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THE NOISE EXPOSURE MODEL (MOD 4)

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16. Abstract

The purpose of this report is threefold:

1. To record the results of efforts at the Transportation Systems Center to refine and expand the Noise Exposure Model, which have specifically resulted in the MOD 4 version described herein;
2. To serve as a User's Manual for the preparation of input information for the Noise Exposure Model MOD 4; and
3. To document the computer program for the Noise Exposure Model MOD 4, primarily for the guidance of computer programmers.

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PREFACE

Special mention should be made of the contributions of the Service Technology Corporation, Cambridge, Massachusetts, and especially of Mr. Phil Shakir, for his programming efforts in preparing the Noise Exposure Model MOD 4.

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INTRODUCTION

The purpose of this report is threefold:

1. To record the results of efforts by the Transportation Systems Center to refine and expand the Noise Exposure Model, resulting in the MOD 4 version described herein;
2. To serve as a User's Manual for preparation of input information for the Noise Exposure Model MOD 4; and
3. To document the computer program for the Noise Exposure Model MOD 4, primarily for the guidance of computer programmers.

BACKGROUND

The initial version of the Noise Exposure Model (designated the MOD 0 version for identification) was developed by Serendipity, Incorporated* of Arlington, Virginia, under Contract DOT-OS-A9-018 to the Office of Noise Abatement, Office of the Secretary, Department of Transportation. In general, the model was based on the draft *Aerospace Recommended Practice 1114 of the Society of Automotive Engineers*, dated 24 March 1970: "Procedures for Developing Aircraft Noise Exposure Contours Around Airports". In September 1970, a copy of the MOD 0 version, originally programmed for a Burroughs 5500 computer, was delivered to the DOT Transportation Systems Center for refinement and expansion. The MOD 4 version described in this report is the result of TSC's efforts from September 1970 to May 1971.

The Noise Exposure Model MOD 4 is programmed in FORTRAN IV specifically for use with the IBM 7094 computer located at TSC. It includes the following features:

a. Ability to calculate Noise Exposure (NE) using flight statistics for an entire 24-hour day, Noise Exposure Forecast (NEF) using flight statistics for two separate periods during a day (normally taken as 0700 - 2200 and 2200 - 0700), or Weighted Equivalent Continuous Perceived Noise Level (WECPNL) using a three-period day (normally 0700 - 1900, 1900 - 2200, and 2200 - 0700);

b. Presentation of calculated results as a grid array of up to 20 points in the X-direction by 25 points in the Y-direction in the horizontal plane (Z = 0), plus the option for automatic CALCOMP plotting of one, two, or three contours of selected value along with automatic calculation of the areas included within each plotted contour;

c. Ability to handle up to 75 flights (a flight is defined as a combination of a single aircraft class, but any number of aircraft within a class, a specific runway, and a specific flight path);

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* "A Study of the Magnitude of Transportation Noise Generation and Potential Abatement", Volume III - Airport/Aircraft System Noise, Report OST-ONA-71-1, November 1970.

d. Ability to define flight paths as any combinations of straight-line and constant-radius curved segments projected onto a horizontal plane (Z = 0) plus a climb (or descent) angle;
e. Ability to consider up to ten runways, the ends of which can be described by three (X,Y,Z) coordinates;
f. Option to use either metric or English units of length and aircraft weight; and
g. Option to use the values of takeoff ground roll and climb angle assumed in the SAE ARP 1114 procedure, which are included in the programmed model, or to override the programmed values with user-selected values of takeoff ground roll and initial climb angle.

The model also includes diagnostic and control options for the display of intermediate computational steps and diagnostic information, as possible aids to better understanding the program operation. The program listing, included as Appendix C to this report (but bound separately for convenience), also includes comment entries for clearer identification of the functions of the various portions.

The limitations of the Noise Exposure Model MOD 4, noted above, are largely those imposed by the capacity of the IBM 7094 computer. To permit larger and more versatile calculations, development continues at the Transportation Systems Center on the MOD 5 version, adapted to the larger IBM 360/75 computer. This version should double the permissible number of individual flights (to 150), and permit the addition of new aircraft noise characteristics to override the basic SAE ARP 1114 information included in the MOD 4 version. The MOD 6 version at TSC is being developed for the Center's H-832/DDP-516 computer complex for on-line use of the model with interactive graphic input and display of calculated contours. The MOD 5 version was operational on 1 June 1971. It is anticipated that the MOD 6 version will be operational prior to 1 January 1972 and will be accessible from remote terminals over telephone links.

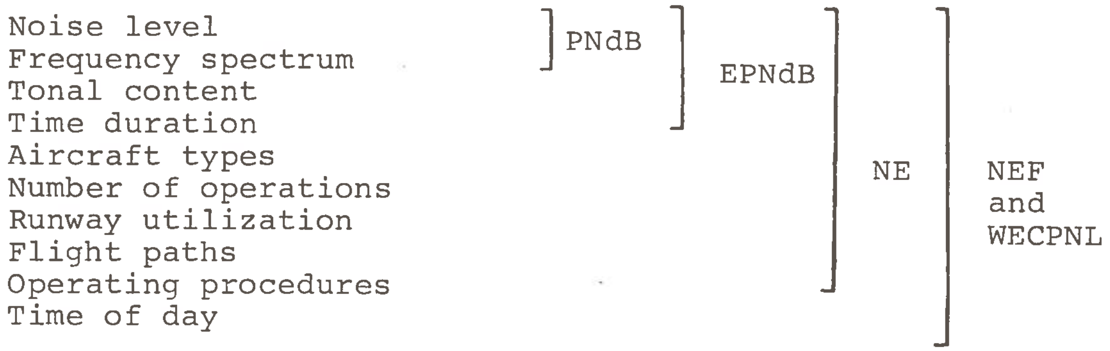
BASIC NOISE EXPOSURE RELATIONS

Noise exposure values are calculated quantities intended to represent the aircraft noise perceived by individuals on the ground near airports. The interpretation and use of these values is a complex subject by itself and is far beyond the scope of this report. A number of somewhat different methods for calculation of noise exposure values have developed, both in the United States and abroad. Three of these measures have been included in the Noise Exposure Model MOD 4 for convenience. These are:

a. Noise Exposure (NE), which calculates the cumulative noise exposure at points on the ground around an airport, assuming equal weighting throughout the period considered (normally an average 24-hour day);
b. Noise Exposure Forecast (NEF), which calculates the cumulative noise exposure in the same manner as the Noise Exposure procedure, but applies a heavier emphasis or weighting for nighttime flights (normally defined as those occurring between 2200 and 0700 during an average day); and
c. Weighted Equivalent Continuous Perceived Noise Level (WECPNL), which again calculates the cumulative noise exposure as the two procedures above, but imposes an intermediate weighting for evening flights (normally defined as those occurring between 1900 and 2200 during an average day). The WECPNL procedure is that recommended by the International Civil Aviation Organization (ICAO) for international use. The NE and NEF procedures were developed within the United States.

In the calculation of noise exposure values, aircraft noise levels are expressed in terms of Effective Perceived Noise Levels (EPNL) in units of EPNdB. This calculated value represents the loudness sensation (called Perceived Noise Level in PNdB) created for an "average" observer, considering the sound intensity and frequency spectrum generated by an aircraft, plus corrections for single frequency (or pure tone) content in the noise spectrum (if any) and the time duration of the aircraft's flyby. In simulating the noise exposure near an airport, it is convenient to group aircraft into classes, based on noise characteristics and takeoff and landing profiles. Each class is assigned a set of EPNdB-versus-distance curves for takeoff and landing, and a set of takeoff climb profiles for appropriate ranges of gross takeoff weight. A standard descent angle of 3° immediately prior to touchdown is assumed for all aircraft classes.

The total noise exposure produced by aircraft operations at an airport is represented by the sum of the effective perceived noise levels produced at each point on the ground by the different aircraft classes flying along simulated flight paths as appropriate. Diagrammatically, the various values and characteristics may be related as follows:



Noise Exposure (NE)

$$NE = 10 \log \sum_{i} \sum_{j} \text{antilog} \frac{NE(i,j)}{10}$$

$$NE(i,j) = EPNL(i,j) + 10 \log N(i,j) - 88$$

where:

$NE(i,j)$ = Noise Exposure value produced by N aircraft of class(i) along flight path (j)

$EPNL(i,j)$ = Effective Perceived Noise Level produced at the point being considered by aircraft of class (i) traveling along flight path (j).

The subtractive factor (88) is included to insure that the NE values which result are distinctly different in magnitude from the EPNL values, so that little likelihood will exist that the two values will be confused.

Noise Exposure Forecast (NEF)

$$\mathrm{NEF} = 10 \log \sum_{i} \sum_{j} \mathrm{antilog} \quad \frac{\mathrm{NEF}\ (i,j)}{10}$$

$$\mathrm{NEF}(i,j) = \mathrm{EPNL}(i,j) + 10 \log \left[\mathrm{ND}(i,j) + 16.67\ \mathrm{NN}(i,j) \right] -88$$

where:

NEF(i,j) = Noise Exposure Forecast value produced by aircraft of class (i) traveling along flight path (j)
EPNL(i,j) = Effective Perceived Noise Level produced at the point being considered by an aircraft of class (i) traveling along flight path (j)
ND(i,j) = Number of operations during daytime period (0700 to 2200) for aircraft of class (i) traveling along flight path (j)
NN(i,j) = Number of operations during nighttime period (2200 to 0700) for aircraft of class (i) traveling along flight path (j).

Again, the subtractive factor (88) is applied to eliminate confusion between NEF and EPNL values.

Weighted Equivalent Continuous Perceived Noise Level (WECPNL)

$$\mathrm{WECPNL} = 10 \log \left[\frac{1}{2}\ \mathrm{antilog} \ \frac{\mathrm{ECPNLD}}{10} + \frac{1}{8}\ \mathrm{antilog}\ \frac{\mathrm{ECPNLE+5}}{10} + \frac{3}{8}\ \mathrm{antilog}\ \frac{\mathrm{ECPNLN} + 10}{10} \right]$$

$$\mathrm{ECPNLD} = 10 \log \sum_{n} \sum_{i} \sum_{j} \left[\mathrm{antilog}\ \frac{\mathrm{EPNL}(n,i,j)}{10} \right] + 10 \log \frac{10}{T}$$

where:

ECPNLD = Equivalent Continuous Perceived Noise Level for the Daytime period (ECPNLE for the Evening period; ECPNLN for the Nighttime period)
EPNL(n,i,j) = Effective Perceived Noise Level produced at the point being considered by the nth aircraft of class (i) traveling along flight path (j)
T = Total period of time (in seconds) included in interval under consideration (0700 - 1900 for daytime, 1900-2200 for evening, 2200 - 0700 for nighttime).

PROGRAM USAGE

Input information required for the Noise Exposure Model MOD 4 is entered into the computer via punched cards using a simple set of pre-printed coding sheets with six-character mnemonic identifiers. Preparation of the input coding is straightforward and systematic, although large airports with many runways, flights, flight paths, and operating procedures may involve a large number of lines of input data.

Input information may be considered in three parts:

a. One-time processing instructions;
b. Runway and flight path descriptions, prepared once and used repetitively in flight operations; and
c. Aircraft flight operations.

Computer output calculations are printed grid values of noise exposure (NE, NEF, or WECPNL as selected), with the additional option of automatic CALCOMP plots of selected contour values with corresponding areas calculated within each plotted contour.

The following sections describe the entries required for each of the three types of input data. Appendix A furnishes samples of the pre-printed coding sheets suggested to simplify preparation of the input data. Appendix B displays a sample problem with the computer solution.

One–Time Processing Instructions

The first category of input data includes the problem title and one-time control and processing instructions.

Identifier	Meaning
TITLEE	(Instruction indicator)
(Actual title appears on card following TITLEE card, utilizing columns 1-21 only.)	
FEETLB	Input/Output data in feet and pounds.
MKSSYS	Input/Output data in meters and kilograms.
DIAGL0	No diagnostics printed.
DIAGL1	Extensive diagnostics printed.
DIAGL3	Complete diagnostics printed (normally for programmer's use only).
NEEVAL	Noise Exposure values to be calculated.

Identifier	Meaning
NEFCAL	Noise Exposure Forecast values to be calculated.
WECPNL	Weighted Equivalent Continuous Perceived Noise Level values to be calculated.
PRTALL	Print all input and output data and certain calculated tables.
CLCMPS	Small-size CALCOMP output plots.
CLCMPL	Large-size CALCOMP output plots.

Note: Where user-selected options are available among the one-time control and processing mnemonic instructions, only one can be included. Thus, either FEETLB or MKSSYS may be selected, but not both; either NEEVAL or NEFCAL or WECPNL but not more than one of these three; either CLCMPS or CLCMPL but not both; either DIAGL0 or DIAGL1 or DIAGL3 but not more than one of these three, although one of this group does not have to be included for normal calculations.

The following one-time data are entered as the last cards in the program input deck.

GRIDCL	Instruction to set values for grid calculations. Must be followed by values assigned to each of the six following instructions.
DELTAX	X-increment between grid points to be calculated.
DELTAY	Y-increment between grid points to be calculated.
FIRSTX	Initial X value for grid calculations.
FIRSTY	Initial Y value for grid calculations.
NOOFXS	Number of X values for grid points (maximum of 20).
NOOFYS	Number of Y values for grid points (maximum of 25).
PROCES	Mandatory instruction to begin computer processing, using preceding input data.
	Instruction to computer for labeling runways on CALCOMP plot. Runway numbers are entered on this line using Format 8A6; that is, as many as eight runway designations may be entered as integers, beginning in columns 1, 7, 13, 19, etc.

ENDRUN	Mandatory final mnemonic instruction to indicate end of input data to program.
	Instruction to computer to plot indicated noise exposure contours. Values of plotted contours are entered on this line using Format 3F10.1; that is, as many as three values may be entered with decimal points and one decimal, beginning in columns 1, 11, and 21.

Runway and Flight Path Descriptions

The second category of input information required for the Noise Exposure Model MOD 4 serves to define the geometry of the runways involved in the flight operations under consideration and the projected flight paths to be used by the simulated aircraft. In general, this information must be prepared once for each problem, but may be used repetitively throughout the problem.

Runways are defined by the three cartesian coordinates of the two ends of each runway, in the metric or English units (meters or feet) specified in the direction of the intended flight path (i.e., for a takeoff, the end at which the aircraft starts its takeoff roll is defined first, and the end toward which it accelerates for liftoff is defined second; for a landing, the threshold end of the runway is defined first, and the end toward which the aircraft rolls as it brakes to a halt is described second).

Flight paths are described as straight-line or constant-radius curved segments projected onto the horizontal reference plane (Z = 0), plus the angle of climb (or descent). For takeoffs, Segment 1 is defined as the takeoff roll along the runway from brake release to liftoff. Segment 2 is the initial climb path immediately after liftoff, essentially a straight-line path with a specific angle of climb. The length of Segment 1 and the climb angle for Segment 2 are included in the Noise Exposure Model MOD 4 and depend on the aircraft class specified and the gross takeoff weight for that aircraft class.

The flight path segments beyond Segment 2 are called extensions and, if used, must be defined by input data describing the extent of each segment (angular extent if a curved segment), climb angle, thrust setting for the aircraft class being considered, and radius of the path (0 for straight-line path, a negative (-) value for counterclockwise turn when viewed from above, a positive (+) value for clockwise turn viewed from above). If there are more than two segments for each path, the length of Segment 2 (the initial climbout path) also must be defined.

For landings, the segments are numbered in reverse order from the path actually followed by an aircraft; that is, the landing roll along the runway from touchdown to the end of roll is defined as Segment 1, while the final glide slope just prior to touchdown is Segment 2. A landing roll (Segment 1) of 5280 feet and a final glide slope of 3° are assumed in the model. The sign convention for curved segments of the landing extensions also is reversed; that is, a counterclockwise turn when viewed from above will have a positive (+) radius, while a clockwise turn when viewed from above will have a negative (-) radius.

The runway and flight path descriptors are as follows:

RUNWAY	Instruction to define runway. Must be followed by values assigned to following six instructions.
XCOORD	Value of X-coordinate of near end and far end of runway (two values required, in units selected for problem, meters or feet).
YCOORD	Value of Y-coordinate of near and far ends of runway.
ZCOORD	Value of Z-coordinate of near and far ends of runway. Normally, both are set to zero (0). Actual provisions for non-zero values of Z are not presently included in the MOD 4 program.
TKGDRL	Distance along runway at which takeoff roll begins (i.e., brake-release point), normally assumed to be at near end of runway (i.e., zero value entered).
TCHDWN	Distance along runway at which touchdown occurs during landings, normally assumed to be 300 meters (1000 feet) to simulate fact that aircraft do not normally touchdown exactly at runway threshold.
NOFLTS	Number of flights using this runway, not to exceed 20. A flight is defined as one aircraft class (may include any number of individual aircraft of the same class) following one flight path. If more than 20 flights are required, the same runway should be redefined and considered as a new runway.

NOEXTS	Number of extensions in the flight path being described. If a simple takeoff roll and straight climbout (or straight-in glide slope and landing roll) are being simulated, enter 0.
PRSEG2	Extent of Segment 2 projected on horizontal reference plane (Z = 0); required if NOEXTS $\neq$ 0.
EXTNSN	Identification instruction that begins definition of extension segment. Must be followed by four following instructions.
EXTENT	Extent of extension segment, expressed in meters (or feet) for straight-line segment, or degrees-of-turn for a constant-radius curved segment, as projected on the horizontal reference plane (Z = 0). Enter 0 if segment is infinite (i.e., last segment of path).
ELEVAT	Angle of climb (or descent) in degrees.
THRUST	Thrust setting for aircraft class simulated during this extension. For takeoffs, 100% thrust setting is normally assumed, unless a noise abatement cutback is to be simulated. During landings, a 45% thrust setting is normally assumed. The Noise Exposure Model MOD 4 includes noise level corrections for reduced thrust settings, appropriate to each aircraft class.
RADIUS	Radius of constant-radius curved flight segment, expressed in meters (or feet) as projected onto the horizontal reference plane (Z = 0). Enter 0 if the segment being described is a straight line, - value if turn is counterclockwise when viewed from above, + value if turn is clockwise for takeoff paths, and the reverse sign convention for landing paths. Normally the farthest segment (last segment for takeoffs, first segment for landings) defined for any flight path should be a straight line; otherwise the program will simulate a helical climb (or descent) path and will calculate corresponding noise values.

Aircraft Flight Operations

The remaining general category of input information for the Noise Exposure Model MOD 4 serves to define the numbers and types of aircraft classes which operate from each of the runways and along each of the flight paths defined in the second information category. As noted previously, aircraft have been grouped into classes having similar noise characteristics and landing and takeoff profiles. The Noise Exposure Model MOD 4 assumes a 3° glide slope for all classes of aircraft for landing. The takeoff profile will depend, however, on the gross weight of each aircraft at takeoff (i.e., the heavier the aircraft is loaded, the more shallow will be its climb during takeoff). The takeoff profiles for each aircraft class, corresponding to their potential gross takeoff weights, are included in the computer program and require only that the aircraft class and gross weight be defined. At the user's option, length of takeoff roll and initial climb angle may be specified, overriding programmed data.

A third required definition for each aircraft class is the thrust setting used during takeoff and landing. Engine noise characteristics change with thrust or power setting, generally decreasing in intensity with decreased thrust. The relation between Effective Perceived Noise Level and thrust setting for each aircraft class is included in the Noise Exposure Model MOD 4 program. Normally, 100% thrust is used for takeoff, while 45% thrust is applied during final landing approach. Many airports require noise abatement power cutbacks after takeoff to reduce annoyance to airport neighbors. A thrust cutback with its associated decrease in rate of climb may be included in the Noise Exposure Model MOD 4 as an extension in the takeoff flight path.

The aircraft flight operations descriptors are the following:

FLIGHT	Instruction to define a single aircraft class flight.
LANDING	Indicates that the flight is a landing operation.
TAKEOFF	Indicates that the flight is a takeoff operation.
ACWGHT	Weight of the aircraft class in kilograms (or pounds).
THRUST	Thrust setting for aircraft class engines during the operation being described, in percent of full thrust.
ACTYPE	One or two digit number code for aircraft class.

NDAYOP	Number of daytime operations of the aircraft class. For NE calculations, the daytime period includes the entire 24-hour period; for NEF calculations, the daytime period includes the period from 0700 to 2200; for WECPNL calculations, the daytime period includes the period from 0700 to 1900.
NEVNOP	Number of evening operations of the aircraft class. Used only for WECPNL calculations, and includes the period from 1900 to 2200.
NNGTOP	Number of nighttime operations of the aircraft. Used only for NEF or WECPNL calculations, and includes the period from 2200 to 0700.
CLIMBA	Angle of climb (or descent) in degrees. Used only if standard takeoff profile (see Table 3) is not desired. If used, the value indicated overrides standard profile value.
PRSEG1	Length of takeoff roll (or landing roll) in meters (or feet). Must be used if CLIMBA is used.

