REPORT NO. DOT-TSC-OST-73-19

PREDICTION OF V/STOL NOISE FOR APPLICATION TO COMMUNITY NOISE EXPOSURE

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MAY 1973
FINAL REPORT

Prepared for:
DEPARTMENT OF TRANSPORTATION
OFFICE OF THE SECRETARY
Office of Noise Abatement
Wahsington, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. DOT-TSC-OST-73-19	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle PREDICTION OF V/STOL NOISE FOR APPLICATION TO COMMUNITY NOISE EXPOSURE	5. Report Date May 1973 6. Performing Organization Code
7. Author(s) Charles L. Munch	8. Performing Organization Report No. DOT-TSC-OST-73-19
9. Performing Organization Name and Address Sikorsky Aircraft Division United Aircraft Corp. North Main Street Stratford, CT 06602	10. Work Unit No. R-2519 11. Contract or Grant No. DOT-TSC-438 OS-207
12. Sponsoring Agency Name and Address Department of Transportation Office of the Asst. Sec. for Sys. Development & Technology, Office of Noise Abatement TST-50 Washington, D.C. 20590	13. Type of Report and Period Covered June 1972-Dec. 1972 Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

Prepared Under Contract No. DOT-TSC-438, DOT-TSC, Cambridge, MA 02142

16. Abstract

A computer program to predict the Effective Perceived Noise Level (EPNL), the tone corrected Perceived Noise Level (PNLT), and the A-Weighted Sound Level (dBA) radiated by a V/STOL vehicle as it flies along a prescribed takeoff, landing, or cruise flight path is described in detail and a complete users guide for the program is presented. The procedures used to predict the noise radiated by helicopter rotors, propellers, turboshaft engines, lift and cruise fans, and jets are described in detail. Helicopter rotor noise and jet noise are theoretically predicted with some empirical modifications while propeller, fan, and turboshaft engine noise is calculated with primarily empirical procedures. The program is designed to be easy to use; thus it should be useful in V/STOL-port planning studies.

There are major limitations of current technology on the use of the program; the noise of VTOL vehicles characterized by impulsive type noise signatures should not be predicted and, because there are not yet adequate methods for predicting the noise from deflected jets, augmentor wings, blown flaps, and the like, noise of augmented lift STOL aircraft cannot yet be predicted. There is, in fact, some evidence to indicate that the EPNL measure does not adequately predict the annoyance of impulsive noise signatures and it is hoped that improved measures to account for the annoyance of impulsive noise will be developed in the near future.

17. Key Words Noise Abatement Aviation Sources, V/STOL Noise, Community Noise Exposure	18. Distribution Statement DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22151.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 280	22. Price

Form DOT F 1700.7 (8-69)

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LIST OF SYMBOLS

A_B - Total blade area
A_i - Total fan inlet area
A_m - Amplitude of m-th sound harmonic
B - Number of blades
BPR - Bypass ratio
C - Radial force on rotor blade
C_m - Complex magnitude of m-th sound harmonic
D - Drag force on rotor blade; Duration correction to calculate EPNL
D_h - Fan hub diameter
D_p - Propeller diameter
D_{t_f} - Fan tip diameter
DF - Fan diffusion factor
DI - Directivity index
DL - Duct length
EPNL - Effective Perceived Noise Level
G - Argument of Bessel Function $(= mMy/r_1)$
$J_n(k)$ - Bessel Function of the first kind, order n, argument k
K - Flight segment number; Constant in Equation (46)
L - Number of blade airloading harmonics
M - Mach number
M_{ax} - Fan axial tip Mach number
M_f - Flight Mach number
M_o - Component of flight Mach number in direction of observer
M_{rel} - Fan relative tip Mach number
M_t - Tip Mach number
N_e - Number of engines

LIST OF SYMBOLS (Cont'd)

N_f - Number of fans
N_p - Number of propellers
N_{max} - Largest Noy value of a given 1/3-octave band spectrum
Noy_i - Noy value of the SPL in the i-th third octave band
P_p - Propeller power input
PNL - Perceived Noise Level
PNLT - Perceived Noise Level, Tone corrected
PR - Pressure Ratio
R - Radius
R_K - Radius of turn of helical flight segment K
R_s - Fan blade suction surface radius of curvature
R_t - Tip radius
T - Thrust force on blade
V_{f_K} - Flight velocity along flight segment K
V_H - Propeller helical tip speed
V_t - Tip speed
$V_{0.7}$ - Speed at 0.7 blade radial station
X'Y'Z' - Stationary coordinate system with origin at start of takeoff roll
$X'_oY'_oZ'_o$ - Starting point coordinates of a flight segment
$X'_{ob}Y'_{ob}$ - Coordinates of primary observer location
$1/3\ OL_j$ - SPL of j-th i/3-octave band

a_{f_j} - Attenuation of sound at frequency f due to filter shape of the j-th 1/3-octave band
a_m - Real part of complex sound pressure of m-th sound harmonic
a'_{mol} - Molecular atmospheric sound absorption
a_o - Speed of sound

LIST OF SYMBOLS (Cont'd)

a_{λ_C} - λ -th radial loading harmonic amplitude

$a_{\lambda D}$ - λ -th drag loading harmonic amplitude

$a_{\lambda T}$ - λ -th thrust loading harmonic amplitude

a_{λ_ψ} - Sine component of rotor blade airloading harmonic λ in the X,Y,Z coordinate system

$a_{\lambda\gamma}$ - Sine component of rotor blade airloading harmonic λ in the x,y coordinate system

b_m - Imaginary part of sound pressure of m-th sound harmonic

b_{λ_ψ} - Cosine component of rotor blade airloading harmonic λ in the X,Y,Z coordinate system

$b_{\lambda\gamma}$ - Cosine component of rotor blade airloading harmonic λ in the x,y coordinate system

c - Blade chord

dBA - A-weighted sound pressure level

f - Frequency

f_{cj} - Center frequency of j-th 1/3-octave band

f_{lj} - Lower cutoff frequency of j-th 1/3-octave band

f_o - Fundamental rotational harmonic frequency

f_s - Peak rotor broadband noise frequency

f_{uj} - Upper cutoff frequency of the j-th 1/3-octave band

h_l - Apparent blade thickness due to blade angle of attack

i_d - Rotor disk incidence angle

l_c - Rotor blade airloading correlation coefficient

m - Sound harmonic number

p - Sound pressure

t - Time

t_c - Blade thickness at ¼-chord point

t_{inc} - Time increment

LIST OF SYMBOLS (Cont'd)

t_{max_K} - Total travel time along flight segment K

t_o - Initial time

Δt - Time increment between successive PNLT calculations

x,y - Helicopter rotor coordinate system (defined in Figure 4.)

α_1 - Rotor blade angle of attack

α_K - Angle of climb or descent along flight segment K

β - Rotor blade coning angle

β^* - Fan air inflow angle

γ - Defined by Figure 4

γ_a - Azimuthal location of observer relative to vehicle

η - Radial blade loading station ($0 \leq \eta \leq 1$)

θ_a - Relative camber angle at leading edge of fan blade

θ_{max_K} - Direction of flight (in the X'Y' plane) at end of segment K

θ_1 - Angle measured from Z axis to r_1

λ - Loading harmonic number

μ - Mach angle

ξ_c - Critical cutoff ratio for combination tones

ξ_K - Cutoff ratio of the K-th combination tone

ξ_{RF} - Fan rotor field cutoff ratio

σ_ϕ - Standard deviation of fan blade tip metal angle

ϕ - Defined by Figure 4 and Equation (30)

ϕ_{C_K} - Angle through which aircraft turns on helical segment K in time t_{inc}

ϕ_{max_K} - Total angle through which aircraft turns on helical flight segment K (+ for left turn, - for right turn)

ψ - Defined by Figure 4

ψ_K - Defined by Equation (25)

Ω - Rotational speed

PREFACE

This report covers work sponsored by the Department of Transportation, Office of the Assistant Secretary for Systems Development and Technology, Office of Noise Abatement, TSC-50. The program was technically monitored by the Transportation Systems Center of the Department of Transportation located in Cambridge, Massachusetts.

The objective of the work was to develop a V/STOL aircraft noise prediction program and to apply the developed program to computers at the Transportation Systems Center.

INTRODUCTION

The many studies conducted in recent years into the mechanisms of noise generation by V/STOL aircraft propulsors such as propellers, fans, rotors, and engines (eg. - References 1 to 19) have resulted in reasonably accurate methods with which to predict both the spectrum shape and level of the component noise. Actual aircraft, however, are made up of several noise producing components; thus, to assess the acoustic impact of a given vehicle it becomes necessary to combine the noise from several components to produce the vehicle noise. With the advent of city-center V/STOL operations the vehicle's acoustic impact can exert considerable influence over all aspects of the system from site location to aircraft design.

Existing methods for evaluating the acoustic impact of flight operations on nearby communities (eg.- Noise Exposure Forecast (NEF), Weighted Equivalent Perceived Noise Level (WECPNL), etc.) provide for current, operational CTOL aircraft, but generally do not account for STOL or VTOL operations; hence, their use is limited to evaluation of existing or planned airports where there is little V/STOL traffic. As V/STOL operations increase at major airports and as city-center operations become a reality, a method must be available whereby the total impact of all vehicles can be evaluated. The objectives of the study presented in this report are to develop a computer program to calculate the noise generated by V/STOL vehicles flying prescribed flight paths and compute the Effective Perceived Noise Level at a ground based observer for input to existing NEF programs and to perform a limited correlation study with measured data.

The vehicles considered in the program are those that are made up of one or more of the following propulsion components: turboshaft engines, helicopter main and tail rotors, propellers, lift fans, cruise fans, fan engines, and to a limited degree, lift jets. Augmented lift devices such as externally or internally blown flaps are not yet included. The flight path followed by the aircraft is composed of both straight line and helical segments so that the path can be a realistic representation of the actual flight path. The methods used to calculate the component noise levels are discussed in detail in the next section. In following sections the structure and usage of the computer program is outlined and illustrated using sample cases. Several comparisons of measured and calculated V/STOL vehicle noise are presented to demonstrate the accuracy of the program.

COMPONENT PREDICTION METHODS

The components that are included in the prediction program are (as mentioned above) main and tail rotors, propellers, fans, turboshaft engines, and jets. No augmented lift devices such as externally or internally blown flaps or augmenter wing are included yet. Because of the modular program concept used, the addition of other sources can be easily accomplished when accurate prediction techniques are developed. By the same token existing component prediction methods can be modified or replaced if newer, more accurate methods become available.

None of the noise prediction methods in the program include the possible shielding effects of structure such as wings, fuselage, etc. Admittedly, shielding can have an effect on the propagated noise, principally changing the observed directivity, however, no comprehensive methods exist for accurately predicting shielding effects. The program thus yields levels higher than those which would be realized for components where shielding may be important (fans, propellers, engines, and jets). Also, no account is made of possible phasing effects due to source/source separation. It is felt that in the far-field where propagation distances are long compared with separation distances the source separation phase effect will be negligible.

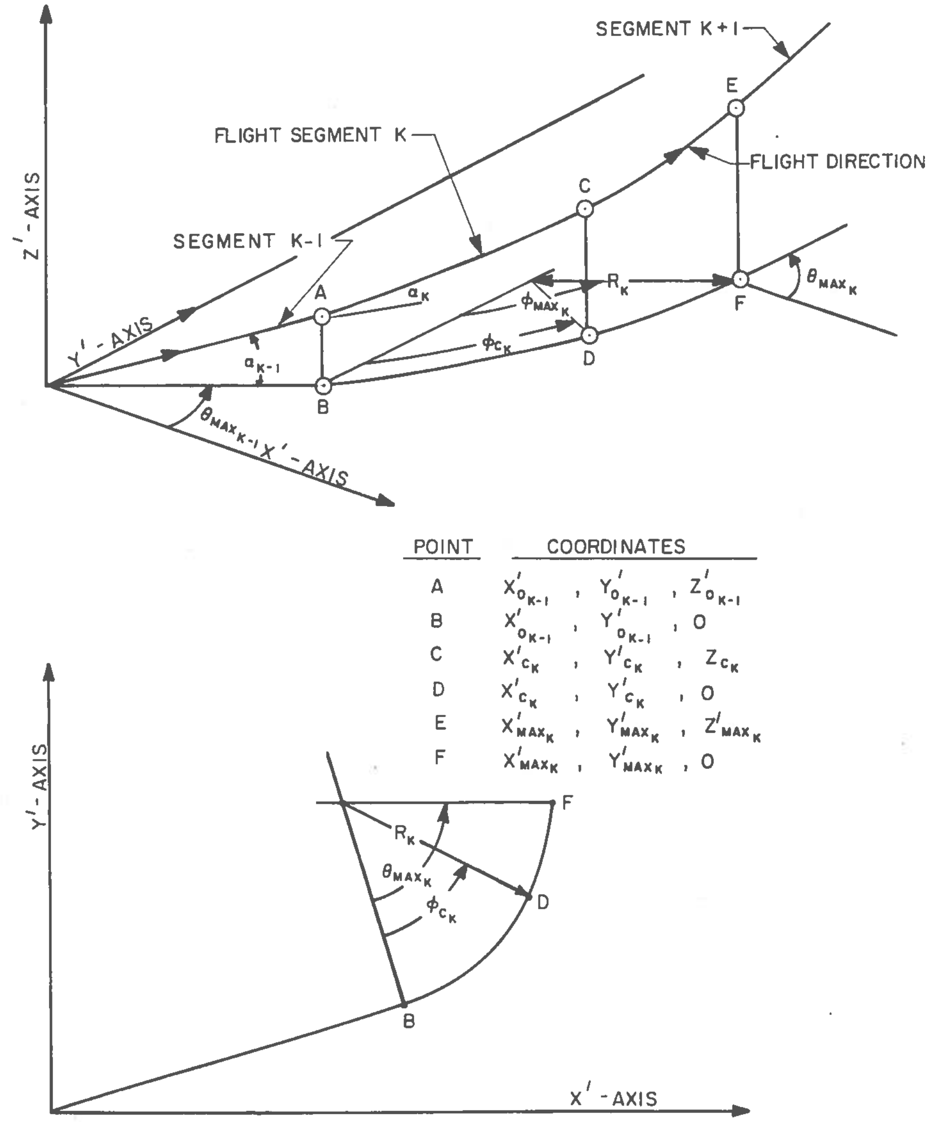
The following sections describe the methods used to predict component noise levels, how they are programmed and the nature of their relationship to the total computer program.

Flight Path Definition

All of the component noise prediction methods to be described below require knowledge of the aircraft's location with respect to an observer. Since the calculation of Effective Perceived Noise Level requires an integration of the vehicle's noise time history the noise for many aircraft locations along the flight path will be required. A subroutine which calculates these locations of the aircraft relative to the observer at successive points (or time increments) along the flight path has been developed.

The flight path is assumed to be made up of a series of straight line and helical trajectories (segments), an example of which is shown in Figure 1. In this example segment K-1 is a straight line segment directed at an angle of $\theta_{\max_{K-1}}$ from the X' axis and the aircraft is climbing at the angle α_{K-1}. Segment K is a helical segment with a turning radius of R_K and the aircraft turns through $\theta_{\max_K}$ degrees (+ for left turn, - for right turn) before flying off on segment K + 1. The aircraft is climbing at an angle of α_K degrees and flies along the K-th segment at a speed of V_{f_K}.

If we now assume that the aircraft starts flying on segment K (Point A of Figure 1) at time $t = t_o$, then at a time $t = t_o + t_{inc}$ later it has turned through an angle ϕ_{C_K} (from A to C) along the flight path, a distance given by



POINT	COORDINATES
A	$X'_{O_{K-1}}$, $Y'_{O_{K-1}}$, $Z'_{O_{K-1}}$
B	$X'_{O_{K-1}}$, $Y'_{O_{K-1}}$, 0
C	X'_{C_K} , Y'_{C_K} , Z_{C_K}
D	X'_{C_K} , Y'_{C_K} , 0
E	X'_{MAX_K} , Y'_{MAX_K} , Z'_{MAX_K}
F	X'_{MAX_K} , Y'_{MAX_K} , 0

FIGURE 1. Coordinate System Arrangement for Calculating Field Point Locations Along A Flight Path - Helical Segments.

$$\overline{AC} = V_{f_K} t_{inc} \qquad (1)$$

and a distance BD along the ground given by

$$\overline{BD} = R_K \phi_{c_K} \qquad (2)$$

Since the aircraft is climbing at α_K degrees, $\overline{BD}$ is also given as

$$\overline{BD} = \overline{AC}\cos(\alpha_K) \qquad (3)$$

Combining Equations (1) and (3) yields:

$$\overline{BD} = V_{f_K} t_{inc} \cos\alpha_K \qquad (4)$$

thus, from Equations (2) and (4):

$$R_K \phi_{c_K} = V_{f_K} t_{inc} \cos\alpha_K \qquad (5)$$

the angle ϕ_{c_K} is then determined to be

$$\phi_{c_K} = \frac{1}{R_K} V_{f_K} t_{inc} \cos\alpha_K \qquad (6)$$

Now the coordinates of the point C can be determined:

$$X'_{cK} = X'_o + 2R_K \sin(\tfrac{1}{2}|\phi_{cK}|)\cos(\theta_{max_{K-1}} + \tfrac{1}{2}\phi_{cK}) \qquad (7)$$

$$Y'_{cK} = Y'_o + 2R_K \sin(\tfrac{1}{2}|\phi_{cK}|)\sin(\theta_{max_{K-1}} + \tfrac{1}{2}\phi_{cK}) \qquad (8)$$

$$Z'_{cK} + Z'_o + R_K|\phi_{cK}|\tan\alpha_K \qquad (9)$$

The coordinates at the end of the segment (point E), the angle ϕ_{max_K} at which the aircraft enters segment K + 1, and the maximum travel time along segment K are given as:

$$X'_{max_K} = X'_o + 2R_K \sin(\tfrac{1}{2}|\phi_{max_K}|)\cos(\theta_{max_{K-1}} + \tfrac{1}{2}\phi_{max_K}) \qquad (10)$$

$$Y'_{max_K} = Y'_o + 2R_K \sin(\tfrac{1}{2}|\phi_{max_K}|)\sin(\theta_{max_{K-1}} + \tfrac{1}{2}\phi_{max_K}) \qquad (11)$$

$$Z'_{max_K} = Z'_o + R_K|\phi_{max_K}|\tan\alpha_K \qquad (12)$$

$$\theta_{max_K} = \theta_{max_{K-1}} + \phi_{max_K} \qquad (13)$$

$$t_{max_K} = R_K|\phi_{max_K}|/(V_{f_K}\cos\alpha_K) \qquad (14)$$

Figure 2 shows the similar situation when segment K is a straight line segment. Again, the aircraft starts at point A at time $t = t_o$ and travels at V_{f_K} ft/sec, reaching point C, at time $t = t_o + t_{inc}$. The coordinates of point C are then calculated:

$$X'_{c_K} = X'_o + (V_{f_K} t_{inc} \cos\alpha_K)\cos\theta_{max_K} \tag{15}$$

$$Y'_{c_K} = Y'_o + (V_{f_K} t_{inc} \cos\alpha_K)\sin\theta_{max_K} \tag{16}$$

$$Z'_{c_K} = Z'_o + V_{f_K} t_{inc} \sin\alpha_K \tag{17}$$

The segment end point coordinates, the exit angle and maximum time of travel along the segment are given below:

$$t_{max_K} = \left| \frac{X'_{max_K} - X'_{max_{K-1}}}{V_{f_K} \cos\theta_{max_K} \cos\alpha_K} \right| \tag{18}$$

however, when $X'_{max_K} = X'_{max_{K-1}}$ (ie. $\theta_{max_K} = \pm 90^\circ, \pm 270^\circ$) t_{max} is given as:

$$t_{max_K} = \left| \frac{Y'_{max_K} - Y'_{max_{K-1}}}{V_{f_K} \cos\alpha_K \sin\theta_{max_K}} \right| \tag{19}$$

$$\theta_{max_K} = \theta_{max_{K-1}} \tag{20}$$

$$X'_{max_K} = X'_o + V_{f_K} t_{max_K} \cos\alpha_K \cos\theta_{max_K} \tag{21}$$

$$Y'_{max_K} = Y'_o + V_{f_K} t_{max_K} \cos\alpha_K \sin\theta_{max_K} \tag{22}$$

$$Z'_{max_K} = V_{f_K} t_{max_K} \sin\alpha_K + Z'_o \tag{23}$$

Because the component noise prediction procedures discussed below require X, Y, Z coordinates relative to the aircraft rather than relative to a fixed spacial point, the X', Y', Z' coordinates must be converted. Figure 3 shows the relationship between the two systems; the transformation is given below:

$$X_{ob_K} = (X'_{ob} - X'_{c_K})\cos\psi_K + (Y'_{ob} - Y'_{c_K})\sin\psi_K \tag{24}$$

$$Y_{ob_K} = -(Y'_{ob} - Y'_{c_K})\cos\psi_K + (X'_{ob} - X'_{c_K})\sin\psi_K$$

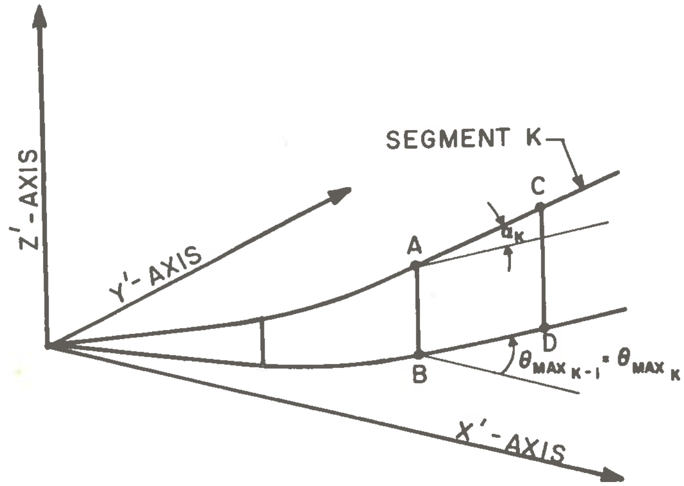


FIGURE 2. Coordinate System Arrangement For Calculating Field Point Locations Along A Flight Path - Straight Line Segments.

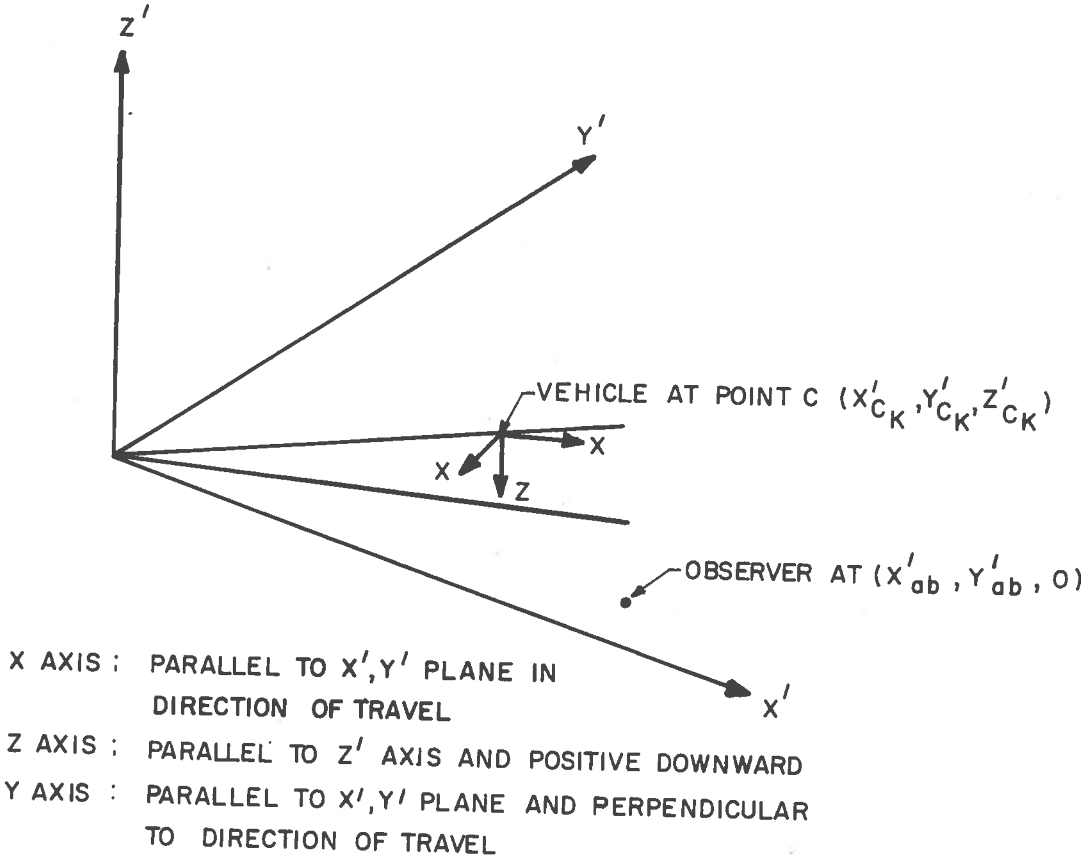


FIGURE 3. Relationship Between Fixed (X',Y',Z') Coordinate System and Coordinate System Originating at the Vehicle (X,Y,Z).

$$Z_{ob_K} = Z'_{c_K}$$

where

$$\psi_K = \begin{cases} \theta_{max_K} \text{ for straight line segments} \\ \theta_{max_K} + \phi_{c_K} \text{ for helical segments} \end{cases} \qquad (25)$$

All of the equations developed so far assumed that the aircraft was conducting a takeoff operation which started at the point X' = Y' = Z' = 0. In the case of a landing terminating at the same point all of the equations except 24 and 25 remain the same and the calculation is carried out as if the aircraft were flying backwards up the flight path. Since at any point the aircraft is simply turned around 180° in the landing case, $(\Psi_K + \pi)$ is substituted for ψ_K in Equation (25) and the coordinate transformation equations, Equations (24) then remain the same.

Helicopter Rotor Noise

The primary requirement for all of the component noise prediction procedures is that they be able to provide reasonably accurate results with a minimum of detailed helicopter performance and airloading data input in minimum computer time. In order to meet these requirements it was decided to use the closed-form solution presented by Lowson and Ollerhead in Reference 10 for rotor rotational noise. This solution, which will be described in greater detail, allows the far-field rotational noise from a rotor to be calculated from an assumed airloading spectrum quite rapidly. Other rotor noise solutions developed for example, by Schlegel, et al. in Reference 1, while accurate are not readily applicable to the present problem since they require detailed knowledge of the aircraft performance parameters and actual blade airloading. They are open-form solutions requiring radial and azimuthal iterations and, as such, are slower than the closed form solution of Reference 10.

The subprogram, as designed, is capable of calculating the total noise generated by a helicopter main and tail rotor, or any two rotors, during both hover and cruise. In the case where the two rotors are very close together, such as for a coaxial design, where the assumption of randomly phased loading is not valid the program should be used with care.

Rotational Noise

The method used to calculate the rotational noise components is the same for both the main and tail rotors, thus in the following paragraphs unless a distinction is made between the two, the term 'rotor' will be taken to mean any rotor.

The basic computer program used to predict the rotational harmonic noise levels for rotors is essentially that described in Section 5.1 of Reference 10. The program computes the closed-form solution to Equation (37) of

Reference 10 which describes the far sound field radiation of a rigid-rotor system whose only blade motion is steady coning. It was shown in Reference 10 that while these limitations may introduce some error when applied to the real helicopter case, the accuracy is sufficient for studying the general helicopter noise problem. Equation (37)10 is reproduced below as Equation (27):

$$C_m = a_m + ib_m = \sum_{\lambda=0}^{\infty} a_{m_\lambda} + ib_{m_\lambda} \tag{26}$$

where a_{m_λ} and b_{m_λ} are the following for $(m + \lambda)$ odd:

$$\begin{aligned}
a_{m_\lambda} &= \frac{m\Omega}{4\pi a_o r_1}\Bigg\{\frac{xa_{\lambda T}}{r_1}\Big[J_{m+\lambda}(G)+(-1)^\lambda J_{m-\lambda}(G)\Big] - \frac{a_{\lambda D}}{mM_t}\Big[(m+\lambda)J_{m+\lambda}(G)+(-1)^\lambda(m-\lambda)J_{m-\lambda}(G)\Big] \\
&\quad + \frac{yb_{\lambda c}}{2r_1}\Big[J_{m+\lambda+1}(G)-J_{m+\lambda-1}(G) - (-1)^\lambda\big(J_{m-\lambda+1}(G)-J_{m-\lambda-1}(G)\big)\Big]\Bigg\}(-1)^{\frac{1}{2}(m+\lambda-1)} \\
b_{m_\lambda} &= \frac{m\Omega}{4\pi a_o r_1}\Bigg\{\frac{-xb_{\lambda T}}{r_1}\Big[-(-1)^\lambda J_{m-\lambda}(G)+J_{m+\lambda}(G)\Big] + \frac{b_{\lambda D}}{mM_t}\Big[(m+\lambda)J_{m+\lambda}(G)-(-1)^\lambda(m-\lambda)J_{m-\lambda}(G)\Big] \\
&\quad + \frac{ya_{\lambda c}}{2r_1}\Big[J_{m+\lambda+1}(G)-J_{m+\lambda-1}(G)+(-1)^\lambda\big(J_{m-\lambda+1}(G)-J_{m-\lambda-1}(G)\big)\Big]\Bigg\}(-1)^{\frac{1}{2}(m+\lambda-1)}
\end{aligned} \tag{27a}$$

if $(m+\lambda)$ is even, then $a_{m\lambda}$ and $b_{m\lambda}$ are the following:

$$\begin{aligned}
a_{m\lambda} &= \frac{m\Omega}{4\pi a_o r_1}\Bigg\{\frac{xb_{\lambda T}}{r_1}\Big[J_{m+\lambda}(G)-(-1)^\lambda J_{m-\lambda}(G)\Big] - \frac{b_{\lambda D}}{mM_t}\Big[(m+\lambda)J_{m+\lambda}(G)-(-1)^\lambda(m-\lambda)J_{m-\lambda}(G)\Big] \\
&\quad - \frac{ya_{\lambda c}}{r_1}\Big[J_{m+\lambda+1}(G)-J_{m+\lambda-1}(G)+(-1)^\lambda\big(J_{m-\lambda+1}(G)-J_{m-\lambda-1}(G)\big)\Big]\Bigg\}(-1)^{\frac{1}{2}(m+1)} \\
b_{m_\lambda} &= \frac{m\Omega}{4\pi a_o r_1}\Bigg\{\frac{xa_{\lambda T}}{r_1}\Big[J_{m+\lambda}(G)+(-1)^\lambda J_{m-\lambda}(G)\Big] - \frac{a_{\lambda D}}{mM_t}\Big[(m+\lambda)J_{m+\lambda}(G)+(-1)^\lambda(m-\lambda)J_{m-\lambda}(G)\Big] \\
&\quad + \frac{yb_{\lambda c}}{2r_1}\Big[J_{m+\lambda+1}(G)-J_{m+\lambda-1}(G)-(-1)^\lambda\big(J_{m-\lambda+1}(G)-J_{m-\lambda-1}(G)\big)\Big]\Bigg\}(-1)^{\frac{1}{2}(m+1)}
\end{aligned} \tag{27b}$$

Before going on to the calculation of airloading harmonic values and program modifications, it is well to describe the use of Equation (27). Equation (27) describes the real (am) and imaginary (bm) components of the sound pressure in terms of the coordinates x and y whereas the inputs to the present program are in terms of the X, Y, Z coordinate system. This requires a change of coordinates from the X, Y, Z input to the x, y system used in Equation (27). Figure 4 shows the relationship between the two systems. The x-axis is in the direction of the rotor thrust and the y-axis is in the plane of the rotor disk, directed toward the observation point. Thus the observation point always lies in the xy plane. The X-axis, on the other hand, lies in the direction of aircraft forward velocity, the Z-axis is directed perpendicularly downward and the Y-axis is mutually perpendicular to the other two. Examination of Figure 4 shows the following system transformations to permit calculation directly by Equation (27) but inputting values in the X, Y, Z coordinate system:

$$x = X \cdot \sin(i_d) - Z \cdot \cos(i_d) \tag{28}$$

$$y = -(X \cdot \cos(i_d) + Z \cdot \sin(i_d))\cos(\phi) - Y \cdot \sin(\phi) \tag{29}$$

$$\phi = \tan^{-1}\left\{\frac{-Y}{-X \cdot \cos(i_d) - Z \cdot \sin(i_d)}\right\} \tag{30}$$

The harmonics of airloading are specified in the X, Y, Z coordinate system and are given as Fourier sine and cosine components $b_{\lambda\psi}$ and $a_{\lambda\psi}$ where the zero reference for ψ is taken to be the -X axis and ψ is the angle, measured in the direction of rotation, from the -X axis to the blade being considered. The loading harmonics must be related to the x, y coordinate system to be of use in Equation 27 thus:

$$\begin{aligned} a_{\lambda\gamma}\cos\lambda\gamma + b_{\lambda\gamma}\sin\lambda\gamma &= a_{\lambda\psi}\cos\lambda\psi + b_{\lambda\psi}\sin\lambda\psi \\ &= a_{\lambda\psi}\cos(\lambda\gamma+\lambda\phi) + b_{\lambda\psi}\sin(\lambda\gamma+\lambda\phi) \\ &= a_{\lambda\psi}(\cos\lambda\gamma\cos\lambda\phi - \sin\lambda\gamma\sin\lambda\phi) \\ &\quad +b_{\lambda\psi}(\sin\lambda\phi\cos\lambda\gamma + \cos\lambda\phi\sin\lambda\gamma) \end{aligned} \tag{31}$$

Then:

$$\begin{aligned} a_{\lambda\gamma} &= a_{\lambda\psi}\cos\lambda\phi + b_{\lambda\psi}\sin\lambda\phi \\ b_{\lambda\gamma} &= - a_{\lambda\psi}\sin\lambda\phi + b_{\lambda\psi}\cos\lambda\phi \end{aligned} \tag{32}$$

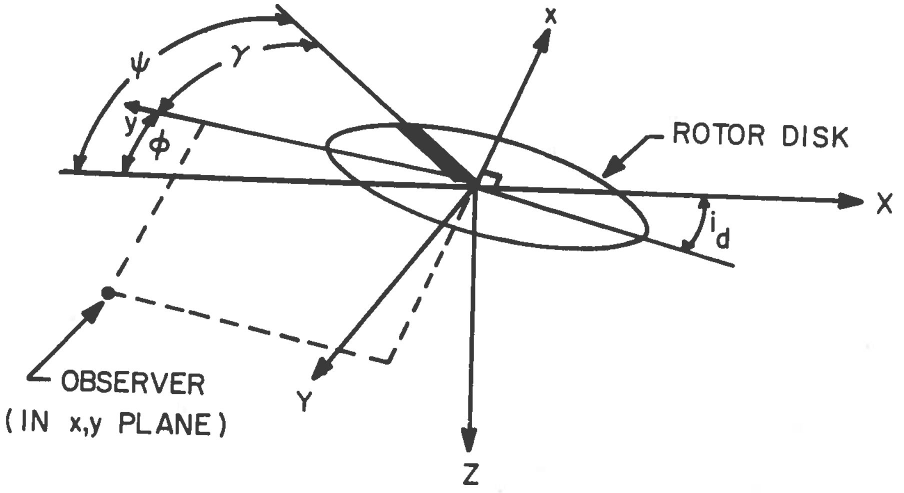


Figure 4. Definition of Rotor Coordinate Systems

However, the assumption is made that the Fourier sine components of loading are zero in the X, Y, Z coordinate system, thus:

$$b_{\lambda\psi} = 0 \tag{33}$$

and

$$a_{\lambda\gamma} = a_{\lambda\psi} \cos\lambda\phi$$

$$b_{\lambda\gamma} = -a_{\lambda\psi} \sin\lambda\phi \tag{34}$$

Note that the assumption of zero sine components ($b_{\lambda\psi} = 0$) in the X, Y, Z coordinate system does not imply zero sine components in the x, y-coordinate system. A further assumption is made that the thrust, drag and outward force components are in phase and that all other phase relationships are random. This then allows Equation 34 to be writen as the following:

$$a_{\lambda} = a_{\lambda\psi} \cos\lambda\phi$$

$$b_{\lambda} = a_{\lambda\psi} \sin\lambda\phi \tag{35}$$

The Equations (35) provide the values for $a_{\lambda T}$, $a_{\lambda D}$, $a_{\lambda C}$, $b_{\lambda T}$, $b_{\lambda D}$, and $b_{\lambda C}$ in Equation 27.

Since the helicopter is in motion along the X-axis, it will have moved a given distance along its flight path by the time the sound it generated reaches the observer. Figure 5 illustrates this situation. If when the helicopter is at A (Figure 5) it generated sound (at time $t = 0$) and if it takes T seconds for that sound to reach the observer, then the helicopter will have moved during the propagation time, T, to a new position, B. As far as the observer is concerned, the helicopter is at B, based on the sound he hears, but in the calculation of the sound generated, it is position A, the "retarded" position of the helicopter which is important. The distance from the observer to the "retarded" position is given by:

$$r' = a_o T \tag{36}$$

and the distance the helicopter moves in this time T is $M_f a_o T$.

Then:

$$r'^2 = (X + M_f a_o T)^2 + Z^2 + Y^2 \tag{37}$$

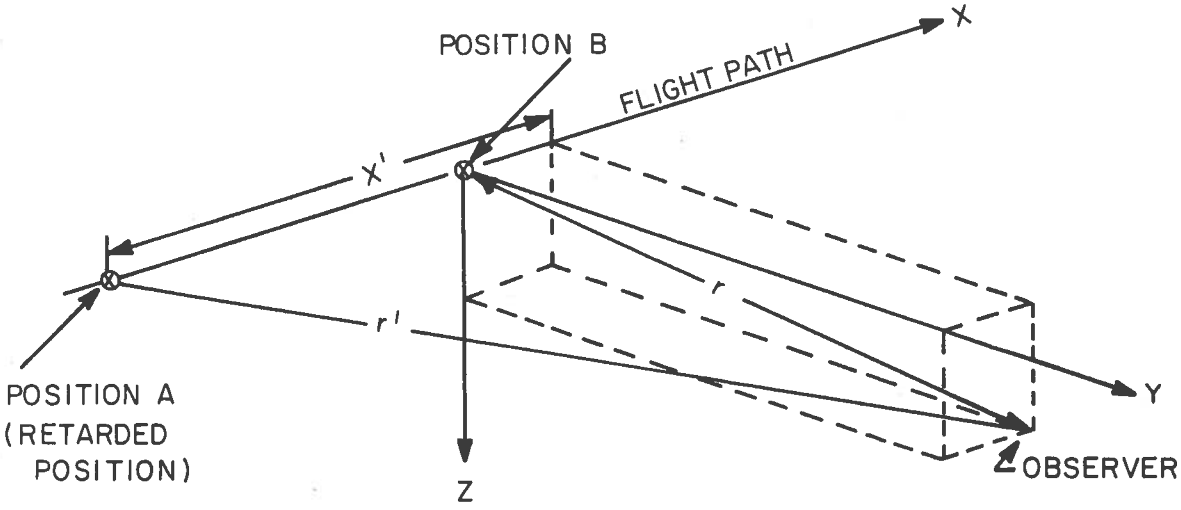


Figure 5. Definition of Helicopter 'Retarded' Position

$$T = \left[\frac{XM_f \pm \sqrt{X^2 + (1 - M_f^2)(Y^2 + Z^2)}}{a_o(1 - M_f^2)} \right] \qquad (38)$$

from which:

$$X' = X + \left[\frac{XM_f^2 + M_f \sqrt{X^2 + (1 - M_f^2)(Y^2 + Z^2)}}{1 - M_f^2} \right] \qquad (39)$$

The value of X' is then used in Equations 28 - 30 as the variable X.

Since the aircraft is in constant motion, the effect of this motion must be accounted for by changing the distance r'. Lowson and Ollerhead[10] showed that this can be accomplished by the following substitution:

$$r_1 = r'(1 - M_o) \qquad (40)$$

This is the value of r_1 used in the computation of Equation 27. As mentioned above all phase relationships are assumed to be random except those between T, D, and C. This then requires that in calculating the magnitude of m^{th} harmonic of sound, the magnitude of the contribution of each loading harmonic must be calculated before it is added to the accumulated sum indicated in Equation 27 , thus:

$$|C_m| = (a_m^2 + b_m^2)^{\frac{1}{2}}$$

$$|C_m| = \sum_{\lambda=0}^{\infty} (a_{m_\lambda}{}^2 + b_{m_\lambda}{}^2)^{\frac{1}{2}} \qquad (41)$$

In order to accurately calculate the noise radiation from the rotor, detailed knowledge of the fluctuating airloads acting on the blades must be known. Information of this type is difficult to obtain to high harmonic frequencies, consequently little or no high-frequency rotor blade loading information is available. However, Reference 10 showed, based on the limited data available, that harmonics of airloading approximately follow an inverse power law based on steady loading amplitude, for conditions of relatively smooth inflow through the rotor disk, such as in hover and forward flight out of ground effect. For rough running conditions, such as in ground effect hover and cruise, and autorotative descent, this inverse power law does not predict the harmonic levels as well.

The program also assumes that the blade load is concentrated at a single point on the blade. Reference 10 showed that results of sufficient accuracy may be obtained using this assumption. The optimum loading point for the main rotor was found to be at the 0.8 radial station (or at a distance 0.8R from the rotor hub). In the case of a tail rotor, however, it was found that the optimum loading point was at the 0.9 radial station. This can probably be explained by the lack of twist on the tail rotor blades tested which caused the loading to be concentrated nearer to the tips.

The amplitude of the λ th loading harmonic due to thrust, drag, or outward components is given by the equation:

$$A_{\lambda T} = A_{OT} l_c \lambda^{-k}$$

$$A_{\lambda D} = A_{OD} l_c \lambda^{-k}$$

$$A_{\lambda C} = A_{OC} l_c \lambda^{-k} \qquad (42)$$

The steady loading due to thrust (A_{OT}) is equal to the thrust force per blade as input to the program. The drag force acting at the loading point selected is calculated from the rotor torque by the relationship:

$$A_{OD} = D/B = Q/\eta RB \qquad (43)$$

The steady loading due to drag forces is then the value of drag as calculated by Equation 43. The steady loading due to outward components is calculated from the radial force component which is determined by the relationship:

$$A_{OC} = C/B = T \sin (\beta)/B \qquad (44)$$

Typical values of the airloading "k" factor are 1.8 to 2.0 for main rotors and 1.5 to 2.0 for tail rotors of standard design (ie. NACA symmetrical airfoil shapes with linear blade twist distributions). Advanced blades with non-linear twist distributions, cambered airfoils, etc tend to have k values somewhat higher (2.0 to 2.5).

The correlation coefficient in Equation (42) may vary from 0 to 1 and is a measure of the scale of phase coherence of the fluctuating airloads along the blade span (see Reference 10). For most cases $l_c = 0.7$.

The number of rotor noise harmonics that may be calculated is dependent on the number of blade loading harmonics available. As established by Reference 10, the maximum number of loading harmonics necessary to calculate m noise harmonics is given by the relationship:

$$L = mB(1+M) \qquad (45)$$

When the number of sound harmonics requested makes it necessary to calculate more than about 60 loading harmonics, computer time becomes prohibitively long. Main rotor harmonics of sound up to about the 1300th would be necessary to accurately calculate third octave band levels up to the band centered at 10000 Hz. This would require calculation of loading harmonics up to the 3900th! Obviously, this is impractical and a method has been developed to calculate higher harmonics of sound that does not require calculation of loading harmonics.

Harmonics of sound up to the limiting value given by:

$$m_{lim} = 60/(B(1+M))$$

are calculated using Equation (27) while harmonics from m_{lim} up to 60 are calculated using an extrapolation method described below. It was shown in Section 6 of Reference 10 that the acoustic intensity of the higher harmonics follows a trend which is given by the asymtotic solution:

$$p^2 = K(mB)^{2-2k} \tag{46}$$

This is true because the airloads are represented by Equation (42). The sound pressure calculated for the m_{lim}-th sound harmonic is used in Equation (46) to evaluate the constant, K, after which Equation (46) is used to calculate the sound pressure of the additional harmonics from $(m_{lim}+1)$ up to the 60-th; alternatively the sound pressure level of these higher harmonics can be calculated directly by the equation:

$$SPL_m = 10((2-2k)\log(mB) + \log(\underline{K}) + 7.39) \tag{47}$$

Calculation of One-Third Octave Levels

The calculation of 1/3- octave band sound pressure levels is divided into two parts, namely (a) calculation of band levels for 1/3-octaves up to one centered at f_{cc} and (b) calculation of band levels for the 1/3-octave whose center frequencies are higher than f_{cc}. The one-third octave band centered at f_{cc} is the highest band whose level can be computed by summing the calculated rotational harmonics. Assuming the -40 dB/octave filter skirt discussed below, the frequency f_{cc} is the third-octave frequency closest to the frequency given by the equation:

$$f_1 = 60f_o/1.6 \tag{48}$$

This guarantees that the level of the 60-th harmonic will be at least 30 dB down from the level of harmonics falling in the passband. The first step necessary for one third octave band level calculations is the assumption of a filter shape. This has been done and is shown in Figure 6. The shape is typical of filters in normal use and approximates the ASA Class III filter shape as given in ASA Specification S1.11-1966. The upper and lower cutoff frequencies, f_{uj} and f_{lj}, are the 3dB down points, f_{cj} is the center frequency of the j^{th} octave band, and the filter skirts drop off at 40 dB per octave. If the harmonics of rotor noise are reduced by this filter only those falling in the flat portion (passband) of the filter will be unaltered. Those falling outside this flat portion will be attenuated an amount which is determined by their frequencies in relation to the center frequency of the band. For harmonic frequencies below f_{lj}, the amount of attenuation is given by the equation:

$$a_{fj} = 133 \log(f/f_{cj}) + 3.65 \qquad f \leq f_{lj} \tag{49}$$

where f is the frequency of the harmonic in question. When the harmonic frequency is above f_{uj}, the attenuation of the harmonic level by the filter is given by the relationship:

$$a_{fj} = 133 \log(f_{cj}/f) + 3.65 \qquad f \geq f_{uj} \tag{50}$$

To illustrate the effect the filter has on a harmonic spectrum Figure 7 has been prepared. Figure 7a shows a typical harmonic spectrum in a frequency range from 10 Hz to 100 Hz and Figure 7b shows how this spectrum would appear after being filtered by the one-third octave band centered at 25 Hz.

