213      XCP(J) = XCP(J) * CONC
214      XSFC(J) = XSFC(J) * CONC
215  C ADD IN BACKGROUND NOISE
216      C50 XCP(J) = XCP(J) + BKG
217      XI(J) = (XSFC(J) * SQRTF(2. / PI) * 8. * SGY / XDIST(J)) + BKG
218      XSFC(J) = XSFC(J) + BKG
219      VI(J) = XCP(J) * SQRTF(TOP1) * (SGZ + SQRTF(CA/PI)) / (1. + CONAA)
220      IF (XSFC(J) - BKG) , , C53
221      A = 0.
222      GO TO C56
223      C53 A = (XI(J) - BKG) / (XSFC(J) - BKG)
224      C56 DEP(J) = TSTEP * ((XI(J) - BKG) * VDEP + PPP * VI(J) * A)
225      IF (TRACE) C60, C60,
226      WOT 3, WT, SMH, SGZ, SGY, CONST, CONA, CONB, CONC, RK, SUM1
227      C60 CONTINUE
228      WT FORMAT (10E10.3)
229      IF (ITDI) E10, E10,
230  C THE FIRST PLOTS ARE OF CENTER CONCENTRATION, GROUND LEVEL CONCENTRATION,
231  C AND SECTOR AVERAGED GROUND LEVEL CONCENTRATION.
232      YMAX = 0.
233      DO D10, J = 1, 28
234      IF (XCP(J) - YMAX) D10, D10,
235      YMAX = XCP(J)
236  D10 CONTINUE
237      YMIN = YMAX * 1.E-6
238      CALL MAPGLL (1.E2, 1.E5, YM1N, YMAX)
239      CALL SETCH (40., 3., 1, 0, 0, 0, 0)
240      WOT 100, WR1
241      CALL SETCH (30., 1., 1)
242      WOT 100, WR2, (BCD(L), L = 1, 6)
243      CALL SETCH (1., 30., 1, 0, 0, 1, 0)
244      WOT 100, WR3
245      CALL SETCH (90., 64., 1, 0, 0, 0, 0)
246      WOT 100, WR4
247      CALL SETCH (90., 63., 1)
248      WOT 100, WR5
249      CALL SETCH (90., 62., 1)
250      WOT 100, WR6
251      CALL TRACEP (XDIST, XCP, 28)
252      CALL TRACEP (XDIST, XSFC, 28)
253      CALL TRACEP (XDIST, XI, 28)
254      CALL SETLCH (XDIST(13), XCP(13), 1, 0, 0, 0, 0)
255      I1 = 1
256      I2 = 2
257      I3 = 3
258      WOT 100, WR7, I1
259      CALL SETLCH (XDIST(13), XSFC(13), 1)
260      WOT 100, WR7, I2
261      CALL SETLCH (XDIST(13), XI(13), 1)
262      WOT 100, WR7, I3
263      CALL FRAME
264  C THE SECOND PLOTS ARE VERTICAL INTEGRAL THROUGH THE CLOUD CENTER AND
265  C TOTAL DEPOSITION.

```

```

266      YMAX = 0,
267      DO D20, J = 1, 28
268      IF (VI(J) - YMAX) D20, D20,
269      YMAX = VI(J)
270  D20  CONTINUE
271      YMIN = YMAX * 1E-6
272      CALL MAPGLL (1.E2, 1.E5, YMIN, YMAX)
273      CALL SETCH (40., 3., 1, 0, 0, 0, 0, 0)
274      WOT 100, WR1
275      CALL SETCH (30., 1., 1)
276      WOT 100, WR2, (BCD(L), L = 1, 6)
277      CALL SETCH (1., 30., 1, 0, 0, 1, 0)
278      WOT 100, WR8
279      CALL SETCH (85., 64., 1, 0, 0, 0, 0)
280      WOT 100, WR9
281      CALL SETCH (85., 63., 1)
282      WOT 100, WR10
283      CALL TRACEP (XDIST, VI, 28)
284      CALL TRACEP (XDIST, DEP, 28)
285      CALL SETLCH (XDIST(13), VI(13), 1, 0, 0, 0, 0)
286      WOT 100, WR7, 11
287      CALL SETLCH (XDIST(13), DEP(13), 1)
288      WOT 100, WR7, 12
289      WOT 3, WR11
290      WOT 3, WR12, (XDIST(J), XCP(J), XSFC(J), XI(J), VI(J), DEP(J), GHT(I,J),
291      1 U(J), UA(J), J = 1, 28)
292      CALL EXIT
293      WR1 FORMAT (21HDISTANCE DOWNWIND - M)
294      WR2 FORMAT (6A10)
295      WR3 FORMAT (26HCNCENTRATION - UNITS/M**3)
296      WR4 FORMAT (23H 1 CENTER CONCENTRATION)
297      WR5 FORMAT (35H 2 GROUND LEVEL CCONC ON CENTER LINE)
298      WR6 FORMAT (31H 3 SECTOR AVG GROUND LEVEL CCONC)
299      WR7 FORMAT (I2)
300      WR8 FORMAT (23HDEPOSITION - UNITS/M**2)
301      WR9 FORMAT (35H 1 VERTICAL INTEGRAL THROUGH CENTER)
302      WR10 FORMAT (35H 2 TOTAL DEP (WET + DRY) OVER TSTEP)
303      WR11 FORMAT (4X, 5HXDIST, 8X, 3HXCP, 8X, 4HXSFC, 9X, 2HXT, 10X, 2HVI, 9X, 3HDEP,
304      1 9X, 3HGBT, 10X, 1HU, 10X, 2HUA)
305      WR12 FORMAT (9E12.4)
306  C THIS LAST PORTION OF THE CODE IS USED ONLY WHEN RUNNING MANY OBSERVATIONS.
307  E10  IF(END) F15A
308  IF (THALF) E30, E30,
309  C DECAY OPTION
310  DO E20, II = 1, 16
311  DO E20, J = 1, 28
312  E20  TDEP(II, J) = TDEP(II, J) * EXPF(-.693 * TSTEP / (3600.* THALF))
313  C STORE THE CONCENTRATION AND DEPOSITION VALUES WHICH WERE COMPUTED
314  C EARLIER. THEY ARE SAVED BY DIRECTION (I).
315  E30  NN(I) = NN(I) + 1
316  DO E40, J = 1, 28
317  IF (XCP(J) - 2.*BKG) E33, E33,
318  XNXCOP(I, J) = XNXCOP(I, J) + 1
319  AXCP(I, J) = AXCP(I, J) + XCP(J)
320  SXCP(I, J) = SXCP(I, J) + LOGF(XCP(J))
321  E33  IF (XSFC(J) - 2.*BKG) E36, E36,
322  XNSFC(I, J) = XNSFC(I, J) + 1
323  AXSFC(I, J) = AXSFC(I, J) + XSFC(J)
324  SXSF(I, J) = SXSF(I, J) + LOGF(XSFC(J))
325  E36  IF (XI(J) - 2.*BKG) E40, E40,
326  XNXI(I, J) = XNXI(I, J) + 1
327  AXI(I, J) = AXI(I, J) + XI(J)
328  SXI(I, J) = SXI(I, J) + LOGF(XI(J))
329  E40  TDEP(I, J) = TDEP(I, J) + DEP(J)
330  IF (TRACE) E52, E52,
331  DO E50 J = 1, 28
332  E50  WOT 3, T2, I, J, AXCP(I, J), SXCP(I, J), AXSFC(I, J),
333  1 SXSF(I, J), AXI(I, J), SXI(I, J), TDEP(I, J)
334  C READ THE INPUT IN HERE & CHECK FOR MORE DATA SETS
335  E52  INPUT DATA D, 2, INPT
336  PPP = 0
337  IF (PRECP) E55, E55,
338  PPP = PP
339  E55  IF (DIR + 999.) A51, , A51
340  E56  REWIND 2
341  RIT 2, W13, (BCD(II), II = 1, 6)
342  INPUT DATA B, 2
343  INPT = 0
344  END = 1
345  C COMPUTE THE ARITHMETIC & GEOMETRIC MEANS AND THE GEOMETRIC STANDARD
346  C DEVIATION FOR CLOUD CENTER AND SURFACE CONCENTRATIONS AND SECTOR
347  C AVERAGED GROUND LEVEL CONCENTRATIONS.
348  IF (NORM) , , E65
349  NNN = 0
350  DO E60 I = 1, 16
351  E60  NNN = NNN + NN(I)
352  TTT = NNN
353  E65  DO F10, I = 1, 16
354  IF (NORM) E70, E70,
355  TTT = NN(I)
356  IF (TTT) , , E70
357  TTT = 1.

```

```

358 E70 D0 F10, J = 1, 28
359 AXCP(I,J) = (AXCP(I,J)) + (TTT-XNXP(I,J)) * BKG) / TTT
360 IF(XNXP(I,J)) F03, F03,
361 SXCP(I,J) = SXCP(I,J) / XNXP(I,J)
362 IF (XNSFC(I,J)) F05, F05,
363 SXSFC(I,J) = SXSFC(I,J) / XNSFC(I,J)
364 F05 AXI(I,J) = (AXI(I,J)) + (TTT-XNXI(I,J)) * BKG) / TTT
365 IF (XNXI(I,J)) F10, F10
366 SXI(I,J) = SXI(I,J) / XNXI(I,J)
367 F10 CONTINUE
368 IF (TRACE) F14, F14,
369 D0 F13 I = 1, 16
370 D0 F13 J = 1, 28
371 WOT 3, WR12, XNXP(I,J), XNSFC(I,J), XNXI(I,J),
372 F13 WOT 3, T2, I, J, AXCP(I,J), SXCP(I,J), AXSFC(I,J),
373 1 SXSFC(I,J), AXI(I,J), SXI(I,J)
374 GO TO F15AA
375 F14 WOT 3, W15
376 D0 F15 I = 1, 16
377 D0 F15 J = 1, 28
378 F15 WOT 3, T2, I, J, XDIST(J), AXCP(I,J), AXSFC(I,J), AXI(I,J), TDEP(I,J)
379 F15AA INPUT DATA D, 2
380 GO TO A05
381 F15A D0 F15AD J = 1, 28
382 IF (XCP(J) - 2. * BKG) F15AB, F15AB,
383 SXCP2(I,J) = SXCP2(I,J) + (LOGF(XCP(J)) - SXCP(I,J))**2
384 F15AB IF (XSFC(J) - 2. * BKG) F15AC, F15AC,
385 SXSFC2(I,J) = SXSFC2(I,J) + (LOGF(XSFC(J)) - SXSFC(I,J))**2
386 F15AC IF (XI(J) - 2. * BKG) F15AD, F15AD,
387 SXI2(I,J) = SXI2(I,J) + (LOGF(XI(J)) - SXI(I,J))**2
388 F15AD CONTINUE
389 INPUT DATA D, 2
390 PPP = 0.
391 IF (PRECP) F15B, F15B,
392 PPP = PP
393 F15B IF (DIR + 999.) A51, , A51
394 F15BA D0 F15E I = 1, 16
395 D0 F15E J = 1, 28
396 IF (XNXP(I,J)) F15C, F15C,
397 SXCP2(I,J) = SQRTF(SXCP2(I,J) / XNXP(I,J))
398 F15C IF (XNSFC(I,J)) F15D, F15D,
399 SXSFC2(I,J) = SQRTF(SXSFC2(I,J) / XNSFC(I,J))
400 F15D IF (XNXI(I,J)) F15E, F15E,
401 SXI2(I,J) = SQRTF(SXI2(I,J) / XNXI(I,J))
402 F15E CONTINUE
403 D0 G90, K = 1, 4
404 CPMAX = 0.
405 SFCMAX = 0.
406 EXIMAX = 0.
407 D0 F40, I = 1, 16
408 D0 F40, J = 1, 28
409 A1 = 1. - XNXP(I,J) / TTT
410 A2 = 1. - XNSFC(I,J) / TTT
411 A3 = 1. - XNXI(I,J) / TTT
412 IF (CON(K) - A1) F16, F16,
413 PL = (CON(K) - A1) / (1. - A1)
414 CALL ZPL(PL)
415 CP(I,J) = EXPF(SXCP2(I,J) * PL + SXCP(I,J))
416 IF (CP(I,J) - BKG) , F20, F20
417 F16 CP(I,J) = BKG
418 F20 IF (CON(K) - A2) F25, F25,
419 PL = (CON(K) - A2) / (1. - A2)
420 CALL ZPL(PL)
421 SFC(I,J) = EXPF(SXSFC2(I,J) * PL + SXSFC(I,J))
422 IF (SFC(I,J) - BKG) , F30, F30
423 F25 SFC(I,J) = BKG
424 F30 IF (CON(K) - A3) F35, F35,
425 PL = (CON(K) - A3) / (1. - A3)
426 CALL ZPL(PL)
427 EXI(I,J) = EXPF(SXI2(I,J) * PL + SXI(I,J))
428 IF (EXI(I,J) - BKG) , F40, F40
429 F35 EXI(I,J) = BKG
430 F40 CONTINUE
431 WOT 3, W16, PRNT(K)
432 D0 F43 I = 1, 16
433 D0 F43 J = 1, 28
434 F43 WOT 3, T2, I, J, XDIST(J), CP(I,J), SFC(I,J), EXI(I,J)
435 T2 FORMAT (213, 10E11.3)
436 XMAX = CPMAX
437 IP = 1
438 SNX = 3. * PI / 8.
439 D0 F45, N = 2, 4
440 SN(N) = SIN(SNX)
441 CS(N) = COS(SNX)
442 F45 SNX = SNX - PI / 8.
443 SN(1) = 1.
444 CS(1) = 0.
445 SN(5) = 0.
446 CS(5) = 1.
447 SN(9) = -1.
448 CS(9) = 0.
449

```

```

450      SN(13) = 0,
451      CS(13) = -1,
452      SN(8) = -SN(2)
453      SN(10) = -SN(2)
454      SN(16) = SN(2)
455      SN(7) = -SN(3)
456      SN(11) = -SN(3)
457      SN(15) = SN(3)
458      SN(6) = -SN(4)
459      SN(12) = -SN(4)
460      SN(14) = SN(4)
461      CS(8) = CS(2)
462      CS(10) = -CS(2)
463      CS(16) = -CS(2)
464      CS(7) = CS(3)
465      CS(11) = -CS(3)
466      CS(15) = -CS(3)
467      CS(6) = CS(4)
468      CS(12) = -CS(4)
469      CS(14) = -CS(4)
470      CS(17) = CS(1)
471      SN(17) = SN(1)
472      F47 CALL GRSZ (CP, XMX, XMN, YMX, YMN)
473      CALL MAPG (XMN, XMX, YMN, YMX)
474      F48 CALL SETCH (30., 3., 1, 0, 0, 0, 0)
475      GO TO (F50, F60, F70 H20, H30, H40, H43, H45, H47, H50), IP
476      F50 WOT 100, W3
477      GO TO F80
478      F60 WOT 100, W4
479      GO TO F80
480      F70 WOT 100, W5
481      F80 CALL SETCH (30., 1, 1)
482      WOT 100, W6, PRNT(K)
483      F85 CALL SETCH (90., 64., 1, 0, 0, 0, 0)
484      WOT 100, W7
485      XX = 63.
486      DO F90, N = 1, NPLETH
487      CALL SETCH (90., XX, 1)
488      WOT 100, W8, PLETH(N)
489      F90 XX = XX - 1
490      IF (XMX + YMX - 2,) , G00
491      CALL SETCH (30., 60., 1)
492      WOT 100, W14
493      GO TO G45
494      G00 DO G02 J = 1, 28
495      G02 CP(17, J) = CP(1, J)
496      DO G40 N = 1, NPLETH
497      DO G30 I = 1, 17
498      DO G05 J = 28, 1, -1
499      IF (PLETH(N) - CP(I, J)) G07, G07,
500      G05 CONTINUE
501      GO TO G20
502      G07 H01 = XDIST(J) + (PLETH(N) - CP(I, J)) / (CP(I, J+1) - CP(I, J))
503      1 * (XDIST(J+1) - XDIST(J))
504      DO G10 J = 1, 28
505      IF (PLETH(N) - CP(I, J)) G11, G11,
506      G10 CONTINUE
507      G11 IF (J = 1) , G12
508      HI1 = (PLETH(N) / CP(I, J)) * XDIST(J)
509      GO TO G13
510      G12 HI1 = XDIST(J-1) + (PLETH(N) - CP(I, J-1)) / (CP(I, J) - CP(I, J-1))
511      1 * (XDIST(J) - XDIST(J-1))
512      G13 X1 = H01 * CS(I)
513      Y1 = H01 * SN(I)
514      X2 = HI1 * CS(I)
515      Y2 = HI1 * SN(I)
516      IF (FLG) , G15
517      IF (I = 1) G17, G17
518      C FIRST BOUNDARY CONDITION
519
520      II = I - 1
521      GO TO GB00
522      G15 CALL LINE (X3, Y3, X1, Y1)
523      CALL LINE (X4, Y4, X2, Y2)
524      G17 X3 = X1
525      Y3 = Y1
526      X4 = X2
527      Y4 = Y2
528      FLG = 1.
529      GO TO G30
530      G20 IF (FLG) G30, G30,
531      C SECOND BOUNDARY CONDITION
532      C
533      C
534      II = I - 1
535      GB00 DELT = (H01 - HI1) / 4.
536      IF (HI1 + DELT - XDIST(1)) , , GB07
537      HM(1) = XDIST(1)
538      GO TO GB08
539      GB07 HM(1) = HI1 + DELT
540      GB08 HM(2) = HI1 + 2. * DELT

```

```

541      HM(3) = H11 + 3. * DELT
542      DO GB20 KK = 1, 3
543      DO GB10 J = 1, 28
544      IF (XDIST(J) - HM(KK)) , , GB15
545      CONTINUE
546      GB15 FACT = (HM(KK) - XDIST(J-1)) / (XDIST(J) - XDIST(J-1))
547      CM(KK) = CP(I,J-1) + FACT * (CP(I,J) - CP(I,J-1))
548      CMA(KK) = CP(II,J-1) + FACT * (CP(II,J) - CP(II,J-1))
549      X = HM(KK) * CS(I)
550      Y = HM(KK) * SN(I)
551      XA = HM(KK) * CS(II)
552      YA = HM(KK) * SN(II)
553      D1 = (CM(KK) - PLETH(N)) / (CM(KK) - CMA(KK))
554      XB(KK+1) = X + D1 * (XA - X)
555      GB20 YB(KK+1) = Y + D1 * (YA - Y)
556      XB(1) = X2
557      XB(5) = X1
558      YB(1) = Y2
559      YB(5) = Y1
560      CALL TRACEP (XB, YB, 5)
561      IF (FLG) G17, G17,
562      FLG = 0.
563      G30 CONTINUE
564      G40 FLG = 0.
565      G45 CALL FRAME
566      GO TO (G50, G70, G90, H60, H80, H90, H110, H130, H150, H200), IP
567      G50 IP = 2
568      DO G60, I = 1, 16
569      DO G60 J = 1, 28
570      CP(I,J) = SFC(I,J)
571      GO TO F47
572      G70 IP = 3
573      DO G80, I = 1, 16
574      DO G80 J = 1, 28
575      CP(I,J) = EXI(I,J)
576      GO TO F47
577      G90 CONTINUE
578      IP = 4
579      DO H10, I = 1, 16
580      DO H10 J = 1, 28
581      CP(I,J) = AXCP(I,J)
582      GO TO F47
583      H20 WOT 100, W9
584      GO TO H55
585      H30 WOT 100, W10
586      GO TO H55
587      H40 WOT 100, W11
588      GO TO H55
589      H43 WOT 100, W17
590      GO TO H55
591      H45 WOT 100, W18
592      GO TO H55
593      H47 WOT 100, W19
594      GO TO H55
595      H50 WOT 100, W12, ITOT
596      H55 CALL SETCH (30, 1)
597      WOT 100, WR2, (BCD(L), L = 1, 6)
598      GO TO F85
599      H60 IP = 5
600      DO H70, I = 1, 16
601      DO H70 J = 1, 28
602      CP(I,J) = AXSFC(I,J)
603      GO TO F47
604      H80 IP = 6
605      DO H85, I = 1, 16
606      DO H85 J = 1, 28
607      CP(I,J) = AXI(I,J)
608      GO TO F47
609      C SET UP TO PLOT GEOMETRIC MEAN VALUES
610      H90 IP = 7
611      WOT 3, W20
612      DO H100 I = 1, 16
613      DO H100 J = 1, 28
614      IF (SXCP(I,J)) , , H93,
615      SXCP(I,J) = EXPF(SXCP(I,J))
616      H93 CP(I,J) = SXCP(I,J)
617      IF (SXSF(I,J)) , , H96,
618      SXSF(I,J) = EXPF(SXSF(I,J))
619      H96 IF (SXI(I,J)) , , H100,
620      SXI(I,J) = EXPF(SXI(I,J))
621
622      C PRINT OUT GEOMETRIC MEAN VALUES
623      H100 WOT 3, T2, I, J, XDIST(J), SXCP(I,J), SXSF(I,J), SXI(I,J)
624      GO TO F47
625      H110 IP = 8
626      DO H120 I = 1, 16
627      DO H120 J = 1, 28
628      H120 CP(I,J) = SXSF(I,J)
629      GO TO F47

```

```

633 H130 IP = 9
634 DO H140 I = 1, 16
635 DO H140 J = 1, 28
636 H140 CP(I,J) = SXI(I,J)
637 GO TO F47
638 H150 IP = 10
639 DO H160, I = 1, 16
640 DO H160, J = 1, 28
641 H160 CP(I,J) = TDEP(I,J)
642 DO H170, I = 1, 16
643 H170 ITOT = ITOT + NN(I)
644 GO TO F47
645 H200 CALL EXIT
646 W3 FORMAT (41HPLUME CENTER CONCENTRATION - UNITS / M**3)
647 W4 FORMAT (54HGROUND LEVEL PLUME CENTER CONCENTRATION - UNITS / M**3)
648 W5 FORMAT (54HGROUND LEVEL SECTOR AVERAGED CONCENTRATION UNITS/M**3)
649 W6 FORMAT (16HWILL BE EXCEEDED, F5.1, 20H PERCENT OF THE TIME)
650 W7 FORMAT (10H CONTOURS)
651 W8 FORMAT (E10. 3)
652 W9 FORMAT (52HPLUME CENTER ARITH. AVG CONCENTRATION - UNITS / M**3)
653 W10 FORMAT (54HGROUND LEVEL PLUME CENTER ARITHMETIC AVG CONCENTRATION,
654 1 15H - UNITS / M**3)
655 W11 FORMAT (43HGROUND LEVEL SECTOR AVERAGED ARITHMETIC AVG,
656 1 29H CONCENTRATION - UNITS / M**3)
657 W12 FORMAT (33HTOTAL ACCUMULATED DEPOSITION OVER, 15, 6H HOURS)
658 W13 FORMAT (6A10)
659 W14 FORMAT (25HCONTOURS BELOW BACKGROUND)
660 W15 FORMAT (1H1,23X, 14HARITHMETIC AVG,/,6H I J,3X,4HDIST,8X,2HCP,
661 1 8X, 3HSFC, 8X, 2HXI, 8X, 4HTDEP)
662 W16 FORMAT (1H1,7X,16HWILL BE EXCEEDED, F5.1, 16H PERCENT OF TIME,/,,
663 1 6H I J, 3X, 4HDIST, 8X, 2HCP, 8X, 3HSFC, 8X, 2HXI)
664 W17 FORMAT ("PLUME CENTER GEOMETRIC AVG CONCENTRATION " UNITS / M**3")
665 W18 FORMAT ("GROUND LEVEL PLUME CENTER GEOMETRIC AVG CONCENTRATION ",
666 1 "- UNITS / M**3")
667 W19 FORMAT ("GROUND LEVEL SECTOR AVERAGED GEOMETRIC AVG ",
668 1 "CONCENTRATION - UNITS / M**3")
669 W20 FORMAT (1H1,23X, 14HGEOMETRIC MEAN,/,6H I J,3X,4HDIST,8X,2HCP,
670 1 8X, 3HSFC, 8X, 2HXI)
671 END
672 SUBROUTINE ZPL(PL)
673 DIMENSION XX(13), YY(13)
674 DATA (XX=.0000685,.01, .05, .1, .15, .3, .5, .7, .85, .9, .95,
675 1 .99, .9999315)
676 DATA (YY=-3.81, -2.33, -1.64, -1.28, -1.04, -.52, 0., .52, 1.04,
677 1 1.28, 1.64, 2.33, 3.81)
678 DO A10 I = 1, 13
679 IF (PL - XX(I)) A20, A20,
680 A10 CONTINUE
681 PL = YY(13)
682 RETURN
683 A20 IF (I = 1) , , A30
684 PL = YY(1)
685 RETURN
686 A30 PL = YY(I-1) + ((PL-XX(I-1)) / (XX(I)-XX(I-1))) * (YY(I)-YY(I-1))
687 RETURN
688 END
689 SUBROUTINE GRSZ (XA, XMX, XMN, YM, YMN)
690 C THIS ROUTINE DETERMINES THE MAPPING FOR THE GRID AND THE VALUES
691 C OF THE CONTOURS.
692 C DIMENSION XA(17,28)
693 C COMMON /A/XDIST(28), SN(17), CS(17), SIZE, TNLG, PLETH(6), PLSET, NPLETH
694 TNLG = LOGF(10.)
695 AMX = 0.
696 XM = XMN = YM = YMN = 0.
697 C IF PLSET = 1 THEN DO NOT COMPUTE PLETH VALUES BUT USE THOSE THAT
698 C WERE INPUT.
699 C IF (PLSET) A04, A04,
700 IF (PLSET) A04, A04,
701 AMX = 10.
702 DO A02 I = 1, NPLETH
703 IF (PLETH(I) - AMX) A02, A02
704 IF (PLETH(I)) A02, A02,
705 AMX = PLETH(I)
706 A02 CONTINUE
707 DO A03 I = 1, 448
708 IF (XA(I)) , , COO
709 A03 CONTINUE
710 GO TO B140
711 A04 DO A05 I = 1, 6
712 A05 PLETH(I) = 0.
713 C THE LINES ARE CONSIDERED IN PAIRS. THE ITH AND THE I+8TH LINES
714 C FORM A LONGER STRAIGHT LINE. TO START WITH THE SMALLEST CONCENTRATION
715 C THAT CAN BE FOUND AT BOTH ENDS IS COMPUTED. THEN THE X AND Y DISTANCES
716 C BETWEEN THESE POINTS ARE COMPUTED AND COMPARED WITH "SIZE". IF
717 C EITHER THE X OR Y DIST IS GREATER THAN "SIZE" THEN A LARGER VALUE
718 C OF CONCENTRATION IS USED. THIS PROCESS IS REPEATED FOR EACH PAIR
719 C OF LINES. THE VALUE OF THE CONCENTRATION IS OF THE FORM 1.*10**N OR
720 C 3.*10**N.
721 C
722 C
723 DO B130 I = 1, 8

```

```

724      J = 28
725  C FIND THE LARGEST CONCENTRATION AT THE END OF A LINE PAIR.
726  A10 IF (XA(I,J) - XA(I+8,J)) , A20, B10
727  XLN = XA(I+8,J)
728  GO TO B20
729  A20 IF (XA(I,J)) , , B10
730  J = J - 1
731  IF (J) B130, B130, A10
732  B10 XLN = XA(I,J)
733
734  C COMPUTE N IN 1.*10**N.
735  B20 LEXP = LOGF(XLN) / TNLG - 1.
736  XM = 10.**LEXP
737  TRE = 0.
738  IF (XM - XLN) , , B40
739  IF (3.*XM - XLN) , , B30, B30
740  B25 XM = XM * 10.
741  GO TO B40
742  B30 XM = XM * 3.
743  TRE = 1.
744  B40 DO B50 J = 27, 1, -1
745  IF (XM - XA(I,J)) B60, B60,
746  B50 CONTINUE
747  X1 = Y1 = 0.
748  GO TO B70
749
750  C COMPUTE THE DIST FRON THE ORIGIN AND THEN THE X AND Y COORDINATES.
751  B60 XD1 = XDIST(J) + (XDIST(J+1) - XDIST(J)) * ((XA(I,J) - XM) /
752  1 (XA(I,J) - XA(I,J+1)))
753  X1 = CS(I) * XD1
754  Y1 = SN(I) * XD1
755  B70 DO B80 J = 27, 1, -1
756  IF (XM - XA(I+8,J)) B90, B90,
757  B80 CONTINUE
758  X2 = Y2 = 0.
759  GO TO B100
760  B90 XD2 = XDIST(J) + (XDIST(J+1) - XDIST(J)) * ((XA(I+8,J) - XM) /
761  1 (XA(I+8,J) - XA(I+8,J+1)))
762  X2 = CS(I+8) * XD2
763  Y2 = SN(I+8) * XD2
764  B100 IF (X1+X2+Y1+Y2) B130,
765  IF (ABS(Y1-Y2) - SIZE) B110, B120, B120,
766  B110 IF (TRE) B30, B30,
767  XM = XM / 3.
768  TRE = 0.
769  GO TO B25
770
771  C
772  C XM IS THE CONCENTRATION CHOSEN FOR A LINE PAIR.
773  C AMX IS THE LARGEST CONCENTRATION CHOSEN FOR ALL LINE PAIRS.
774  C B120 IF (XM - AMX) B130, B130,
775  AMX = XM
776  TR = TRE
777  B130 CONTINUE
778  IF (AMX)
779  B140 XMX = YMx = 1.
780  RETURN
781
782  C
783  C NOW COMPUTE THE MAX AND MIN X AND Y FOR THE GRID.
784  COO DO C70 I = 1, 16
785  DO C10 J = 27, 1, -1
786  IF (AMX - XA(I,J)) C20, C20,
787  C10 CONTINUE
788  X1 = Y1 = 0.
789  GO TO C70
790  C20 XD1 = XDIST(J) + (XDIST(J+1) - XDIST(J)) * ((XA(I,J) - AMX) /
791  1 (XA(I,J) - XA(I,J+1)))
792  X1 = CS(I) * XD1
793  Y1 = SN(I) * XD1
794  C30 IF (XMN - X1) C40, C40,
795  XMN = X1
796  C40 IF (XMX - X1) , C50, C50
797  XMX = X1
798  C50 IF (YMN - Y1) C60, C60,
799  YMN = Y1
800  C60 IF (YMX - Y1) , C70, C70
801  YMX = Y1
802  C70 CONTINUE
803  IF (XMX) , C70A
804  XMX = -XMN * .1
805  GO TO C70B
806  C70A IF (XMN) C70B , , C70B
807  XMN = -XMX * .1
808  C70B IF (YMX) , , C70C
809  YMX = -YMN * .1
810  GO TO C70D
811  C70C IF (YMN) C70D, , C70D
812  YMN = -YMX * .1
813  C70D CONTINUE
814  C
815  C THIS IS TO MAKE SURE THAT XMX-XMN = SIZE AND YMx-YMN = SIZE.

```