While aircraft class gross takeoff weight is the best characteristic for determination of the takeoff profile within each class of aircraft, it is often the case that airport operations are available only in categories of trip length rather than gross takeoff weight. Tables 1 and 2 relate these two characteristics for use in coding input information for the Noise Exposure Model MOD 4. These tables also indicate the aircraft classes included in the program and the identifying code for each. Table 3 defines the various standardized takeoff and landing profiles included in the model. The lengths of takeoff roll are useful for determining the lengths of projected Segment 2, when coding takeoff flight path extensions. The programmed climb angles also are useful when coding takeoff flight path extensions, if no thrust cutback is involved. If a thrust cutback is required, for noise abatement operational purposes for example, the corresponding reduction in climb angle for the aircraft class under consideration is used. As noted above, the CLIMBA and PRSEG1 mnemonic instructions override the programmed standardized profiles, allowing the user the option of entering his own profiles.

Table 1. Aircraft Classification and Takeoff Profiles

Aircraft Class	Aircraft Type	Aircraft Takeoff Profile Corresponding to Gross Weight*					
		AA	A	B	C	D	E
1	4-engine HBPR turbofan (747)	NA	NA	400 to 500	500 to 605	605 to 710	710 to 800
2	3-engine HBPR turbofan (DC-10, L-1011)	NA	200 to 250	250 to 300	300 to 350	350 to 400	400 to 450
3	4-engine LBPR turbofan (707-320B/C, DC-8-50/60)	NA	200 to 215	215 to 250	250 to 280	280 to 315	315 to 350
4	4-engine turbojets (707-120, 720, DC-8-10/40)	NA	NA	200 to 220	220 to 250	250 to 275	257 to 305
5	3-engine LBPR turbofan (727-100/200)	NA	100 to 115	115 to 135	135 to 150	150 to 170	NA
6	2-engine LBPR turbofan (DC-9, BAC-111, 737)	NA	60 to 80	80 to 100	100 to 120	NA	NA
7	General Aviation 4-engine LBPR turbofan	40 to 50	50 to 60	NA	NA	NA	NA
8	General Aviation 4-engine turbojets	24 to $31\frac{1}{2}$	$31\frac{1}{2}$ to $38\frac{1}{2}$	$38\frac{1}{2}$ to 42	NA	NA	NA
9	General Aviation 2-engine LBPR turbofan	16 to 20	20 to 25	25 to 30	NA	NA	NA
10	General Aviation 2-engine turbojet	up to 12	12 to 15	NA	NA	NA	NA
11	2-engine propjet		PA profile				
12	4-engine propjet		PA profile				

* In thousands of pounds

Table 2. Aircraft Classifications and Takeoff Profiles

Aircraft Class	Aircraft Type	Aircraft Takeoff Profile Corresponding to Trip Length* 0-500	500-1000	1000-1500	1500-2500	2500-3500	3500-4500	4500+
1	4-engine HBPR turbofan (747)	B	B	B	B	C	D	E
2	3-engine HBPR turbofan (DC-10, L-1011)	B	C	C	D	D		
3	4-engine LBPR turbofan (707-320B/C, DC-8-50/60)	B	B	B	B	C	D	E
4	4-engine turbojet (707-120, 720, DC-8-10/40)	B	B	B	C	D	E	E
5	3-engine LBPR turbofan (727-100/200)	B	C	D	D	D		
6	2-engine LBPR turbofan (DC-9, BAC-111, 737)	B	B	B	B			

* In nautical miles for trip length

Table 3. Descriptions of Standardized Profiles

Profile	Length of Takeoff Roll	Climb Angle
AA	2550 feet (780 meters)	18° 25'
A	4000 " (1220 ")	11° 48'
B	5500 " (1675 ")	9° 35'
C	6800 " (2070 ")	7° 35'
D	9200 " (2800 ")	6° 00'
E	10600 " (3230 ")	5° 00'
PA	2800 " (850 ")	5° 11'

Profile	Length of Landing Roll	Descent Angle
All	5280 feet (1610 meters)	3° 00'

PROGRAMMER'S MANUAL

The objective of this section is to provide assistance to the computer programmer in preparing the input deck and in making corrections to cases that fail to execute successfully for the Noise Exposure Model MOD 4.

Input Instruction Format

The input instructions/data are entered into the computer by punched cards in the following format:

<u>CARD</u> <u>FORMAT</u>

cols 1-6	Six-character Instruction/Data mnemonic.
cols 7, 8	Blank.
cols 9-23	First data field (if any) with mandatory decimal point in column 18.
cols 24,25	Blank.
cols 26-40	Second data field (if any) with mandatory decimal point in column 35.
cols 41-72	Blank (not read by program and can be used for comments).
cols 73-80	For user's use.

Deck Setup

The following is the deck setup for running the Noise Exposure Model MOD 4. The computer is an IBM 7094 and the operating system is IBSYS Version 13.

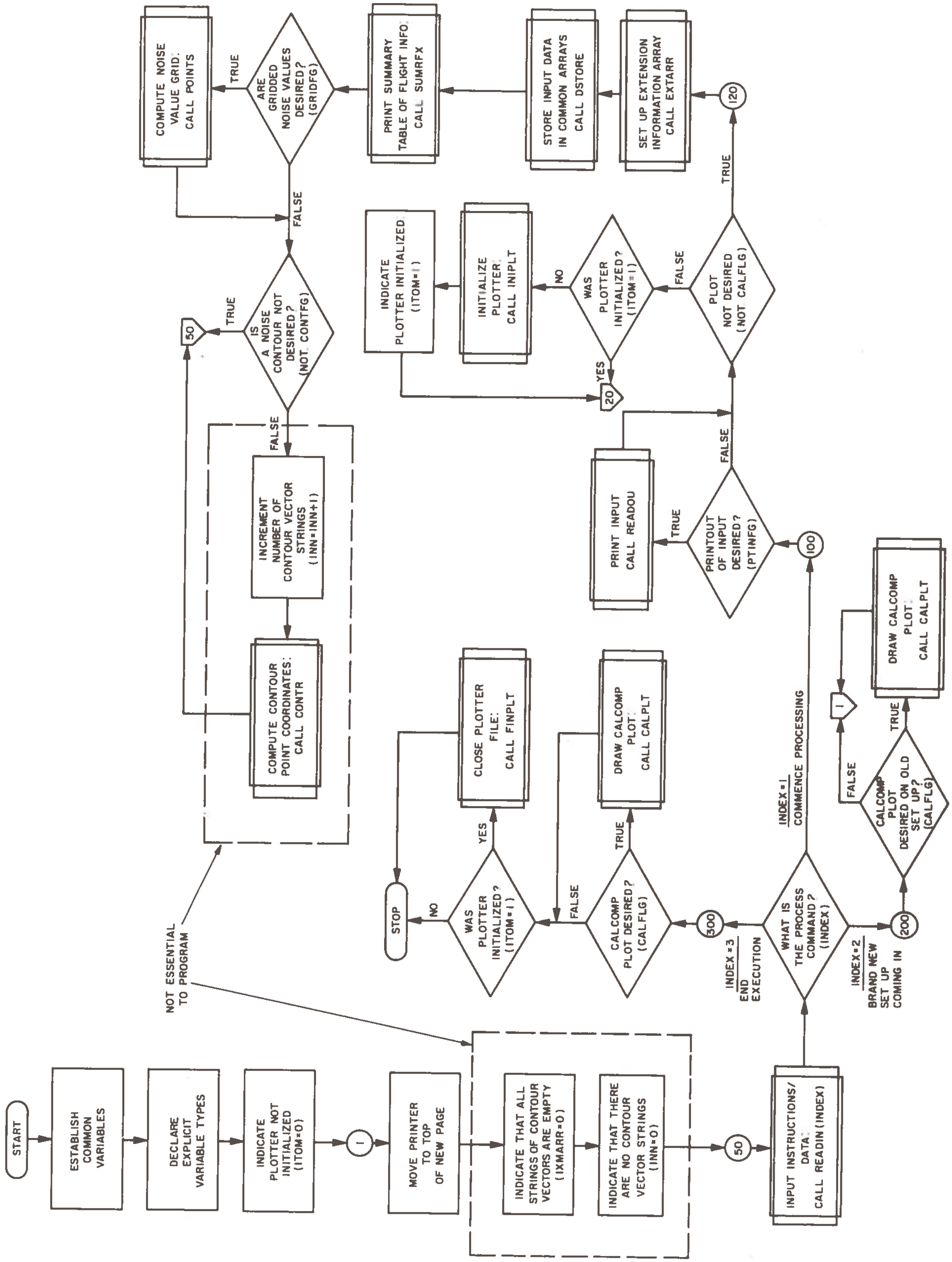
Column 1	Column 16
Job Card	
$IBSYS	
$ATTACH	B5
$AS	SYSCK1
$EXECUTE	IBJOB
$IBJOB	FIOCS
$IEDIT	SYSCK1, SRCH
$IBLDR MAIN	
$LBLOR BLDA	
$IBLDR KGLB	
$IBLDR LBKG	
$IBLDR MTF	
$IBLDR FTM	
$ORIGIN	ALPHA
$IBLDR SUMRFX	
$ORIGIN	ALPHA
$IBLDR POIX	
$IBLDR GENF	
$IBLDR I	
$IBLDR VUN	
$IBLDR DOT	
$IBLDR CROS	
$IBLDR ADD	
$IBLDR SUB	
$IBLDR SCL	
$IBLDR MAG	
$IBLDR NOISE	
$IBLDR DAT	
$IBLDR ATTX	
$IBLDR SLP	
$IBLDR IBN	
$IBLDR BN	
$IBLDR DGT	
$IBLDR XIN	
$IBLDR NAC	
$IBLDR ET2	
$IBLDR ET3	
$IBLDR ET4	
$IBLDR EX	
$IBLDR VCT	
$IBLDR THR	
$IBLDR CNTX	
$IBLDR FAIX	
$IBLDR HBEX	

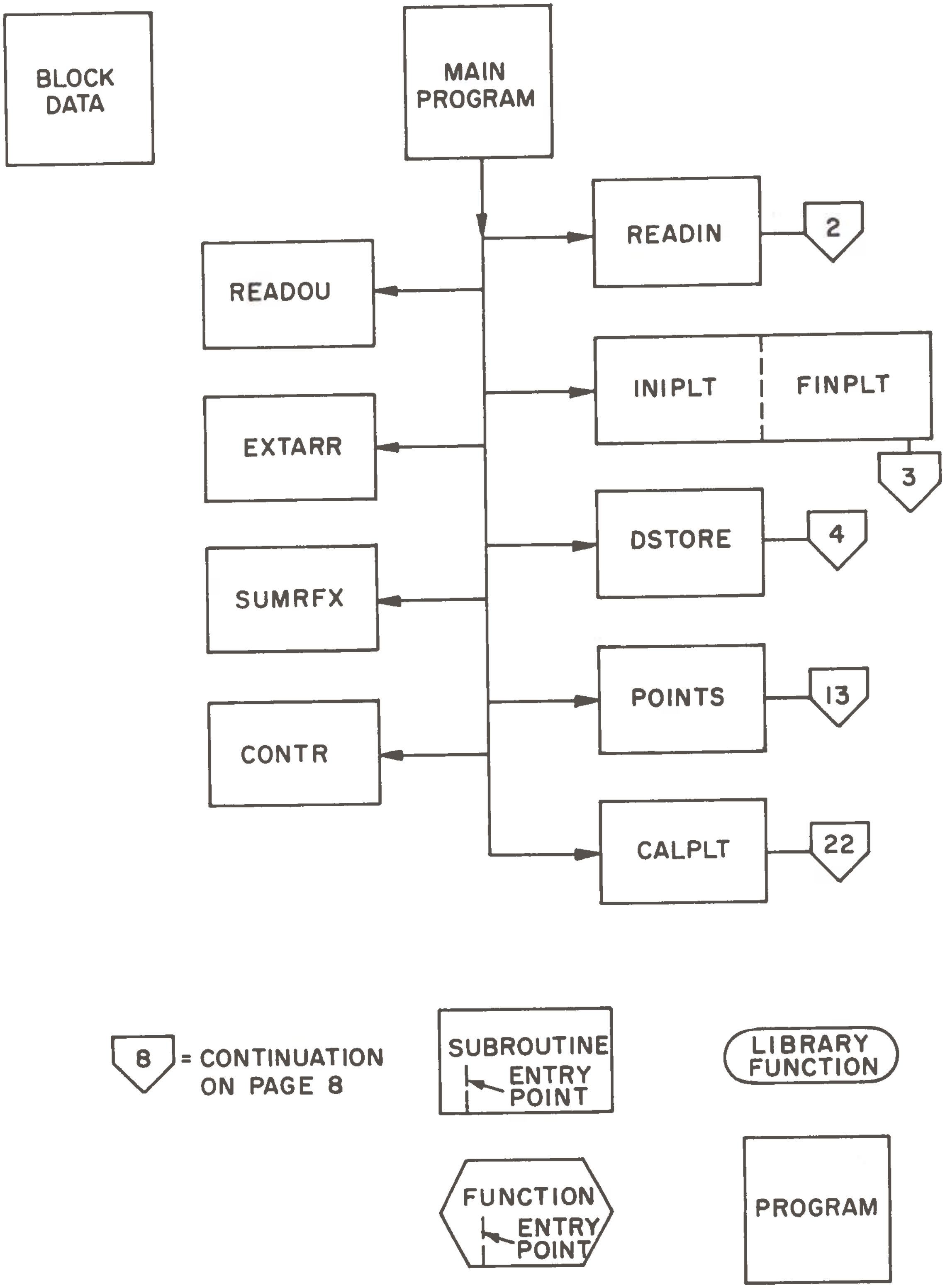
```
Column 1                           Column 16

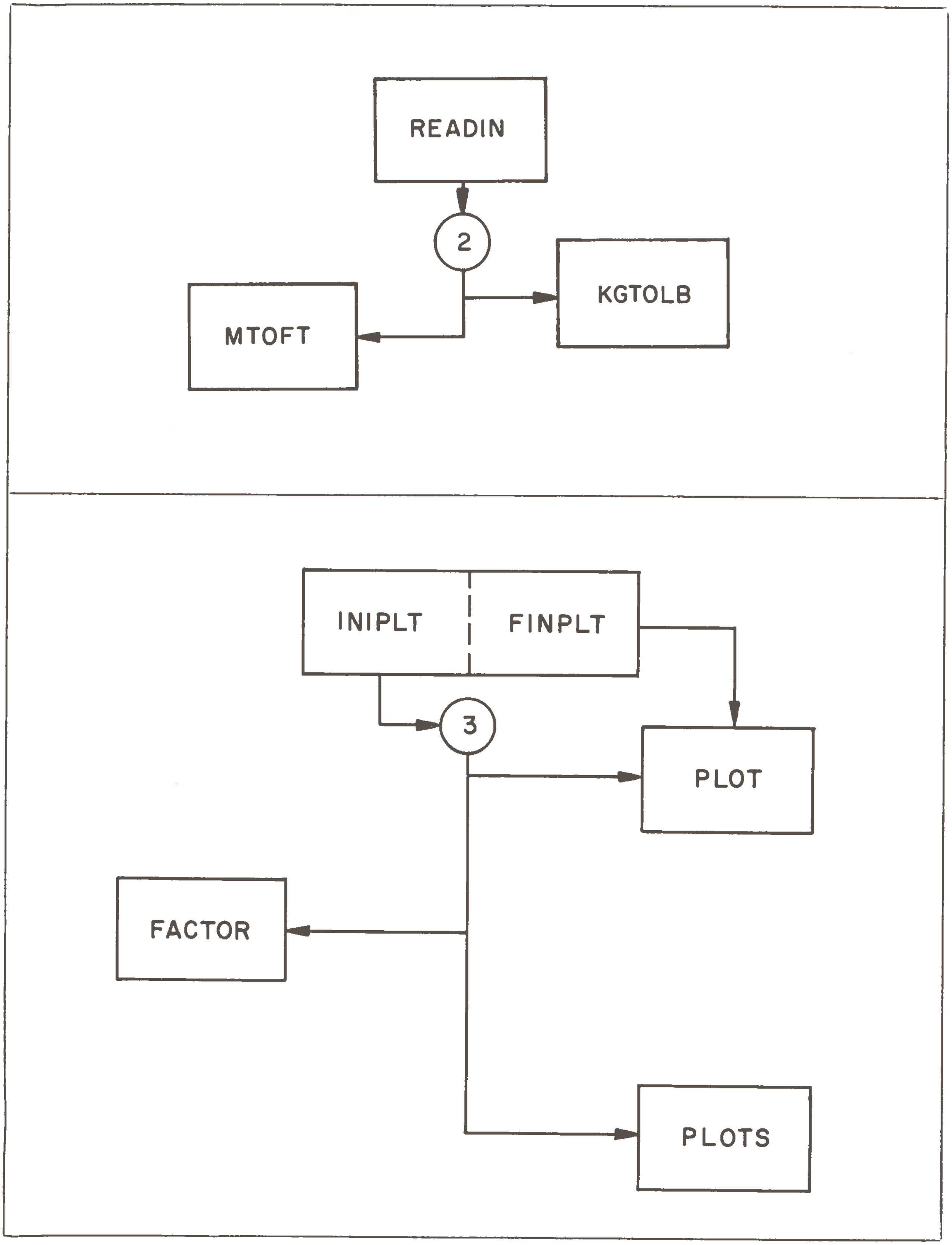
$IBLDR F1X
$IBLDR F2X
$IBLDR F3X
$IBLDR SECX
$IBLDR PARX
$IBLDR FNHX
$IBLDR FUDX
$IBLDR ELUX
$IBLDR EXTX
$IBLDR HMNDX
$IBLDR HLMNX
$IBLDR CENHX
$IBLDR RDOX
$ORIGIN                            BETA
$IBLDR EEXPNE
$IBLDR ET5N
$ORIGIN                            BETA
$IBLDR EEXPWE
$IBLDR ET5W
$ORIGIN                            BETA
$IBLDR STORE
$ORIGIN                            ALPHA
$IBLDR SUB5OF
$ORIGIN                            ALPHA
$IBLDR CALPWM
$IBLDR RWLGX
$IBLDR INIP
$IBLDR NOMX
$IBLDR REF
$IBLDR RUN
$IBLDR DLIN
$IBLDR PTA
$IBLDR LNE
$IBLDR AXE2
$ORIGIN                            GAMMA
$IBLDR HD
$ORIGIN                            GAMMA
$IBLDR ACXX
$IBLDR CRECX
$IBLDR CUBX
$IBLDR ITPTX
$IBLDR STRKX
$IEDIT                             SYSIN1
$DATA
    Instructions/Data go here
7 - 8 card
7 - 8 card
```