The one-third octave band level as determined by a filter of the shape shown in Figure 6 is the logarithmic sum of the harmonic levels after they have been modified by the effect of the filter shape (i.e., the logarithmic sum of the harmonic levels of Figure 7b). The j^{th} one-third octave band level is then given by the equation:

$$1/3\ OL_j = 10 \log \sum_{m=1}^{N} \text{antilog} \left(\frac{A_m}{10} + \frac{a_{fjm}}{10}\right) \tag{51}$$

where m is the harmonic number. Equation (51) is used by the computer program to calculate the sound pressure level of all third-octave bands up to the one centered at f_{cc}.

In order to expedite calculation of the sound pressure level for one-third octaves above f_{cc} an extrapolation method has been devised. This is possible because the higher harmonics follow the asymptotic trend given by Equation (46) which is reproduced below:

$$p^2 = K(mB)^{2-2k} \tag{46}$$

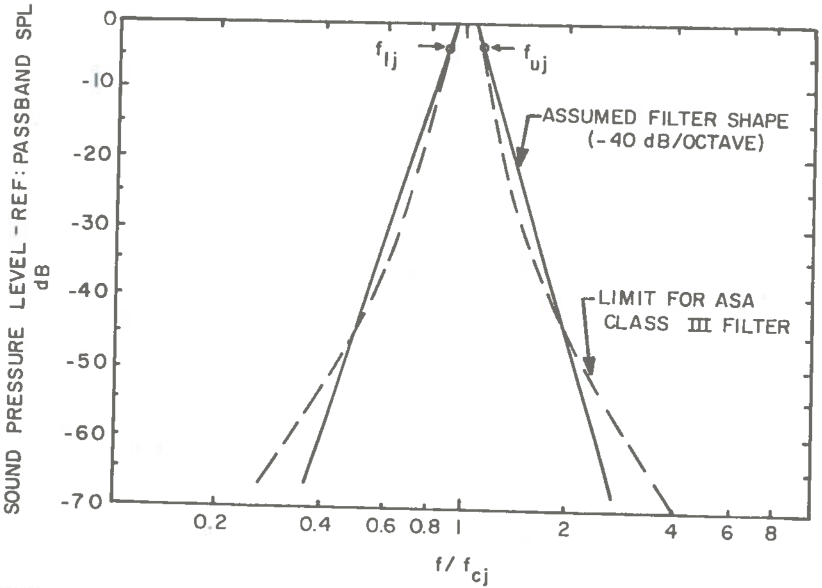
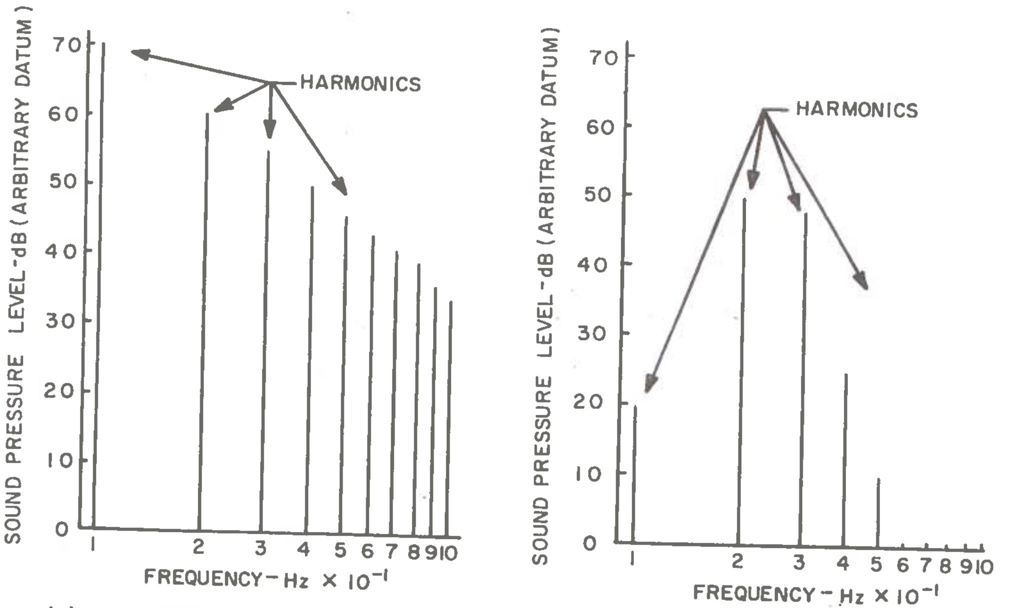


Figure 6. Assumed 1/3-Octave Band Filter Shape



(a) LINE SPECTRUM BEFORE FILTERING

(b) LINE SPECTRUM AFTER FILTERING

Figure 7. Effect of One-Third Octave Filter (25 Hz Center Frequency) on Sample Line Spectrum

If we let (N + 1) be the number of the lowest harmonic contained in the passband of the j -th third octave, N is given by:

$$N = \mathrm{mod}\left\{ \frac{f_{cj}}{2^{1/6} f_o} \right\} \tag{52}$$

and if we assume that the level of the j -th third octave band is the sum of the harmonics contained in the passband (ie - between the upper and lower cutoff frequencies) then the level of the j -th third octave band is the sum of the harmonics from N + 1 to $2^{1/3}N$ since $f_{uj} = 2^{1/3} f_{lj}$:

$$1/3\ OL_j = 10 \log \sum_{n=N+1}^{2^{1/3}N} K(n)^{2-2k} - SPL_{ref} \tag{53}$$

By the same token the harmonics contained in the passband of the (j + 1)-th third octave band are from $(2^{1/3}N + 1)$ to $2^{2/3}N$ and the level of (j + 1)-th band is given

$$1/3\ OL_{j+1} = 10 \log \sum_{n=2^{1/3}N+1}^{2^{2/3}N} K(n)^{2-2k} - SPL_{ref} \tag{54}$$

The increment between the two band levels is given:

$$\Delta dB = 1/3\ OL_{j+1} - 1/3\ OL_j \tag{55}$$

$$\Delta dB = 10 \log \sum_{n=2^{1/3}N+1}^{2^{2/3}N} K(n)^{2-2k} - 10 \log \sum_{n=N+1}^{2^{1/3}N} K(n)^{2-2k} \tag{56}$$

$$\Delta dB = 10 \log \frac{\sum_{2^{1/3}N+1}^{2^{2/3}N} K(n)^{2-2k}}{\sum_{n=N+1}^{2^{1/3}N} K(n)^{2-2k}} \tag{57}$$

$$1/3\ OL_{j+1} = 1/3\ OL_j + 10\ \mathrm{Log} \frac{(2^{1/3}N+1)^{\alpha} + (2^{1/3}N+2)^{\alpha} + \ldots + (2^{2/3}N)^{\alpha}}{(N+1)^{\alpha} + (N+2)^{\alpha} + \ldots + (2^{1/3}N)^{\alpha}} \tag{58}$$

where

$$\alpha = 2-2k$$

Thus the level of the one-third octave band at $2^{1/3} f_{cc}$ is given by:

$$1/3\ OL_{2^{1/3} f_{cc}} = 1/3\ OL_{f_{cc}} + 10 \text{Log} \frac{(2^{1/3}N+1)^{\alpha}+(2^{1/3}N+2)^{\alpha}+\ldots+(2^{2/3}N)^{\alpha}}{(N+1)^{\alpha}+(N+2)^{\alpha}+\ \ldots\ +(2^{1/3}N)^{\alpha}} \qquad (59)$$

Equation 58 then, is used to calculate the third octave band levels for all the bands centered above f_{cc}.

Rotor Broadband Noise

Rotor generated broad-band noise has been included in the computer program. A complete discussion of broad-band rotor noise is included in References 1 and 20 thus only a short summary will be included here.

The basic conclusion established by Lowson in Reference 20 is that the overall level of rotor generated broad band noise is most accurately calculated by means of the equation developed by Schlegel, et al (Reference 1). Lowson [20], however, developed a factor to modify Schlegel's equation to account for directionality effects. This factor and the spectrum shape are given as:

(a) Directionality:

$$DI = 10 \text{ Log} \left\{ \frac{\cos^2(\theta_1) + 0.1}{\cos^2(70)} \right\} \qquad (60)$$

where θ_1 is the angle measured from the rotor rotational axis ($\theta_1 = 0^\circ$ below the rotor). As noted in Reference 20, the factor ($\cos^2(70^\circ)$) is included to normalize the directivity factor to the measurement location used by Schlegel, et al.[1]

(b) Spectrum Shape:

The spectrum shape is that developed by Schlegel, et al and shown in Figure 8

(c) Peak frequency:

The relationship used by Schlegel in Reference 1 to determine the peak vortex frequency was given as the relation:

$$f_s = 0.28\ V_{0.7}/h_1 \qquad (61)$$

where:

$$h_1 = c \sin(\alpha_1) + t_c \cos(\alpha_1)$$

and $V_{0.7}$ is the rotational speed at the seven-tenth radial station, c is the blade chord, t is the blade thickness, and α_1 is the angle of attack at 0.7R.

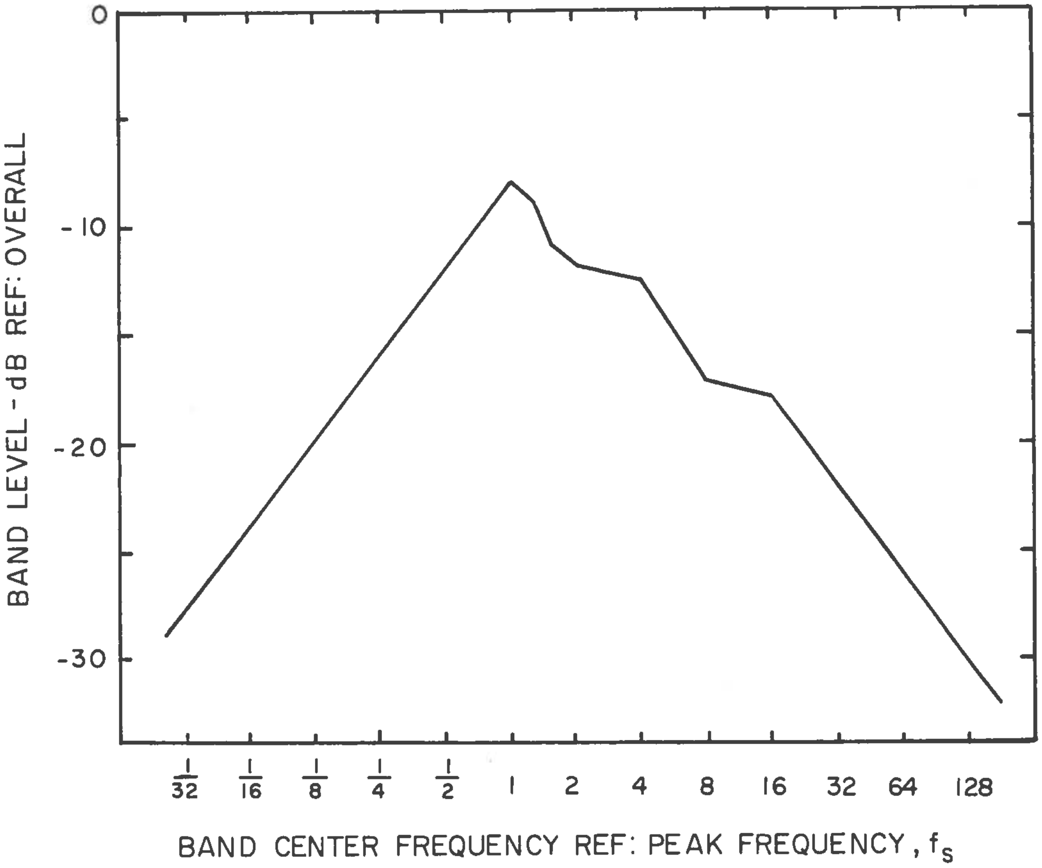


Figure 8. Rotor Broadband Noise Spectrum Shape

In order to provide a solution requiring less detailed knowledge of the blade geometry, data collapses where performed using measured rotor data. These data provided the following relation for f_s:

$$f_s = -240 \operatorname{Log}(T) + 0.746 V_t + 786 \tag{62}$$

which was used in the program for the peak vortex frequency.

When all these factors are combined with Schlegel's, et al[1] equation, the sound pressure level of the j -th third octave band of rotor broadband noise is given by the following:

$$\begin{aligned} SPL_{Vj} &= 20 \operatorname{Log}(V_t) + 20 \operatorname{Log}(T) - 10 \operatorname{Log}(B) - 10 \operatorname{Log}(R) \\ &\quad - 10 \operatorname{Log}(c) - 20 \operatorname{Log}(r') + 10 \operatorname{Log}(\cos^2\theta_1 + 0.1) + S_j + 19.4 \end{aligned} \tag{63}$$

where S_j is the spectrum shape correction number given in Figure 8. The complete rotor spectrum is the band by band energy sum of the rotational and broadband noise. When a tail rotor is included its' complete spectrum is added to the main rotor spectrum to produce a total rotors spectrum which is stored for later use in calculating the vehicle spectrum.

Propeller Noise

As in the case of rotor noise, calculation of propeller noise consists of two parts, rotational and broadband noise. The rotational noise calculation procedure is empirically derived from several sources (References 14, 17, 19, 27, and 33) and the broadband noise is calculated from Hubbard's (Ref. 34) interpretation of Yudin's (Reference 35) work with rotating round rods. This procedure yields acceptable correlation with measured data as will be shown in a following section.

Rotational Noise

The first step in the procedure is to calculate the overall rotational noise level, $OASPL_R$, at the correct distance r and azimuth γ_a. This has been determined to be

$$\begin{aligned} OASPL_R &= 15.5 \operatorname{Log}(P_p) - 20(\operatorname{Log}(D_p) + \operatorname{Log}(B_p)) + 40M_t \\ &\quad + 10 \operatorname{Log}(N_p) + DI(\gamma_a) - 20 \operatorname{Log}(r/500) + 50.2 \end{aligned} \tag{64}$$

The value of r, the distance from observer to aircraft is calculated from the field point values X, Y, Z. The azimuth angle is defined in Figure 9 and the directivity index DI is calculated from:

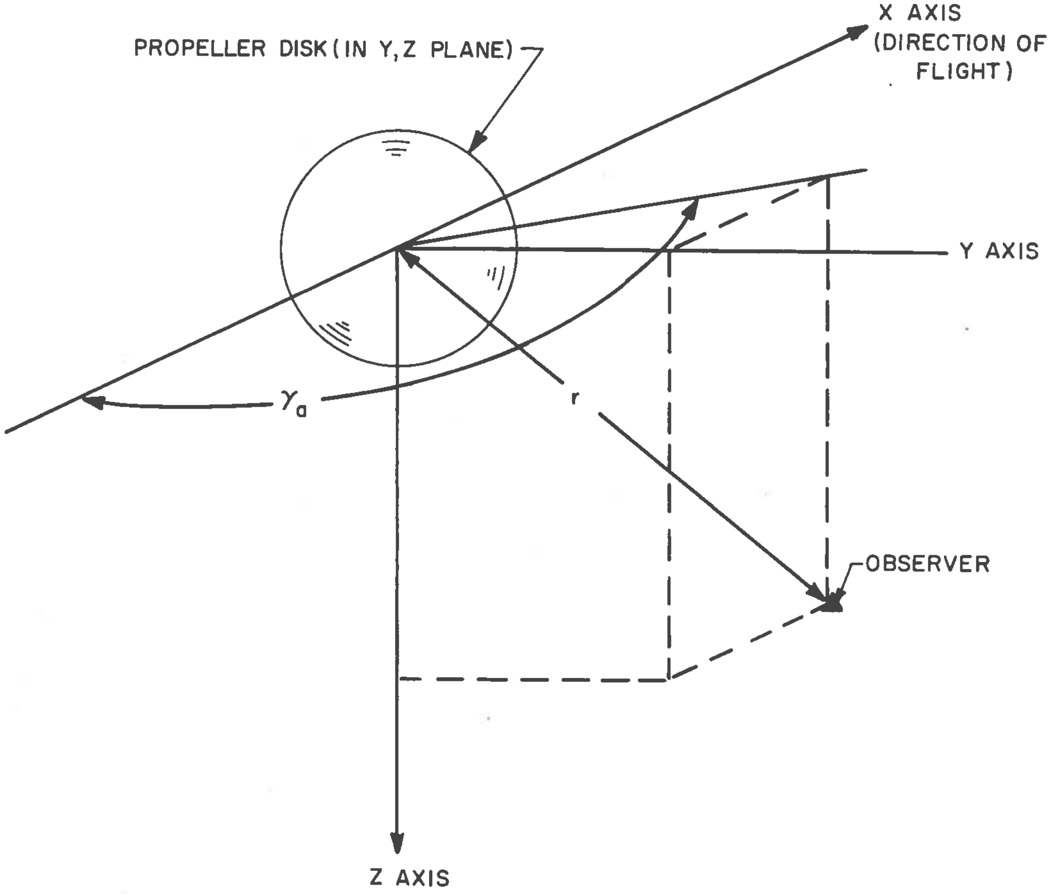


FIGURE 9. Definition of Field Point Azimuth Angle γ_a For Propeller Noise Calculation.

$$DI = \begin{cases} 0.1200\phi_1 - 7.00 & 0^\circ \leq \phi_1 < 50^\circ \\ 0.0286\phi_1 - 2.43 & 50^\circ < \phi_1 < 120^\circ \\ -.3080\phi_1 + 38.0 & 120^\circ < \phi_1 < 180^\circ \end{cases} \qquad (65)$$

where $\phi_1 = |180^\circ - \gamma_a|$. The first ten rotational harmonics are calculated from the $OASPL_R$ value and the helical tip Mach number M_H by the use of Figure 10. The harmonic frequencies are integral multiples of the fundamental rotational frequency f_o given by:

$$f_o = V_H B_p / D_p \qquad (66)$$

$$f_m = mV_H B_p / D_p \qquad (67)$$

$$V_H = \sqrt{V_T^2 + V_f^2} \qquad (68)$$

The harmonic spectrum is converted to a one-third octave spectrum by adding the harmonics which fall in a given one-third octave band to produce the band level. For example, the harmonic spectrum of Figure 11a results in the (ideal) third octave spectrum of Figure 11b. For the sake of simplicity the third octave filters are assumed to have an ideal shape (infinitely steep skirts).

Broadband Noise

The broadband noise component is calculated from the vortex noise equation for propellers given by Hubbard (Reference 34):

$$OASPL_v = 10 \text{ Log}(3.8 \times 10^{-11} A_B V_{0.7}) - 20 \text{ Log}(r/500) \qquad (69)$$

While there are more sophisticated methods being developed (eg. Reference 17) they are somewhat more complicated to use and require the use of empirically derived constants. The Equation (69) above appears to yield reasonably accurate results and is relatively simple to use.

The one-third octave band spectrum is determined from the $OASPL_V$ of Equation (69) and the spectrum shape shown in Figure 12 adapted from Beranek's (Reference 27) vortex noise spectrum shape. The peak frequency is given by Beranek[17] as:

$$f_s = 0.85V_H/c \qquad (70)$$

where c is the mean blade chord.

The complete propeller spectrum is the band by band energy summation of the rotational and broadband components:

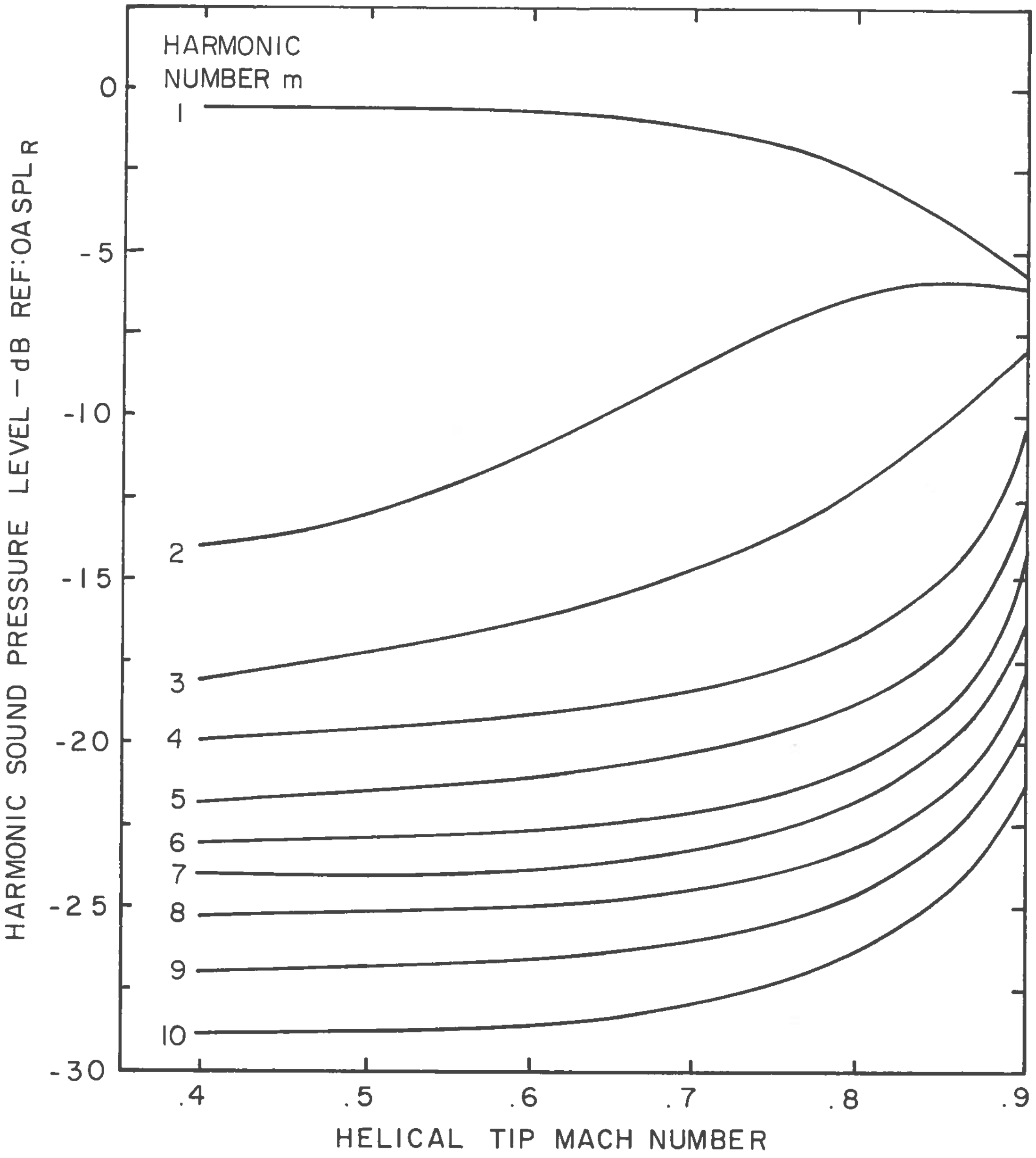
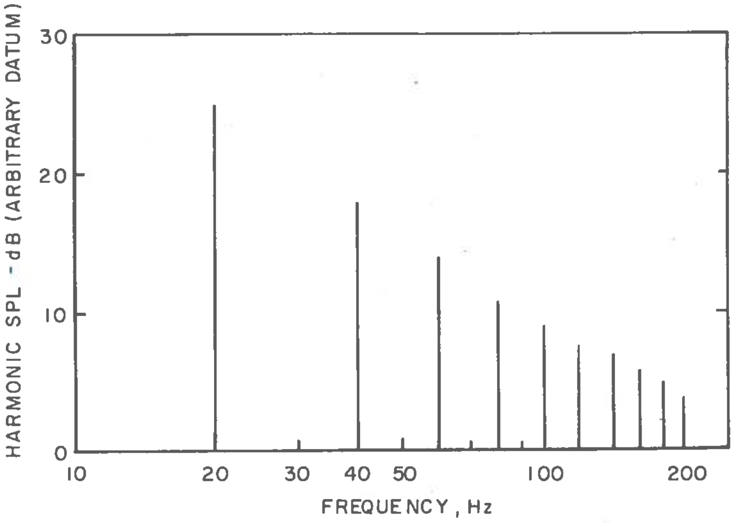
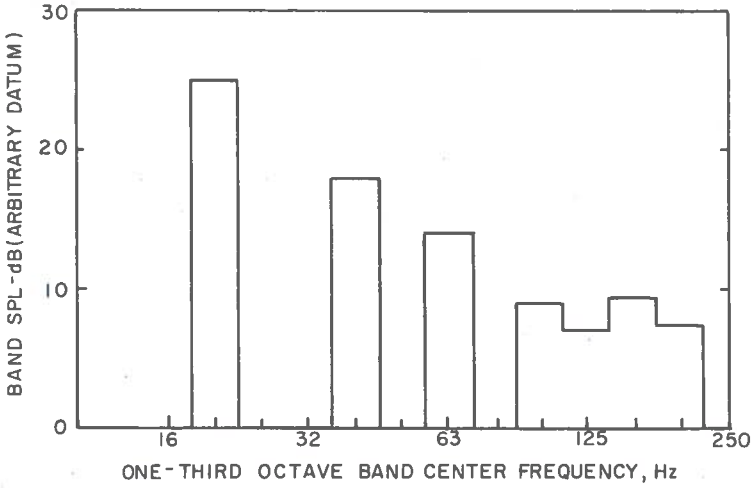


Figure 10. Relationship of Propeller Rotational Harmonic Sound Pressure Level to the Calculated $OASPL_R$ As a Function of Helical Tip Mach Number M_H



(a) SAMPLE HARMONIC (LINE) SPECTRUM



(b) CORRESPONDING ONE-THIRD OCTAVE SPECTRUM

FIGURE 11. Conversion of Harmonic Spectrum to a One-Third Octave Spectrum.

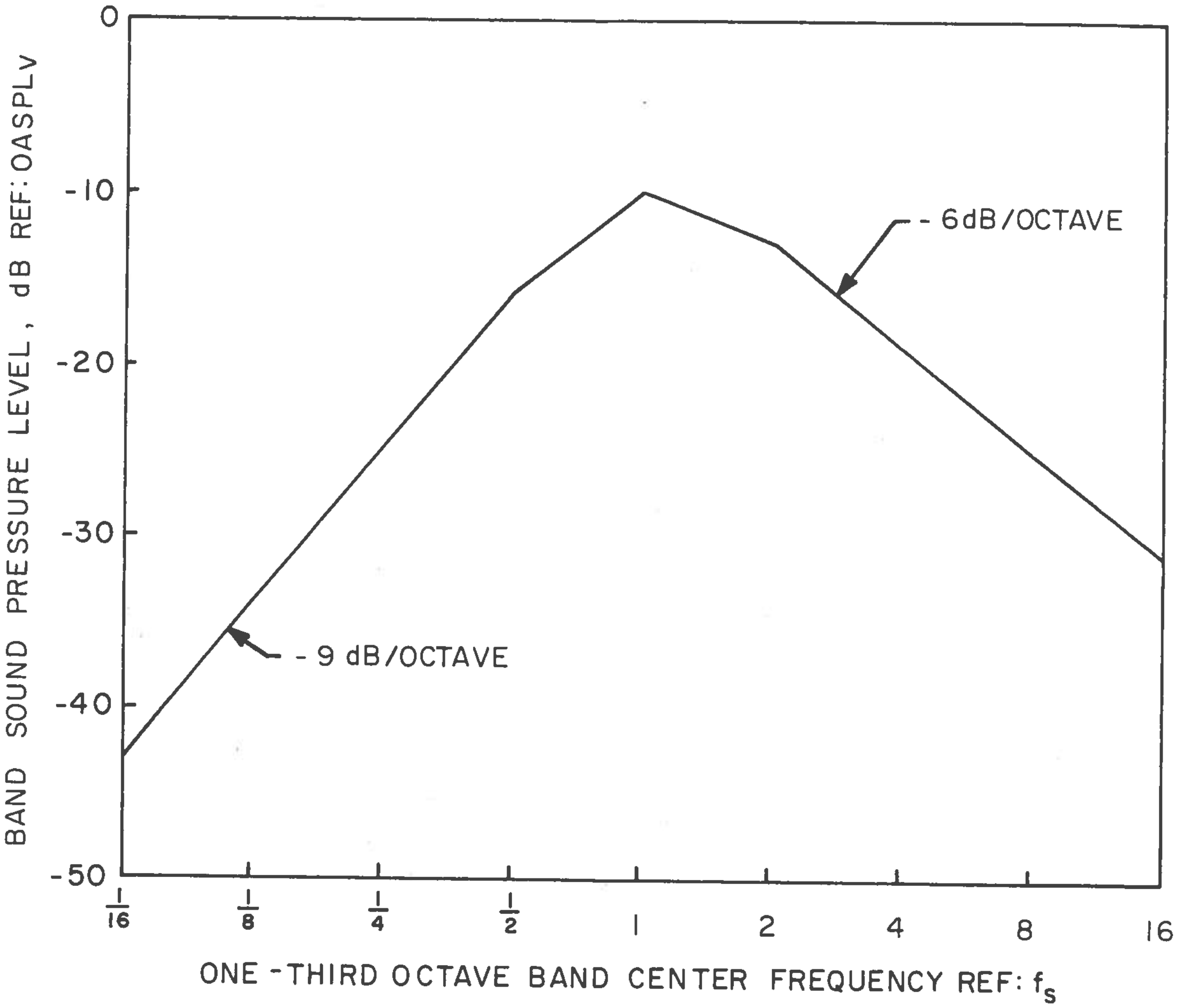


Figure 12. Assumed Propeller One-Third Octave Band Spectrum Shape (Reference 27)

$$OL_j = 10 \text{ Log} \left\{ \text{Antilog} \left[\frac{OL_{Rj}}{10} \right] + \text{Antilog} \left[\frac{OL_{Vj}}{10} \right] \right\} \qquad (71)$$

Fan Noise

The method used to calculate the noise radiated from fans and fan engines is the analytical/empirical procedure described by Burdsall and Urban in Reference 15. The method is described in detail in Reference 15 hence only a limited discussion will be presented here.

Three components are calculated: discrete tone, broadband, and combination tone noise. Combination tone noise occurs at multiples of the fan rotational frequency when the fan blades operate at relative tip Mach numbers above 1. Because of the detailed design parameters required provision has been made to delete the combination tone noise calculation. For this case the calculated fan noise is an approximation. The calculated values for discrete tone noise do not include the possibility of propagating rotor/stator interaction tones. Burdsall and Urban's method for calculating discrete tone noise is developed from engine data in which there are no propagating interaction tones, hence interaction tone noise is not explicitly included in the final method. A check is performed to determine the presence of interaction tones and a warning is printed out in the event they are present. In general, when they exist they are only important for blade/vane spacings less than about four chords.

Discrete Tone Noise

The Burdsall/Urban[15] method calculates the first two harmonics of blade passing noise for aft ($0^o < \gamma_a < 90^o$) and for forward ($90^o < \gamma_a < 180^o$) radiation using the following empirical equations based on rotor field cutoff ratio ξ_{RF}:

$$\xi_{RF} = \frac{M_t}{M^* \sqrt{1 - M_{ax}^2}} \qquad (72)$$

where

$$M^* = 1 + 0.84 B_f^{-2/3} \qquad (73)$$

The forward radiated mean SPL in the first harmonic for $\xi_{RF} \leq 1.05$ is calculated to be:

$$SPL'_{1F} = 121.84 + 38.28\xi_{RF} - 303.79\xi_{RF}^2 + 635.85\xi_{RF}^3 - 483.36\xi_{RF}^4 + 122.8\xi_{RF}^5$$

$$+ 10 \text{ Log} \left\{ (PR-1) \left[\frac{D_{tf}}{24} \right]^2 \right\} - 20 \text{ Log}(r) + 5.55 \qquad (74)$$

When ξ_{RF} is between 1.05 and 1.5, the value for SPL_{1F} is the value calculated in Equation (74) minus 20 log (DL):

$$SPL_{1F} = SPL'_{1F} - 20\ \mathrm{Log}(DL) \tag{75}$$

When ξ_{RF} is greater than 1.5 the forward radiated sound pressure level is calculated by the following equation:

$$SPL_{1F} = 127 + 10\ \mathrm{Log}\left\{(PR-1)\left[\frac{D_{tf}}{24}\right]^2\right\} - 20\ \mathrm{Log}(DL) - 20\ \mathrm{Log}(r) + 5.55 \tag{76}$$

The aft radiated, first harmonic sound power level for $\xi_{RF} < 1.5$ is given as:

$$\begin{aligned} SPL_{1R} = {} & 184 - 203.18\xi_{RF} - 21.98\xi_{RF}^2 + 550.99\xi_{RF}^3 - 534.97\xi_{RF}^4 + 151.26\xi_{RF}^5 \\ & + 10\ \mathrm{Log}\left\{(PR-1)\left[\frac{D_{tf}}{24}\right]^2\right\} - 20\ \mathrm{Log}(r) + 5.55 \end{aligned} \tag{77}$$

and for $\xi_{RF} < 1.5$:

$$SPL_{1R} = 129 + 10\ \mathrm{Log}\left\{(PR-1)\left[\frac{D_{tf}}{24}\right]^2\right\} - 20\ \mathrm{Log}(r) + 5.55 \tag{78}$$

The mean SPL of the second harmonic is calculated from the first in the following way:

$$SPL_{2F} = SPL_{1F} - C_F \tag{79}$$

$$SPL_{2R} = SPL_{1R} - C_R \tag{80}$$

where C_F and C_R are:

$$C_F = \begin{cases} 3.3 & N_c = 1 \\ 5.7 & N_c = 2 \\ 6.8 & N_c = 3 \end{cases} \tag{81}$$

$$C_R = \begin{cases} 3.2 & N_c = 1 \\ 3.5 & N_c = 2 \\ 2.5 & N_c = 3 \end{cases} \tag{82}$$

$$N_c = \mathrm{Mod}\ \left(1 + \frac{\xi_{RF}}{.91}\right) \tag{83}$$

The sound pressure level at a specified azimuth angle γ_a is determined from the directivity curves of Figure 13 or the following equation:

$$SPL(\gamma_a) = SPL + K_1 + K_2(180-\gamma_a) + K_3(180-\gamma_a)^2 + K_4(180-\gamma_a)^3 + K_5(180-\gamma_a)^4 + K_6(180-\gamma_a)^5 \qquad (84)$$

The values of K_1 through K_6 are given in Table 1.

TABLE 1
Constants K_i For Calculation of Discrete
Tone Sound Pressure Level

	ξ RK	K_1	K_2	K_3	K_4	K_5	K_6
$SPL'_{1F}(\gamma_a)$	≤1.05	-1.2669	5.4963×10^{-2}	-2.9492×10^{-3}	7.6284×10^{-5}	3.4487×10^{-7}	-1.2323×10^{-8}
$SPL_{1F}(\gamma_a)$	>1.05	-3.0339	7.2853×10^{-2}	4.0824×10^{-4}	2.8230×10^{-7}	-8.8591×10^{-8}	-6.3146×10^{-10}
$SPL_{1R}(\gamma_a)$	ALL	-56.418	0.6450	2.0970×10^{-3}	-6.7782×10^{-6}	2.8956×10^{-7}	8.5944×10^{-10}

The frequency of the first harmonic and of the second harmonic are calculated:

$$f_{o_f} = \frac{B_f \Omega_{Nf}}{60} \quad \text{(first harmonic)} \qquad (85)$$

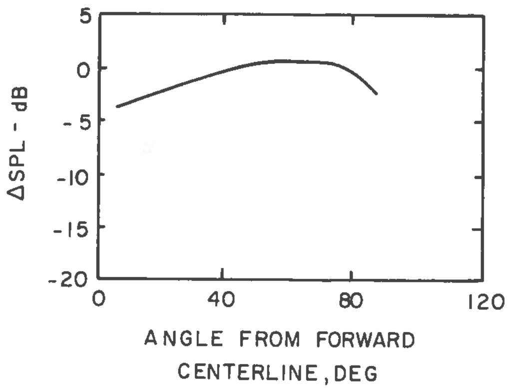
$$f_{1_f} = 2 f_{o_f} \quad \text{(second harmonic)} \qquad (86)$$

The levels of the one-third octave bands containing the fundamental and the second harmonic are equal to the calculated sound pressure levels of the first and second harmonic respectively. These band levels are stored for later combination with the broadband and combination tone spectra to produce the complete spectrum.

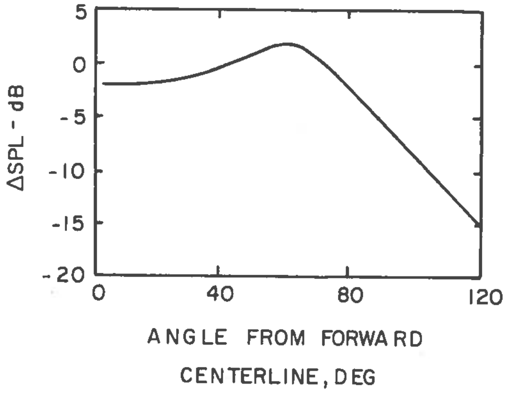
Broadband Noise

The overall broadband noise level at 60° from the inlet (150 ft away) is calculated from the relation:

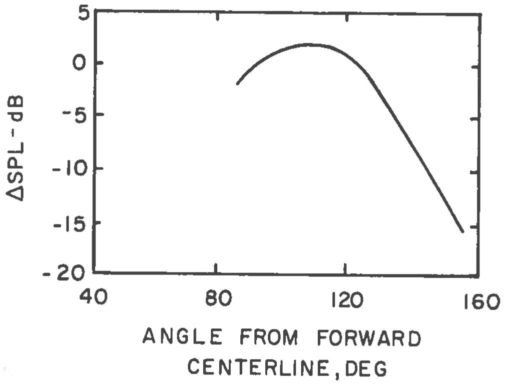
$$OLSPL_{v,60} = OSPL(DF,M_t) + 20\,Log\left(\frac{D_{tf}}{52}\right) - 20\,Log(r/150) + \sigma_o(90)\left\{10\,Log\left\{\frac{BPR/(BPR+1)}{0.833}\right\}\right\} \qquad (87)$$



(a) DISCRETE TONE DIRECTIVITY FOR $\xi_{RK} \leq 1.05$ - FORWARD RADIATION



(b) DISCRETE TONE DIRECTIVITY FOR $\xi_{RK} > 1.05$ - FORWARD RADIATION



(c) DISCRETE TONE DIRECTIVITY FOR AFT RADIATION

Figure 13. Fan Discrete Tone Noise Directivity

where: $\sigma_o(90) = 0$ if $\gamma_a \geq 90^o$ and $\sigma_o(90) = 1$ if $\gamma_a < 90^o$. OSPL (DF, M_t) is taken from the Figure 14 curve. The sound pressure level at angles other than 60^o is given by:

$$OLSPL_{\gamma_a} = OLSPL_{60} + F_1(DI_{sub}) + (1-I_1)(DI_{sup}) \qquad (88)$$

The directivity indicies DI_{SUB} and DI_{SUP} are taken from Figure 15 and F_1 is calculated to be:

$$F_1 = \tfrac{1}{2}\left\{1 - \tanh\left(\frac{M_{rel}-0.95}{0.2}\right)\right\} \qquad (89)$$

$$M_{rel} = \sqrt{M_{ax}^2 + M_t^2} \qquad (90)$$

M_{ax} = axial tip Mach number

M_t = circumfrential tip Mach number

The overall level is converted to a one-third octave band spectrum using the Figure 16 spectrum shapes based on the reduced frequency f* where f* is given as

$$f^* = \frac{fR_t}{a_o} \qquad \text{for } M_{rel} \geq 1.0$$

$$f^* = \frac{fc\sqrt{1-M_{rel}}}{a_o M_{rel}} \qquad \text{for } M_{rel} < 1.0 \qquad (91)$$

and f is the one-third octave center frequency for which the sound pressure level is being calculated.

Combination Tone Noise

As Burdsall and Urban[15] point out, combination tone noise is a spectral transfer of energy from the blade passage tone and harmonics to the shaft rotational frequency and all of its harmonics. Combination tones occur only when the flow over the blade tips is supersonic and results from small blade-to-blade manufacturing irregularities which are amplified by the non-linear nature of shock wave propagation. Because the calculation of combination tone noise requires rather detailed knowledge of the fan design geometry the program contains the option to delete its calculation in the event these design details are not available. In this case, the calculated fan noise represents a first approximation to the actual levels.