```
816      IF (XMX - XMN) , , C71
817      XMX = .5 * SIZE
818      XMN = -.5 * SIZE
819      GO TO C72
820  C71  FACT = SIZE / (XMX - XMN)
821      XMX = XMX * FACT
822      XMN = XMN * FACT
823  C72  IF (YMX - YMN) , , C73
824      YMX = .5 * SIZE
825      YMN = -.5 * SIZE
826      GO TO C74
827  C73  FACT = SIZE / (YMX - YMN)
828      YMX = YMX * FACT
829      YMN = YMN * FACT
830  C   C NOW COMPUTE THE VALUES OF THE INNER CONTOUR LINES.
831  C74  IF (PLSET) , , C90
832      IF (TR) , , C75
833      PLETH(2) = 'AMX' * 3.
834      GO TO C80
835  C75  PLETH(2) = AMX / 3. * 10.
836  C80  PLETH(1) = AMX
837      PLETH(3) = PLETH(1) * 10.
838      PLETH(5) = PLETH(3) * 10.
839      PLETH(4) = PLETH(2) * 10.
840      PLETH(6) = PLETH(4) * 10.
841
842  C90  RETURN
843  END
```

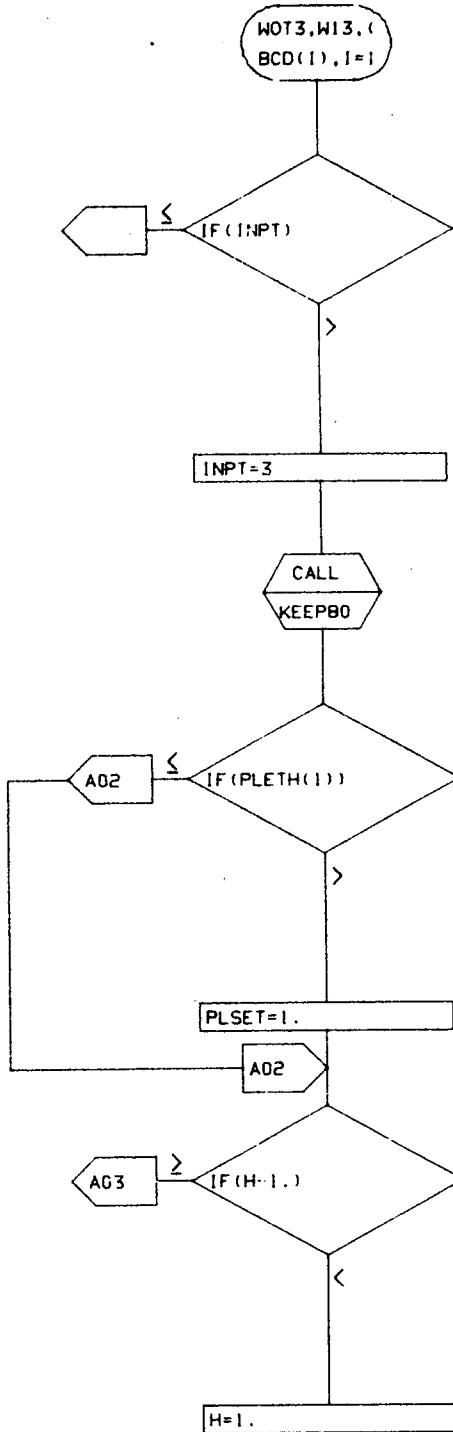
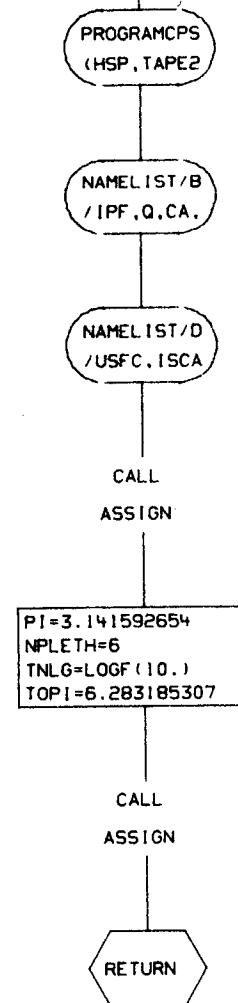
# Computer-Prepared Flow Chart

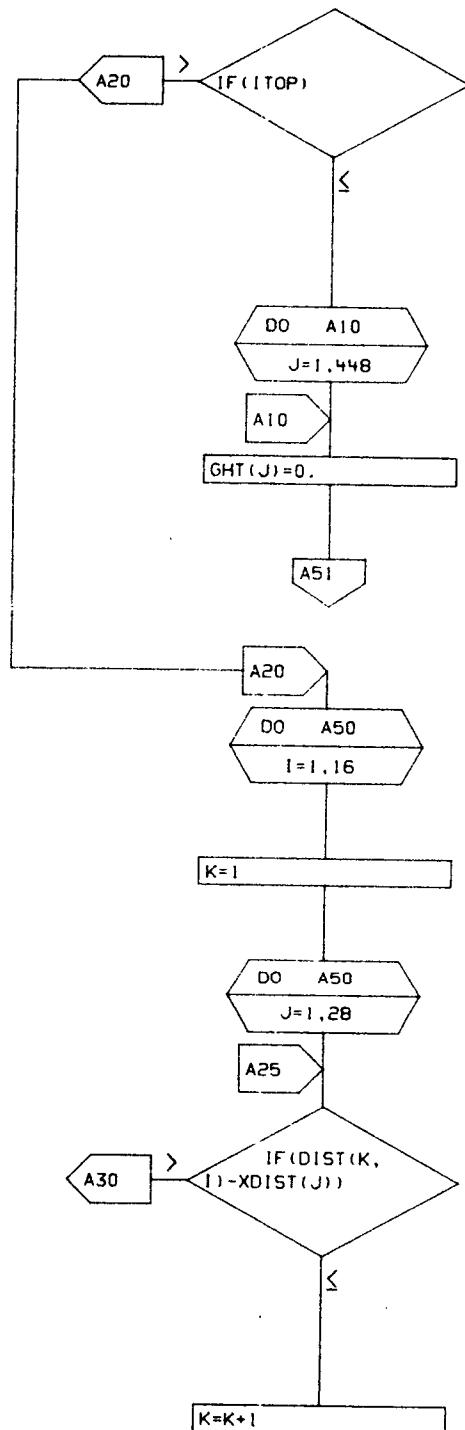
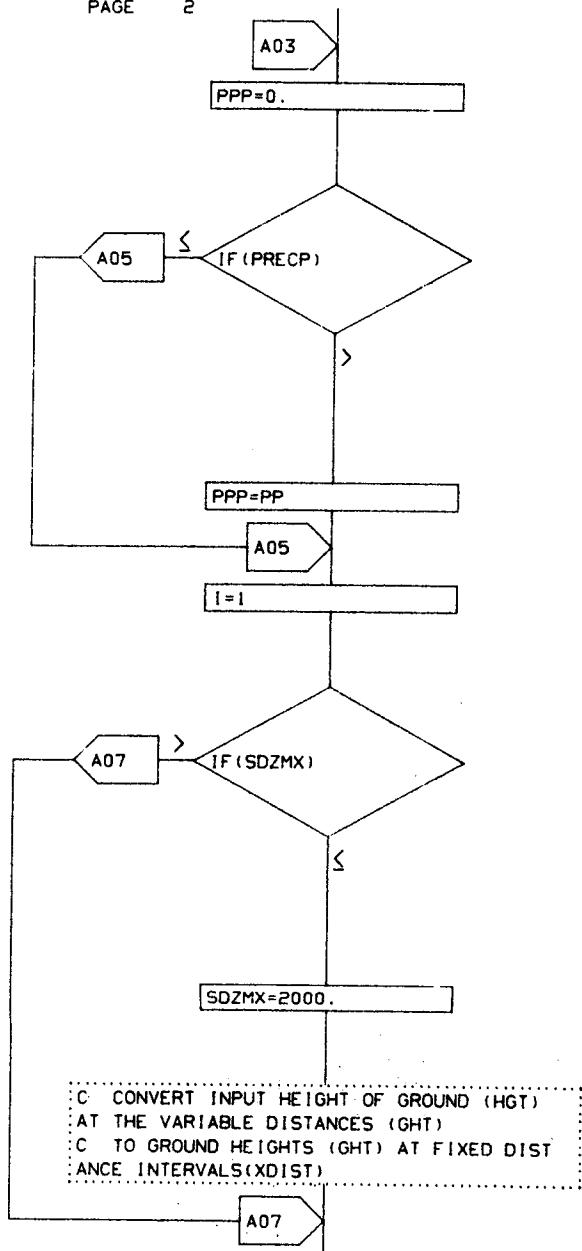
PAGE 1

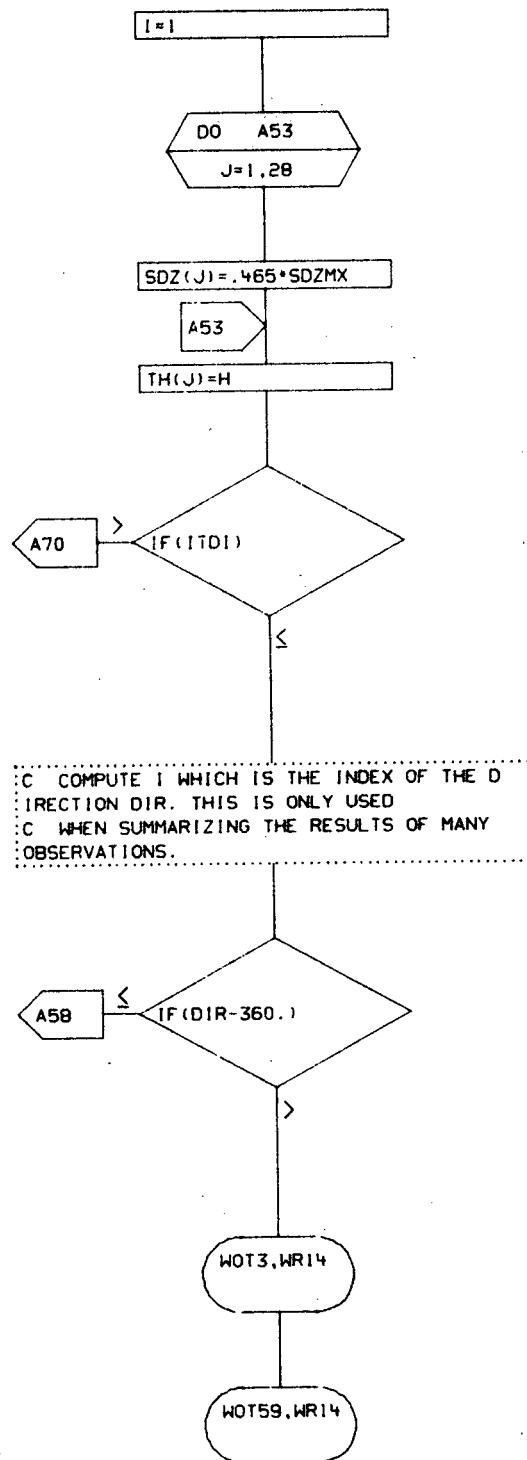
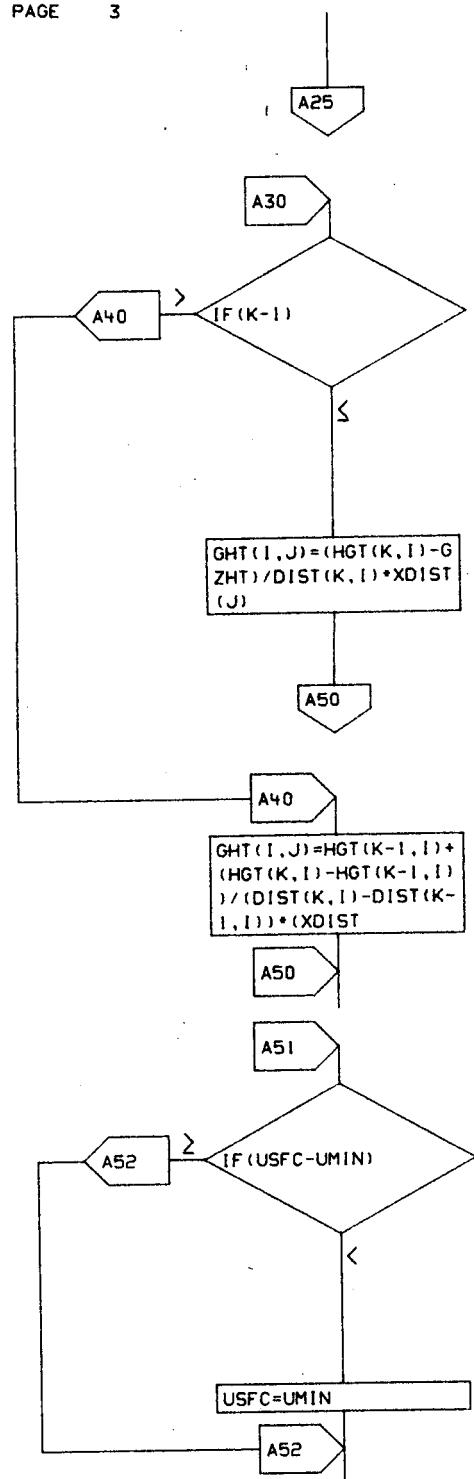
```