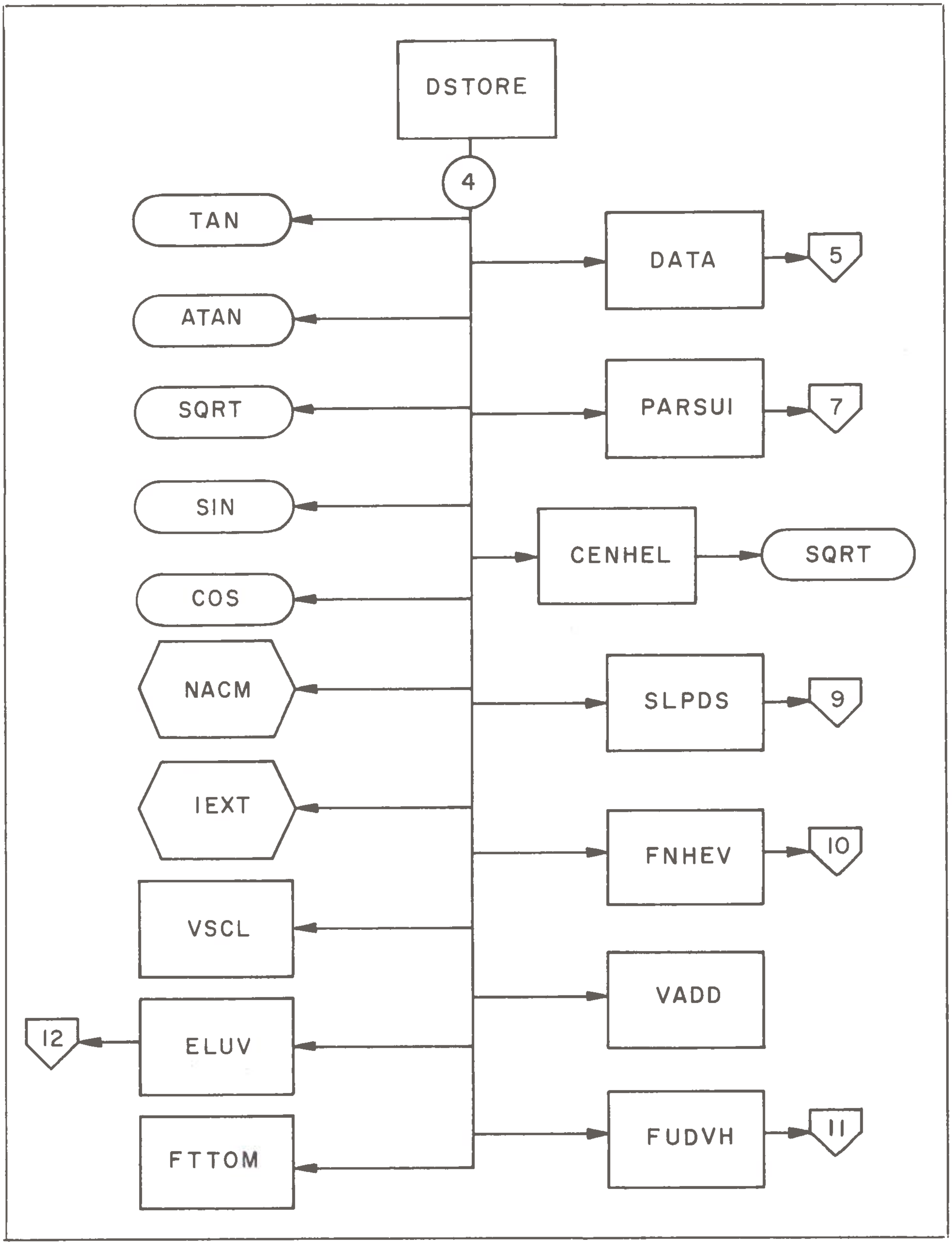
Flow Charts

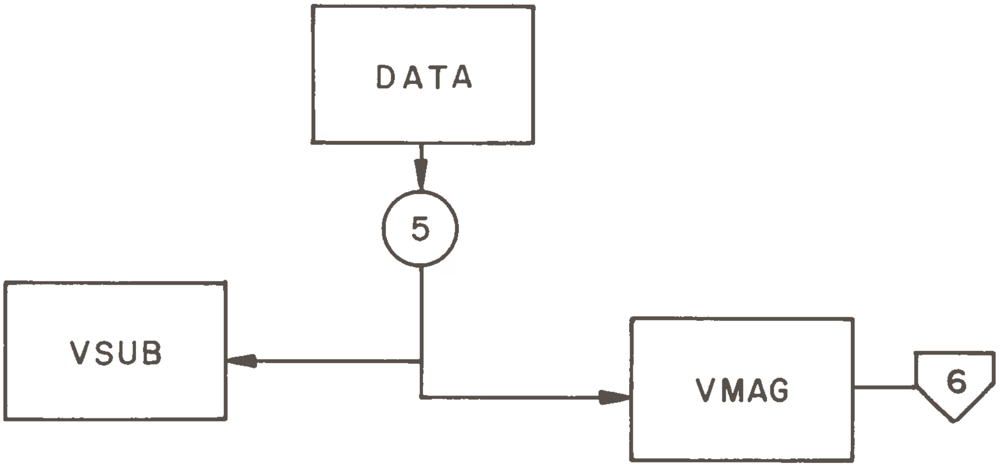
This section contains the overall program flow chart and a flow chart for each of the subroutines.

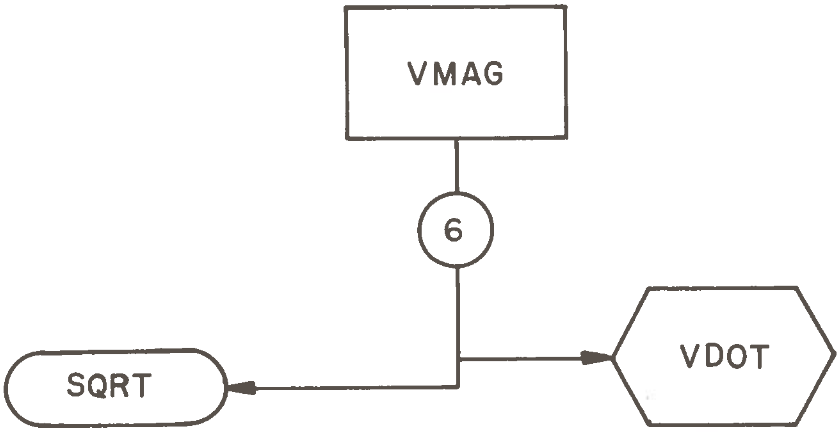

START
ESTABLISH COMMON VARIABLES
DECLARE EXPLICIT VARIABLE TYPES
INDICATE PLOTTER NOT INITIALIZED (ITOM=0)
1
MOVE PRINTER TO TOP OF NEW PAGE
INDICATE THAT ALL STRINGS OF CONTOUR VECTORS ARE EMPTY (IXMARR=0)
INDICATE THAT THERE ARE NO CONTOUR VECTOR STRINGS (INN=0)
50
INPUT INSTRUCTIONS/ DATA: CALL READIN (INDEX)
NOT ESSENTIAL TO PROGRAM
WHAT IS THE PROCESS COMMAND? (INDEX)
INDEX=3 END EXECUTION
300
CALCOMP PLOT DESIRED? (CALFLG)
TRUE
DRAW CALCOMP PLOT: CALL CALPLT
FALSE
WAS PLOTTER INITIALIZED? (ITOM=1)
YES
CLOSE PLOTTER FILE: CALL FINPLT
NO
STOP
INDEX=2 BRAND NEW SET UP COMING IN
200
CALCOMP PLOT DESIRED ON OLD SET UP? (CALFLG)
TRUE
DRAW CALCOMP PLOT: CALL CALPLT
FALSE
1
INDEX=1 COMMENCE PROCESSING
100
PRINTOUT OF INPUT DESIRED? (PTINFG)
TRUE
PRINT INPUT CALL READOU
FALSE
PLOT NOT DESIRED (NOT CALFLG)
FALSE
WAS PLOTTER INITIALIZED? (ITOM=1)
NO
INITIALIZE PLOTTER: CALL INIPLT
INDICATE PLOTTER INITIALIZED (ITOM=1)
YES
20
TRUE
120
SET UP EXTENSION INFORMATION ARRAY CALL EXTARR
STORE INPUT DATA IN COMMON ARRAYS CALL DSTORE
PRINT SUMMARY TABLE OF FLIGHT INFO: CALL SUMRFX
ARE GRIDDED NOISE VALUES DESIRED? (GRIDFG)
TRUE
COMPUTE NOISE VALUE GRID: CALL POINTS
FALSE
IS A NOISE CONTOUR NOT DESIRED? (NOT CONTFG)
TRUE
50
FALSE
INCREMENT NUMBER OF CONTOUR VECTOR STRINGS (INN=INN+1)
COMPUTE CONTOUR POINT COORDINATES: CALL CONTR

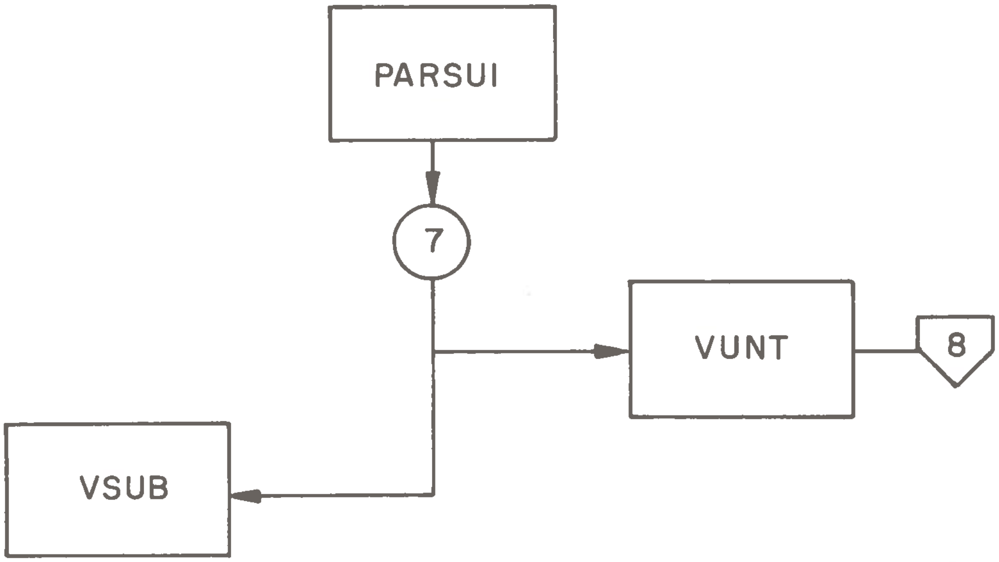

BLOCK DATA
MAIN PROGRAM
READIN
2
READOU
INIPLT
FINPLT
3
EXTARR
DSTORE
4
SUMRFX
POINTS
13
CONTR
CALPLT
22
8
= CONTINUATION ON PAGE 8
SUBROUTINE
ENTRY POINT
LIBRARY FUNCTION
FUNCTION
ENTRY POINT
PROGRAM