The overall sound power level of combination tone noise is calculated with the following empirical equation[17]:

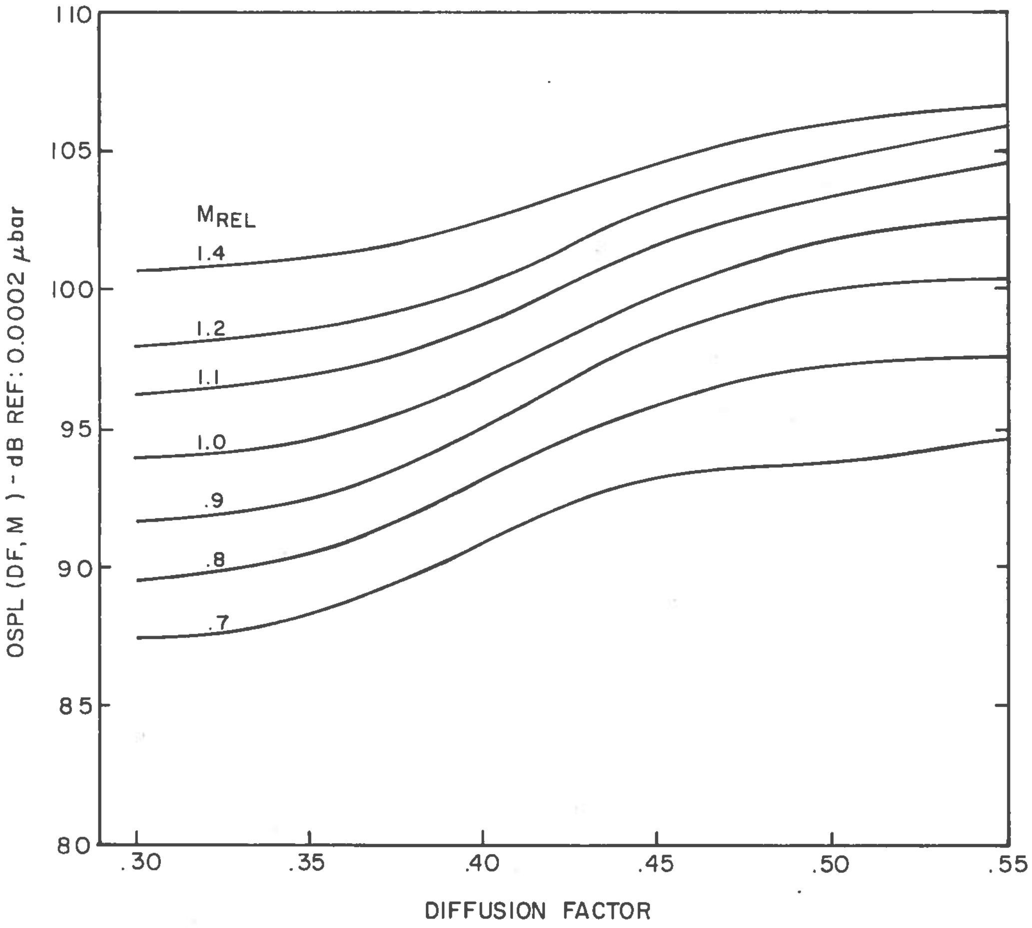


Figure 14. Fan Broadband Noise Level as a Function of Relative Tip Mach Number and Diffusion Factor

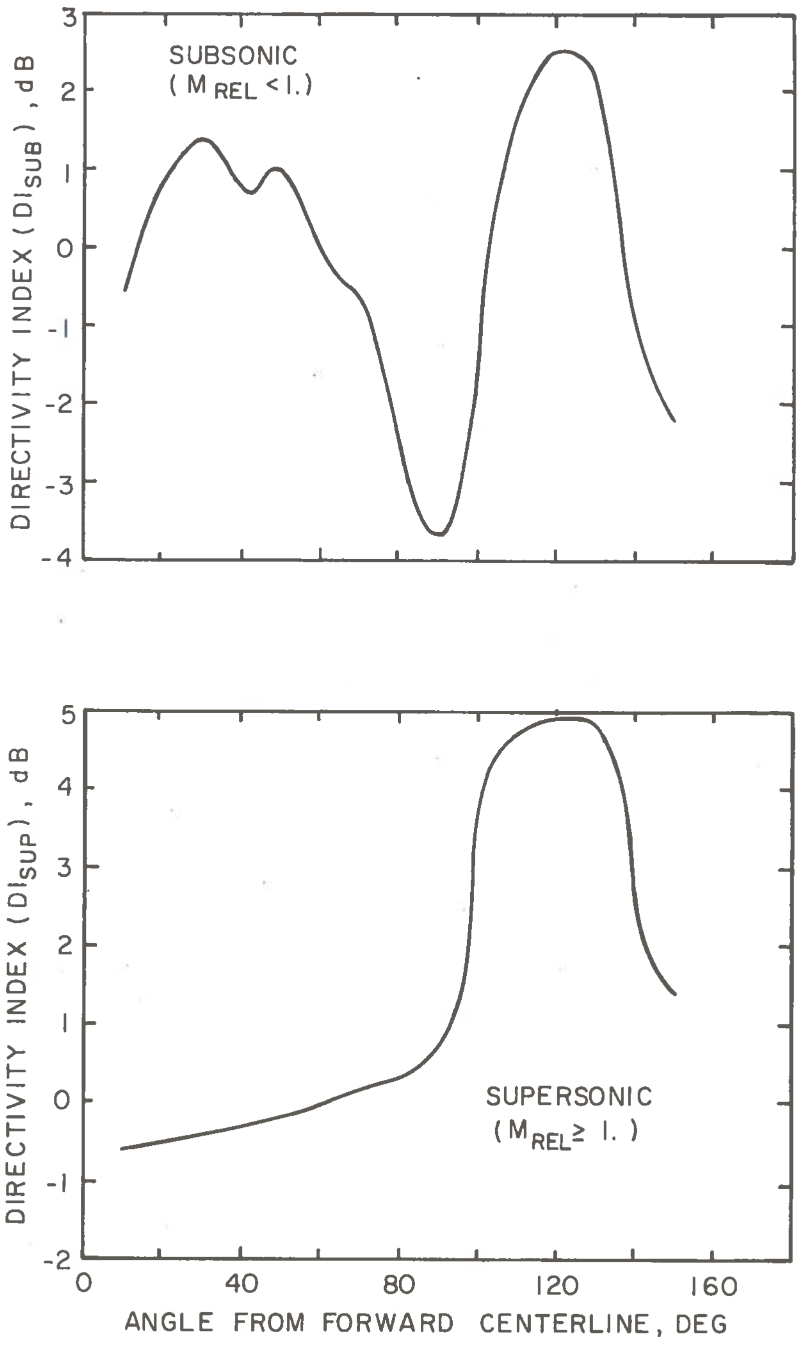


Figure 15. Fan Broadband Noise Directivity Correction

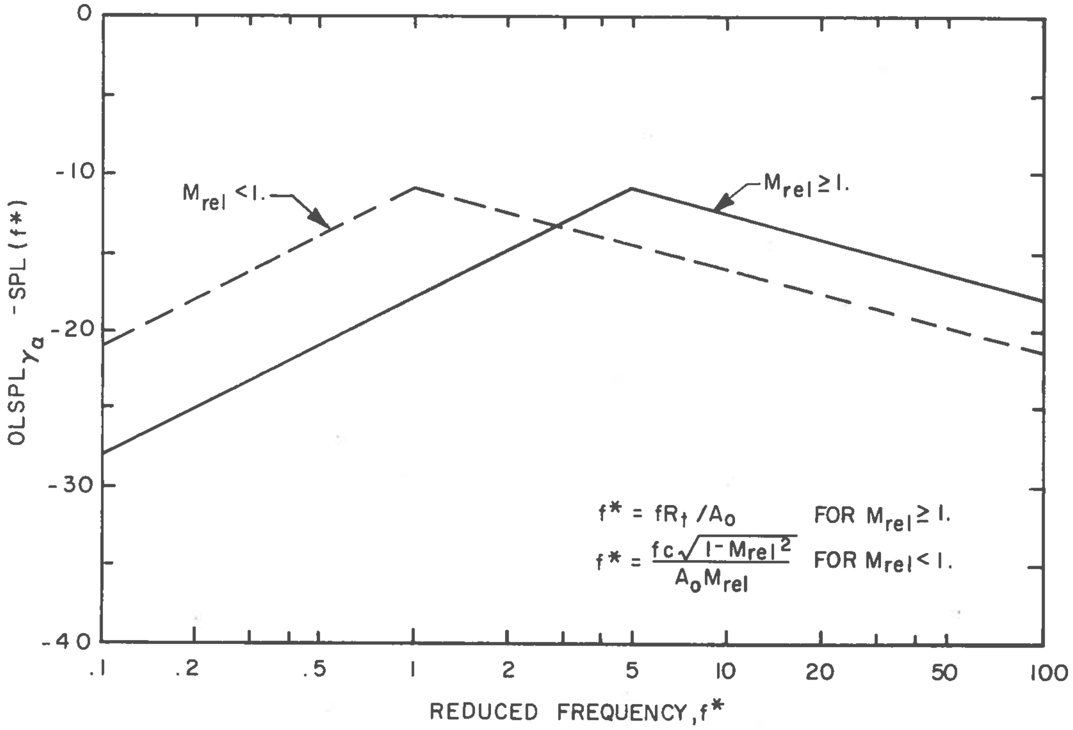


FIGURE 16. Fan Broadband Noise Spectrum Shape.

$$\mathrm{OAWPL} = 189.16 + 727.24M_{rel} - 488.93M^2_{rel} + 107.69M^3_{rel} + 10 \,\mathrm{Log}\, \frac{A_i}{144} - 20 \,\mathrm{Log}(\eta_f B) \tag{92}$$

Where:

$$\eta_f = \tfrac{1}{2}(1 + \mathrm{erf}(\psi_2)) \tag{93}$$

$$\mathrm{erf}(\psi_2) = \begin{cases} 0 & \text{for } \psi_2 = 0 \\ 1 & \text{for } \psi_2 > 0 \quad \text{and } T \leq 0.43 \\ -1 & \text{for } \psi_2 < 0 \quad \text{and } T \leq 0.43 \\ +Q & \text{for } \psi_2 > 0 \quad \text{and } T > 0.43 \\ -Q & \text{for } \psi_2 < 0 \quad \text{and } T > 0.43 \end{cases} \tag{94}$$

$$T = 1 \,/\, (\,1 - 0.328|\psi_2|) \tag{95}$$

$$Q = 1 - Te^{-\psi_2^2}\left[1.061T^4 - 1.43T^3 + 1.42T^2 - 0.284T + 0.255\right] \tag{96}$$

$$\psi_2 = (\phi_e - \phi_a) \big/ \sqrt{2} \cdot \sigma_\phi \tag{97}$$

$$\theta_a = 13.5 \left[\frac{R'_s \sin \mu}{\sin(\mu + \beta^*)}\right]^{-0.875} \tag{98}$$

$$\mu = \tan^{-1}(1/M_{rel}) \tag{99}$$

$$\beta^* = \tan^{-1}(M_{ax}/M_t) \tag{100}$$

$$\theta_e = 2\mathrm{Tan}^{-1}\left[\frac{-\sin + \sqrt{\sin\mu^2 + (T/R'_s)\sin(\mu-\beta^*)(2\cos\mu - (T/R'_s)\sin(\mu-\beta^*))}}{2\cos\mu - (T/R'_s)\sin(\mu-\beta^*)}\right] \tag{101}$$

$$R'_s = R_s R_F/(R_S - R_F) \qquad \text{for } R_F \neq R_s \tag{102}$$

$$R_F = \frac{(1-M^2_{ax})M^2_{rel}}{2\cos\beta^*(1+(M^2_{ax}/f))M_{ax}M_t} \cdot \frac{D_t^2 - D_h^2}{D_t(dD_t/dx) + D_h(dD_h/dx)} \tag{103}$$

According to Burdsall and Urban's[15] analytical development the distribution of power into the rotational harmonics is given by the equation

$$\mathrm{PWL}(K) = 170.8 + 10\,\mathrm{Log}\left[\left\{\frac{1}{4K}\left[\frac{\eta B}{\pi K}\right]^3\left[1-\cos\frac{2\pi K}{\eta B}\right] + 2\left[\frac{\pi K}{\eta B}\right]^2\left[1-\frac{\eta B}{\pi K}\sin\frac{2\pi K}{\eta B}\right]\right\} \cdot \left\{1 + \sigma_a^2 + \exp\left[-4\sigma_e^2\left(\frac{\pi K}{\eta B}\right)^2\right](B\delta_{KN} - 1)\right\}\right] \tag{104}$$

$$\delta_{KN} = \begin{cases} 0 & K \neq B \\ 1 & K = B \end{cases} \tag{105}$$

$$\sigma_a = 0.1 \tag{106}$$

$$\sigma_e^2 = 1 - \eta + 2\eta\alpha'^2\left\{\sigma_\phi^2 + 2\sigma_\phi^3 \; 2/\pi\left[\left\{\psi_1^2 + 2^{1.5}\sigma_\phi\psi_1 + (2\sigma_\phi)^2 e^{-\psi_1^2}\right\} - \left\{\psi_2^2 + 2^{1.5}\sigma_\phi\psi_2 + (2\sigma_\phi)^2 e^{-\psi_2^2}\right\}\right]\right\} \tag{107}$$

$$\alpha = \frac{R'_s}{\tau} \cdot \frac{\sin(\mu+\theta_a)}{\sin(\mu+\beta^*)} \tag{108}$$

Since only those harmonics above cutoff will propagate the tones below cutoff are eliminated and their energy added to the remaining tones to keep the total energy constant. The cutoff ratio of each tone(ξ_k) is calculated to be:

$$\xi_K = \frac{M_t}{(1 + 0.84K^{-2/3})\sqrt{1-M_{ax}^2}} \tag{109}$$

and is compared to the critical cutoff ratio ξ_c:

$$\xi_c = 1 - 0\frac{1}{10}\exp\left\{23(1-M_{rel})\right\} \tag{110}$$

Those harmonics K whose ξ_k is less than ξ_c are eliminated.

The final step in calculating combination tone noise is to correct for directivity, convert to sound pressure level and calculate the third octave spectrum by summing those harmonics contained in each band. The sound pressure level of the K-th harmonic at the angle γ_a and distance γ is given by the empirical equation:

$$\mathrm{SPL}_{K,\gamma a} = \mathrm{PWL}_K - 20\,\mathrm{Log}(r) + \sum_{i=1}^{5} D_{\gamma_i}\,(\xi_K)^i - 3.85 \tag{111}$$

The coefficients $D_{\gamma i}$ are given in Table 2.

TABLE 2

Coefficient $D_{\gamma i}$ Values

γ_a	D_1					
(deg)	i=0	i=1	i=2	i=3	i=4	i=5
170	-475.92	1088.41	-832.01	207.78	0	0
160	-488.88	1164.19	-929.26	244.73	0	0
150	-491.57	1202.70	-987.87	269.86	0	0
140	- 14.22	7.71	2.85	0.	0	0
130	419.53	-1046.58	867.72	-238.17	0	0
120	12.96	- 43.78	53.02	- 20.72	0	0
110	-286.74	- 635.16	-432.44	105.71	-48.71	-26.11
100	181.25	- 411.47	295.32	- 67.81	0	0
90	1618.24	-3933.70	3133.88	-821.89	0	0
80	4033.55	-9869.94	7937.61	-2104.66	0	0
70	6613.32	-16167.20	12994.70	-3443.76	0	0

Turboshaft Engine Noise

The procedure for predicting turboshaft engine noise is entirely empirical, based on noise measurements made on several engines. The first step in the procedure is to determine the PNL at 500 feet to the side of the engine using the 'average' or 'loud' engine line of Figure 17 . These lines are represented by the following equations:

Avg: $$PNL_{500} = 4.4 \text{ Log(horsepower/10)} + 79.0 + 10 \text{ Log } (N_e) \qquad (112)$$

Loud: $$PNL_{500} = 5.8 \text{ Log(horsepower/10)} + 80.2 + 10 \text{ Log}(N_e)$$

$$N_e = \text{Number of engines} \qquad (113)$$

The directivity index of Figure 18, derived from several engines, is used to correct the sideline PNL to the azimuth location required. Since most available engine data is presented in terms of octave band levels, the calculated value of PNL is first converted to an octave band spectrum using the curves of Figure 19. These are composite curves representing an average of several different engines, thus the calculated engine spectrum represents a reasonable estimate of the engine generated noise. For most aircraft, turboshaft engine noise contributes only very little to the final EPNL value, consequently the current method is deemed adequate for the purposes of this study. When a simple, more accurate prediction method becomes available it can easily be incorporated into the program.

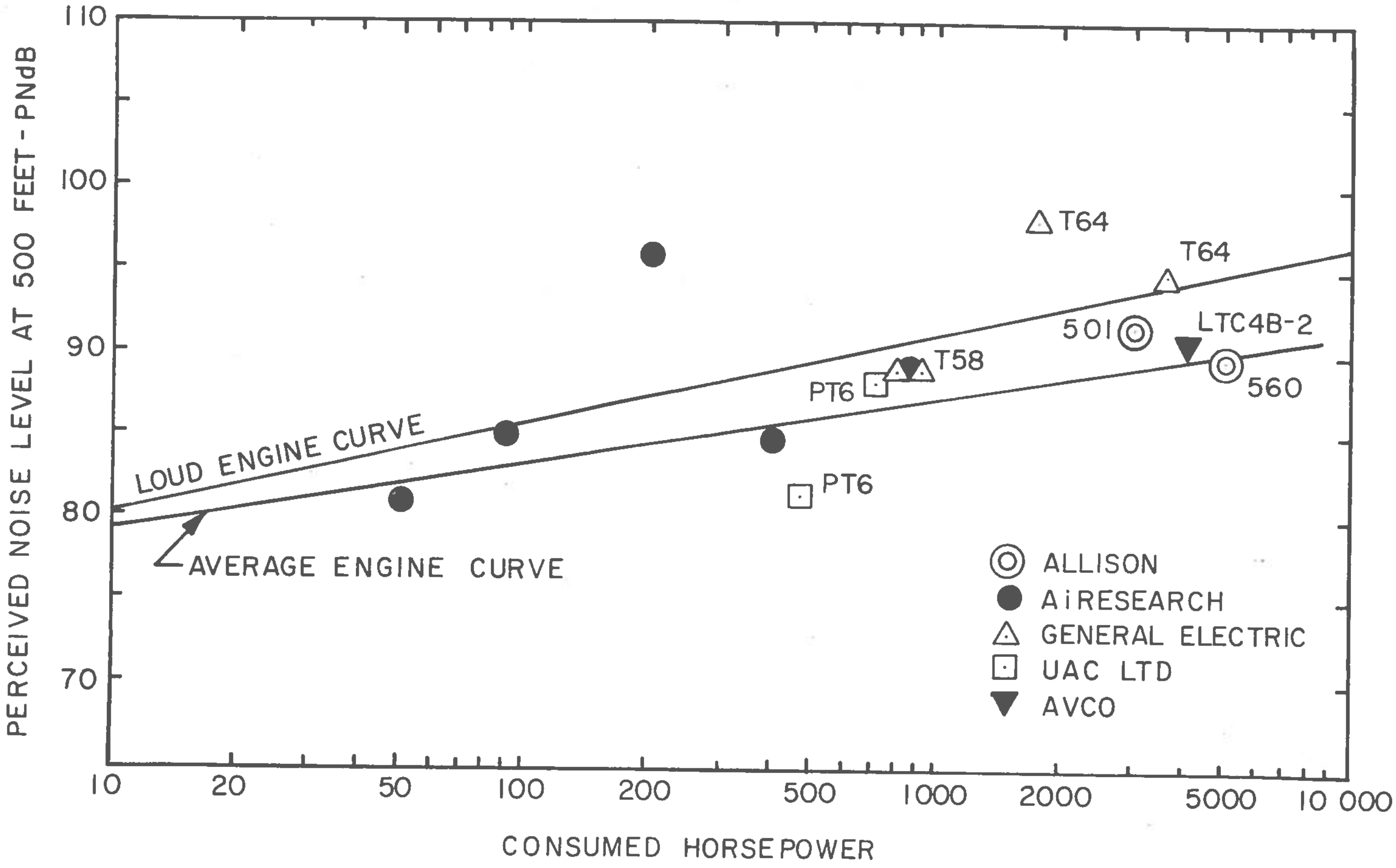


Figure 17. Derivation of Turboshaft Engine Noise Level

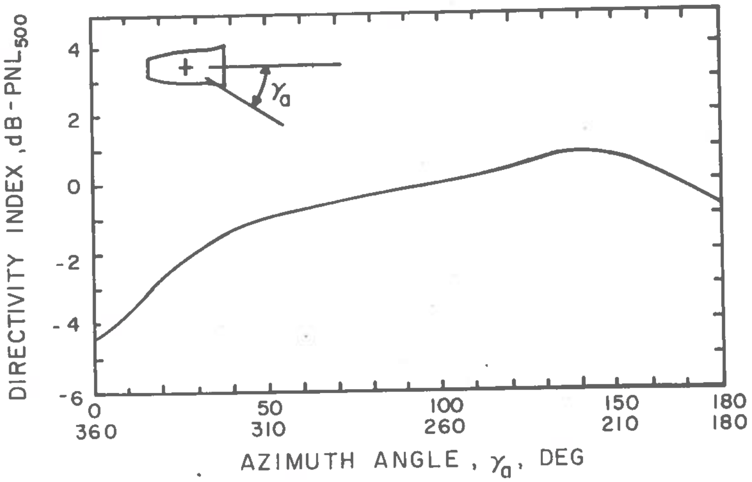


Figure 18. Turboshaft Engine Noise Directivity Index

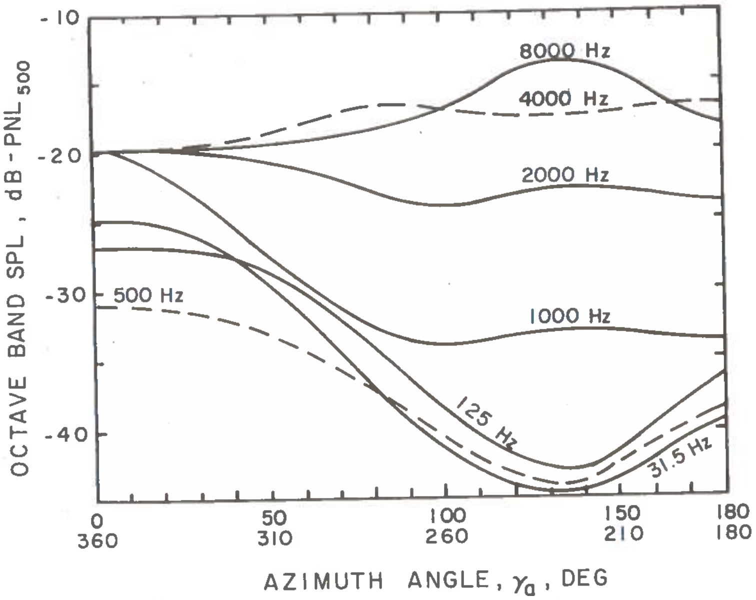


Figure 19. Turboshaft Engine Correction Factors to Determine Octave Band Spectrum

Jet Noise

Although jet noise was the subject of many studies several years ago the complexity of the subject is such that prediction of jet noise has yet to be represented accurately. The problem is further compounded in the case of direct lift jets or deflected jets where sound power levels, directivity, and spectrum can be significantly altered. However, in order to provide the V/STOL noise model with the ability to at least determine an order of magnitude estimate for those vehicles using jets the following empirically based prediction method for undeflected jets is included in the program.

According to Richards and Clarkson (Reference 32) the total acoustic power output from a subsonic jet is given as

$$PWL_j = 60 \text{ Log}(V_j) + 10 \text{ Log}(A) - 48. \qquad \text{db ref: } 10^{-13} \text{ watt} \tag{114}$$

and for supersonic jet velocities as

$$PWL_j = 13.5 \text{ Log} \left\{ \frac{0.67 w V_f^2}{g} \right\} + 78. \qquad \text{db ref: } 10^{-13} \text{ watt} \tag{115}$$

where:

$V_j = tg/w =$ exit velocity (ft/sec)

t = engine thrust (lb)

w = total weight flow (air + fuel) through engine (lb/sec)

g = acceleration due to gravity (ft/sec/sec)

A = nozzle area (sq. in.)

According to Beranek (Reference 27) the total acoustic power can be corrected for non-standard atmospheric conditions by

$$\Delta PWL = 10 \text{ Log} \frac{P_a}{P_{a_o}} + 40 \text{ Log} \frac{T_j}{T_{j_o}} - 35 \text{ Log} \frac{T_a}{T_{a_o}} \tag{116}$$

where: $T_{a_o} = 59.0^{\circ}F$

$P_{a_o} = 29.92$ in Hg.

T_{j_o} = Jet tailpipe temperature for ambient conditions T_{a_o}, P_{a_o}

P_a = Ambient operating pressure (in Hg)

T_a = Ambient operating temperature (^{o}F)

T_j = Tailpipe temperature

Then the overall sound pressure level at a distance R feet from the jet (assuming hemispherical radiation) is given as

$$SPL_j = PWL_j - 10 \, Log(4\pi R^2) + 3 + DI \tag{117}$$

where DI is the azimuthal directivity index (shown in Figure 20) based on the data from Reference 31. The one-third octave band spectrum is determined from the overall level and the relative jet velocity using Figure 21 adapted from Reference 32. The relative jet velocity is the velocity of the jet relative to the surrounding air; thus if the aircraft is moving with velocity V_f the relative jet velocity, V_{rel}, is given as

$$V_{rel} = V_j - V_f \tag{118}$$

Attenuation

All sound, once generated, is attenuated by various mechanisms as it travels from source to observer. These mechanisms include spherical divergence, atmospheric absorption, ground absorption, and small-scale turbulence. Effects such as thermal and wind gradients and wind effects are not included because their existance and exact structure is never precisely known and cannot be predicted with reasonable accuracy.

Spherical Divergence

In an ideal medium the total sound power radiated by a point source far from any ground plane through an expanding spherical wave front remains constant over the surface of the sphere so that sound pressure levels are reduced by 6 dB for each doubling of a distance from the source. At sufficiently large distances from a helicopter in the air and out of ground effect, the helicopter will appear to an observer as a point source and the spherical divergence attenuation then follows the 6 dB per doubling of distance law. In the near field region where the physical dimensions of the source are not negligible so that sound radiated by the source reaches the observer from different directions and where non-propagating "hydrodynamic" pressure fluctuations cause the apparent sound level to be amplified, this attenuation law does not hold. Also , when the source or microphone is close to the ground, reflection effects

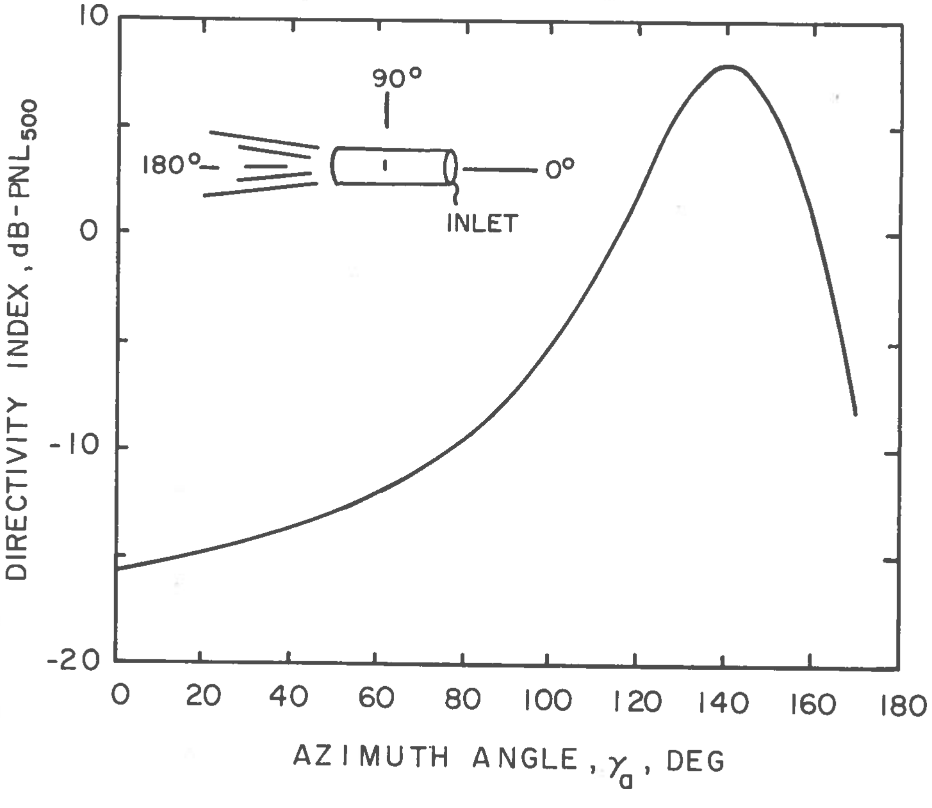


Figure 20. Directivity Index for Jet Noise

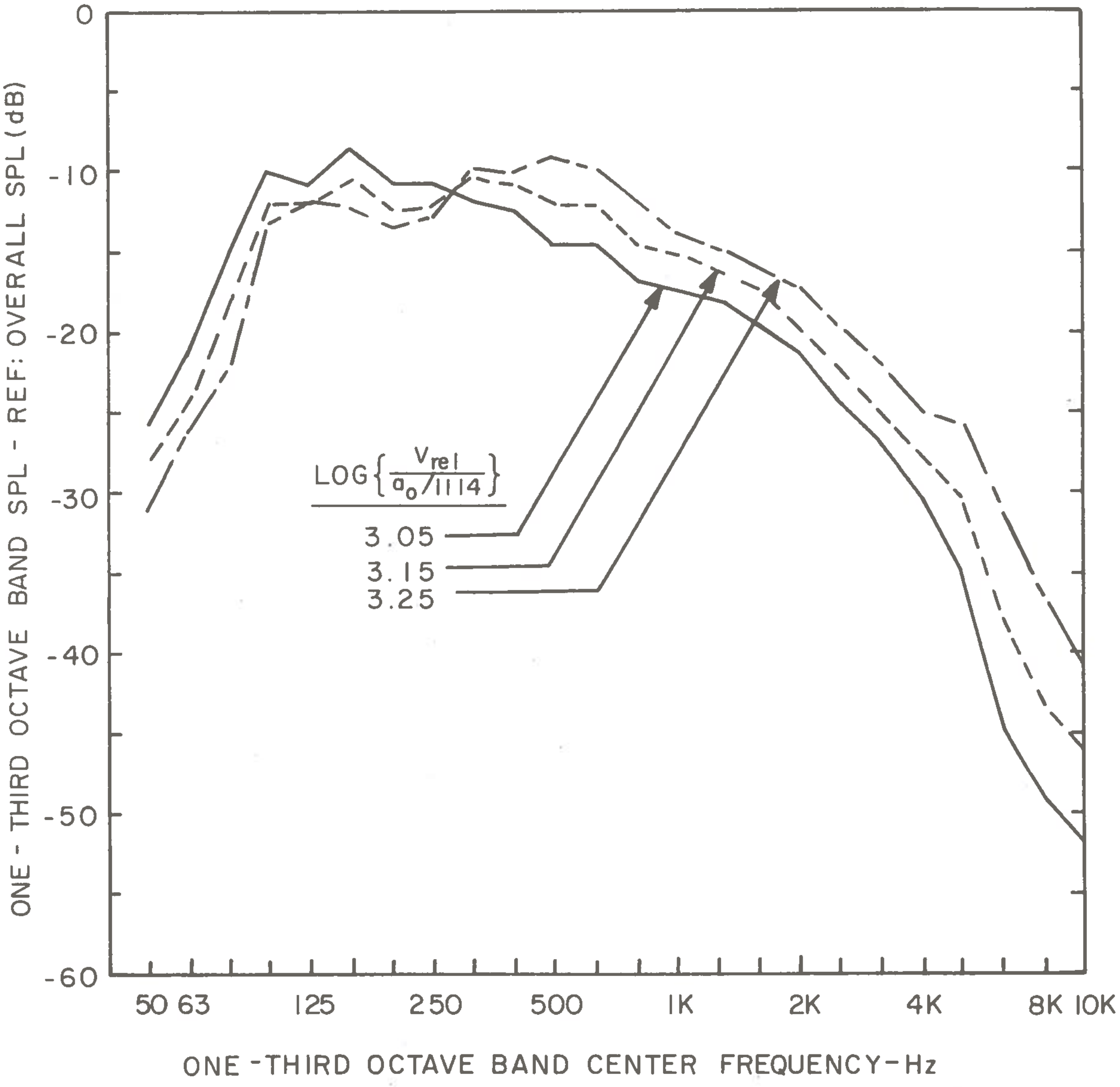


Figure 21. Jet Noise One-Third Octave Band Spectrum Shapes

cause interference between the direct and reflected waves producing large variations in the apparent sound pressure level. The computer program does not account for these near-field and reflection effects, thus it is restricted to the calculation of far-field sound levels for the vehicle out of ground effect. The program does, however, account for the far-field spherical divergence attenuation of 6 dB per doubling of distance based on the input information regarding the observer location.

Atmospheric Absorption

Attenuation of sound waves due to absorption by the air is composed of two parts, classical absorption due to viscous and heat conduction effects and molecular absorption. Of these two, only molecular absorption is important in the audible frequency range, classical absorption being about an order of magnitude less than molecular absorption at 10,000 H_z with increasing divergence for lower frequencies. Figure 22 shows both of these losses as functions of frequency.

The curves for molecular absorption a' of Figure 22 were derived from a new analytical/empirical formula adapted from Reference 21, which gives excellent agreement with experimental data and is based on the theory as discussed by Kenser (Reference 22). Figures 23 and 24 taken from Reference 21 show the agreement between the expression for a'_{mol} given as Equation (119) below and both laboratory and field experimental data taken from References 23 to 27. The molecular absorption calculated by the computer program is then given by the following expression as adapted from Reference 21:

$$a'_{mol} = a_{max} \left\{ \left[\frac{0.18f}{f_m} \right]^{-2} + \left[\frac{2(f/f_m)^2}{1+(f/f_m)^2} \right]^2 \right\}^{\frac{1}{2}} \qquad (119)$$

where

$$a_{max} = 0.0078\, f_m (T^*)^{-2.5} \exp\, (7.77\, (1-1/T^*)) \qquad (119a)$$

$$f_m = (10 + 6600h + 44{,}400h^2)P^*/(T^*)^{0.8} \text{ Hz} \qquad (119b)$$

$$h = \frac{h'}{7.57} \cdot \frac{T^*}{P^*} \text{ Percent mole ratio} \qquad (119c)$$

h' = humidity in gm/m^3

P^* = pressure normalized to 14.7 psi

T^* = temperature normalized to 519°R (59°F)

f = frequency for which molecular absorption is being computed

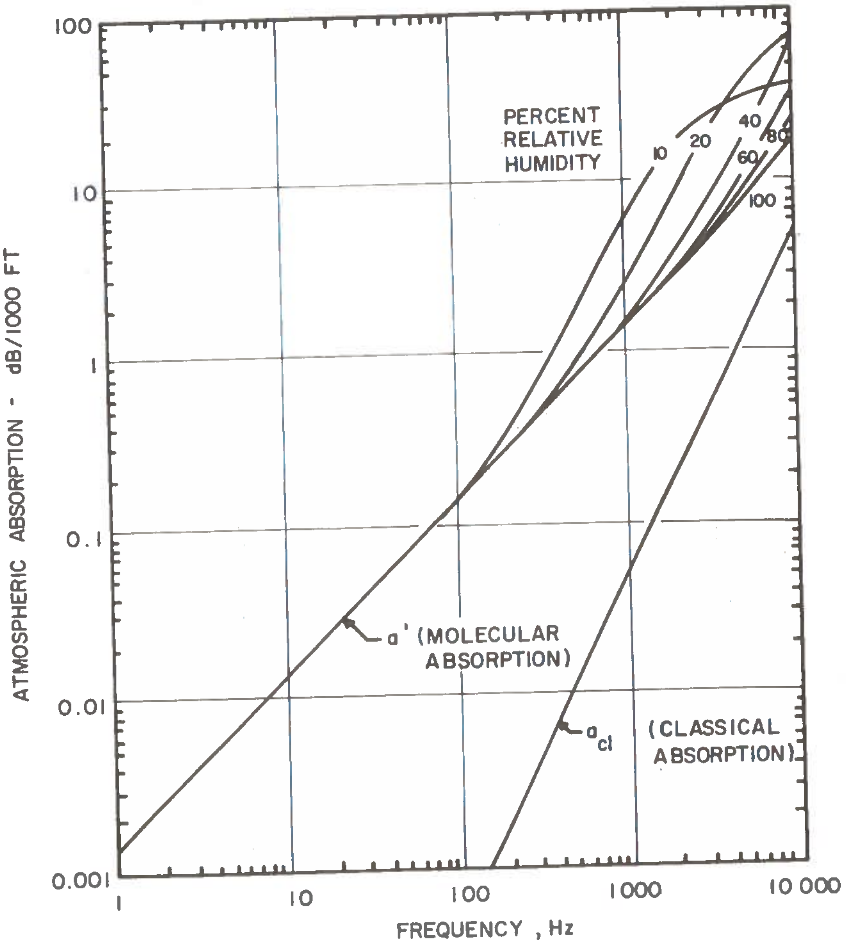


Figure 22. Atmospheric Absorption Losses for SLS Conditions at Several Relative Humidities (from Ref. 21).

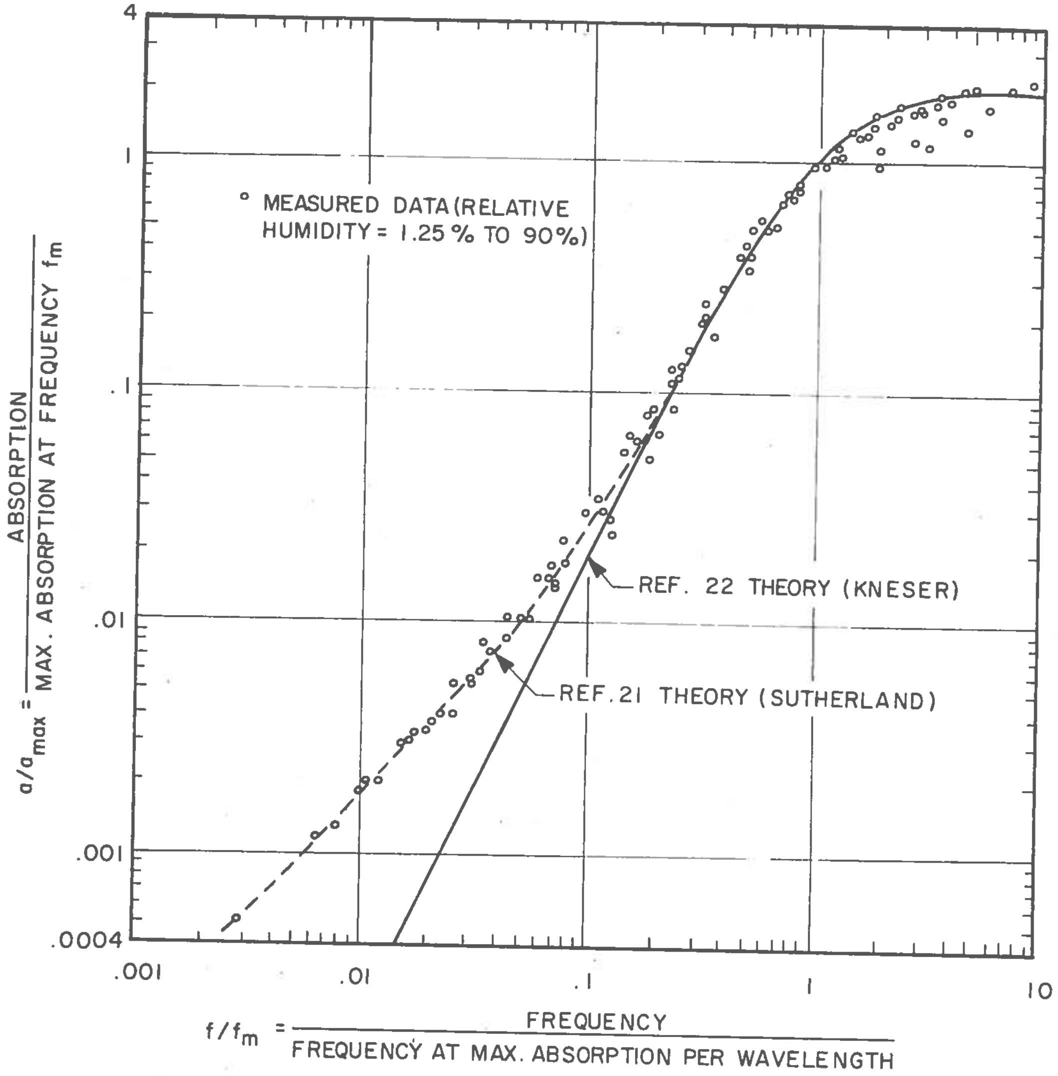


Figure 23. Comparison of Laboratory Measurements of Molecular Absorption Loss With Reference 21 and 22 Theories (Measured Data From Reference 23 and 24 Corrected for Classical Absorption Loss).

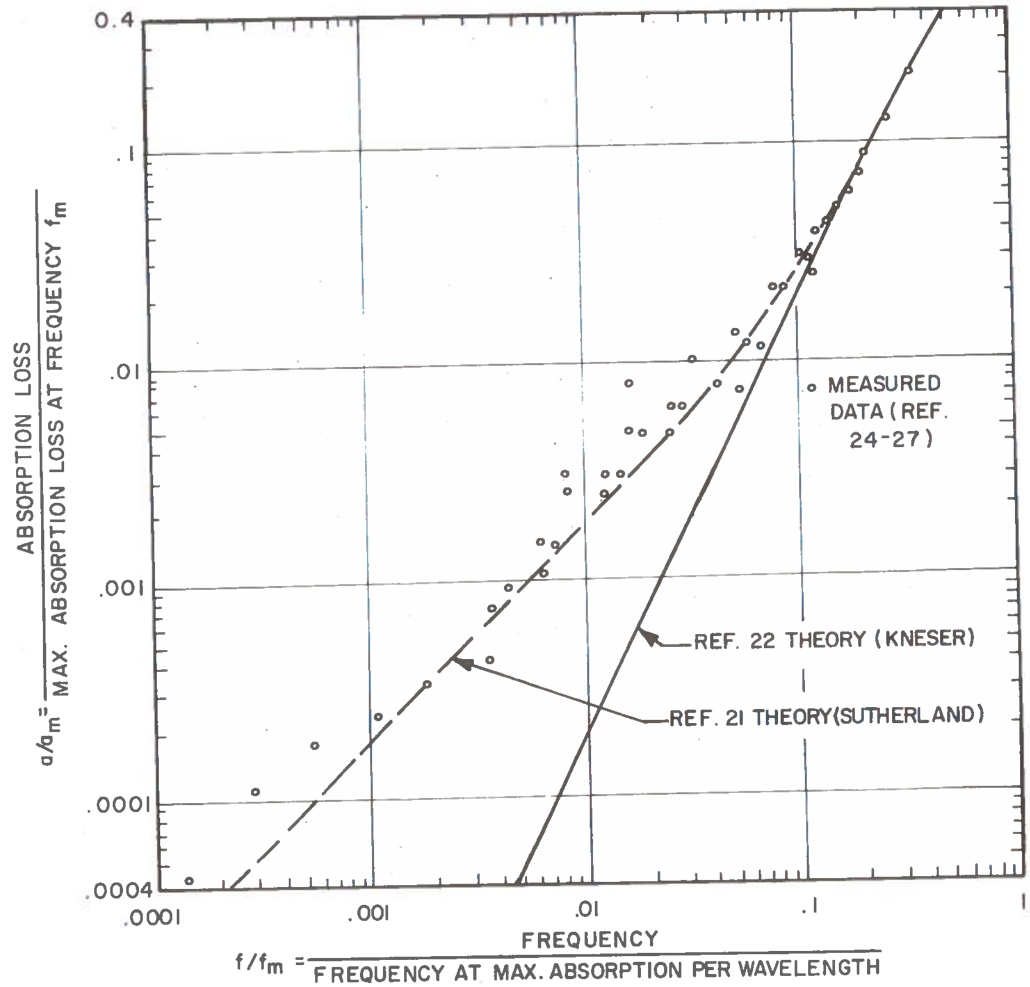


Figure 24. Comparison of Observed Air to Ground Absorption Loss With Reference 21 and 22 Theories. Adapted from Reference 21).

For the standard conditions of 14.7 psi and 59°F the Equations (119a-c) reduce as follows:

$h' = 6.41$ gm/m^3 at 50% relative humidity

$h = 0.847$

$f_m = 37{,}400$

$a_{max} = 292.0$

and the equation used in the computer program to calculate molecular absorption becomes:

$$a'_{mol} = 292.0 \left\{ (4.81 \times 10^{-6} f)^2 + \left[\frac{1.43 \times 10^{-9} f^2}{1 + 7.14 \times 10^{-8} f^2} \right]^2 \right\}^{1/2} \quad (120)$$

dB/1000 ft

or

$$a'_{mol} = 292.0 \left(\frac{r'}{1000} \right) \left\{ (4.81 \times 10^{-6} f)^2 + \left[\frac{1.43 \times 10^{-9} f^2}{1 + 7.14 \times 10^{-8} f^2} \right]^2 \right\}^{1/2} \quad (121)$$

The program, then, computes the atmospheric attenuation (molecular absorption) for sea-level-standard conditions of temperature and pressure and for 50% relative humidity.

Ground Absorption

Of all attenuation losses, that due to ground cover is the least understood. Very little experimental data are available for either laboratory or field conditions. Those laboratory experiments which have been performed have produced insufficient results to verify the theory or to point out any theoretical inaccuracies. Field experiments have been performed, but they suffer from lack of accurate knowledge of atmospheric conditions and their fluctuations along the propagation path. Difficulty in separating the effects of unpredictable small scale turbulence and local wind and temperature gradients along the path from ground attenuation effects has further hampered the gathering of accurate field data. Pao (Ref. 28) has recently developed an analytical method to predict ground attenuation but it requires detailed knowledge of the ground cover not generally available. For these reasons and because the elevation angle between observer and aircraft for V/STOL-part operation is usually greater than about 7°, it was decided not to include ground absorption in the program.

Small Scale Turbulence

The propagation of sound waves is influenced by "small scale turbulence" in the atmosphere through a process of refraction. The overall effect may be one of attenuation or of augmentation depending upon the initial directivity pattern of the sound source. Basically, the scattering of an irregular sound field will tend to cause an equalization of the acoustic intensity propagating in all directions at large distances from the source. It is the direct result of multiple refraction of the sound through patches of non-uniform sound velocity in the atmosphere which may be due to air velocity or temperature fluctuations. The effect will only be important when the acoustic wavelength is of the order of the atmospheric disturbance scale. In the case of rotor or propeller noise, turbulence scattering may be expected to cause results similar to that illustrated as an example in Figure 25 where the most important feature is the "filling-in" of the depressions in the directivity curves where theoretically, acoustic cancellation effects cause no sound to be radiated. Thus, from a practical standpoint turbulence scattering will only be of concern in considerations of the sound radiated at small angles above the rotor disc. The reason for this is that due to the analytical summations over very many blade airload harmonics together with the adoption of randomized phasing, the computed directivity contours are always "well rounded" with the single exception of a severe trough for the low frequency harmonics at about 5° above the plane of rotation. In this region scattering effects could be simulated by averaging the intensity over a finite area enclosing the minimum. This is exactly equivalent to the physical effects of scattering.

In a recent extensive study of rocket noise propagation (Reference 21) it was determined that the effects of scattering caused an average attenuation of the sound in the direction of maximum radiation of 0.5 dB per 1000 feet at frequencies above 60 Hz. This value decreased at lower frequencies reaching a minimum of 0.06 dB per 1000 feet below seven Hz. Now rocket noise is highly directional and these results reflect a scattering of sound away from the highly directional lobes. Elsewhere a reduction in absorption would be found. Helicopter noise is significantly less directional in character and lesser effects are to be expected. Consequently it is considered valid to ignore scattering effects, everywhere except for small angles of propagation above the rotor plane.

Calculation of PNL, PNLT, EPNL, and dBA Levels

After the vehicle one-third octave band noise spectrum has been calculated for each point along the flight path (ie. - each increment of time) and corrected for the attenuations described above the time history of Perceived Noise Level, Tone corrected (PNLT) is calculated by converting the noise spectrum at each time increment to its' corresponding PNLT value with the methods described below. The Effective Perceived Noise Level (EPNL) is calculated for the observer location in question from the PNLT time history. For comparison purposes, the A-weighted sound level (dBA) is also calculated at each time increment.

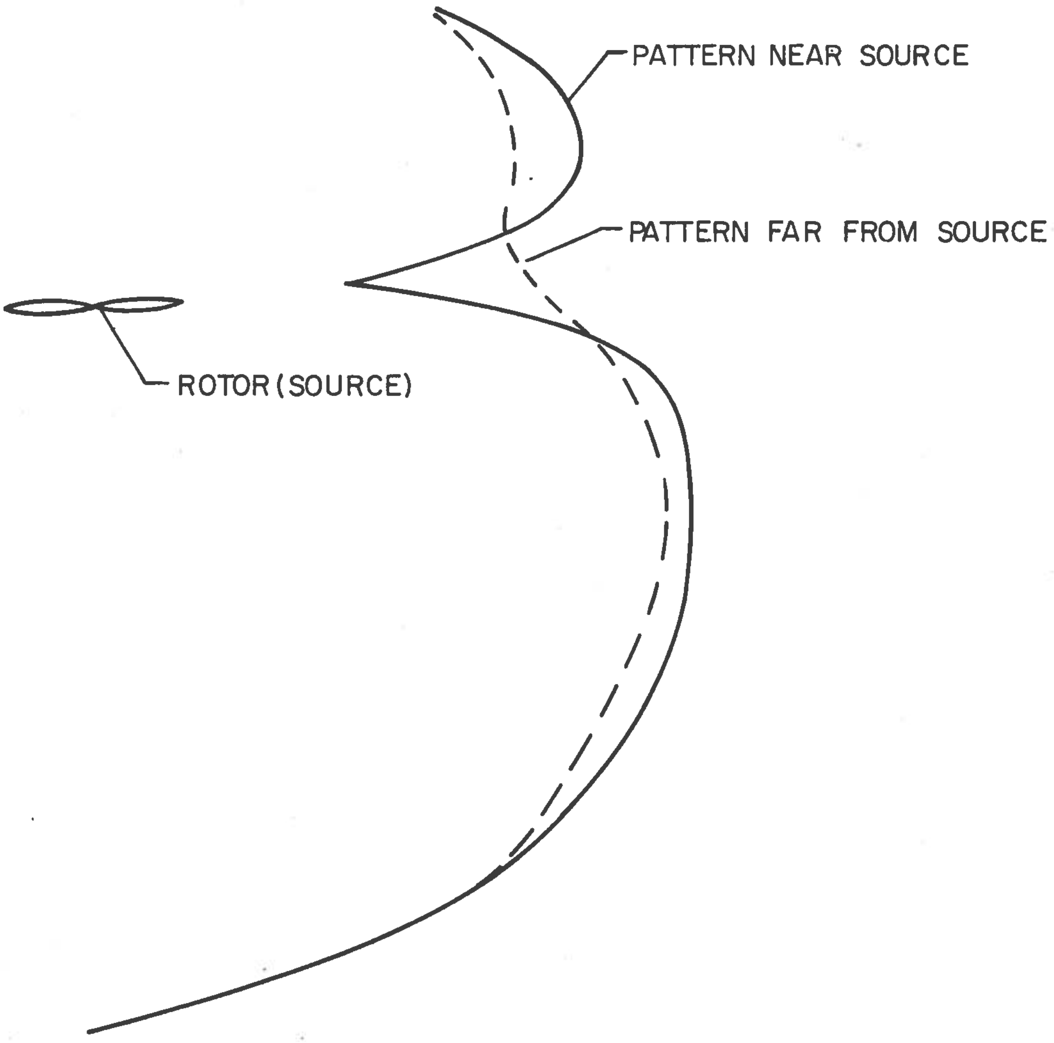


Figure 25. Effect of Small-Scale Turbulence Scattering on Source Radiation Pattern

Perceived Noise Level

The Perceived Noise Level is calculated at each time increment from the calculated one-third octave band spectrum by the SAE method of Reference 29. The Reference 29 noy tables, however, are replaced by the mathematical formulation presented by Pinker (Ref. 30) and referenced by Sperry (Ref. 31). This formulation allows direct calculation of the noy value for each band of noise rather than requiring the use of noy tables, hence significantly less computer storage is required.