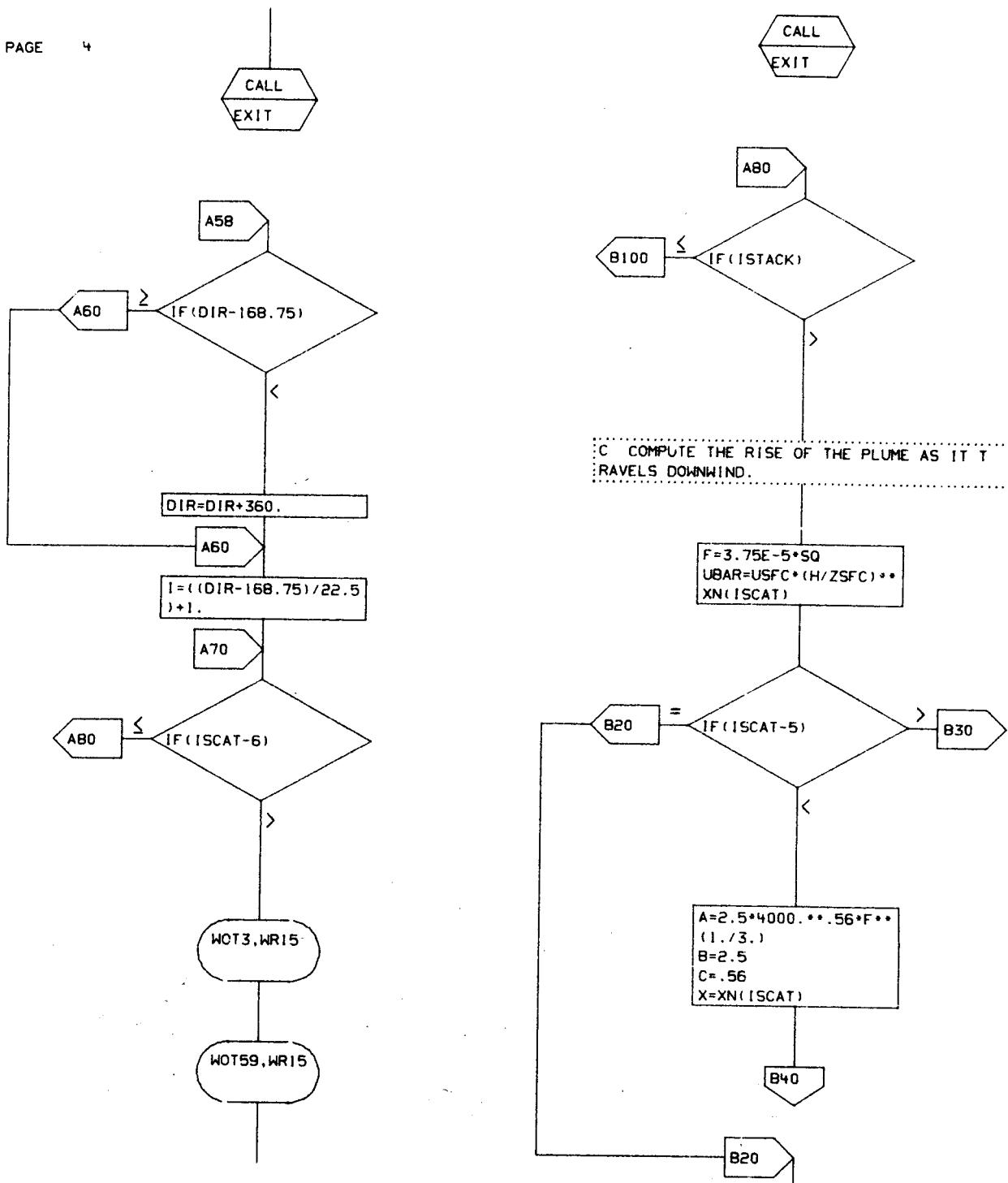
C DATE AND NATURE OF LAST CHANGE
C 10/17/73 ADDED PRINT OUTS OF GEOMETR
C IC MEAN VALUES
C 8/1/73 CORRECTIONS MADE TO BOUNDARY
OF CONTOUR PLOTS
C 7/5/73 ADDED CONTOUR PLOTS FOR SINGL
E OBSERVATIONS
C 2/20/76 PROVISION ADDED FOR NORMAL V
S. ACCID. RELEASE (NORM)

```

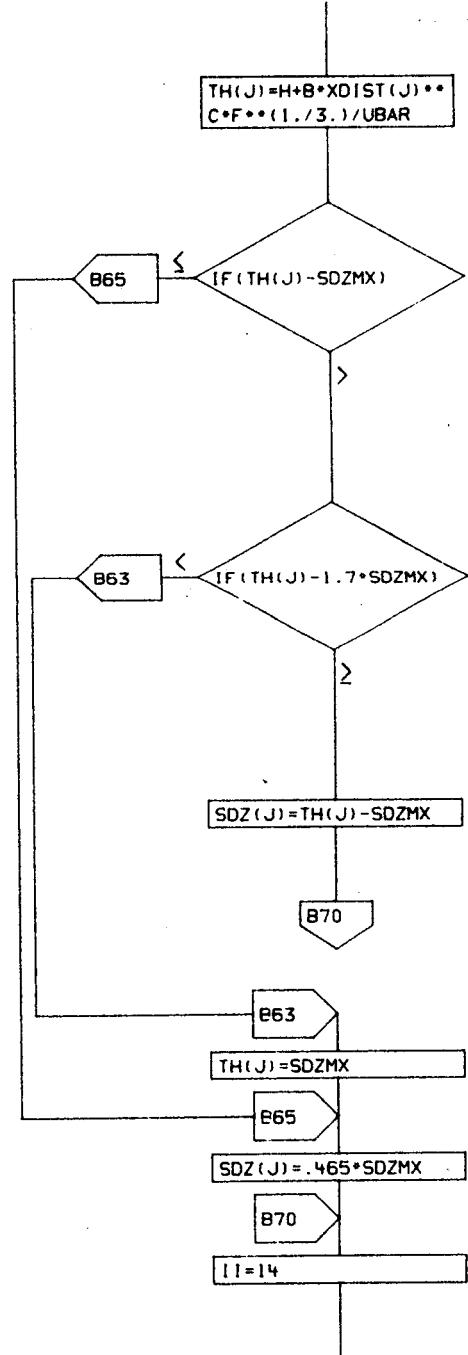
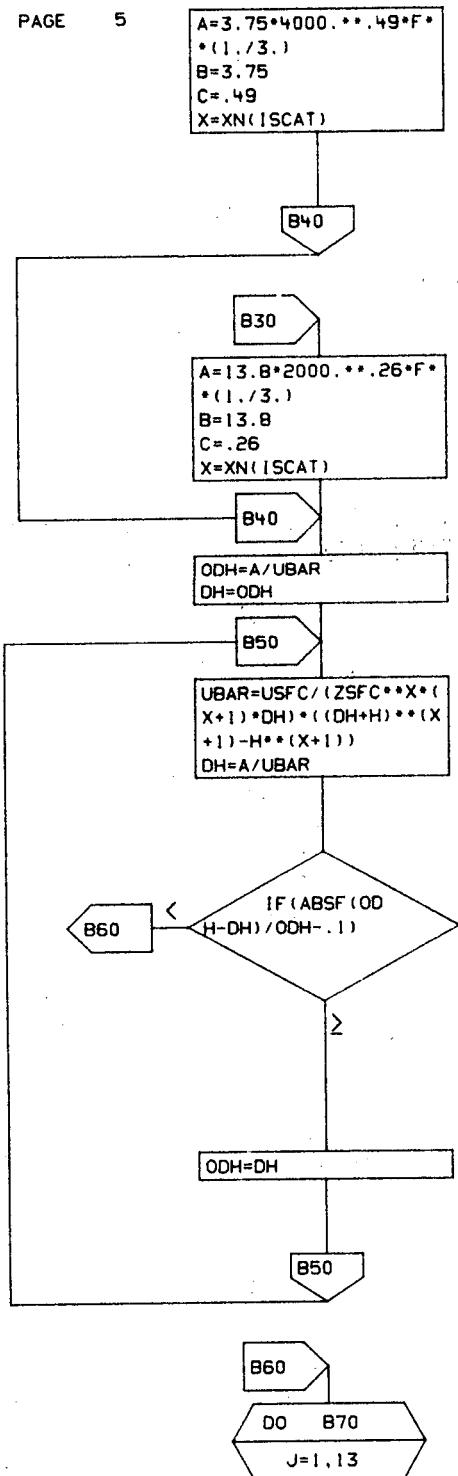


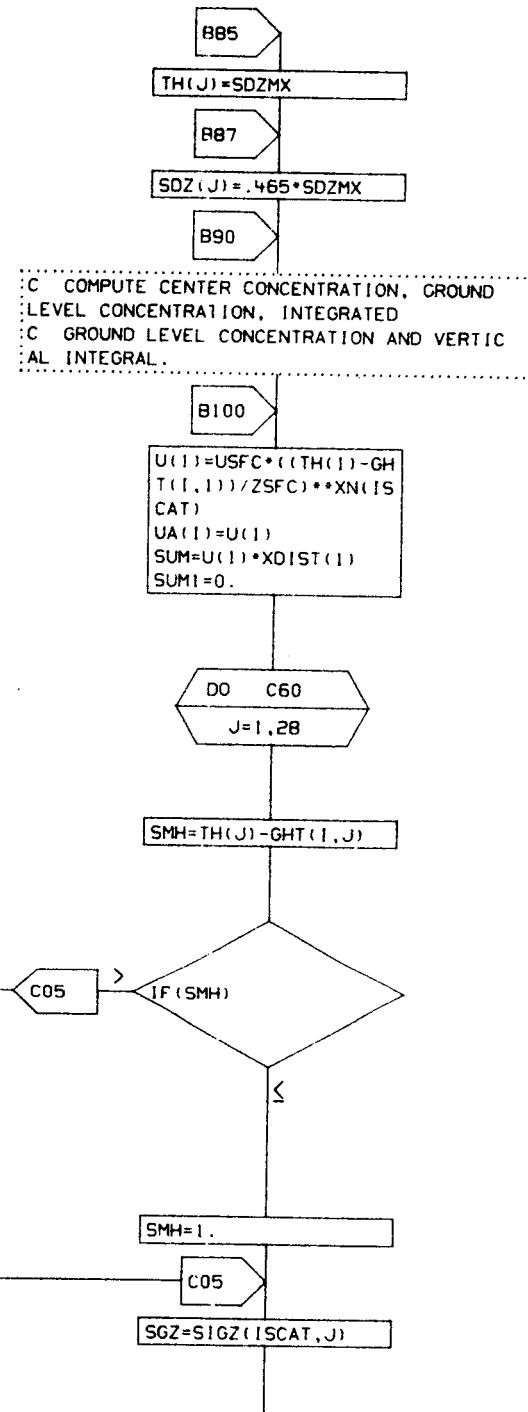
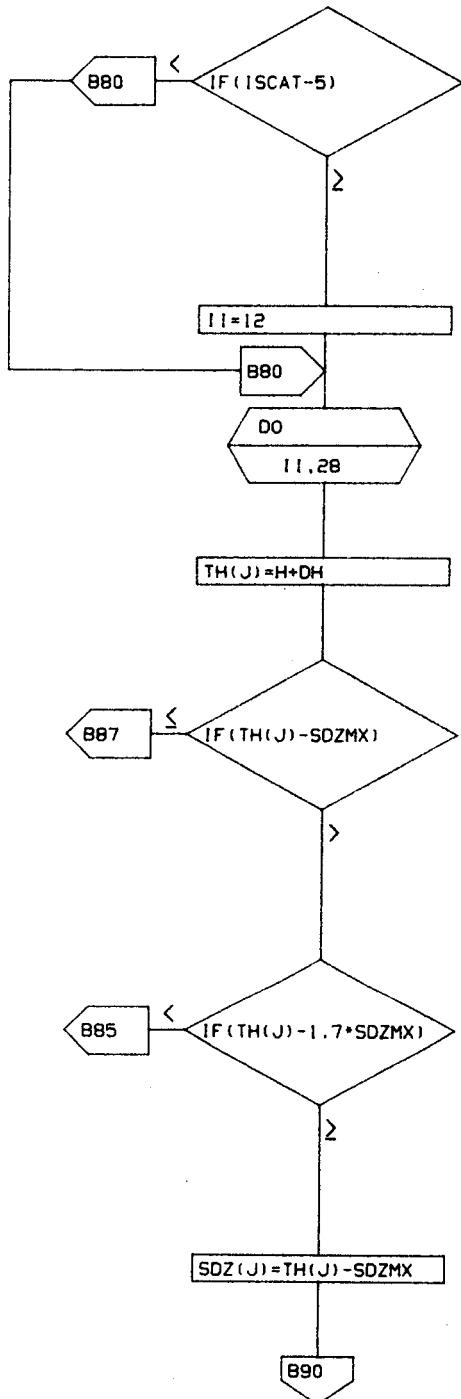


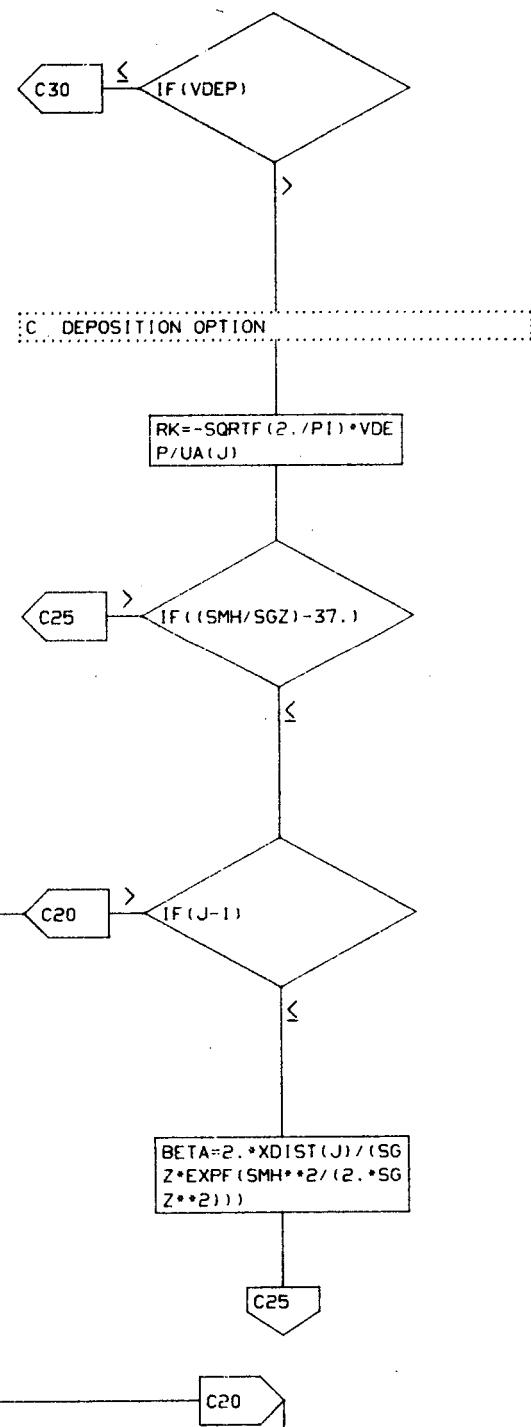
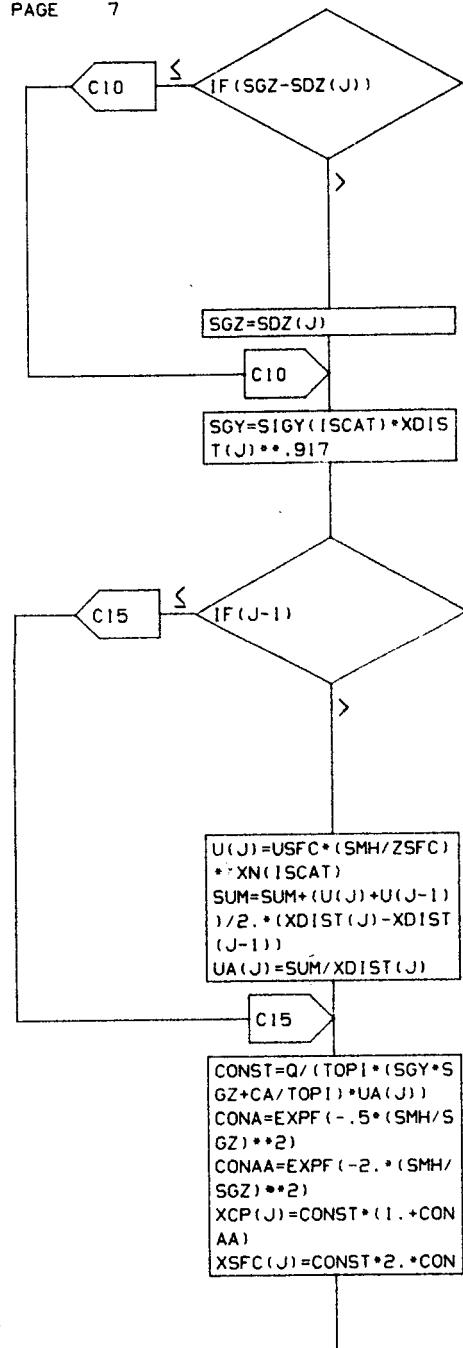




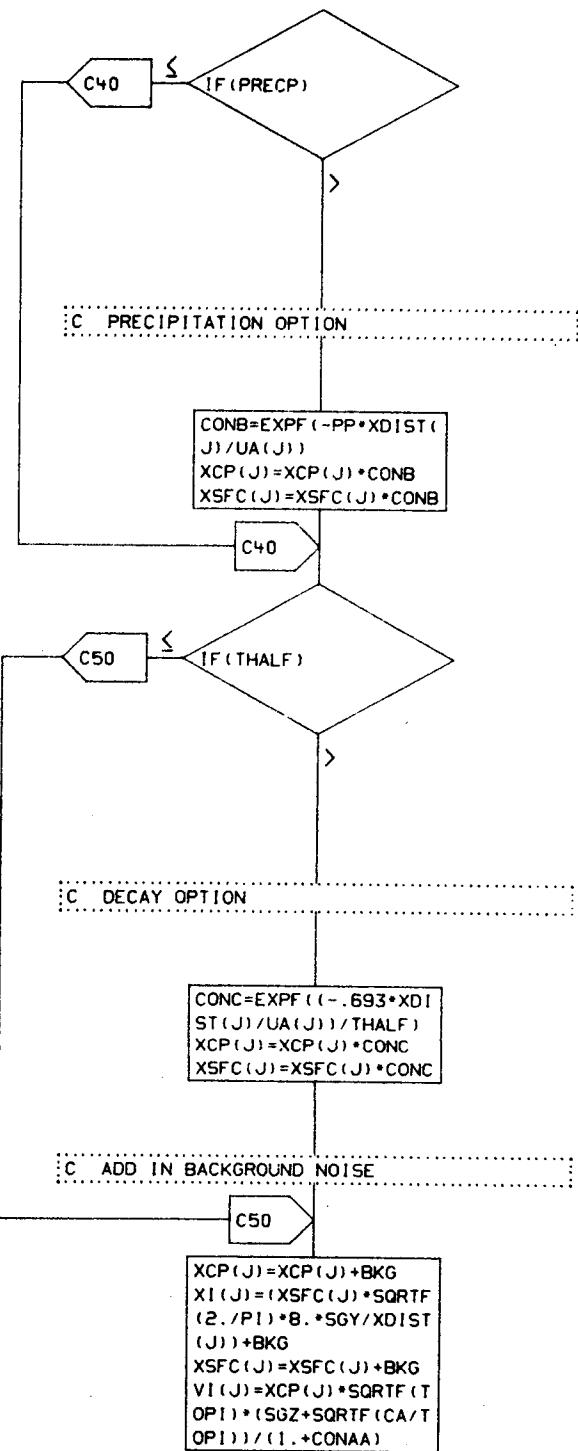
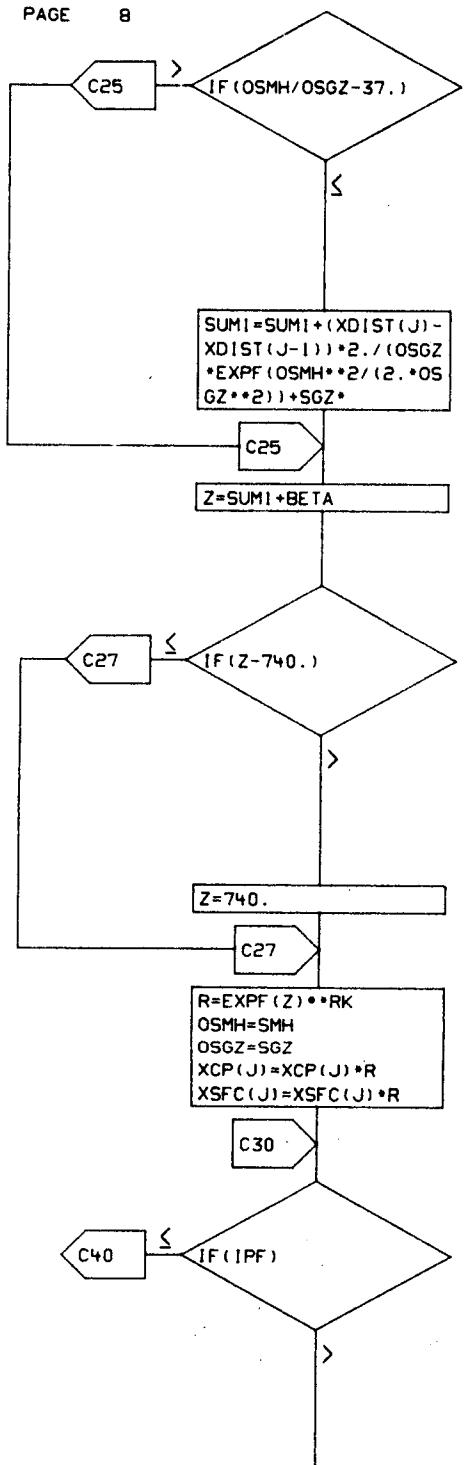
PAGE 5



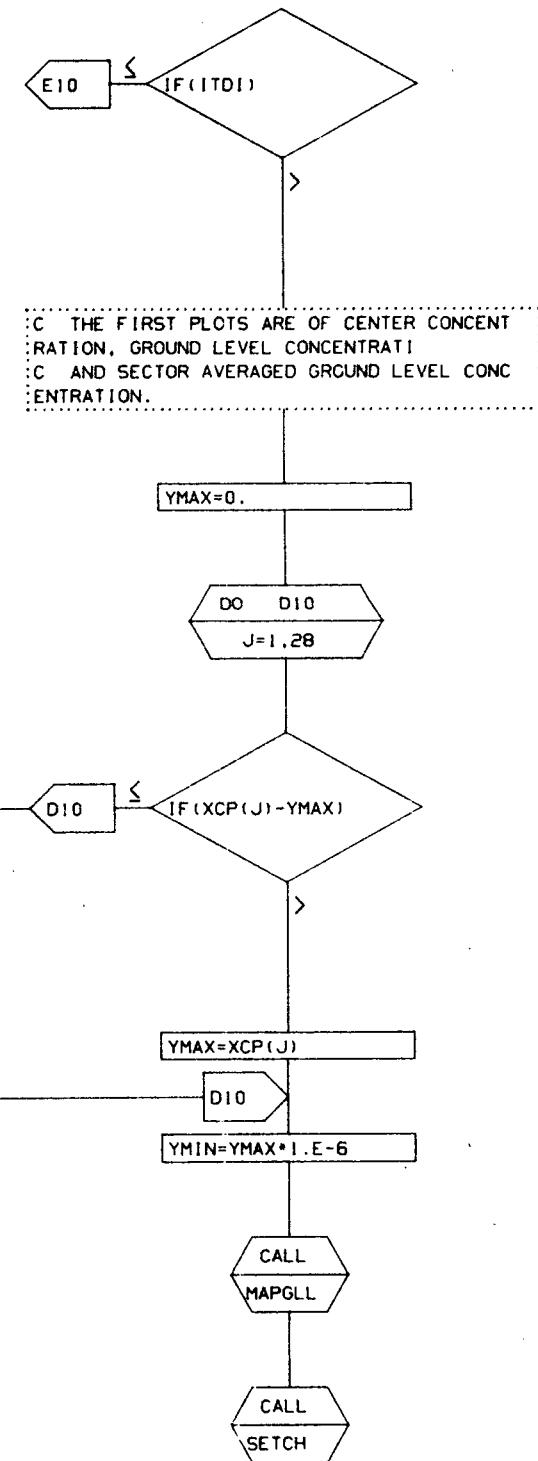
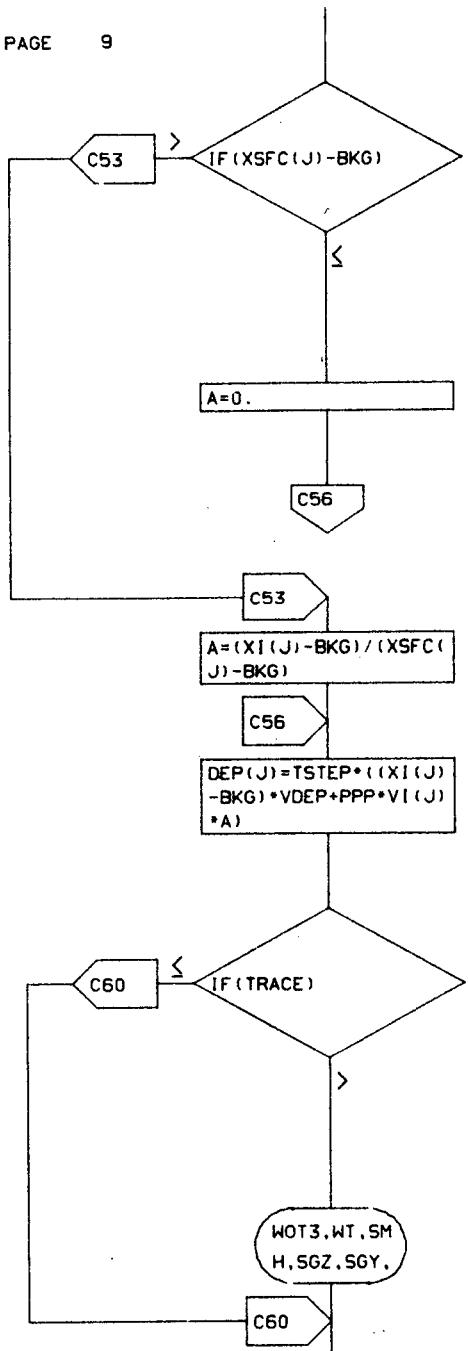


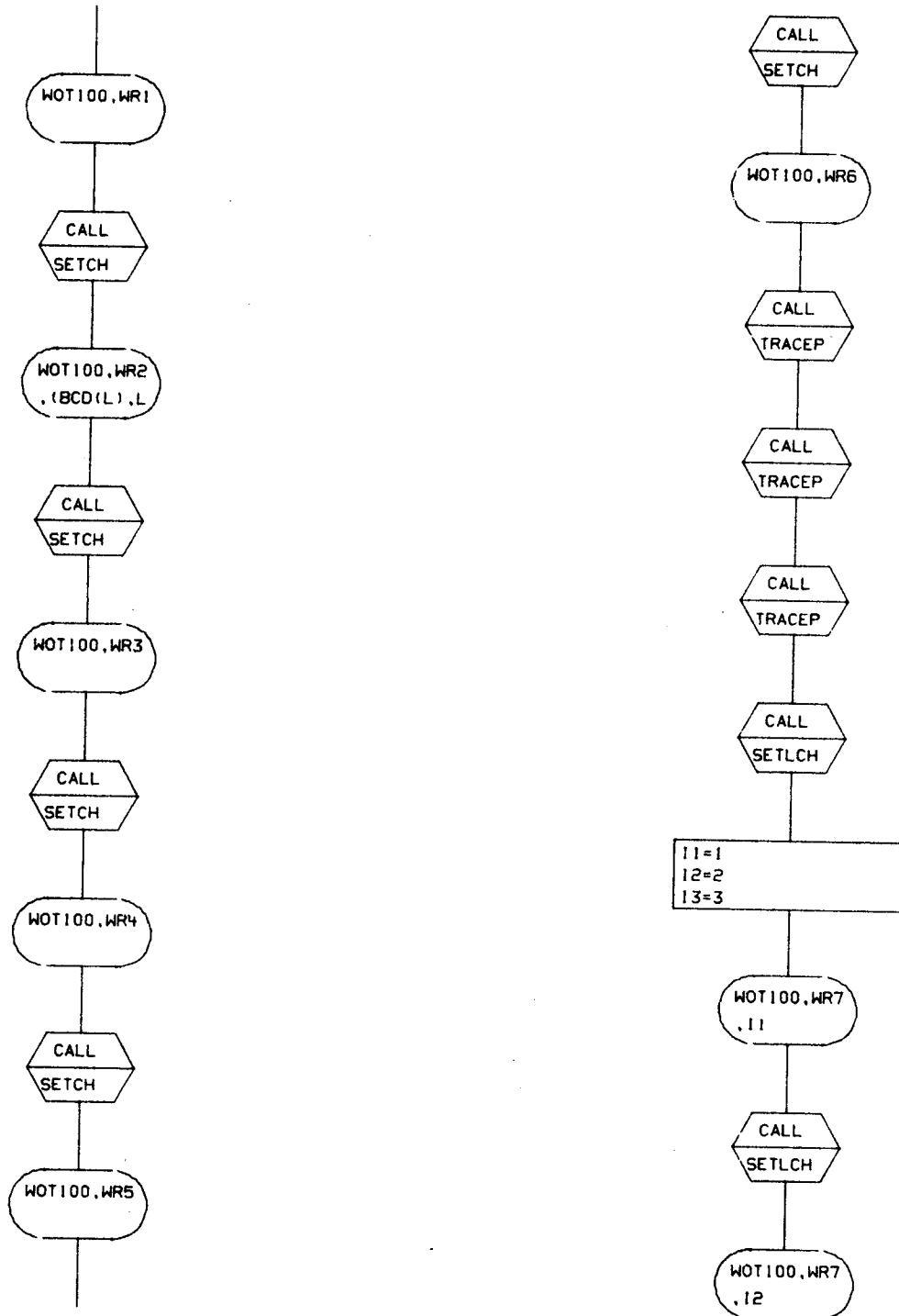


PAGE 8

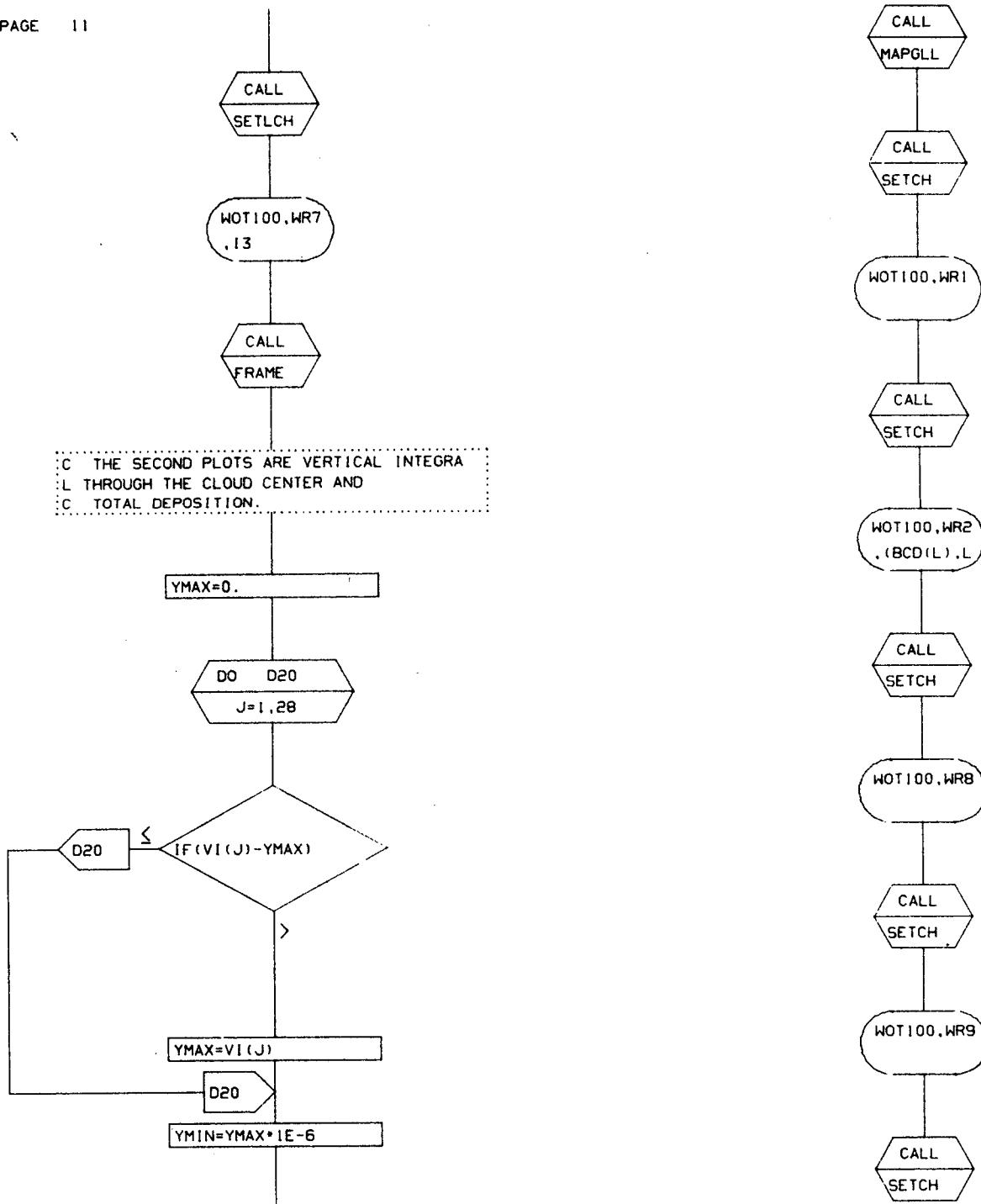


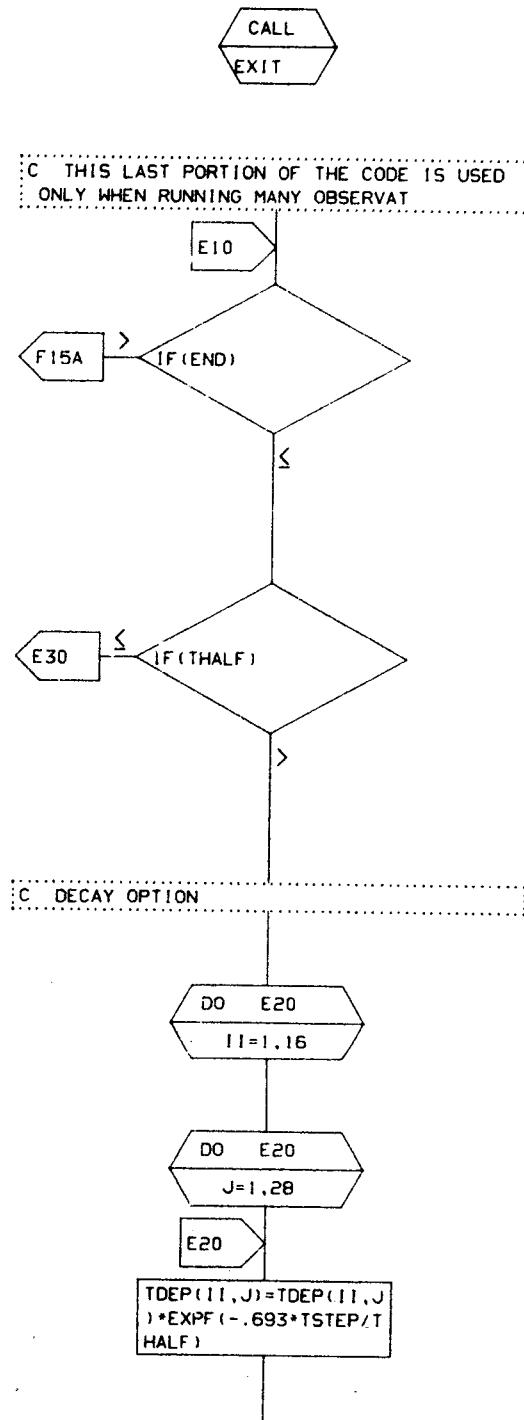
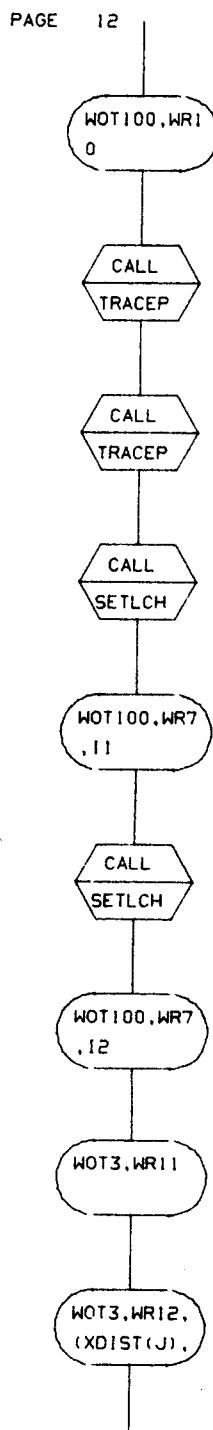
PAGE 9





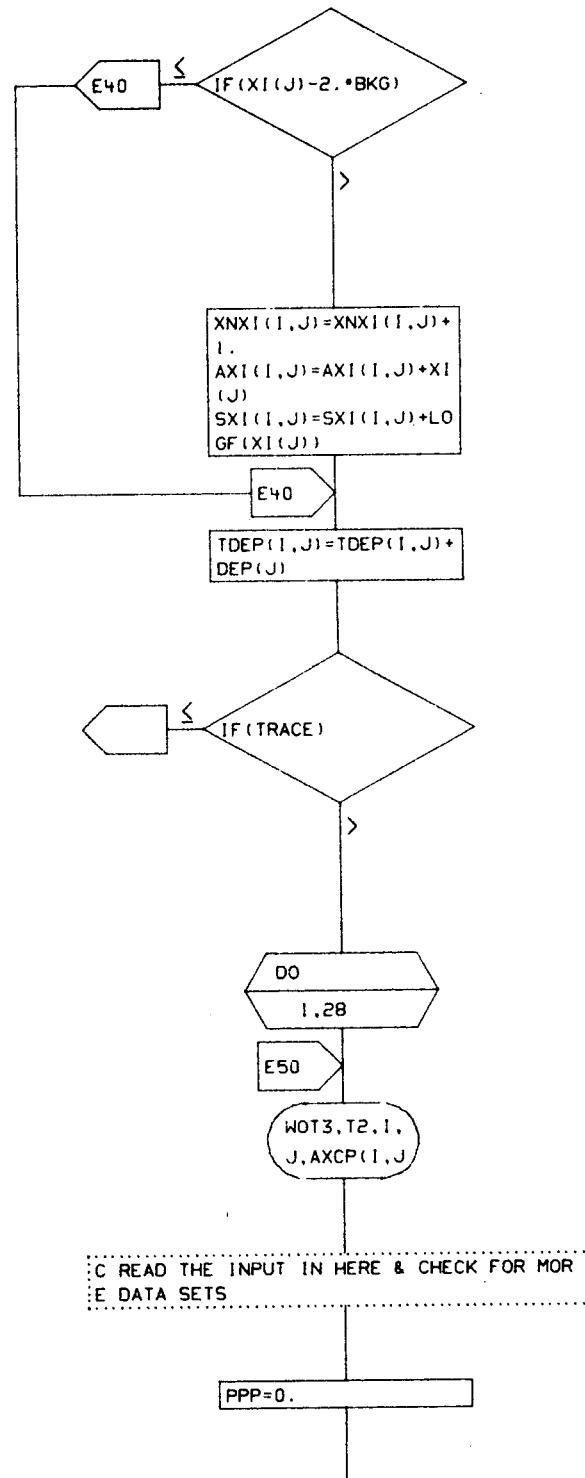
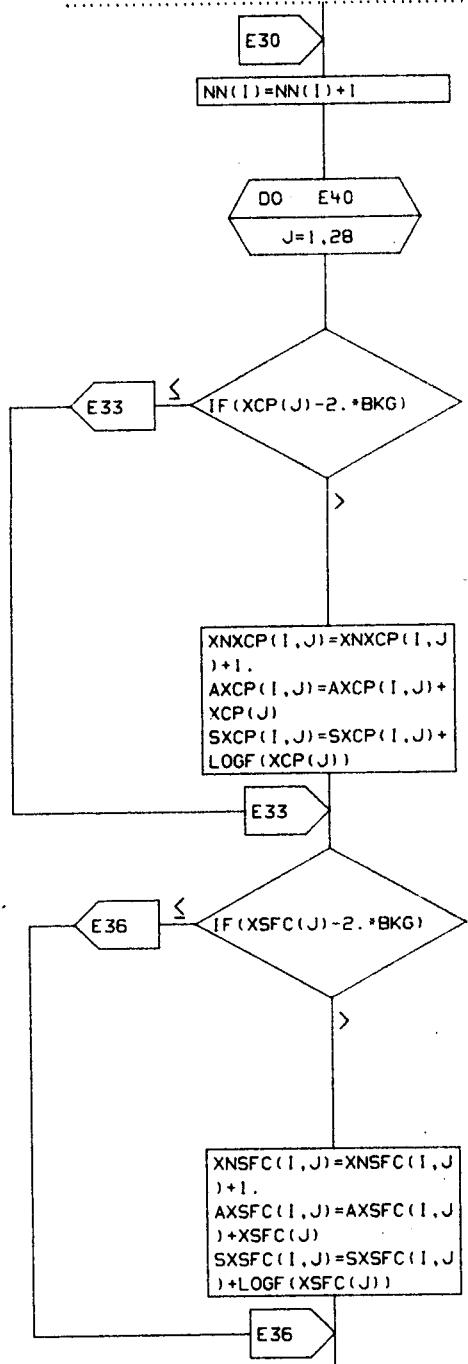
PAGE 11

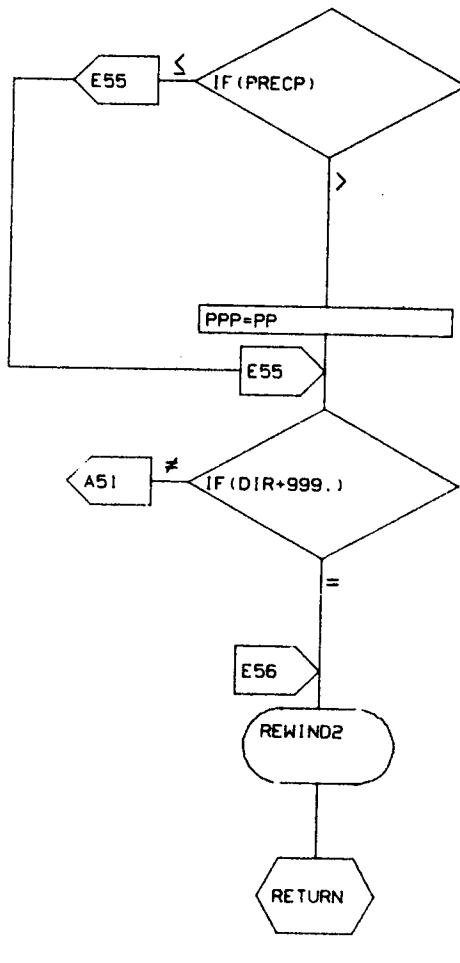




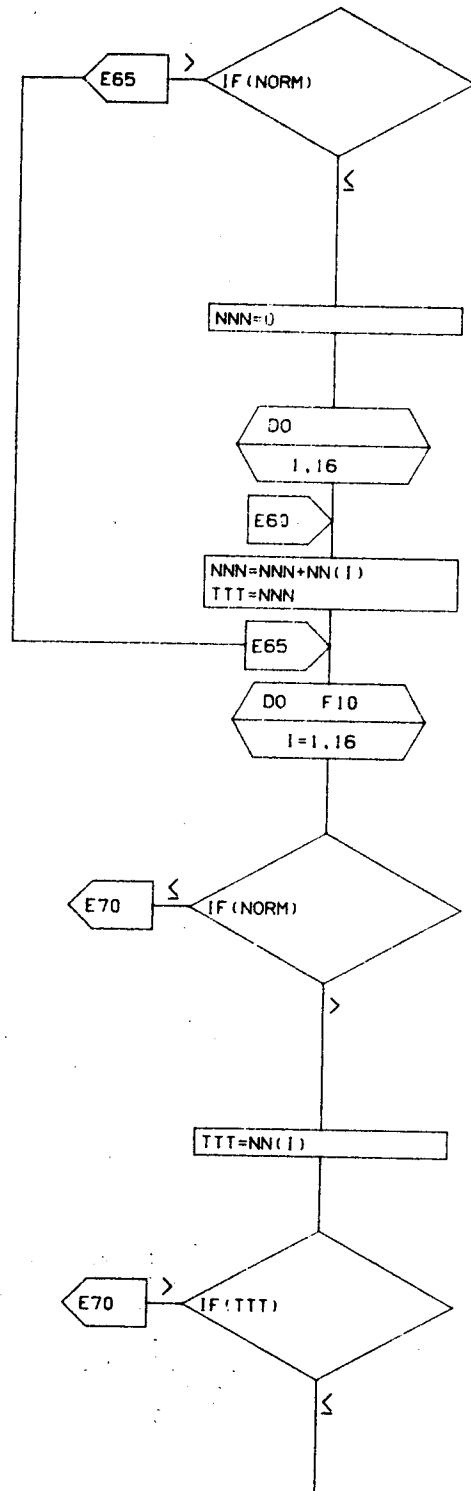
PAGE 13

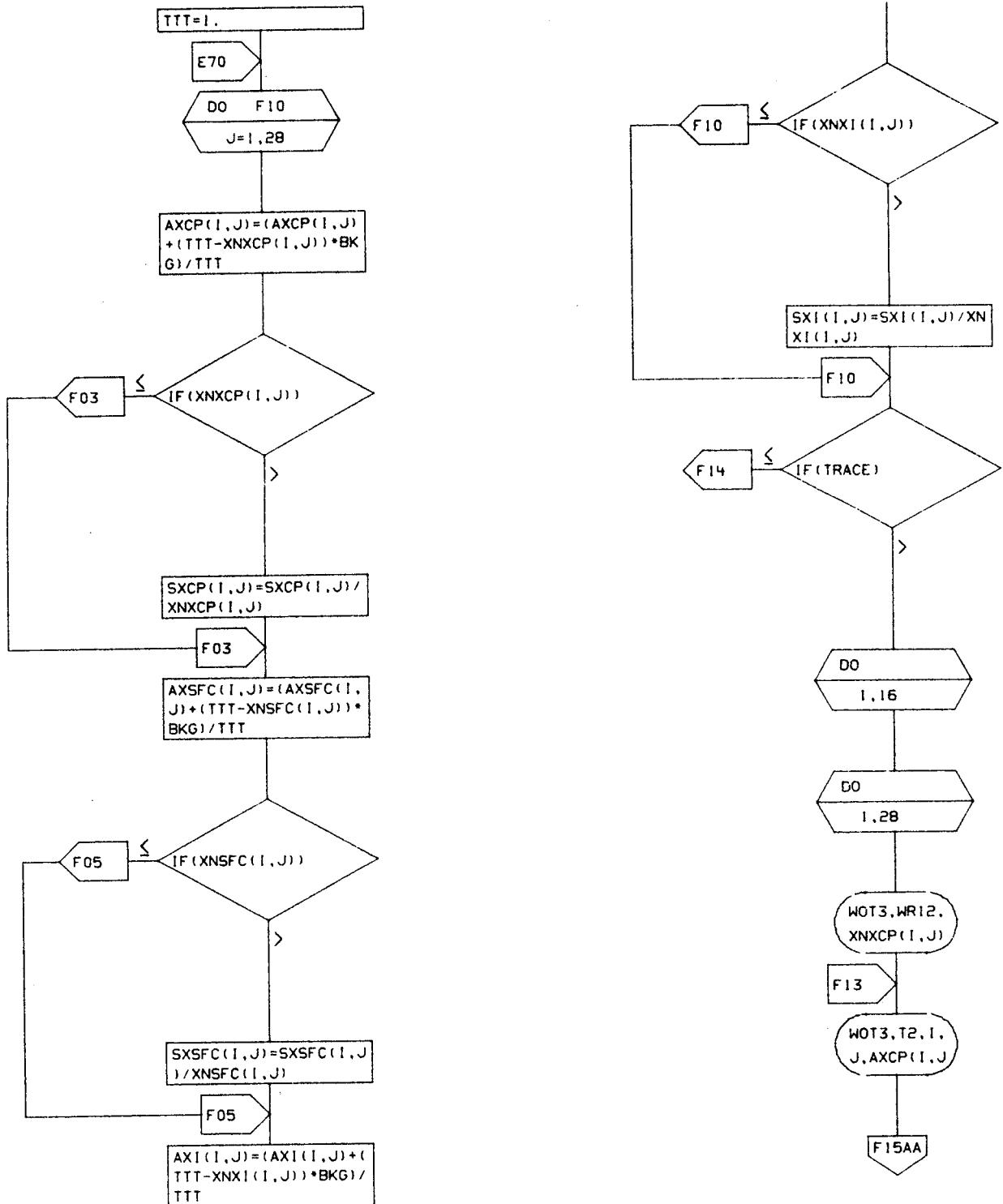
C STORE THE CONCENTRATION AND DEPOSITIO  
N VALUES WHICH WERE COMPUTED  
C EARLIER. THEY ARE SAVED BY DIRECTION  
(I).

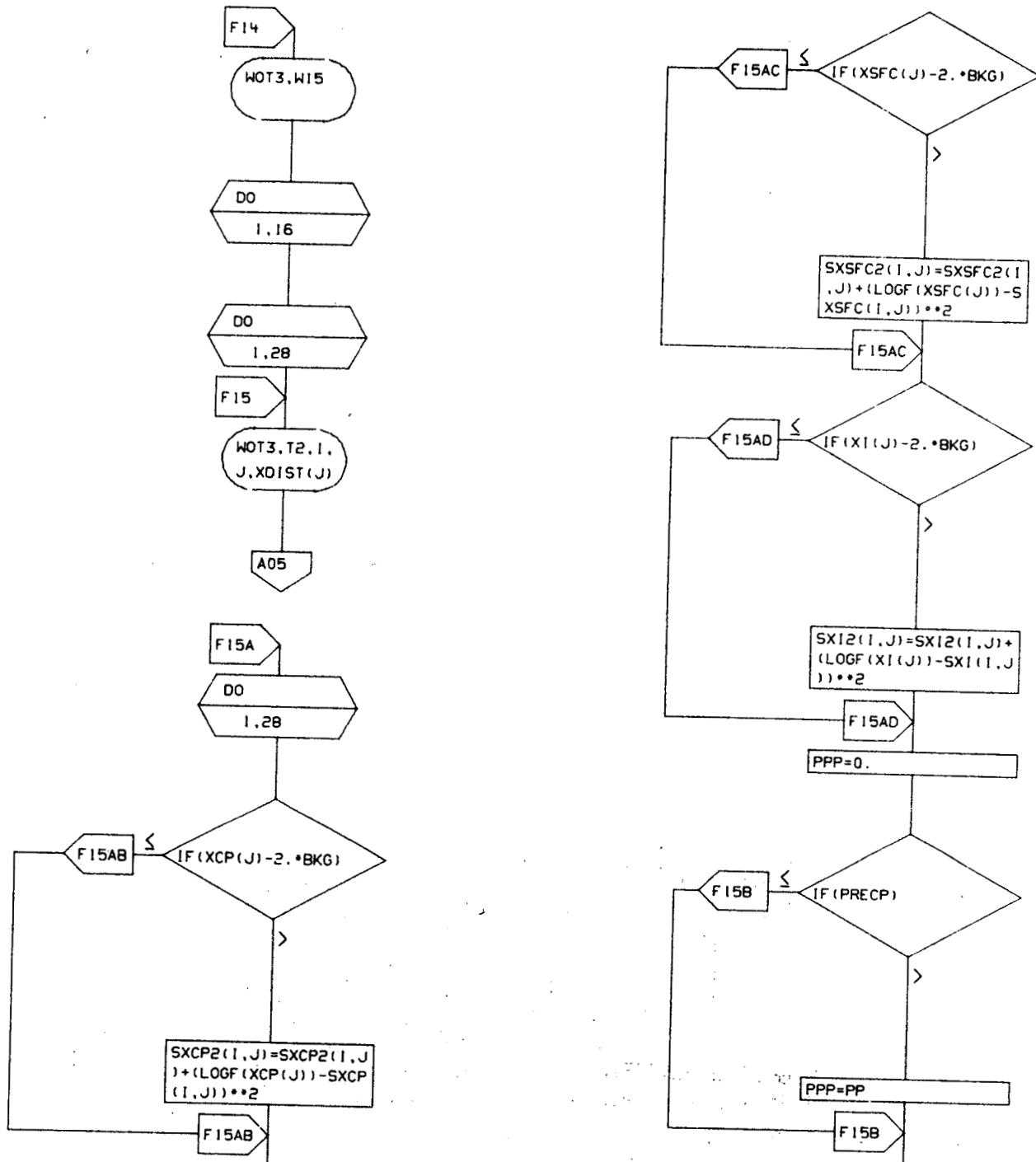


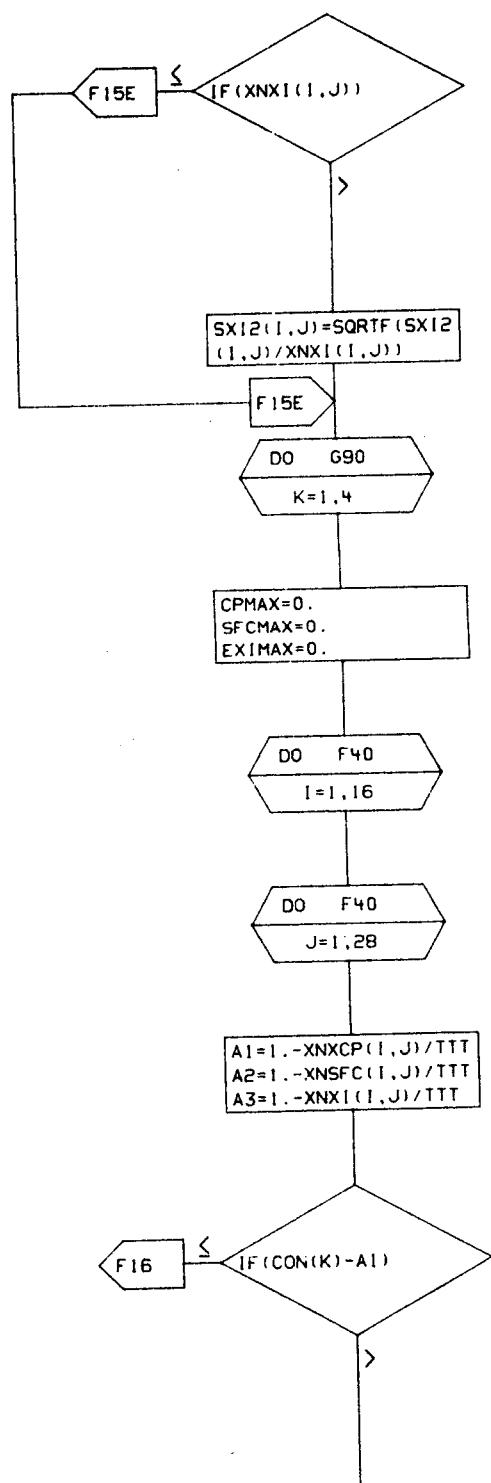
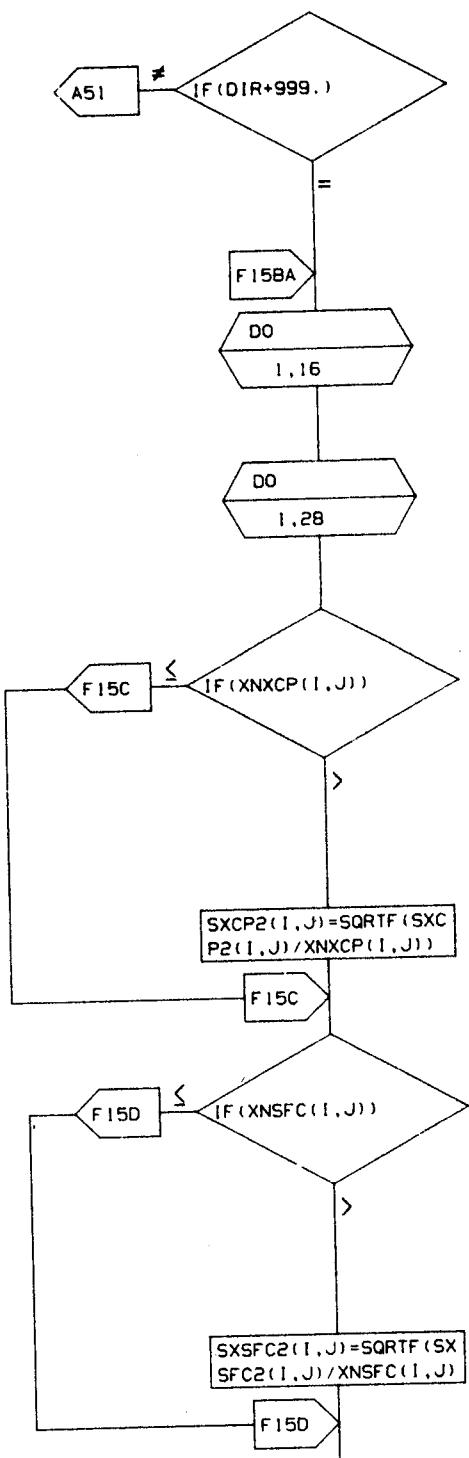


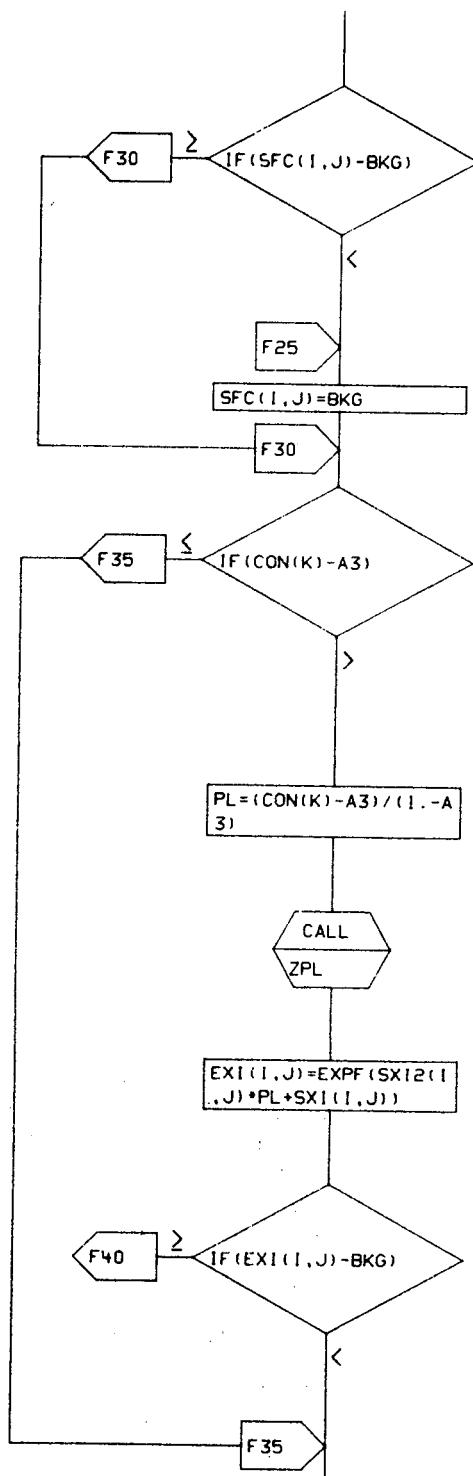
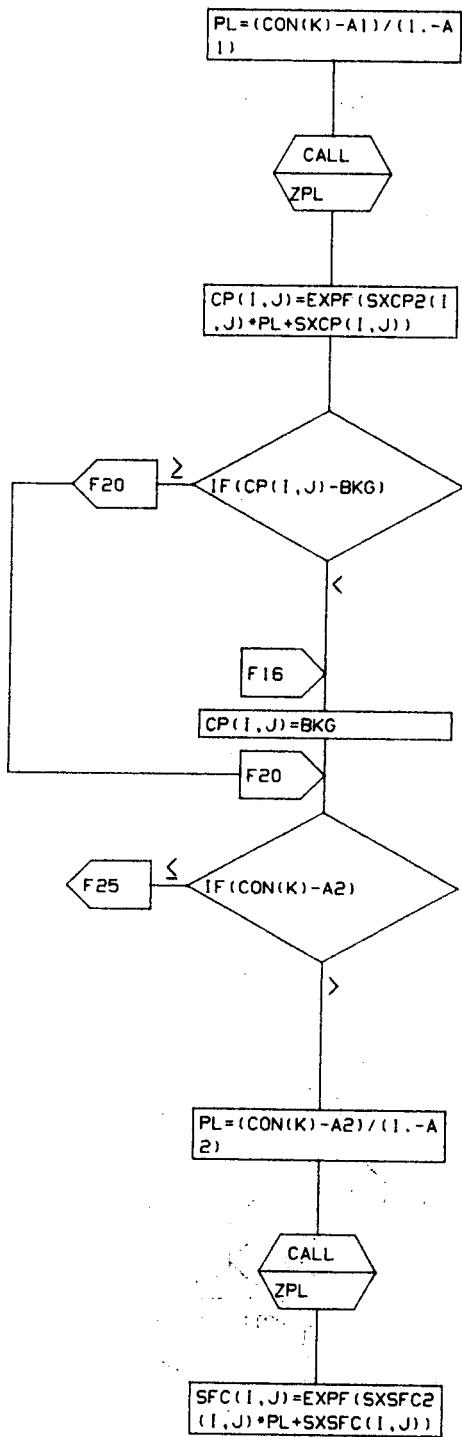