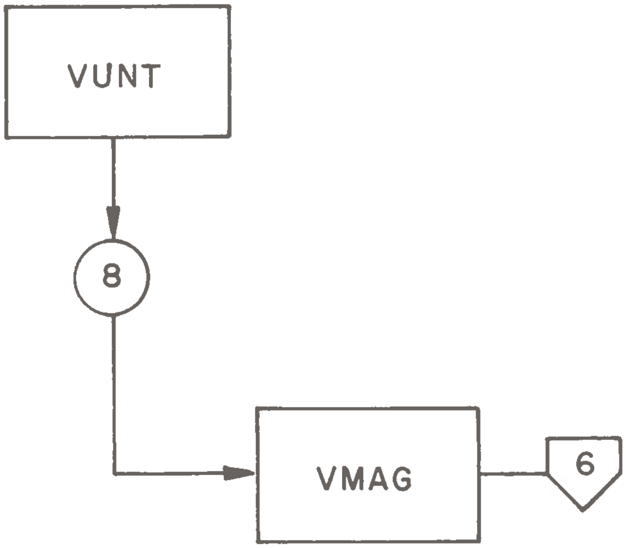

READIN
2
MTOFT
KGTOLB
INIPLT
FINPLT
3
PLOT
FACTOR
PLOTS

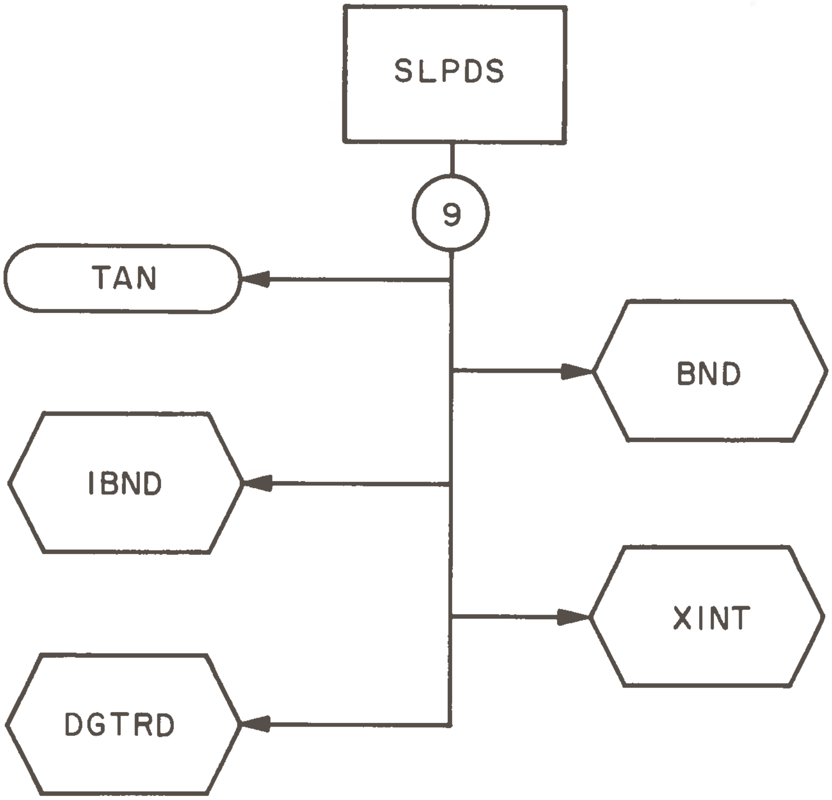

DSTORE
4
TAN
DATA
5
ATAN
SQRT
PARSUI
7
SIN
CENHEL
SQRT
COS
NACM
SLPDS
9
IEXT
FNHEV
10
VSCL
VADD
12
ELUV
FTTOM
FUDVH
11

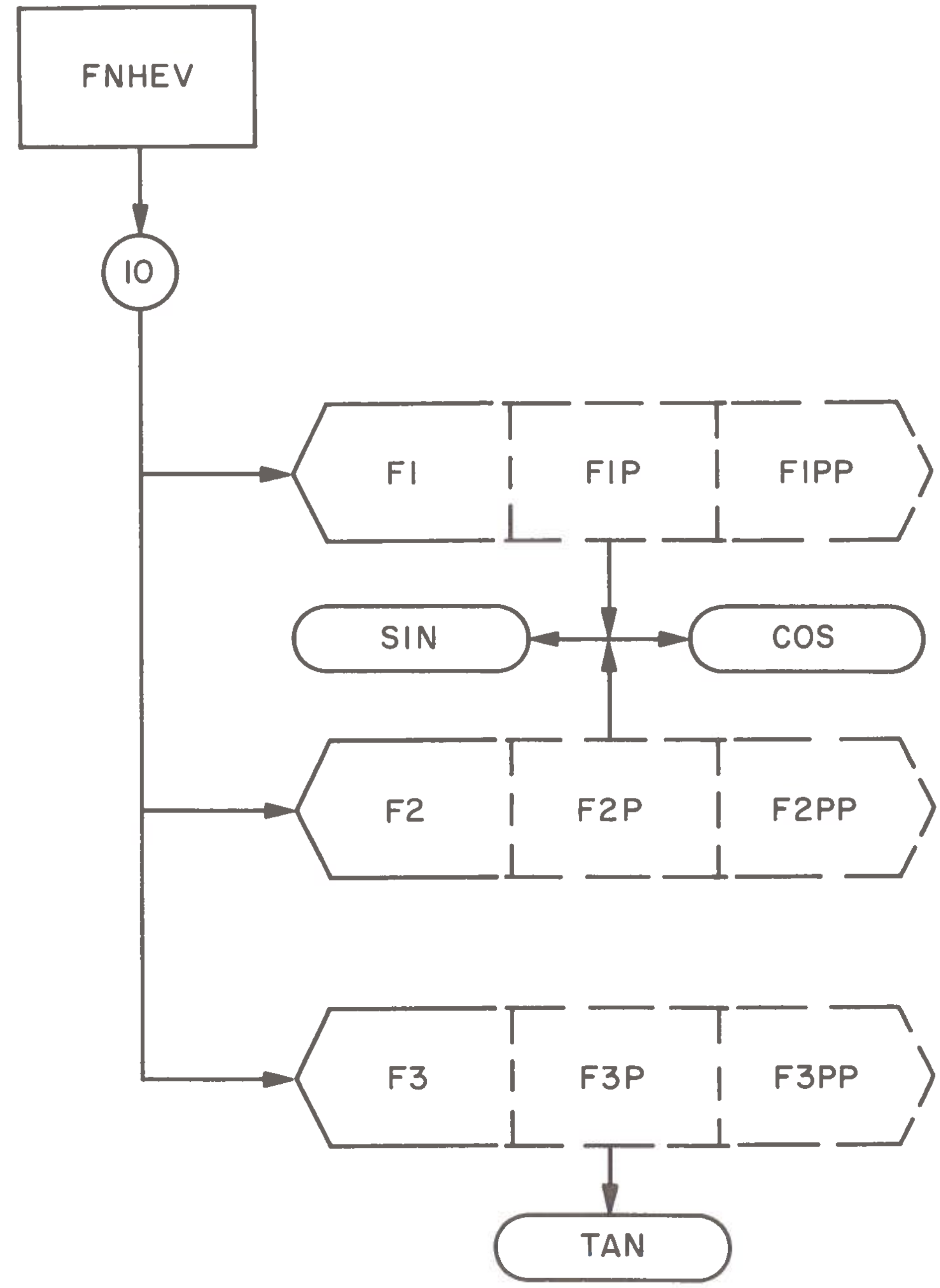

DATA
5
VSUB
VMAG
6

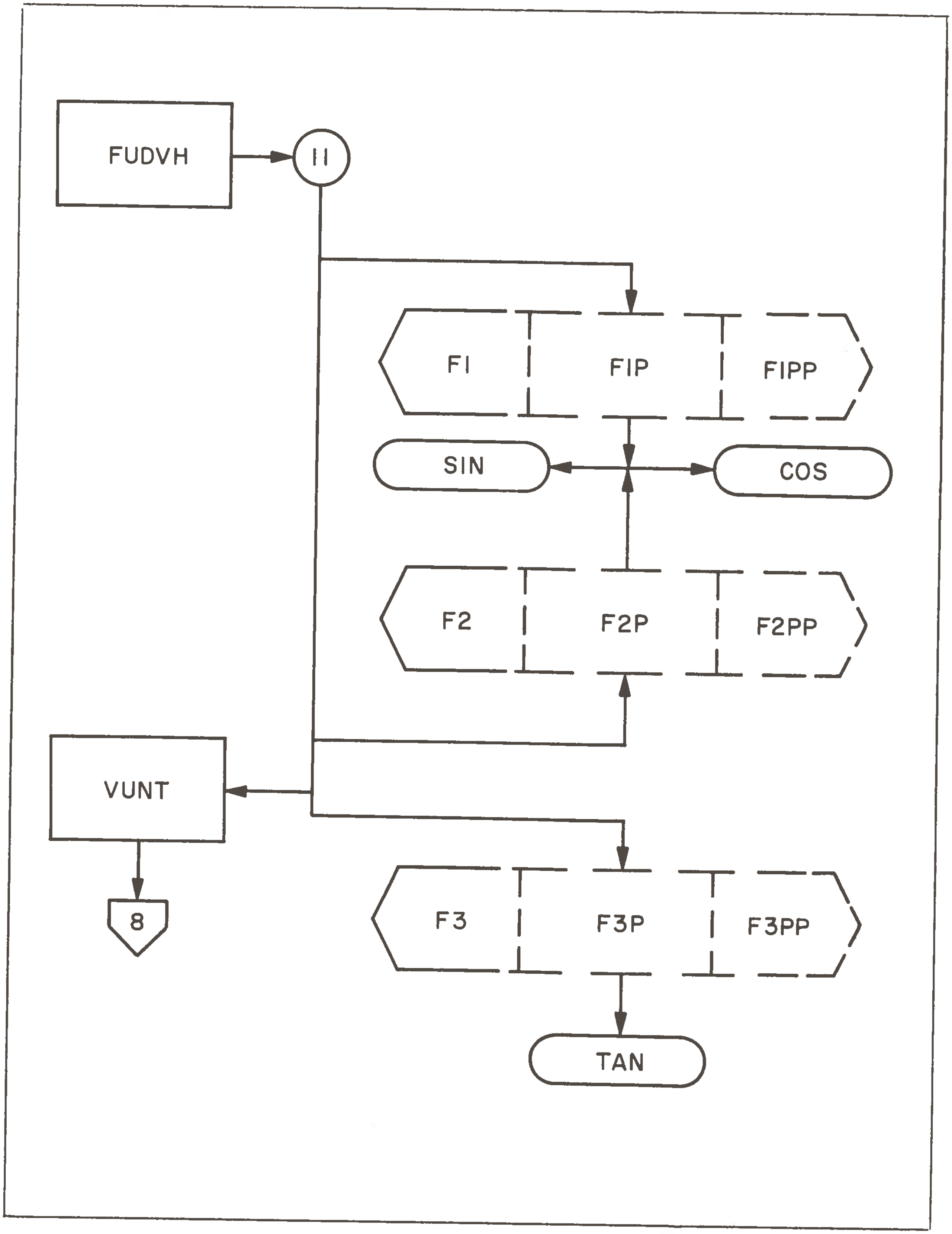

VMAG
6
SQRT
VDOT

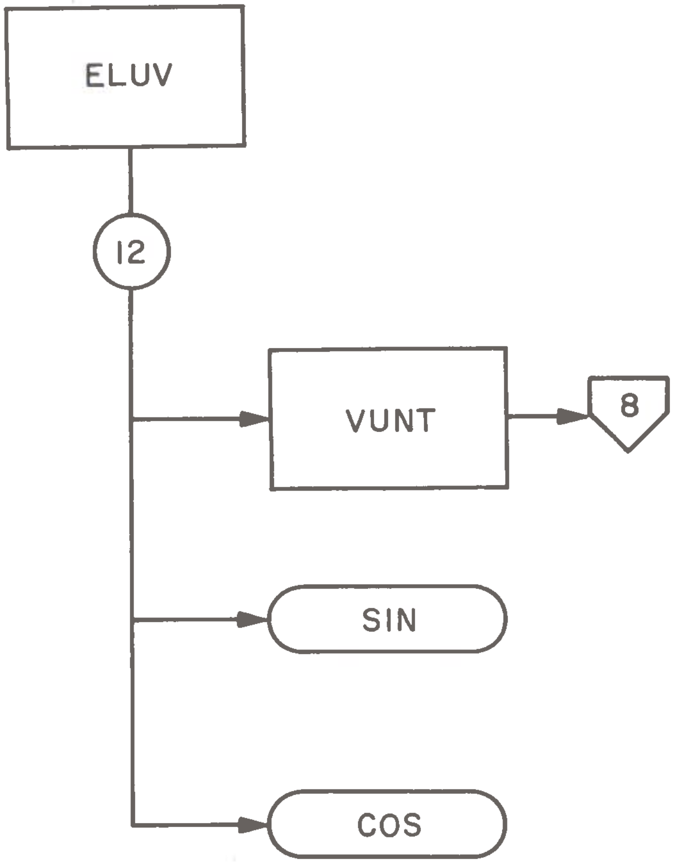

PARSUI
7
VUNT
8
VSUB

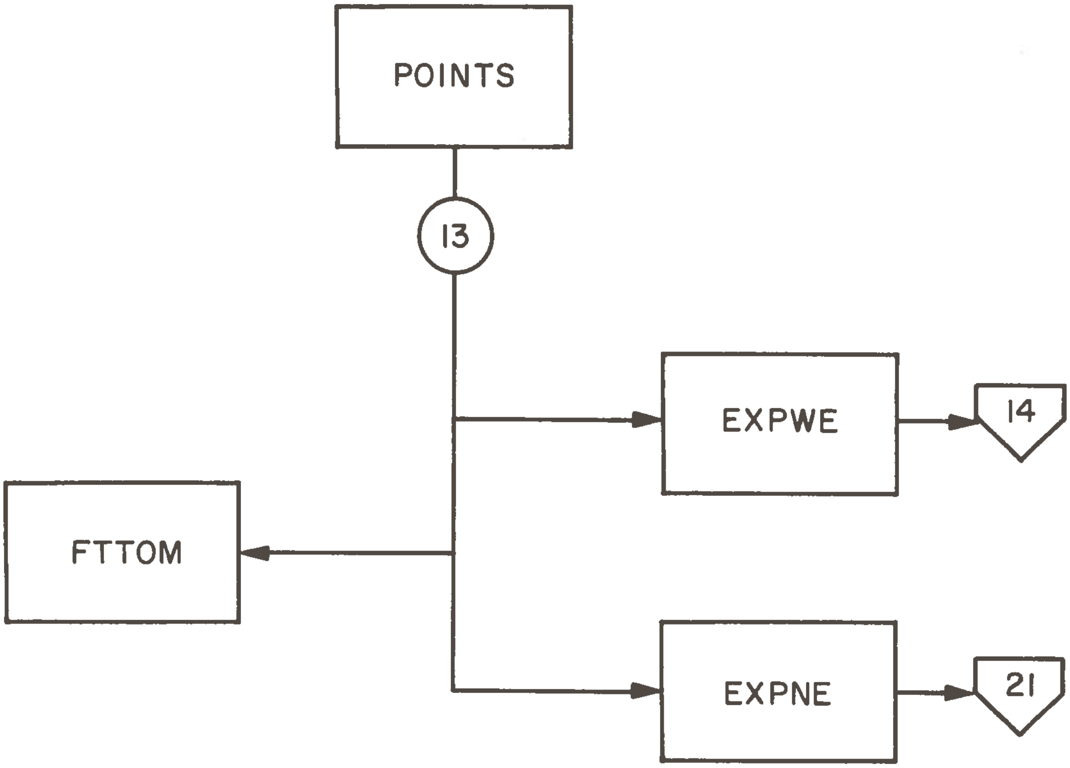

VUNT
8
VMAG
6

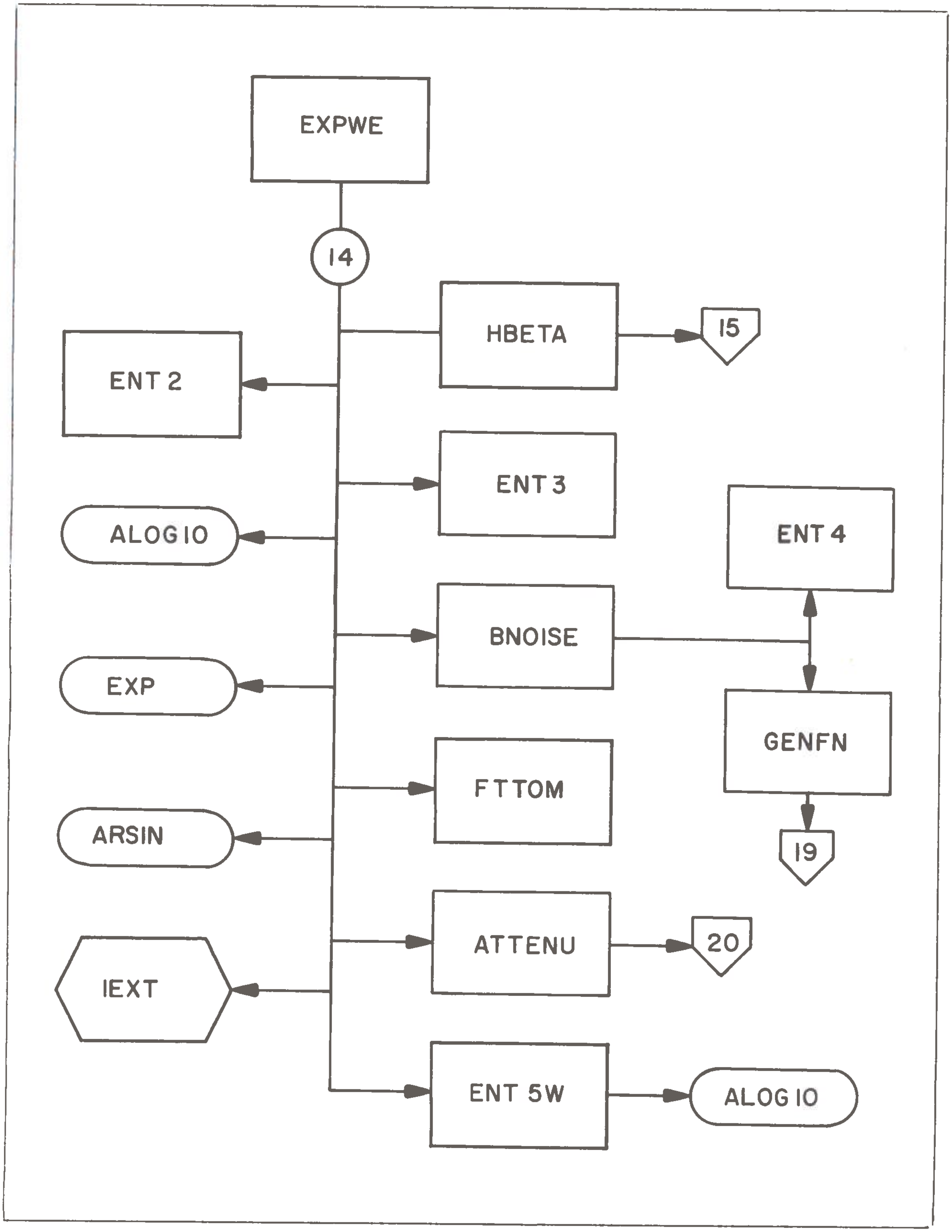

SLPDS
9
TAN
BND
IBND
XINT
DGTRD

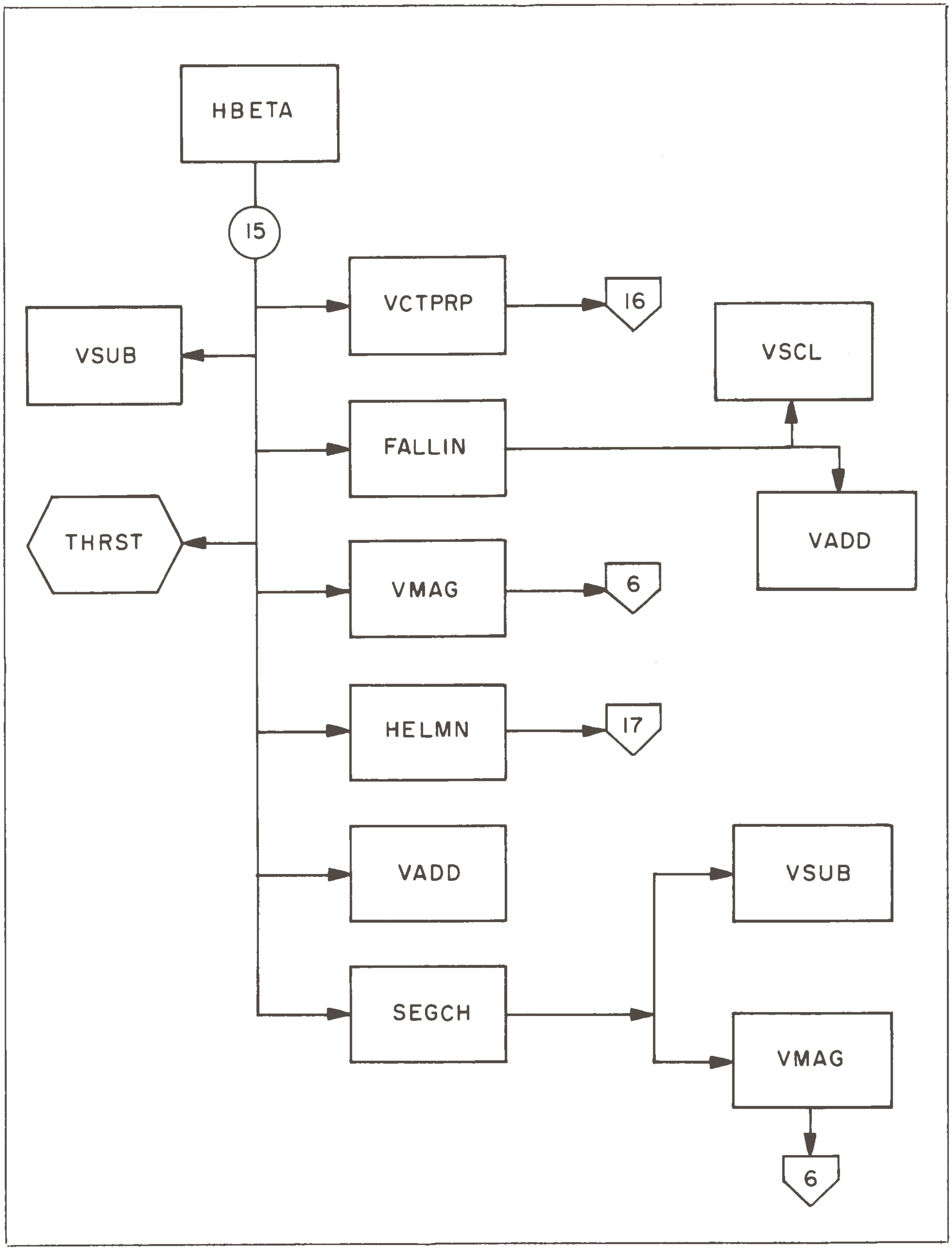

FNHEV
10
F1
F1P
F1PP
SIN
COS
F2
F2P
F2PP
F3
F3P
F3PP
TAN

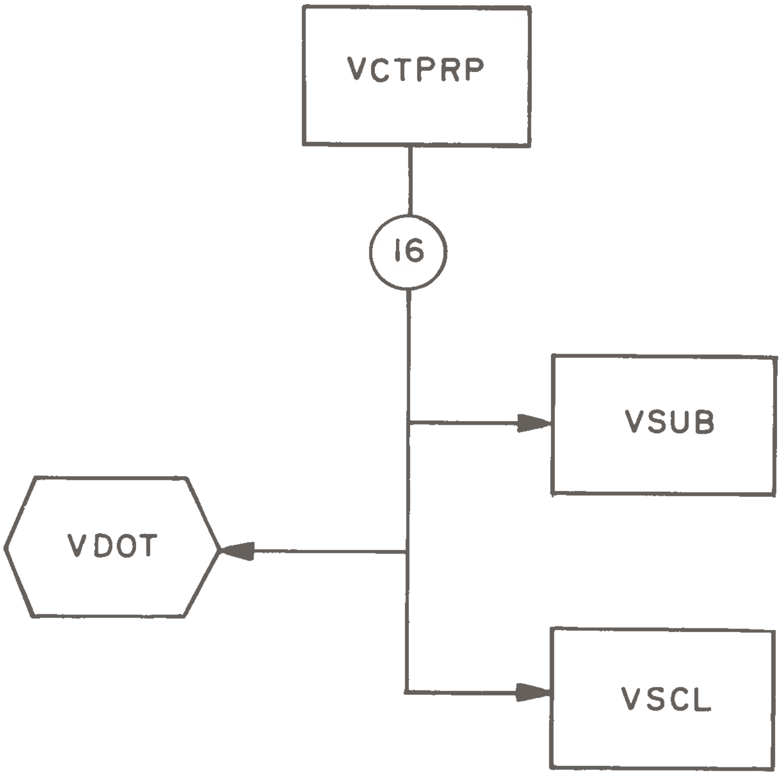

FUDVH
11
F1
F1P
F1PP
SIN
COS
F2
F2P
F2PP
VUNT
8
F3
F3P
F3PP
TAN


ELUV
12
VUNT
8
SIN
COS

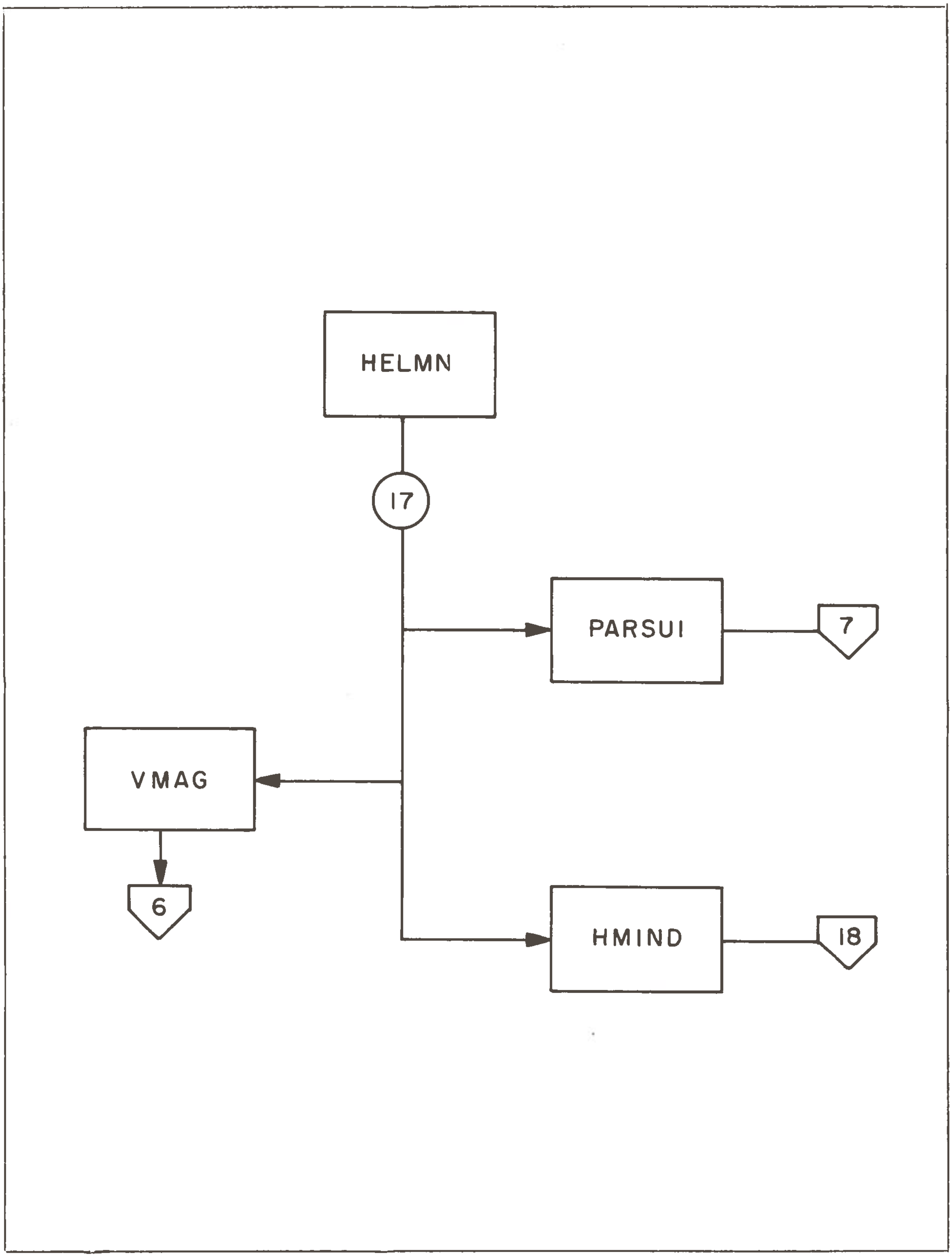

POINTS
13
EXPWE
14
FTTOM
EXPNE
21

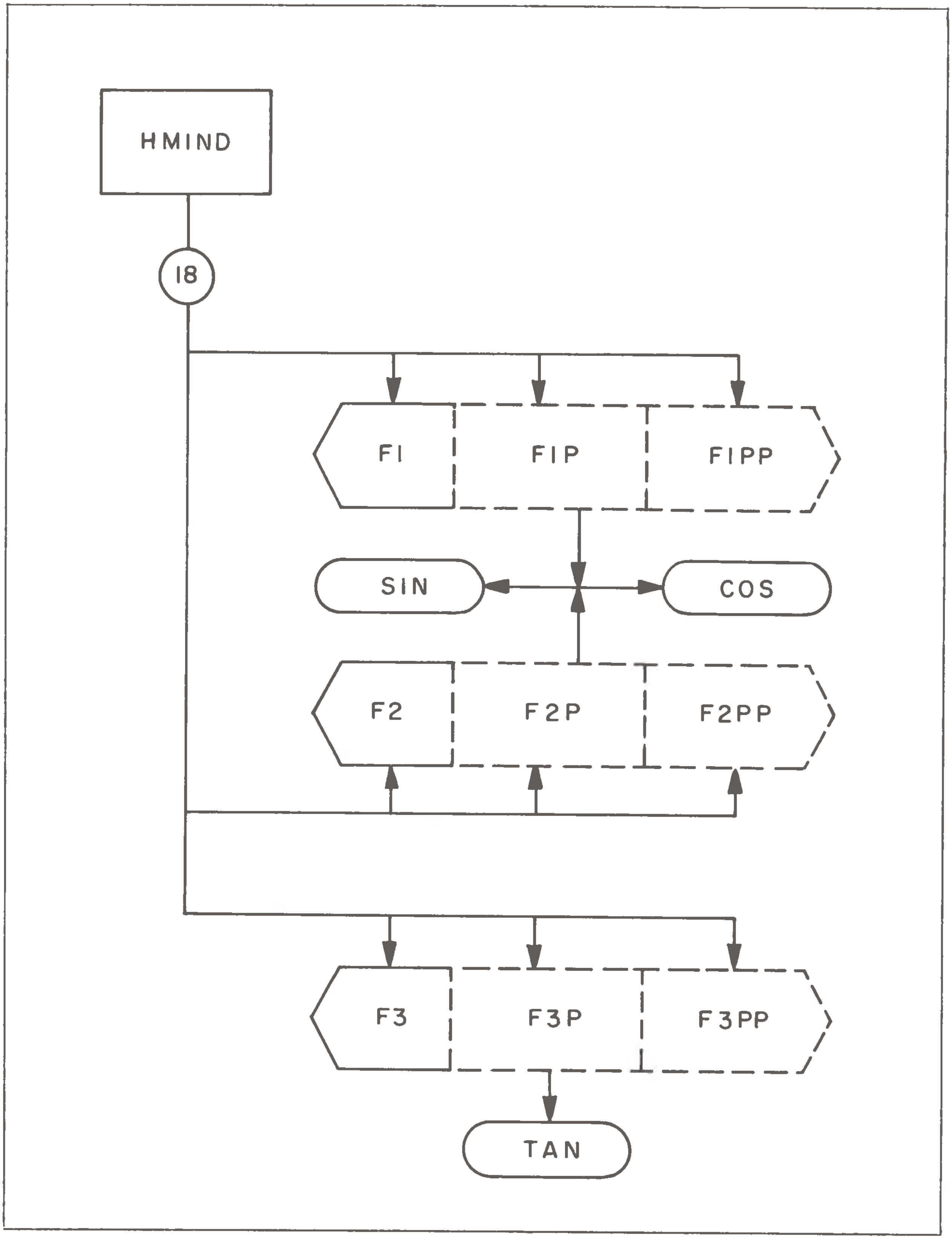

EXPWE
14
HBETA
15
ENT 2
ENT 3
ALOG IO
ENT 4
BNOISE
EXP
GENFN
FTTOM
ARSIN
19
ATTENU
20
IEXT
ENT 5W
ALOG IO