After each one-third octave band from 50 Hz to 10,000 Hz has been converted to its' corresponding noy value, the value of N_T is computed:

$$N_T = 0.15 \sum_{i=1}^{24} \text{Noy}_i + 0.85 N_{max} \qquad (122)$$

where N_{max} is the maximum of all the 24 noy values. The PNL is then calculated:

$$\text{PNL} = 40 + 33.3 \text{ Log}(N_T) \qquad (123)$$

Tone Corected Perceived Noise Level

Because the calculation of EPNL requires the time history of tone corrected Perceived Noise Level, a tone correction that is applied to the PNL is computed at each time increment. The tone correction is an attempt to account for any additional annoyance resulting from the presence of pure tone components in the spectrum. The calculation method, contained in Appendix A, is not exact since it uses adjacent one-third octave band levels to extablish the presence of a tone rather than using a narrow band analysis of the spectrum. Nonetheless it is the only method available and is the one recommended by the FAA (Reference 31), hence it is the one incorporated in the program.

Effective Perceived Noise Level

The Effective Perceived Noise Level is computed by adding a duration correction to the maximum PNLT value. The duration correction is calculated by integrating the PNLT time history between the two points that are 10 dB down from the maximum PNLT. In practice the integration becomes a summation because there generally is no convenient mathematical representation for the PNLT time history. This summation is given by Sperry (Ref. 31) as:

$$D = 10 \text{ Log} \left\{ (1/T) \sum_{k=0}^{d/\Delta t} \Delta t \text{ antilog} \left[\frac{\text{PNLT}(k)}{10} \right] \right\} - \text{PNLT}_{max} \qquad (124)$$

where D = duration correction in dB

T = normalizing time constant (sec.)

t = time increment (sec.)

d = duration time defined by the 10 dB-down points (sec.)

For the value of $T = 10$ sec given by Sperry [31]:

$$D = 10 \text{ Log}\left\{\left(\frac{\Delta t}{10}\right) \sum_{k=0}^{d/\Delta t} \text{antilog}\left[\frac{PNLT(k)}{10}\right]\right\} - PNLT_{max} \tag{125}$$

The generally recommended value for Δt is 0.5 seconds, however the program allows other values of Δt to be input in order to conserve computer time. Since the computed PNLT time history usually varies smoothly with time, little accuracy is sacrificed if values of t larger than 0.5 seconds are used. The EPNL value can now be defiend:

$$EPNL = PNLT_{max} + D \tag{126}$$

or combining Equations (125) and (126):

$$EPNL = 10 \text{ Log}\left\{\frac{\Delta t}{10} \sum_{k=0}^{d/\Delta t} \text{antilog}\left[\frac{PNLT(k)}{10}\right]\right\} \tag{127}$$

A-Weighted Sound Level

The A-Weighted Sound Level is a single number rating of a sound spectrum which attempts to simulate the way the human ear hears the sound. It is a measure of the total energy of the spectrum after the spectrum has been passed through a "filter" whose shape is that of Figure 26. In the program the claculated one-third octave spectrum is corrected to the A-Weighting shape by applying the correction numbers of Table 3 (taken from Figure 26) to each band. The A-weighted sound level is then the energy sum of all of the corrected band levels:

$$dBA = 10 \text{ Log} \sum_{j=1}^{24} \text{antilog } \frac{1/3\ OL_j + CORR_A}{10} \tag{128}$$

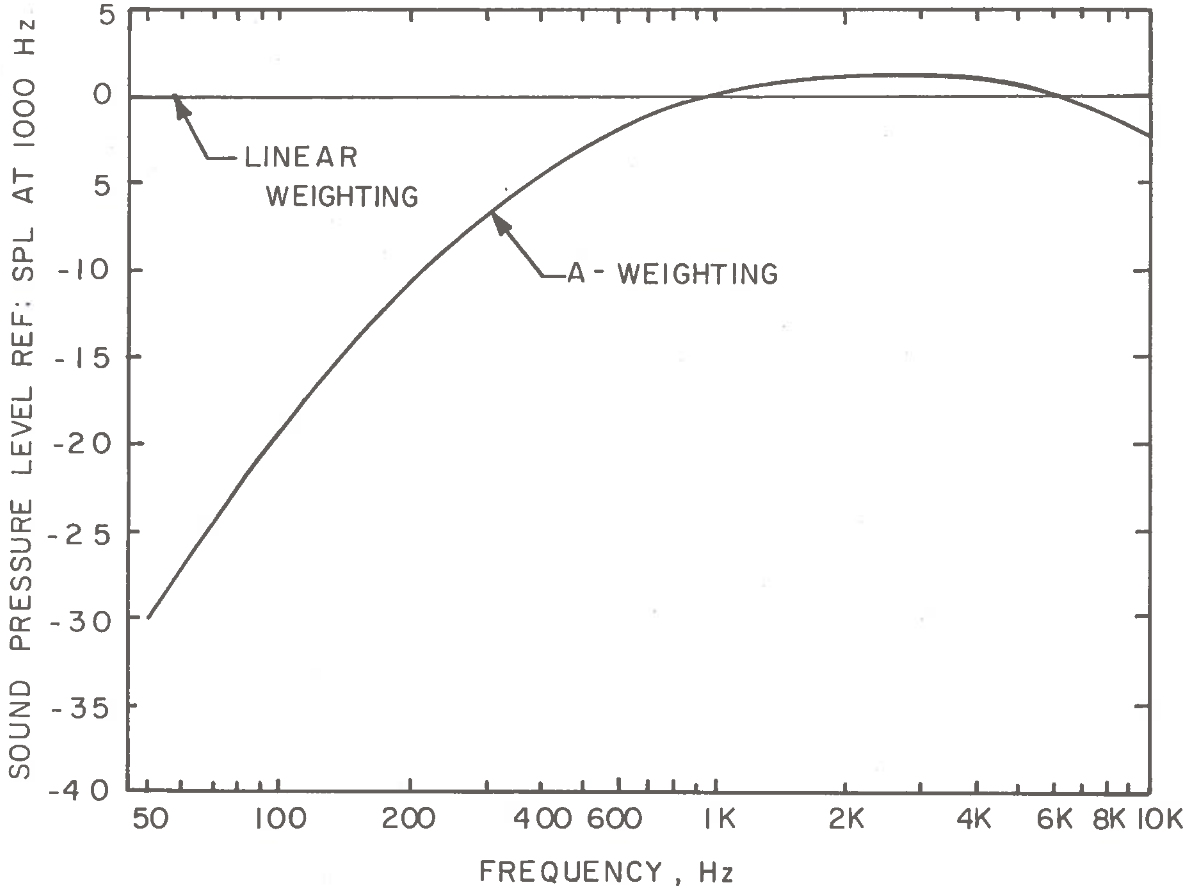


Figure 26. A-Weighting Frequency Spectrum

TABLE 3
A-Weighting Correction Numbers For 1/3-Octave Bands

ONE-THIRD OCTAVE BAND Hz	CORR_A dB
50	-30.2
63	-26.1
80	-22.3
100	-19.1
125	-16.2
160	-13.2
200	-10.8
250	-8.6
315	-6.5
400	-4.8
500	-3.3
630	-1.9
800	-0.8
1000	0.0
1250	0.5
1600	1.0
2000	1.2
2500	1.2
3150	1.2
4000	1.0
5000	0.5
6300	-0.2
8000	-1.1
10000	-2.3

COMPUTER PROGRAM

The computer program developed from the component noise calculation procedures is described in detail in Appendices B, C, and D. A simplified flow diagram of the main program and Subroutine ACPNLT is shown in Figures 27 and 28. Briefly the main program (Figure 27) loads the necessary input data for each flight path segment, calculates the PNL, PNLT, and dBA time history at the observer locations, and calculates the EPNL value. Subroutine ACPNLT calls the required noise component subroutines, accumulates a complete one-third octave spectrum, adjusts the spectrum for atmospheric attenuation, and calculates the associated PNL, PNLT, and dBA values. A more detailed description follows.

Main Program Operation

The Program begins (box M.1 of Figure 27) by loading data for flight segment 1 via the LOADER Subroutine. At this point all of the component operating parameters for flight segment 1 (Figure 29), whether a landing or takeoff, are entered along with the complete flight path description and observer location. Table 4 lists all of the possible input. The loader subroutine stores the input data in pre-designated COMMON locations indicated by the column of Table 4 titled Input Sequence Location, thus the first COMMON location is occupied by the variable SAZ while the 25-th location is occupied by the variable DIA. On input the data are assigned to their respective locations, not sequentially stored; thus only necessary data need be entered.

After data for the first flight segment has been entered, 100 values of X, Y, Z (the observer coordinates relative to the aircraft for each time increment) are calculated (box M.2) along with the slant range (minimum distance from observer to aircraft), and the increment number of the end point of each flight segment. In the box M.3 the field point (K), flight segment (N), observer location (L), and segment end position (IK) indices are initialized and all the input variables in COMMON are printed out in box M4.

At this point SUBROUTINE ACPNLT is called (box M.5) and it returns the PNL, PNLT, and dBA values at the L-th observer location when the aircraft is at a location (X_k, Y_k, Z_k) on the flight path. These noise values are stored (in box M.6)and (in box M.7) they are compared with previously calculated noise values to determine the maximum value, which is stored for future use. The test in box M.8 cycles the program back to box M.5 to calculate PNL, PNLT and dBA values for additional observer locations up to a value IFPT (maximum of 10). When the observer location loop is satisfied, control passes to box M.9 where L (the observer location index) is reset to 1, K (the field point index) is increased by one, and a PNLT value that is 10 dB less than the maximum PNLT value at the IFPT-th observer location is computed (DUM).

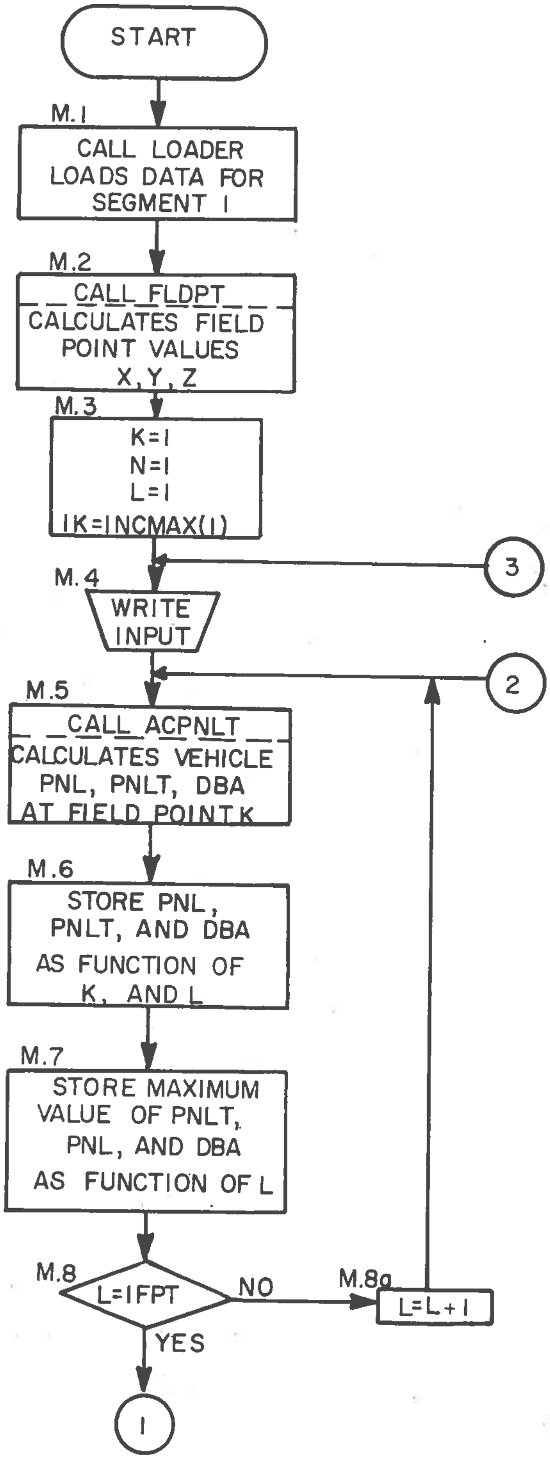


FIGURE 27. Main Program Flow Chart.

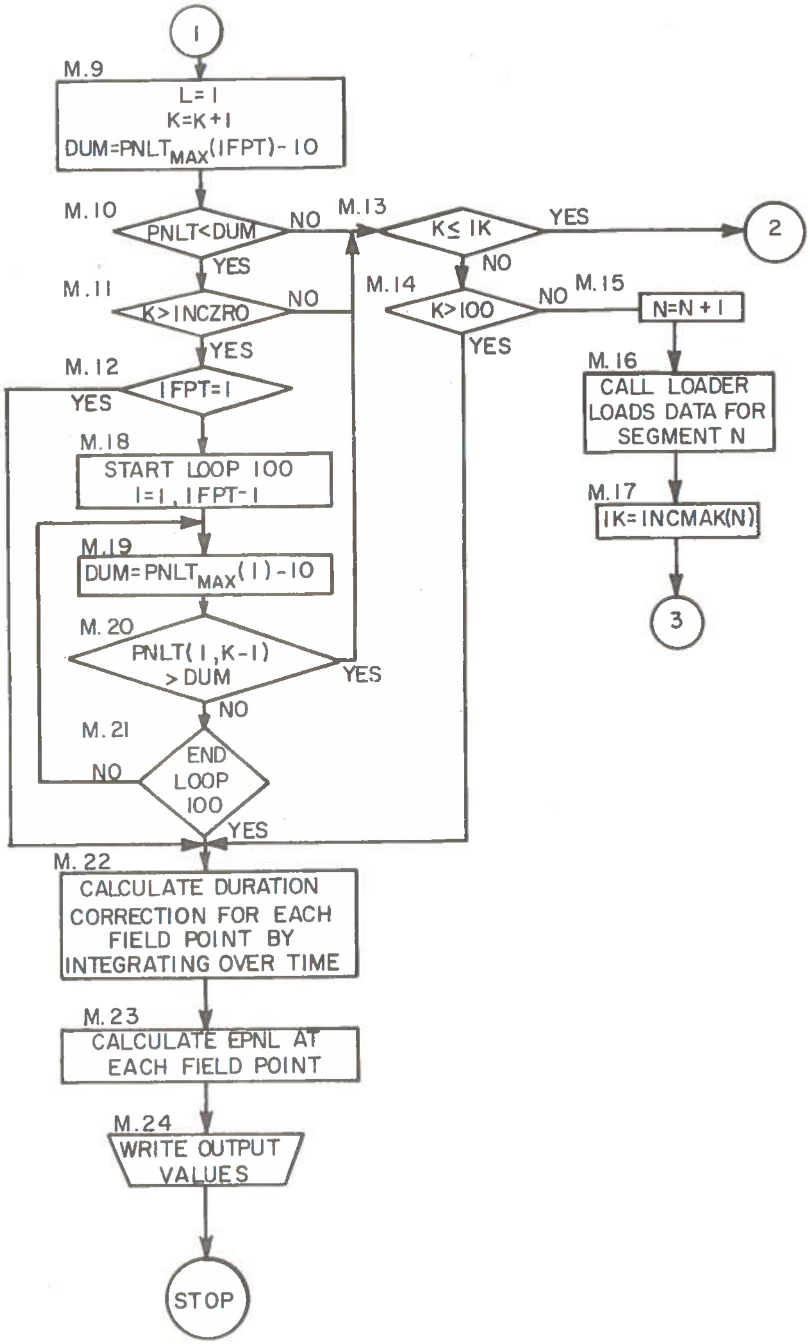


FIGURE 27. Continued

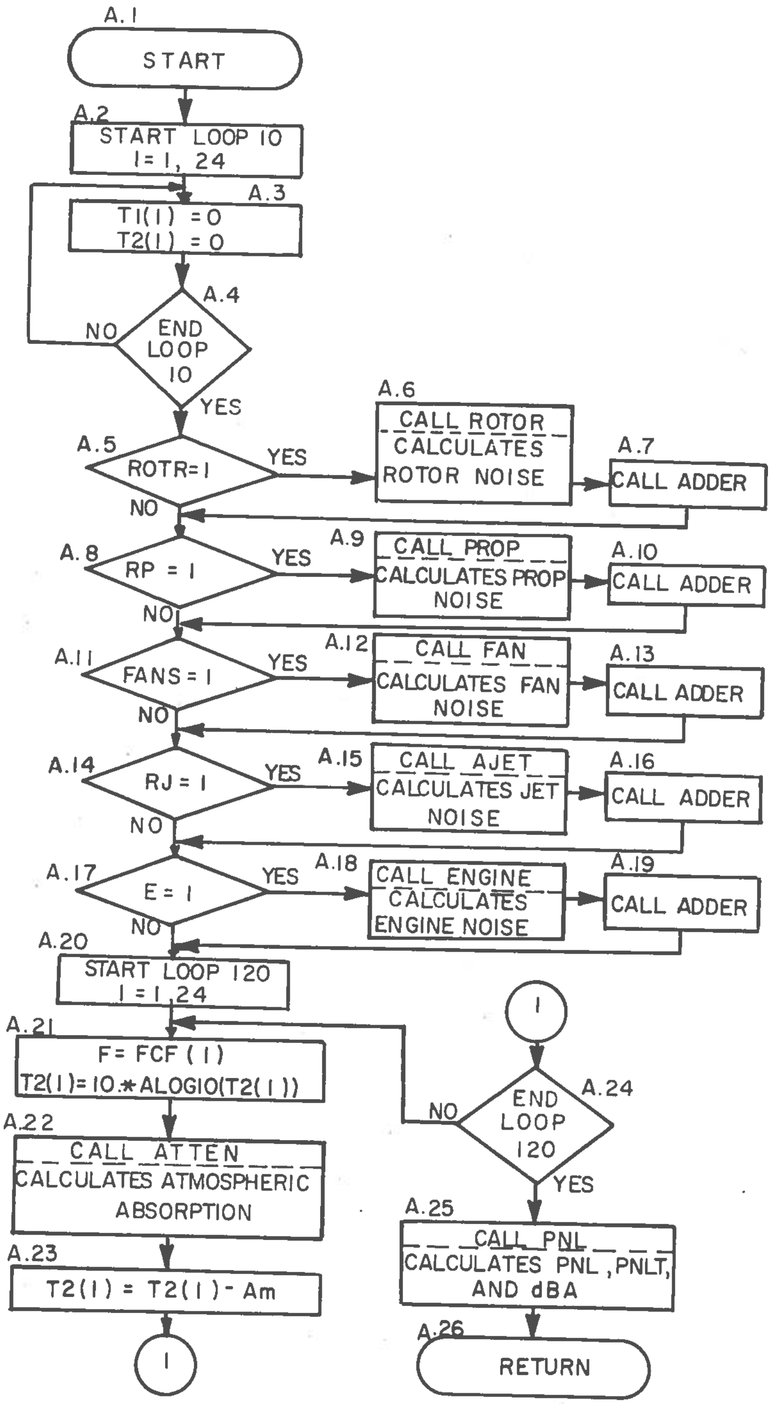


FIGURE 28. Subroutine ACPNLT Flow Chart.

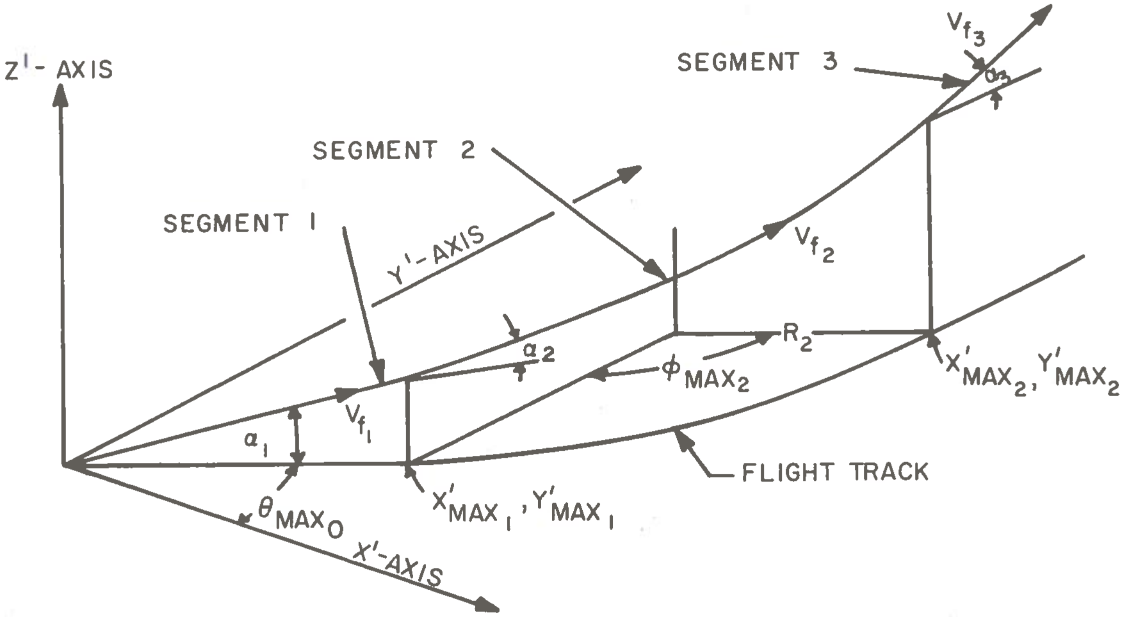


Figure 29. Definition of Flight Path Segments

The most recently calculated value of PNLT is compared with DUM in box M.10 and if it is less than DUM and if K is greater than INCZRO (i.e. the aircraft has passed the last observer) control is passed on box M.12. If either criteria is false control pases to box M.13 where the current value of K is compared to the increment number corresponding to the end point of the N-th flight segment, IK. If K $\leq$ IK the program is cycled back to box M.5. If K is greater than IK (i.e. - the vehicle has passed on to flight segment N + 1) and if K is not greater than 100 (box M.14) the flight path segment index N is increased by one (box M.15) and any new noise component parameter values for the new flight path segment are loaded (box M.16). Only those parameters that change or those that are new need be entered since all old values are retained. In the event that no parameters change from segment N to segment N + 1 one dummy variable must be loaded since the LOADER subroutine is called each time the segment changes. In box M.17 IK is now set equal to the increment number of the end point of the new segment and control is cycled back to box M.4 where all the input variables in COMMON are printed out again.

Control is received at box M.12 when the calculated value of PNLT is more than 10 PNdB down from the peak and the aircraft has passed the last observer. If the calculation is only for one observer location (IFPT=1) control is passed to box M.22. If there is more than one observer control passes to a loop (boxes M.18 - M.21) that assures there is a point which is at least 10 PNdB down from the maximum PNLT at each observer location. If not, control is passed back through box M.13 for further calculation. If all the 10 PNdB down points exist, control passes to box M.22 where the integrated duration correction is calculated at each observer location and then to box M.23 to calculate the EPNL value at each observer. In box M.24 all of the calculated values are printed out.

Subroutine ACPNLT Operation

Subroutine ACPNLT is the primary subroutine because it controls the calculation of the vehicle spectrum and associated PNL, PNLT, and dBA values. Control is received from MAIN in box A.1 (Figure 28) and passes to the loop (boxes A.2 - A.4) which initializes the two dummy spectrum arrays T1 and T2. If the calculation is to include rotors (ROTR=1) box A.5 transfers control to box A.6 which returns in array T1 a one-third octave band spectrum for the rotors. In box A.7 the calculated spectrum (array T1) is added to the spectrum in array T2 (which is used to accumulate the total vehicle spectrum). In box A.7 array T1 simply is transferred to array T2 because this is the first call to the subroutine and T2 has been initialized. Control passes to box A.8 (either directly from A.5 or through boxes A.6 and A.7) where a similar test and sum accumulation takes place for propeller noise (boxes A.8 - .10), assuming propellers are included. Similar cycles take place for fans (boxes A.11 - A.13), jets (boxes A.14 - A.16) and engines (boxes A.17 - .19).

The T2 array now contains the one-third octave spectrum of the complete vehicle and control passes to box A.20. This begins a loop to convert each one-third octave band sound pressure to sound pressure level (box A.21), to calculate the atmospheric attenuation at the band center frequency F (box A.22), and to correct each bands' SPL for this attenuation (box A.23). When these corrections have been made the PNL, PNLT, and dBA values of the spectrum are calculated in box A.25 and returned to MAIN in box A.26.

Users Manual

1. Determine the aircraft configuration and operating parameters. Use Forms 3 through 7 at the end of this section to tabulate the necessary values.

2. Prepare on X', Y', coordinate paper the flight track on the ground of the flight path. The flight path can consist of up to 50 straight line and helical segments. When two adjacent segments are straight lines the only restriction is that they be colinear because all turns must be accomplished by helical segments. Figures 30 and 31 demonstrate an example case (additional sample cases are presented in Appendix B). The origin of the X', Y' coordinate system is at the start of takeoff roll or at the end of ground roll; the X' axis need not be in the direction of the runway. Note that segments are numbered in increasing order starting with the segment closest to the origin, regardless of whether the flight is a takeoff or landing and that the last segment (highest segment number) must be straight line.

3. Using the flight track diagram (Figure 31) enter the required flight path information on Form 1 (Figure 32 at end of this section), and on Form 1A (Figure 33) if there are more than 25 flight path segments. Figure 32 shows the Form 1 filled out for the example of Figure 31. When the segment is straight line no values are entered for ϕ_{max} and RADIUS; for helical segments no values are entered for X'_{max} and Y'_{max} . Note that α_n is the angle of climb or descent, measured from the ground plane. The value of ϕ_{max} is entered as positive for counterclockwise turns and as negative for clockwise turns. The values of X'_{max} and Y'_{max} are estimates of the end point coordinates of straight line segments; they will be changed by the program if they disagree with the end points calculated by the program.

4. Prepare a Form 2 (Figure 34) for the first flight path segment. Include on this form all of the information from Form 1 (and 1A) and Forms 3-7 as applicable. Also include the primary observer coordinates (X'_{ob} and Y'_{ob}), the angle that the first flight track makes with the X' axis (Θ_{max_o}) if the first segment is straight, the altitude (A_o) at the origin of the X', Y' coordinate system (e.g. - hover altitude before takeoff for a helicopter), the time increment (t_{inc}) to be used between successive aircraft locations on the flight path, and the number of total observer locations (ANMFPT). Figure 31 shows how the additional observer locations will be determined. List on Form 2 only those propulsion components and their operating parameters actually used on segment 1. Figure 34 shows Form 2 filled out for segment 1 of our sample case (assumed to be a compound helicopter with propellers for auxiliary propulsion).

5. Prepare a Form 2 for each additional flight segment. Note that <u>only</u> those parameters that change from segment to segment or that are new are entered; however, if no parameters change a dummy input will be required for the segment since the program will attempt to read in data for every segment. This can be done by repeating a variable from the previous segment (as is done in the example case - see Figure 35), or by assigning a value to a variable not used in the particular case. Figures 35 through 38 show Form 2 filled out for our example case. In this example the aircraft is in the helicopter mode (rotors only) for segments 1 and 2 and no parameters change from segment 1 to segment 2. On segment 3 the propellers are operating and parameters change from segment 3 to 4 to 5.

6. Prepare the input data cards using the information from the FORM 2's and the coding format sheet shown in Figure 39. The Figure 39 format is that used by the LOADER subroutine to load data into the specified COMMON locations. Referring to Figure 39, <u>column 1</u> is reserved for a minus sign which tells the loader to stop reading data, thus the last data card for each flight segment must contain a - in column 1. <u>Column 2</u> tells how many data points (up to 5) are contained on the card and <u>columns 3-6</u> indicate into which COMMON location the first data field is placed (additional data fields on the card are sequentially placed after the first)

   Figure 40 shows the coding form filled out for the entire example case. The data for segment 1 is contained on cards 1 through 15, segment 2 on card 16, segment 3 on cards 17 through 21, segment 4 on cards 22 and 23, and segment 5 on cards 24 and 25. Card 7, for example, puts the value 2000. in location 80, 0. in location 81, and 5000. in location 82. Card 15 is the last card of segment 1 (- in column 1) and it puts the value 1. in location 417, puts zeros in locations 418, 419, and 420, and puts 1. in location 421.

7. Program Operation.

The program is set up such that at times data for all segments may not be read and used. When the noise (PNLT) at the primary observer (X'_{ob}, Y'_{ob}) is 10 $PNdB_t$ down from the maximum level and the aircraft has passed the observer, the calculation of further PNLT values is halted and the EPNL values are calculated. Since the 10 dB down point may be reached before the aircraft reaches the last flight segments the data cards for these segments will be ignored.

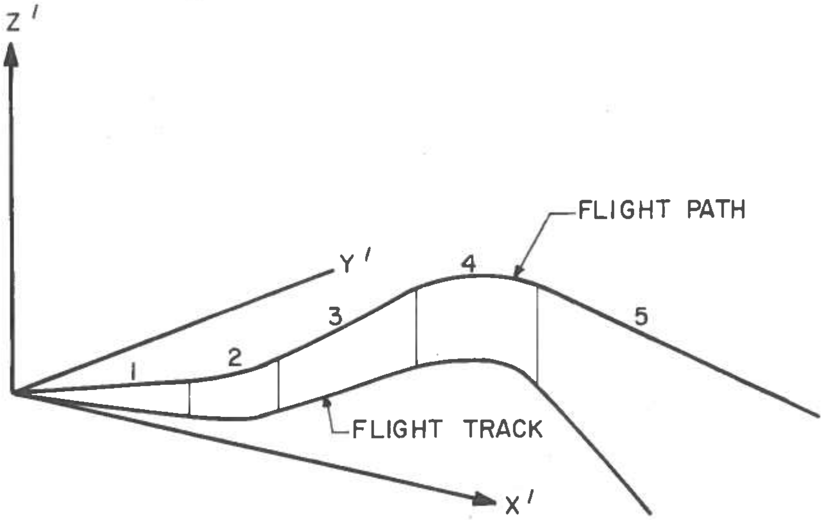


Figure 30. Example Take-off Flight For V/STOL Noise Model

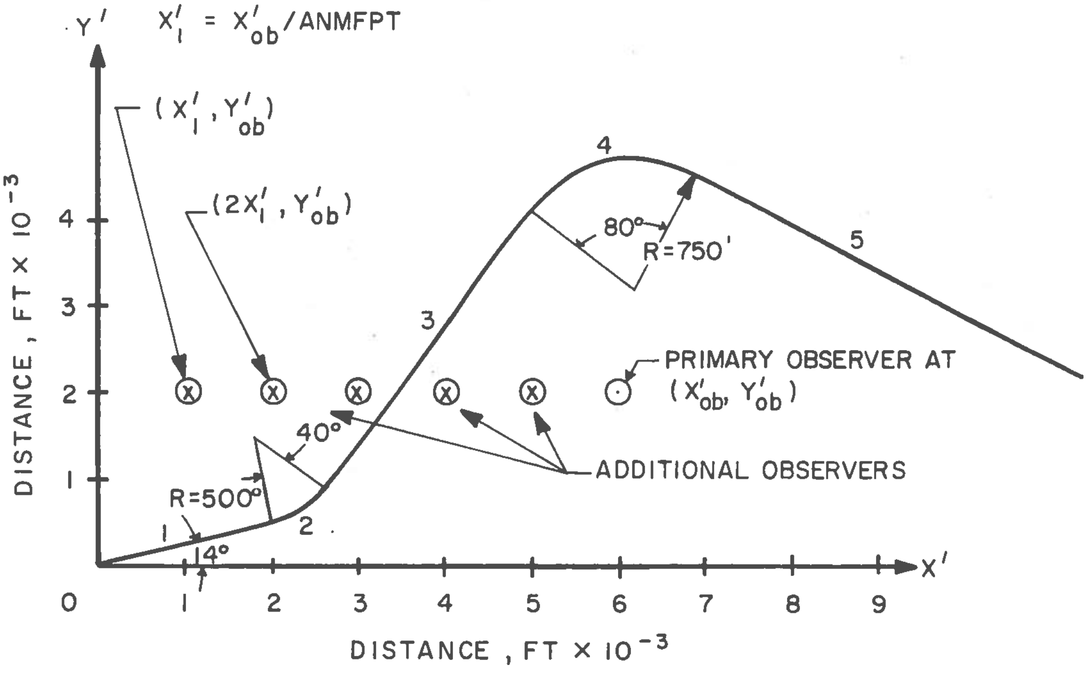


Figure 31. Example Take-off Flight - Flight Track

TABLE 4

V/STOL VEHICLE NOISE PREDICTION PROGRAM
INPUT PARAMETERS

Veriable	Program Name	Description	Input Sequence Location
a_o	SAZ	Speed of sound (ft/sec)	1
-	SEG	Number of flight path segments (up to 50)	2
	FLYTYPE	Takeoff = 1. Landing = 2.	3
		<u>HELICOPTER ROTOR PARAMETERS</u>	
k_r	RCASE	Main rotor harmonic loading factor	4
η_r	RETA	Main rotor blade radial loading station (%R)	5
B_r	RBIGB	Number of main rotor blades	6
R_r	RBIGR	Main rotor radius (ft)	7
Ω_{N_r}	ROMEGN	Main rotor rotational speed (rpm)	8
i_{d_r}	RSID	Main rotor disk incidence angle (degrees)	9
C_r	RCHORD	Main rotor blade chord (inches)	10
T_r	RTHRUS	Main rotor thrust (lb)	11
Q_r	RTORQ	Main Rotor torque (lb-ft)	12
β_r	RBETA	Main rotor coning (degrees)	13
k_t	TCASE	Tail rotor harmonic loading factor	14
η_t	TETA	Tail rotor blade radial loading station (%R)	15
B_t	TBIGB	Number of tail rotor blades	16
R_t	TBIGR	Tail rotor radius (ft)	17
Ω_{N_t}	TOMEGN	Tail rotor rotational speed (rpm)	18
i_{d_t}	TSID	Tail rotor disk incidence (degrees)	19
C_t	TCHORD	Tail rotor blade chord (inches)	20
T_t	TTHRUS	Tail rotor thrust (lb)	21
Q_t	TTORQ	Tail rotor torque (lb-ft)	22
β_t	TBETA	Tail rotor coning (degrees)	23

TABLE 4 (Cont'd)

Variable	Program Name	Description	Input Sequence Location
		PROPELLER PARAMETERS	
P_p	PPWR	Propeller Shaft Power (hp)	24
D_p	DIA	Propeller diameter (ft)	25
B_p	BIGB	Number of propeller blades	26
Ω_p	RPMP	Propeller rotational speed (rpm)	27
-	ANMPRP	Number of propellers	28
c_p	CHORDP	Propeller mean blade chord (ft)	29
		TURBOSHAFT ENGINE PARAMETERS	
P_e	HPENG	Engine power output (hp)	386
-	SLEVEL	Engine noise level (1 = Average, 2 = Loud)	387
-	ANENG	Number of engines	388
		FAN AND FAN ENGINE PARAMETERS	
D_t	DIAT	Fan tip diameter (inches)	389
D_H	DIAH	Fan hub diameter (inches)	390
B_f	B	Number of fan blades	391
-	BPR	Bypass ratio	392
C_t	CHORD	Fan blade tip chord (inches)	393
D_{g_t}	DDDXT	Tip diameter gradient (in/in)	394
D_{g_h}	DDXH	Hub diameter gradient (in/in)	395
R_s	RS	Blade suction surface radius of curvature (in)	396
σ_ϕ	SIGPHI	Standard deviation of blade tip metal angle (rad)	397
L	DL	Inlet duct length (ft)	398
Ω_f	RPM	Fan rotational speed (rpm)	399
m	SPAF	Specific airflow rate (lb/sec/ft^2)	400

TABLE 4 (Cont'd)

Vari-able	Program Name	Description	Input Sequence Location
M_t	XMXTIP	Tip axial Mach number	401
P_r	PR	Fan pressure ratio	402
-	DF	Fan blade diffusion factor	403
T_2	TT2	Ambient inlet temperature (°F)	404
P_2	PT2	Ambient inlet pressure (in. Hg)	405
α_f	ALFA	Inclination of fan to horizontal (+90°=vertical)	406
-	FN	Number of fans	407
	COMB	Control factor to permit skipping of combination tone calculation (0 = No Calc.)	408
		JET ENGINE PARAMETERS	
t	THRUST	Static thrust (lb)	409
W	WTFL	Gas weight flow through engine (lb/sec)	410
a_j	AREAJ	Nozzle area (sq. in)	411
P_a	PSUBA	Ambient inlet pressure (in Hg)	412
T_a	TSUBA	Ambient inlet temperature (°F)	413
T_j	TSUBJ	Tailpipe temperature (°F)	414
T_{j_o}	TSUBJO	Tailpipe temperature at standard conditions (°F)	415
α_j	ALFAJ	Inclination of jet thrust axis to horizontal (deg) (+90° = vertical)	416
-	ROTR	Control factor to include calculation of rotors*	417
-	RP	Control factor to include calculation of propellers*	418
-	FANS	Control factor to include calculation of fans*	419
-	RJ	Control factor to include calculation of jets*	420
-	E	Control factor to include calculation of turbo-shaft engine*	421

* for control factors 1 = Yes 0 = No

TABLE 4 (Cont'd)

Variable	Program Name	Description	Input Sequence Location
		FLIGHT PATH PARAMETERS	
-	PATH(N)	Flight Segment type (1 = Helical, 2 = Straight)	30 thru 79
X'_{max_n} Y'_{max_n}	XMAX(N) YMAX(N)	X', Y' coordinate system location of end point of segment N (straight line segments only)	80 thru 129
$\phi\ max_n$	PHMAX(N)	Maximum angle through which aircraft turns on helical flight segments N (+ for left turns, - for right turns)	180 thru 229
R_n	RADIUS(N)	Turning radius of helical segment N	230 thru 279
$V_f(n)$	VF1(N)	Flight velocity segment N	280 thru 329
α_n	ALF(N)	Flight path angle to horizontal for segment N	330 thru 379
X'_{ob} Y'_{ob}	XPRZRO ZPRZRO	Observer coordinate location on ground	381
Θ_{max_o}	THMAXO	Angle first flight segment makes with the positive x'-axis	382
A_o	AZWEO	Altitude at the X'=0, Y'=o location	383
t_{inc}	TINC	Time increment between successive PNL calculations	384
-	ANMFPT	Number of observer locations	385

FORM 1
V/STOL NOISE MODEL

CASE:__________ DESCRIPTION:____

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) ϕ max (deg)	RADIUS (ft)	V_f (ft/sec)	α_n (deg)
1	2.	2000.	500.	-	-	85.	20.
2	1.	-	-	40.	500.	100.	10.
3	2.	5000.	4100.	-	-	130.	10.
4	1.	-	-	-80.	750.	150.	15.
5	2.	-	-	-	-	190.	15.
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

(a) Flight path type: 1 = helical, 2 = straight
(b) Positive for counterclockwise, negative for clockwise turns

Note: Values in this table are for an example case.

Figure 32. V/STOL Noise Model Form 1

FORM 1A
V/STOL NOISE MODEL

CASE:__________ DESCRIPTION:____

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) ϕ_{max} (deg)	RADIUS (ft)	V_f (ft/sec)	α_n (deg)
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							
41							
42							
43							
44							
45							
46							
47							
48							
49							
50							

(a) Flight path type: 1 = helical, 2 = straight
(b) Positive for counterclockwise, negative for clockwise turns

Figure 33. V/STOL Noise Model Form 1A

V/STOL NOISE MODEL

FORM 2

CASE: Example 1

FLIGHT SEGMENT NUMBER: 1

DESCRIPTION: Compound helicopter, Rotors only on segments 1 and 2. Propellers and rotors on segment 3, 4, and 5.

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ	1117.	80	XMAX(1)	2000.	235	RADIUS(6)		390	DIAH	
2	SEG	5.	81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE	1.	82	XMAX(3)	5000.	237	RADIUS(8)		392	BPR	
4	RCASE	2.	83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA	0.8	84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB	6.	85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR	29.4	86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN	228.	87	XMAX(8)		280	VF1(1)	85.	397	SIGPHI	
9	RSID	0.	88	XMAX(9)		281	VF1(2)	100.	398	DL	
10	RCHORD	15.	89	XMAX(10)		282	VF1(3)	130.	399	RPM	
11	RTHRUS	28200.	↓	↓		283	VF1(4)	150.	400	SPAF	
12	RTORQ	117000.	129	XMAX(50)		284	VF1(5)	190.	401	XMXTIP	
13	RBETA	2.	130	YMAX(1)	500.	285	VF1(6)		402	PR	
14	TCASE	2.5	131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA	0.8	132	YMAX(3)	4100.	287	VF1(8)		404	TT2	
16	TBIGB	6.	133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR	6.5	134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN	1030.	135	YMAX(6)		↓	↓		407	FN	
19	TSID	0.	136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD	9.2	137	YMAX(8)		330	ALF(1)	20.	409	THRUST	
21	TTHRUS	2150.	138	YMAX(9)		331	ALF(2)	10.	410	WTFL	
22	TTORQ	795.	139	YMAX(10)		332	ALF(3)	10.	411	AREAJ	
23	TBETA	0.	↓	↓		333	ALF(4)	15.	412	PSUBA	
24	PPWR		179	YMAX(50)		334	ALF(5)	15.	413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)	40.	336	ALF(7)		415	TSUBJO	
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)	-80.	338	ALF(9)		417	ROTR	1.
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	0.
30	PATH(1)	2.	185	PHMAX(6)		↓	↓		419	FANS	0.
31	PATH(2)	1.	186	PHMAX(7)		379	ALF(50)		420	RJ	0.
32	PATH(3)	2.	187	PHMAX(8)		380	XPRZRO	6000.	421	E	1.
33	PATH(4)	1.	188	PHMAX(9)		381	YPRZRO	2000.			
34	PATH(5)	2.	189	PHMAX(10)		382	THMAXO	14.			
35	PATH(6)		↓	↓		383	AZERO	0.			
36	PATH(7)		229	PHMAX(50)		384	TINC	1.			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT	6.			
38	PATH(9)		231	RADIUS(2)	500.	386	HPENG	3780.			
39	PATH(10)		232	RADIUS(3)		387	SLEVEL	2.			
↓	↓		233	RADIUS(4)	750.	388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

Figure 34. V/STOL Noise Model Form 2

V/STOL NOISE MODEL

FORM 2

CASE: Example 1

FLIGHT SEGMENT NUMBER: 2

DESCRIPTION: Parameters do not change from segment 1 to segment 2, thus a dummy input is provided

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE VALUE
1	SAZ	1117.	80	XMAX(1)		235	RADIUS(6)		390	DIAH
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI
9	RSID		88	XMAX(9)		281	VF1(2)		398	DL
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM
11	RTHRUS		↓	↓		283	VF1(4)		400	SPAF
12	RTORQ		129	XMAX(50)		284	VF1(5)		401	XMXTIP
13	RBETA		130	YMAX(1)		285	VF1(6)		402	PR
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST
21	TTHRUS		138	YMAX(9)		331	ALF(2)		410	WTFL
22	TTORQ		139	YMAX(10)		332	ALF(3)		411	AREAJ
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA
24	PPWR		179	YMAX(50)		334	ALF(5)		413	TSUBA
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ
26	BIGB		181	PHMAX(2)		336	ALF(7)		415	TSUBJO
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ
28	ANMPRP		183	PHMAX(4)		338	ALF(9)		417	ROTR
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E
33	PATH(4)		188	PHMAX(9)		381	YPRZRO			
34	PATH(5)		189	PHMAX(10)		382	THMAXO			
35	PATH(6)		↓	↓		383	AZERO			
36	PATH(7)		229	PHMAX(50)		384	TINC			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT			
38	PATH(9)		231	RADIUS(2)		386	HPENG			
39	PATH(10)		232	RADIUS(3)		387	SLEVEL			
↓	↓		233	RADIUS(4)		388	ANENG			
79	PATH(50)		234	RADIUS(5)		389	DIAT			

Figure 35. Form 2 for Example, Segment 2

V/STOL NOISE MODEL

FORM 2

CASE: Example 1

DESCRIPTION: Propellers are now turned on

FLIGHT SEGMENT NUMBER: 3

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ		80	XMAX(1)		235	RADIUS(6)		390	DIAH	
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI	
9	RSID		88	XMAX(9)		281	VF1(2)		398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM	
11	RTHRUS	15000.	↓	↓		283	VF1(4)		400	SPAF	
12	RTORQ	32300.	129	XMAX(50)		284	VF1(5)		401	XMXTIP	
13	RBETA	1.	130	YMAX(1)		285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST	
21	TTHRUS	730.	138	YMAX(9)		331	ALF(2)		410	WTFL	
22	TTORQ	378.	139	YMAX(10)		332	ALF(3)		411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA	
24	PPWR	1236.	179	YMAX(50)		334	ALF(5)		413	TSUBA	
25	DIA	14.76	180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB	3.	181	PHMAX(2)		336	ALF(7)		415	TSUBJO	
27	RPMP	1180.	182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP	2.	183	PHMAX(4)		338	ALF(9)		417	ROTR	
29	CHORDP	1.	184	PHMAX(5)		339	ALF(10)		418	RP	1.
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS	
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ	
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E	
33	PATH(4)		188	PHMAX(9)		381	YPRZRO				
34	PATH(5)		189	PHMAX(10)		382	THMAXO				
35	PATH(6)		↓	↓		383	AZERO				
36	PATH(7)		229	PHMAX(50)		384	TINC				
37	PATH(8)		230	RADIUS(1)		385	ANMFPT				
38	PATH(9)		231	RADIUS(2)		386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)		388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

Figure 36. Form 2 for Example 1, Segment 3

V/STOL NOISE MODEL

FORM 2

CASE: Example 1
FLIGHT SEGMENT NUMBER: 4

DESCRIPTION: ______________________________

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ		80	XMAX(1)		235	RADIUS(6)		390	DIAH	
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI	
9	RSID		88	XMAX(9)		281	VF1(2)		398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)		400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)		401	XMXTIP	
13	RBETA		130	YMAX(1)		285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)		410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)		411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA	
24	PPWR	1358.	179	YMAX(50)		334	ALF(5)		413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)		336	ALF(7)		415	TSUBJO	
27	RPMP	1210.	182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)		338	ALF(9)		417	ROTR	
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS	
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ	
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E	
33	PATH(4)		188	PHMAX(9)		381	YPRZRO				
34	PATH(5)		189	PHMAX(10)		382	THMAXO				
35	PATH(6)		↓	↓		383	AZERO				
36	PATH(7)		229	PHMAX(50)		384	TINC				
37	PATH(8)		230	RADIUS(1)		385	ANMFPT				
38	PATH(9)		231	RADIUS(2)		386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)		388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

Figure 37. Form 2 for Example 1, Segment 4

V/STOL NOISE MODEL

FORM 2

CASE: Example 1 DESCRIPTION:

FLIGHT SEGMENT NUMBER: 5

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ		80	XMAX(1)		235	RADIUS(6)		390	DIAH	
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI	
9	RSID		88	XMAX(9)		281	VF1(2)		398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)		400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)		401	XMXTIP	
13	RBETA		130	YMAX(1)		285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)		410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)		411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA	
24	PPWR	1480.	179	YMAX(50)		334	ALF(5)		413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)		336	ALF(7)		415	TSUBJO	
27	RPMP	1240.	182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)		338	ALF(9)		417	ROTR	
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS	
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ	
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E	
33	PATH(4)		188	PHMAX(9)		381	YPRZRO				
34	PATH(5)		189	PHMAX(10)		382	THMAXO				
35	PATH(6)		↓	↓		383	AZERO				
36	PATH(7)		229	PHMAX(50)		384	TINC				
37	PATH(8)		230	RADIUS(1)		385	ANMFPT				
38	PATH(9)		231	RADIUS(2)		386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)		388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

Figure 38. Form 2 for Example 1, Segment 5

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

		WORD COUNT FIELD	LOCATION FIELD				DATA FIELD 1												DATA FIELD 2												DATA FIELD 3												DATA FIELD 4												DATA FIELD 5											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	4	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	

Figure 39. V/STOL Noise Model Input Coding Form

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

	1	WORD COUNT FIELD (2)	LOCATION FIELD (3–6)	DATA FIELD 1 (7–18)	DATA FIELD 2 (19–30)	DATA FIELD 3 (31–42)	DATA FIELD 4 (43–54)	DATA FIELD 5 (55–66)
1		5	1	1117.	5.	1.	2.	0.8
2		5	6	6.	29.4	228.	0.	15.
3		5	11	28200.	117000.	2.	2.5	0.8
4		5	16	6.	6.5	1030.	0.	9.2
5		3	21	2150.	795.	0.		
6		5	30	2.	1.	2.	1.	2.
7		3	80	2000.	0.	5000.		
8		3	1330	500.	0.	4140.		
9		3	181	40.	0.	-80.		
10		3	231	500.	0.	750.		
11		5	280	85.	100.	130.	150.	190.
12		5	330	20.	10.	10.	15.	15.
13		5	380	6000.	2000.	14.	0.	1.
14		4	385	6.	3780.	2.	2.	
15	-	5	417	1.	0.	0.	0.	1.
16	-	1	1	1117.				
17		3	11	15000.	32300.	1.		
18		2	21	730.	378.			
19		5	24	1236.	14.76	3.	1180.	2.
20		1	29	1.				
21	-	1	418	1.				
22		1	24	1358.				
23	-	1	27	1210.				
24		1	24	1480.				
25	-	1	27	1240.				