INPT=0  
 END=1.  
 C COMPUTE THE ARITHMETIC & GEOMETRIC MEANS AND THE GEOMETRIC STANDARD  
 C DEVIATION FOR CLOUD CENTER AND SURFACE CONCENTRATIONS AND SECTOR  
 C AVERAGED GROUND LEVEL CONCENTRATIONS.

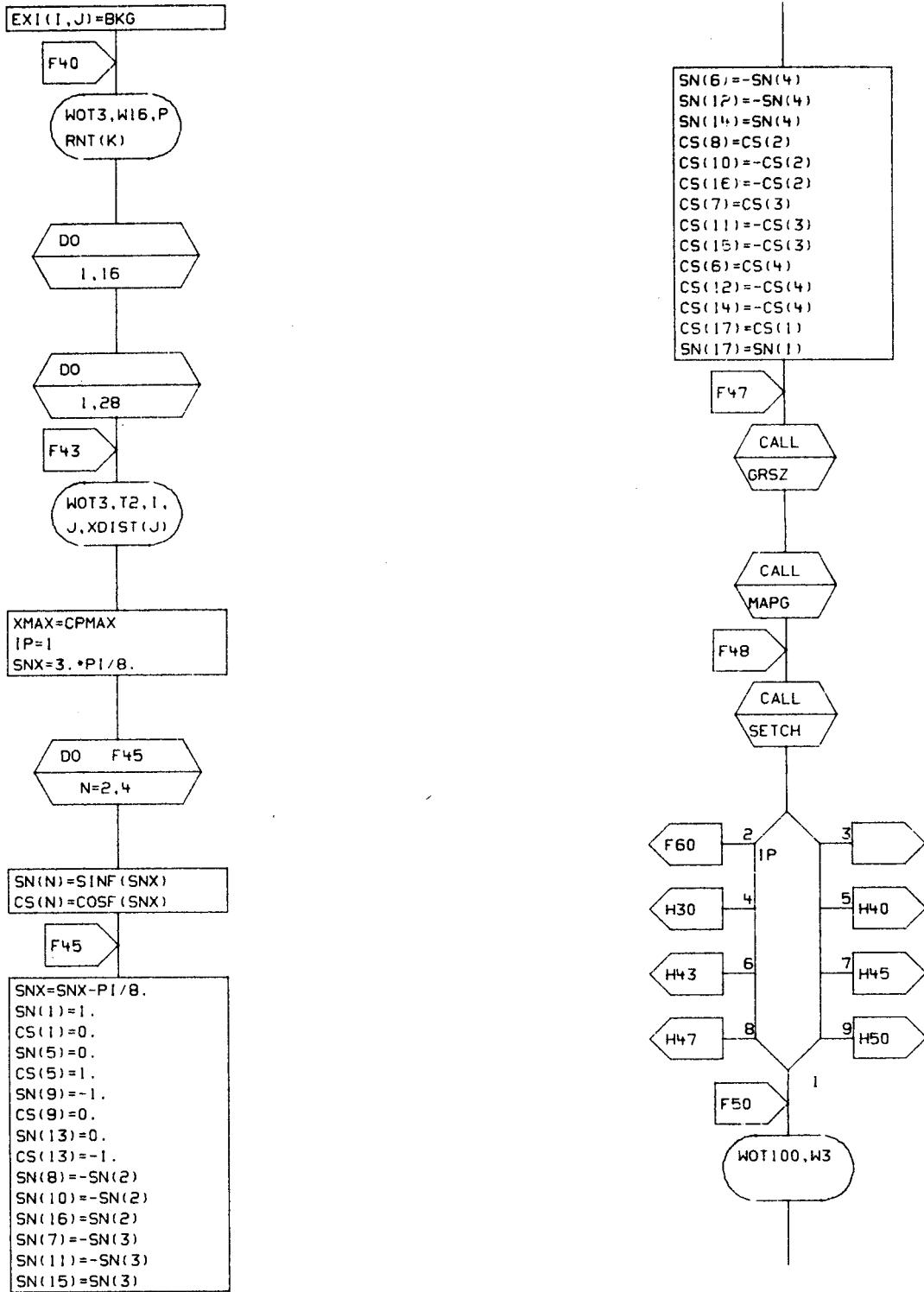


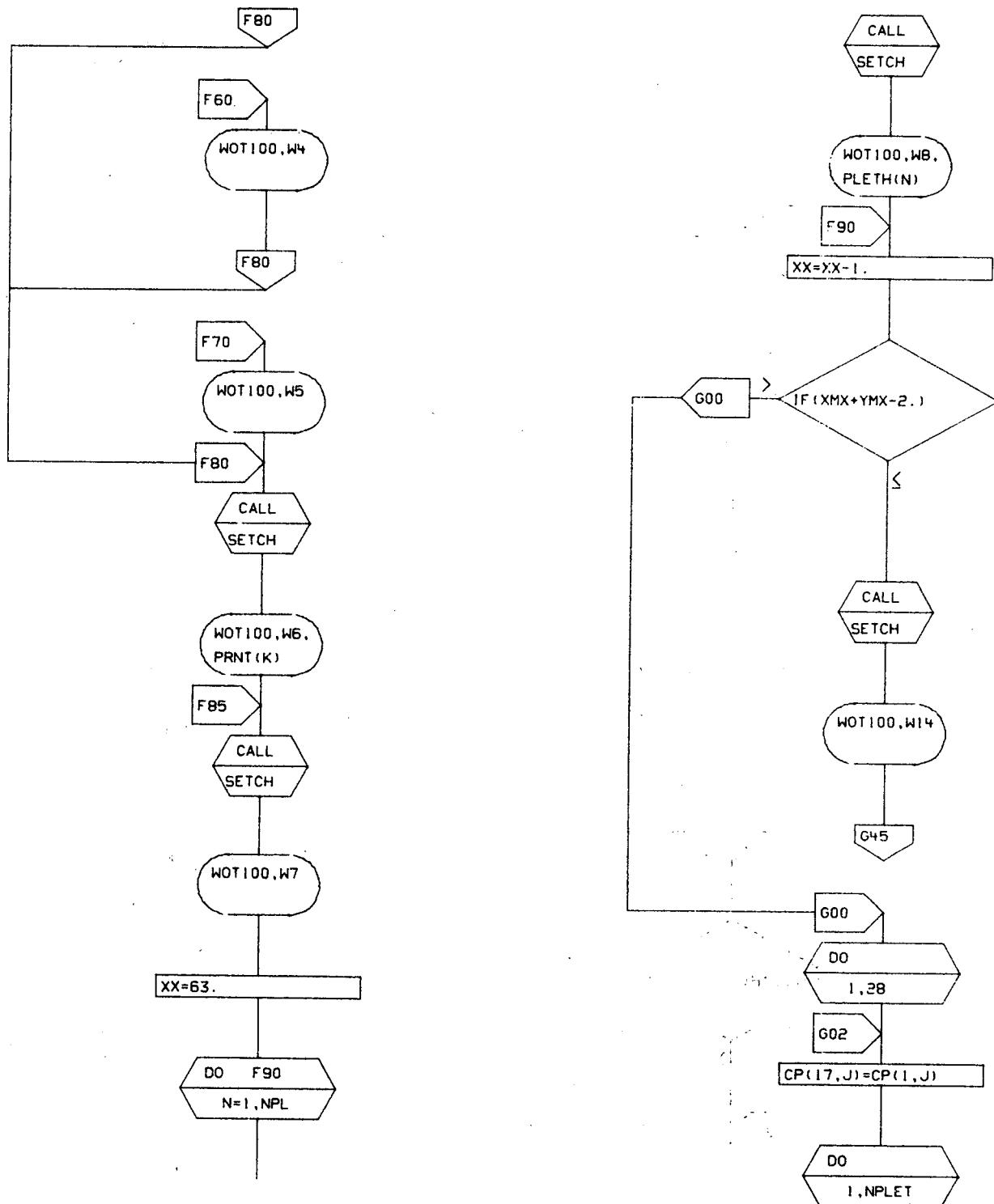


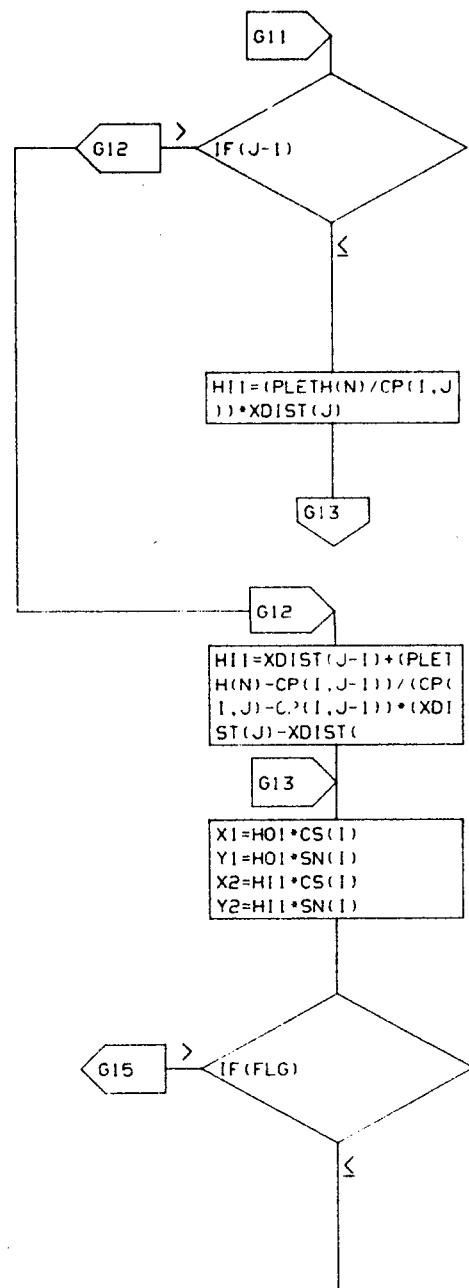
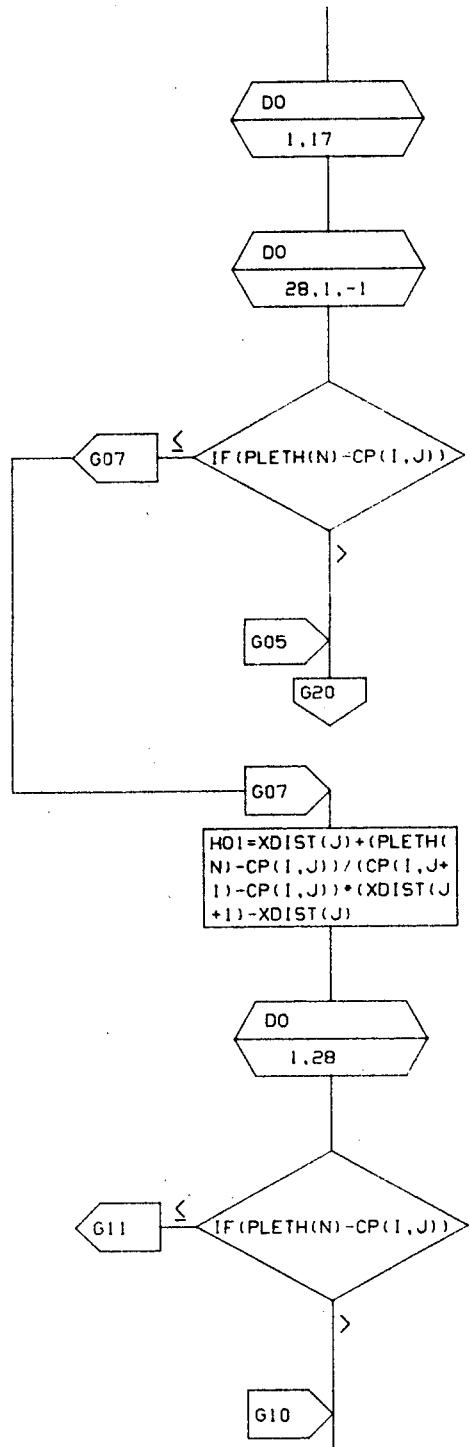


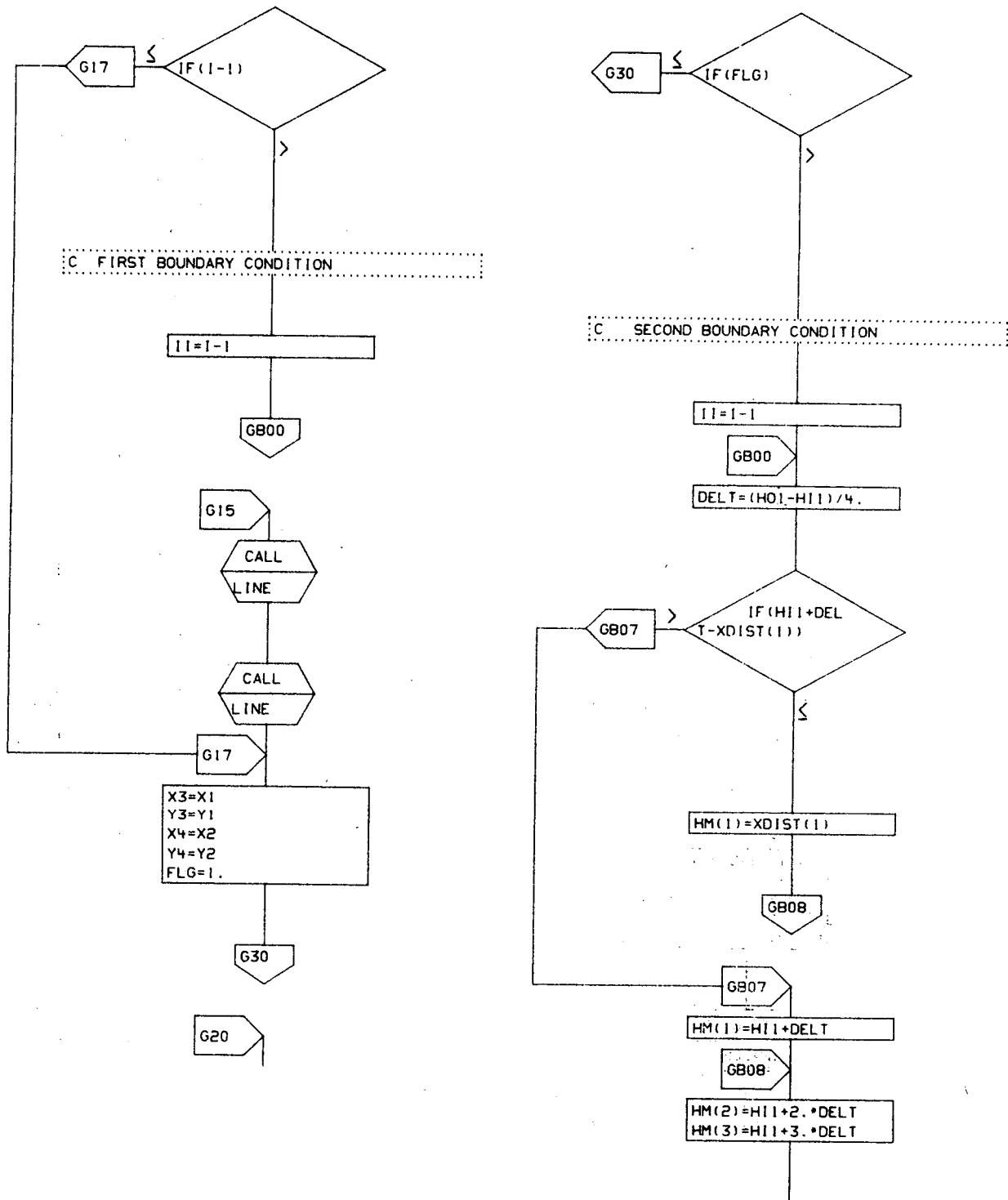


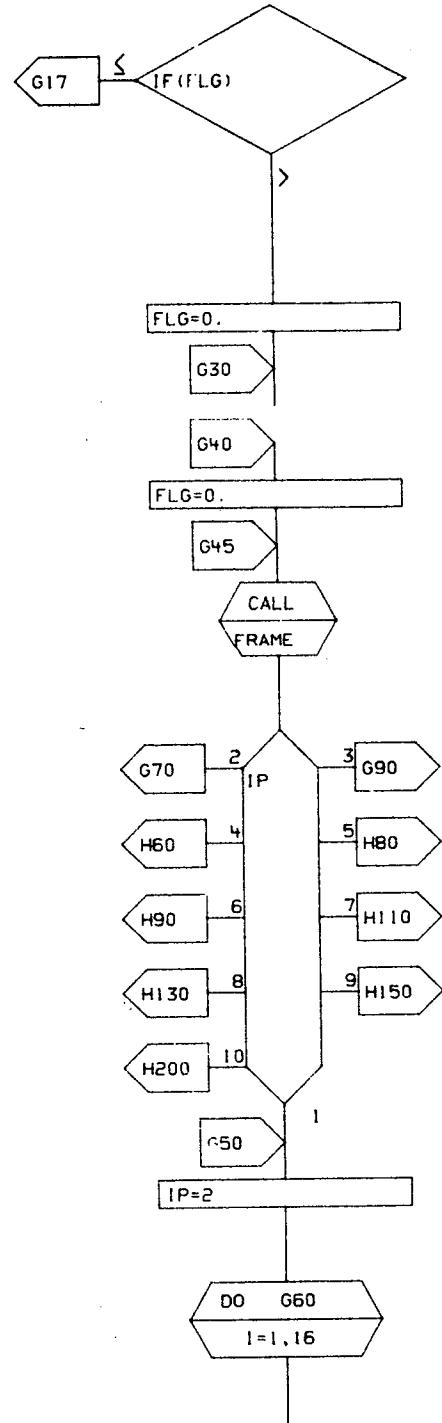
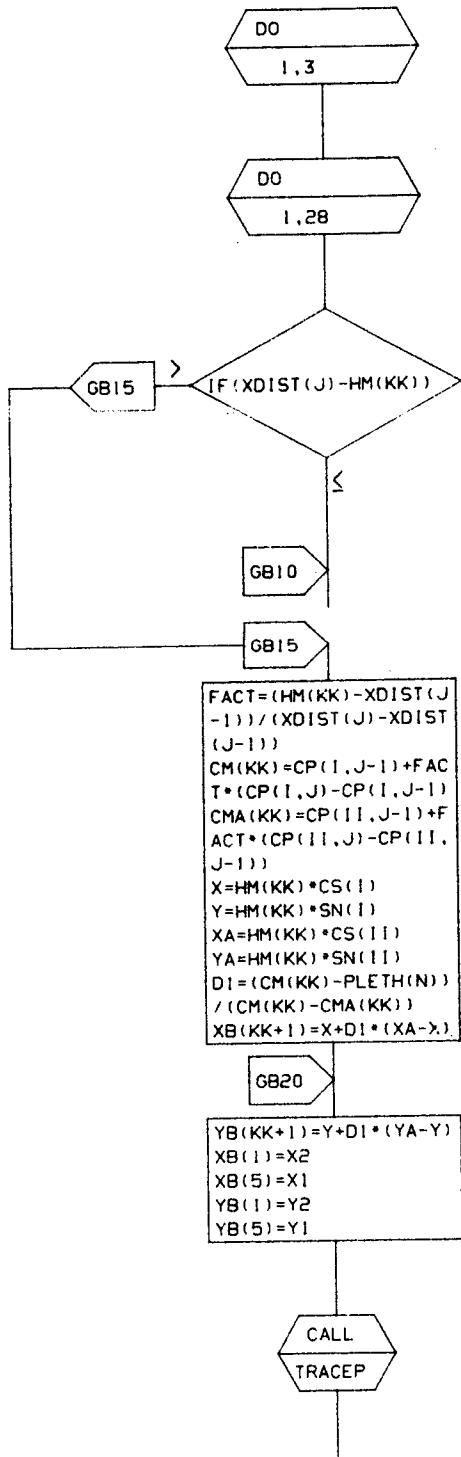


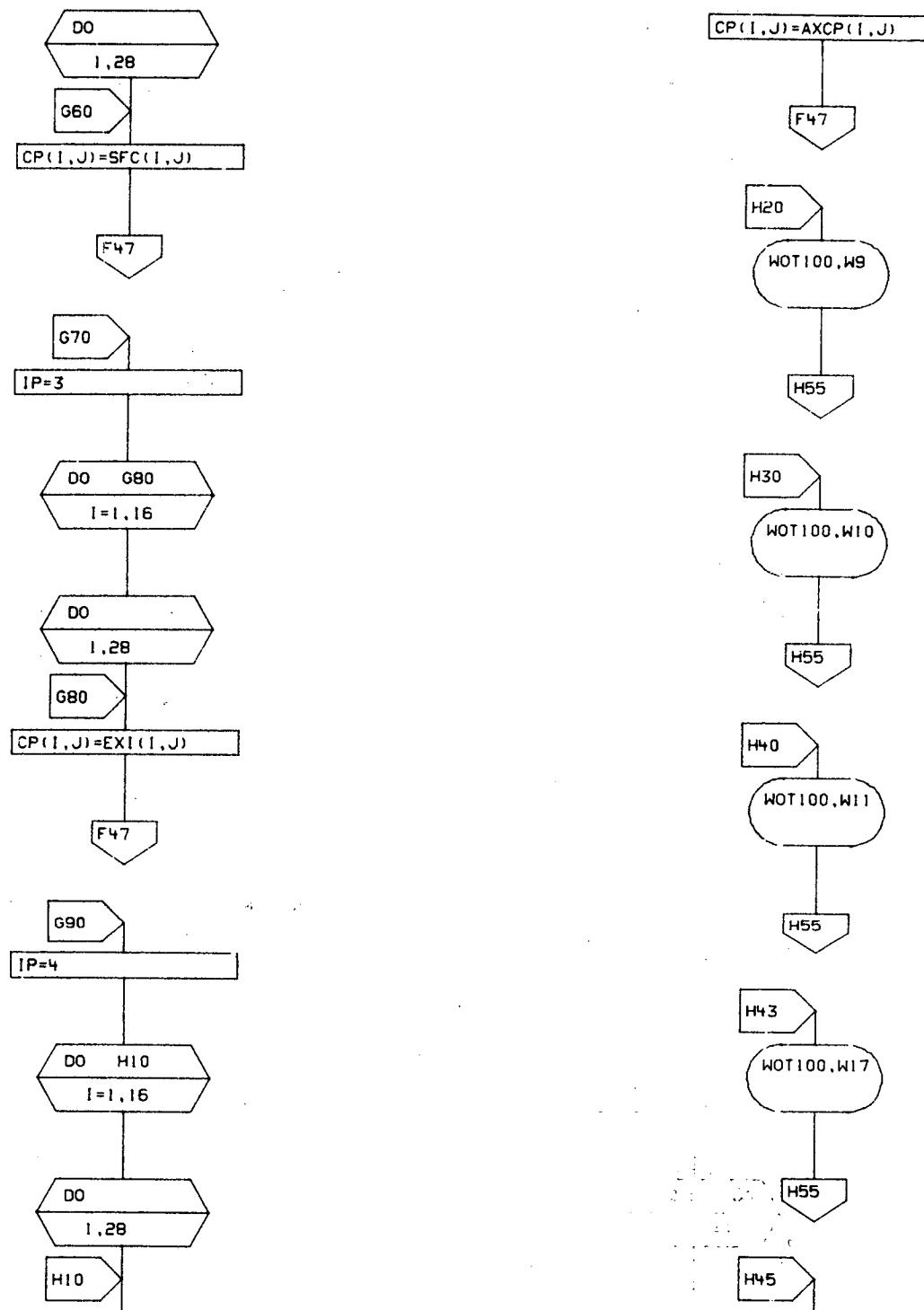


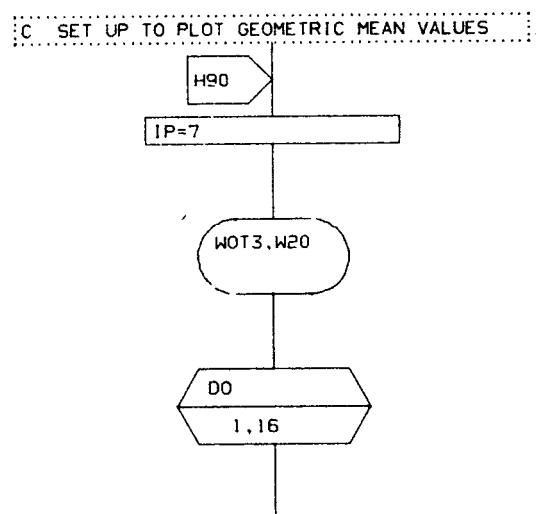
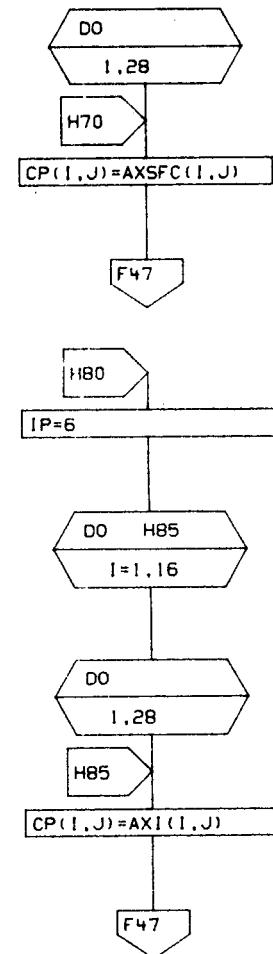
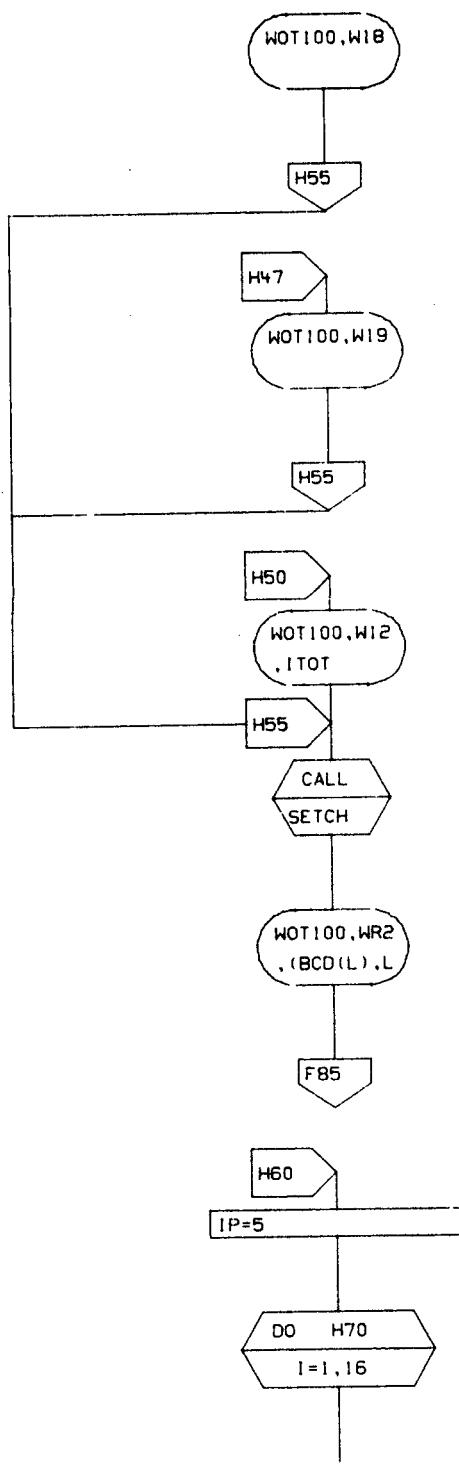


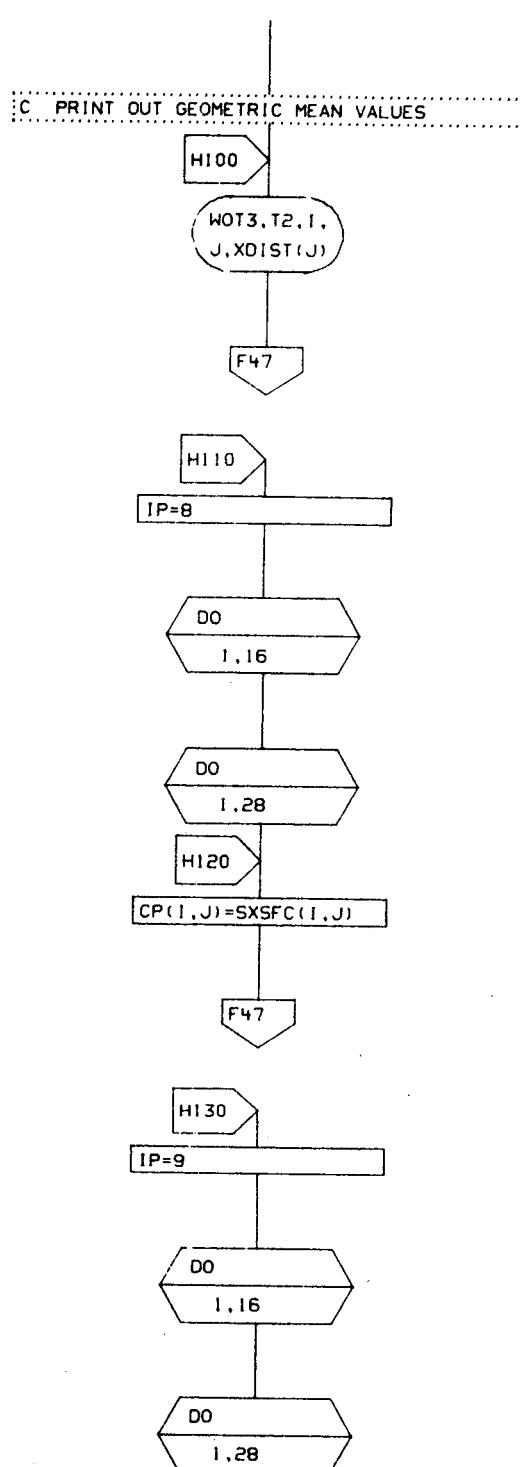
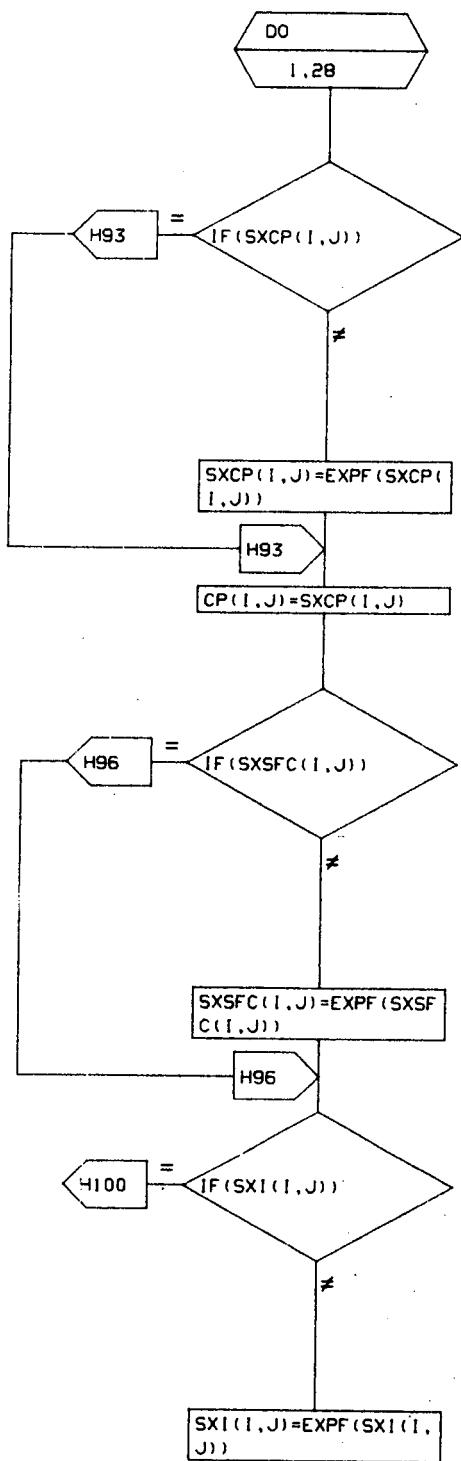


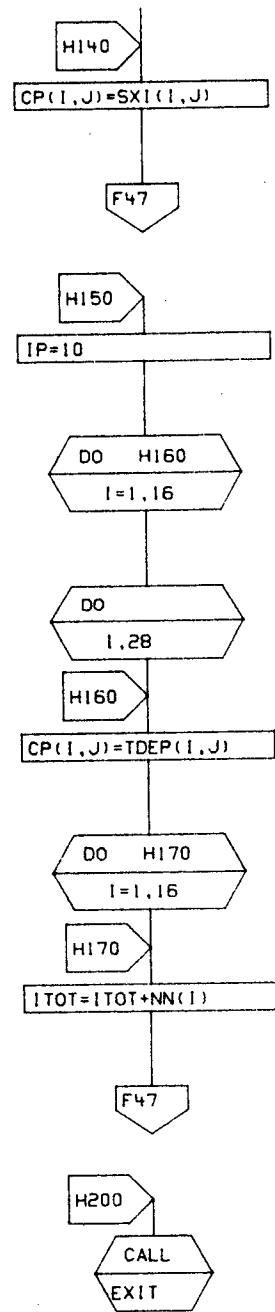












PAGE 28

## JOBCHART

ROUTINE MAIN.

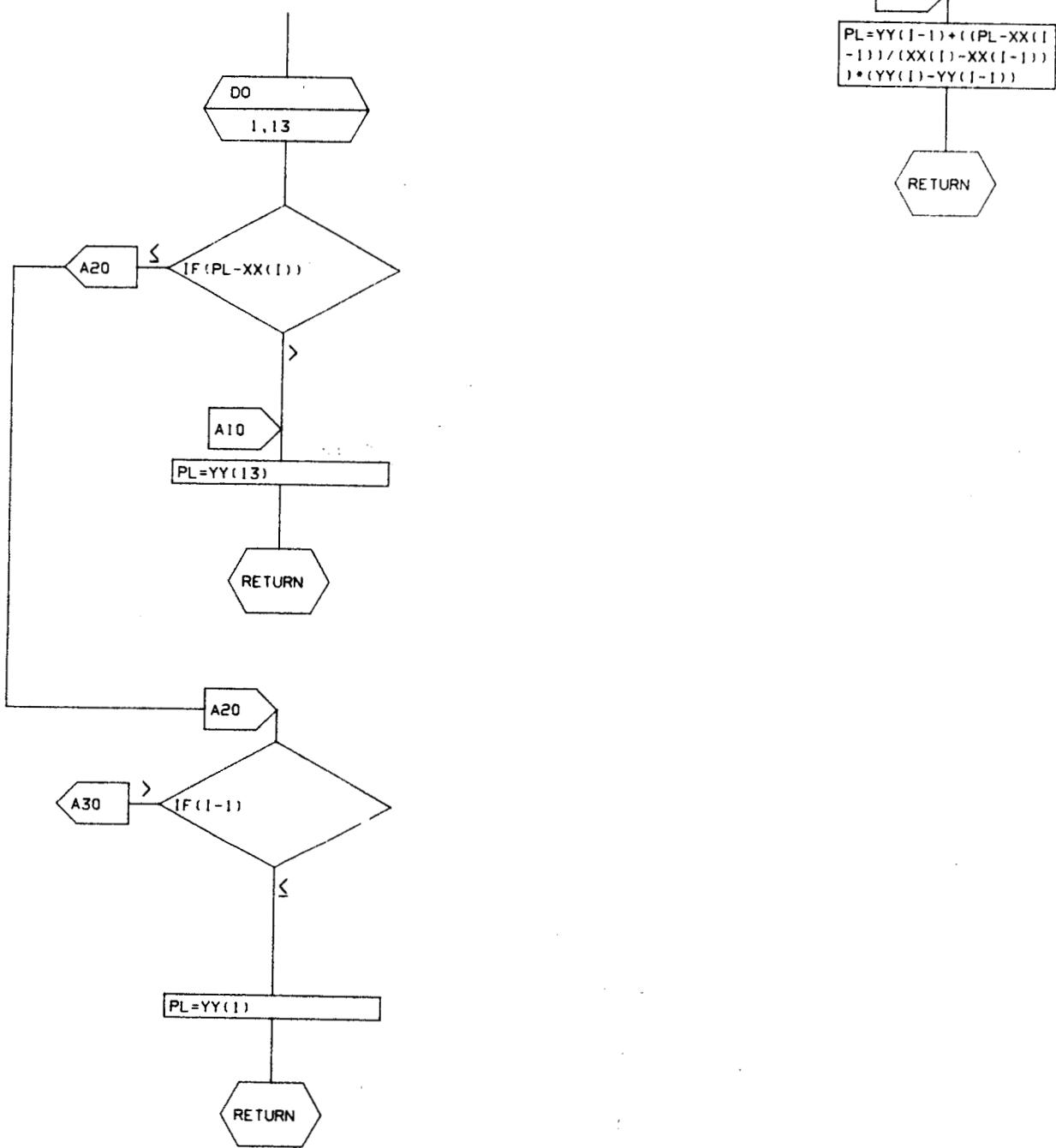
CALLS : ASSIGN, KEEPBO, EXIT , MAPGLL, SETCH , TRACEP, SETLCH, FRAME , ZPL , GRSZ , MAPG , LINE

LABEL	PAGE	PAGES CONTAINING REFERENCES
A02	1	1.
A03	2	1.
A05	2	2, 16.
A07	2	2,
A10	2	
A20	2	2,
A25	2	3,
A30	3	2,
A40	3	3,
A50	3	3,
A51	3	2, 14, 17,
A52	3	3,
A53	3	
A58	4	3,
A60	4	4,
A70	4	3,
A80	4	4,
B20	4	4,
B30	5	4,
B40	5	4, 5,
B50	5	5,
B60	5	5,
B63	5	5,
B65	5	5,
B70	5	5,
B80	6	6,
B85	6	6,
B87	6	6,
B90	6	6,
B100	6	4,
C05	6	6,
C10	7	7,
C15	7	7,
C20	7	7,
C25	8	7, 7, 8,
C27	8	8,
C30	8	7,
C40	8	8, 8,
C50	8	8,
C53	9	9,
C56	9	9,
C60	9	9,
D10	9	9,
D20	11	11,
E10	12	9,
E20	12	