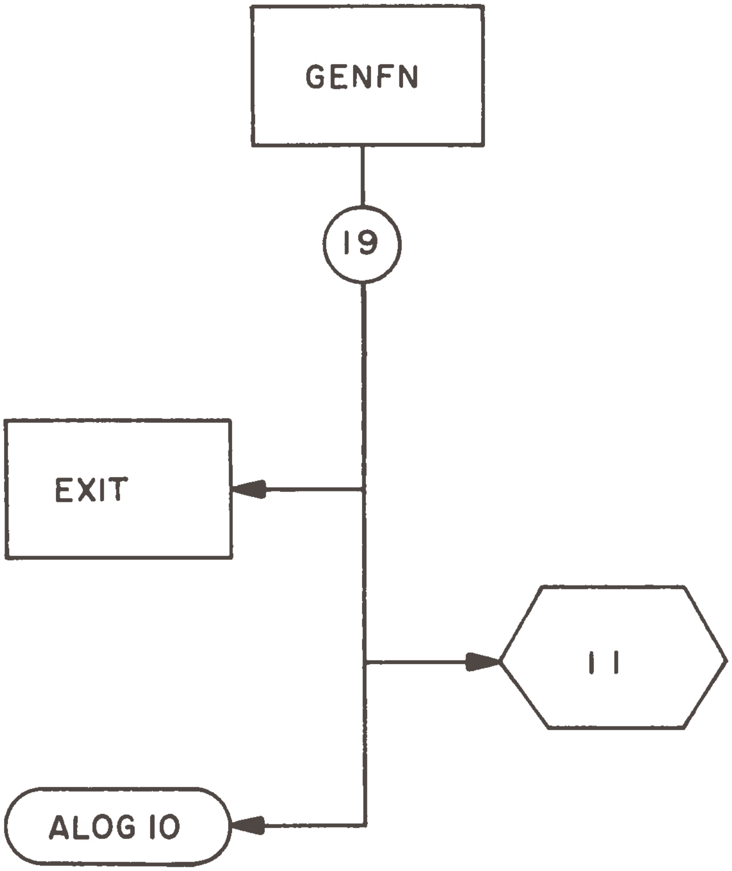

HBETA
15
VCTPRP
16
VSUB
VSCL
FALLIN
THRST
VADD
VMAG
6
HELMN
17
VADD
VSUB
SEGCH
VMAG
6

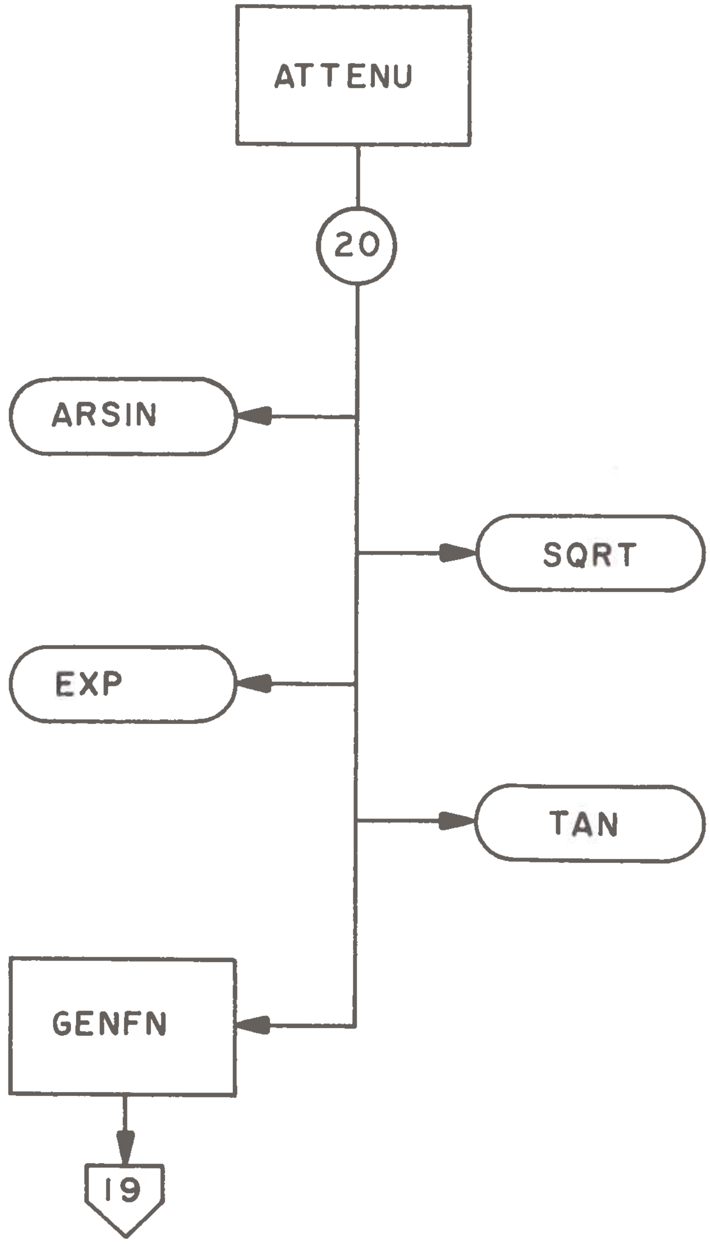


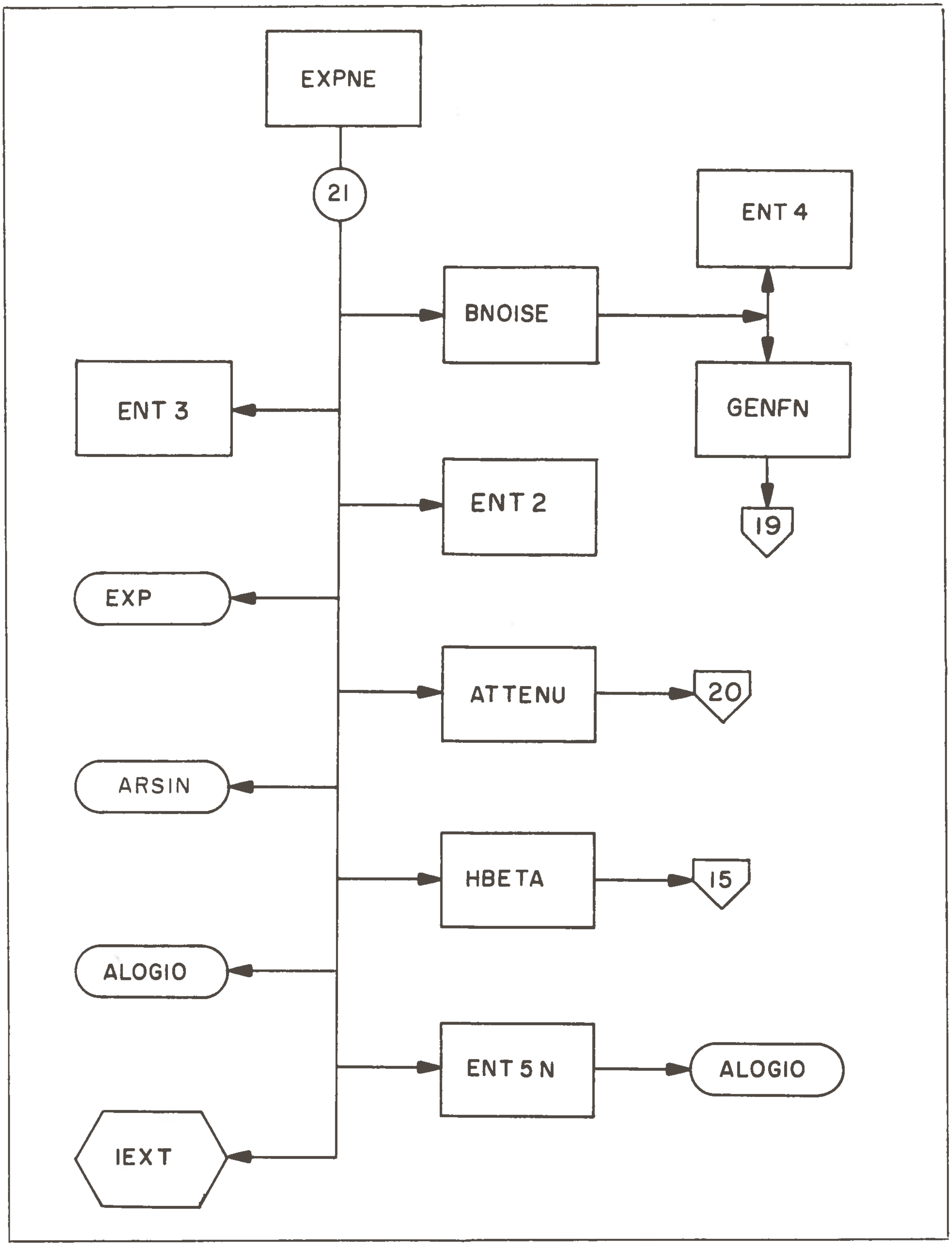
VCTPRP
16
VSUB
VDOT
VSCL

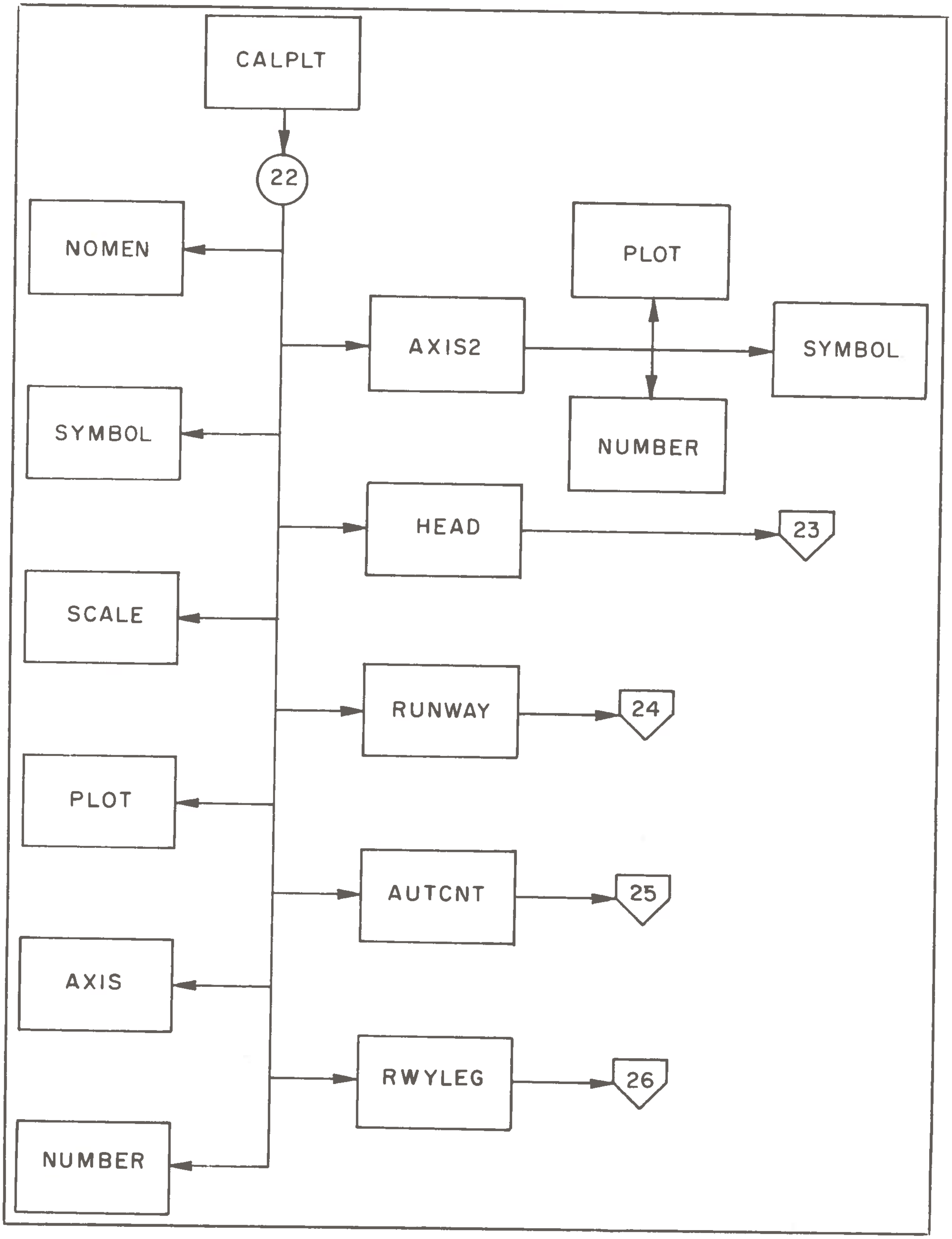

HELMN
17
PARSUI
7
VMAG
6
HMIND
18

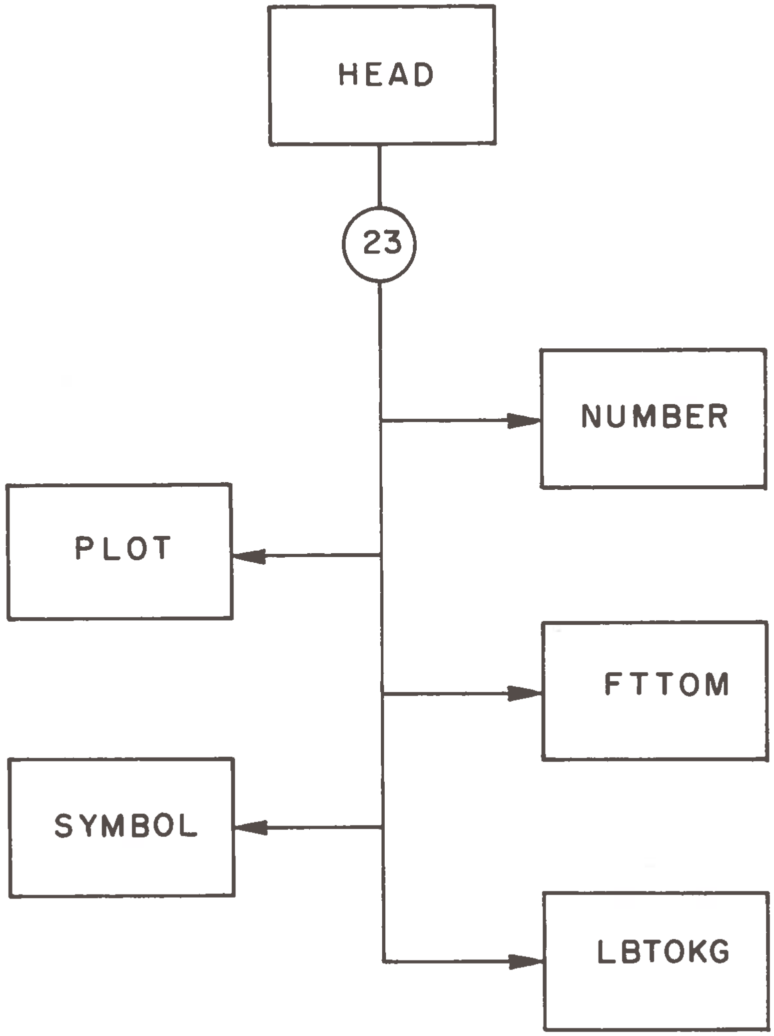

HMIND
18
F1
F1P
F1PP
SIN
COS
F2
F2P
F2PP
F3
F3P
F3PP
TAN

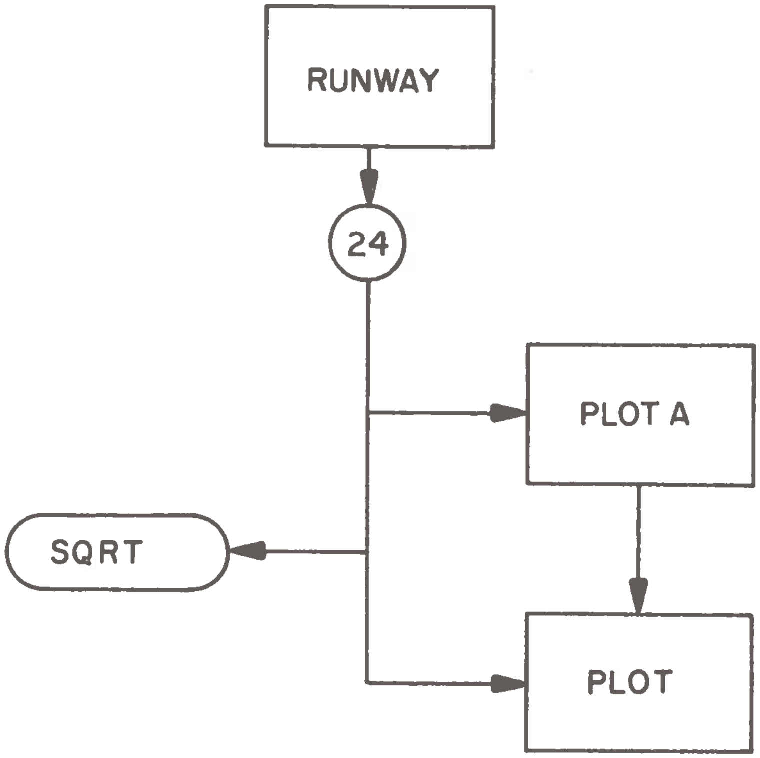

GENFN
19
EXIT
11
ALOG 10

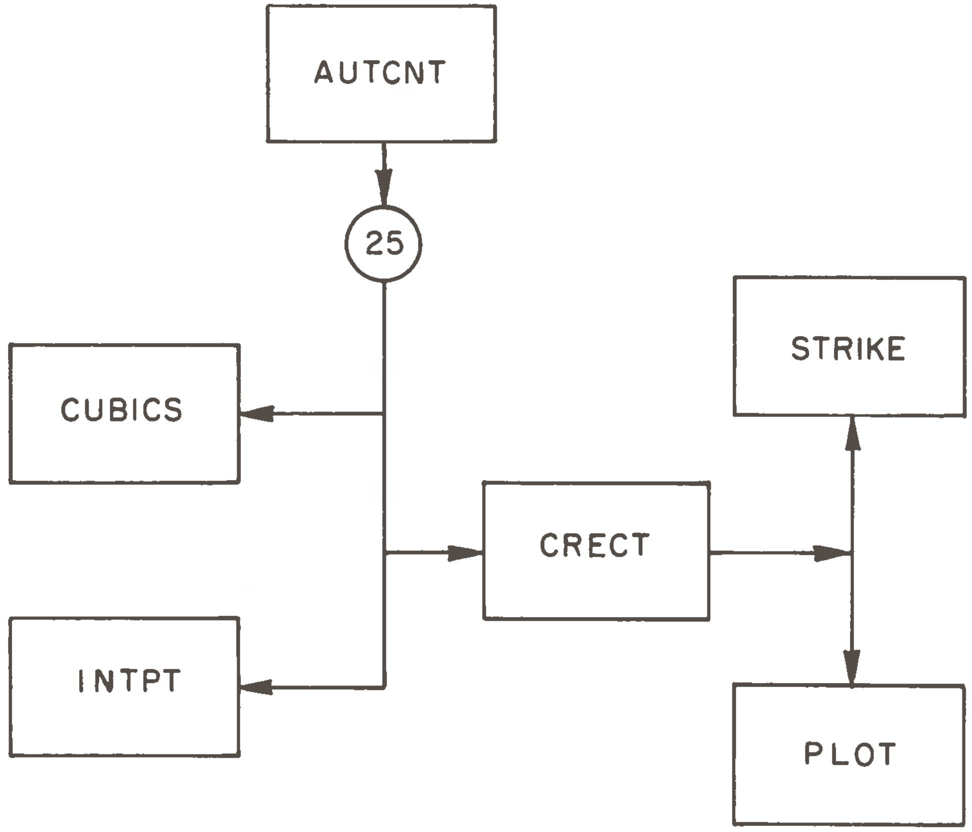

ATTENU
20
ARSIN
SQRT
EXP
TAN
GENFN
19

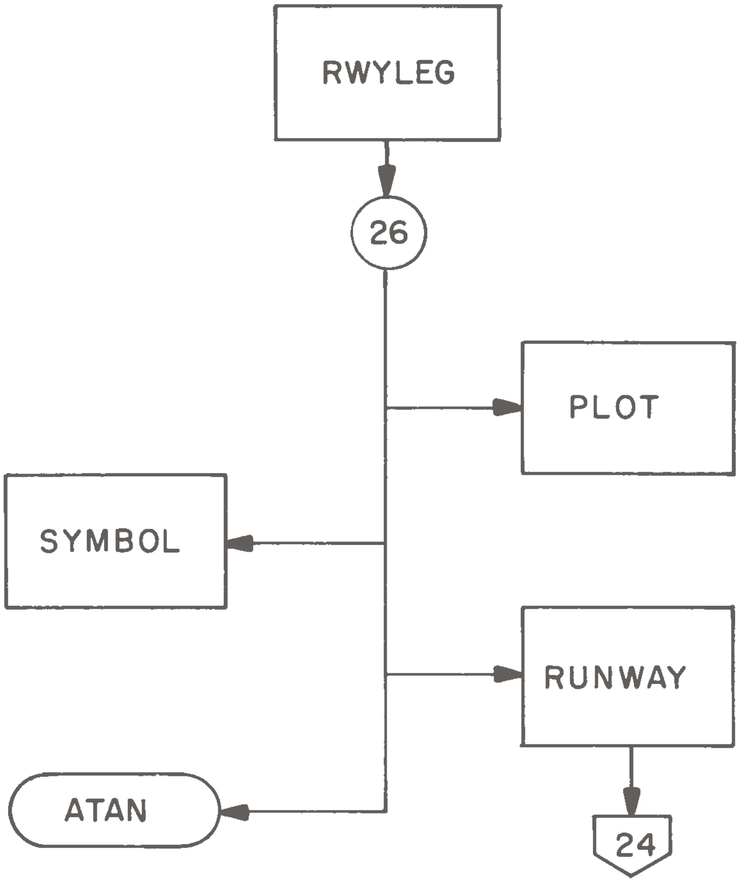

EXPNE
21
ENT 4
BNOISE
ENT 3
GENFN
ENT 2
19
EXP
ATTENU
20
ARSIN
HBETA
15
ALOGIO
ENT 5 N
ALOGIO
IEXT


CALPLT
22
NOMEN
PLOT
AXIS2
SYMBOL
SYMBOL
NUMBER
HEAD
23
SCALE
RUNWAY
24
PLOT
AUTCNT
25
AXIS
RWYLEG
26
NUMBER


HEAD
23
NUMBER
PLOT
FTTOM
SYMBOL
LBTOKG


RUNWAY
24
PLOT A
SQRT
PLOT


AUTCNT
25
CUBICS
CRECT
STRIKE
INTPT
PLOT


RWYLEG
26
PLOT
SYMBOL
RUNWAY
ATAN
24

Description of Each Routine

This section describes the main program and all the subroutines.