Figure 40. V/STOL Noise Model Input Coding Form for Example Case 1

FORM 3
V/STOL NOISE MODEL
Helicopter Rotor Parameters

VARIABLE		PROG NAME	FLIGHT PATH SEGMENT NUMBER									
			1	2	3	4	5	6	7	8	9	10
MAIN ROTOR												
Loading harmonic K factor	(a)	RCASE										
Radial loading station %r	(b)	RETA										
Number of blades		RBIGB										
Radius	ft	RBIGR										
Rotational speed	rpm	ROMEGN										
Disk incidence angle	deg	RSID										
Blade chord	in	RCHORD										
Thrust	lb	RTHRUS										
Torque	lb-ft	RTORQ										
Coning angle	deg	RBETA										
TAIL ROTOR												
Loading harmonic factor	(c)	TCASE										
Radial loading station %R	(b)	TETA										
Number of blades		TBIGB										
Radius	ft	TBIGR										
Rotational speed	rpm	TOMEGN										
Disk incidence	deg	TSID										
Blade chord	in	TCHORD										
Thrust	lb	TTHRUS										
Torque	lb-ft	TTORQ										
Coning angle	deg	TBETA										

(a) Typical value is 1.8 to 2.0 for most multi-blade rotor systems
(b) Use a value of 0.8 for normal rotor systems
(c) Typical value is 1.9 to 2.2 for most motors

CASE NUMBER:__________ DESCRIPTION:______________________________

FORM 4
V/STOL NOISE MODEL
Propeller Parameters

VARIABLE		PROG NAME	FLIGHT PATH SEGMENT NUMBER									
			1	2	3	4	5	6	7	8	9	10
Shaft Power	hp	PPWR										
Diameter	ft	DIA										
Number of blades		BIGB										
Rotational speed	rpm	RPMP										
Number of propellers		ANMPRP										
Mean blade chord	ft	CHORDP										

CASE NUMBER:____________ DESCRIPTION:____

FORM 5
V/STOL NOISE MODEL
Turboshaft Engine Noise

VARIABLE		PROG NAME	FLIGHT PATH SEGMENT NUMBER				
			1	2	3	4	5
Power output	hp	HPENG					
Noise level curve	(a)	SLEVEL					
Number of engines		ANENG					

VARIABLE		PROG NAME	FLIGHT PATH SEGMENT NUMBER				
			6	7	8	9	10
Power output	hp	HPENG					
Noise level curve	(a)	SLEVEL					
Number of engines		ANENG					

(a) 1 = average 2 = loud

CASE NUMBER:__________ DESCRIPTION:______________________________

FORM 6
V/STOL NOISE MODEL
Jet Engine Parameters

VARIABLE	PROG NAME	FLIGHT PATH SEGMENT NUMBER									
		1	2	3	4	5	6	7	8	9	10
Static thrust lb	THRUST										
Gas weight flow lb/sec	WTFL										
Nozzle area sq in	AREAJ										
Ambient inlet pressure in Hg	PSUBA										
Ambient inlet temperature F	TSUBA										
Tailpipe temperature F	TSUBJ										
Tailpipe temperature at SLS conditions F	TSUBJO										
Inclination of thrust axis to horizontal(+90=inlet up)deg	ALFAJ										

CASE NUMBER:_______________ DESCRIPTION:_______________________________

FORM 7
V/STOL NOISE MODEL
FAN Engine Parameters

VARIABLE	PROG NAME	FLIGHT PATH SEGMENT NUMBER									
		1	2	3	4	5	6	7	8	9	10
Tip diameter in	DIAT										
Hub diameter in	DIAH										
Number of blades	B										
Bypass ratio	BPR										
Blade tip chord	CHORD										
Tip diameter gradient(a) in/in	DDDXT										
Hub diameter gradient(a) in/in	DDDXH										
Blade suction surface radius of curvature(a) in	RS										
Standard deviation of blade tip metal angle(a) rad	SIGPHI										
Inlet duct length ft	DL										
Rotational speed rpm	RPM										
Specific airflow lb/sec/ft^2	SPAF										
Tip axial Mach number	XMXTIP										
Pressure ratio	PR										
Blade diffusion factor DF	DF										
Ambient inlet temperature F	TT2										
Ambient inlet pressure in Hg	PT2										
Inclination to horizontal (+90^o=vertical) deg	ALFA										
Number of fans	FN										
Control factor to skip calculation of combination tones (0=no)	COMB										

(a) Need not be entered if COMB = 0

CASE NUMBER:____________ DESCRIPTION:____________________________

CORRELATION WITH MEASURED DATA

The program was run to determine its accuracy when applied to existing V/STOL aircraft. Data for two aircraft configurations, a helicopter and a turbo-prop STOL, were used to determine the degree of correlation with predicted levels.

Helicopter

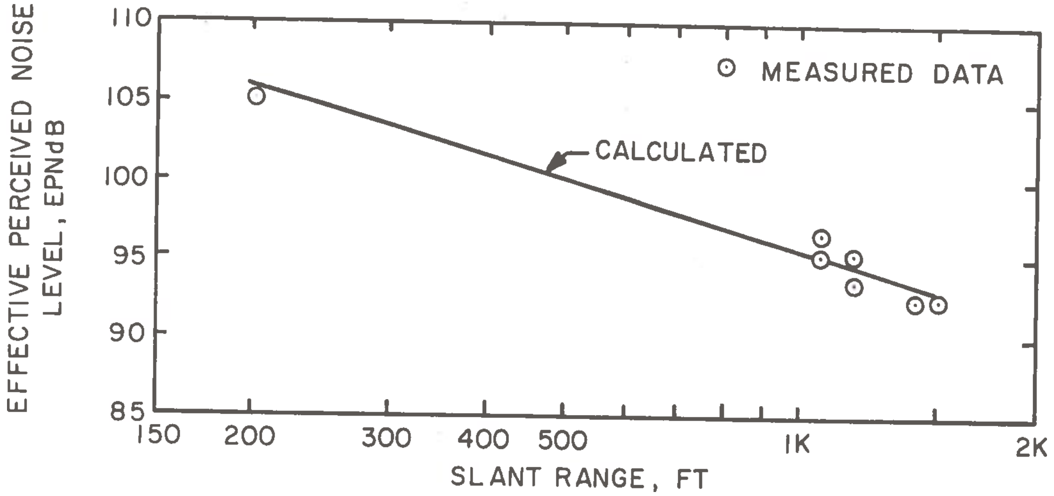
The helicopter for which measured data was available is the CH-53D transport helicopter at a gross weight of 36,000 pounds. Noise measurements were made at several slant range positions for typical commercial type take-offs and aircraft operating parameters were monitored during the flight. Figure 41 presents comparisons of the measured and calculated values of maximum tone corrected Perceived Noise Level ($PNLT_{max}$) and of Effective Perceived Noise Level (EPNL). The value of primary concern here, the EPNL, as well as the $PNLT_{max}$ shows good agreement between measured and calculated levels. Figure 42 shows the very good agreement achieved between the measured and calculated time histories of PNLT for two of the Figure 41 data points.

Figure 43 shows measured and predicted noise spectra at two azimuth positions around the aircraft and Figure 44 shows predicted main rotor and tail rotor rotational harmonics compared with a time averaged 2.5 Hz analysis of measured data. In all cases it can be seen that there is good correlation between measured and predicted levels.

Turboprop STOL

The data presented in Reference 36 for the McDonnell-Douglas 188 turboprop STOL aircraft was used to further demonstrate program accuracy. The test described in Reference 36 was conducted at the National Aviation Facility Experimental Center (NAFEC) near Atlantic City, New Jersey with the aircraft at a gross weight of 43,000 to 45,000 pounds. Figure 45 presents the measured data along with the predicted EPNL and $PNLT_{max}$ levels of takeoff. The EPNL values show quite good correlation, however the calculated PNLT values are a bit high although they are within one standard deviation of the mean measured values. Part of the problem may be due to the fact that aircraft operating parameters were not closely monitored during the flight and they had to be estimated from material supplied by McDonnell-Douglas. This is especially true for the landing case (Figure 46) where the agreement between measured and calculated levels is not as good as for the takeoff case. The agreement between measured and calculated levels in both takeoff and landing cases is however, felt to be acceptable.

Since reliable turbofan STOL aircraft noise data with sufficiently detailed operating parameters were not available correlation was not checked for the fan portion of the program. Because the fan noise program was developed by an engine manufacturer (Pratt and Whitney Aircraft) from measured full-scale engine data it is felt that reasonable accuracy will be achieved with this program.



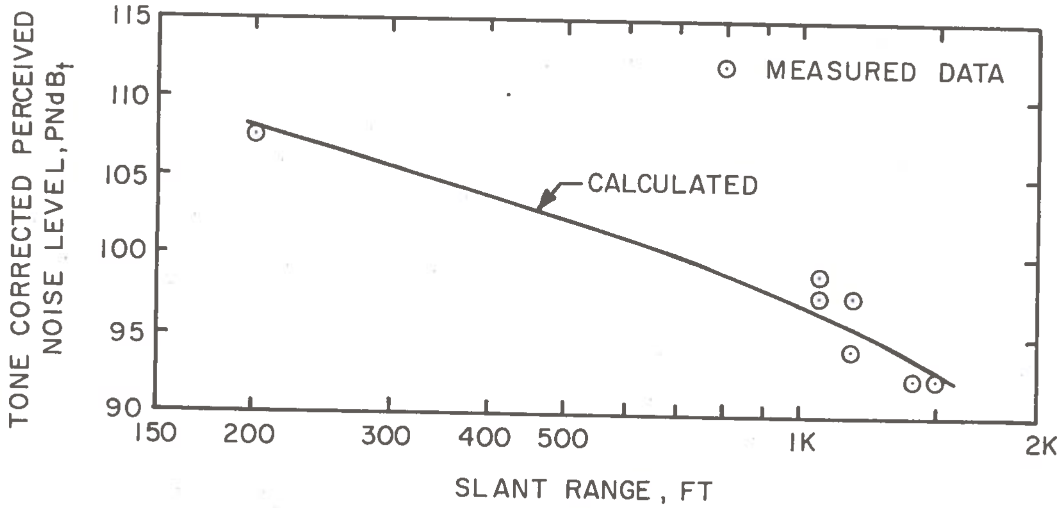
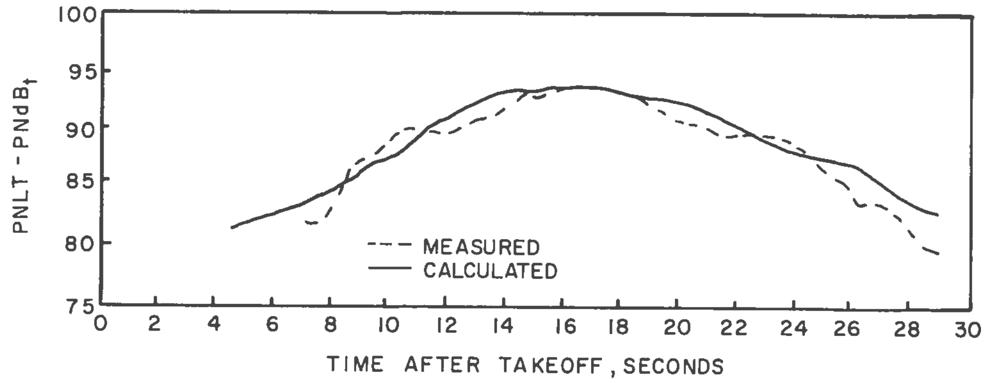
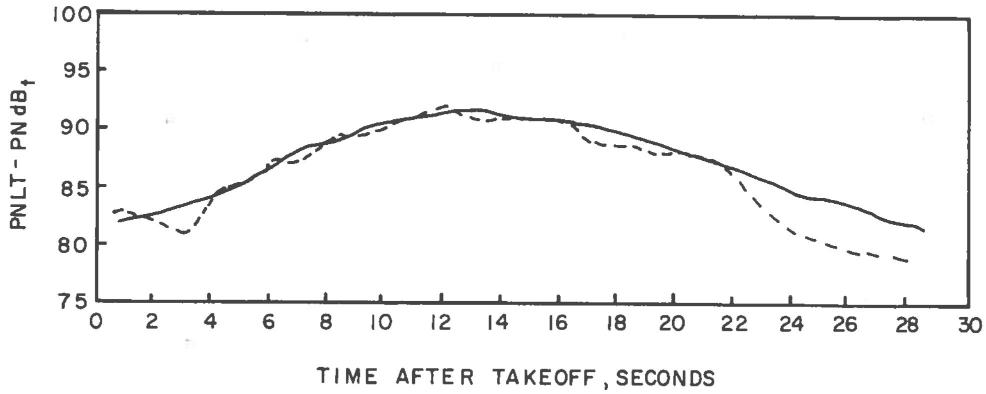


Figure 41. Comparison of Measured and Calculated EPNL and Maximum PNLT Values for a Helicopter Takeoff



(a) TAKEOFF ONE



(b) TAKEOFF TWO

Figure 42. Comparison of Measured and Calculated PNLT Time History for a Helicopter Takeoff

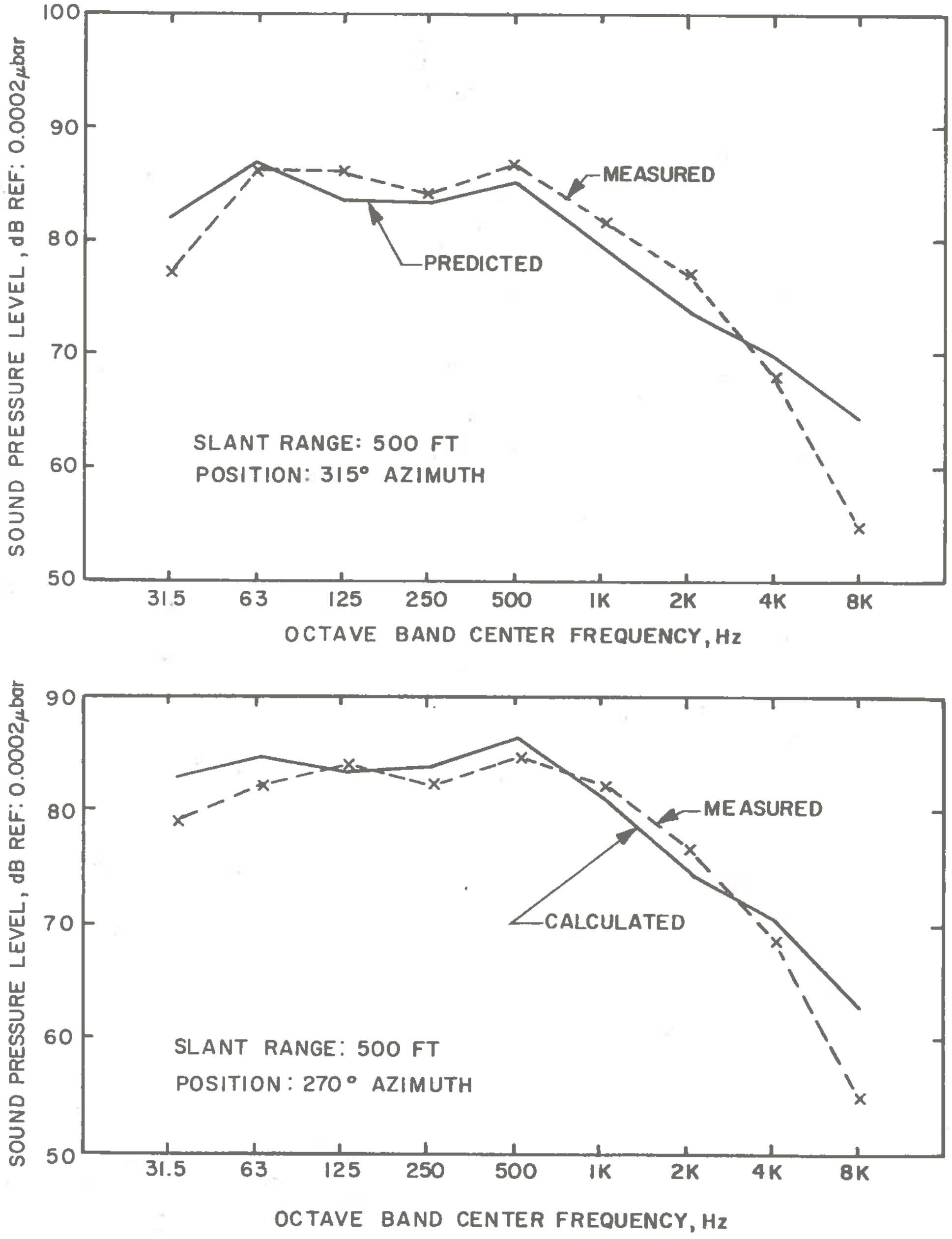


FIGURE 43. Comparison of Measured and Predicted Helicopter Noise Spectra.

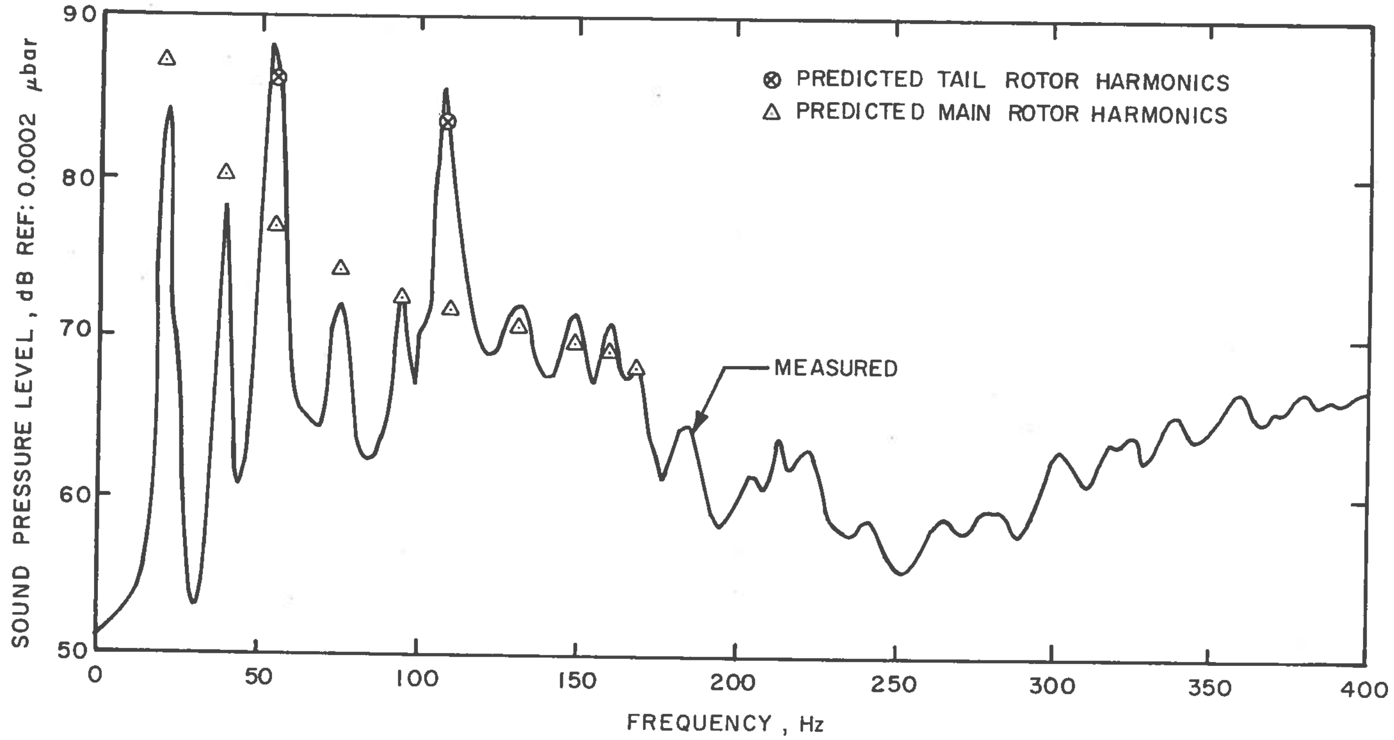


FIGURE 44. Comparison of Measured and Predicted Rotor Rotational Sound Levels.

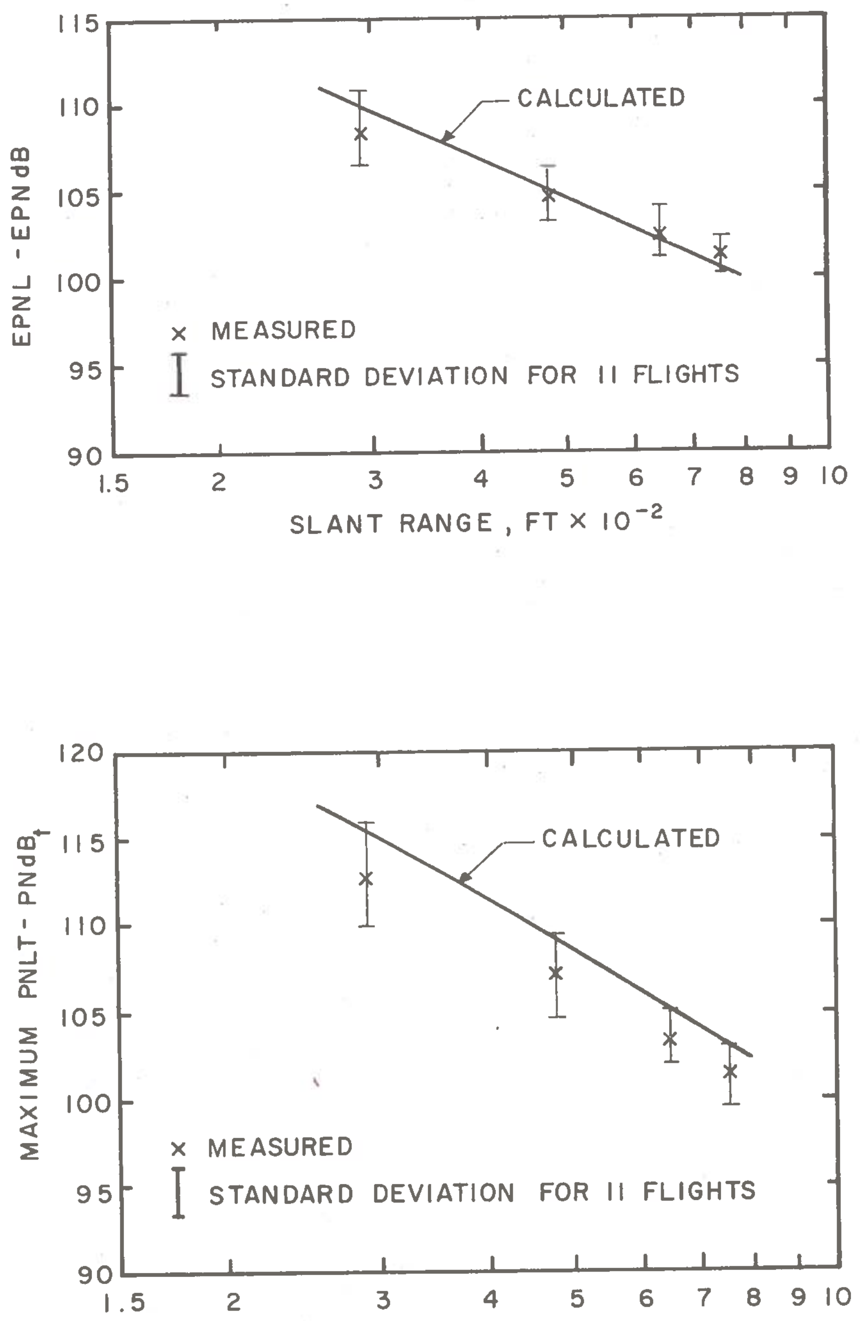


Figure 45. Comparison of Measured and Calculated Take-off PNLT_{max} and EPNL Values for a McDonnell-Douglas 188 (Breguet 941) Turboprop STOL Airplane

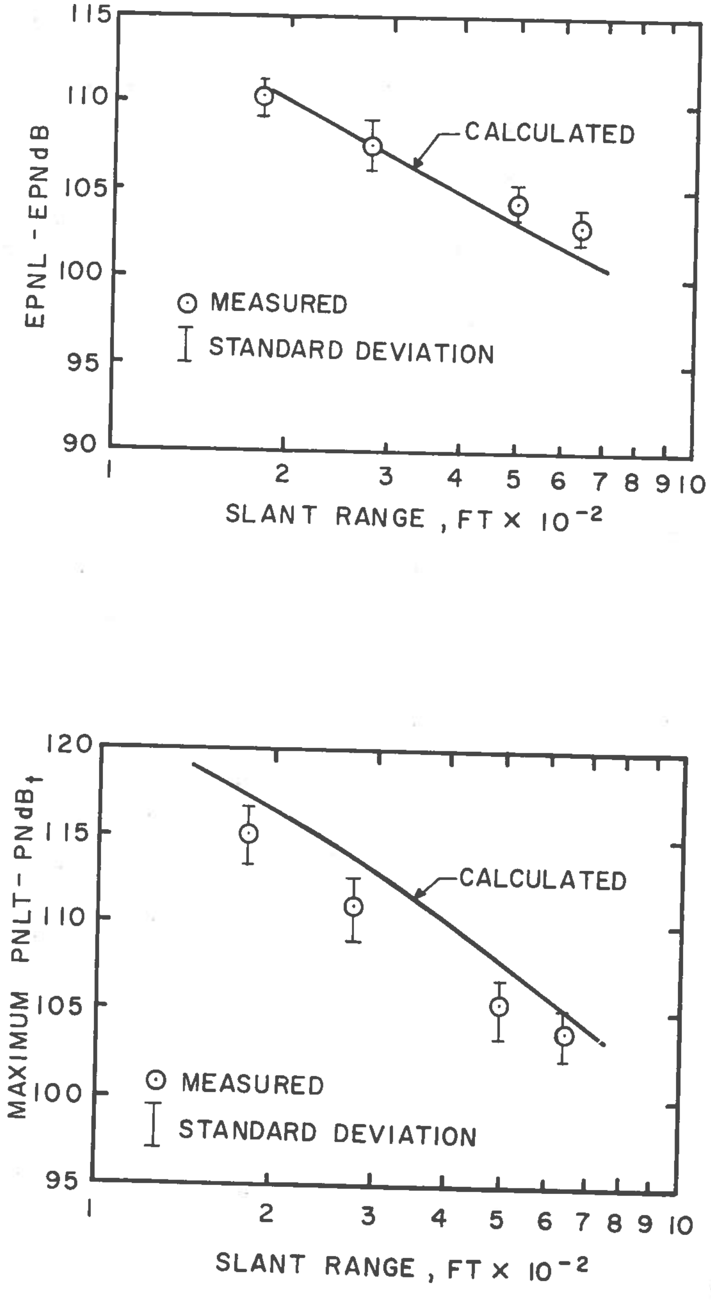


Figure 46. Comparison of Measured and Calculated Landing $PNLT_{max}$ and EPNL Values for a McDonnell-Douglas 188 (Breguet 941) Turboprop STOL Airplane

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The procedure described herein will predict the noise radiated by non-augmented lift V/STOL vehicles; in particular, it will predict the Effective Perceived Noise Level of these vehicles for typical take-off, landing, and cruise operations with an estimated accuracy of ± 2.5 EPNDB.

2. Comparisons of measured and predicted noise for a heavy transport helicopter and for a four engine turboprop STOL showed agreement within 2 dB for EPNL comparisons and within 3 dB for the maximum PNLT values.

3. The program cannot yet be used to calculate the noise from augmented lift STOLs because no generally accepted methods to predict the noise from these vehicles are currently available. An undeflected jet noise prediction procedure is, however, included to provide a baseline (minimum) estimate for those aircraft using deflected jets for lift.

4. The program should not be used to predict the noise of those VTOL vehicle types characterized by impulsive noise signatures. This includes both blade/vortex interaction and high speed compressibility (drag) impulsive noise. In fact, it is highly questionable as to whether the PNL (PNLT) measure adequately describes the annoyance of impulsive noise signatures. An independent study conducted in 1970 (Ref. 37) showed that the PNL method of predicting annoyance underpredicted the annoyance of impulsive noise by more than 4 dB.

5. It should also be noted that, apparently, the adequacy of the PNL (PNLT) measure of evaluating the annoyance of propeller or fan noise whose spectral content is rich in harmonics of the blade passage frequency has also not been demonstrated. Indeed, Adcock and Ollerhead concluded from a study of CTOL and STOL annoyance measures that:

   > "All methods (of rating annoyance) were significantly less consistent in estimating the noisiness of the STOL aircraft than they were for the CTOL aircraft. However, the difference could not be identified with any STOL performance characteristic. It seems more likely that the difference is associated with the fact that the STOL aircraft were all propeller or rotor driven."

Caution should, therefore, be exercised when evaluating the annoyance of vehicles with such acoustic characteristics.

6. The rotor noise prediction method used was developed for current state-of-the-art (NACA 0012 type) symmetrical airfoils and linearly twisted blades. The method should not be used for advanced blade designs having new airfoils with nonlinear chord and twist distributions. As methods become available to predict the noise characteristics of these newly developed rotors, such methods should be incorporated into this prediction procedure.

Recommendations

1. Methods to predict helicopter rotor impulsive noise should be developed and incorporated into the V/STOL Noise Model. Recent unpublished studies to develop a prediction method for high-speed (compressibility) drag impulsive noise has shown encouraging results in this direction.
2. Further research studies should be conducted to develop an annoyance measure similar to EPNL which accounts for the added annoyance of impulsive type noise signatures as well as harmonic trains in the mid- to high frequency range typical of some propeller configurations.
3. Procedures to predict the noise from augmented lift STOLs and deflected jets should be developed and incorporated into the V/STOL Noise Model.
4. Component noise prediction procedures should be updated or replaced as newer, more accurate, or more efficient procedures are developed.
5. The model should be modified at some future time to automatically produce a series of EPNL- slant range curves in punched computer card form for use in a V/STOL noise subroutine incorporated in the NEM Mod-5 and Mod-6 programs at the Transportation Systems Center.
6. A prediction method should be developed to predict the acoustic characteristics of the more advanced single and coaxial rotor configurations now under development.

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APPENDIX A

TONE CORRECTION CALCULATION PROCEDURE

The method for calculating the tone correction applied to the PNL to determine the PNLT is taken from Reference 31 and is presented below. An example of the method is given in Table A-2.

Step 1.

Starting with the measured sound pressure level in the 80 Hz one-third octave band (band number 3), calculate the changes in level, S, (or "slopes") in the remainder of the 24 bands as follows:

$$s(3) = \text{no value} \qquad \text{(A-1)}$$

$$s(4) = SPL(4) - SPL(3) \qquad \text{(A-2)}$$

$$\vdots$$

$$s(i) = SPL(i) - SPL(i-1) \qquad \text{(A-3)}$$

$$\vdots$$

$$s(24) = SPL(24) - SPL(23) \qquad \text{(A-4)}$$

Step 2.

Encircle the value of the slope s(i) where the absolute value of the change in slope is greater than five; that is, where

$$|\Delta s(i)| = |s(i) - s(i-1)| > 5 \qquad \text{(A-5)}$$

Step 3.

(a) If the encircled value of the slope s(i) is positive and algebraically greater than the slope s(i-1), encircle the level SPL(i).

(b) If the encircled value of the slope s(i) is zero or negative and the slope s(i-1) is positive, encircle the level SPL(i-1).

(c) For all other cases, no level is to be encircled.

Step 4.

Omit all SPL(i) encircled in Step 3 and compute new levels as follows:

(a) For non-encircled levels, let the new levels equal the original levels,

$$SPL'(i) = SPL(i) \tag{A-6}$$

(b) For encircled levels, let the new level equal the arithmetic average of the preceding and following levels,

$$SPL'(i) = 1/2 \left[SPL(i-1) + SPL(i+1)\right] \tag{A-7}$$

(c) If the level in the highest frequency band is encircled, let the new level equal

$$SPL'(24) = SPL(23) + s(24) \tag{A-8}$$

Step 5.

Recompute new slopes including one for an imaginary 25-th band as follows:

$$s'(3) = s'(4) \tag{A-9}$$

$$s'(4) = SPL'(4) - SPL'(3) \tag{A-10}$$

.

.

.

$$s'(i) = SPL'(i) - SPL'(i-1) \tag{A-11}$$

.

.

.

$$s'(24) = SPL'(24) - SPL'(23) \tag{A-12}$$

$$s'(25) = s'(24) \tag{A-13}$$

Step 6.

Compute the arithmetic average of the three adjacent slopes as follows:

$$\bar{s}(i) = 1/3 \cdot \left[s'(i) + s'(i+1) + s'(i+2) \right] \qquad \text{(A-14)}$$

Step 7.

Compute final adjusted levels by beginning with band number 3 and proceeding to band number 24 as follows:

$$SPL''(3) = SPL(3) \qquad \text{(A-15)}$$

$$SPL''(4) = SPL''(3) + \bar{s}(3) \qquad \text{(A-16)}$$

$$\vdots$$

$$SPL''(i) = SPL''(i-1) + \bar{s}(i-1) \qquad \text{(A-17)}$$

$$\vdots$$

$$SPL''(24) = SPL''(23) + \bar{s}(23) \qquad \text{(A-18)}$$

Step 8.

Calculate the difference between the original and adjusted levels as follows:

$$F(i) = SPL(i) - SPL''(i) \qquad \text{(A-19)}$$

and note only values greater than zero.

Step 9.

Tone correction levels C are determined for any one-third octave band in accordance with Table A.1 or Figure A-1. However, only the maximum one is used.

Step 10.

The value of PNLT is given by:

$$PNLT = PNL + C_{max} \qquad \text{(A-20)}$$

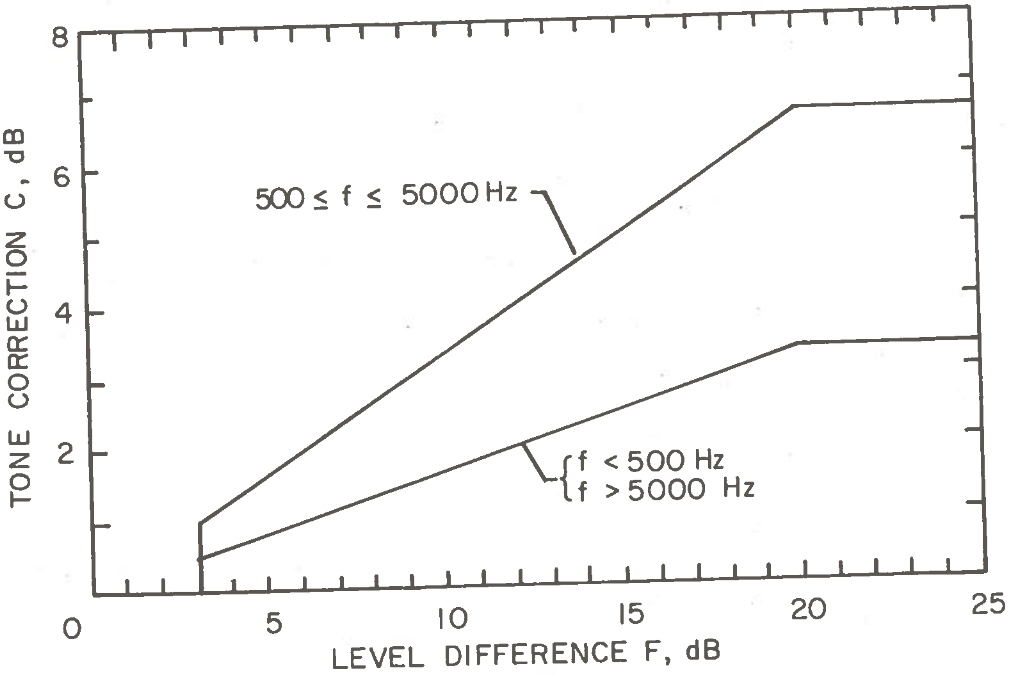

Figure A-1. Tone Correction Factors

TABLE A.1

TONE CORRECTION FACTORS

FREQUENCY f, Hz	LEVEL DIFFERENCE F, dB	TONE CORRECTION C, dB
$50 \le f < 500$	$F < 3$ $3 \le F < 20$ $20 \le F$	0 $F/6$ $3^{1}/_{3}$
$500 \le f \le 5000$	$F < 3$ $3 \le F < 20$ $20 \le F$	0 $F/3$ $6^{2}/_{3}$
$5000 < f \le 10000$	$F < 3$ $3 \le F < 20$ $20 \le F$	0 $F/6$ $3^{2}/_{3}$

TABLE A.2

EXAMPLE OF TONE CORRECTION CALCULATION

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
BAND (i)	F Hz	SPL dB	S dB Step 1	S dB Step 2	SPL' dB Step 4	S' dB Step 5	$\bar{S}$ dB Step 6	SPL'' dB Step 7	F dB Step 8	C dB Step 9
1	50	-	-	-	-	-	-	-	-	-
2	63	-	-	-	-	-	-	-	-	-
3	80	70	-	-	70	-8	$-2{}^{1}/3$	70	-	
4	100	62	-8	-	62	-8	$+3{}^{1}/3$	$67{}^{2}/3$	-	
5	125	70	+8	16	71	+9	$+6{}^{2}/3$	71	-	
6	160	80	+10	2	80	+9	$+2{}^{2}/3$	$77{}^{2}/3$	$2{}^{1}/3$	
7	200	82	+2	8	82	+2	$-1{}^{1}/3$	$80{}^{1}/3$	$1{}^{2}/3$	
8	250	83	+1	1	79	-3	$-1{}^{1}/3$	79	4	2/3
9	315	76	-7	8	76	-3	$+{}^{1}/3$	$77{}^{1}/3$		
10	400	80	+4	11	78	+2	+1	78	2	
11	500	80	0	4	80	+2	0	79	1	
12	630	79	-1	1	79	-1	0	79	-	
13	800	78	-1	0	78	-1	$-{}^{1}/3$	79		
14	1000	80	+2	3	80	+2	$-{}^{2}/3$	$78{}^{2}/3$	$1{}^{1}/3$	
15	1250	78	-2	4	78	-2	$-{}^{1}/3$	78	-	
16	1600	76	-2	0	76	-2	$+{}^{1}/3$	$77{}^{2}/3$	-	
17	2000	79	+3	5	79	+3	+1	78	1	
18	2500	85	+6	3	79	0	$-{}^{1}/3$	79	6	②
19	3150	79	-6	12	79	0	$-2{}^{2}/3$	$78{}^{2}/3$	$1/3$	
20	4000	78	-1	5	78	-1	$-6{}^{1}/3$	76	2	
21	5000	71	-7	6	71	-7	-8	$69{}^{2}/3$	$1{}^{1}/3$	
22	6300	60	-11	4	60	-11	$-8{}^{2}/3$	$61{}^{2}/3$	-	
23	8000	54	-6	5	54	-6	-8	53	1	0
24	10000	45	-9	3	45	-9	-	45	-	
						-9				

Step 1	③(i) - ③(i-1)
Step 2	④(i) - ④(i-1)
Step 3	see instructions
Step 4	see instructions
Step 5	⑥(i) - ⑥(i-1)

Step 6	[⑦(i) + ⑦(i+1) + ⑦(i+2)] /3
Step 7	⑨(i-1) + ⑧(i-1)
Step 8	③(i) - ⑨(i)
Step 9	see Table A.1

APPENDIX B

SAMPLE PROGRAM CASES - INPUT/OUTPUT

Five sample cases are presented to demonstrate the operation of the program. Complete sets of the input along with the corresponding program output are shown. For the sake of simplicity the flight path is the same for all of the cases.