E30	13	12,
E33	13	13,
E36	13	13,
E40	13	13,
E50	13	
E55	14	14,
E56	14	
E60	14	
E65	14	14,
E70	15	14, 14,
F03	15	15,

F05	15	15,
F10	15	15,
F13	15	
F14	16	15,
F15	16	
F15A	16	12,
F15AB	16	16,
F15AC	16	16,
F15AD	16	16,
F15B	16	16,
F15BA	17	
F15C	17	17,
F15D	17	17,
F15E	17	17,
F16	18	17,
F20	18	18,
F25	18	18,
F30	18	18,
F35	18	18,
F40	19	18,
F43	19	
F45	19	
F47	19	24, 24, 24, 25, 25, 26, 26, 27, 27,
F48	19	
F50	19	
F60	20	19,
F70	20	
F80	20	20, 20,
F85	20	25,
F90	20	
G00	20	20,
G02	20	
G05	21	
G07	21	21,
G10	21	
G11	21	21,
G12	21	21,
G13	21	21,
G15	22	21,
G17	22	22, 23,
G20	22	21,
GB00	22	22,
GB07	22	22,
GB08	22	22,
GB10	23	
GB15	23	23,
GB20	23	
G30	23	22, 22,
G40	23	
G45	23	20,
G50	23	
G60	24	
G70	24	23,
G80	24	
G90	24	23,
H10	24	
H20	24	
H30	24	19,
H40	24	19,

H43	24	19,
H45	24	19,
H47	25	19,
H50	25	19,
H55	25	24, 24, 24, 25, 25,
H60	25	23,
H70	25	
H80	25	23,
H85	25	
H90	25	23,
H93	26	26,
H96	26	26,
H100	26	26,
H110	26	23,
H120	26	
H130	26	23,
H140	27	
H150	27	23,
H160	27	
H170	27	
H200	27	23,

PAGE 1

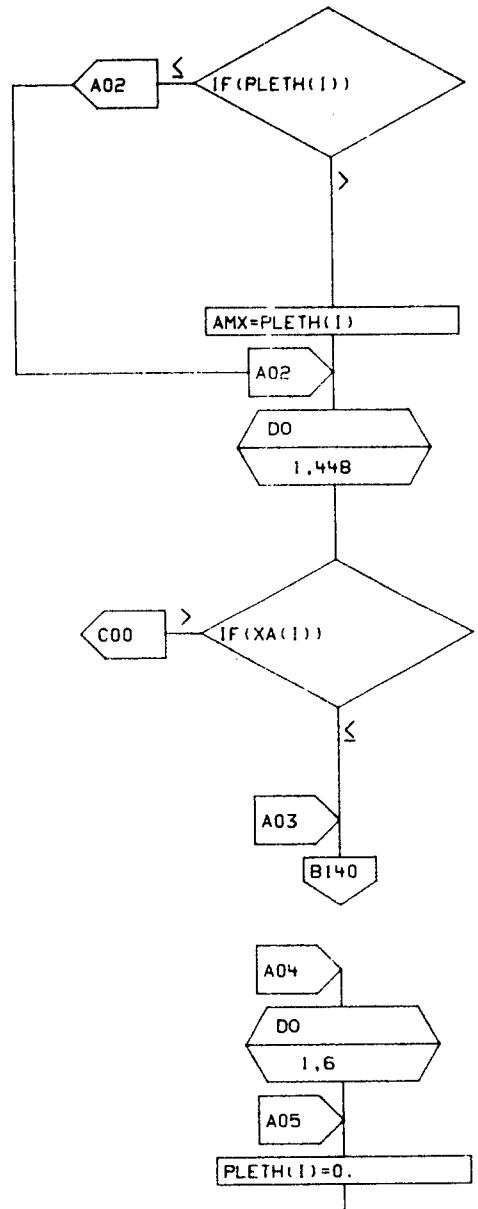
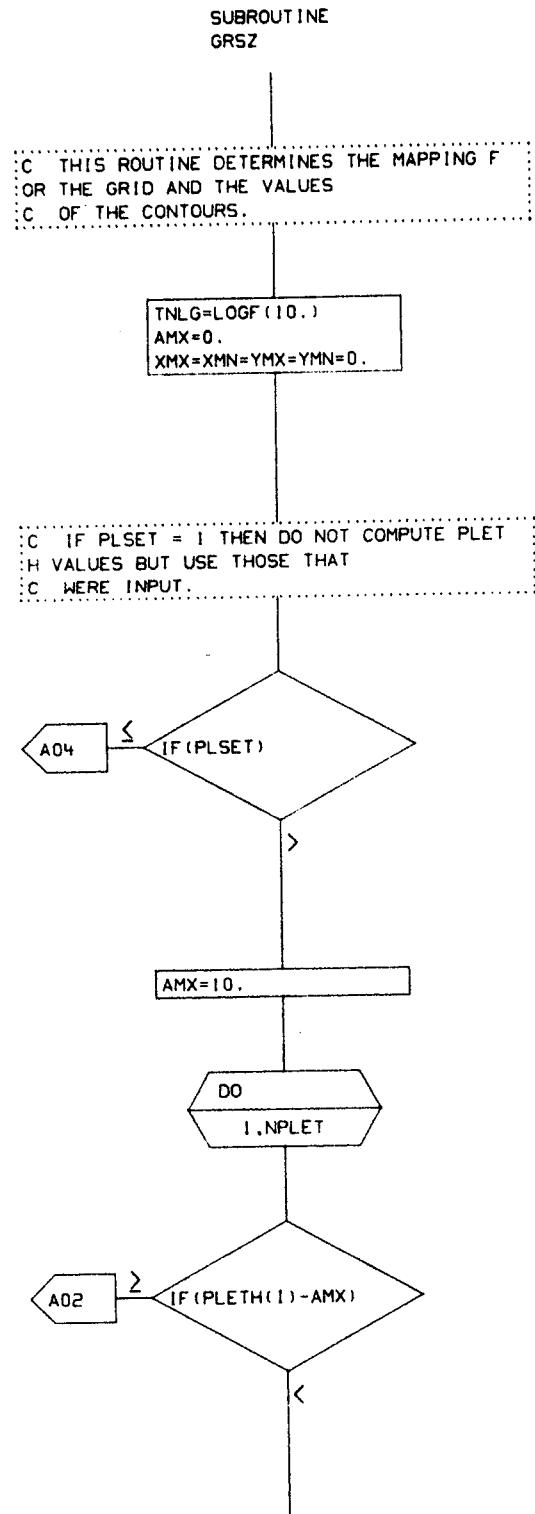
SUBROUTINE  
ZPL

PAGE 2

ROUTINE ZPL

## JOBCHART

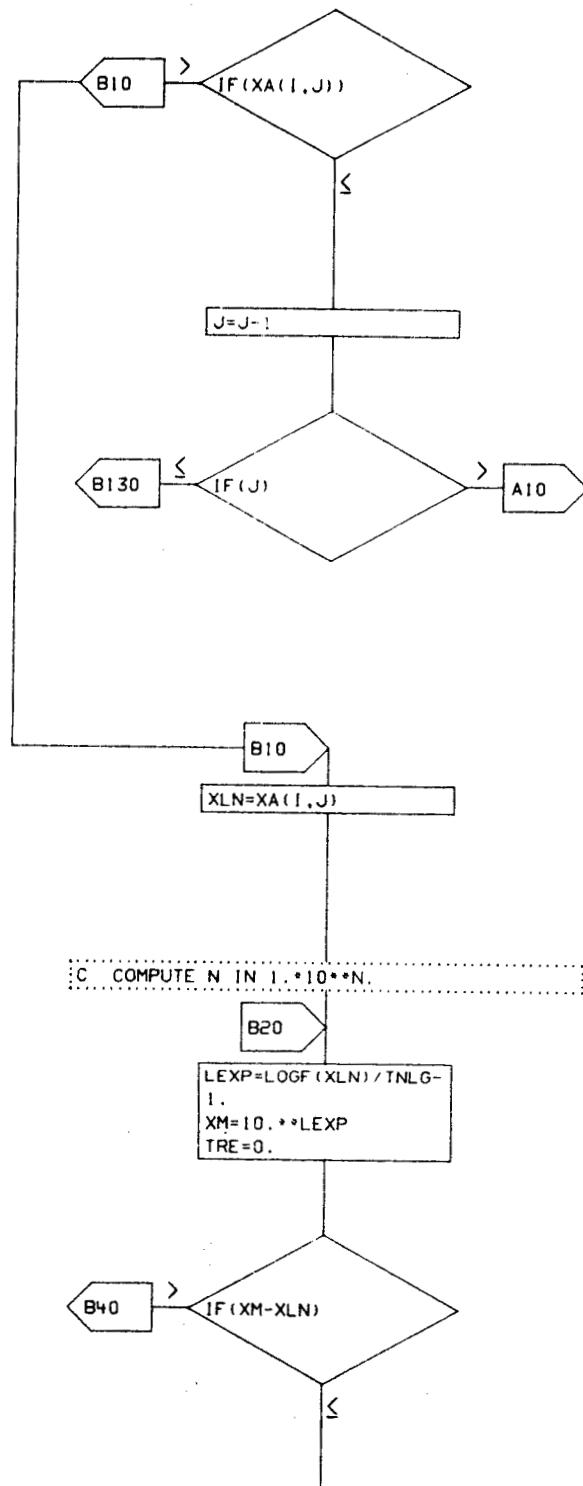
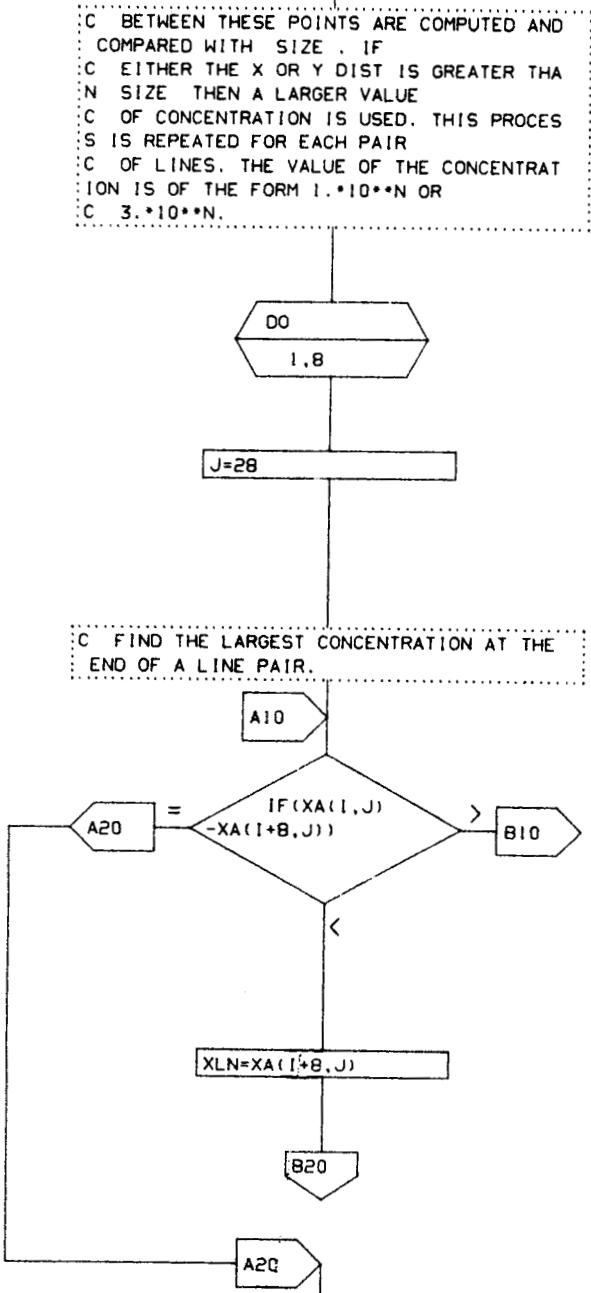
LABEL	PAGE	PAGES CONTAINING REFERENCES
A10	1	
A20	1	1,
A30	1	1,

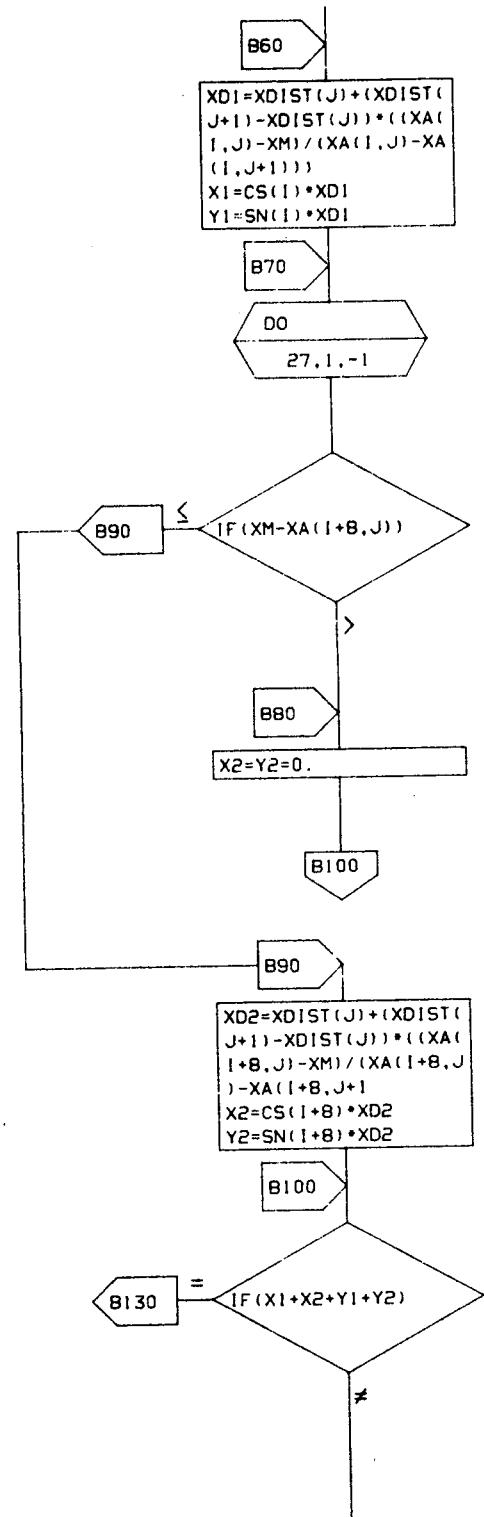
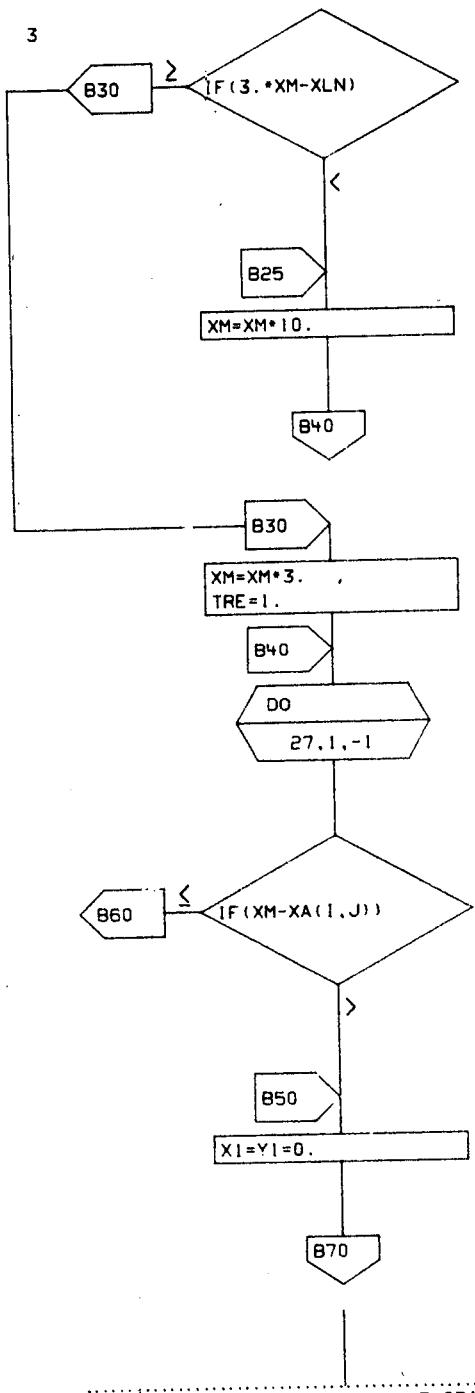


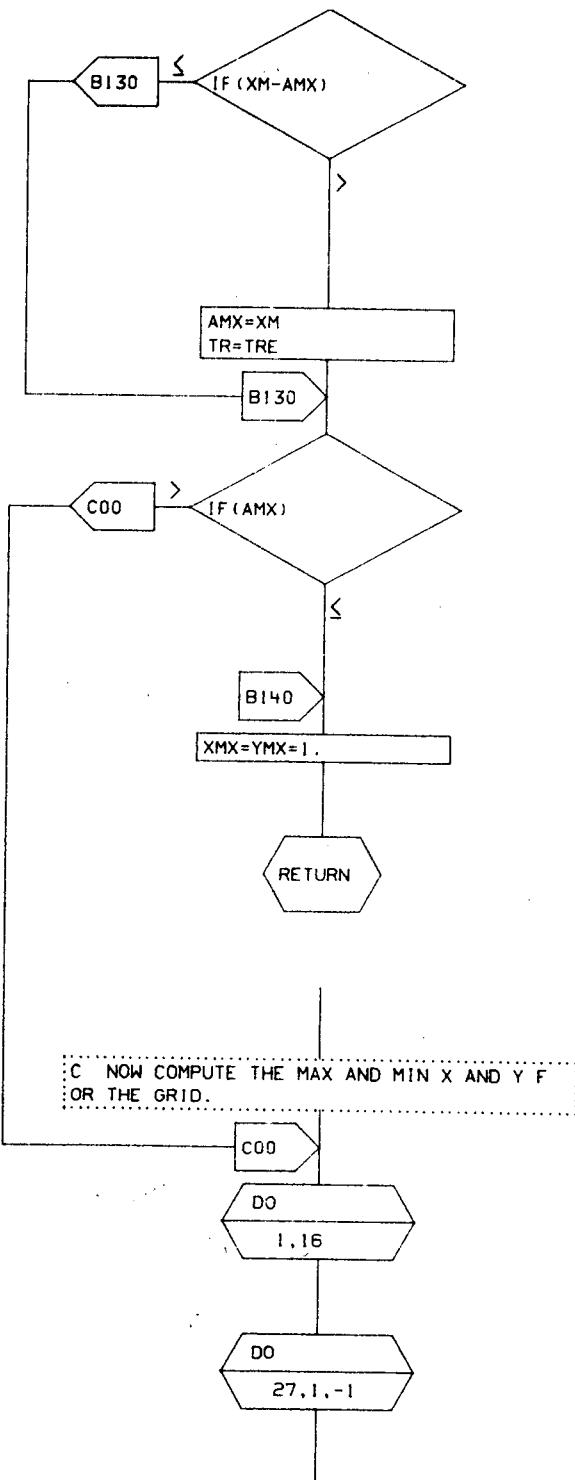
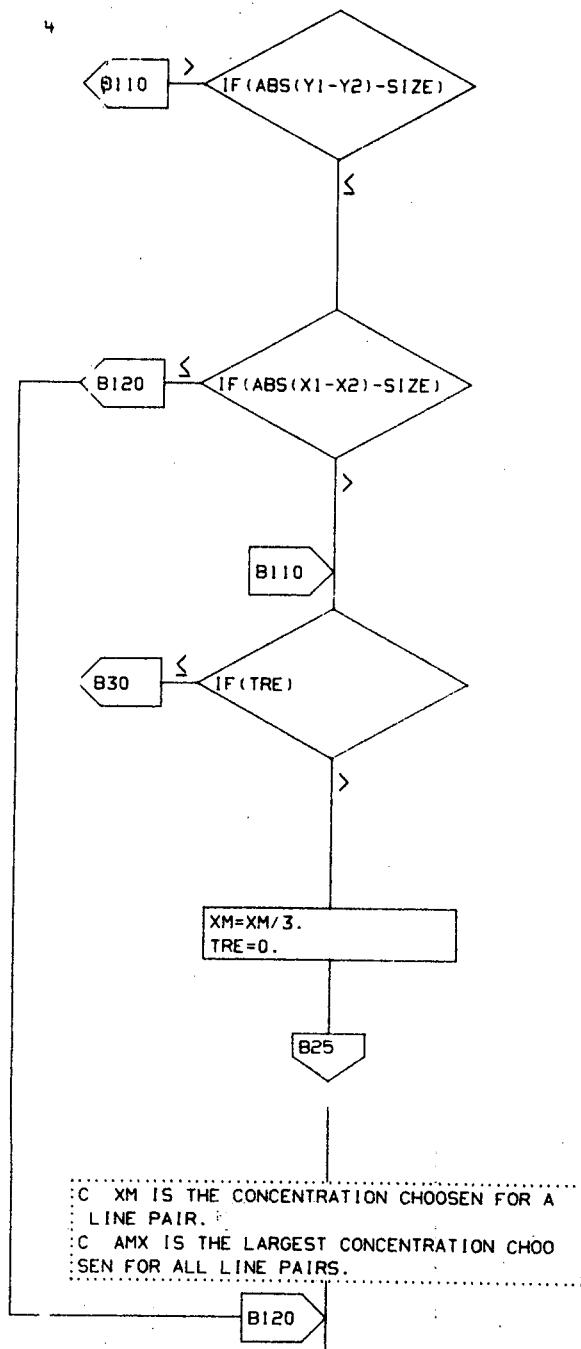
```