MAIN PROGRAM

The MAIN program is the overall control program. It calls the READIN subroutine to read the input instructions/data and, on return, branches to either the initialization-and-processing section, the NEWSET section, or the ENDRUN section. For the last two returns, the MAIN program determines if CALCOMP plotting is to be done, in which case the subroutine CALPLT is called.

SUBROUTINE GENFN (M,X,MVAR,XXX)

GENFN performs a linear or log-linear interpolation or extrapolation on tables stored in its DATA statements. It does this by isolating the correct interval of a finite set that represents the curve, and then it proceeds to interpolate. Only the X-axis may be a log scale.

M	The number of the curve of interest.
X	X-value for which corresponding Y-value is desired.
MVAR	Indicator of type of quantity X-axis represents.
XXX	Interpolated Y-value.

FUNCTION II(N1, N2)

II is a function subroutine which calculates the number of the middle interval between the intervals N1 and N2. It is used for isolating the interval of the X-value for interpolation purposes.

N1	Number of left-most interval under consideration.
N2	Number of right-most interval under consideration.

SUBROUTINE VUNT (C,A)

VUNT calculates the unit vector in the direction of any general vector.

C	Resulting unit vector.
A	Input vector.

FUNCTION VDOT (A,B)

VDOT is a function subroutine which calculates the dot product of any two general vectors A and B.

A	Input vector.
B	Input vector.

SUBROUTINE VCROS (C,A,B)

VCROS calculates the vector cross product of any two general vectors (i.e., C=AxB).

C	Vector cross product.
A	First vector.
B	Second vector.

SUBROUTINE VADD (C,A,B)

VADD calculates the sum of two vectors (i.e., C=A+B)

C	Vector sum.
A	Vector addend.
B	Vector addend.

SUBROUTINE VSUB (C,A,B)

VSUB calculates the difference of two vectors (i.e., C=A-B).

C	Vector difference
A	Vector minuend.
B	Vector subtrahend.

SUBROUTINE VSCL (C,F,A)

VSCL calculates the vector scalar product (i.e., C=FA).

C	Vector scalar product.
F	Scalar.
A	Vector.

SUBROUTINE VMAG (A,XXX)

VMAG calculates the magnitude of a vector.

A	Input vector.
XXX	Scalar magnitude.

SUBROUTINE BNOISE (TAC, HX)

BNOISE calculates the EPNdB value associated with the aircraft type and distance from observer to flight path.

TAC	Aircraft type number.
HX	Perpendicular distance from observer to flight path.

SUBROUTINE DATA (J)

DATA calculates the unit vector of the flight path segment on the runway and the distances of the touchdown and take-off roll points from the start of the runway.

J	Runway number.

SUBROUTINE ATTENU (SB,HX, FTT, XXX)

ATTENU calculates the ground attenuation as a function of the distance to the observer and the observer's elevation angle.

SB	Sine of the elevation angle from observer to flight path.
HX	Perpendicular distance from observer to flight path.
FTT	$\begin{cases} \neq 0 & \text{landing.} \\ = 0 & \text{takeoff.} \end{cases}$
XXX	Ground attenuation value.

SUBROUTINE SLPDS (NZ, ACWT, DIST, IE, XXX)

SLPDS calculates the tangent of the climbout or descent angle for takeoff and landing flights respectively. In the case of takeoffs, it also calculates the distance along the runway from start of takeoff ground roll to takeoff.

NZ	Aircraft type number (+ if takeoff, - if landing).
ACWT	Aircraft weight.
DIST	0. returned if landing; otherwise distance from start of takeoff ground roll to takeoff point.
IE	Error indicator set by subroutine.

XXX	Tangent of climbout or descent angle.

LOGICAL FUNCTION IBND (IV, IS,IH)

IBND is a function subroutine of LOGICAL type that assumes the value FALSE unless the first argument lies between the second and third arguments (i.e., $IS \leq IV \leq IH$). All arguments are of type INTEGER.

IV	Test value.
IS	Lower bound.
IH	Upper bound.

LOGICAL FUNCTION BND (V, S, H)

BND is a function subroutine of LOGICAL type which assumes the value FALSE unless the first argument lies between the second and third arguments (i.e., $S \leq U \leq H$). All arguments are of type REAL.

V	Test value.
S	Lower bound.
H	Upper bound.

FUNCTION DGTRD (DG)

DGTRD is a function subroutine which converts a quantity in degrees to radians.

DG	Quantity in degrees.

FUNCTION XINT (PT, Y)

XINT is a function subroutine which calculates the X-coordinate of the point lying on the straight-line segment between two given points.

PT	The array of length 4 containing the coordinates of the two given points stored thus: X_1, Y_1, X_2, Y_2.
Y	Y-coordinate of point of interest.

FUNCTION NACM (FL, ACT)

NACM is a function subroutine which assigns a positive sign to the aircraft type number for takeoffs and a negative sign for landings.

FL	0. takeoff. 1. landing.

ACT	Aircraft type number.

SUBROUTINE ENT2 (CAT, TW, PNF, IXX, FLT)

ENT2 is a diagnostic subroutine used to print intermediate values.

CAT	Aircraft type number.
TW	Aircraft weight.
PNF	Aircraft thrust in percent.
IXX	Aircraft profile number.
FLT	0. takeoff. 1. landing.

SUBROUTINE ENT3 (XQ, NQ, DQ)

ENT3 is a diagnostic subroutine used to print intermediate values.

XQ	Elevation angle from observer to flight path in degrees.
NQ	Number of operations (classified as day operations for NE calculations, as day-evening-night operations for WECPNL calculations, and as day-night operations for NEF calculations).
DQ	Distance from observer to flight path.

SUBROUTINE ENT4 (IFN, XCOR, XTH, XEPN)

ENT4 is a diagnostic subroutine used to print intermediate values.

IFN	Number of particular EPNdB vs distance curve.
XCOR	Correction to curve (of an additive nature).
XTH	Thrust correction to curve (because of varying thrust).
XEPN	Raw EPNdB value from curve.

SUBROUTINE ENT5N (XI, YI,ZI, XNEI,AXEI); SUBROUTINE ENT5W (XI, YI, ZI, XNEI, AXEI)

Subroutines ENT5N and ENT5W are diagnostic subroutines used for printout of intermediate values.

XI	Attenuation value.
YI	Shielding value.
ZI	Noise contribution from identical operations (day operations in ENT5N and day-evening-night operations in ENT5W).

XNEI	Net EPNdB value.
AXEI	EPNdB subtotal.

INTEGER FUNCTION IEXT (IS, JS)

IEXT is a function subroutine of the INTEGER type which gives the location in a set of arrays where information about the extension of a flight can be obtained. The total of all extensions is designated by NEXT. If the value KS, where $I \le KS \le NEXT$, corresponds to the first extension of some flight and some runway, then KS+I designates the second extension if there is one of the same flight and runway. KS denotes the location in the set of arrays at which information pertaining to the extension is available. If the given flight and runway have no extensions, then the value of 0 is returned by the function.

IS	Flight number.
JS	Runway number.

SUBROUTINE VCTPRP (POS, UNIT, PR, PRP)

VCTPRP calculates the vector V from a given point P to a given line L.

POS	Some point through which line L passes.
UNIT	A unit vector in direction of line L.
PT	The given point P.
PRP	Vector from point to line V.

FUNCTION THRST (TH1, TH2, X)

THRST is a function subroutine which adjusts the thrust between two segments of a flight path so that the transition of thrusts between the segments will be continuous.

TH1	Percent thrust on first segment.
TH2	Percent thrust on second segment.
X	Distance along second segment.

SUBROUTINE HBETA (HX, BETAS, PEN, MAXSET, OBR, ISEG, NFL)

HBETA calculates the distance from observer to each segment of the flight path, the elevation angle, and the percent thrust for a given runway, flight, and observer position. HBETA calls either subroutine VCTPRP to compute minimum distances to linear segments or subroutine HELMN to compute minimum distances to helical segments.

HX	Distance from observer to flight path.

BETAS	Sine of elevation angle of observer to flight path distance above plane of runway.
PEN	Percent thrust.
MAXSEG	Segment number which yields maximum noise.
OBR	Observer position.
ISEG	Number of segments for this flight.
NFL	Number of flight (cumulative over all flights).

SUBROUTINE DSTORE

DSTORE calculates from the input data the values of the arrays in the labeled COMMON block XNEW. These include the position vectors of the end points of the segments of each flight and the unit vectors in the direction of the segments of each flight. For helical segments, DSTORE calls CENHEL to find the position vector of the center of the helix. If requested, DSTORE also prints a table of each flight's segments with the above information.

BLOCK DATA

The BLOCK DATA subprogram assigns via DATA statements values to such quantities as number of aircraft types, take-off profile data, elevation angles for various aircraft weights, scaling constants, common mathematical constants, and noise exposure constants.

SUBROUTINE POINTS

POINTS calculates either the Noise Exposure values (NE), the Noise Exposure Forecast values (NEF), or the Weighted Equivalent Continuous Perceived Noise Levels (WECPNL) throughout the points of a grid. The grid is defined via input in subroutine READIN.

SUBROUTINE KGTOLB (A, IDIM)

KGTOLB converts kilograms to pounds.

A	Array of kilogram quantities converted to pounds.
IDIM	Dimension of array.

SUBROUTINE LBTOKG (A, IDIM)

KBTOKG converts pounds to kilograms.

A	Array of pounds quantities converted to kilograms.
IDIM	Dimension of array.

SUBROUTINE ELUV (NSEGM, NFL)

ELUV calculates the unit vector at the initial point of a flight segment,given the unit vector at the terminal point of the preceding flight segment and the elevation angle above the XY plane of the current segment.

NSEGM	Number of segment.
NFL	Number of flight (cumulative).

SUBROUTINE EXTARR

EXTARR sets up the extension information for flights with extensions in certain arrays, each of which describes some property of the extension.

SUBROUTINE HMIND (THET1, THET2, THET, VEC)

HMIND finds that value of the angle THET which yields the minimum distance from a point (the observer) to the helix. The components of the helix are defined in the function subprograms F1, F2, and F3 called HMIND. A Newton-Raphson iterative technique is used to solve the minimum distance equation for THET. Failure to converge is indicated by assigning the value -99999. to THET.

THET1	Angle in radians representing the lower bound of interval of interest (usually 0).
THET2	Angle in radians representing the upper bound of interval of interest.
THET	Angle in radians at which minimum distance occurs.
VEC	Minimum distance vector from observer position to helix.

SUBROUTINE HELMN (OBR, I, NFL, VEC, TH)

HELMN is the control subroutine which finds the minimum distance vector from an observer position to the helix and the angle at which this minimum occurs. The actual computations are done by HMIND, which is called by HELMN.

OBR	The observer position vector.
I	Segment number of helical segment.
NFL	Number of flight (cumulative).
VEC	Minimum distance vector from observer to helix.
TH	Angle in radians at which minimum distance occurs.

SUBROUTINE CENHEL (NSEGM, NFL)

CENHEL finds the position vector of the center of a helical segment and stores the vector in the array HELCN.

NSEGM	Segment number of helical segment.
NFL	Number of flight (cumulative).

FUNCTION F1(X); FUNCTION F2(X); FUNCTION F3(X)

F1, F2, and F3 are function subroutines which compute the three components respectively of the vector from the observer position to the point on the helix which subtends the central angle X (where X=0. corresponds to the start of the helix). Entry points also exist to calculate the first two derivatives of these components.

X	Central angle in radians subtended by point on helix.

SUBROUTINE SEGCH (NSEGM, NFL, OBR)

SEGCH chooses the flight path segment onto which the projected distance from an observer position falls and which yields the minimum distance. It does this by examining the array IDTOSI set up by subroutine FALLIN. If the projected distance does not fall within any of the flight segments, it chooses the appropriate segment according to an algorithm.

NSEGM	Returned segment number.
NFL	Number of flight (cumulative).
OBR	Observer position.

SUBROUTINE READIN (INDEX)

READIN is the master input subroutine that reads all the instructions/data cards following the $DATA control card. Whenever a PROCES card is read, it returns control to the MAIN program with INDEX set to 1 to signal that processing should commence; finally when an ENDRUN is read, INDEX is set to 3 and return indicates that execution is to end.

SUBROUTINE PARSUI (OBR, NSEGM, NFL)

PARSUI calculates the appropriate values for the parameters in the labeled COMMON block CHELX used by the function subprograms F1, F2, and F3.

OBR	Observer position.
NSEGM	Segment number.

NFL	Number of flight (cumulative).

SUBROUTINE FNHEV (TH, VEC)

FNHEV finds the vector from the center of the helix to the helix for any given angle TH (TH=0. is the start of the helix).

TH	Angle in radians.
VEC	Vector from center of helix to helix.

SUBROUTINE FUDVH (TH, VECI)

FUDVH finds the unit vector which is tangent to the helix and in the direction of flight at the angle TH (TH=0. is the start of the helix).

TH	Angle in radians.
VECI	Tangential unit vector.

SUBROUTINE MTOFT (A, IDIM)

MTOFT converts meters to feet.

A	Array of meter quantities converted to feet.
IDIM	Dimension of array.

SUBROUTINE FTTOM (A, IDIM)

FTTOM converts feet to meters.

A	Array of feet quantities converted to meters.
IDIM	Dimension of array.

SUBROUTINE EXPNE (DUMY, XXX); SUBROUTINE EXPWE (DUMY, XXX)

EXPNE and EXPWE are the overall control programs for calculating the NE, NEF, and WECPNL values respectively. Although the algorithms are slightly different, each subroutine essentially first calculates the distance and elevation angle of the observer position to the proper flight path segment and the runway under consideration; from that, the EPNdB value is computed and then modified for ground attenuation, shielding, and identical operations to get a noise value for that particular flight and runway. Finally, a weighted addition is performed for all flights and all runways to get the NE, NEF, or WECPNL values respectively.

DUMY	Dummy argument.
XXX	NE, NEF, or WECPNL value.

SUBROUTINE CONTR

CONTR computes the contour associated with a specific NE, NEF, or WECPNL value, using the Newton-Raphson iterative technique for the Y value associated with a given X value and given NE or WECPNL value. Failure to converge after 6 iterations terminates the processing for that contour.

SUBROUTINE FALLIN (INSEGM, NFL, X)

FALLIN determines whether a projected observer point lies within or outside a given segment of a flight path. If outside the segment, it determines whether it lies before or after (in a chronological sense) the segment. It also indicates whether it is unable to determine where the projected point lies in relation to the segment or if there is no projected point.

NSEGM	Segment number of flight.
NFL	Flight number (cumulative).
X	-100. linear segment. -99999. previously unable to determine projected point to helical segment; otherwise, angle in radians associated with projected point onto helical segment.

SUBROUTINE HEAD (NUM)

HEAD is the subroutine which plots detailed text descriptions of the flights constituting the run. Since it is detailed, it is not called when the number of distinct flights exceeds 10.

NUM	Total number of flights.

SUBROUTINE PLOTA (X, Y, I)

PLOTA is a subroutine which performs the same function as the CALCOMP subroutine PLOT except that the point X, Y is rotated before plotting a specified angle about a specified point. The specified angle and specified point are contained in the labeled COMMON block IANG. PLOTA is used, for example, to draw runways at various angles.

X, Y	Coordinates of point under consideration before rotation.
I	Same argument as in PLOT subroutine.

SUBROUTINE AXIS2 (X0, Y0, AMAX, AMIN, DELX, AINCH, BCD, NCH, NDEC, DELN)

AXIS2 is a subroutine used in place of the CALCOMP subroutine AXIS when data are to be scaled to an axis rather than the axis being fitted to the data.

X0, Y0	Coordinates of starting point of axis.
AMAX, AMIN	Maximum and minimum values on axis.
DELX	The increment along the axis at which tic marks and labeling will occur.
AINCH	The length of the axis in inches; if negative, horizontal axis is drawn, and if positive, a vertical axis is drawn.
BCD	The title for the axis.
NCH	Number of characters in the title.
NDEC	The number of decimal places on the numerical labels at tic marks; if -1, no decimal places and no decimal point are drawn.
DELN	Scale value to be used in scaling data to this axis; this value is returned by AXIS2.

SUBROUTINE ALINE (X, Y, N, XM, DELX, YM, DELY)

ALINE is a subroutine which draws a line connecting a set of points to user-specified scaling.

X	Array of X-coordinates of set of points.
Y	Array of corresponding Y-coordinates of set of points.
N	Number of points in each array.
XM	Minimum value on X-axis.
YM	Minimum value on Y-axis.
DELX	Increment along X-axis.
DELY	Increment along Y-axis.

SUBROUTINE CALPLT

CALPLT is the main subroutine which controls CALCOMP plotting. It performs appropriate conversions, sets up the FLIGHT array for plotting detailed text flight descriptions (provided the number of flights is not greater than 10), draws the axes with proper labeling, calls the RUNWAY subroutine to plot the runways, calls the NOMEN subroutine for optional additional labeling, and calls the AUTCNT subroutine up to three times to generate contour plots for a specified noise value. It also notifies the CALCOMP operator when to change pen colors.

SUBROUTINE INIPLT

INIPLT initializes and finalizes the CALCOMP plotter capability. It also calls the subroutine FACTOR to scale the entire plotting data to either the small-size or large-size plot paper. The entry for finalization is FINPLT.

SUBROUTINE RUNWAY (X1, Y1, X2, Y2)

RUNWAY draws the runway with specified coordinates on the CALCOMP plotter.

X1, Y1	Coordinates of runway point A.
X2, Y2	Coordinates of runway point D.