Table of Contents - Appendix B

FORM 1
V/STOL NOISE MODEL

CASE: Sample #1

DESCRIPTION: Checkout for Subroutine ROTOR

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) ϕ_{max} (deg)	RADIUS (ft)	V_f (ft/sec)	α_n (deg)
1	2.	1000.	0.	-	-	75.	15.
2	1.	-	-	60.	500.	100.	5.
3	2.	2000.	1240.	-	-	150.	10.
4	1.	-	-	30.	500.	175.	10.
5	2.	-	-	-	-	175.	20.
6							
7							
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24							
25							

(a) Flight path type: 1 = helical, 2 = straight
(b) Positive for counterclockwise, negative for clockwise turns

V/STOL NOISE MODEL

FORM 2

CASE: Sample 1

DESCRIPTION: Checkout for Subroutine ROTOR

FLIGHT SEGMENT NUMBER: 1

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ	1117.	80	XMAX(1)	1000.	235	RADIUS(6)		390	DIAH	
2	SEG	5.	81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE	1.	82	XMAX(3)	2000.	237	RADIUS(8)		392	BPR	
4	RCASE	2.	83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA	.8	84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB	6.	85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR	29.4	86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN	228	87	XMAX(8)		280	VF1(1)		397	SIGPHI	
9	RSID	0	88	XMAX(9)		281	VF1(2)	75.	398	DL	
10	RCHORD	15	89	XMAX(10)		282	VF1(3)	100.	399	RPM	
11	RTHRUS	28200.	↓	↓		283	VF1(4)	150.	400	SPAF	
12	RTORQ	117000.	129	XMAX(50)		284	VF1(5)	175.	401	XMXTIP	
13	RBETA	2.	130	YMAX(1)	0.	285	VF1(6)	175.	402	PR	
14	TCASE	2.5	131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA	0.8	132	YMAX(3)	1240.	287	VF1(8)		404	TT2	
16	TBIGB	6.	133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR	6.5	134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN	1030.	135	YMAX(6)		↓	↓		407	FN	
19	TSID	0.	136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD	9.2	137	YMAX(8)		330	ALF(1)	15.	409	THRUST	
21	TTHRUS	2150.	138	YMAX(9)		331	ALF(2)	5.	410	WTFL	
22	TTORQ	795.	139	YMAX(10)		332	ALF(3)	10.	411	AREAJ	
23	TBETA	0.	↓	↓		333	ALF(4)	10.	412	PSUBA	
24	PPWR		179	YMAX(50)		334	ALF(5)	20.	413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)	60.	336	ALF(7)		415	TSUBJO	
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)	30.	338	ALF(9)		417	ROTR	1.
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	0.
30	PATH(1)	2.	185	PHMAX(6)		↓	↓		419	FANS	0.
31	PATH(2)	1.	186	PHMAX(7)		379	ALF(50)		420	RJ	0.
32	PATH(3)	2.	187	PHMAX(8)		380	XPRZRO	2500.	421	E	0.
33	PATH(4)	1.	188	PHMAX(9)		381	YPRZRO	500.			
34	PATH(5)	2.	189	PHMAX(10)		382	THMAXO	0.			
35	PATH(6)		↓	↓		383	AZERO	0.			
36	PATH(7)		229	PHMAX(50)		384	TINC	1.			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT	1.			
38	PATH(9)		231	RADIUS(2)	500.	386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)	500.	388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

V/STOL NOISE MODEL

FORM 2

CASE: Sample #1 DESCRIPTION:
FLIGHT SEGMENT NUMBER: 2

LOC	VARIABLE	VALUE
1	SAZ	
2	SEG	
3	FLTYPE	
4	RCASE	
5	RETA	
6	RBIGB	
7	RBIGR	
8	ROMEGN	
9	RSID	2.
10	RCHORD	
11	RTHRUS	
12	RTORQ	
13	RBETA	
14	TCASE	
15	TETA	
16	TBIGB	
17	TBIGR	
18	TOMEGN	
19	TSID	
20	TCHORD	
21	TTHRUS	
22	TTORQ	
23	TBETA	
24	PPWR	
25	DIA	
26	BIGB	
27	RPMP	
28	ANMPRP	
29	CHORDP	
30	PATH(1)	
31	PATH(2)	
32	PATH(3)	
33	PATH(4)	
34	PATH(5)	
35	PATH(6)	
36	PATH(7)	
37	PATH(8)	
38	PATH(9)	
39	PATH(10)	
↓	↓	
79	PATH(50)	
80	XMAX(1)	
81	XMAX(2)	
82	XMAX(3)	
83	XMAX(4)	
84	XMAX(5)	
85	XMAX(6)	
86	XMAX(7)	
87	XMAX(8)	
88	XMAX(9)	
89	XMAX(10)	
↓	↓	
129	XMAX(50)	
130	YMAX(1)	
131	YMAX(2)	
132	YMAX(3)	
133	YMAX(4)	
134	YMAX(5)	
135	YMAX(6)	
136	YMAX(7)	
137	YMAX(8)	
138	YMAX(9)	
139	YMAX(10)	
↓	↓	
179	YMAX(50)	
180	PHMAX(1)	
181	PHMAX(2)	
182	PHMAX(3)	
183	PHMAX(4)	
184	PHMAX(5)	
185	PHMAX(6)	
186	PHMAX(7)	
187	PHMAX(8)	
188	PHMAX(9)	
189	PHMAX(10)	
↓	↓	
229	PHMAX(50)	
230	RADIUS(1)	
231	RADIUS(2)	
232	RADIUS(3)	
233	RADIUS(4)	
234	RADIUS(5)	
235	RADIUS(6)	
236	RADIUS(7)	
237	RADIUS(8)	
238	RADIUS(9)	
239	RADIUS(10)	
↓	↓	
279	RADIUS(50)	
280	VF1(1)	
281	VF1(2)	
282	VF1(3)	
283	VF1(4)	
284	VF1(5)	
285	VF1(6)	
286	VF1(7)	
287	VF1(8)	
288	VF1(9)	
289	VF1(10)	
↓	↓	
329	VF1(50)	
330	ALF(1)	
331	ALF(2)	
332	ALF(3)	
333	ALF(4)	
334	ALF(5)	
335	ALF(6)	
336	ALF(7)	
337	ALF(8)	
338	ALF(9)	
339	ALF(10)	
↓	↓	
379	ALF(50)	
380	XPRZRO	
381	YPRZRO	
382	THMAXO	
383	AZERO	
384	TINC	
385	ANMFPT	
386	HPENG	
387	SLEVEL	
388	ANENG	
389	DIAT	
390	DIAH	
391	B	
392	BPR	
393	CHORD	
394	DDDXT	
395	DDDXH	
396	RS	
397	SIGPHI	
398	DL	
399	RPM	
400	SPAF	
401	XMXTIP	
402	PR	
403	DF	
404	TT2	
405	PT2	
406	ALFA	
407	FN	
408	COMB	
409	THRUST	
410	WTFL	
411	AREAJ	
412	PSUBA	
413	TSUBA	
414	TSUBJ	
415	TSUBJO	
416	ALFAJ	
417	ROTR	
418	RP	
419	FANS	
420	RJ	
421	E	

V/STOL NOISE MODEL

FORM 2

CASE: Sample #1

FLIGHT SEGMENT NUMBER: 3

DESCRIPTION: ____________________

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE VALUE
1	SAZ		80	XMAX(1)		235	RADIUS(6)		390	DIAH
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI
9	RSID	5.	88	XMAX(9)		281	VF1(2)		398	DL
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM
11	RTHRUS		↓	↓		283	VF1(4)		400	SPAF
12	RTORQ		129	XMAX(50)		284	VF1(5)		401	XMXTIP
13	RBETA		130	YMAX(1)		285	VF1(6)		402	PR
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST
21	TTHRUS		138	YMAX(9)		331	ALF(2)		410	WTFL
22	TTORQ		139	YMAX(10)		332	ALF(3)		411	AREAJ
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA
24	PPWR		179	YMAX(50)		334	ALF(5)		413	TSUBA
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ
26	BIGB		181	PHMAX(2)		336	ALF(7)		415	TSUBJO
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ
28	ANMPRP		183	PHMAX(4)		338	ALF(9)		417	ROTR
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E
33	PATH(4)		188	PHMAX(9)		381	YPRZRO			
34	PATH(5)		189	PHMAX(10)		382	THMAXO			
35	PATH(6)		↓	↓		383	AZERO			
36	PATH(7)		229	PHMAX(50)		384	TINC			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT			
38	PATH(9)		231	RADIUS(2)		386	HPENG			
39	PATH(10)		232	RADIUS(3)		387	SLEVEL			
↓	↓		233	RADIUS(4)		388	ANENG			
79	PATH(50)		234	RADIUS(5)		389	DIAT			

V/STOL NOISE MODEL

FORM 2

CASE: Sample #1

DESCRIPTION:

FLIGHT SEGMENT NUMBER: 4

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ		80	XMAX(1)		235	RADIUS(6)		390	DIAH	
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI	
9	RSID	5.	88	XMAX(9)		281	VF1(2)		398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)		400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)		401	XMXTIP	
13	RBETA		130	YMAX(1)		285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)		410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)		411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA	
24	PPWR		179	YMAX(50)		334	ALF(5)		413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)		336	ALF(7)		415	TSUBJO	
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)		338	ALF(9)		417	ROTR	
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS	
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ	
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E	
33	PATH(4)		188	PHMAX(9)		381	YPRZRO				
34	PATH(5)		189	PHMAX(10)		382	THMAXO				
35	PATH(6)		↓	↓		383	AZERO				
36	PATH(7)		229	PHMAX(50)		384	TINC				
37	PATH(8)		230	RADIUS(1)		385	ANMFPT				
38	PATH(9)		231	RADIUS(2)		386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)		388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

V/STOL NOISE MODEL

FORM 2

CASE: Sample #1

DESCRIPTION:

FLIGHT SEGMENT NUMBER: 5

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ		80	XMAX(1)		235	RADIUS(6)		390	DIAH	
2	SEG		81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE		82	XMAX(3)		237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)		397	SIGPHI	
9	RSID	5.	88	XMAX(9)		281	VF1(2)		398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)		399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)		400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)		401	XMXTIP	
13	RBETA		130	YMAX(1)		285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)		287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)		409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)		410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)		411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)		412	PSUBA	
24	PPWR	1358.	179	YMAX(50)		334	ALF(5)		413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)		336	ALF(7)		415	TSUBJO	
27	RPMP	1210.	182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)		338	ALF(9)		417	ROTR	
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	
30	PATH(1)		185	PHMAX(6)		↓	↓		419	FANS	
31	PATH(2)		186	PHMAX(7)		379	ALF(50)		420	RJ	
32	PATH(3)		187	PHMAX(8)		380	XPRZRO		421	E	
33	PATH(4)		188	PHMAX(9)		381	YPRZRO				
34	PATH(5)		189	PHMAX(10)		382	THMAXO				
35	PATH(6)		↓	↓		383	AZERO				
36	PATH(7)		229	PHMAX(50)		384	TINC				
37	PATH(8)		230	RADIUS(1)		385	ANMFPT				
38	PATH(9)		231	RADIUS(2)		386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)		388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

FORM 3
V/STOL NOISE MODEL
Helicopter Rotor Parameters

VARIABLE		PROG NAME	FLIGHT PATH SEGMENT NUMBER									
			1	2	3	4	5	6	7	8	9	10
MAIN ROTOR												
Loading harmonic K factor	(a)	RCASE	2.0	2.0	2.0	2.0	2.0					
Radial loading station %R	(b)	RETA	0.8	0.8	0.8	0.8	0.8					
Number of blades		RBIGB	6	6	6	6	6					
Radius	ft	RBIGR	29.4	29.4	29.4	29.4	29.4					
Rotational speed	rpm	ROMEGN	185	185	185	185	185					
Disk incidence angle	deg	RSID	0	2	5	5	5					
Blade chord	in	RCHORD	15	15	15	15	15					
Thrust	lb	RTHRUS	28200	28200	28200	28200	28200					
Torque	lb-ft	RTORQ	117000	117000	117000	117000	117000					
Coning angle	deg	RBETA	2	2	2	2	2					
TAIL ROTOR												
Loading harmonic factor	(c)	TCASE	2.5	2.5	2.5	2.5	2.5					
Radial loading station %R	(b)	TETA	0.8	0.8	0.8	0.8	0.8					
Number of blades		TBIGB	6	6	6	6	6					
Radius	ft	TBIGR	6.5	6.5	6.5	6.5	6.5					
Rotational speed	rpm	TOMEGN	1030	1030	1030	1030	1030					
Disk incidence	deg	TSID	0	0	0	0	0					
Blade chord	in	TGHORD	9.2	9.2	9.2	9.2	9.2					
Thrust	lb	TTHRUS	2150	2150	2150	2150	2150					
Torque	lb-ft	TTORQ	795	795	795	795	795					
Coning angle	deg	TBETA	0	0	0	0	0					

(a) Typical value is 1.8 to 2.0 for most multi-blade rotor systems
(b) Use a value of 0.8 for normal rotor systems
(c) Typical value is 1.9 to 2.2 for most rotors

CASE NUMBER: Sample #1 DESCRIPTION: Checkout case for subroutine ROTOR

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

Sample Case 1
Checkout Case for Rotor
Subroutine

	1	WORD COUNT FIELD	LOCATION FIELD	DATA FIELD 1	DATA FIELD 2	DATA FIELD 3	DATA FIELD 4	DATA FIELD 5
1		5	1	1117.	5.	1.	2.	0.8
2		5	6	6.	29.4	228.	0.	15.
3		5	11	28200.	117000.	2.	2.5	0.5
4		5	16	6.	6.5	1030.	0.	0.2
5		3	21	2150.	795.	0.		
6		5	30	2.	1.	2.	1.	2.
7		3	80	1000.	0.	2000.		
8		3	130	0.	0.	1240.		
9		4	180	0.	60.	0.	30.	
10		4	230	0.	500.	0.	500.	
11		5	280	75.	100.	150.	175.	175.
12		5	330	15.	5.	10.	10.	20.
13		5	380	2500.	500.	0.	0.	1.
14		1	385	1.				
15	-	5	417	1.	0.	0.	0.	0.
16	-	1	9	2.				
17	-	1	9	5.				
18	-	1	9	5.				
19	-	1	9	5.				
20								
21								
22								
23								
24								
25								

Sample Case 1 (Rotor)

```
*******************************************************************************************************************

                                                LOADER CARD INPUT

                  COLUMN 2 4 6           19          31          43          55          67
                         * *              *           *           *           *           *
                         * *              *           *           *           *           *
                         5  1    1117.          5.          1.          2.         0.8
                         5  6       6.       29.4        228.          0.         15.
                         5 11   28200.    117000.          2.         2.5         0.8
                         5 16       6.        6.5       1030.          0.         9.2
                         3 21    2150.       795.          0.
                         5 30       2.         1.          2.          1.          2.
                         3 80    1000.         0.       2000.
                         3 130      0.         0.       1240.
                         4 180      0.        60.          0.         30.
                         4 230      0.       500.          0.        500.
                         5 280     75.       100.        150.        175.        175.
                         5 330     15.         5.         10.         10.         20.
                         5 380   2500.       500.          0.          0.          1.
                         1 385      1.
                        -5 417      1.         0.          0.          0.          0.

*******************************************************************************************************************



************************INPUT VARIABLES************************
***********************FLIGHT SEGMENT  1************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR = 1.0 RP =  .0 FANS =  .0 RJ =  .0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K = 2.00   BIGB =  6.00   BIGR =  29.40   OMEGN =  228.00   THRUS =  28200.0
 ETA =  .80   BETA =  2.00   CHORD =  15.00   SID   =     .00   TORQ  = 117000.0

TAIL ROTOR VARIABLES :

-------------------
 SM-K = 2.50   BIGB =  6.00   BIGR =   6.50   OMEGN = 1030.00   THRUS =   2150.0
 ETA =  .80   BETA =   .00   CHORD =   9.20   SID   =     .00   TORQ  =    795.0
```

```
PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =      .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT =   .00  B    =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=    .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =   .0 ALFA=  .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =    500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK   YBREAK   INCMAX
 ---  ------  ------  --------  --------  ------
   1   15.00   75.00  1000.00       .00     13
   2    5.00  100.00  1433.02    250.02     19
   3   10.00  150.00  2000.00   1232.14     26
   4   10.00  175.00  2066.98   1482.15     28
   5   20.00  175.00      .00       .00      0

*********************************************************************************************************************************************************

                                                    LOADER CARD INPUT

                        COLUMN 2 4 6            19            31            43            55            67
                                 *   *            *             *             *             *             *
                                 *   *            *             *             *             *             *
                                -1   9       2.

*********************************************************************************************************************************************************
```

```
************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  2************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR = 1.0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K = 2.00   BIGB =  6.00   BIGR =  29.40   OMEGN =  228.00   THRUS =  28200.0
 ETA =  .80   BETA =  2.00   CHORD =  15.00   SID   =    2.00   TORQ  = 117000.0

TAIL ROTOR VARIABLES :

-------------------
 SM-K = 2.50   BIGB =  6.00   BIGR =   6.50   OMEGN = 1030.00   THRUS =   2150.0
 ETA =  .80   BETA =   .00   CHORD =   9.20   SID   =     .00   TORQ  =    795.0

PROPELLER VARIABLES :

------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00
```

```
 SEG   THETA   SPEED   XBREAK   YBREAK   INCMAX
 ---  ------  ------  --------  -------  ------
  1    15.00   75.00   1000.00      .00    13
  2     5.00  100.00   1433.02   250.02    19
  3    10.00  150.00   2000.00  1232.14    26
  4    10.00  175.00   2066.98  1482.15    28
  5    20.00  175.00       .00      .00     0

**************************************************************************************************************************

                                                 LOADER CARD INPUT

                  COLUMN 2 4 6            19          31          43          55          67
                         * *              *           *           *           *           *
                         * *              *           *           *           *           *
                        -1 9      5.

**************************************************************************************************************************


************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  3************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR = 1.0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K = 2.00   BIGB =  6.00   BIGR =  29.40   OMEGN =  228.00   THRUS =  28200.0
 ETA =  .80   BETA =  2.00   CHORD =  15.00   SID   =    5.00   TORQ  = 117000.0

TAIL ROTOR VARIABLES :

-------------------
 SM-K = 2.50   BIGB =  6.00   BIGR =   6.50   OMEGN = 1030.00   THRUS =   2150.0
 ETA =  .80   BETA =   .00   CHORD =   9.20   SID   =     .00   TORQ  =    795.0

PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00
```

```
ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT =   .00  B    =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=    .00  ALFA =   .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =   .0 ALFA=  .0

FIELD POINT VARIALBES :

---------------------
 AZERO =    .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK   YBREAK   INCMAX
 ---  ------  ------  -------  -------  ------
   1   15.00   75.00  1000.00      .00     13
   2    5.00  100.00  1433.02   250.02     19
   3   10.00  150.00  2000.00  1232.14     26
   4   10.00  175.00  2066.98  1482.15     28
   5   20.00  175.00      .00      .00      0

************************************************************************************************

                                   LOADER CARD INPUT

                 COLUMN 2 4 6            19          31          43          55          67
                        * *              *           *           *           *           *
                        * *              *           *           *           *           *
                       -1 9      5.

************************************************************************************************


*************************INPUT VARIABLES*************************
************************FLIGHT SEGMENT  4*************************

COMMON VARIABLES :
```

```
---------------
SAZ =  1117.00  SEG =  5.00  ROTR = 1.0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0
MAIN ROTOR VARIABLES :

-------------------
 SM-K = 2.00   BIGB =  6.00   BIGR =  29.40   OMEGN =  228.00   THRUS =  28200.0
 ETA =  .80    BETA =  2.00   CHORD =  15.00   SID   =    5.00   TORQ  = 117000.0
TAIL ROTOR VARIABLES :

-------------------
 SM-K = 2.50   BIGB =  6.00   BIGR =   6.50   OMEGN = 1030.00   THRUS =   2150.0
 ETA =  .80    BETA =   .00   CHORD =   9.20   SID   =     .00   TORQ  =    795.0
PROPELLER VARIABLES :

-------------------
POWER =    .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00
ENGINE VARIABLES :

----------------
 POWER =    .0  SLEVEL =  .0  NUMENG =  .0
FAN VARIABLES :

------------
 DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =    .00
JET VARIABLES :

------------
 THRUST =     .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =   .0 ALFA=   .0
FIELD POINT VARIALBES :

--------------------
 AZERO =    .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC =  .00  THMAXO =   .00  ANMFPT = 1.00
 SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
 ---  ------  ------  -------   -------   -----
   1   15.00   75.00  1000.00       .00     13
   2    5.00  100.00  1433.02    250.02     19
   3   10.00  150.00  2000.00   1232.14     26
   4   10.00  175.00  2066.98   1482.15     28
   5   20.00  175.00      .00       .00      0
```

```
**************************************************************************************************************************
                                                 LOADER CARD INPUT
                  COLUMN 2 4 6            19          31          43          55          67
                         *   *             *           *           *           *           *
                         *   *             *           *           *           *           *

                        -1   9        5.

**************************************************************************************************************************



************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  5************************
COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR = 1.0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0
MAIN ROTOR VARIABLES :

--------------------
 SM-K = 2.00   BIGB =  6.00   BIGR =  29.40   OMEGN =  228.00   THRUS =  28200.0
 ETA =  .80   BETA =  2.00   CHORD =  15.00   SID   =    5.00   TORQ  = 117000.0
TAIL ROTOR VARIABLES :

--------------------
 SM-K = 2.50   BIGB =  6.00   BIGR =   6.50   OMEGN = 1030.00   THRUS =   2150.0
 ETA =  .80   BETA =   .00   CHORD =   9.20   SID   =     .00   TORQ  =    795.0
PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00
ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0
FAN VARIABLES :
```

```
-------------
 DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

--------------------
 AZERO =      .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK   YBREAK  INCMAX
 ---  ------  ------  -------  -------  ------
   1   15.00   75.00  1000.00      .00    13
   2    5.00  100.00  1433.02   250.02    19
   3   10.00  150.00  2000.00  1232.14    26
   4   10.00  175.00  2066.98  1482.15    28
   5   20.00  175.00      .00      .00     0

                   CHECKOUT CASE FOR V/STOL VEHICLE NOISE PREDICTION PROGRAM
                   -------------------------------------------------------

 TINC= 1.00  XPRZRO=   2500.00  YPRZRO=    500.00  AZERO=     .00  THMAXO=    .00

   SEG    PATH   ALFN    VF1     XMAX    YMAX  RADIUS  PHIMAX

 ---------------------------------------------------------------
       1       2.0   15.0   75.0 1000.0      .0      .0      .0
       2       1.0    5.0  100.0 1433.0   250.0   500.0    60.0
       3       2.0   10.0  150.0 2000.0  1232.1      .0      .0
       4       1.0   10.0  175.0 2067.0  1482.1   500.0    30.0
       5       2.0   20.0  175.0     .0      .0      .0      .0

   RANGE   EPNL    PNLTM    PNL     DBA       XPR
 ------------------------------------------------------
   913.6   83.77   84.17   84.17   72.38    2500.0
```

```
PNLT TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
    66.07     66.50     66.95     67.75     67.71     68.23     68.77     69.64     70.54     71.18
    71.84     72.53     73.47     73.77     74.85     75.76     76.81     78.25     79.54     80.80
    82.05     83.15     83.85     84.17     84.12     83.64     83.00     81.49     79.52     78.07
    76.78     75.34     74.23     73.19       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00

PNL TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
    65.52     65.97     66.43     67.25     67.71     68.23     68.77     69.64     70.54     71.18
    71.84     72.53     73.47     73.77     74.85     75.76     76.81     78.25     79.54     80.80
    82.05     83.15     83.85     84.17     84.12     83.64     83.00     81.49     79.52     78.07
    76.78     75.34     74.23     73.19       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00

DBA TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
    56.05     56.47     56.90     57.36     57.80     58.29     58.81     59.35     59.92     60.51
    61.13     61.77     62.44     62.62     63.48     64.39     65.34     66.67     67.85     68.90
    70.09     71.24     71.94     72.33     72.38     71.96     71.45     70.12     68.55     67.21
    66.03     64.84     63.79     62.82       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
      .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
```

FORM 1
V/STOL NOISE MODEL

CASE: Sample #2 DESCRIPTION: Checkout case for subroutine PROP

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) ϕ max (deg)	RADIUS (ft)	V_f (ft/sec)	α n (deg)
1	2.	1000.	0.	-	-	75.	15.
2	1.	-	-	60.	500.	100.	5.
3	2.	2000.	1240.	-	-	150.	10.
4	1.	-	-	30.	500.	175.	10.
5	2.	-	-	-	-	175.	20.
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

(a) Flight path type: 1=helical, 2=straight
(b) Positive for counterclockwise, negative for clockwise turns

V/STOL NOISE MODEL

FORM 2

CASE: Sample #2

FLIGHT SEGMENT NUMBER: 1

DESCRIPTION: Checkout for Subroutine PROP
Since parameters do not change from segment
to segment only dummy inputs will be
provided for segments 2- 5 (see coding sheet)

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ	1146.	80	XMAX(1)	1000.	235	RADIUS(6)		390	DIAH	
2	SEG	5.	81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE	1.	82	XMAX(3)	2000.	237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)	75.	397	SIGPHI	
9	RSID		88	XMAX(9)		281	VF1(2)	100.	398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)	150.	399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)	175.	400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)	175.	401	XMXTIP	
13	RBETA		130	YMAX(1)	0.	285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)	1240.	287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)	15.	409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)	5.	410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)	10.	411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)	10.	412	PSUBA	
24	PPWR	3260.	179	YMAX(50)		334	ALF(5)	20.	413	TSUBA	
25	DIA	13.5	180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB	4.	181	PHMAX(2)	60.	336	ALF(7)		415	TSUBJO	
27	RPMP	1020.	182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP	4.	183	PHMAX(4)	30.	338	ALF(9)		417	ROTR	0.
29	CHORDP	.75	184	PHMAX(5)		339	ALF(10)		418	RP	1.
30	PATH(1)	2.	185	PHMAX(6)		↓	↓		419	FANS	0.
31	PATH(2)	1.	186	PHMAX(7)		379	ALF(50)		420	RJ	0.
32	PATH(3)	2.	187	PHMAX(8)		380	XPRZRO	2500.	421	E	0.
33	PATH(4)	1.	188	PHMAX(9)		381	YPRZRO	500.			
34	PATH(5)	2.	189	PHMAX(10)		382	THMAXO	0.			
35	PATH(6)		↓	↓		383	AZERO	0.			
36	PATH(7)		229	PHMAX(50)		384	TINC	1.			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT	1.			
38	PATH(9)		231	RADIUS(2)	500.	386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)	500.	388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

FORM 4
V/STOL NOISE MODEL
Propeller Parameters

VARIABLE		PROG NAME	FLIGHT PATH SEGMENT NUMBERS									
			1	2	3	4	5	6	7	8	9	10
Shaft power	hp	PPWR	3260	3260	3260	3260	3260					
Diameter	ft	DIA	13.5	13.5	13.5	13.5	13.5					
Number of blades		BIGB	4	4	4	4	4					
Rotational speed	rpm	RPMP	1020	1020	1020	1020	1020					
Number of propellers		ANMPRP	4	4	4	4	4					
Mean blade chord	ft	CHORDP	0.75	0.75	0.75	0.75	0.75					

CASE NUMBER: Sample #2

DESCRIPTION: Checkout case for Subroutine PROP

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

Sample Case 2
Checkout case for subroutine PROP

	WORD COUNT FIELD 1–2	LOCATION FIELD 3–6	DATA FIELD 1 7–18	DATA FIELD 2 19–30	DATA FIELD 3 31–42	DATA FIELD 4 43–54	DATA FIELD 5 55–66
1	3	1	1146.	5.	1.		
2	5	24	3260.	13.5	4.	1020.	4.
3	5	29	0.75	2.	1.	2.	1.
4	1	34	2.				
5	3	80	1000.	0.	2000.		
6	3	130	0.	0.	1240.		
7	4	180	0.	60.	0.	30.	
8	4	230	0.	500.	0.	500.	
9	5	280	75.	100.	150.	175.	175.
10	3	330	15.	5.	10.	10.	20.
11	5	380	2500.	500.	0.	0.	1.
12	1	385	1.				
13	-5	417	0.	1.	0.	0.	0.
14	-1	3	1.				
15	-1	3	1.				
16	-1	3	1.				
17	-1	3	1.				
18							
19							
20							
21							
22							
23							
24							
25							

Sample Case 2 (Prop)

```
*****************************************************************************************************************
                                   LOADER CARD INPUT
         COLUMN 2  4  6            19          31          43          55          67
                *  *               *           *           *           *           *
                *  *               *           *           *           *           *
                3  1    1146.         5.          1.
                5 24    3260.        13.5         4.       1020.          4.
                5 29        .75       2.          1.          2.          1.
                1 34       2.
                3 80    1000.         0.       2000.
                3 130      0.         0.       1240.
                4 180      0.        60.          0.         30.
                4 230      0.       500.          0.        500.
                5 280     75.       100.        150.        175.        175.
                5 330     15.         5.         10.         10.         20.
                5 380   2500.       500.          0.          0.          1.
                1 385      1.
               -5 417      0.         1.          0.          0.          0.

*****************************************************************************************************************


************************INPUT VARIABLES************************
***********************FLIGHT SEGMENT  1************************

COMMON VARIABLES :

----------------
SAZ =  1146.00  SEG =  5.00  ROTR =  .0 RP = 1.0 FANS =  .0 RJ =  .0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00    BETA =   .00   CHORD =   .00   SID   =     .00   TORQ  =      .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00    BETA =   .00   CHORD =   .00   SID   =     .00   TORQ  =      .0
```

```
PROPELLER VARIABLES :
-------------------
POWER = 3260.0  DIA =  13.50  BIGB =  4.0  RPM = 1020.00  NUMPRP =  4.0  CHORD =    .75

ENGINE VARIABLES :
----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

 FAN VARIABLES :
 -------------
  DIAT =   .00  B    =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
  DIAH =   .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
  CHORD=   .00  COMB=    .00  ALFA =    .00  FN =     .00

-JET VARIABLES :
 -------------
  THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

 FIELD POINT VARIALBES :
 ---------------------
  AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

  SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
  ---  ------  ------  --------  --------  ------
    1   15.00   75.00   1000.00       .00     13
    2    5.00  100.00   1433.02    250.02     19
    3   10.00  150.00   2000.00   1232.14     26
    4   10.00  175.00   2066.98   1482.15     28
    5   20.00  175.00       .00       .00      0

 ********************************************************************************************

                                       LOADER CARD INPUT

                 COLUMN 2 4 6          19         31         43         55         67
                        *   *          *          *          *          *          *
                        *   *          *          *          *          *          *
                       -1   3      1,

 ********************************************************************************************
```

```
*************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  2*************************
COMMON VARIABLES :

---------------
SAZ =  1146.00  SEG =  5.00  ROTR =  .0 RP = 1.0 FANS =  .0 RJ =  .0 E =  .0 ANMFPT =  1.0
MAIN ROTOR VARIABLES :

------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0
TAIL ROTOR VARIABLES :

------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0
PROPELLER VARIABLES :

------------------
POWER = 3260.0  DIA =  13.50  BIGB =  4.0  RPM = 1020.00  NUMPRP =  4.0  CHORD =    .75
ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0
FAN VARIABLES :

-------------
 DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00
JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =   .0  TSUBJO =    .0 ALFA=   .0
FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00
```

```
SEG   THETA   SPEED   XBREAK   YBREAK   INCMAX
---  ------  ------  -------- --------  ------
  1   15.00   75.00  1000.00      .00     13
  2    5.00  100.00  1433.02   250.02     19
  3   10.00  150.00  2000.00  1232.14     26
  4   10.00  175.00  2066.98  1482.15     28
  5   20.00  175.00      .00      .00      0

*****************************************************************************************************

                                        LOADER CARD INPUT

                  COLUMN 2 4 6           19          31          43          55          67
                         *   *            *           *           *           *           *
                         *   *            *           *           *           *           *
                        -1   3       1.

*****************************************************************************************************


 ************************INPUT VARIABLES************************
 ************************FLIGHT SEGMENT  3************************

 COMMON VARIABLES :

 ---------------
 SAZ =  1146.00  SEG =  5.00  ROTR =  .0 RP = 1.0 FANS =  .0 RJ =  .0 E =  .0 ANMFPT =  1.0

 MAIN ROTOR VARIABLES :

 --------------------
  SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
  ETA =  .00    BETA =  .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

 TAIL ROTOR VARIABLES :

 --------------------
  SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
  ETA =  .00    BETA =  .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

 PROPELLER VARIABLES :

 -------------------
 POWER = 3260.0  DIA =  13.50  BIGB =  4.0  RPM = 1020.00  NUMPRP =  4.0  CHORD =    .75
```

```
ENGINE VARIABLES :

----------------
 POWER =      .0  SLEVEL =  .0   NUMENG =  .0

FAN VARIABLES :

------------
 DIAT =   .00  B    =   .00  DDDXT =    .00  RS =      .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR  =   .00  DDDXH =    .00  DL =      .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=    .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =       .0  WTFL =    .00  AREAJ =    .00  PSUBA =    .00  TSUBA =    .00  TSUBJ =     .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

-------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA    SPEED    XBREAK     YBREAK    INCMAX
 ---   ------   ------   --------   --------   ------
   1   15.00    75.00   1000.00       .00      13
   2    5.00   100.00   1433.02    250.02      19
   3   10.00   150.00   2000.00   1232.14      26
   4   10.00   175.00   2066.98   1482.15      28

   5   20.00   175.00       .00       .00       0

*****************************************************************************************************************

                                       LOADER CARD INPUT

                   COLUMN 2 4 6           19          31          43          55          67
                          *   *           *           *           *           *           *
                          *   *           *           *           *           *           *
                         -1   3     1.

*****************************************************************************************************************


************************INPUT VARIABLES************************
***********************FLIGHT SEGMENT  4***********************

COMMON VARIABLES :
```

```
--------------
SAZ =  1146.00  SEG =  5.00  ROTR =  .0 RP = 1.0 FANS =  .0 RJ =  .0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =    .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =    .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

TAIL ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =    .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =    .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

PROPELLER VARIABLES :

-------------------
POWER = 3260.0  DIA =  13.50  BIGB =  4.0  RPM = 1020.00  NUMPRP =  4.0  CHORD =    .75

ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

------------
 DIAT =   .00  B    =   .00  DDDXT =    .00  RS =      .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =     .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =      .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00

JET VARIABLES :

------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =   .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

-------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK   YBREAK   INCMAX
 ---  ------  ------  -------  -------  ------
   1   15.00   75.00  1000.00      .00     13
   2    5.00  100.00  1433.02   250.02     19
   3   10.00  150.00  2000.00  1232.14     26
   4   10.00  175.00  2066.98  1482.15     28
   5   20.00  175.00      .00      .00      0
```

```
                 CHECKOUT CASE FOR V/STOL VEHICLE NOISE PREDICTION PROGRAM
                 ---------------------------------------------------------

TINC= 1.00  XPRZRO=   2500.00  YPRZRO=    500.00  AZERO=    .00  THMAXO=    .00

  SEG    PATH   ALFN    VF1    XMAX    YMAX  RADIUS  PHIMAX
------------------------------------------------------------
    1     2.0   15.0    75.0 1000.0      .0      .0      .0
    2     1.0    5.0   100.0 1433.0   250.0   500.0    60.0
    3     2.0   10.0   150.0 2000.0  1232.1      .0      .0
    4     1.0   10.0   175.0 2067.0  1482.1   500.0    30.0
    5     2.0   20.0   175.0     .0      .0      .0      .0

  RANGE   EPNL   PNLTM    PNL     DBA       XPR
------------------------------------------------
  913.6   95.36  96.46   93.13   78.61    2500.0

PNLT TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
    79.65      80.20      80.60      81.00      81.42      82.01      82.45      82.91      83.38      84.01
    84.65      85.17      85.72      86.04      85.31      86.17      88.38      90.52      92.72      93.98
    94.86      95.56      96.09      96.40      96.46      96.29      94.97      86.15        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
```

```
PNL TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
    76.31      76.87      77.26      77.67      78.09      78.67      79.12      79.58      80.05      80.68
    81.31      81.84      82.39      82.71      81.97      82.84      85.05      87.19      89.39      90.64
    91.52      92.23      92.76      93.06      93.13      92.96      91.64      82.82        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00

DBA TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
    63.57      63.89      64.22      64.57      64.92      65.28      65.66      66.04      66.44      66.85
    67.28      67.72      68.17      68.43      67.79      68.42      70.46      72.64      74.90      76.15
    76.96      77.67      78.21      78.53      78.61      78.47      77.17      68.35        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
      .00        .00        .00        .00        .00        .00        .00        .00        .00        .00
```

FORM 1
V/STOL NOISE MODEL

CASE: Sample #3

DESCRIPTION: Checkout Case for Subroutine FAN

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) ϕ max (deg)	RADIUS (ft)	V_f (ft/sec)	α_n (deg)
1	2.	1000.	0.	-	-	75.	15.
2	1.	-	-	60.	500.	100.	5.
3	2.	2000.	1240.	-	-	150.	10.
4	1.	-	-	30.	500.	175.	10.
5	2.	-	-	-	-	175.	20.
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

(a) Flight path type: 1 = helical, 2 = straight
(b) Positive for counterclockwise, negative for clockwise turns

V/STOL NOISE MODEL

FORM 2

CASE: Sample #3

FLIGHT SEGMENT NUMBER: 1

DESCRIPTION: Checkout case for subroutine FAN
Since parameters do not change from segment to segment only dummy inputs will be provided for segments 2 - 5 (see coding sheet).

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ	1080.	80	XMAX(1)	1000.	235	RADIUS(6)		390	DIAH	20.2
2	SEG	5.	81	XMAX(2)		236	RADIUS(7)		391	B	46.
3	FLTYPE	1.	82	XMAX(3)	2000.	237	RADIUS(8)		392	BPR	5
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	4.38
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	5
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	.44
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	-12.78
8	ROMEGN		87	XMAX(8)		280	VF1(1)	75.	397	SIGPHI	.02
9	RSID		88	XMAX(9)		281	VF1(2)	100.	398	DL	3.
10	RCHORD		89	XMAX(10)		282	VF1(3)	150.	399	RPM	4690
11	RTHRUS		↓	↓		283	VF1(4)	175.	400	SPAF	30.6
12	RTORQ		129	XMAX(50)		284	VF1(5)	175.	401	XMXTIP	.331
13	RBETA		130	YMAX(1)	0.	285	VF1(6)		402	PR	1.317
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	.454
15	TETA		132	YMAX(3)	1240.	287	VF1(8)		404	TT2	21.
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	29.90
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	0.
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	1.
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	1.
20	TCHORD		137	YMAX(8)		330	ALF(1)	15.	409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)	5.	410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)	10.	411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)	10.	412	PSUBA	
24	PPWR		179	YMAX(50)		334	ALF(5)	20.	413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)	60.	336	ALF(7)		415	TSUBJO	
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)	30.	338	ALF(9)		417	ROTR	0.
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	0.
30	PATH(1)	2.	185	PHMAX(6)		↓	↓		419	FANS	1.
31	PATH(2)	1.	186	PHMAX(7)		379	ALF(50)		420	RJ	0.
32	PATH(3)	2.	187	PHMAX(8)		380	XPRZRO	2500.	421	E	0.
33	PATH(4)	1.	188	PHMAX(9)		381	YPRZRO	500.			
34	PATH(5)	2.	189	PHMAX(10)		382	THMAXO	0.			
35	PATH(6)		↓	↓		383	AZERO	0.			
36	PATH(7)		229	PHMAX(50)		384	TINC	2.			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT	1.			
38	PATH(9)		231	RADIUS(2)	500.	386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)	500.	388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT	52.3			

FORM 7

V/STOL NOISE MODEL

FAN Engine Parameters

VARIABLE	PROG NAME	FLIGHT PATH SEGMENT NUMBER									
		1	2	3	4	5	6	7	8	9	10
Tip diameter in	DIAT	52.3	52.3	52.3	52.3	52.3					
Hub diameter in	DIAH	20.2	20.2	20.2	20.2	20.2					
Number of blades	B	46	46	46	46	46					
Bypass ratio	BPR	5	5	5	5	5					
Blade tip chord in	CHORD	4.38	4.38	4.38	4.38	4.38					
Tip diameter gradient(a) in/in	DDDXT	0.5	0.5	0.5	0.5	0.5					
Hub diameter gradient(a) in/in	DDDXH	0.44	0.44	0.44	0.44	0.44					
Blade suction surface radius of curvature(a) in	RS	-12.78	-12.78	-12.78	-12.78	-12.78					
Standard deviation of blade tip metal angle(a) rad	SIGPHI	.02	.02	.02	.02	.02					
Inlet duct length ft	DL	3	3	3	3	3					
Rotational speed rpm	RPM	4690	4690	4690	4690	4690					
Specific airflow lb/sec/ft^2	SPAF	30.6	30.6	30.6	30.6	30.6					
Tip axial Mach number	XMXTIP	.331	.331	.331	.331	.331					
Pressure ratio	PR	1.317	1.317	1.317	1.317	1.317					
Blade diffusion factor DF	DF	.454	.454	.454	.454	.454					
Ambient inlet temperature F	TT2	21.	21.	21.	21.	21.					
Ambient inlet pressure in Hg	PT2	29.9	29.9	29.9	29.9	29.9					
Inclination to horizontal (+90^o = vertical) deg	ALFA	0	0	0	0	0					
Number of fans	FN	1	1	1	1	1					
Control factor to skip calculation of combination tones (0 = no)	COMB	1	1	1	1	1					

(a) Need not be entered if COMB = 0

CASE NUMBER: Sample #3

DESCRIPTION: Checkout Case for Subroutine FAN

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

Sample case 3
Checkout for subroutine
FAN

		WORD COUNT FIELD	LOCATION FIELD	DATA FIELD 1	DATA FIELD 2	DATA FIELD 3	DATA FIELD 4	DATA FIELD 5
1		3	1	1080.	5.	1.		
2		5	30	2.	1.	2.	1.	2.
3		3	80	1000.	0.	1000.		
4		3	130	0.	0.	1240.		
5		4	180	0.	60.	0.	30.	
6		4	230	0.	500.	0.	500.	
7		5	280	75.	100.	150.	175.	175.
8		5	330	15.	5.	10.	10.	20.
9		5	380	2500.	500.	0.	0.	2.
10		1	385	1.				
11		5	389	52.3	20.2	46.	5.	4.38
12		5	394	0.5	0.44	-12.779	0.02	3.
13		5	399	4690.	30.6	0.331	1.317	0.454
14		5	404	21.	29.9	0.	1.	1.
15	-	5	417	0.	0.	1.	0.	0.
16	-	1	3	1.				
17	-	1	3	1.				
18	-	1	3	1.				
19	-	1	3	1.				
20								
21								
22								
23								
24								
25								

Sample Case 3 (Fan)

```
**************************************************************************************************
                                  LOADER CARD INPUT

                COLUMN 2 4 6            19          31          43          55          67
                       *   *            *           *           *           *           *
                       *   *            *           *           *           *           *
                       3   1     1080.          5.          1.
                       5  30       2.           1.          2.          1.          2.
                       3  80     1000.          0.       2000.
                       3 130       0.           0.       1240.
                       4 180       0.          60.          0.         30.
                       4 230       0.         500.          0.        500.
                       5 280      75.         100.        150.        175.        175.
                       5 330      15.           5.         10.         10.         20.
                       5 380    2500.         500.          0.          0.          2.
                       1 385       1.
                       5 389      52.3        20.2         46.          5.          4.3A
                       5 394       0.5          .44    -12.779         .02         3.
                       5 399    4690.          30.6        .331       1.317        .454
                       5 404      21.          29.9         0.         1.0         1.0
                      -5 417       0.           0.          1.          0.          0.

**************************************************************************************************


************************INPUT VARIABLES************************
***********************FLIGHT SEGMENT  1***********************
COMMON VARIABLES :

----------------
SAZ =  1080.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS = 1.0 RJ =  .0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0
```

```
PROPELLER VARIABLES :

-------------------
POWER =      .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

-----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT = 52.30  B   = 46.00  DDDXT =    .50  RS =  -12.78  TT2 = 21.00  DF =   .45  SIGPHI =  .02  RPM =4690.00
 DIAH = 20.20  BPR =  5.00  DDDXH =    .44  DL =    3.00  PT2 = 29.90  PR =  1.32  XMXTIP =  .33  SPAF =  30.60
 CHORD=  4.38  COMB=  1.00  ALFA =    .00  FN =    1.00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 2.00  THMAXO =    .00  ANMFPT = 1.00

 SEG   THETA    SPEED    XBREAK    YBREAK   INCMAX
 ---   ------   ------   -------   -------  ------
   1   15.00    75.00   1000.00       .00      6
   2    5.00   100.00   1433.02    250.02      9
   3   10.00   150.00   2000.00   1232.14     13
   4   10.00   175.00   2066.98   1482.15     14
   5   20.00   175.00       .00       .00      0

************************************************************************************************************

                                                LOADER CARD INPUT

                    COLUMN 2 4 6            19          31          43          55          67
                           * *              *           *           *           *           *
                           * *              *           *           *           *           *
                          -1 3       1.

************************************************************************************************************
```

```
************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  2************************

COMMON VARIABLES :

---------------
SAZ =  1080.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS = 1.0 RJ =  .0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =    .00   THRUS =     .0

 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =    .00   TORQ  =     .0

TAIL ROTOR VARIABLES :

------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =    .00   THRUS =     .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =    .00   TORQ  =     .0

PROPELLER VARIABLES :

-----------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

---------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

------------
 DIAT = 52.30  B    = 46.00  DDDXT =    .50  RS =  -12.78  TT2 = 21.00  DF =   .45  SIGPHI =  .02  RPM =4690.00
 DIAH = 20.20  BPR =  5.00  DDDXH =    .44  DL =    3.00  PT2 = 29.90  PR =  1.32  XMXTIP =  .33  SPAF =  30.60
 CHORD=  4.38  COMB=  1.00  ALFA =   .00  FN =    1.00

JET VARIABLES :

------------
 THRUST =     .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

-------------------
 AZERO =    .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 2.00  THMAXO =   .00  ANMFPT = 1.00
```

```
SEG   THETA   SPEED    XBREAK    YBREAK   INCMAX
---  ------  ------   -------   -------   ------
  1   15.00   75.00   1000.00       .00      6
  2    5.00  100.00   1433.02    250.02      9
  3   10.00  150.00   2000.00   1232.14     13
  4   10.00  175.00   2066.98   1482.15     14
  5   20.00  175.00       .00       .00      0

****************************************************************************************************
                                  LOADER CARD INPUT

               COLUMN 2 4 6            19          31          43          55          67
                        *   *           *           *           *           *           *
                        *   *           *           *           *           *           *
                       -1   3      1.

****************************************************************************************************

************************INPUT VARIABLES************************
************************FLIGHT SEGMENT  3************************
COMMON VARIABLES :

---------------
SAZ =  1080.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS = 1.0 RJ =  .0 E =  .0 ANMFPT =  1.0
MAIN ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =     .00   OMEGN =      .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =     .00   SID   =      .00   TORQ  =       .0
TAIL ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =     .00   OMEGN =      .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =     .00   SID   =      .00   TORQ  =       .0
PROPELLER VARIABLES :

------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =   .00
```

```
ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT = 52.30  B   = 46.00  DDDXT =     .50  RS =  -12.78  TT2 = 21.00  DF =   .45  SIGPHI =  .02  RPM =4690.00
 DIAH = 20.20  BPR =  5.00  DDDXH =     .44  DL =    3.00  PT2 = 29.90  PR =  1.32  XMXTIP =  .33  SPAF =  30.60
 CHORD=  4.38  COMB=  1.00  ALFA =     .00  FN =    1.00
JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

-------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 2.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA    SPEED    XBREAK    YBREAK   INCMAX
 ---  ------   ------   --------  --------  ------
   1   15.00    75.00   1000.00       .00      6
   2    5.00   100.00   1433.02    250.02      9

   3   10.00   150.00   2000.00   1232.14     13
   4   10.00   175.00   2066.98   1482.15     14
   5   20.00   175.00       .00       .00      0

*************************************************************************************************************************

                                               LOADER CARD INPUT

                  COLUMN 2 4 6            19            31            43            55            67
                         * *              *             *             *             *             *
                         * *              *             *             *             *             *
                        -1 3       1.


*************************************************************************************************************************



************************INPUT VARIABLES*************************
************************FLIGHT SEGMENT  4************************

COMMON VARIABLES :
```

```
---------------
SAZ =  1080.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS = 1.0 RJ =  .0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT = 52.30  B   = 46.00  DDDXT =     .50  RS =  -12.78  TT2 = 21.00  DF =   .45  SIGPHI =  .02  RPM =4690.00
 DIAH = 20.20  BPR =  5.00  DDDXH =     .44  DL =    3.00  PT2 = 29.90  PR =  1.32  XMXTIP =  .33  SPAF =   30.60
 CHORD=  4.38  COMB=  1.00  ALFA =    .00  FN =     1.00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

---------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 2.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK   YBREAK   INCMAX
 ---   -----   -----   ------   ------   -----
   1   15.00   75.00  1000.00      .00      6
   2    5.00  100.00  1433.02   250.02      9
   3   10.00  150.00  2000.00  1232.14     13
   4   10.00  175.00  2066.98  1482.15     14
   5   20.00  175.00      .00      .00      0
```

```
*******************************************************************************************************
                                        LOADER CARD INPUT
                    COLUMN 2 4 6          19          31          43          55          67
                           *   *           *           *           *           *           *
                           *   *           *           *           *           *           *
                          -1   3       1.
*******************************************************************************************************


************************INPUT VARIABLES************************
***********************FLIGHT SEGMENT  5************************
COMMON VARIABLES :
-----------------
SAZ =  1080.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS = 1.0 RJ =  .0 E =  .0 ANMFPT =  1.0
MAIN ROTOR VARIAbLES :
--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0
TAIL ROTOR VARIAbLES :
--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0
PROPELLER VARIABLES :
------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =   .00
ENGINE VARIABLES :
----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0
FAN VARIABLES :
```

```
-------------
 DIAT = 52.30  B    = 46.00  DDDXT =     .50  RS =  -12.78  TT2 = 21.00  DF =    .45  SIGPHI =  .02  RPM =4690.00
 DIAH = 20.20  BPR =  5.00  DDDXH =     .44  DL =    3.00  PT2 = 29.90  PR =  1.32  XMXTIP =  .33  SPAF =  30.60
 CHORD=  4.38  COMB=  1.00  ALFA =    .00  FN =    1.00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 2.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
 ---  ------  ------  --------  --------  -----
   1   15.00   75.00   1000.00       .00     6
   2    5.00  100.00   1433.02    250.02     9
   3   10.00  150.00   2000.00   1232.14    13
   4   10.00  175.00   2066.98   1482.15    14
   5   20.00  175.00       .00       .00     0

                       CHECKOUT CASE FOR V/STOL VEHICLE NOISE PREDICTION PROGRAM
                      -----------------------------------------------------------

 TINC= 2.00  XPRZRO=   2500.00  YPRZRO=    500.00  AZERO=     .00  THMAXO=    .00

   SEG     PATH    ALFN    VF1     XMAX    YMAX  RADIUS  PHIMAX

  ------------------------------------------------------------
     1      2.0    15.0    75.0 1000.0      .0      .0      .0
     2      1.0     5.0   100.0 1433.0   250.0   500.0    60.0
     3      2.0    10.0   150.0 2000.0  1232.1      .0      .0
     4      1.0    10.0   175.0 2067.0  1482.1   500.0    30.0
     5      2.0    20.0   175.0     .0      .0      .0      .0


   RANGE    EPNL    PNLTM     PNL      DBA       XPR
  ------------------------------------------------------
   913.6   99.63   101.48   99.49    88.96    2500.0
```

```
PNLT TIME HISTORY IN 2.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   80.94    81.89    83.05    84.11    86.02    87.17    88.41    90.33    92.06   101.48
  100.05    98.42    98.92    95.73    92.26    89.38      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00

PNL TIME HISTORY IN 2.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   79.44    80.41    81.59    82.67    84.78    85.95    87.20    88.28    92.06    99.49
   98.57    97.26    98.92    94.61    91.13    88.23      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00

DBA TIME HISTORY IN 2.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   69.04    69.91    70.82    71.76    73.79    74.81    75.93    76.59    80.49    88.96
   87.46    85.81    86.98    83.44    80.34    77.63      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
     .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
```