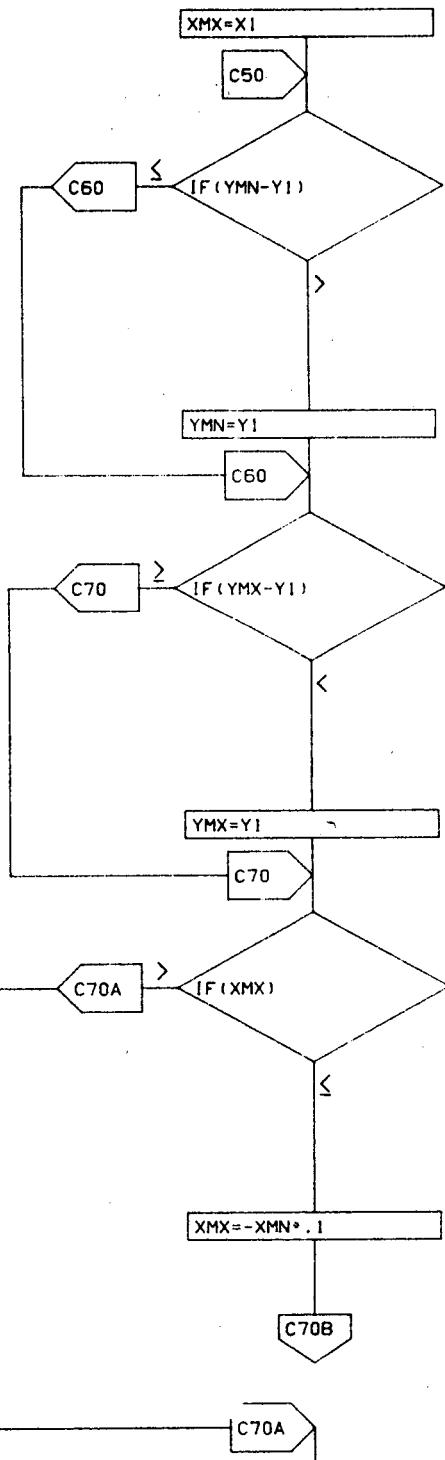
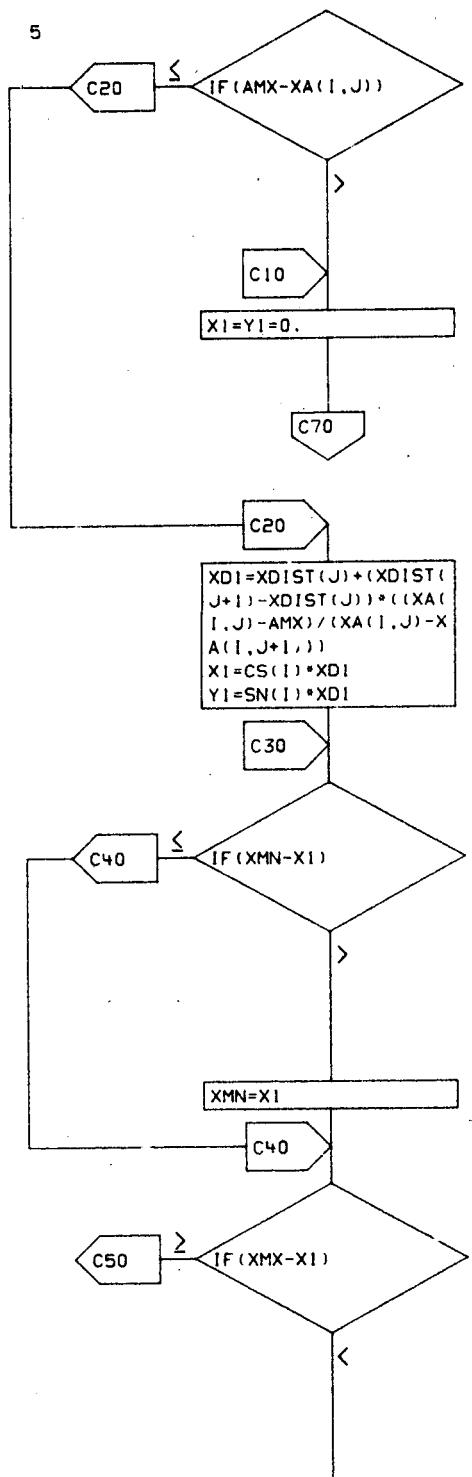
C THE LINES ARE CONSIDERED IN PAIRS. TH
E ITH AND THE I+8TH LINES
C FORM A LONGER STRAIGHT LINE. TO START
WITH THE SMALLEST CONCENTRATION
C THAT CAN BE FOUND AT BOTH ENDS IS COM
PUTED. THEN THE X AND Y DISTANCE