APPENDIX A

Suggested coding work sheets for Noise Exposure Model MOD 4

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

Form NA-1

STATEMENT

Name 1–8	Operation 10–14 / Operand / Comments
TITLEE	
NEEVAL	(select one control instruction only)
NEFCAL	
WECPNL	
FEETLB	(select one control instruction only)
MKSSYS	
PRTALL	
DIAGL0	(select none or one control instruction)
DIAGL1	
DIAGL3	
CLCMPS	(select one control instruction only)
CLCMPL	

SAMPLE CODING SHEET NA-1

Noise Exposure Model MOD 4

Control Option Selection Sheet

SAMPLE CODING SHEET NA-2

Noise Exposure Model MOD 4

Runway Coding Sheet

Form NA-2

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

STATEMENT

Name | Operation | Operand | Comments

1 8 10 14 16 20 25 30 35 40 45 50 55 60

```
RUNWAY
XCOORD           .                .
YCOORD           .                .
ZCOORD           .                .
TKGDRL           .
TCHDWN           .
NOFLTS           .
```

SAMPLE CODING SHEET NA-3

Noise Exposure Model MOD 4

Flight Coding Sheet

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC				
PROGRAMMER	DATE		PUNCH				

Form NA-3

STATEMENT

Name 1	Operation 8 10 14	Operand 16 20 25 30 35 40 45 50	Comments 55 60
FLIGHT			
LANDNG			
TAKOFF			
ACWGHT		.	
THRUST		.	
ACTYPE		.	
NDAYOP		.	
NEVNOP		.	
NNGTOP		.	
NOEXTS		.	
PRSEG1		.	
CLIMBA		.	
PRSEG2		.	
EXTNSN			
EXTENT		.	
ELEVAT		.	
THRUST		.	
RADIUS		.	
EXTNSN			
EXTENT		.	
ELEVAT		.	
THRUST		.	
RADIUS		.	

SAMPLE CODING SHEET NA-3A

Noise Exposure Model MOD 4

Additional Extensions Coding Sheet

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC
PROGRAMMER	DATE		PUNCH

Form NA-3A

STATEMENT

Name	Operation	Operand	Comments
1 – 8	10 – 14	16 – 20 – 25 – 30 – 35 – 40 – 45 – 50 – 55	60

```
EXTNSN
EXTENT           .
ELEVAT           .
THRUST           .
RADIUS           .

EXTNSN
EXTENT           .
ELEVAT           .
THRUST           .
RADIUS           .

EXTNSN
EXTENT           .
ELEVAT           .
THRUST           .
RADIUS           .

EXTNSN
EXTENT           .
ELEVAT           .
THRUST           .
RADIUS           .
```

SAMPLE CODING SHEET NA-4

Noise Exposure Model MOD 4

Grid Specifications Coding Sheet

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC	
PROGRAMMER	DATE		PUNCH	

Form NA-4

STATEMENT

```
Name      Operation      Operand                                Comments
1      8 10       14 16   20    25    30    35    40    45    50    55    60
GRIDCL
DELTAX           .
DELTAY           .
FIRSTX           .
FIRSTY           .
NOOFXS           .
NOOFYS           .
PROCES

ENDRUN
```

APPENDIX B

Sample problem to illustrate use of Noise Exposure Model MOD 4

Sample Problem

To assist in explaining the actual use of the Noise Exposure Model MOD 4 and to illustrate the type of results the model produces, this sample problem is included, along with copies of the associated coding sheets and the printed computer results. This sample problem includes only two runways and 14 flights. Note that 20 flights are actually listed in the description of daily operations given below, but that several types of aircraft fall into the same classification (for example, both the DC-9 and BAC-111 aircraft are two-engine LBPR turbofan types). Thus, only 14 flights are needed for the model computation. The typical airport for which noise exposure calculations are required will be considerably more elaborate.

Sample Airport requires Noise Exposure Forecast (NEF) contours for 1975. Sample Airport consists of two runways: the 4000-meter-long Runway 3-21, and the 3000-meter-long Runway 8-26 (see Figure B-1). The aircraft using this airport follow reasonably well-defined paths for both takeoffs and landings. Because of a residential area east of the airport, aircraft taking off on Runway 8 and continuing eastward are required to throttle back at a 4% climb at a distance 12,000 meters from the end of the runway. The latest prediction for numbers, types, and distribution of daily operations at Sample Airport for 1975 were provided as follows (again see Figure B-1) for clarity):

Runway 8 - Flight Path A (landings):

Flight A-1	727-type aircraft	43 daytime	14 nighttime
A-2	DC-9-type aircraft	32	7
A-3	BAC-111-type aircraft	6	2

Runway 8 - Flight Path B (takeoffs):

Flight B-1	727-type aircraft (57,000 kg)	29 daytime	2 nighttime
B-2	727-type aircraft (72,000 kg)	8	3
B-3	DC-9-type aircraft (40,000 kg)	24	2
B-4	BAC-111-type (42,000 kg)	4	0

Runway 8 - Flight Path C (takeoffs):

Flight C-1	727-type aircraft (57,000 kg)	8 daytime	2 nighttime
C-2	727-type aircraft (72,000 kg)	5	0
C-3	DC-9-type aircraft (40,000 kg)	10	3
C-4	BAC-111-type (42,000 kg)	3	1

Runway 21 - Flight Path D (landings):				
Flight	D-1	747-type aircraft	7 daytime	2 nighttime
	D-2	707-320B/C types	23	12
	D-3	DC-8-50/60 types	15	9
Runway 21 - Flight Path E (takeoffs):				
Flight	E-1	747-type aircraft (200,000 kg)	6 daytime	1 nighttime
	E-2	707-320B/C types (95,000 kg)	15	7
	E-3	DC-8-50/60 types (95,000 kg)	9	4
Runway 21 - Flight Path F (takeoffs):				
Flight	F-1	747-type aircraft (200,000 kg)	2 daytime	0 nighttime
	F-2	707-320B/C types (95,000 kg)	10	3
	F-3	DC-8-50/60 types (95,000 kg)	9	2
Total operations			268 daytime	76 nighttime
			344 operations/day	

Sample coding sheets and the computer printout follow, for purposes of illustrating the use of the Noise Exposure Model, MOD 4. Not all of the coding sheets are included, to reduce the size of the report, but all of the input data is shown in the computer printout. Recall that columns 41 and beyond are not used for computational purposes, but can be used for comments. In the sample which follows, this feature has been used to label each runway and each flight for bookkeeping purposes.

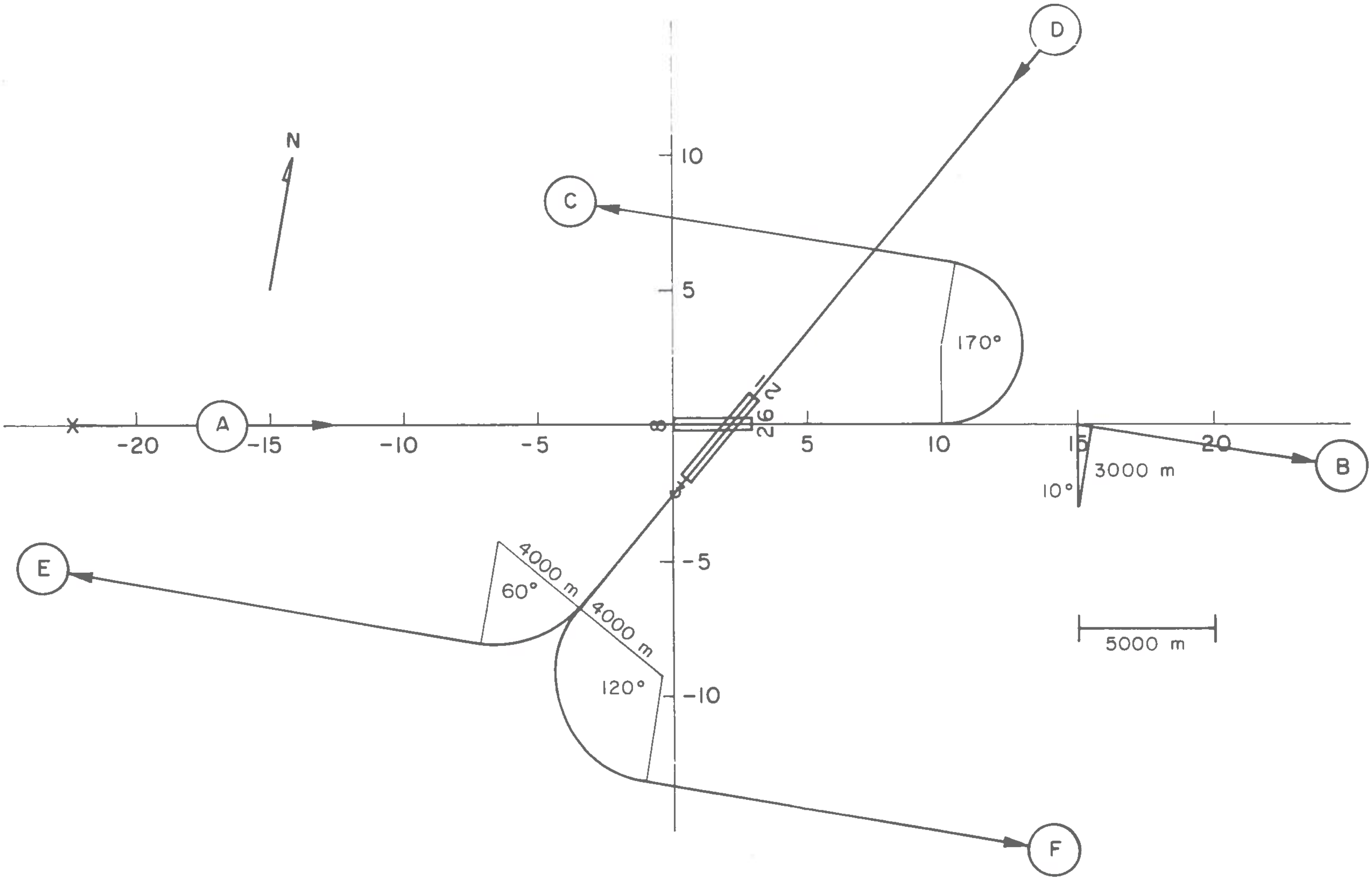


Figure B-1. Sample Airport

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

Form NA-1

STATEMENT

Name 1–8	Operation 10–14	Operand 16–
TITLEE		
SAMPLE A	IRPORT	1975
~~NEEVAL~~		
NEFCAL		
~~WECPNL~~		
~~FEETLB~~		
MKSSYS		
PRTALL		
~~DIAGL0~~		
~~DIAGL1~~		
~~DIAGL3~~		
CLCMPS		
~~CLCMPL~~		

Control Option Selection Sheet indicates name of problem and specifies NEF calculations, using the metric system, printing input and output data, with contour plots on the small CALCOMP.

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

Form NA-2

STATEMENT

Name	Operation	Operand	Comments

```
RUNWAY                                  8
XCOORD          0.            3000.
YCOORD          0.               0.
ZCOORD          0.               0.
TKGDRL          0.
TCHDWN        300.
NOFLTS          8.
```

Runway Coding Sheet defines Runway 8.

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

Form NA-3

STATEMENT

Name	Operation	Operand	Comments
FLIGHT		A - 1	
LANDNG			
~~TAKOFF~~			
ACWGHT		57000.	
THRUST		45.	
ACTYPE		5.	
NDAYOP		43.	
~~NEVNOP~~		.	
NNGTOP		14.	
NOEXTS		0.	
~~PRSEG1~~		.	
~~CLIMBA~~		.	
~~PRSEG2~~		.	
~~EXTNSN~~			
~~EXTENT~~		.	
~~ELEVAT~~		.	
~~THRUST~~		.	
~~RADIUS~~		.	
~~EXTNSN~~			
~~EXTENT~~		.	
~~ELEVAT~~		.	
~~THRUST~~		.	
~~RADIUS~~		.	

Flight Coding Sheet defining a landing flight for a Type 5 aircraft (three-engine LBPR turbofan), using 45% thrust settings for engines during landing, with 43 landings of this type aircraft between 0700 and 2200 on an average day, and 14 landings between 2200 and 0700.

Flight Coding Sheet defining a landing flight for Type 6 aircraft (two-engine LBPR turbofan), with 45% engine thrust settings, including 38 daytime landings (between 0700 and 2200) and 9 nighttime landings (between 2200 and 0700). Note that landings for the specified DC-9 and BAC-111 aircraft types have been considered together, since both are Type 6 (two-engine LBPR turbofan) aircraft.

Form NA-3

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

STATEMENT

Name	Operation	Operand	Comments
FLIGHT			A - 2
LANDNG			
~~TAKOFF~~			
ACWGHT		40000.	
THRUST		45.	
ACTYPE		6.	
NDAYOP		38.	
~~NEVNOP~~		.	
NNGTOP		9.	
NOEXTS		0.	
~~PRSEG1~~		.	
~~CLIMBA~~		.	
~~PRSEG2~~		.	
~~EXTNSN~~			
~~EXTENT~~		.	
~~ELEVAT~~		.	
~~THRUST~~		.	
~~RADIUS~~		.	
~~EXTNSN~~		.	
~~EXTENT~~		.	
~~ELEVAT~~		.	
~~THRUST~~		.	
~~RADIUS~~		.	

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

Form NA-3

STATEMENT

B - 3

Name	Operation	Operand	Comments
FLIGHT			
~~LANDNG~~			
TAKOFF			
ACWGHT		57000.	
THRUST		100.	
ACTYPE		5.	
NDAYOP		29.	
~~NEVNOP~~		.	
NNGTOP		2.	
NOEXTS		2.	
~~PRSEG1~~		.	
~~CLIMBA~~		.	
PRSEG2		13325.	
EXTNSN			
EXTENT		10.	
ELEVAT		2.3	
THRUST		60.	
RADIUS		30000.	
EXTNSN			
EXTENT		0.	
ELEVAT		2.3	
THRUST		60.	
RADIUS		0.	

Flight Coding Sheet defining a takeoff flight for Type 5 aircraft (three-engine LBPR turbofan), using 100% engine thrust settings during takeoff, and 29 takeoffs during the daytime, 2 takeoffs during nighttime. The flight described as two extensions, requiring a 10° right turn using a 3000-meter radius, and then a straight climb. Both extensions include an engine thrust cutback to 75% thrust, with a corresponding decrease in climb angle to 2.3° (4% slope).

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC				
PROGRAMMER	DATE		PUNCH				

Form NA-3

STATEMENT

Name (1–8)	Operation (10–14)	Operand (16–)	Comments (55–60)
FLIGHT			B - 4
~~LANDNG~~			
TAKOFF			
ACWGHT		72000.	
THRUST		100.	
ACTYPE		5.	
NDAYOP		8.	
~~NEVNOP~~		.	
NNGTOP		3.	
NOEXTS		2.	
~~PRSEG1~~		.	
~~CLIMBA~~		.	
PRSEG2		12200.	
EXTNSN			
EXTENT		10.	
ELEVAT		2.3	
THRUST		75.	
RADIUS		3000.	
EXTNSN			
EXTENT		0.	
ELEVAT		2.3	
THRUST		75.	
RADIUS		0.	

Flight Coding sheet defining a takeoff flight for Type 5 aircraft (three-engine LBPR turbofan) with gross takeoff weight of 72,000 kilograms, 100% thrust setting, 8 daytime takeoffs and 3 nighttime takeoffs. Flight path includes a 10° right turn and noise-abatement thrust cutback.

PROGRAM

PROGRAMMER | DATE

PUNCHING INSTRUCTIONS | GRAPHIC | PUNCH

Form NA-3

STATEMENT

Name	Operation	Operand	Comments
FLIGHT		B - 5	
~~LANDNG~~			
TAKOFF			
ACWGHT		40000.	
THRUST		100.	
ACTYPE		6.	
NDAYOP		28.	
~~NEVNOP~~		.	
NNGTOP		2.	
NOEXTS		2.	
~~PRSEG1~~		.	
~~CLIMBA~~		.	
PRSEG2		13325.	
EXTNSN			
EXTENT		10.	
ELEVAT		2.3	
THRUST		55.	
RADIUS		3000.	
EXTNSN			
EXTENT		0.	
ELEVAT		2.3	
THRUST		55.	
RADIUS		0.	

Flight Coding Sheet describing a takeoff flight for Type 6 aircraft (two-engine LBPR turbofan), with 100% takeoff thrust setting, 10° right turn after takeoff, and thrust reduction to 55% thrust and 2.3° (4%) climb.

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC				
PROGRAMMER	DATE		PUNCH				

Form NA-3

STATEMENT

Name	Operation	Operand	Comments
FLIGHT			C -6
~~LANDNG~~			
TAKOFF			
ACWGHT		57000.	
THRUST		100.	
ACTYPE		5.	
NDAYOP		8.	
~~NEVNOP~~		.	
NNGTOP		2.	
NOEXTS		2.	
~~PRSEG1~~		.	
~~CLIMBA~~		.	
PRSEG2		8325.	
EXTNSN			
EXTENT		170.	
ELEVAT		9.58	
THRUST		100.	
RADIUS		-3000.	
EXTNSN			
EXTENT		0.	
ELEVAT		9.58	
THRUST		100.	
RADIUS		0.	

Flight Coding Sheet describing takeoff flight for Type 5 aircraft (three-engine LBPR turbofan), including a 170° left turn and continuous 100% thrust settings.

Grid Specifications Coding Sheet, specifying grid calculations at 2000-meter intervals from -18,000 meters to 20,000 meters in the X-direction, and from 15,000 meters to -15,000 meters in the Y-direction, with the resulting plot to label Runways 8 and 21, and plot NEF 30 and NEF 40 contours.

PROGRAM

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

STATEMENT

Form NA-4

Name 1 8 Operation 10 14 16 Operand 20 25 30 35 40 45 50 55 Comments 60

```
GRIDCL
DELTAX       2000.
DELTAY      -2000.
FIRSTX     -18000.
FIRSTY      15000.
NOOFXS         20.
NOOFYS         16.
PROCES
8     21
ENDRUN
30.0      40.0
```

```
$JOB 02001A 2 STC    FOREMAN MOD 4                010 010

00/00/71  TIME... 0000.00 MIN
           $IBSYS
           $ATTACH          B5
           $AS              SYSCK1
           $EXECUTE         IBJOB
IBJOB VERSION 5 HAS CONTROL.
$IBJOB         FIOCS
$IEDIT         SYSCK1,SRCH
$IBLDR MAIN
$IBLDR BLDA
$IBLDR KGLB
$IBLDR LBKG
$IBLDR MFT
$IBLDR FTM
$ORIGIN        ALPHA
$IBLDR SUMREX
$ORIGIN        ALPHA
$IBLDR POIX
$IBLDR GENF
$IBLDR I
$IBLDR VUN
$IBLDR DIT
$IBLDR CROS
$IBLDR ADD
$IBLDR SUB
$IBLDR SCL
$IBLDR MAG
$IBLDR NOISE
$IBLDR DAT
$IBLDR ATTX
$IBLDR SLP
$IBLDR IBN
$IBLDR BN
$IBLDR DGT
$IBLDR XIN
$IBLDR NAC
$IBLDR ET2
$IBLDR ET3
$IBLDR ET4
$IBLDR EX
$IBLDR VCT
$IBLDR THR
$IBLDR CNTX
$IBLDR FAIX
$IBLDR HBEX
$IBLDR F1X
$IBLDR F2X
$IBLDR F3X
$IBLDR SECX
$IBLDR PARX
$IBLDR FNHX
$IBLDR FUDX
$IBLDR FLUX
$IBLDR FXTX
```

Listing of control cards necessary to
run Noise Exposure Model MOD 4 from tape.

```
$ORIGIN         BETA
                                                          07/08/71            PAGE  1


$IBLDR EEXPWE
$IBLDR ET5W
$ORIGIN         BETA
$IBLDR STORE
$ORIGIN         ALPHA
$IBLDR SUB5CF
$ORIGIN         ALPHA
$IBLDR CALPWM
$IBLDR RWLGX
$IBLDR INIP
$IBLDR NOMX
$IBLDR REF
$IBLDR RUN
$IBLDR DLIN
$IBLDR PTA
$IBLDR LNE
$IBLDR AXE2
$ORIGIN         GAMMA
$IBLDR HD
$ORIGIN         GAMMA
$IBLDR ACXX
$IBLDR CRECX
$IBLDR CURX
$IBLDR ITPTX
$IBLDR STRKX
$IEDIT          SYSIN1
$DATA
```

```
TITLEE
SAMPLE APT 1975 (H8)
NEFCAL
MKSSYS
PRTALL
CLCMPS
RUNWAY
XCOORD          0.00000      3000.00000
YCOORD          0.00000         0.00000
ZCOORD          0.00000         0.00000
TKGDRL          0.00000
TCHDWN        300.00000
NOFLTS          8.00000
FLIGHT
LANDNG
ACWGHT      57000.00000
THRUST         45.00000
ACTYPE          5.00000
NDAYOP         43.00000
NNGTOP         14.00000
NOEXTS          0.00000
FLIGHT
LANDNG
ACWGHT      40000.00000
THRUST         45.00000
ACTYPE          6.00000
NDAYOP         39.00000
NNGTOP          9.00000
NOEXTS          0.00000
FLIGHT
TAKOFF
ACWGHT      57000.00000
THRUST        100.00000
ACTYPE          5.00000
NDAYOP         29.00000
NNGTOP          2.00000
NOEXTS          2.00000
PRSEG2      13325.00000
EXTNSN
EXTENT         10.00000
ELEVAT          2.30000
THRUST         60.00000
RADIUS       3000.00000
EXTNSN
EXTENT          0.00000
ELEVAT          2.30000
THRUST         60.00000
RADIUS          0.00000
FLIGHT
TAKOFF
ACWGHT      72000.00000
THRUST        100.00000
ACTYPE          5.00000
NDAYOP          8.00000
NNGTOP          3.00000
NOEXTS          2.00000
PRSEG2      12200.00000
```