FORM 1
V/STOL NOISE MODEL

CASE: Sample #4 DESCRIPTION: Checkout for Subroutine AJET

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) ϕ_{max} (deg)	RADIUS (ft)	V_f (ft/sec)	α_n (deg)
1	2.	1000.	0.	-	-	75.	15.
2	1.	-	-	60.	500.	100.	5.
3	2.	2000.	1240.	-	-	150.	10.
4	1.	-	-	30.	500.	175.	10.
5	2.	-	-	-	-	175.	20.
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

(a) Flight path type: 1 = helical, 2 = straight
(b) Positive for counterclockwise, negative for clockwise turns

V/STOL NOISE MODEL

FORM 2

c CASE: Sample #4

FLIGHT SEGMENT NUMBER: 1

DESCRIPTION: Checkout for subroutine AJET

Since parameters do not change from segment to segment only dummy inputs will be provided for segments 2 - 5 (see coding sheet)

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ	1117.	80	XMAX(1)	1000.	235	RADIUS(6)		390	DIAH	
2	SEG	5.	81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE	1.	82	XMAX(3)	2000.	237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)	75.	397	SIGPHI	
9	RSID		88	XMAX(9)		281	VF1(2)	100.	398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)	150.	399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)	175.	400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)	175.	401	XMXTIP	
13	RBETA		130	YMAX(1)	0.	285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)	1240.	287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)	15.	409	THRUST	10000
21	TTHRUS		138	YMAX(9)		331	ALF(2)	5.	410	WTFL	170
22	TTORQ		139	YMAX(10)		332	ALF(3)	10.	411	AREAJ	2.18
23	TBETA		↓	↓		333	ALF(4)	10.	412	PSUBA	29.92
24	PPWR		179	YMAX(50)		334	ALF(5)	20.	413	TSUBA	59.
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	1000.
26	BIGB		181	PHMAX(2)	60.	336	ALF(7)		415	TSUBJO	1000.
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ	0.
28	ANMPRP		183	PHMAX(4)	30.	338	ALF(9)		417	ROTR	0.
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	0.
30	PATH(1)	2.	185	PHMAX(6)		↓	↓		419	FANS	0.
31	PATH(2)	1.	186	PHMAX(7)		379	ALF(50)		420	RJ	1.
32	PATH(3)	2.	187	PHMAX(8)		380	XPRZRO	2500.	421	E	0.
33	PATH(4)	1.	188	PHMAX(9)		381	YPRZRO	500.			
34	PATH(5)	2.	189	PHMAX(10)		382	THMAXO	0.			
35	PATH(6)		↓	↓		383	AZERO	0.			
36	PATH(7)		229	PHMAX(50)		384	TINC	1.			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT	1.			
38	PATH(9)		231	RADIUS(2)	500.	386	HPENG				
39	PATH(10)		232	RADIUS(3)		387	SLEVEL				
↓	↓		233	RADIUS(4)	500.	388	ANENG				
79	PATH(50)		234	RADIUS(5)		389	DIAT				

FORM 6
V/STOL NOISE MODEL
Jet Engine Parameters

VARIABLE	PROG NAME	FLIGHT PATH SEGMENT NUMBER									
		1	2	3	4	5	6	7	8	9	10
Static thrust lb	THRUST	10000	10000	10000	10000	10000					
Gas weight flow lb/sec	WTFL	170	170	170	170	170					
Nozzle area sq in	AREAJ	2.18	2.18	2.18	2.18	2.18					
Ambient inlet pressure in Hg	PSUBA	29.92	29.92	29.92	29.92	29.92					
Ambient inlet temperature °F	TSUBA	59	59	59	59	59					
Tailpipe temperature °F	TSUBJ	1000	1000	1000	1000	1000					
Tailpipe temperature at SLS conditions °F	TSUBJO	1000	1000	1000	1000	1000					
Inclination of thrust axis to horizontal ($+90^{\circ}$=inlet up) deg	ALFAJ	0	0	0	0	0					

CASE NUMBER: Sample #4

DESCRIPTION: Checkout Case for Subroutine AJET

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

Sample Case 4
Checkout for subroutine
AJET

	1	2 WORD COUNT FIELD	3–6 LOCATION FIELD	DATA FIELD 1 7–18	DATA FIELD 2 19–30	DATA FIELD 3 31–42	DATA FIELD 4 43–54	DATA FIELD 5 55–66
1		3	1	1117.	5.	1.		
2		5	30	2.	1.	2.	1.	2.
3		3	80	1000.	0.	2000.		
4		3	130	0.	0.	1240.		
5		4	180	0.	60.	0.	30.	
6		4	230	0.	500.	0.	500.	
7		5	280	75.	100.	150.	175.	175.
8		5	330	15.	5.	10.	10.	20.
9		5	380	2500.	500.	0.	0.	1.
10		5	409	10000.	170.	2.18	29.92	59.
11		5	414	1000.	1000.	0.	0.	0.
12	-	3	419	0.	1.	0.		
13	-	1	3	1.				
14	-	1	3	1.				
15	-	1	3	1.				
16	-	1	3	1.				
17								
18								
19								
20								
21								
22								
23								
24								
25								

Sample Case 4 (Ajet)

```
*******************************************************************************************************

                                        LOADER CARD INPUT

                 COLUMN 2 4 6           19          31          43          55          67
                        *   *            *           *           *           *           *
                        *   *            *           *           *           *           *
                        3   1    1117.          5.          1.
                        5  30       2.          1.          2.          1.          2.
                        3  80    1000.          0.       2000.
                        3 130       0.          0.       1240.
                        4 180       0.         60.          0.         30.
                        4 230       0.        500.          0.        500.
                        5 280      75.        100.        150.        175.        175.
                        5 330      15.          5.         10.         10.         20.
                        5 380    2500.        500.          0.          0.          1.
                        1 385       1.
                        5 409   10000.        170.        2.18       29.92         59.
                        5 414    1000.       1000.          0.          0.          0.
                       -2 420       1.          0.

*******************************************************************************************************


************************INPUT VARIABLES************************
************************FLIGHT SEGMENT  1************************

COMMON VARIABLES :

----------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ = 1.0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

TAIL ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0
```

```
PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00
ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0
FAN VARIABLES :

-------------
 DIAT =   .00  B    =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =     .00
 DIAH =   .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=    .00  ALFA =    .00  FN =     .00
JET VARIABLES :

-------------
 THRUST = 10000.0  WTFL = 170.00  AREAJ =   2.18  PSUBA = 29.92  TSUBA = 59.00  TSUBJ =1000.0  TSUBJO =1000.0 ALFA=   .0
FIELD POINT VARIALBES :

--------------------
 AZERO =      .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00
 SEG   THETA   SPEED    XBREAK    YBREAK   INCMAX
 ---   ------  ------   --------  -------  ------
   1   15.00   75.00   1000.00       .00    13
   2    5.00  100.00   1433.02    250.02    19
   3   10.00  150.00   2000.00   1232.14    26
   4   10.00  175.00   2066.98   1482.15    28
   5   20.00  175.00       .00       .00     0

****************************************************************************************************************
                                            LOADER CARD INPUT

                       COLUMN 2 4 6          19          31          43          55          67
                              *   *           *           *           *           *           *
                              *   *           *           *           *           *           *
                             -1   3      1.

****************************************************************************************************************
```

```
*************************INPUT VARIABLES*************************
************************FLIGHT SEGMENT  2************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ = 1.0 E =  .0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

TAIL ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
 DIAT =   .00  B   =   .00  DDDXT =   .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =   .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST = 10000.0  WTFL = 170.00  AREAJ =   2.18  PSUBA = 29.92  TSUBA = 59.00  TSUBJ =1000.0  TSUBJO =1000.0 ALFA=   .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00
```

```
 SEG   THETA   SPEED   XBREAK   YBREAK  INCMAX
 ---  ------  ------  -------- -------- ------
   1   15.00   75.00  1000.00      .00    13
   2    5.00  100.00  1433.02   250.02    19
   3   10.00  150.00  2000.00  1232.14    26
   4   10.00  175.00  2066.98  1482.15    28
   5   20.00  175.00      .00      .00     0

****************************************************************************************************************

                                       LOADER CARD INPUT

                   COLUMN 2 4 6          19          31          43          55          67
                          *   *          *           *           *           *           *
                          *   *          *           *           *           *           *
                         -1   3     1.

****************************************************************************************************************

 ***********************INPUT VARIABLES***********************
 ***********************FLIGHT SEGMENT  3***********************
 COMMON VARIABLES :

 ---------------
 SAZ =  1117.00   SEG =  5.00   ROTR =  .0 RP =  .0 FANS =  .0 RJ = 1.0 E =  .0 ANMFPT =  1.0
 MAIN ROTOR VARIABLES :

 -------------------
  SM-K =  .00   BIGB =   .00   BIGR =     .00   OMEGN =     .00   THRUS =      .0
  ETA =  .00   BETA =   .00   CHORD =     .00   SID   =     .00   TORQ  =      .0
 TAIL ROTOR VARIABLES :

 -------------------
  SM-K =  .00   BIGB =   .00   BIGR =     .00   OMEGN =     .00   THRUS =      .0
  ETA =  .00   BETA =   .00   CHORD =     .00   SID   =     .00   TORQ  =      .0
 PROPELLER VARIABLES :

 ------------------
 POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00
```

```
ENGINE VARIABLES :

----------------
POWER =     .0  SLEVEL =  .0  NUMENG =  .0

FAN VARIABLES :

-------------
DIAT =   .00  B    =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
DIAH =   .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =   .00
CHORD=   .00  COMB=    .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
THRUST = 10000.0  WTFL = 170.00  AREAJ =   2.18  PSUBA = 29.92  TSUBA = 59.00  TSUBJ =1000.0  TSUBJO =1000.0 ALFA=   .0

FIELD POINT VARIALBES :

---------------------
AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
---  ------  ------  --------  --------  ------
 1   15.00   75.00   1000.00       .00     13
 2    5.00  100.00   1433.02    250.02     19
 3   10.00  150.00   2000.00   1232.14     26
 4   10.00  175.00   2066.98   1482.15     28
 5   20.00  175.00       .00       .00      0

*******************************************************************************************************

                                         LOADER CARD INPUT

               COLUMN 2 4 6           19          31          43          55          67
                      *   *           *           *           *           *           *
                      *   *           *           *           *           *           *
                     -1   3      1.

*******************************************************************************************************


************************INPUT VARIABLES************************
************************FLIGHT SEGMENT  4************************

COMMON VARIABLES :
```

```
---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ = 1.0 E =  .0 ANMFPT =  1.0
MAIN ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =    .00   THRUS =     .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =    .00   TORQ  =     .0
TAIL ROTOR VARIABLES :

-------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =    .00   THRUS =     .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =    .00   TORQ  =     .0
PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =   .00
ENGINE VARIABLES :

----------------
 POWER =     .0  SLEVEL =  .0  NUMENG =  .0
FAN VARIABLES :

-------------
 DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =    .00  DF =    .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =    .00  PR =    .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00
JET VARIABLES :

-------------
 THRUST = 10000.0  WTFL = 170.00  AREAJ =   2.18  PSUBA = 29.92  TSUBA = 59.00  TSUBJ =1000.0  TSUBJO =1000.0 ALFA=   .0
FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =    .00  ANMFPT = 1.00
 SEG   THETA    SPEED    XBREAK    YBREAK   INCMAX
 ---   ------   -----   -------   -------   ------
   1   15.00    75.00   1000.00       .00      13
   2    5.00   100.00   1433.02    250.02      19
   3   10.00   150.00   2000.00   1232.14      26
   4   10.00   175.00   2066.98   1482.15      28
   5   20.00   175.00       .00       .00       0
```

```
**************************************************************************************************************

                                            LOADER CARD INPUT

                        COLUMN 2 4 6          19          31          43          55          67
                               * *            *           *           *           *           *
                               * *            *           *           *           *           *
                              -1 3      1.

**************************************************************************************************************


 ************************INPUT VARIABLES************************
 ************************FLIGHT SEGMENT  5***********************

 COMMON VARIABLES :

 ----------------
 SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ = 1.0 E =  .0 ANMFPT =  1.0

 MAIN ROTOR VARIABLES :

 -------------------
  SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
  ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

 TAIL ROTOR VARIABLES :

 -------------------
  SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
  ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

 PROPELLER VARIABLES :

 -------------------
 POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

 ENGINE VARIABLES :

 ----------------
  POWER =     .0  SLEVEL =  .0  NUMENG =  .0

 FAN VARIABLES :
```

```
-------------
DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =   .00
CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00
JET VARIABLES :
-------------
THRUST = 10000.0  WTFL = 170.00  AREAJ =   2.18  PSUBA = 29.92  TSUBA = 59.00  TSUBJ =1000.0  TSUBJO =1000.0 ALFA=   .0
FIELD POINT VARIALBES :
-------------------
AZERO =     .00  XPRZRO =  2500.0  YPRZRO =    500.0  TINC = 1.00  THMAXO =    .00  ANMFPT = 1.00

SEG  THETA   SPEED   XBREAK   YBREAK   INCMAX
---  ------  ------  -------  -------  ------
 1   15.00   75.00   1000.00      .00    13
 2    5.00  100.00   1433.02   250.02    19
 3   10.00  150.00   2000.00  1232.14    26
 4   10.00  175.00   2066.98  1482.15    28
 5   20.00  175.00       .00      .00     0


                    CHECKOUT CASE FOR V/STOL VEHICLE NOISE PREDICTION PROGRAM
                    ---------------------------------------------------------

TINC= 1.00  XPRZRO=   2500.00  YPRZRO=    500.00  AZERO=     .00  THMAXO=    .00

  SEG    PATH   ALFN   VF1    XMAX    YMAX  RADIUS  PHIMAX

 ---------------------------------------------------------
    1     2.0   15.0   75.0 1000.0     .0      .0      .0
    2     1.0    5.0  100.0 1433.0  250.0   500.0    60.0
    3     2.0   10.0  150.0 2000.0 1232.1      .0      .0
    4     1.0   10.0  175.0 2067.0 1482.1   500.0    30.0
    5     2.0   20.0  175.0     .0     .0      .0      .0


 RANGE   EPNL   PNLTM    PNL    DBA      XPR
------------------------------------------------
 913.6  110.37  116.36  115.67  105.02   2500.0
```

```
PNLT TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   86.82     87.14     87.47     87.81     88.25     88.61     88.98     89.05     90.48     90.89
   91.38     91.81     92.25     92.73     92.39     93.12     94.95     96.20     97.88     98.68
   99.88    101.45    103.77    105.34    107.63    110.18    113.51    116.36    109.92    108.65
  107.48    106.40     96.23       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00

PNL TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   85.71     86.05     86.40     86.76     87.21     87.59     87.97     88.37     89.80     90.21
   90.69     91.12     91.56     92.05     91.70     92.44     94.27     95.52     97.20     97.99
   99.19    100.77    103.09    104.66    106.95    109.50    112.82    115.67    109.24    107.97
  106.80    105.71     95.54       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00

DBA TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   76.10     76.42     76.75     77.09     77.43     77.78     78.14     78.51     79.88     80.26
   80.66     81.06     81.47     81.92     81.56     82.25     83.95     85.15     86.77     87.52
   88.68     90.18     92.47     94.00     96.27     98.81    102.14    105.02     98.73     97.52
   96.42     95.40     85.45       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
```

FORM 1
V/STOL NOISE MODEL

CASE: Sample #5   DESCRIPTION: Checkout for Subroutine ENGINE

SEG	(a) PATH	X'_{max} (ft)	Y'_{max} (ft)	(b) φ_{max} (deg)	RADIUS (ft)	V_f (ft/sec)	α_n (deg)
1	2.	1000.	0.	-	-	75.	15.
2	1.	-	-	60.	500.	100.	5.
3	2.	2000.	1240.	-	-	150.	10.
4	1.	-	-	30.	500.	175.	10.
5	2.	-	-	-	-	175.	20.
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							

(a) Flight path type: 1 = helical, 2 = straight

(b) Positive for counterclockwise, negative for clockwise turns

V/STOL NOISE MODEL

FORM 2

CASE: Sample #5

FLIGHT SEGMENT NUMBER: 1

DESCRIPTION: Checkout for subroutine ENGINE

Since parameters to not change from segment to segment only dummy inputs will be provided for segments 2 - 5 (see coding sheet).

LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE	LOC	VARIABLE	VALUE
1	SAZ	1117.	80	XMAX(1)	1000.	235	RADIUS(6)		390	DIAH	
2	SEG	5.	81	XMAX(2)		236	RADIUS(7)		391	B	
3	FLTYPE	1.	82	XMAX(3)	2000.	237	RADIUS(8)		392	BPR	
4	RCASE		83	XMAX(4)		238	RADIUS(9)		393	CHORD	
5	RETA		84	XMAX(5)		239	RADIUS(10)		394	DDDXT	
6	RBIGB		85	XMAX(6)		↓	↓		395	DDDXH	
7	RBIGR		86	XMAX(7)		279	RADIUS(50)		396	RS	
8	ROMEGN		87	XMAX(8)		280	VF1(1)	75.	397	SIGPHI	
9	RSID		88	XMAX(9)		281	VF1(2)	100.	398	DL	
10	RCHORD		89	XMAX(10)		282	VF1(3)	150.	399	RPM	
11	RTHRUS		↓	↓		283	VF1(4)	175.	400	SPAF	
12	RTORQ		129	XMAX(50)		284	VF1(5)	175.	401	XMXTIP	
13	RBETA		130	YMAX(1)	0.	285	VF1(6)		402	PR	
14	TCASE		131	YMAX(2)		286	VF1(7)		403	DF	
15	TETA		132	YMAX(3)	1240.	287	VF1(8)		404	TT2	
16	TBIGB		133	YMAX(4)		288	VF1(9)		405	PT2	
17	TBIGR		134	YMAX(5)		289	VF1(10)		406	ALFA	
18	TOMEGN		135	YMAX(6)		↓	↓		407	FN	
19	TSID		136	YMAX(7)		329	VF1(50)		408	COMB	
20	TCHORD		137	YMAX(8)		330	ALF(1)	15.	409	THRUST	
21	TTHRUS		138	YMAX(9)		331	ALF(2)	5.	410	WTFL	
22	TTORQ		139	YMAX(10)		332	ALF(3)	10.	411	AREAJ	
23	TBETA		↓	↓		333	ALF(4)	10.	412	PSUBA	
24	PPWR		179	YMAX(50)		334	ALF(5)	20.	413	TSUBA	
25	DIA		180	PHMAX(1)		335	ALF(6)		414	TSUBJ	
26	BIGB		181	PHMAX(2)	60.	336	ALF(7)		415	TSUBJO	
27	RPMP		182	PHMAX(3)		337	ALF(8)		416	ALFAJ	
28	ANMPRP		183	PHMAX(4)	30.	338	ALF(9)		417	ROTR	0.
29	CHORDP		184	PHMAX(5)		339	ALF(10)		418	RP	0.
30	PATH(1)	2.	185	PHMAX(6)		↓	↓		419	FANS	0.
31	PATH(2)	1.	186	PHMAX(7)		379	ALF(50)		420	RJ	0.
32	PATH(3)	2.	187	PHMAX(8)		380	XPRZRO	2500.	421	E	1.
33	PATH(4)	1.	188	PHMAX(9)		381	YPRZRO	500.			
34	PATH(5)	2.	189	PHMAX(10)		382	THMAXO	0.			
35	PATH(6)		↓	↓		383	AZERO	0.			
36	PATH(7)		229	PHMAX(50)		384	TINC	1.			
37	PATH(8)		230	RADIUS(1)		385	ANMFPT	1.			
38	PATH(9)		231	RADIUS(2)	500.	386	HPENG	1500.			
39	PATH(10)		232	RADIUS(3)		387	SLEVEL	1.			
↓	↓		233	RADIUS(4)	500.	388	ANENG	2.			
79	PATH(50)		234	RADIUS(5)		389	DIAT				

FORM 5
V/STOL NOISE MODEL
Turboshaft Engine Noise

VARIABLE	PROG NAME	FLIGHT PATH SEGMENT NUMBER 1	2	3	4	5
Power output hp	HPENG	1500	1500	1500	1500	1500
Noise level curve (a)	SLEVEL	1	1	1	1	1
Number of engines	ANENG	2	2	2	2	2

VARIABLE	PROG NAME	FLIGHT PATH SEGMENT NUMBER 6	7	8	9	10
Power output hp	HPENG					
Noise level curve (a)	SLEVEL					
Number of engines	ANENG					

(a) 1 = average, 2 = loud

CASE NUMBER: Sample #5 DESCRIPTION: Checkout Case for Subroutine ENGINE

CODING INSTRUCTIONS

1. LOCATION FIELD MUST BE AN INTEGER NUMBER RIGHT ADJUSTED.
2. DATA FIELDS 1 THRU 5 MUST CONTAIN A DECIMAL POINT, THEREFORE AN "E" OR "F" FORMAT MUST BE USED.
3. LAST DATA CARD OF CASE MUST CONTAIN A MINUS SIGN (-) IN CC 1.

Sample Case #5

Checkout for subroutine ENGINE

	1	WORD COUNT FIELD 2	LOCATION FIELD 3–6	DATA FIELD 1 7–18	DATA FIELD 2 19–30	DATA FIELD 3 31–42	DATA FIELD 4 43–54	DATA FIELD 5 55–66
1		3	1	1117.	5.	1.		
2		5	30	2.	1.	2.	1.	2.
3		3	80	1000.	0.	2000.		
4		3	130	0.	0.	1240.		
5		4	180	0.	60.	0.	30.	
6		4	230	0.	500.	0.	500.	
7		5	280	75.	100.	150.	175.	175.
		5	330	15.	5.	10.	10.	20.
		5	380	2500.	500.	0.	0.	1.
10		4	385	1.	1500.	1.	2.	
11	-	5	417	0.	0.	0.	0.	1.
12	-	1	3	1.				
13	-	1	3	1.				
14	-	1	3	1.				
15	-	1	3	1.				
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

Sample Case 5 (Engine)

```
*******************************************************************************************************

                                                 LOADER CARD INPUT

                  COLUMN 2 4 6            19          31          43          55          67
                         *   *            *           *           *           *           *
                         *   *            *           *           *           *           *
                         3   1     1117.          5.          1.
                         5  30        2.          1.          2.          1.          2.
                         3  80     1000.          0.       2000.
                         3 130        0.          0.       1240.
                         4 180        0.         60.          0.         30.
                         4 230        0.        500.          0.        500.
                         5 280       75.        100.        150.        175.        175.
                         5 330       15.          5.         10.         10.         20.
                         5 380     2500.        500.          0.          0.          1.
                         4 385        1.       1500.          1.          2.
                        -5 417        0.          0.          0.          0.          1.

*******************************************************************************************************


************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  1************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0
```

```
PROPELLER VARIABLES :

-------------------
POWER =      .0  DIA =     .00  BIGB =    .0  RPM =      .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

----------------
 POWER = 1500.0  SLEVEL = 1.0  NUMENG = 2.0

FAN VARIABLES :

-------------
 DIAT =   .00  B    =   .00  DDDXT =     .00  RS =      .00  TT2 =    .00  DF =    .00  SIGPHI =  .00  RPM =     .00
 DIAH =   .00  BPR =    .00  DDDXH =     .00  DL =      .00  PT2 =    .00  PR =    .00  XMXTIP =  .00  SPAF =     .00
 CHORD=   .00  COMB=    .00  ALFA =     .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =    .00  TSUBA =    .00  TSUBJ =     .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

-------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =    500.0  TINC = 1.00  THMAXO =    .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
 ---  ------  ------  --------  --------  ------
   1   15.00   75.00  1000.00       .00     13
   2    5.00  100.00  1433.02    250.02     19
   3   10.00  150.00  2000.00   1232.14     26
   4   10.00  175.00  2066.98   1482.15     28
   5   20.00  175.00      .00       .00      0

**************************************************************************************************************************

                                              LOADER CARD INPUT

                        COLUMN 2 4 6           19          31          43          55          67
                               *   *            *           *           *           *           *
                               *   *            *           *           *           *           *
                              -1   3       1.

**************************************************************************************************************************
```

```
************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  2************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

TAIL ROTOR VARIABLES :

 --------------------
  SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =      .0
  ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =      .0

 PROPELLER VARIABLES :

 ------------------
 POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

 ENGINE VARIABLES :

 ----------------
  POWER = 1500.0  SLEVEL = 1.0  NUMENG = 2.0

 FAN VARIABLES :

 -------------
  DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
  DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
  CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00

 JET VARIABLES :

 -------------
  THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =   .0 ALFA=   .0

 FIELD POINT VARIALBES :

 -------------------
  AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00
```

```
SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
---   ------  ------  --------  --------  ------
  1   15.00   75.00   1000.00       .00     13
  2    5.00  100.00   1433.02    250.02     19
  3   10.00  150.00   2000.00   1232.14     26
  4   10.00  175.00   2066.98   1482.15     28
  5   20.00  175.00       .00       .00      0

*******************************************************************************************************************

                                                     LOADER CARD INPUT

                      COLUMN 2 4 6          19          31          43          55          67
                             * *            *           *           *           *           *
                             * *            *           *           *           *           *
                            -1 3       1.

*******************************************************************************************************************


************************INPUT VARIABLES*************************

************************FLIGHT SEGMENT  3*************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

PROPELLER VARIABLES :

------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00
```

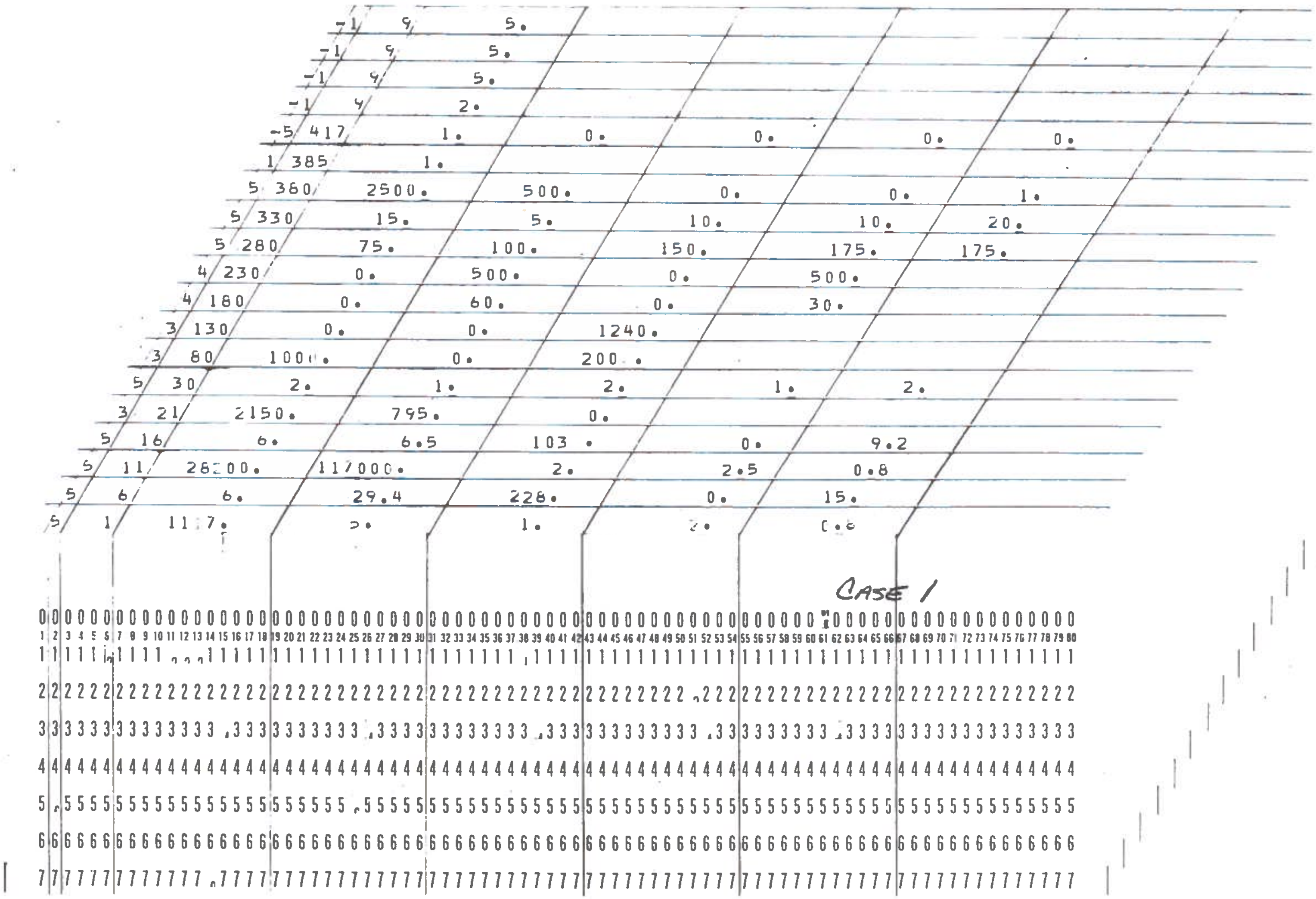
```
ENGINE VARIABLES :

---------------
 POWER = 1500.0  SLEVEL = 1.0  NUMENG = 2.0

FAN VARIABLES :

-------------
 DIAT =   .00  B    =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =   .00
 CHORD=   .00  COMB=    .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
 ---  ------  ------  --------  --------  ------
   1   15.00   75.00   1000.00       .00     13
   2    5.00  100.00   1433.02    250.02     19
   3   10.00  150.00   2000.00   1232.14     26
   4   10.00  175.00   2066.98   1482.15     28
   5   20.00  175.00       .00       .00      0

***********************************************************************************************************

                                      LOADER CARD INPUT

                  COLUMN 2 4 6          19          31          43          55          67
                         *  *           *           *           *           *           *
                         *  *           *           *           *           *           *
                        -1  3     1.

***********************************************************************************************************



**************************INPUT VARIABLES*************************
************************FLIGHT SEGMENT  4*************************

COMMON VARIABLES :
```

```
---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

PROPELLER VARIABLES :

--------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =      .00  NUMPRP =    .0  CHORD =    .00

ENGINE VARIABLES :

-----------------
 POWER = 1500.0  SLEVEL = 1.0  NUMENG = 2.0

FAN VARIABLES :

-------------
 DIAT =   .00  B   =   .00  DDDXT =    .00  RS =     .00  TT2 =   .00  DF =   .00  SIGPHI =  .00  RPM =    .00
 DIAH =   .00  BPR =   .00  DDDXH =    .00  DL =     .00  PT2 =   .00  PR =   .00  XMXTIP =  .00  SPAF =    .00
 CHORD=   .00  COMB=   .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =    .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=   .0

FIELD POINT VARIALBES :

----------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
 ---   ------  ------  --------  -------- ------
   1   15.00   75.00  1000.00       .00    13
   2    5.00  100.00  1433.02    250.02    19
   3   10.00  150.00  2000.00   1232.14    26
   4   10.00  175.00  2066.98   1482.15    28
   5   20.00  175.00      .00       .00     0
```

```
************************************************************************************************************************

                                                                       LOADER CARD INPUT

                  COLUMN 2 4 6             19          31          43          55          67
                         *   *             *           *           *           *           *
                         *   *             *           *           *           *           *
                        -1   3         1.

************************************************************************************************************************



************************INPUT VARIABLES*************************
***********************FLIGHT SEGMENT  5************************

COMMON VARIABLES :

---------------
SAZ =  1117.00  SEG =  5.00  ROTR =  .0 RP =  .0 FANS =  .0 RJ =  .0 E = 1.0 ANMFPT =  1.0

MAIN ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

TAIL ROTOR VARIABLES :

--------------------
 SM-K =  .00   BIGB =   .00   BIGR =    .00   OMEGN =     .00   THRUS =       .0
 ETA =  .00   BETA =   .00   CHORD =    .00   SID   =     .00   TORQ  =       .0

PROPELLER VARIABLES :

-------------------
POWER =     .0  DIA =    .00  BIGB =   .0  RPM =     .00  NUMPRP =   .0  CHORD =    .00

ENGINE VARIABLES :

----------------
 POWER = 1500.0  SLEVEL = 1.0  NUMENG = 2.0

FAN VARIABLES :
```

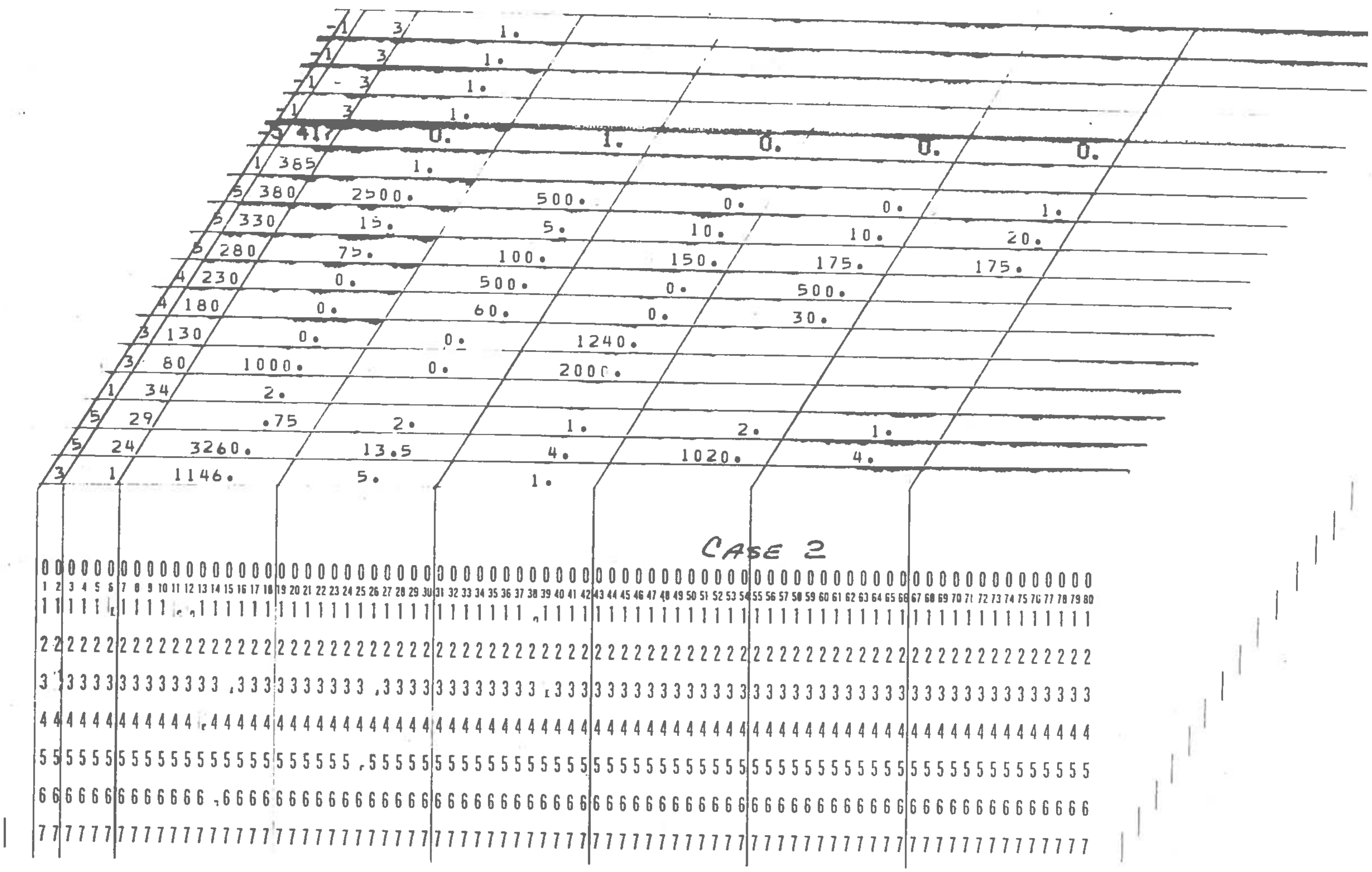
```
-------------
 DIAT =    .00  B   =    .00  DDDXT =    .00  RS =     .00  TT2 =    .00  DF =    .00  SIGPHI =  .00  RPM =     .00
 DIAH =    .00  BPR =    .00  DDDXH =    .00  DL =     .00  PT2 =    .00  PR =    .00  XMXTIP =  .00  SPAF =    .00
 CHORD=    .00  COMB=    .00  ALFA =    .00  FN =     .00

JET VARIABLES :

-------------
 THRUST =      .0  WTFL =    .00  AREAJ =    .00  PSUBA =   .00  TSUBA =   .00  TSUBJ =    .0  TSUBJO =    .0 ALFA=    .0

FIELD POINT VARIALBES :

--------------------
 AZERO =     .00  XPRZRO =  2500.0  YPRZRO =   500.0  TINC = 1.00  THMAXO =   .00  ANMFPT = 1.00

 SEG   THETA   SPEED   XBREAK    YBREAK   INCMAX
 ---   ------  ------  --------  --------  ------
   1   15.00   75.00  1000.00       .00     13
   2    5.00  100.00  1433.02    250.02     19
   3   10.00  150.00  2000.00   1232.14     26
   4   10.00  175.00  2066.98   1482.15     28
   5   20.00  175.00      .00       .00      0

                        CHECKOUT CASE FOR V/STOL VEHICLE NOISE PREDICTION PROGRAM
                        ---------------------------------------------------------


TINC= 1.00  XPRZRO=   2500.00  YPRZRO=    500.00  AZERO=    .00  THMAXO=    .00

  SEG    PATH   ALFN   VF1    XMAX   YMAX  RADIUS  PHIMAX

-------------------------------------------------------
    1     2.0    15.0    75.0 1000.0     .0     .0     .0
    2     1.0     5.0   100.0 1433.0  250.0  500.0   60.0
    3     2.0    10.0   150.0 2000.0 1232.1     .0     .0
    4     1.0    10.0   175.0 2067.0 1482.1  500.0   30.0
    5     2.0    20.0   175.0     .0     .0     .0     .0


  RANGE   EPNL    PNLTM    PNL     DBA      XPR
-----------------------------------------------
  913.6   77.05   77.38   77.38   65.07   2500.0
```

```
PNLT TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   57.13     58.35     58.91     59.48     59.57     60.73     61.36     62.04     63.29     63.99
   65.10     65.80     66.52     67.65     68.50     69.66     71.40     73.26     73.83     75.21
   76.52     76.47     77.38     77.19     77.06     77.17     75.92     74.11     71.63     69.43
   67.55     65.68       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00

PNL TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   56.58     57.82     58.40     58.98     59.57     60.73     61.36     62.04     63.29     63.99
   65.10     65.80     66.52     67.65     68.50     69.66     71.40     73.26     73.83     75.21
   76.52     76.47     77.38     77.19     77.06     77.17     75.92     74.11     71.63     69.43
   67.55     65.68       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00

DBA TIME HISTORY IN 1.0 SECOND INCREMENTS FOR  1 FIELD POINTS
   48.79     49.30     49.83     50.37     50.91     51.47     52.04     52.62     53.81     54.42
   55.03     55.66     56.30     57.00     57.41     58.46     60.13     61.99     62.50     63.62
   64.63     64.53     65.07     64.87     64.75     64.65     63.42     62.44     60.74     59.25
   57.87     56.58       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00       .00       .00       .00       .00       .00       .00       .00
```



-1	9	5.				
-1	9	5.				
-1	4	5.				
-1	4	2.				
-5	417	1.	0.	0.	0.	0.
1	385	1.				
5	360	2500.	500.	0.	0.	1.
5	330	15.	5.	10.	10.	20.
5	280	75.	100.	150.	175.	175.
4	230	0.	500.	0.	500.	
4	180	0.	60.	0.	30.	
3	130	0.	0.	1240.		
3	80	1000.	0.	200.		
5	30	2.	1.	2.	1.	2.
3	21	2150.	795.	0.		
5	16	6.	6.5	103.	0.	9.2
5	11	28[illegible]00.	117000.	2.	2.5	0.8
5	6	6.	29.4	228.	0.	15.
5	1	11[illegible]7.	5.	1.	2.	0.6

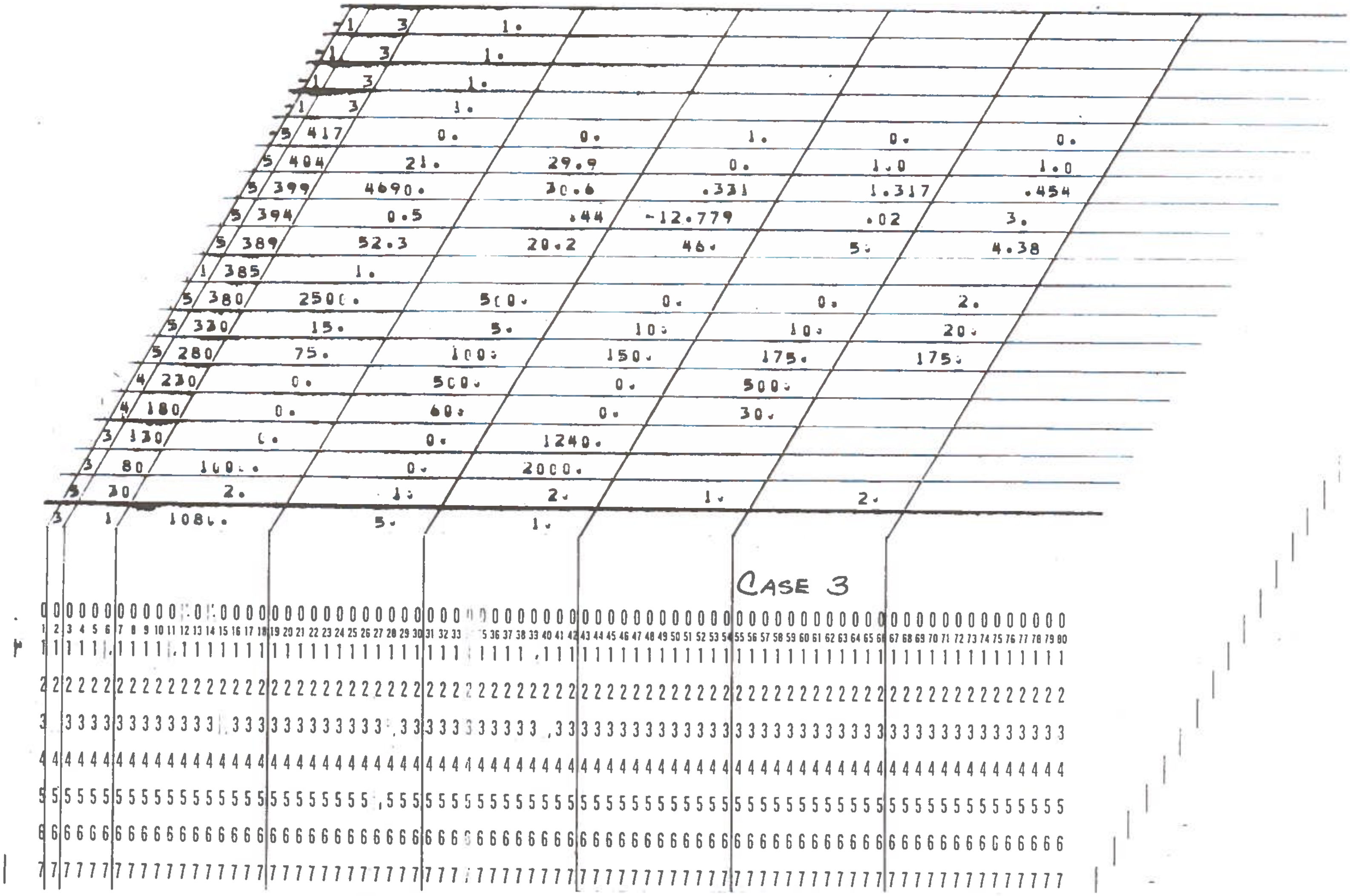
Figure B-1. Input Cards For Sample Case 1



-1	3	1.					
-1	3	1.					
-1	- 3	1.					
-1	3	1.					
-3	417	0.	1.	0.	0.	0.	
1	365	1.					
5	380	2500.	500.	0.	0.	1.	
5	330	15.	5.	10.	10.	20.	
5	280	75.	100.	150.	175.	175.	
4	230	0.	500.	0.	500.		
4	180	0.	60.	0.	30.		
3	130	0.	0.	1240.			
3	80	1000.	0.	2000.			
1	34	2.					
5	29	.75	2.	1.	2.	1.	
5	24	3260.	13.5	4.	1020.	4.	
3	1	1146.	5.	1.			