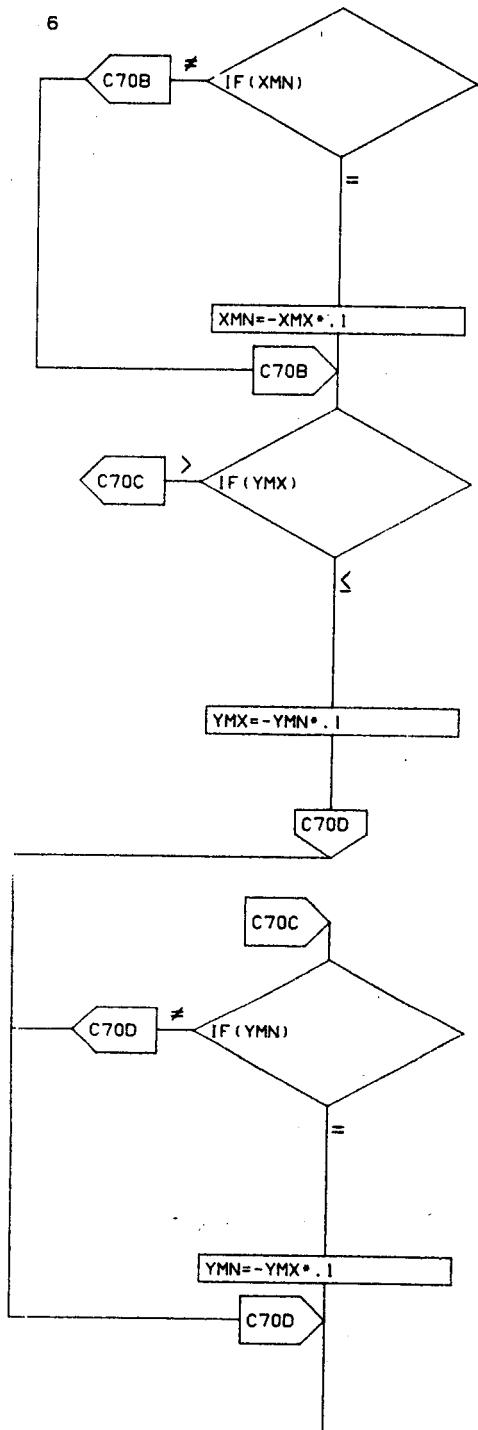
```



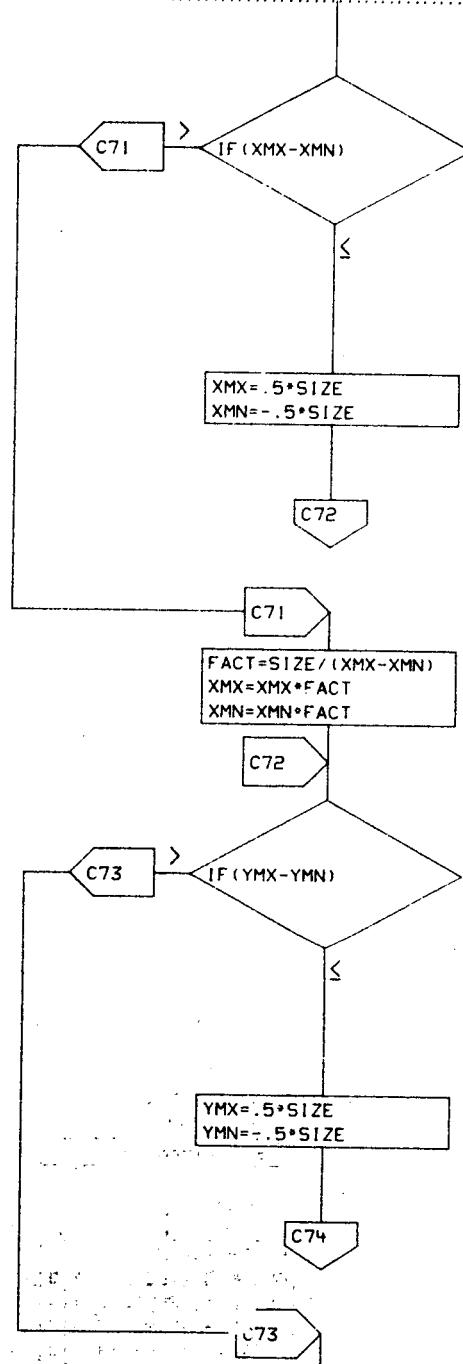


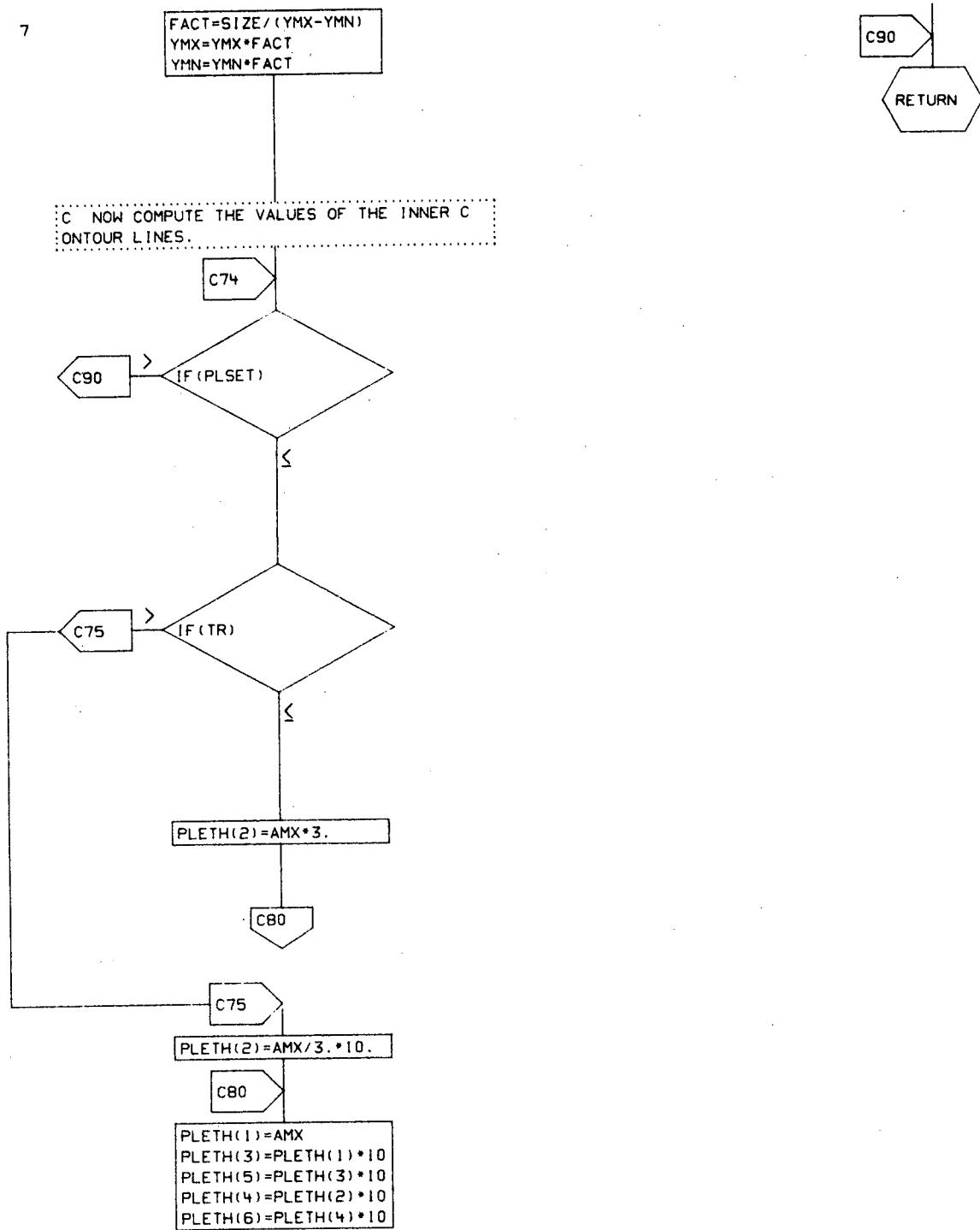






C THIS IS TO MAKE SURE THAT XMX-XMN = SIZE AND YMX-YMN = SIZE.





PAGE 8

ROUTINE GRSZ

JOBCHART

LABEL	PAGE	PAGES CONTAINING REFERENCES
A02	1	1.
A03	1	
A04	1	1.
A05	1	
A10	2	2.
A20	2	2.
B10	2	2. 2.
B20	2	2.
B25	3	4.
B30	3	3. 4.
B40	3	2. 3.
B50	3	
B60	3	3.
B70	3	3.
B80	3	
B90	3	3.
B100	3	3.
B110	4	4.
B120	4	4.
B130	4	2. 3. 4.
B140	4	1.
C00	4	1. 4.
C10	5	
C20	5	5.
C30	5	
C40	5	5.
C50	5	5.
C60	5	5.
C70	5	5. 5.
C70A	5	5.
C70B	6	5. 6.
C70C	6	6.
C70D	6	6. 6.
C71	6	6.
C72	6	6.
C73	6	6.
C74	7	6.
C75	7	7.
C80	7	7.
C90	7	7.

## Appendix B

### Sample CPS Problems

#### PROBLEM 1

The first sample problem is for the one-data-set mode. A source of 2500 units/sec is released at ambient temperature from a 60-m stack. The effluent half-life is 1.5 hr. As indicated by the DIST and HGT input, the terrain downwind rises slowly out to 3 km and then descends to sea level at 15 km. The terrain rises again at 30 km and continues to rise out to 110 km. Note in the printout (Table B-1) that NORM, NPLETH, PLETH, and SIZE are not entered since these variable names are only encountered in the many-data-set mode. The distances DIST may be in mixed format with a sufficient number of zeros following  $1.1 \times 10^5$  m to make up 10 entries.

In the first plot, Fig. B-1, the slightly curved line from upper right to lower left represents the plume-centerline concentration. The effect of topography is evident, but not too prominent. The other two curves are surface concentrations (both with and without sector averaging) under the plume centerline. The effect of the terrain falloff to sea level and the subsequent rise in topography are

clearly evident. Figure B-2 shows the vertical integral through the plume center and dry surface deposition; the latter curve is for a 1-hr (TSTEP = 3600 sec) period of deposition at a deposition velocity VDEP of 0.01 m/sec.

#### PROBLEM 2

The second sample problem is for a 3-month normal operating release (NORM = 0) of 1 unit/sec. These input variables and data sets are for a portion of the data used in preparing a Safety Analysis Report for the LLL Livermore Pool Type Reactor (LPTR). About 3300 data sets, representing 30-min averages obtained from strip charts, were used in the calculation.

To conserve space only one page of meteorology printout is shown in this report. The remainder of the printout consists of concentration versus distance, arranged in 16 sectors. I = 1 is for a wind from the south. Again, to conserve space, only the first page of each type of concentration is shown (the arithmetic average, concentrations that will be exceeded 10, 5, 1, and 0.5%

of the time, and the geometric average).

In the printout, CP, SFC, and XI are the plume center, surface, and sector-averaged concentrations, respectively; TDEP is the total deposition over the data period (approximately  $3300 \times 0.5 = 1650$  hr). Since VDEP = 0, all TDEP values are zero. Arithmetic and geometric average and probability contour plots are prepared for CP, SFC, and XI concentrations. In this appendix only plots for the 5% probability of being exceeded and the arithmetic and geometric averages are shown. (A deposition plot is prepared, but is blank in this case since VDEP = 0.)

The plots for the normal operating case are shown in Figs. B-3 through B-11. In each of these plots, the top value in the list of contours represents the outer contour. Unless otherwise specified, six contour values are listed, but are not drawn

when they do not exist. Those plots that do not fill or overfill the page can be regenerated by using a different value for SIZE and rerunning the code. Reference to the initial printout is helpful in selecting the correct value for SIZE. Note that if the contour for two or more adjacent sectors lies outside the grid, the contour will not be drawn; the code will select the next smallest contour instead.

### PROBLEM 3

The third sample problem is identical with the second, except that NORM = 1, representing an accidental release. The printout for this problem is omitted. Figures B-12 through B-20 show contours for the accident case and are arranged in the same order as Figs. B-3 through B-11 for the normal release.

Table B-1

CPS EXAMPLE - ONE DATA SET  
 Q=2500. H=60. VDEP=.01 TSTEP=3600.  
 GZHT=400. ZSFC=10. UMIN=.5 THALF=5400.  
 ITOP=1 ITDI=1 SDZMX=1500. CA=0.  
 ISTACK=0 SQ=0. IPF=0 PP=0.  
 BKG=0. INPT=1 KEPLOT=1  
 DIST= 2000. 3000. 5000. 1.E4 1.5E4 3.E4 4.E4 1.1E4 0. 0.  
 HGT= 450. 600. 500. 300. 0. 0. 200. 300. 0. 0.  
 ZZZZZ

DIR=310. USFC=5.0 ISCAT=4 PRECP=0. ZZZZZ 1500 030176	XDIST	XCP	XSFc	XI	VI	DEP	GHT	U	UA
	1.0000E+02	1.2531E+00	4.8008E-29	2.5091E-29	1.5706E+01	9.0328E-28	2.5000E+00	7.7426E+00	7.7426E+00
	1.3000E+02	7.8180E-01	3.7511E-18	1.9183E-18	1.2346E+01	6.9059E-17	3.2500E+00	7.7172E+00	7.7397E+00
	1.7000E+02	5.0043E-01	4.1421E-12	2.0716E-12	9.6588E+00	7.4577E-11	4.2500E+00	7.6830E+00	7.7304E+00
	2.2000E+02	3.2059E-01	4.5747E-08	2.2395E-08	7.6341E+00	8.0623E-07	5.5000E+00	7.6396E+00	7.7147E+00
	2.8000E+02	2.0381E-01	2.3680E-05	1.1363E-05	6.1307E+00	4.0906E-04	7.0000E+00	7.5865E+00	7.6929E+00
	3.6000E+02	1.2985E-01	8.0214E-04	3.7696E-04	4.8823E+00	1.3570E-02	9.0000E+00	7.5139E+00	7.6612E+00
	4.6000E+02	8.6752E-02	4.6006E-03	2.1184E-03	3.9142E+00	7.6264E-02	1.1500E+01	7.4200E+00	7.6189E+00
	6.0000E+02	5.5948E-02	1.3810E-02	6.2204E-03	3.0846E+00	2.2395E-01	1.5000E+01	7.2824E+00	7.5565E+00
	7.7000E+02	3.6868E-02	2.3362E-02	1.0307E-02	2.4692E+00	3.7106E-01	1.9250E+01	7.1040E+00	7.4763E+00
	1.0000E+03	2.5739E-02	2.7056E-02	1.1681E-02	1.9584E+00	4.2050E-01	2.5000E+01	6.8389E+00	7.3602E+00
	1.3000E+03	2.1555E-02	2.4512E-02	1.0355E-02	1.5564E+00	3.7276E-01	3.2500E+01	6.4388E+00	7.1937E+00
	1.7000E+03	1.7644E-02	1.8618E-02	7.6917E-03	1.2404E+00	2.7690E-01	4.2500E+01	5.7503E+00	6.9351E+00
	2.2000E+03	1.4123E-02	1.4125E-02	5.7118E-03	1.0446E+00	2.0563E-01	8.0000E+01	2.8117E+00	6.3320E+00
	2.8000E+03	1.0582E-02	1.0583E-02	4.1948E-03	9.1531E-01	1.5101E-01	1.7000E+02	2.8117E+00	5.5776E+00
	3.6000E+03	7.7308E-03	7.7314E-03	3.0012E-03	7.7525E-01	1.0804E-01	1.7000E+02	2.8117E+00	4.9630E+00
	4.6000E+03	5.6054E-03	5.6057E-03	2.1322E-03	6.3938E-01	7.6760E-02	1.2000E+02	2.8117E+00	4.4953E+00
	6.0000E+03	3.6272E-03	3.6274E-03	1.3496E-03	5.0011E-01	4.8587E-02	6.0000E+01	2.8117E+00	4.1025E+00
	7.7000E+03	1.7078E-03	1.8871E-03	6.8774E-04	3.5254E-01	2.4759E-02	-8.0000E+00	8.0742E+00	4.3984E+00
	1.0000E+04	6.5743E-04	6.7506E-04	2.4074E-04	2.2416E-01	8.6668E-03	-1.0000E+02	1.0000E+01	5.4653E+00
	1.3000E+04	3.3828E-04	9.1531E-05	3.1939E-05	1.4410E-01	1.1498E-03	-2.8000E+02	1.2074E+01	6.7510E+00
	1.7000E+04	1.9617E-04	2.0934E-05	7.1440E-06	9.3429E-02	2.5719E-04	-4.0000E+02	1.3021E+01	8.1149E+00
	2.2000E+04	1.2000E-04	2.1790E-05	7.2786E-06	6.3161E-02	2.6203E-04	-4.0000E+02	1.3021E+01	9.2301E+00
	2.8000E+04	7.0913E-05	2.6067E-05	8.5346E-06	4.4387E-02	3.0725E-04	-4.0000E+02	1.3021E+01	1.0042E+01
	3.6000E+04	4.6241E-05	4.2043E-05	1.3481E-05	3.0839E-02	4.8533E-04	-2.8000E+02	1.2074E+01	1.0599E+01
	4.6000E+04	2.7753E-05	1.8236E-05	5.7297E-06	2.1305E-02	2.0627E-04	-4.0000E+02	1.3021E+01	1.1023E+01
	6.0000E+04	1.5991E-05	1.3618E-05	4.1853E-06	1.3900E-02	1.5067E-04	-4.0000E+02	1.3021E+01	1.1489E+01
	7.7000E+04	9.6139E-06	9.2675E-06	2.7899E-06	9.0003E-03	1.0044E-04	-4.0000E+02	1.3021E+01	1.1827E+01
	1.0000E+05	5.4123E-06	5.7128E-06	1.6829E-06	5.4329E-03	6.0585E-05	-4.0000E+02	1.3021E+01	1.2102E+01

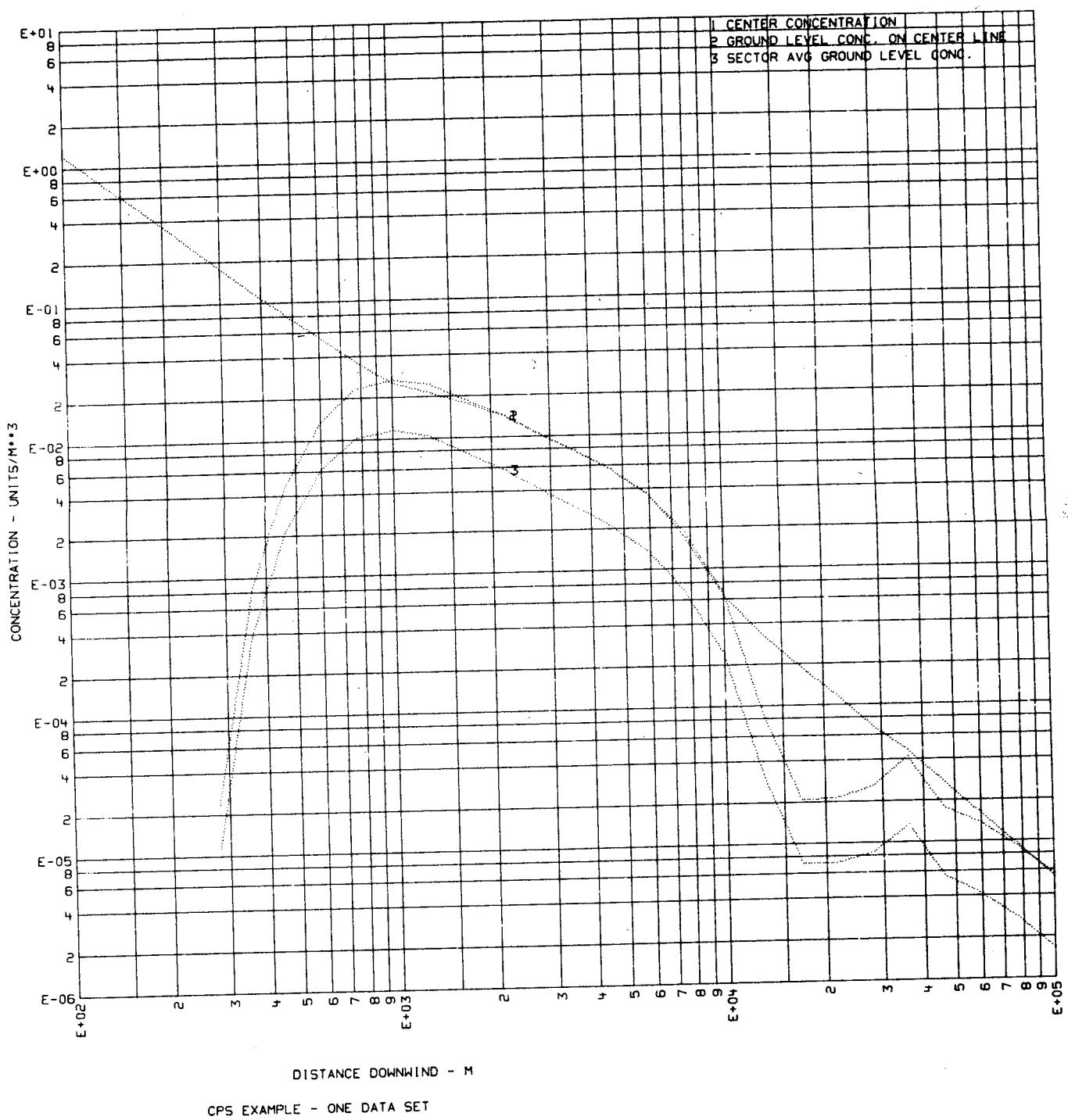


Fig. B-1

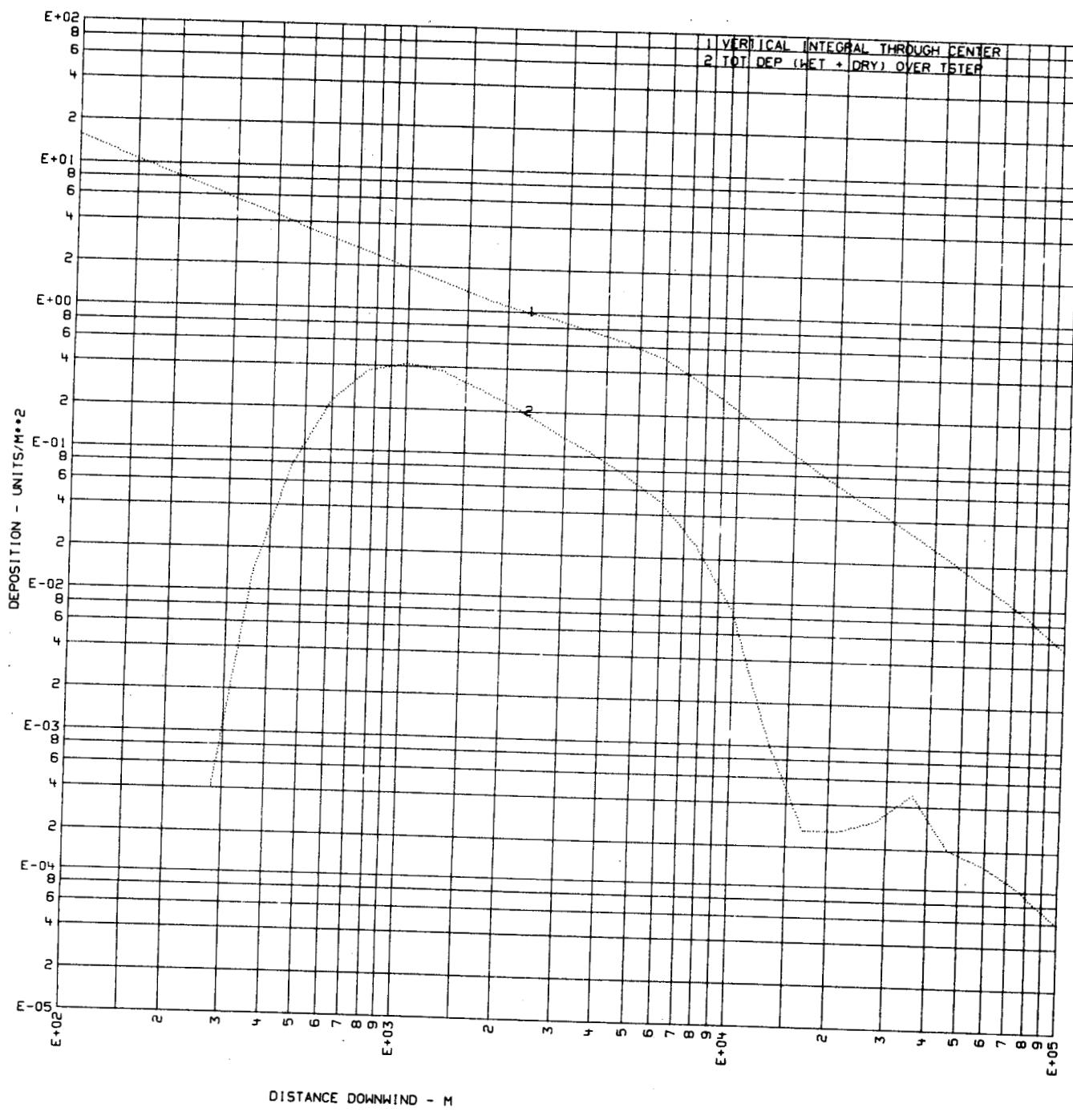


Fig. B-2

DIFFUSION ESTIMATES - DEC. TO FEB. - LLL REACTOR  
 Q=1, H=15.9 VDEP=0, NORM=0  
 GZHT=189, ZSFC=10, UMIN=.5 THALF=0.  
 ITOP=1 ITDI=0 SD2MX=0, CA=300.  
 ISTACK=0 SQ=0, IPF=0 PP=0  
 BKG=0 INPT=1 SIZE=1.E5 KEPLOT=1  
 TSTEP=1800.  
 DIST= 6000. 7000. 11000. 12000. 15000. 16000. 19000. 20000. 26000.  
 100001.  
 4000. 5000. 6000. 7000. 8000. 9000. 10000. 12000. 13000. 100001.  
 3000. 4000. 5000. 6000. 7000. 8000. 9000. 10000. 16000. 100001.  
 2000. 5000. 7000. 8000. 9000. 10000. 12000. 15000. 18000. 100001.  
 4000. 7000. 10000. 14000. 16000. 18000. 20000. 24000. 29000. 100001.  
 4000. 7000. 8000. 9000. 10000. 10500. 15000. 18000. 20000. 100001.  
 5000. 8000. 11000. 15000. 18000. 23000. 26000. 100001. 0. 0.  
 4000. 6000. 9000. 10000. 11000. 14000. 17000. 18000. 26000. 100001.  
 3000. 9000. 11000. 14000. 17000. 20000. 21000. 22000. 26000. 100001.  
 6000. 8000. 10000. 12000. 15000. 16000. 18000. 19000. 24000. 100001.  
 6000. 8000. 9000. 15000. 18000. 19000. 22000. 23000. 24000. 100001.  
 12000. 13000. 14000. 15000. 17000. 20000. 23000. 24000. 26000. 100001.  
 10000. 19000. 21000. 22000. 23000. 25000. 100001. 0. 0. 0.  
 9000. 10000. 11000. 12000. 14000. 15000. 21000. 26000. 100001. 0.  
 5000. 11000. 15000. 16000. 17000. 19000. 21000. 22000. 23000. 100001.  
 7000. 10000. 11000. 13000. 15000. 16000. 18000. 20000. 23000. 100001.  
 HGT= 366. 488. 274. 335. 244. 274. 61. 122. 30. 0.  
 274. 183. 366. 244. 305. 274. 305. 152. 274. 0.  
 244. 396. 305. 366. 244. 274. 152. 183. 30. 0.  
 213. 427. 335. 183. 213. 183. 122. 61. 30. 0.  
 305. 488. 366. 244. 274. 183. 91. 61. 30. 0.  
 305. 610. 488. 579. 335. 457. 213. 700. 305. 0.  
 305. 518. 671. 732. 762. 914. 853. 0. 0. 0.  
 244. 366. 549. 366. 488. 975. 792. 618. 618. 0.  
 213. 366. 244. 701. 1097. 1097. 914. 610. 914. 0.  
 305. 213. 457. 244. 610. 366. 732. 610. 213. 0.  
 244. 152. 244. 122. 274. 122. 366. 244. 366. 0.  
 244. 305. 244. 122. 122. 488. 122. 244. 122. 0.  
 122. 244. 244. 366. 244. 366. 0. 0. 0. 0.  
 152. 274. 500. 274. 244. 152. 183. 152. 0. 0.  
 152. 244. 244. 305. 244. 244. 427. 366. 488. 0.  
 183. 305. 427. 488. 427. 613. 549. 549. 701. 0.  
 ZZZZZZ  
 USFC=2.5 PRECP=0. ISCAT=1 DIR=030. ZZZZZZ 1  
 USFC=3.5 PRECP=0. ISCAT=2 DIR=100. ZZZZZZ 1  
 USFC=3.0 PRECP=0. ISCAT=2 DIR=270. ZZZZZZ 1  
 USFC=1.0 PRECP=0. ISCAT=1 DIR=340. ZZZZZZ 1  
 USFC=1.5 PRECP=0. ISCAT=3 DIR=335. ZZZZZZ 1  
 USFC=1.0 PRECP=0. ISCAT=1 DIR=045. ZZZZZZ 1  
 USFC=1.5 PRECP=0. ISCAT=1 DIR=100. ZZZZZZ 1  
 USFC=2.5 PRECP=0. ISCAT=5 DIR=180. ZZZZZZ 1  
 USFC=3.0 PRECP=0. ISCAT=5 DIR=170. ZZZZZZ 1  
 USFC=4.0 PRECP=0. ISCAT=1 DIR=135. ZZZZZZ 1  
 USFC=2.0 PRECP=0. ISCAT=1 DIR=245. ZZZZZZ 1  
 USFC=2.0 PRECP=0. ISCAT=3 DIR=090. ZZZZZZ 1  
 USFC=1.5 PRECP=0. ISCAT=4 DIR=100. ZZZZZZ 1  
 LISFC=2.0 PRECP=0. ISCAT=5 DIR=140. ZZZZZZ 1  
 USFC=2.5 PRECP=0. ISCAT=5 DIR=170. ZZZZZZ 1  
 USFC=2.0 PRECP=0. ISCAT=4 DIR=180. ZZZZZZ 1  
 USFC=5.0 PRECP=0. ISCAT=5 DIR=100. ZZZZZZ 1  
 USFC=6.0 PRECP=0. ISCAT=6 DIR=095. ZZZZZZ 1  
 USFC=6.0 PRECP=0. ISCAT=5 DIR=100. ZZZZZZ 1

I	J	DIST	ARITHMETIC AVG			XI	TDEP
			CP	SFC			
1	1	1.000E+02	1.925E-05	5.093E-06		6.157E-06	0.
1	2	1.300E+02	1.565E-05	5.636E-06		5.716E-06	0.
1	3	1.700E+02	1.258E-05	6.303E-06		5.110E-06	0.
1	4	2.200E+02	9.922E-06	7.265E-06		4.581E-06	0.
1	5	2.800E+02	8.157E-06	7.993E-06		4.065E-06	0.
1	6	3.600E+02	7.175E-06	7.750E-06		3.341E-06	0.
1	7	4.600E+02	6.450E-06	6.585E-06		2.548E-06	0.
1	8	6.000E+02	5.028E-06	5.042E-06		1.846E-06	0.
1	9	7.700E+02	3.815E-06	3.823E-06		1.324E-07	0.
1	10	1.000E+03	2.726E-06	2.730E-06		8.998E-07	0.
1	11	1.300E+03	1.923E-06	1.925E-06		6.177E-07	0.
1	12	1.700E+03	1.377E-06	1.378E-06		4.214E-07	0.
1	13	2.200E+03	9.735E-07	9.740E-07		2.888E-07	0.
1	14	2.800E+03	6.994E-07	6.997E-07		2.020E-07	0.
1	15	3.600E+03	5.156E-07	5.157E-07		1.452E-07	0.
1	16	4.600E+03	3.753E-07	3.754E-07		1.031E-07	0.
1	17	6.000E+03	2.666E-07	2.666E-07		7.128E-08	0.
1	18	7.700E+03	1.903E-07	1.904E-07		4.970E-08	0.
1	19	1.000E+04	1.373E-07	1.373E-07		3.506E-08	0.
1	20	1.300E+04	9.911E-08	9.912E-08		2.467E-08	0.
1	21	1.700E+04	6.900E-08	6.902E-08		1.695E-08	0.
1	22	2.200E+04	1.932E-08	1.664E-08		5.035E-09	0.