Computer listing of input data.

```
EXTNSN
EXTENT        10.00000
ELEVAT         2.30000
THRUST        75.00000
RADIUS      3000.00000
EXTNSN
EXTENT         0.00000
ELEVAT         2.30000
THRUST        75.00000
RADIUS         0.00000
FLIGHT
TAKOFF
ACWGHT     40000.00000
THRUST       100.00000
ACTYPE         6.00000
NDAYOP        28.00000
NNGTOP         2.00000
NOEXTS         2.00000
PRSEG2     13325.00000
EXTNSN
EXTENT        10.00000
ELEVAT         2.30000
THRUST        55.00000
RADIUS      3000.00000
EXTNSN
EXTENT         0.00000
ELEVAT         2.30000
THRUST        55.00000
RADIUS         0.00000
FLIGHT
TAKOFF
ACWGHT     57000.00000
THRUST       100.00000
ACTYPE         5.00000
NDAYOP         8.00000
NNGTOP         2.00000
NOEXTS         2.00000
PRSEG2      8325.00000
EXTNSN
EXTENT       170.00000
ELEVAT         9.58000
THRUST       100.00000
RADIUS     -3000.00000
EXTNSN
EXTENT         0.00000
ELEVAT         9.58000
THRUST       100.00000
RADIUS         0.00000
FLIGHT
TAKOFF
ACWGHT     72000.00000
THRUST       100.00000
ACTYPE         5.00000
NDAYOP         5.00000
NNGTOP         0.00000
NOEXTS         2.00000
PRSEG2      7200.00000
```

```
EXTNSN
EXTENT        170.00000
ELEVAT          6.00000
THRUST        100.00000
RADIUS      -3000.00000
EXTNSN
EXTENT          0.00000
ELEVAT          6.00000
THRUST        100.00000
RADIUS          0.00000
FLIGHT
TAKOFF
ACWGHT      40000.00000
THRUST        100.00000
ACTYPE          6.00000
NDAYOP         13.00000
NNGTOP          4.00000
NOEXTS          2.00000
PRSEG2       8325.00000
EXTNSN
EXTENT        170.00000
ELEVAT          9.58000
THRUST        100.00000
RADIUS      -3000.00000
EXTNSN
EXTENT          0.00000
ELEVAT          9.58000
THRUST        100.00000
RADIUS          0.00000
RUNWAY
XCOORD       3000.00000       500.00000
YCOORD       1000.00000     -2000.00000
ZCOORD          0.00000         0.00000
TKGDRL          0.00000
TCHDWN        300.00000
NOFLTS          6.00000
FLIGHT
LANDNG
ACWGHT     200000.00000
THRUST         45.00000
ACTYPE          1.00000
NDAYOP          7.00000
NNGTOP          2.00000
NOEXTS          0.00000
FLIGHT
LANDNG
ACWGHT      95000.00000
THRUST         45.00000
ACTYPE          3.00000
NDAYOP         39.00000
NNGTOP         21.00000
NOEXTS          0.00000
FLIGHT
TAKOFF
```

```
ACWGHT      200000.00000
THRUST         100.00000
ACTYPE           1.00000
NDAYOP           6.00000
NNGTOP           1.00000
NOEXTS           2.00000
PRSEG2        8325.00000
EXTNSN
EXTENT          60.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS        4000.00000
EXTNSN
EXTENT           0.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS           0.00000
FLIGHT
TAKOFF
ACWGHT       95000.00000
THRUST         100.00000
ACTYPE           3.00000
NDAYOP          24.00000
NNGTOP          11.00000
NOEXTS           2.00000
PRSEG2        8325.00000
EXTNSN
EXTENT          60.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS        4000.00000
EXTNSN
EXTENT           0.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS           0.00000
FLIGHT
TAKOFF
ACWGHT      200000.00000
THRUST         100.00000
ACTYPE           1.00000
NDAYOP           2.00000
NNGTOP           0.00000
NOEXTS           2.00000
PRSEG2        8325.00000
EXTNSN
EXTENT         120.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS       -4000.00000
EXTNSN
EXTENT           0.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS           0.00000
FLIGHT
TAKOFF
```

```
ACWGHT       95000.00000
THRUST         100.00000
ACTYPE           3.00000
NDAYOP          19.00000
NNGTOP           5.00000
NOEXTS           2.00000
PRSEG2        8325.00000
EXTNSN
EXTENT         120.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS       -4000.00000
EXTNSN
EXTENT           0.00000
ELEVAT           9.58000
THRUST         100.00000
RADIUS           0.00000
GRIDCL
DELTAX        2000.00000
DELTAY       -2000.00000
FIRSTX      -18000.00000
FIRSTY       15000.00000
NOOFXS          20.00000
NOOFYS          16.00000
PROCES
```

```
***POSITION VECTORS OF END POINTS OF SEGMENTS, UNIT VECTORS OF SEGMENTS, AND POSITION VECTORS OF HELIX CENTERS***

RUNWAY  1    FLIGHT  1   NO. OF EXTENSIONS  0
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1     45.0     1909.347       0.000        0.000        -1.000       -0.000       -0.000
  2     45.0      300.000      -0.000       -0.000        -0.999       -0.000        0.052

RUNWAY  1    FLIGHT  2   NO. OF EXTENSIONS  0
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1     45.0     1909.347       0.000        0.000        -1.000       -0.000       -0.000
  2     45.0      300.000      -0.000       -0.000        -0.999       -0.000        0.052

RUNWAY  1    FLIGHT  3   NO. OF EXTENSIONS  2
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1    100.0        0.000       0.000        0.000         1.000        0.000        0.000
  2    100.0     1676.403       0.000        0.000         0.986        0.000        0.167
  3     60.0    15001.403       0.000     2251.925         0.984       -0.174        0.040   15001.403   -3000.000    2251.925
  4     60.0    15522.348     -45.577     2272.955         0.984       -0.174        0.040

RUNWAY  1    FLIGHT  4   NO. OF EXTENSIONS  2
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1    100.0        0.000       0.000        0.000         1.000        0.000        0.000
  2    100.0     2804.166       0.000        0.000         0.995        0.000        0.104
  3     75.0    15004.165       0.000     1281.000         0.984       -0.174        0.040   15004.165   -3000.000    1281.000
  4     75.0    15525.110     -45.577     1302.030         0.984       -0.174        0.040

RUNWAY  1    FLIGHT  5   NO. OF EXTENSIONS  2
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1    100.0        0.000       0.000        0.000         1.000        0.000        0.000
  2    100.0     1676.403       0.000        0.000         0.986        0.000        0.167
  3     55.0    15001.403       0.000     2251.925         0.984       -0.174        0.040   15001.403   -3000.000    2251.925
  4     55.0    15522.348     -45.577     2272.955         0.984       -0.174        0.040

RUNWAY  1    FLIGHT  6   NO. OF EXTENSIONS  2
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1    100.0        0.000       0.000        0.000         1.000        0.000        0.000
  2    100.0     1676.403       0.000        0.000         0.986        0.000        0.167
  3    100.0    10001.403       0.000     1406.925        -0.971        0.171        0.166   10001.403    3000.000    1406.925
  4    100.0    10522.347    5954.423     2909.251        -0.971        0.171        0.166

RUNWAY  1    FLIGHT  7   NO. OF EXTENSIONS  2
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1    100.0        0.000       0.000        0.000         1.000        0.000        0.000
  2    100.0     2804.166       0.000        0.000         0.995        0.000        0.104
  3    100.0    10004.165       0.000      756.000        -0.979        0.173        0.105   10004.165    3000.000     756.000
  4    100.0    10525.110    5954.423     1691.552        -0.979        0.173        0.105

RUNWAY  1    FLIGHT  8   NO. OF EXTENSIONS  2
SEG  THRUST      GAMMA X      GAMMA Y      GAMMA Z        UNIT X       UNIT Y       UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
  1    100.0        0.000       0.000        0.000         1.000        0.000        0.000
  2    100.0     1676.403       0.000        0.000         0.986        0.000        0.167
  3    100.0    10001.403       0.000     1406.925        -0.971        0.171        0.166   10001.403    3000.000    1406.925
  4    100.0    10522.347    5954.423     2909.251        -0.971        0.171        0.166
```

Computer listing of calculated results

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RUNWAY  2   FLIGHT  1   NO. OF EXTENSIONS  0
SEG  THRUST     GAMMA X     GAMMA Y     GAMMA Z       UNIT X      UNIT Y      UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
 1    45.0     1777.666    -466.801       0.000        0.640       0.769      -0.000
 2    45.0     2807.945     769.534      -0.000        0.639       0.767       0.052

RUNWAY  2   FLIGHT  2   NO. OF EXTENSIONS  0
SEG  THRUST     GAMMA X     GAMMA Y     GAMMA Z       UNIT X      UNIT Y      UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
 1    45.0     1777.666    -466.801       0.000        0.640       0.768      -0.000
 2    45.0     2807.945     769.534      -0.000        0.639       0.767       0.052

RUNWAY  2   FLIGHT  3   NO. OF EXTENSIONS  2
SEG  THRUST     GAMMA X     GAMMA Y     GAMMA Z       UNIT X      UNIT Y      UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
 1   100.0     3000.000    1000.000       0.000       -0.640      -0.768       0.000
 2   100.0     1926.793    -287.849       0.000       -0.631      -0.757       0.167
 3   100.0    -3402.742   -6683.291    1406.925       -0.972       0.168       0.166   -6475.627   -4122.553    1406.925
 4   100.0    -7156.848   -8064.118    2113.902       -0.972       0.168       0.166

RUNWAY  2   FLIGHT  4   NO. OF EXTENSIONS  2
SEG  THRUST     GAMMA X     GAMMA Y     GAMMA Z       UNIT X      UNIT Y      UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
 1   100.0     3000.000    1000.000       0.000       -0.640      -0.768       0.000
 2   100.0     2297.537     157.044       0.000       -0.627      -0.752       0.205
 3   100.0    -3031.998   -6238.398    1739.925       -0.972       0.168       0.166   -6104.883   -3677.660    1739.925
 4   100.0    -6786.104   -7619.225    2446.902       -0.972       0.168       0.166

RUNWAY  2   FLIGHT  5   NO. OF EXTENSIONS  2
SEG  THRUST     GAMMA X     GAMMA Y     GAMMA Z       UNIT X      UNIT Y      UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
 1   100.0     3000.000    1000.000       0.000       -0.640      -0.768       0.000
 2   100.0     1926.793    -287.849       0.000       -0.631      -0.757       0.167
 3   100.0    -3402.742   -6683.291    1406.925        0.972      -0.168       0.166    -329.857   -9244.028    1406.925
 4   100.0    -1011.078  -13185.593    2820.879        0.972      -0.168       0.166

RUNWAY  2   FLIGHT  6   NO. OF EXTENSIONS  2
SEG  THRUST     GAMMA X     GAMMA Y     GAMMA Z       UNIT X      UNIT Y      UNIT Z HELIX CEN X HELIX CEN Y HELIX CEN Z
 1   100.0     3000.000    1000.000       0.000       -0.640      -0.768       0.000
 2   100.0     2297.537     157.044       0.000       -0.627      -0.752       0.205
 3   100.0    -3031.998   -6238.398    1739.925        0.972      -0.168       0.166      40.887   -8799.135    1739.925
 4   100.0     -640.334  -12740.700    3153.879        0.972      -0.168       0.166
```

```
                                   **********************************************
                                   * SUMMARY OF RUNWAYS AND ASSOCIATED FLIGHTS *
                                   *   (INCLUDING AIRCRAFT TYPE NUMBERS AND     *
                                   *       LANDING/TAKEOFF INFORMATION)         *
                                   **********************************************

   FLIGHTS 1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20    TOTAL
RUNWAYS
8       L  5 L  6 T  5 T  5 T  6 T  5 T  5 T  6                                                                     8

21      L  1 L  3 T  1 T  3 T  1 T  3                                                                               6
                                                                                                               -----
                                                                                                         FLIGHTS  14
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Computer listing of runways and flights included in calculations, for verification purposes.

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***NEF VALUES IN A GRID***

X VALS -18000.-16000.-14000.-12000.-10000. -8000. -6000. -4000. -2000.     0.  2000.  4000.  6000.  8000. 10000. 12000.
        14000. 16000. 18000. 20000.

 Y VALS

 15000.   14.0   14.0   14.0   11.4   11.6   11.7   11.8   11.9   11.9   11.9   12.0   12.2   12.5   13.4   14.5   17.2
          27.7   23.0   15.4   12.4

 13000.   14.9   15.0   15.0   12.7   12.9   13.1   13.3   13.5   13.6   13.7   13.8   14.0   14.5   15.4   17.7   27.3
          26.6   17.1   13.6   11.9

 11000.   15.6   15.7   15.9   15.9   14.0   14.4   14.7   15.1   15.4   15.6   15.8   16.1   16.9   18.3   26.1   31.1
          17.8   15.9   13.6   12.3

  9000.   16.1   16.3   16.4   16.6   15.0   15.0   15.6   16.2   16.8   17.3   17.8   18.4   19.6   24.8   37.0   19.6
          19.5   16.7   14.3   12.9

  7000.   16.7   16.8   16.9   17.0   15.3   15.7   15.6   16.3   17.2   18.0   19.0   20.1   23.9   42.4   24.3   21.6
          20.4   18.2   15.3   13.7

  5000.   17.5   17.5   17.6   17.7   17.7   16.4   16.8   16.8   14.5   16.1   19.6   22.8   43.9   26.2   21.2   23.7
          22.7   20.1   16.6   15.0

  3000.   18.7   18.8   18.9   19.0   19.0   18.4   18.2   18.8   19.5   19.1   23.2   39.6   29.9   24.8   24.1   25.3
          25.1   22.2   18.4   16.9

  1000.   21.6   21.9   22.3   22.6   22.9   23.3   24.4   25.8   27.5   30.0   35.3   36.6   33.5   32.2   30.9   30.0
          28.2   23.5   21.7   20.2

 -1000.   22.7   22.9   23.2   23.4   23.7   24.1   25.3   27.2   30.4   38.1   45.8   34.7   33.5   32.2   30.8   29.3
          27.6   23.6   23.5   23.5

 -3000.   23.0   23.1   23.2   23.4   23.6   23.9   25.1   28.2   34.2   41.3   33.1   27.3   24.8   24.4   24.0   23.4
          22.5   19.1   19.6   19.8

 -5000.   24.0   24.5   25.0   25.4   25.8   26.2   27.2   31.3   36.0   32.9   28.0   25.4   21.8   20.4   19.8   17.9
          19.8   17.5   17.2   17.1

 -7000.   23.9   24.6   25.5   26.4   27.4   28.6   30.1   32.7   31.8   28.0   25.3   23.3   20.0   19.7   19.1   17.7
          18.3   16.6   16.3   16.0

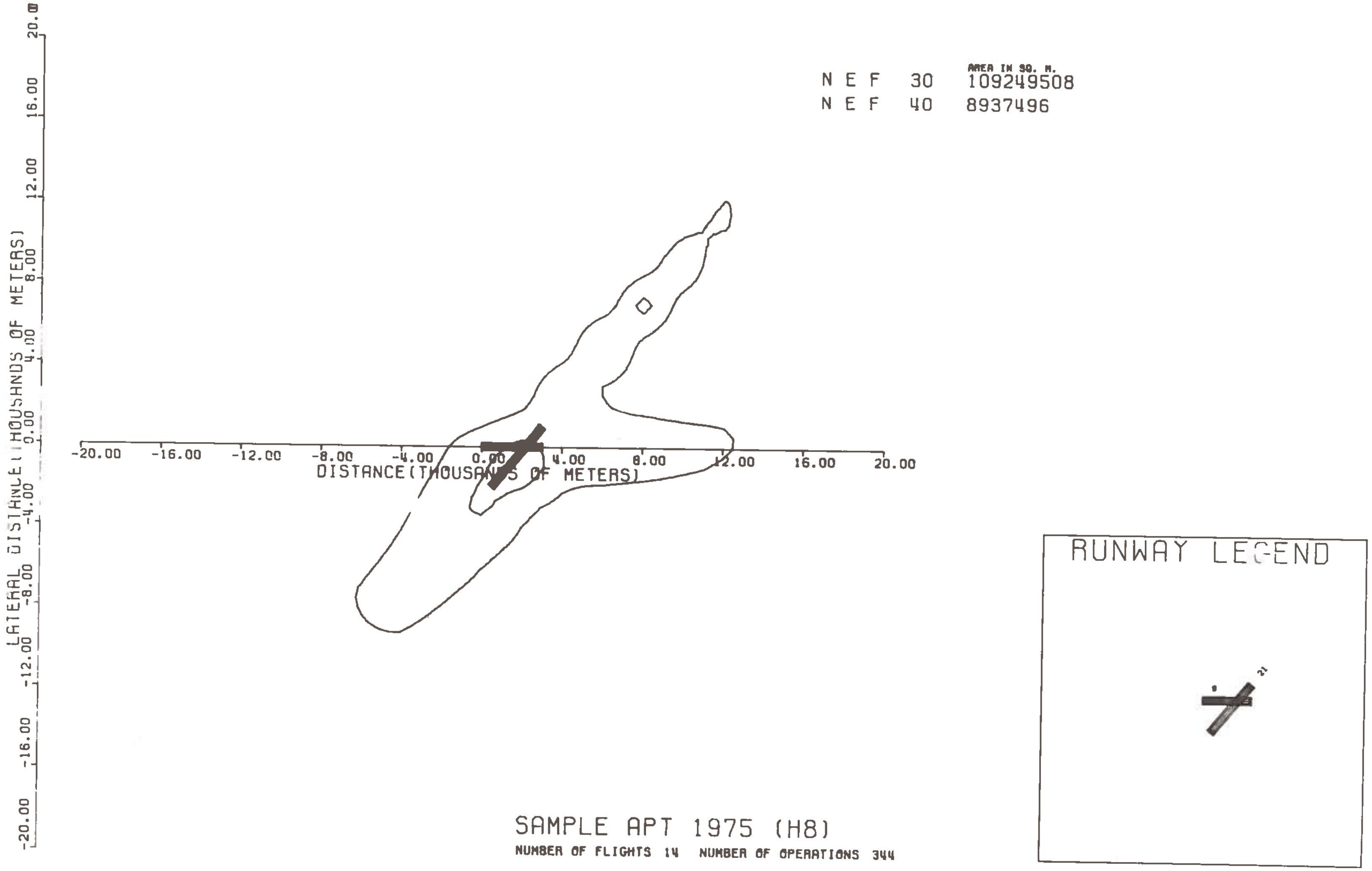
 -9000.   22.5   23.3   24.1   25.1   26.3   27.7   29.4   30.3   28.0   25.3   23.4   22.2   20.8   19.7   19.0   17.8
          17.9   16.7   16.3   15.9

-11000.   20.9   21.5   22.2   23.0   24.0   25.2   26.6   27.6   26.5   24.7   23.5   22.5   21.6   20.2   19.6   18.5
          18.3   17.3   16.8   16.4

-13000.   19.3   19.9   20.5   21.2   22.0   23.1   24.2   25.1   25.3   24.6   23.7   22.9   22.0   21.0   20.2   19.4
          18.9   18.1   17.5   17.0

-15000.   18.0   18.5   19.0   19.7   20.4   21.2   22.1   22.8   23.2   23.0   22.6   22.2   21.7   21.1   20.3   19.7
          19.2   18.5   18.0   17.5
```

Computer listing of grid calculations.



		AREA IN SQ. M.
N E F	30	109249508
N E F	40	8937496

SAMPLE APT 1975 (H8)

NUMBER OF FLIGHTS 14 NUMBER OF OPERATIONS 344

APPENDIX C

(Bound separately)

Computer listing for Noise Exposure Model MOD 4.

Appendix C to the basic report entitled "The Noise Exposure Model MOD 4" contains the computer program listing for the Noise Exposure Model MOD 4. This listing is bound separately from the basic report for convenience. It is available as report number DOT-TSC-OST-71-16.