1	23	2.800E+04	8.578E-09	5.397E-09		1.938E-09	0.
1	24	3.600E+04	4.807E-09	3.489E-09		1.242E-09	0.
1	25	4.600E+04	3.045E-09	2.399E-09		8.452E-10	0.
1	26	6.000E+04	2.003E-09	1.619E-09		5.670E-10	0.
1	27	7.700E+04	1.408E-09	1.148E-09		4.000E-10	0.
1	28	1.000E+05	9.921E-10	8.080E-10		2.806E-10	0.
2	1	1.000E+02	1.393E-05	3.727E-06		4.450E-06	0.
2	2	1.300E+02	1.095E-05	4.240E-06		4.287E-06	0.
2	3	1.700E+02	8.490E-06	4.572E-06		3.834E-06	0.
2	4	2.200E+02	6.408E-06	4.966E-06		3.348E-06	0.
2	5	2.800E+02	4.930E-06	5.033E-06		2.856E-06	0.
2	6	3.600E+02	3.952E-06	4.368E-06		2.209E-06	0.
2	7	4.600E+02	3.241E-06	3.450E-06		1.609E-06	0.
2	8	6.000E+02	2.518E-06	2.552E-06		1.136E-06	0.
2	9	7.700E+02	1.874E-06	1.876E-06		7.946E-07	0.
2	10	1.000E+03	1.336E-06	1.337E-06		5.400E-07	0.
2	11	1.300E+03	9.578E-07	9.583E-07		3.758E-07	0.
2	12	1.700E+03	6.570E-07	6.572E-07		2.492E-07	0.
2	13	2.200E+03	4.639E-07	4.640E-07		1.703E-07	0.
2	14	2.800E+03	3.320E-07	3.320E-07		1.191E-07	0.
2	15	3.600E+03	2.422E-07	2.422E-07		8.518E-08	0.
2	16	4.600E+03	1.751E-07	1.751E-07		6.009E-08	0.
2	17	6.000E+03	1.225E-07	1.225E-07		4.112E-08	0.
2	18	7.700E+03	8.656E-08	8.657E-08		2.842E-08	0.
2	19	1.000E+04	6.243E-08	6.243E-08		2.001E-08	0.
2	20	1.300E+04	4.422E-08	4.422E-08		1.388E-08	0.
2	21	1.700E+04	3.236E-08	3.236E-08		9.910E-09	0.
2	22	2.200E+04	2.337E-08	2.337E-08		7.025E-09	0.
2	23	2.800E+04	1.698E-08	1.698E-08		5.020E-09	0.
2	24	3.600E+04	1.132E-08	1.132E-08		3.341E-09	0.
2	25	4.600E+04	6.371E-09	6.476E-09		1.943E-09	0.
2	26	6.000E+04	3.112E-09	3.298E-09		1.016E-09	0.
2	27	7.700E+04	1.623E-09	1.771E-09		5.662E-10	0.
2	28	1.000E+05	8.756E-10	8.892E-10		3.045E-10	0.
3	1	1.000E+02	2.368E-05	3.702E-06		4.346E-06	0.
3	2	1.300E+02	1.942E-05	4.318E-06		4.289E-06	0.

WILL BE EXCEEDED 10.0 PERCENT OF TIME

	DIST	CP	SFC	XI
1	1	1.000E+02	0.	0.
1	2	1.300E+02	0.	0.
1	3	1.700E+02	0.	0.
1	4	2.200E+02	0.	0.
1	5	2.800E+02	0.	0.
1	6	3.600E+02	0.	0.
1	7	4.600E+02	0.	0.
1	8	6.000E+02	0.	0.
1	9	7.700E+02	0.	0.
1	10	1.000E+03	0.	0.
1	11	1.300E+03	0.	0.
1	12	1.700E+03	0.	0.
1	13	2.200E+03	0.	0.
1	14	2.800E+03	0.	0.
1	15	3.600E+03	0.	0.
1	16	4.600E+03	0.	0.
1	17	6.000E+03	0.	0.
1	18	7.700E+03	0.	0.
1	19	1.000E+04	0.	0.
1	20	1.300E+04	0.	0.
1	21	1.700E+04	0.	0.
1	22	2.200E+04	0.	0.
1	23	2.800E+04	0.	0.
1	24	3.600E+04	0.	0.
1	25	4.600E+04	0.	0.
1	26	6.000E+04	0.	0.
1	27	7.700E+04	0.	0.
1	28	1.000E+05	0.	0.
2	1	1.300E+02	0.	0.
2	2	1.700E+02	0.	0.
2	3	2.200E+02	0.	0.
2	4	2.800E+02	0.	0.
2	5	3.600E+02	0.	0.
2	6	4.600E+02	0.	0.
2	7	6.000E+02	0.	0.
2	8	7.700E+02	0.	0.
2	9	1.000E+03	0.	0.
2	10	1.300E+03	0.	0.
2	11	1.700E+03	0.	0.
2	12	2.200E+03	0.	0.
2	13	2.800E+03	0.	0.
2	14	3.600E+03	0.	0.
2	15	4.600E+03	0.	0.
2	16	6.000E+03	0.	0.
2	17	7.700E+03	0.	0.
2	18	1.000E+04	0.	0.
2	19	1.300E+04	0.	0.
2	20	1.700E+04	0.	0.
2	21	2.200E+04	0.	0.
2	22	2.800E+04	0.	0.
2	23	3.600E+04	0.	0.
2	24	4.600E+04	0.	0.
2	25	6.000E+04	0.	0.
2	26	7.700E+04	0.	0.
2	27	1.000E+05	0.	0.
2	28	1.300E+02	0.	0.
3	1	1.300E+02	0.	0.

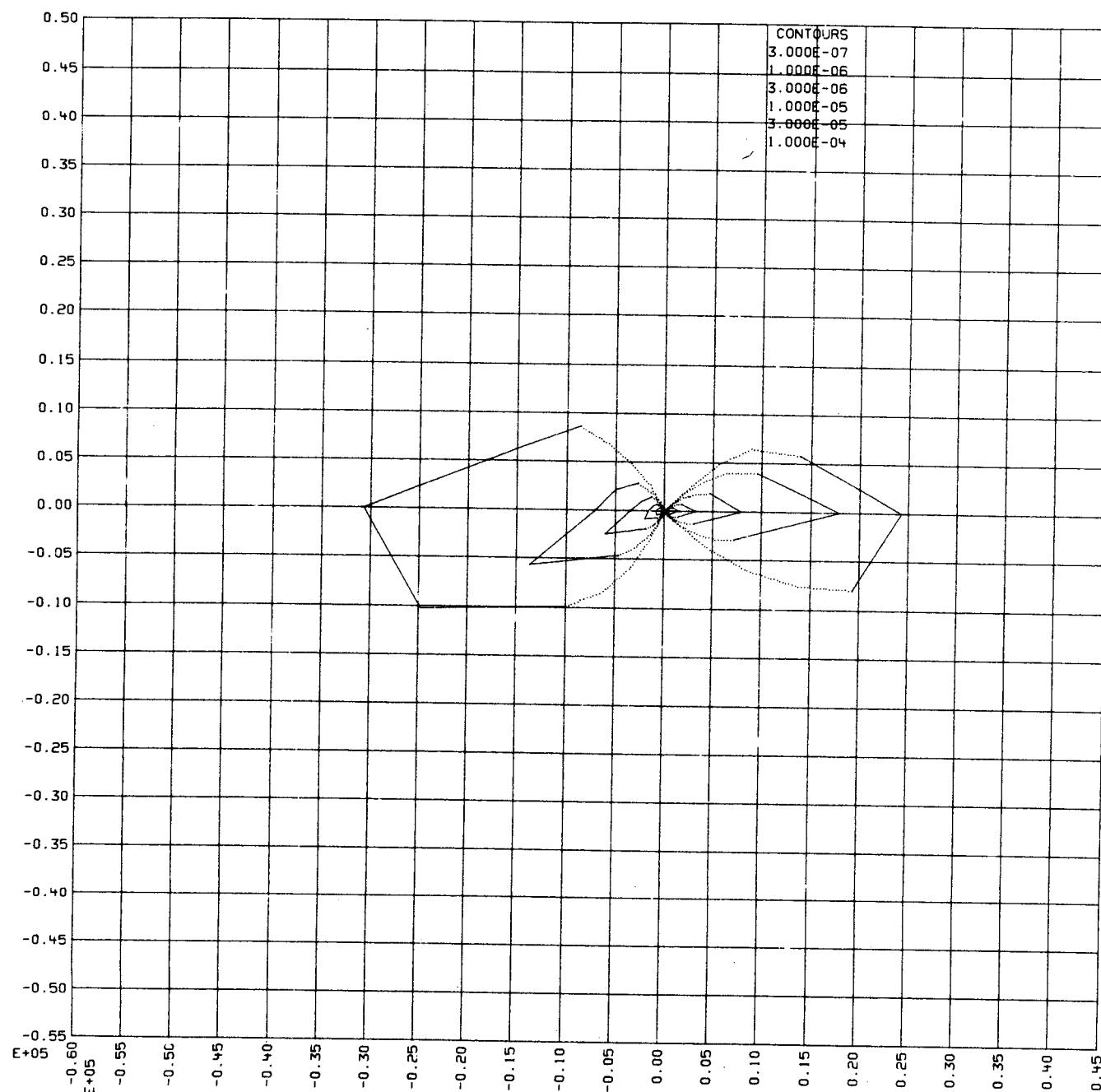


WILL BE EXCEEDED 1.0 PERCENT OF TIME

I	J	DIST	CP	SFC	XI
1	1	1.000E+02	6.097E-04	6.686E-04	6.063E-04
1	2	1.300E+02	4.925E-04	4.194E-04	3.686E-04
1	3	1.700E+02	3.937E-04	2.809E-04	2.344E-04
1	4	2.200E+02	3.092E-04	2.358E-04	1.609E-04
1	5	2.800E+02	2.542E-04	2.564E-04	1.295E-04
1	6	3.600E+02	2.178E-04	2.330E-04	1.067E-04
1	7	4.600E+02	1.818E-04	1.844E-04	8.067E-05
1	8	6.000E+02	1.353E-04	1.356E-04	5.765E-05
1	9	7.700E+02	9.868E-05	9.880E-05	4.083E-05
1	10	1.000E+03	6.780E-05	6.785E-05	2.728E-05
1	11	1.300E+03	4.724E-05	4.726E-05	1.856E-05
1	12	1.700E+03	3.176E-05	3.172E-05	1.217E-05
1	13	2.200E+03	2.177E-05	2.177E-05	8.156E-06
1	14	2.800E+03	1.529E-05	1.529E-05	5.635E-06
1	15	3.600E+03	1.117E-05	1.117E-05	4.034E-06
1	16	4.600E+03	8.033E-06	8.034E-06	2.845E-06
1	17	6.000E+03	5.641E-06	5.642E-06	1.957E-06
1	18	7.700E+03	3.987E-06	3.988E-06	1.358E-06
1	19	1.000E+04	2.863E-06	2.863E-06	9.559E-07
1	20	1.300E+04	2.039E-06	2.039E-06	6.686E-07
1	21	1.700E+04	1.442E-06	1.442E-06	4.641E-07
1	22	2.200E+04	5.120E-07	4.886E-07	1.597E-07
1	23	2.800E+04	2.396E-07	1.681E-07	6.237E-08
1	24	3.600E+04	1.386E-07	1.091E-07	4.011E-08
1	25	4.600E+04	8.929E-08	7.532E-08	2.729E-08
1	26	6.000E+04	5.936E-08	5.099E-08	1.831E-08
1	27	7.700E+04	4.204E-08	3.624E-08	1.293E-08
1	28	1.000E+05	2.978E-08	2.553E-08	9.092E-09
2	1	1.000E+02	5.237E-04	6.076E-05	5.314E-05
2	2	1.300E+02	4.087E-04	1.327E-04	1.127E-04
2	3	1.700E+02	3.148E-04	1.688E-04	1.352E-04
2	4	2.200E+02	2.354E-04	1.863E-04	1.276E-04
2	5	2.800E+02	1.772E-04	1.817E-04	1.089E-04
2	6	3.600E+02	1.352E-04	1.467E-04	8.331E-05
2	7	4.600E+02	1.014E-04	1.063E-04	5.852E-05
2	8	6.000E+02	7.458E-05	7.531E-05	4.043E-05
2	9	7.700E+02	5.133E-05	5.137E-05	2.694E-05
2	10	1.000E+03	3.325E-05	3.327E-05	1.705E-05
2	11	1.300E+03	2.321E-05	2.322E-05	1.163E-05
2	12	1.700E+03	1.569E-05	1.570E-05	7.678E-06
2	13	2.200E+03	1.085E-05	1.085E-05	5.192E-06
2	14	2.800E+03	7.685E-06	7.686E-06	3.611E-06
2	15	3.600E+03	5.690E-06	5.691E-06	2.619E-06
2	16	4.600E+03	4.120E-06	4.120E-06	1.857E-06
2	17	6.000E+03	2.928E-06	2.928E-06	1.291E-06
2	18	7.700E+03	2.082E-06	2.082E-06	8.997E-07
2	19	1.000E+04	1.502E-06	1.502E-06	6.356E-07
2	20	1.300E+04	1.069E-06	1.069E-06	4.432E-07
2	21	1.700E+04	7.782E-07	7.782E-07	3.160E-07
2	22	2.200E+04	5.654E-07	5.654E-07	2.252E-07
2	23	2.800E+04	4.157E-07	4.157E-07	1.627E-07
2	24	3.600E+04	2.922E-07	2.922E-07	1.121E-07
2	25	4.600E+04	1.796E-07	1.815E-07	6.847E-08
2	26	6.000E+04	9.663E-08	1.004E-07	3.733E-08
2	27	7.700E+04	5.450E-08	5.812E-08	2.137E-08
2	28	1.000E+05	3.098E-08	3.163E-08	1.167E-08
3	1	1.000E+02	6.679E-04	1.436E-03	1.116E-03
3	2	1.300E+02	5.547E-04	6.880E-04	5.199E-04

		GEOMETRIC MEAN			
		DIST	CP	SFC	X1
1	1	1.000E+02	3.981E-04	3.027E-06	2.098E-06
1	2	1.300E+02	3.144E-04	3.577E-05	2.425E-05
1	3	1.700E+02	2.448E-04	9.901E-05	6.565E-05
1	4	2.200E+02	1.834E-04	1.448E-04	9.399E-05
1	5	2.800E+02	1.386E-04	1.420E-04	9.035E-05
1	6	3.600E+02	1.046E-04	1.094E-04	6.819E-05
1	7	4.600E+02	7.331E-05	7.394E-05	4.514E-05
1	8	6.000E+02	5.134E-05	5.140E-05	3.070E-05
1	9	7.700E+02	3.307E-05	3.310E-05	1.936E-05
1	10	1.000E+03	1.952E-05	1.953E-05	1.118E-05
1	11	1.300E+03	1.323E-05	1.323E-05	7.412E-06
1	12	1.700E+03	9.055E-06	9.058E-06	4.961E-06
1	13	2.200E+03	6.279E-06	6.280E-06	3.367E-06
1	14	2.800E+03	4.405E-06	4.405E-06	2.315E-06
1	15	3.600E+03	3.296E-06	3.297E-06	1.697E-06
1	16	4.600E+03	2.434E-06	2.434E-06	1.228E-06
1	17	6.000E+03	1.765E-06	1.765E-06	8.707E-07
1	18	7.700E+03	1.283E-06	1.283E-06	6.201E-07
1	19	1.000E+04	9.406E-07	9.407E-07	4.448E-07
1	20	1.300E+04	6.826E-07	6.827E-07	3.158E-07
1	21	1.700E+04	4.918E-07	4.919E-07	2.226E-07
1	22	2.200E+04	2.230E-07	2.211E-07	9.790E-08
1	23	2.800E+04	1.169E-07	9.527E-08	4.136E-08
1	24	3.600E+04	7.218E-08	6.324E-08	2.689E-08
1	25	4.600E+04	4.849E-08	4.451E-08	1.854E-08
1	26	6.000E+04	3.321E-08	3.089E-08	1.259E-08
1	27	7.700E+04	2.400E-08	2.240E-08	8.342E-09
1	28	1.000E+05	1.732E-08	1.612E-08	6.295E-09
2	1	1.000E+02	4.211E-04	1.589E-05	1.180E-05
2	2	1.300E+02	3.254E-04	7.338E-05	5.332E-05
2	3	1.700E+02	2.477E-04	1.281E-04	9.100E-05
2	4	2.200E+02	1.810E-04	1.504E-04	1.046E-04
2	5	2.800E+02	1.308E-04	1.344E-04	9.163E-05
2	6	3.600E+02	9.392E-05	1.003E-04	6.695E-05
2	7	4.600E+02	6.412E-05	6.648E-05	4.350E-05
2	8	6.000E+02	4.522E-05	4.556E-05	2.916E-05
2	9	7.700E+02	2.893E-05	2.894E-05	1.814E-05
2	10	1.000E+03	1.717E-05	1.717E-05	1.053E-05
2	11	1.300E+03	1.179E-05	1.179E-05	7.076E-06
2	12	1.700E+03	8.111E-06	8.112E-06	4.762E-06
2	13	2.200E+03	5.666E-06	5.667E-06	3.256E-06
2	14	2.800E+03	4.026E-06	4.026E-06	2.268E-06
2	15	3.600E+03	3.028E-06	3.028E-06	1.670E-06
2	16	4.600E+03	2.229E-06	2.229E-06	1.205E-06
2	17	6.000E+03	1.617E-06	1.617E-06	8.547E-07
2	18	7.700E+03	1.171E-06	1.171E-06	6.064E-07
2	19	1.000E+04	8.557E-07	8.557E-07	4.336E-07
2	20	1.300E+04	6.171E-07	6.171E-07	3.060E-07
2	21	1.700E+04	4.522E-07	4.522E-07	2.193E-07
2	22	2.200E+04	3.316E-07	3.316E-07	1.574E-07
2	23	2.800E+04	2.475E-07	2.475E-07	1.151E-07
2	24	3.600E+04	1.789E-07	1.789E-07	8.151E-08
2	25	4.600E+04	1.152E-07	1.161E-07	5.181E-08
2	26	6.000E+04	6.582E-08	6.770E-08	2.956E-08
2	27	7.700E+04	3.924E-08	4.120E-08	1.762E-08
2	28	1.000E+05	2.338E-08	2.394E-08	1.002E-08
3	1	1.000E+02	4.243E-04	1.102E-08	6.033E-09
3	2	1.300E+02	3.413E-04	1.797E-06	9.627E-07

		WILL BE EXCEEDED		0.5 PERCENT OF TIME	
	J	DIST	CP	SFC	X1
1	1	1.000E+02	8.254E-04	3.101E-02	3.405E-02
1	2	1.300E+02	6.776E-04	2.413E-03	2.551E-03
1	3	1.700E+02	5.518E-04	5.895E-04	5.792E-04
1	4	2.200E+02	4.483E-04	3.334E-04	2.357E-04
1	5	2.800E+02	3.912E-04	3.902E-04	1.672E-04
1	6	3.600E+02	3.668E-04	3.986E-04	1.467E-04
1	7	4.600E+02	3.469E-04	3.531E-04	1.219E-04
1	8	6.000E+02	2.694E-04	2.701E-04	9.023E-05
1	9	7.700E+02	2.146E-04	2.150E-04	6.939E-05
1	10	1.000E+03	1.643E-04	1.645E-04	5.145E-05
1	11	1.300E+03	1.167E-04	1.168E-04	3.565E-05
1	12	1.700E+03	7.748E-05	7.751E-05	2.302E-05
1	13	2.200E+03	5.267E-05	5.269E-05	1.530E-05
1	14	2.800E+03	3.704E-05	3.705E-05	1.061E-05
1	15	3.600E+03	2.658E-05	2.658E-05	7.465E-06
1	16	4.600E+03	1.877E-05	1.877E-05	5.170E-06
1	17	6.000E+03	1.289E-05	1.289E-05	3.480E-06
1	18	7.700E+03	8.926E-06	8.927E-06	2.370E-06
1	19	1.000E+04	6.315E-06	6.316E-06	1.647E-06
1	20	1.300E+04	4.438E-06	4.438E-06	1.140E-06
1	21	1.700E+04	3.096E-06	3.097E-06	7.826E-07
1	22	2.200E+04	9.242E-07	9.587E-07	2.262E-07
1	23	2.800E+04	3.988E-07	2.518E-07	8.354E-08
1	24	3.600E+04	2.203E-07	1.608E-07	5.331E-08
1	25	4.600E+04	1.378E-07	1.095E-07	3.593E-08
1	26	6.000E+04	8.970E-08	7.280E-08	2.391E-08
1	27	7.700E+04	6.261E-08	5.102E-08	1.681E-08
1	28	1.000E+05	4.379E-08	3.540E-08	1.181E-08
2	1	1.300E+02	7.337E-04	4.838E-04	5.450E-04
2	2	1.700E+02	5.813E-04	3.317E-04	3.584E-04
2	3	2.200E+02	4.563E-04	2.587E-04	2.496E-04
2	4	2.800E+02	3.533E-04	2.595E-04	1.736E-04
2	5	3.600E+02	2.833E-04	2.898E-04	1.422E-04
2	6	4.600E+02	2.373E-04	2.644E-04	1.168E-04
2	7	6.000E+02	1.617E-04	2.196E-04	9.257E-05
2	8	7.700E+02	1.240E-04	1.639E-04	6.701E-05
2	9	1.000E+03	9.248E-05	1.247E-04	4.965E-05
2	10	1.300E+03	6.619E-05	9.253E-05	3.592E-05
2	11	1.700E+03	4.355E-05	6.622E-05	2.509E-05
2	12	2.200E+03	2.983E-05	4.356E-05	1.607E-05
2	13	2.800E+03	2.089E-05	2.964E-05	1.068E-05
2	14	3.600E+03	1.510E-05	2.089E-05	7.414E-06
2	15	4.600E+03	1.065E-05	1.510E-05	5.252E-06
2	16	6.000E+03	7.337E-06	7.338E-06	2.444E-06
2	17	7.700E+03	5.073E-06	5.073E-06	1.656E-06
2	18	1.000E+04	3.589E-06	3.589E-06	1.148E-06
2	19	1.300E+04	2.502E-06	2.502E-06	7.863E-07
2	20	1.700E+04	1.802E-06	1.802E-06	5.561E-07
2	21	2.200E+04	1.290E-06	1.290E-06	3.920E-07
2	22	2.800E+04	9.270E-07	9.270E-07	2.775E-07
2	23	3.600E+04	6.242E-07	6.243E-07	1.837E-07
2	24	4.600E+04	3.570E-07	3.623E-07	1.054E-07
2	25	6.000E+04	1.750E-07	1.848E-07	5.354E-08
2	26	7.700E+04	9.058E-08	9.895E-08	2.881E-08
2	27	1.000E+05	4.789E-08	4.868E-08	1.477E-08
2	28	1.300E+02	8.348E-04	4.709E-01	4.344E-01
3	1	1.300E+02	7.043E-04	1.282E-02	1.148E-02



HILL BE EXCEEDED 5.0 PERCENT OF THE TIME

Fig. B-3

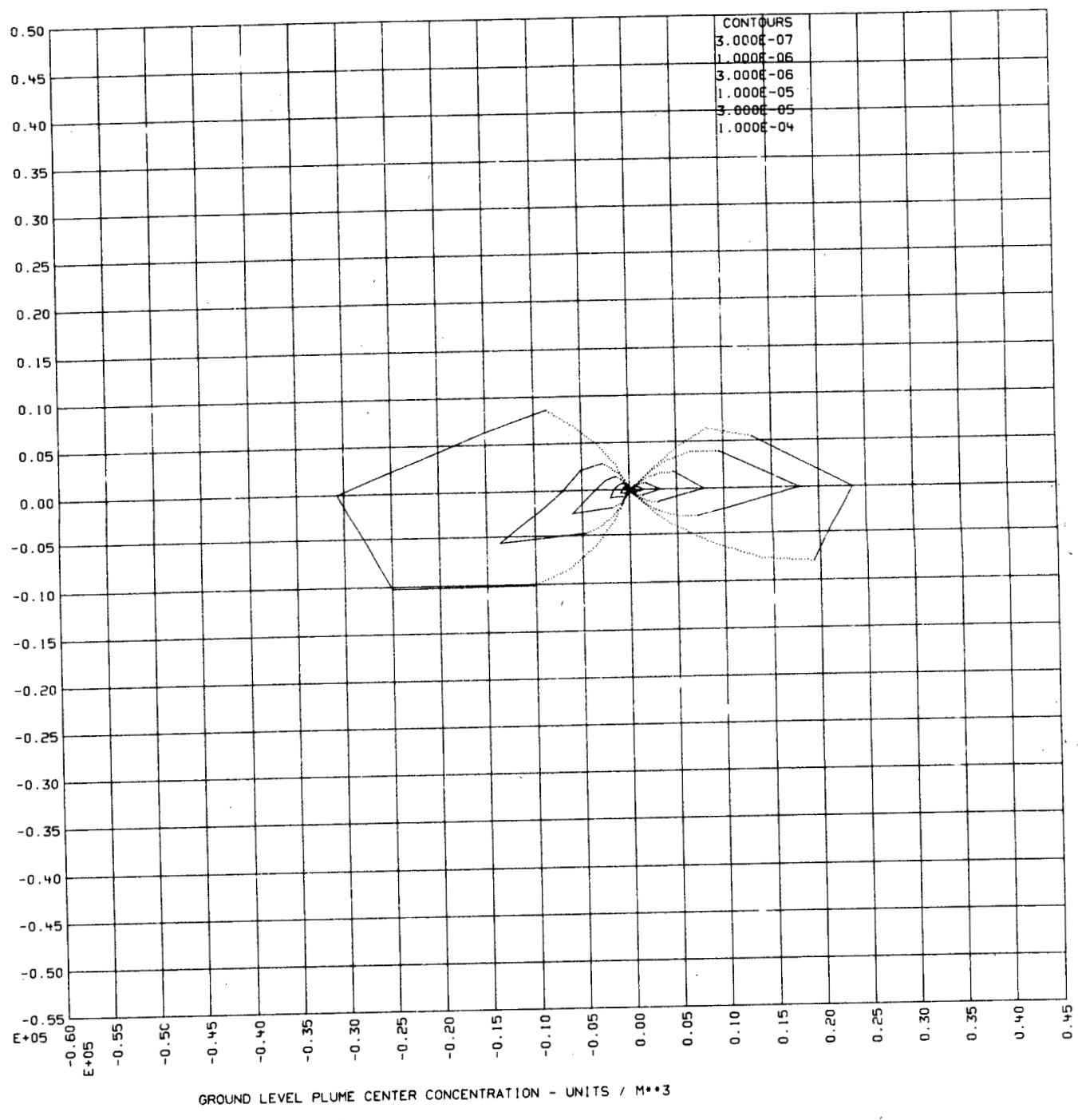


Fig. B-4

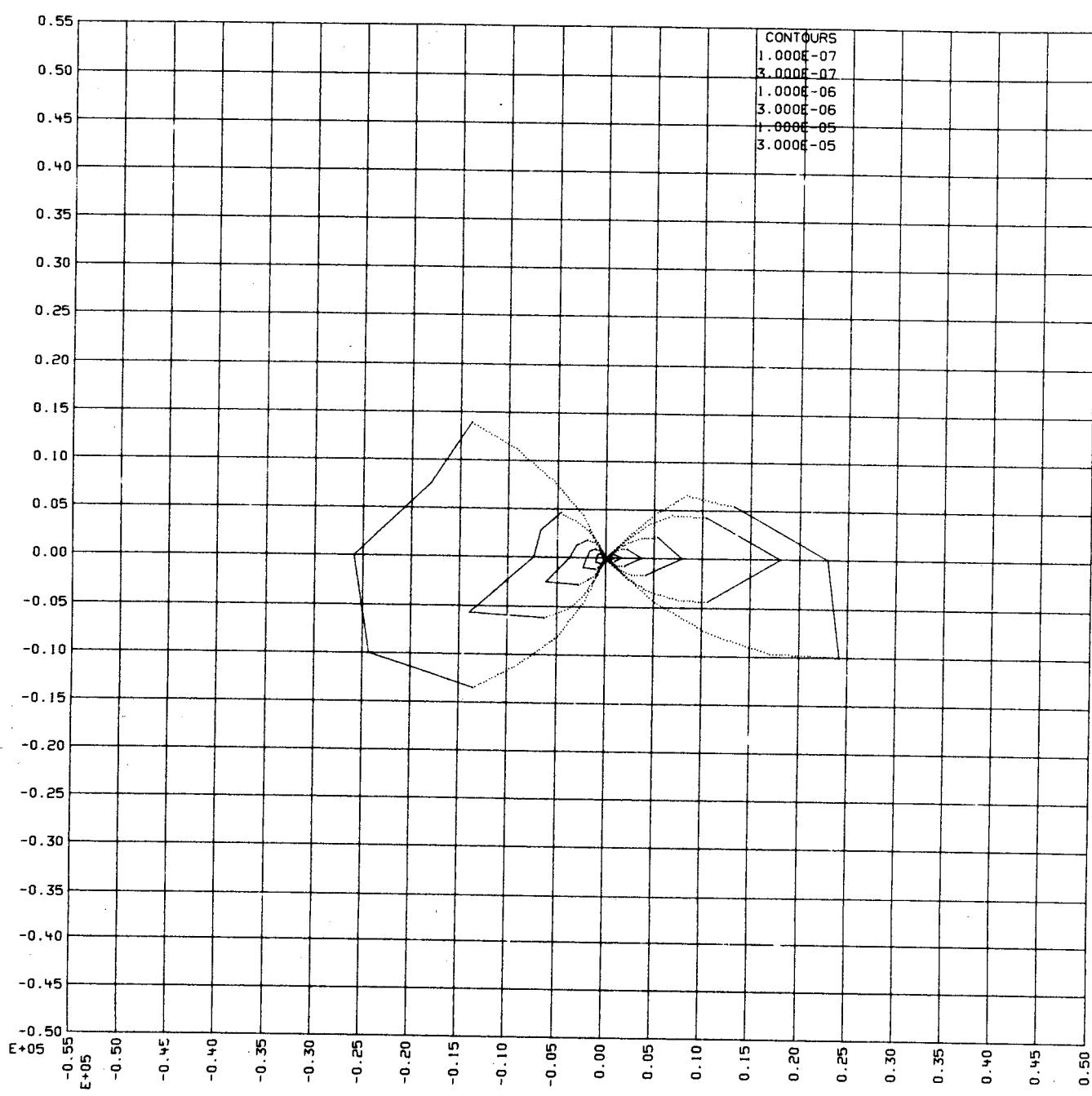


Fig. B-5

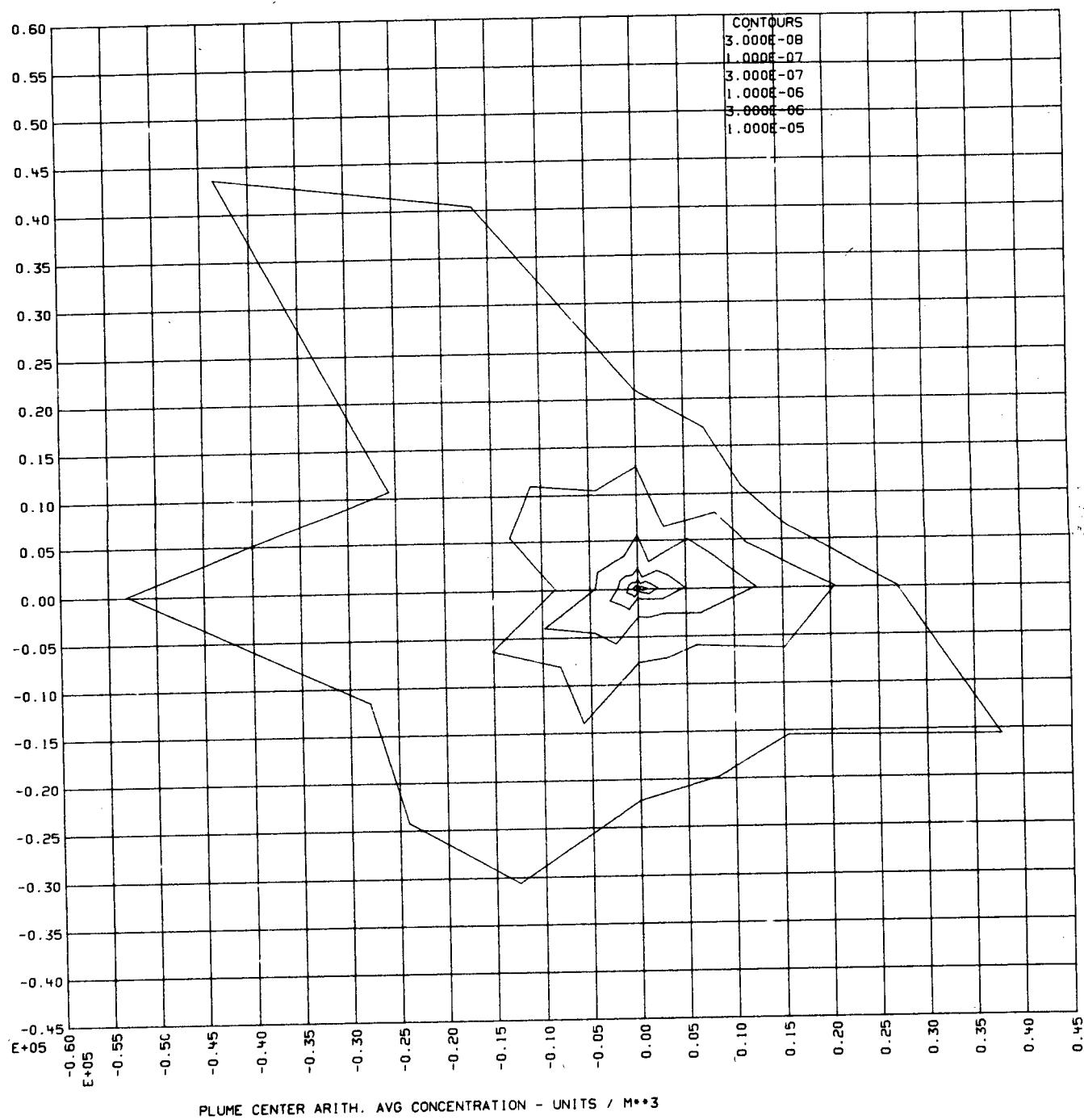


Fig. B-6

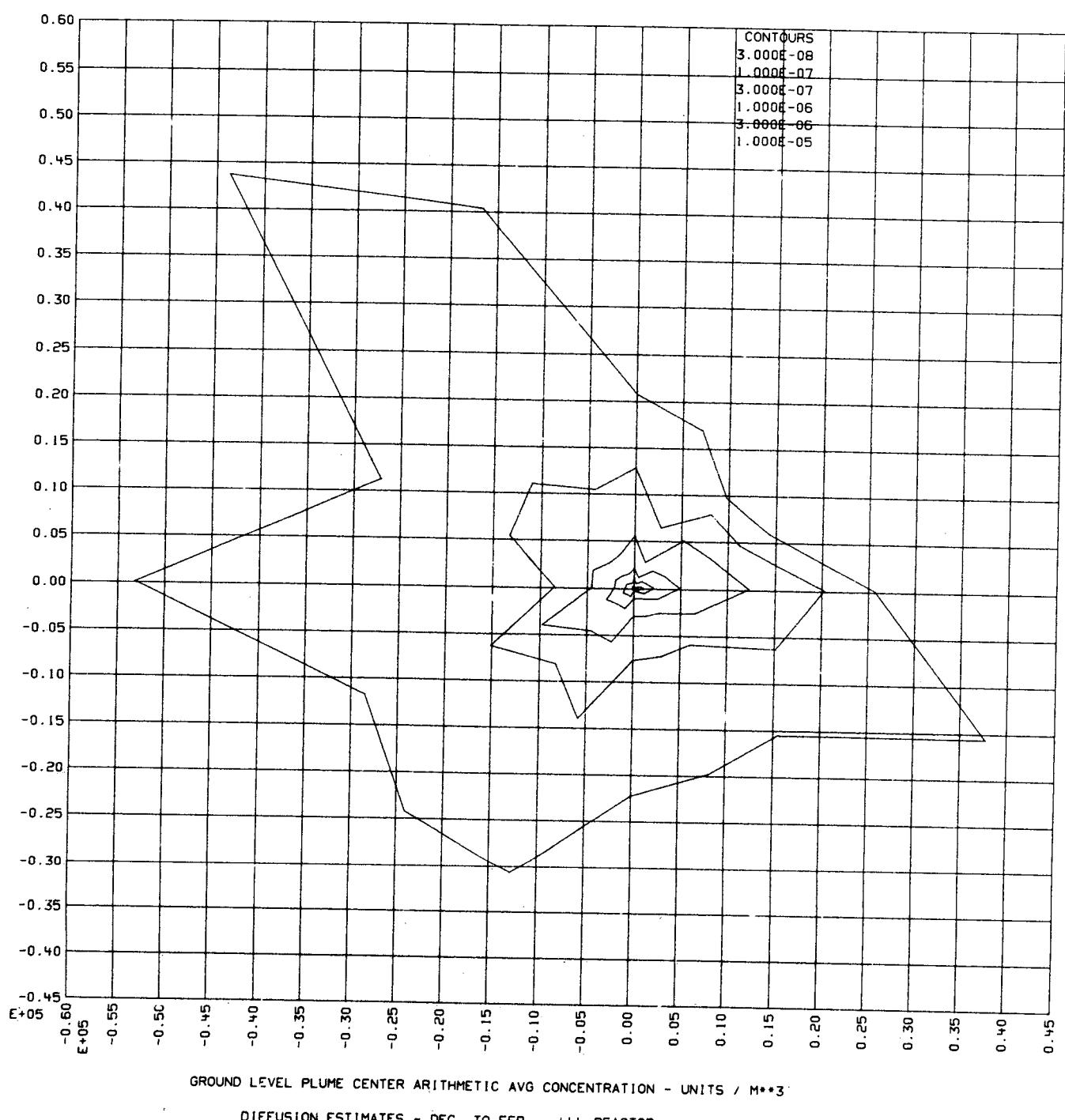


Fig. B-7

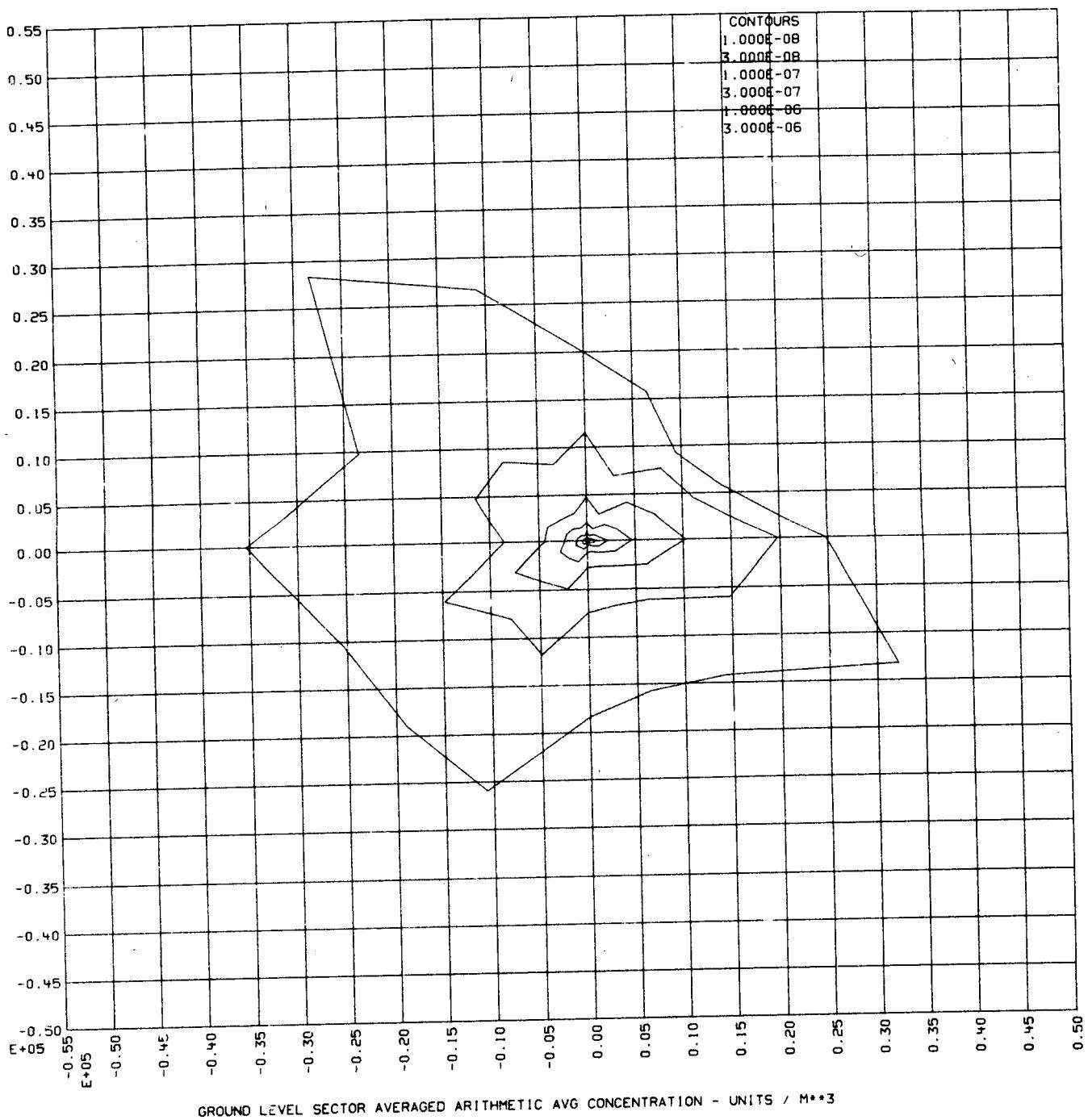


Fig. B-8

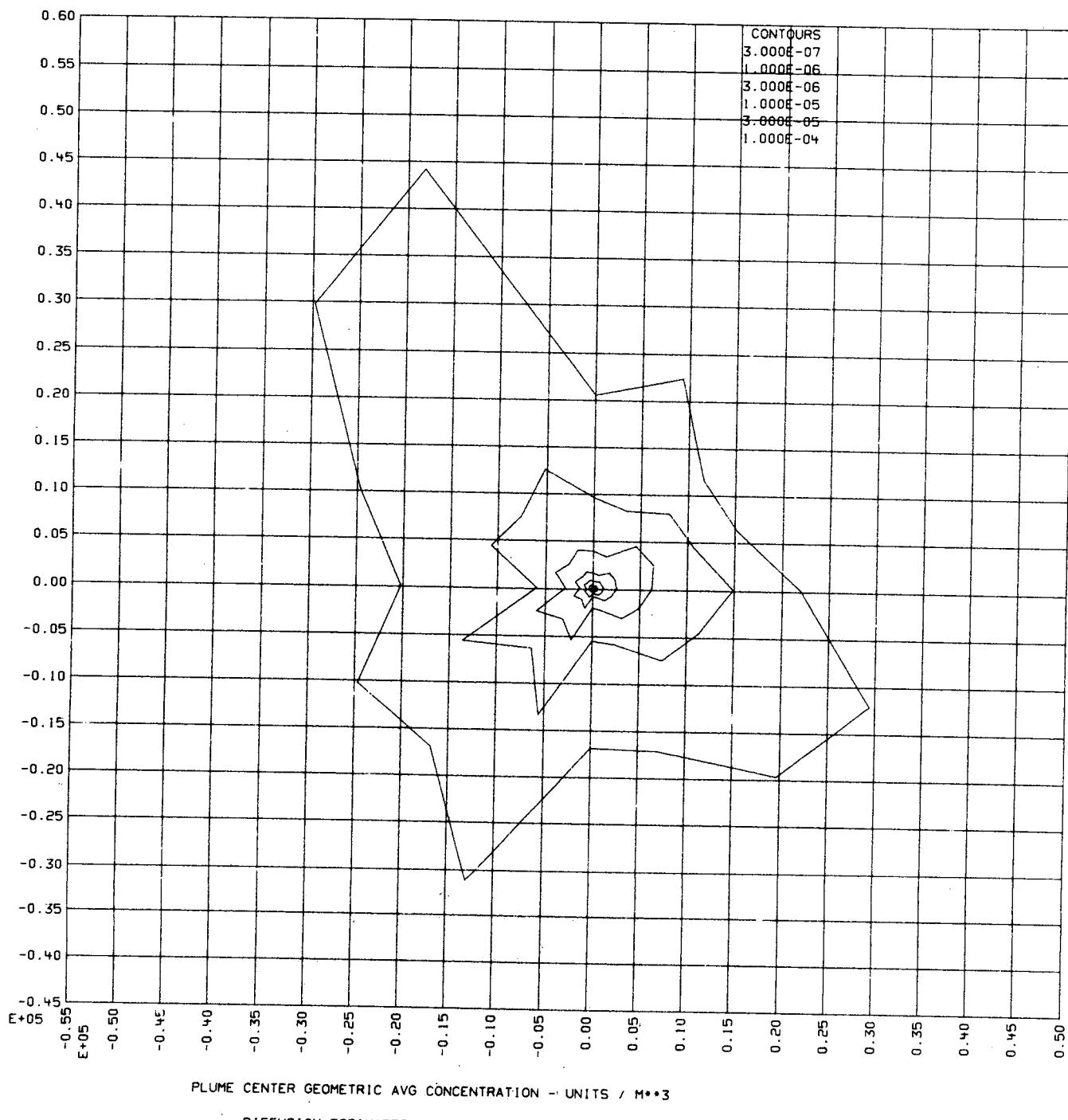


Fig. B-9

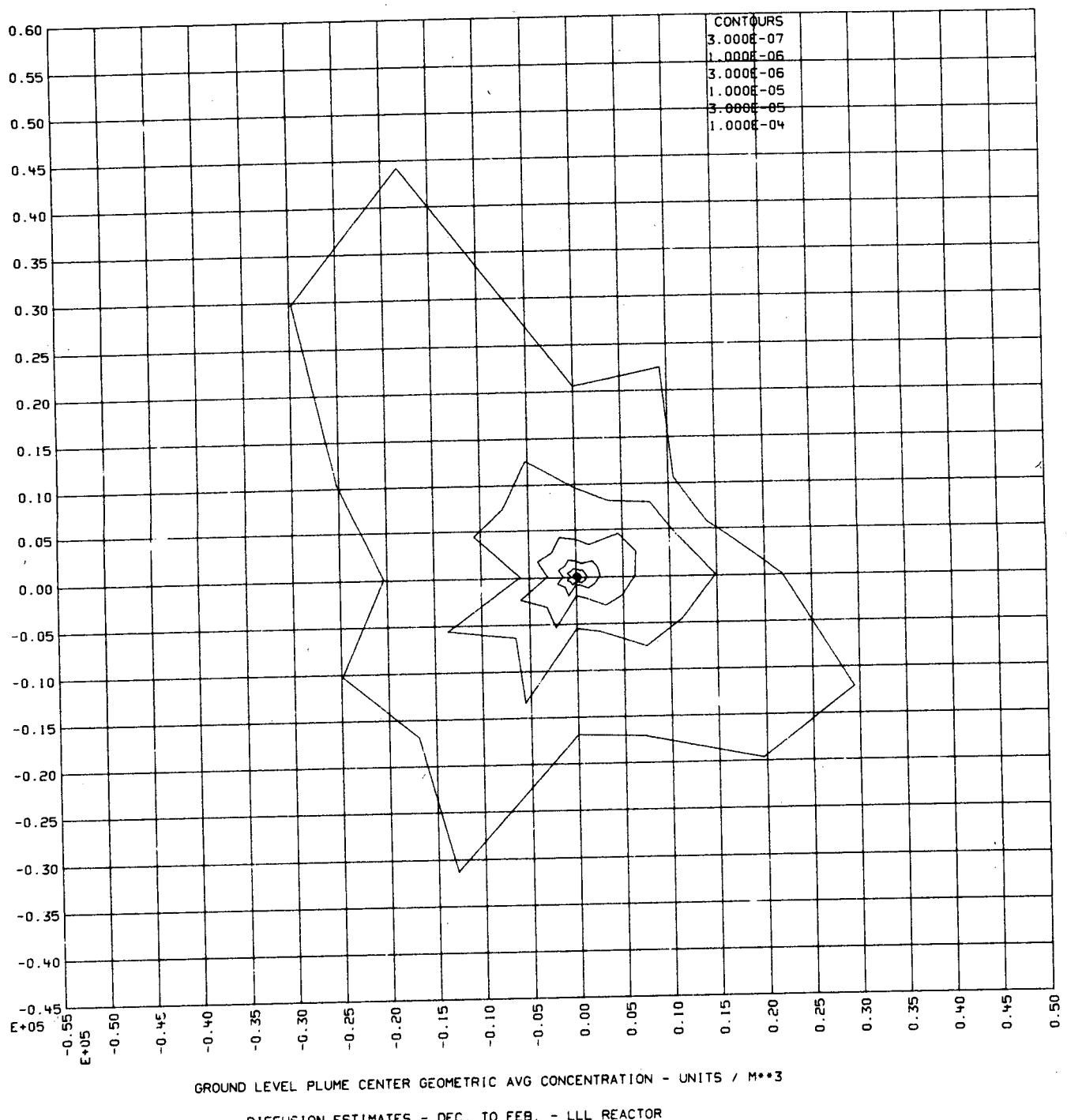


Fig. B-10

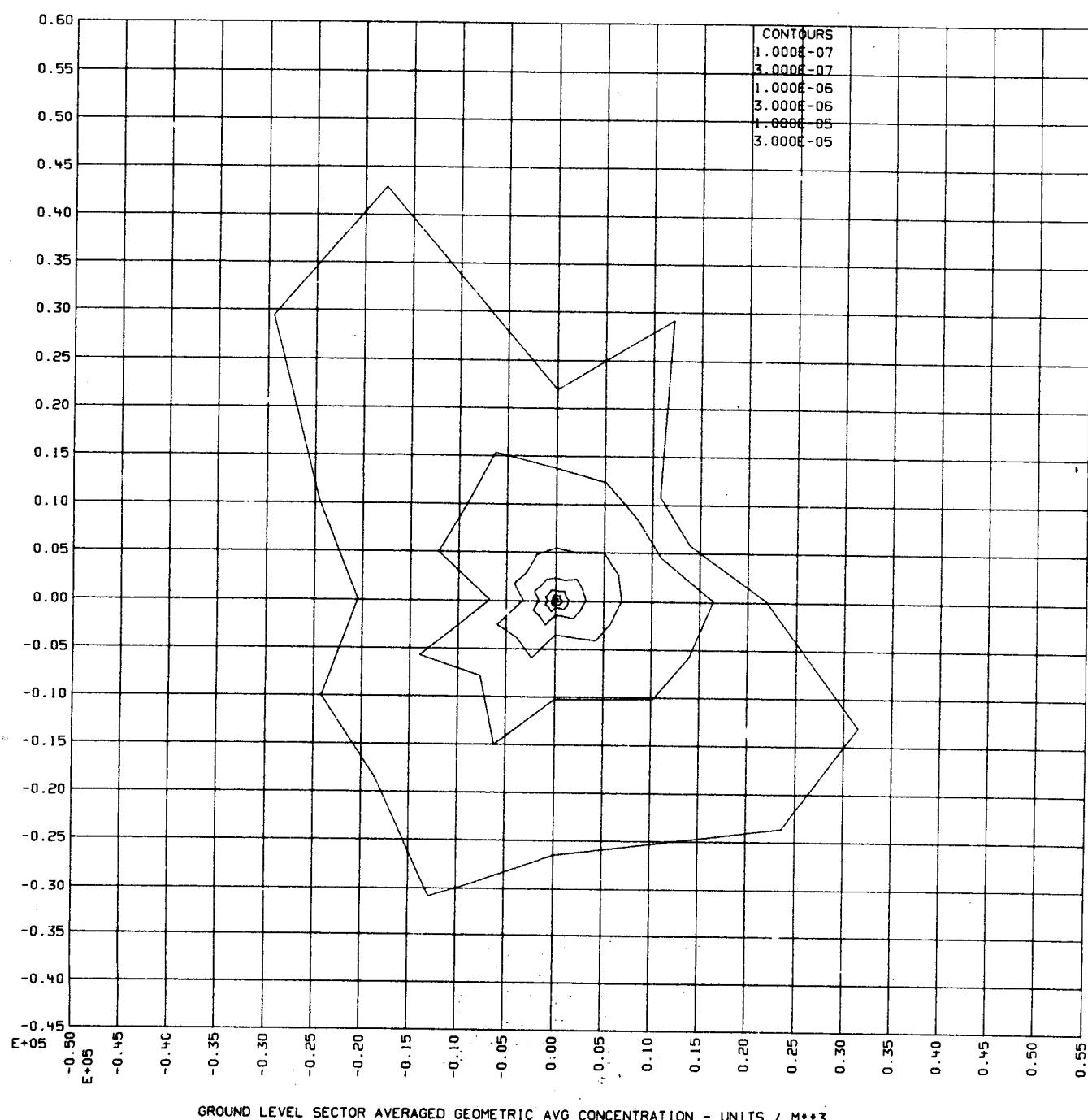


Fig. B-11

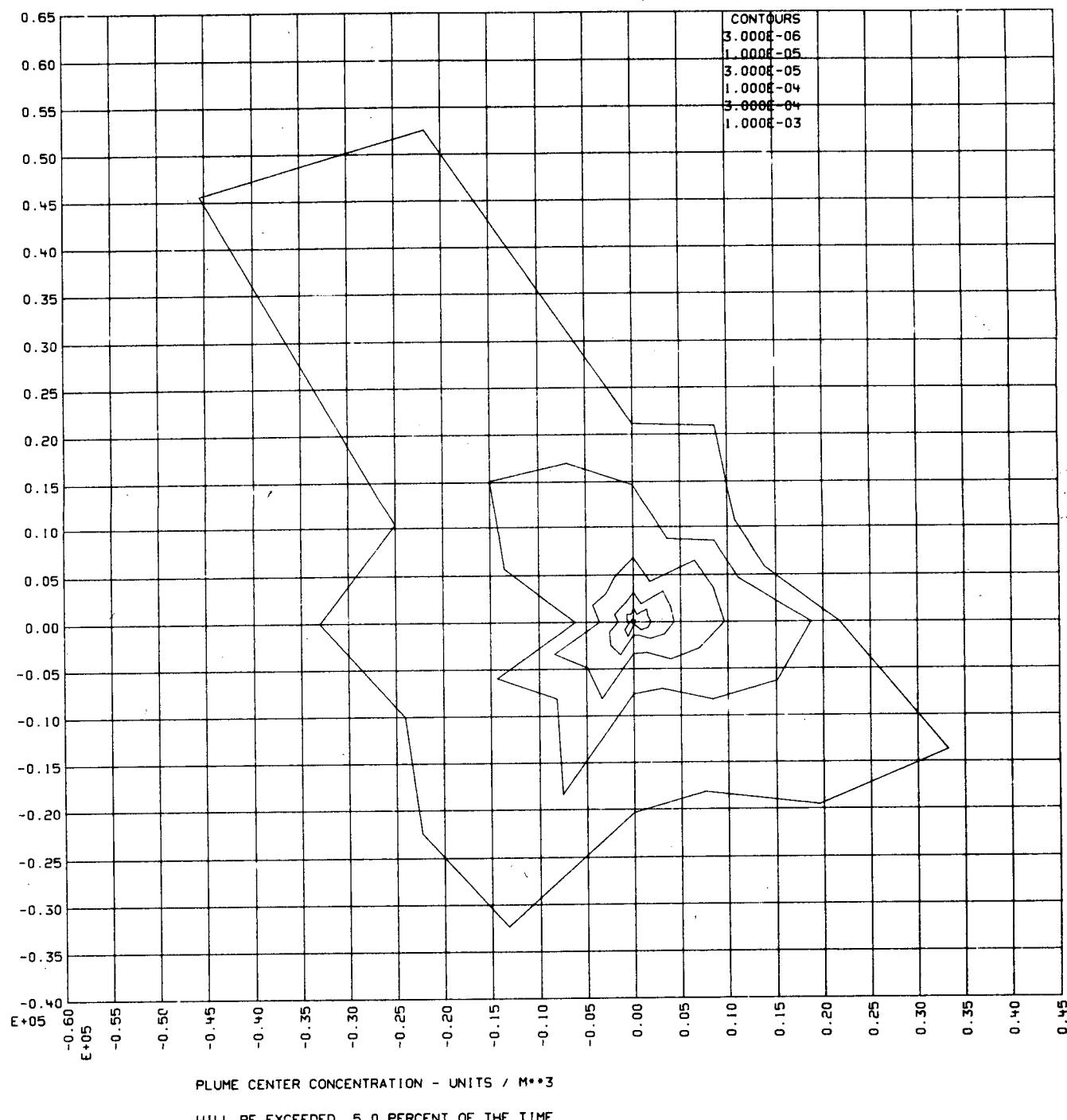


Fig. B-12

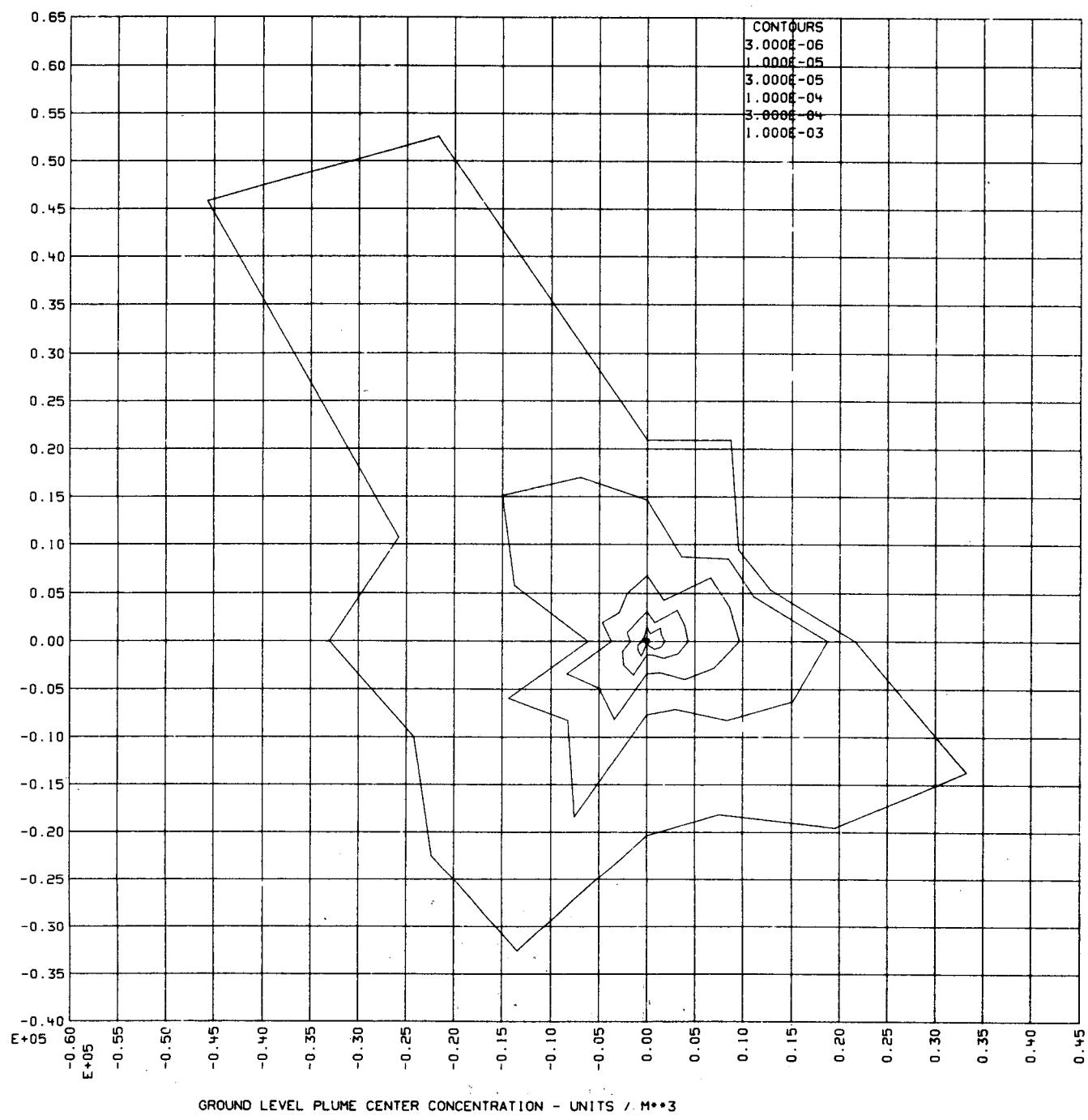


Fig. B-13

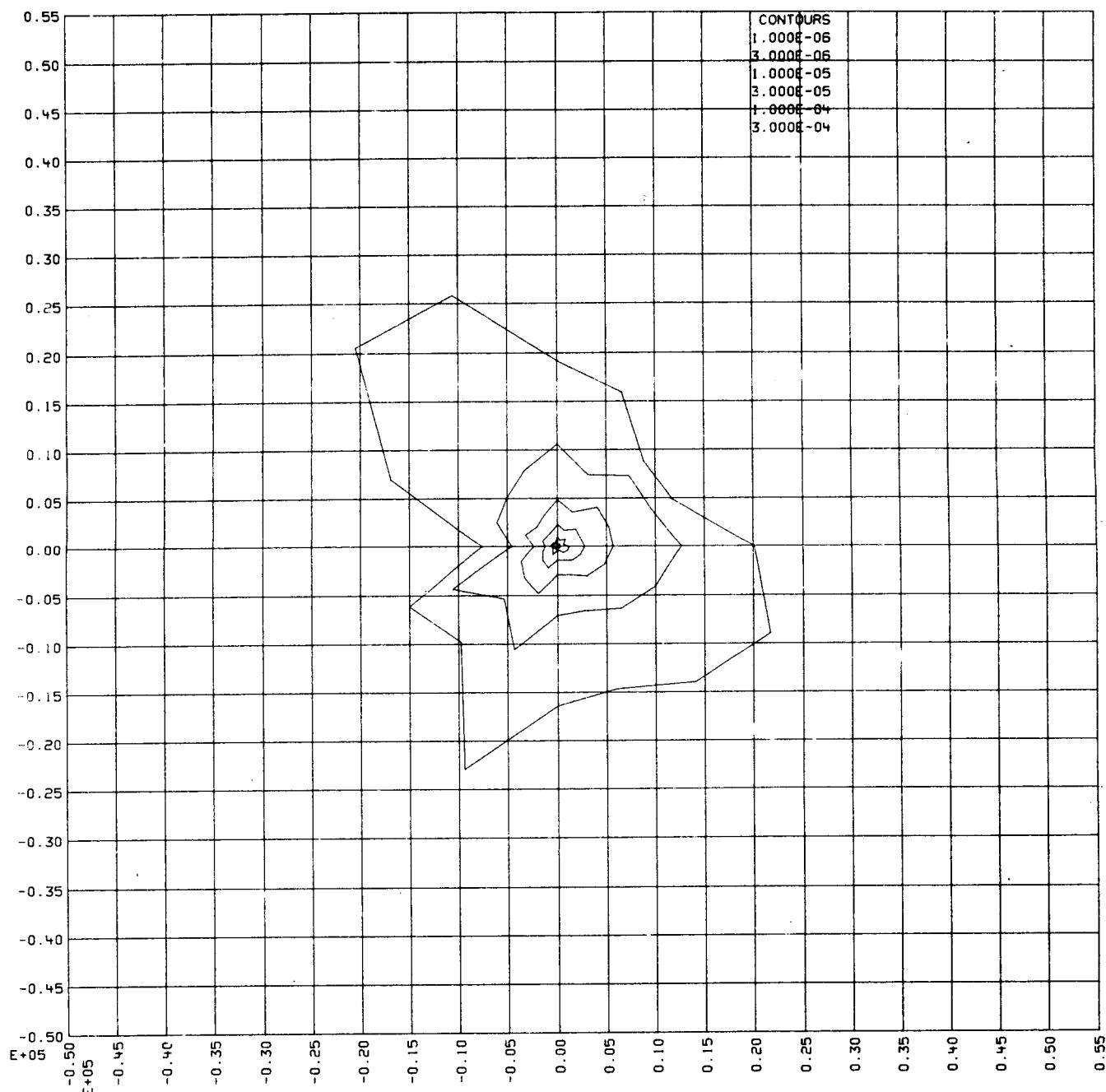


Fig. B-14

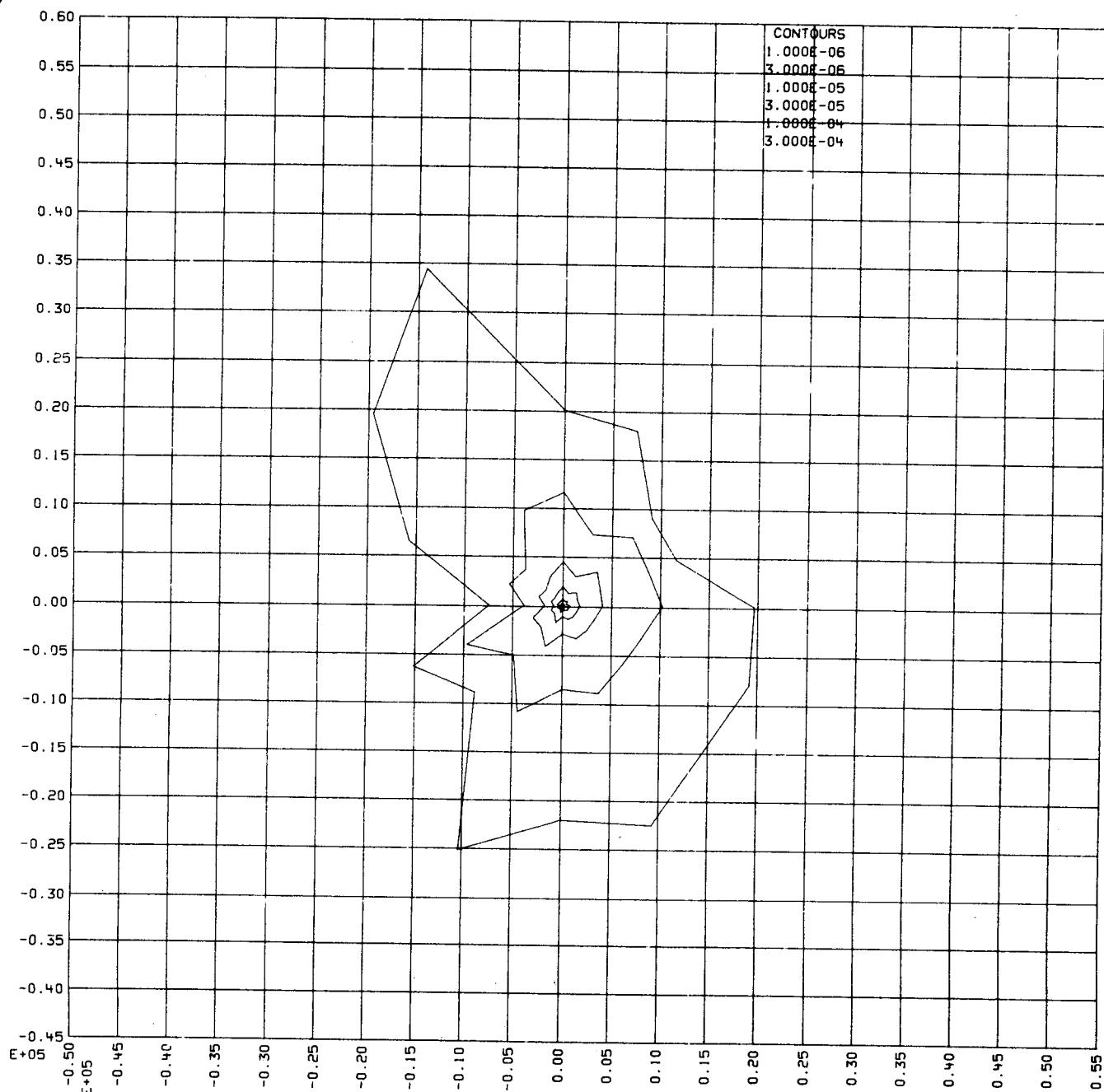


Fig. B-15

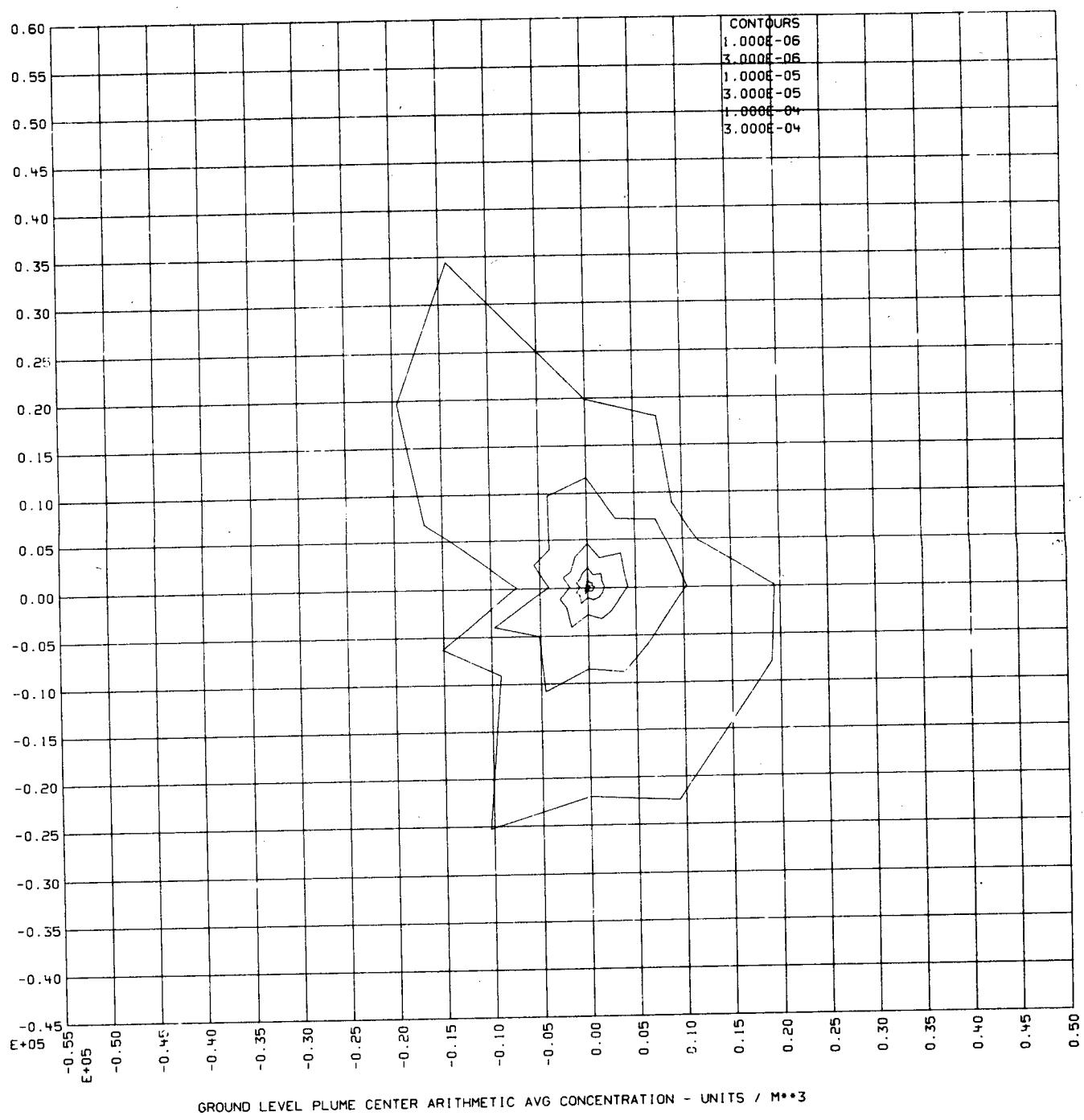


Fig. B-16

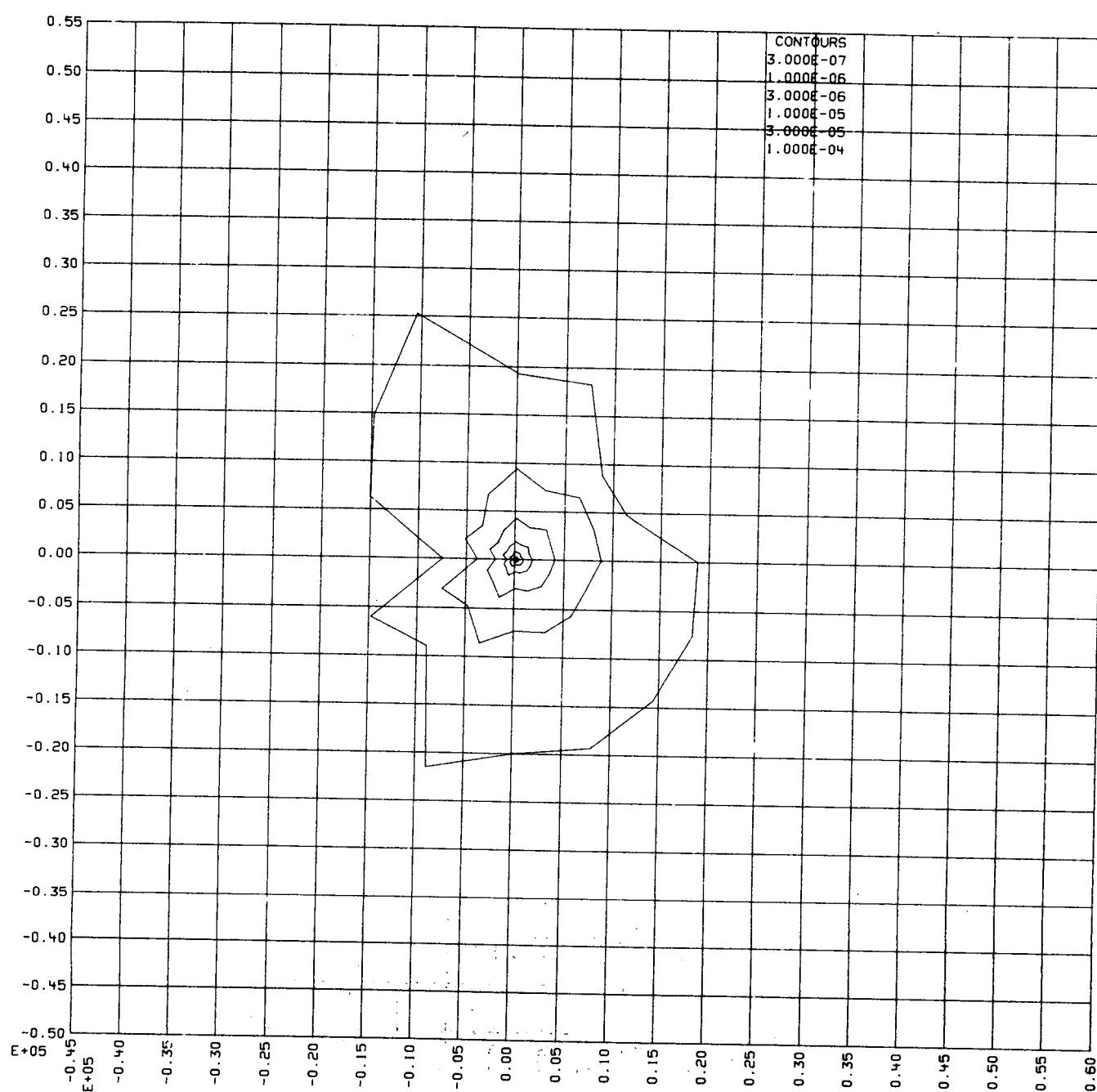


Fig. B-17

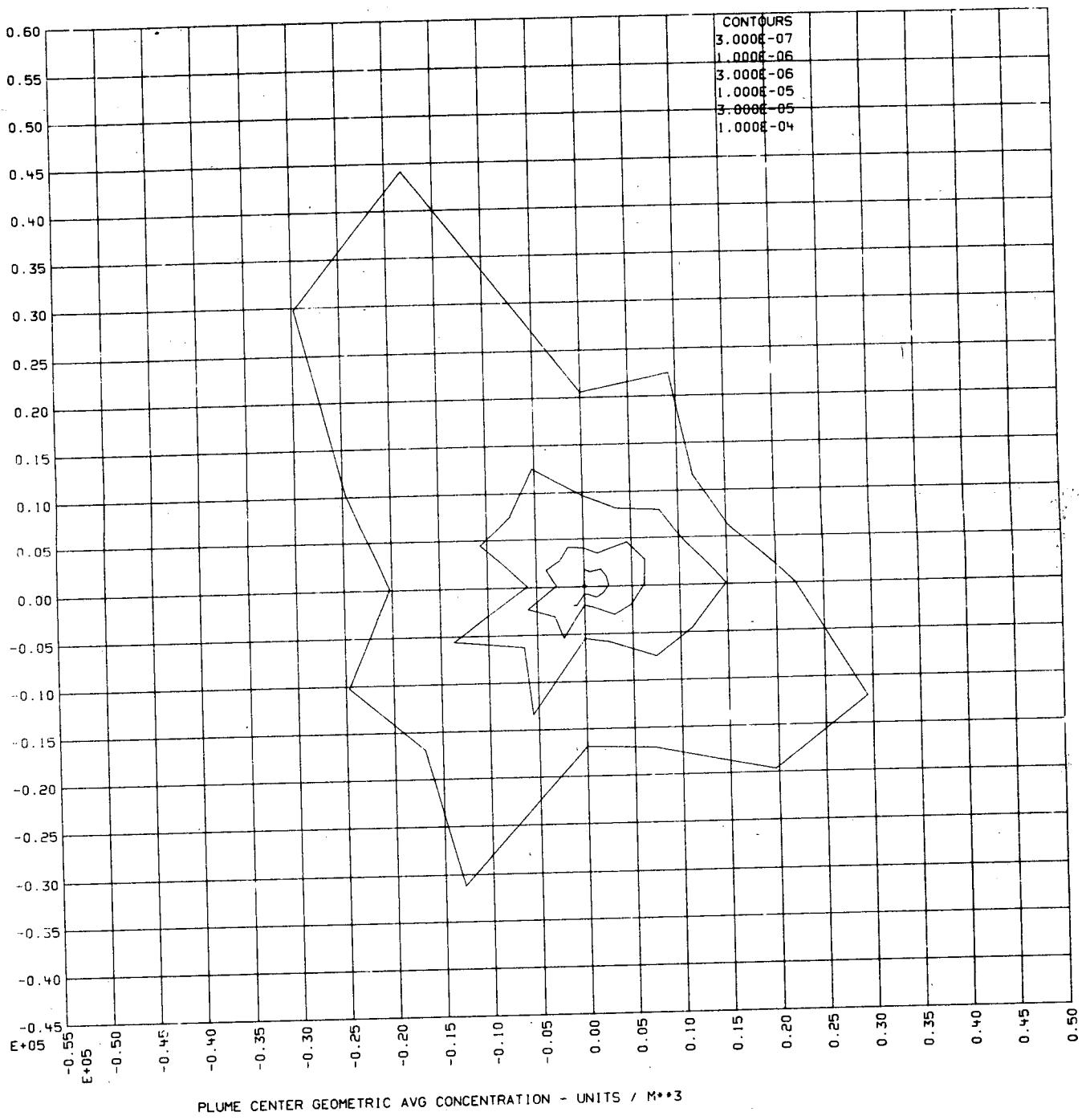


Fig. B-18

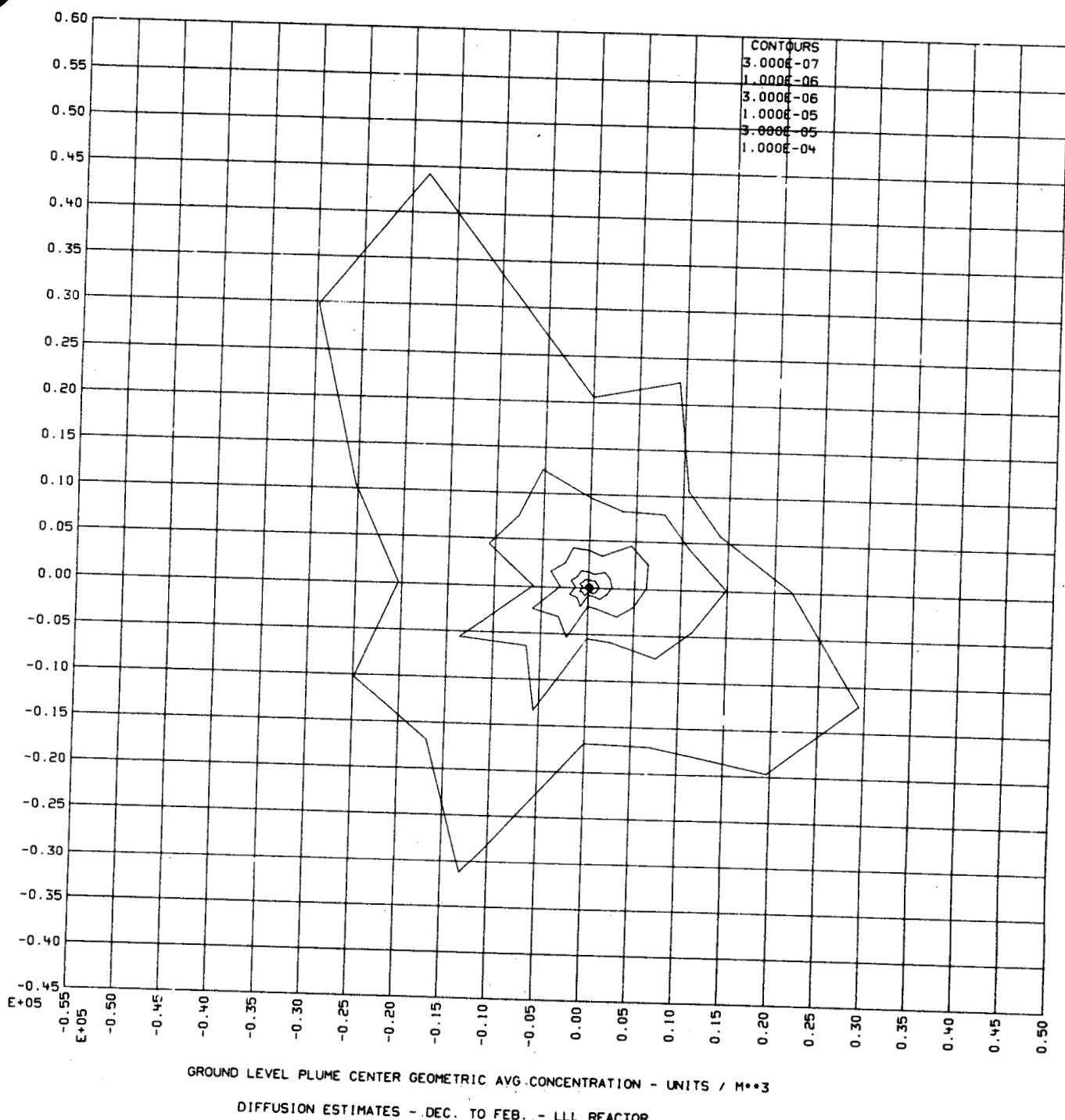


Fig. B-19

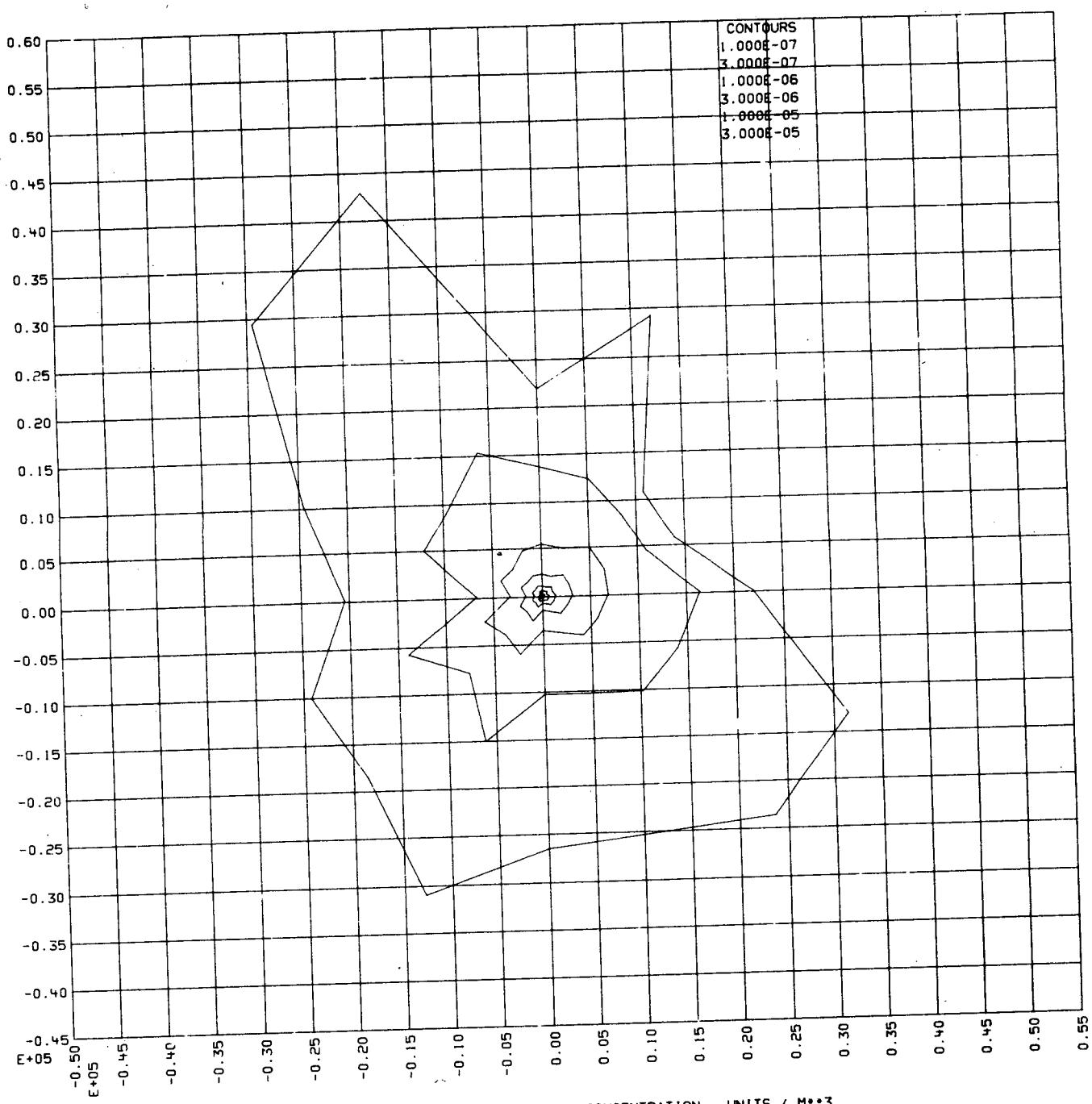


Fig. B-20

WC/nus

-100-