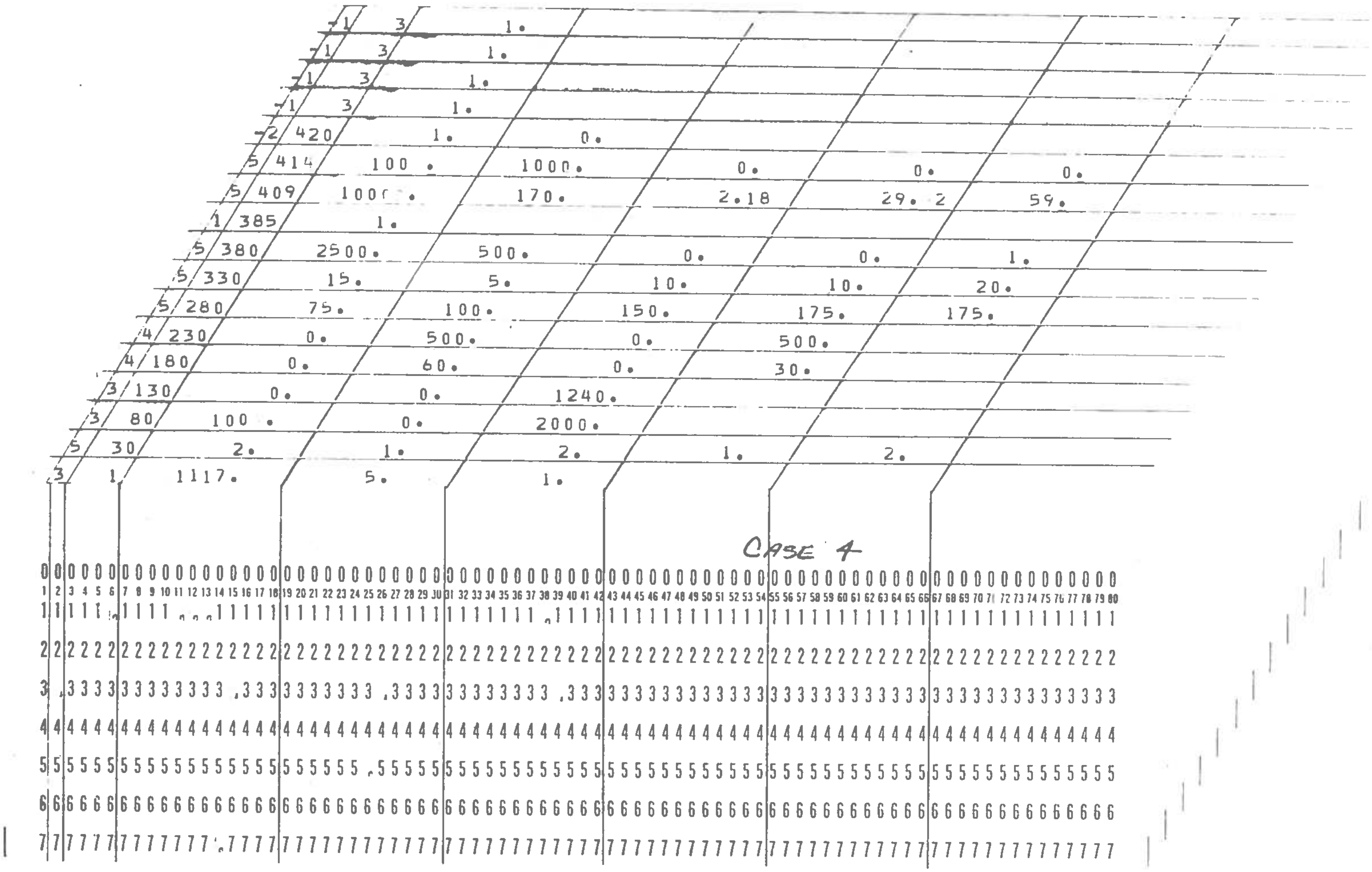
CASE 2

Figure B-2. Input Cards For Sample Case 2



1	3	1.				
1	3	1.				
1	3	1.				
1	3	1.				
5	417	0.	0.	1.	0.	0.
5	404	21.	29.9	0.	1.0	1.0
5	399	4690.	30.6	.331	1.317	.454
5	394	0.5	.44	-12.779	.02	3.
5	389	52.3	20.2	46.	5.	4.38
1	385	1.				
5	380	2500.	500.	0.	0.	2.
5	330	15.	5.	10.	10.	20.
5	280	75.	100.	150.	175.	175.
4	230	0.	500.	0.	500.	
4	180	0.	60.	0.	30.	
3	130	0.	0.	1240.		
3	80	1000.	0.	2000.		
5	30	2.	1.	2.	1.	2.
3	1	1086.	5.	1.		

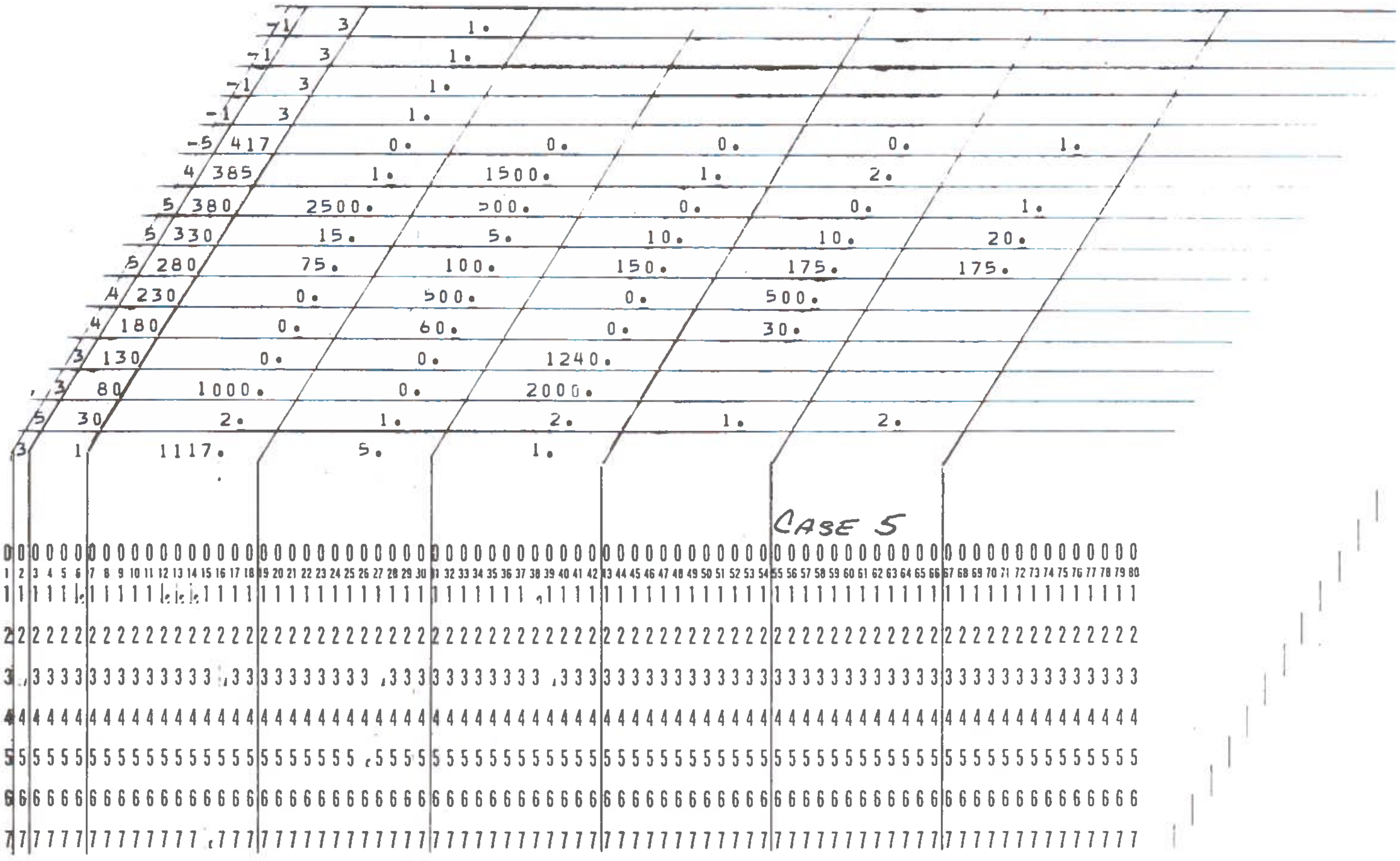
Figure B-3. Input Cards For Sample Case 3



-1	3	1.					
-1	3	1.					
-1	3	1.					
-1	3	1.					
-2	420	1.	0.				
5	414	100.	1000.	0.	0.	0.	
5	409	1000.	170.	2.18	29.2	59.	
1	385	1.					
5	380	2500.	500.	0.	0.	1.	
5	330	15.	5.	10.	10.	20.	
5	280	75.	100.	150.	175.	175.	
4	230	0.	500.	0.	500.		
4	180	0.	60.	0.	30.		
3	130	0.	0.	1240.			
3	80	100.	0.	2000.			
5	30	2.	1.	2.	1.	2.	
3	1	1117.	5.	1.			

CASE 4

Figure B-4. Input Cards For Sample Case 4

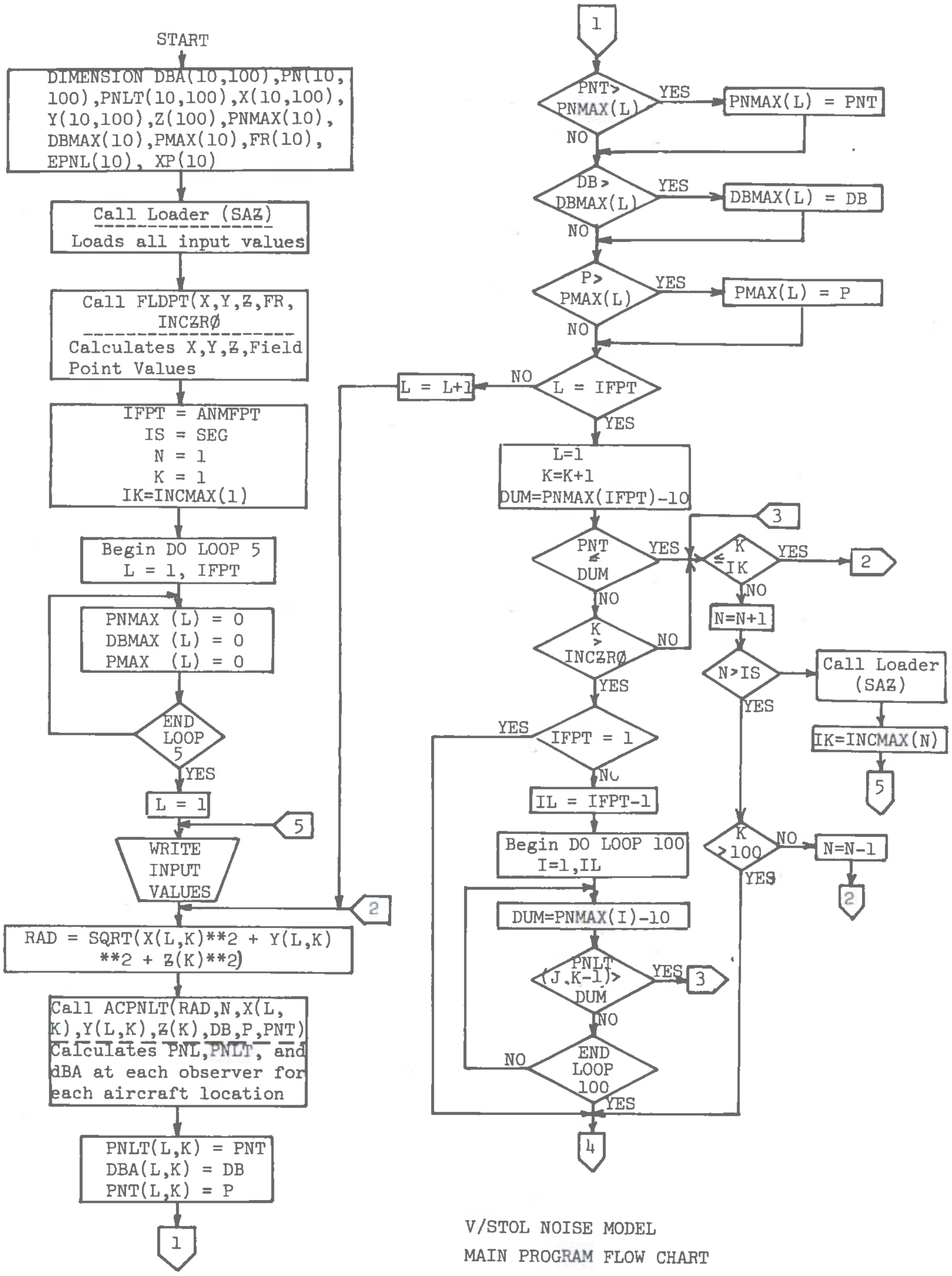


-1	3	1.				
-1	3	1.				
-1	3	1.				
-1	3	1.				
-5	417	0.	0.	0.	0.	1.
4	385	1.	1500.	1.	2.	
5	380	2500.	500.	0.	0.	1.
5	330	15.	5.	10.	10.	20.
5	280	75.	100.	150.	175.	175.
4	230	0.	500.	0.	500.	
4	180	0.	60.	0.	30.	
3	130	0.	0.	1240.		
3	80	1000.	0.	2000.		
5	30	2.	1.	2.	1.	2.
3	1	1117.	5.	1.		

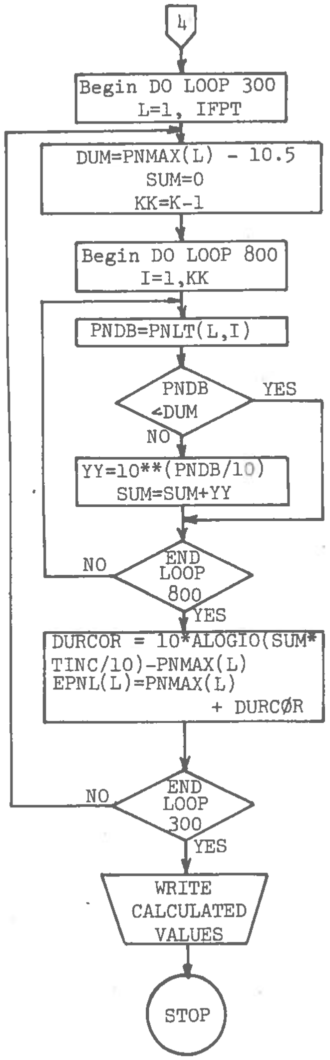
Figure B-5. Input Cards For Sample Case 5

APPENDIX C

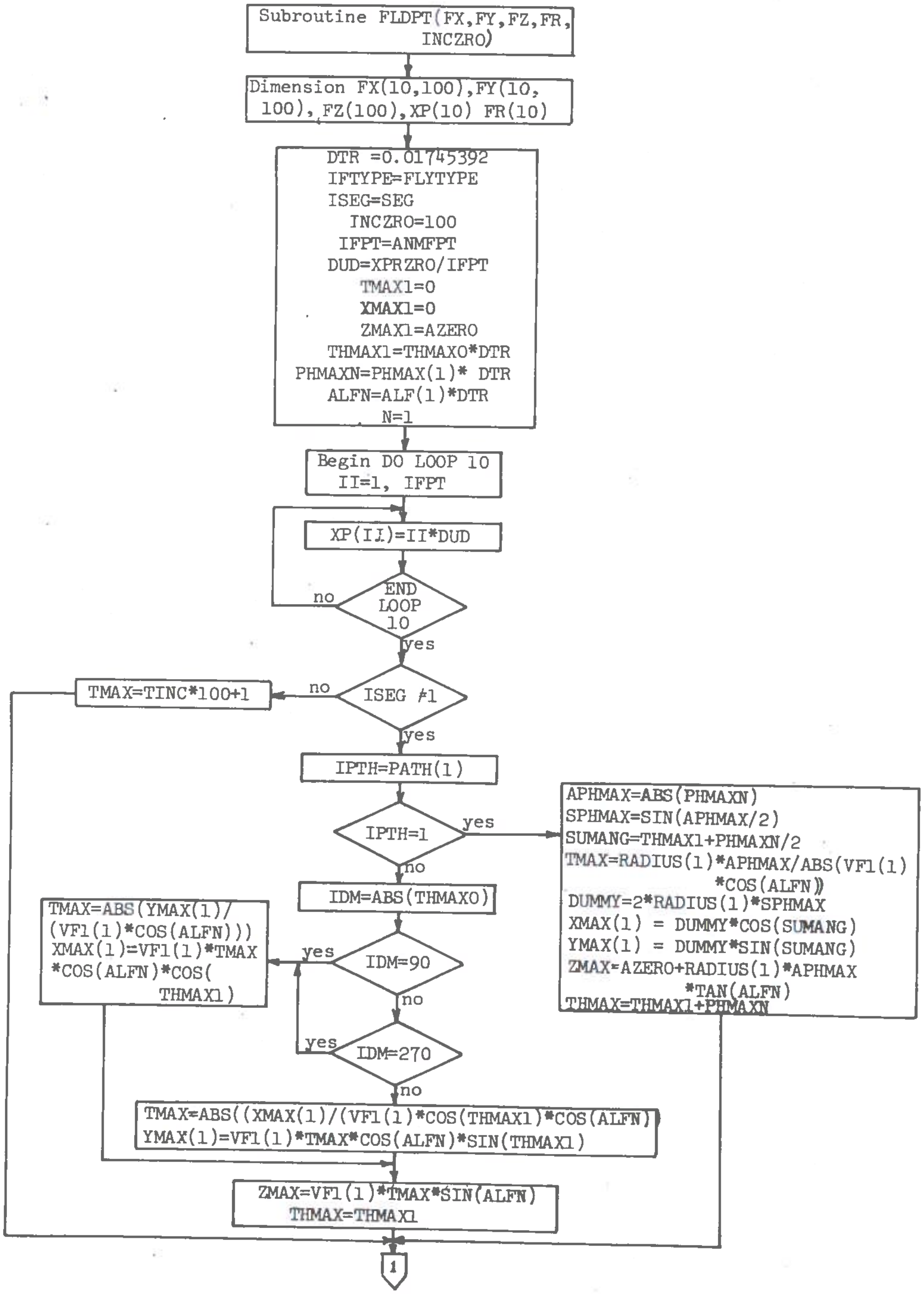
V/STOL Noise Model - Flow Charts



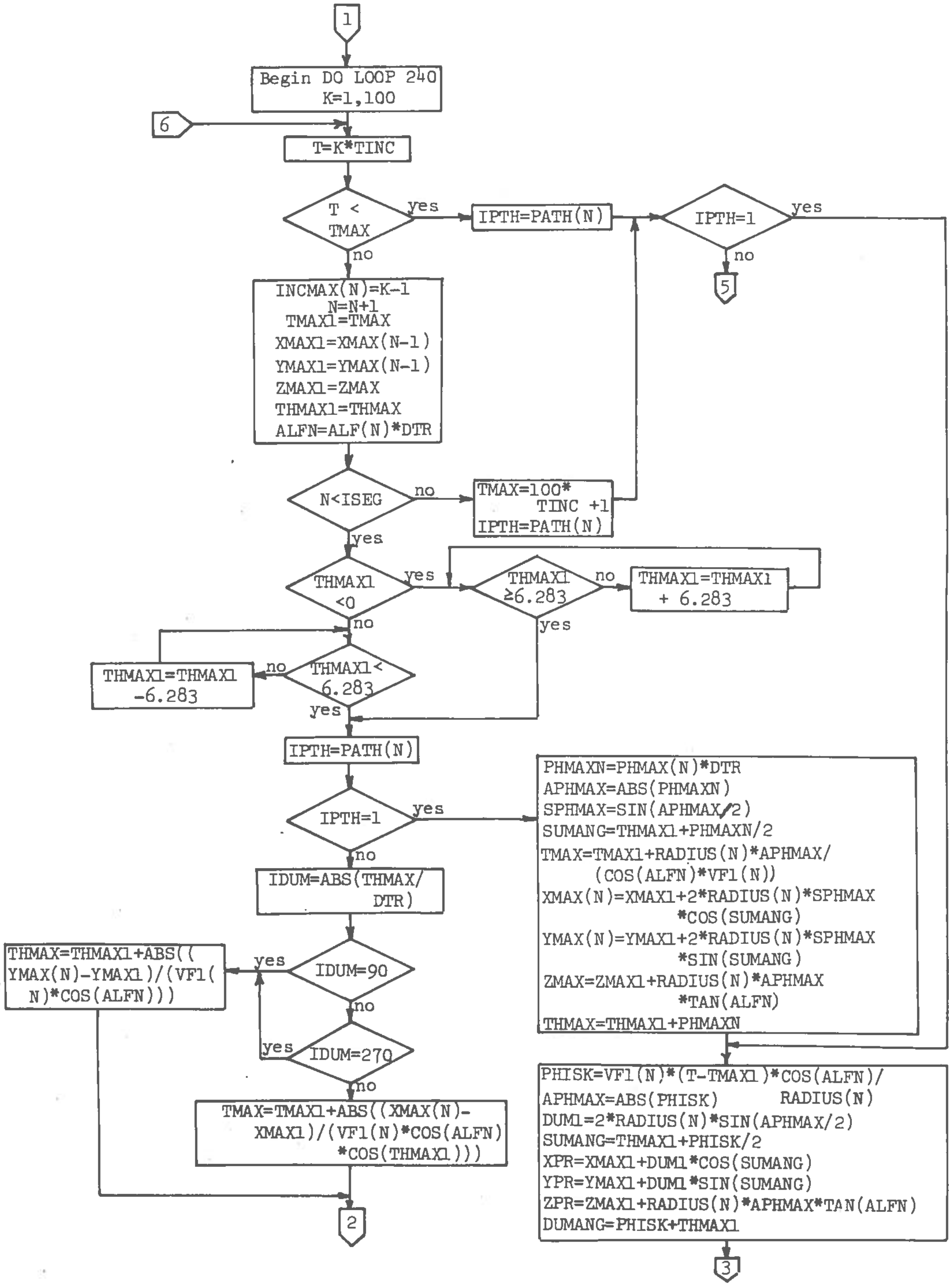
V/STOL NOISE MODEL
MAIN PROGRAM FLOW CHART



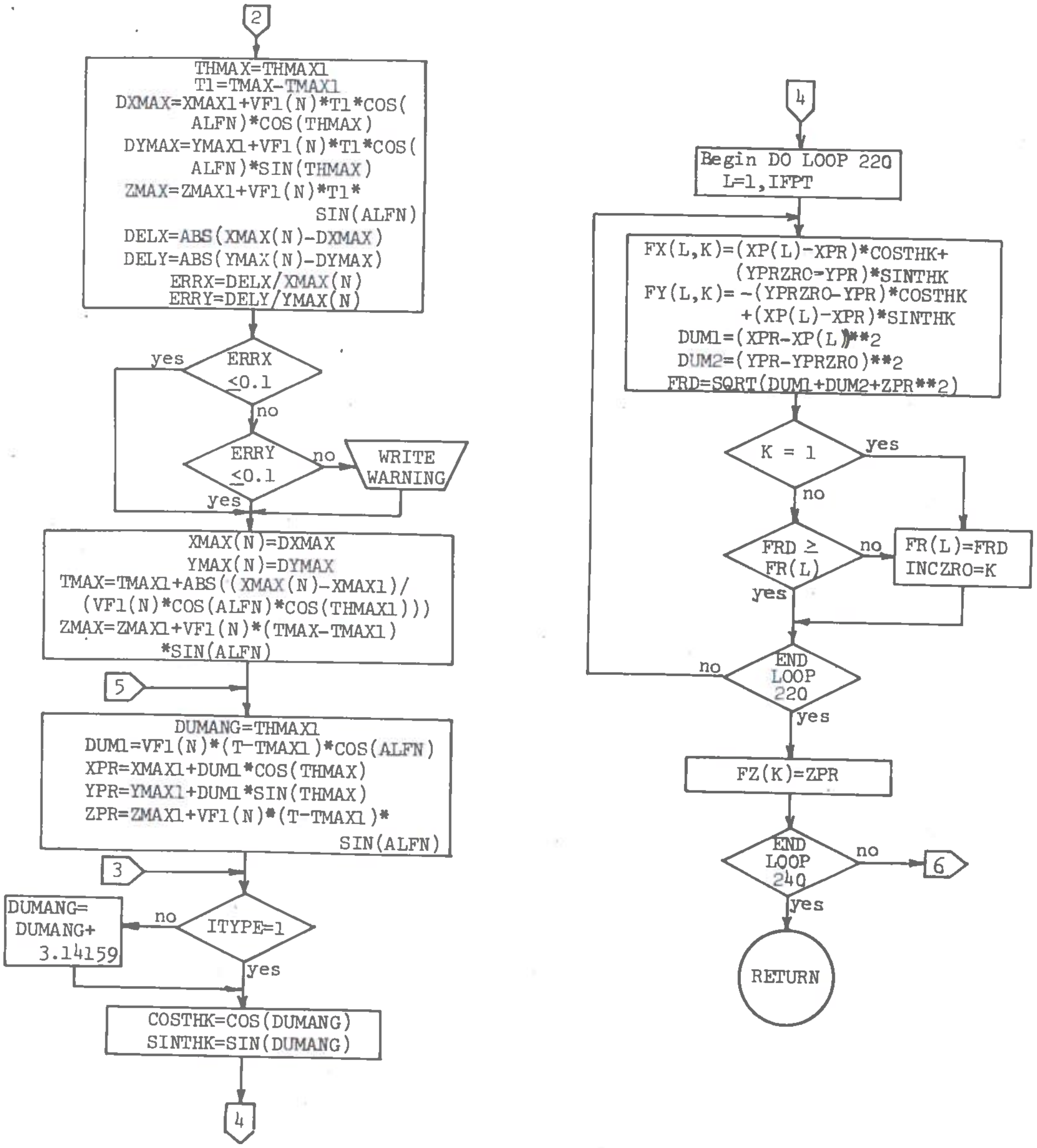
V/STOL NOISE MODEL - MAIN PROGRAM
FLOW CHART (CONT)



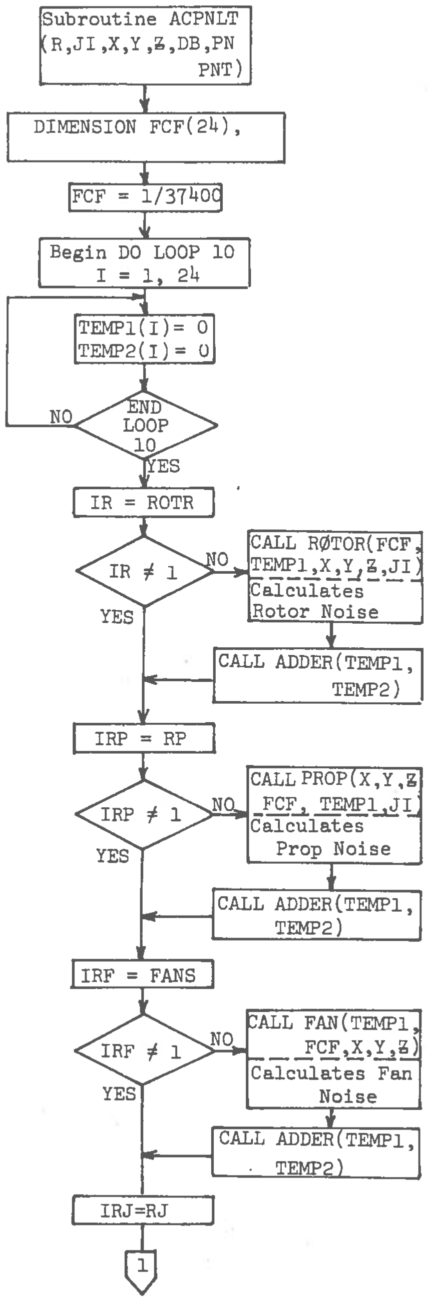
Subroutine FLDPT Flow Chart

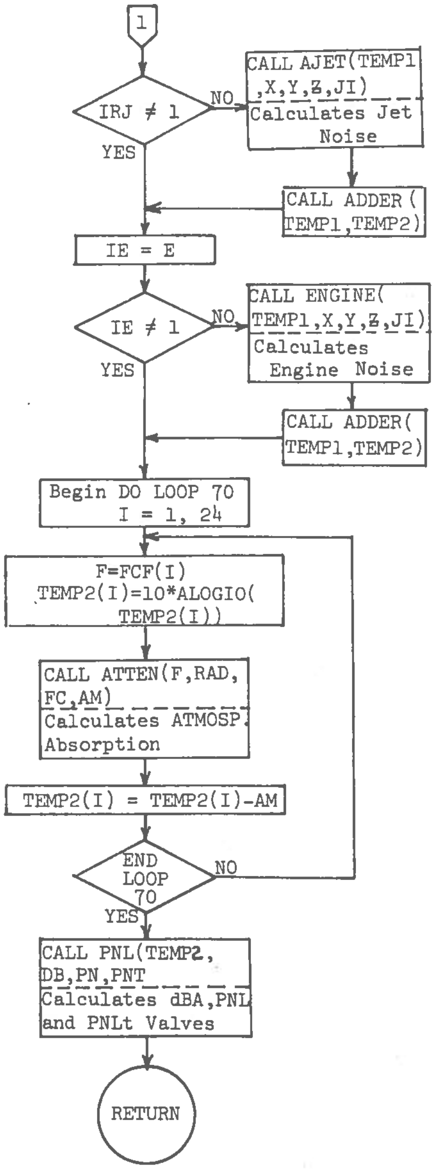


Subroutine FLDPT

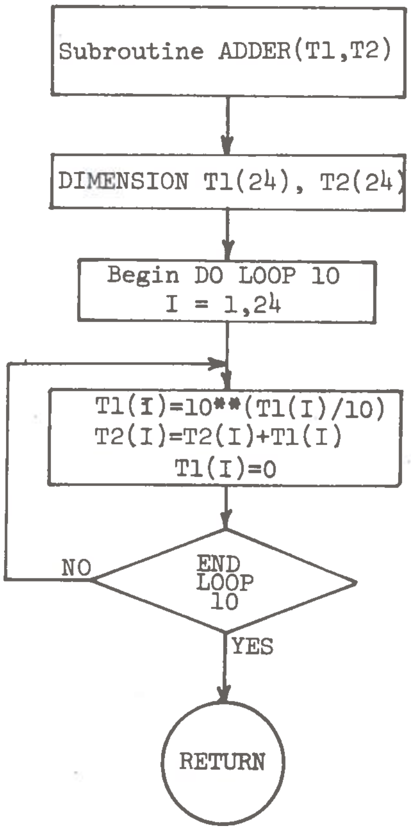


Subroutine FLDPT

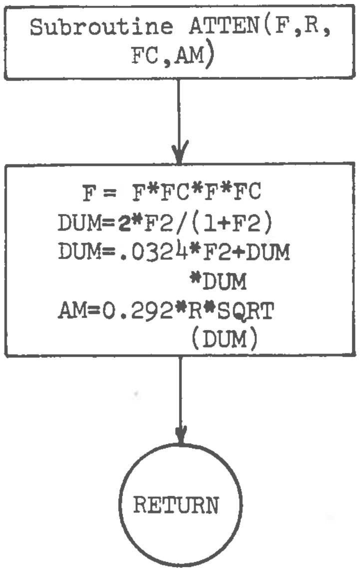




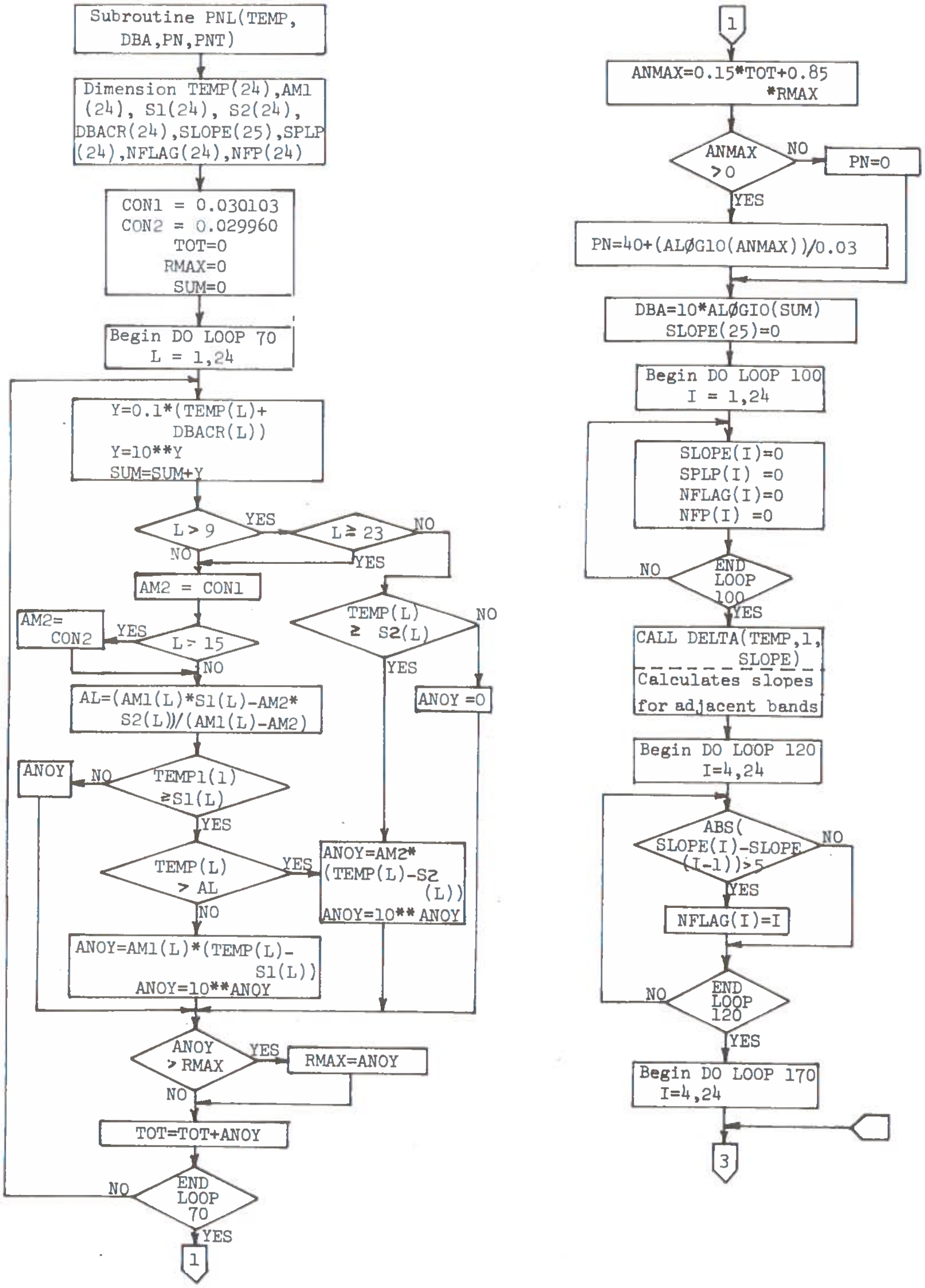
Subroutine ACPNLT
Flow Chart



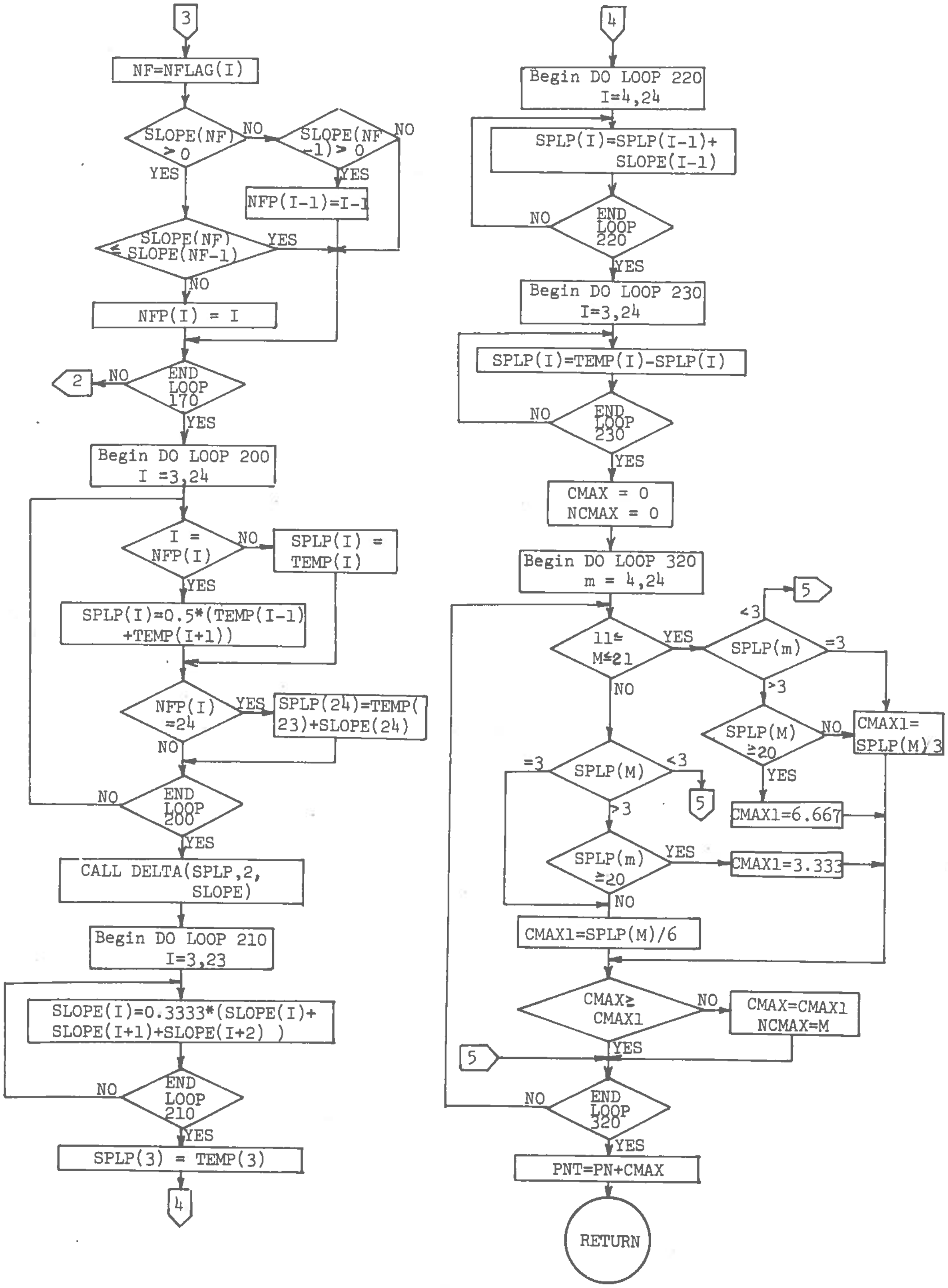
SUBROUTINE ADDER - FLOW CHART



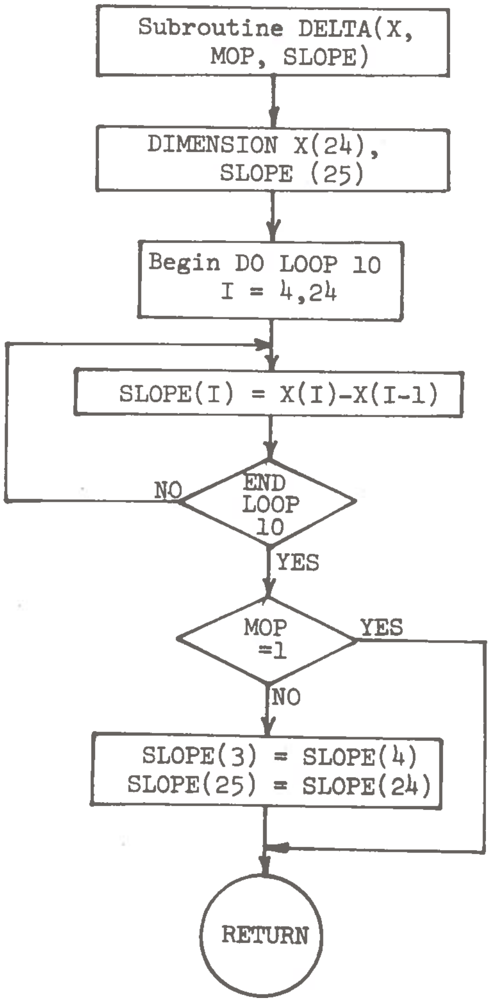
SUBROUTINE ATTEN FLOW CHART



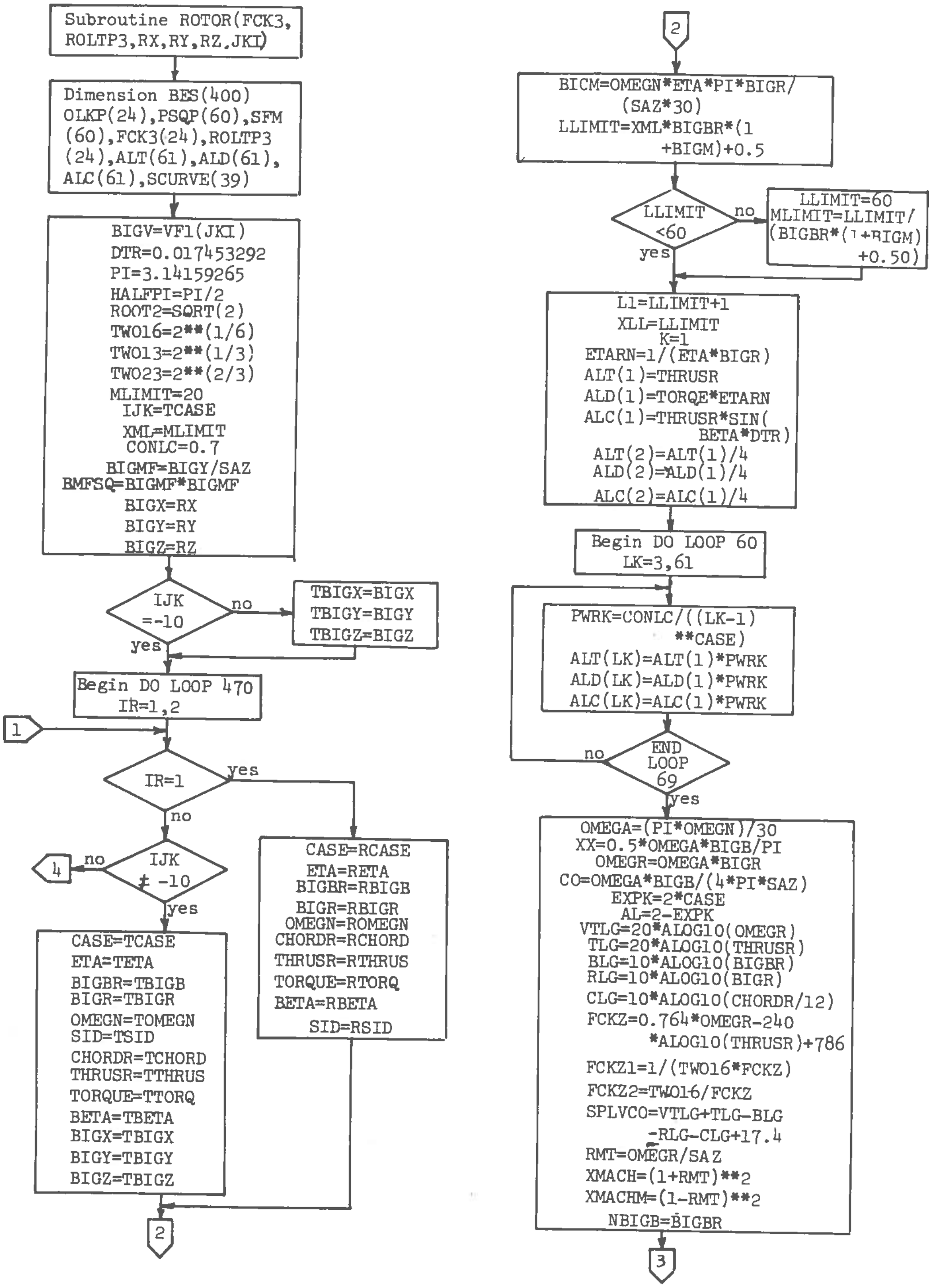
Subroutine PNL Flow Chart



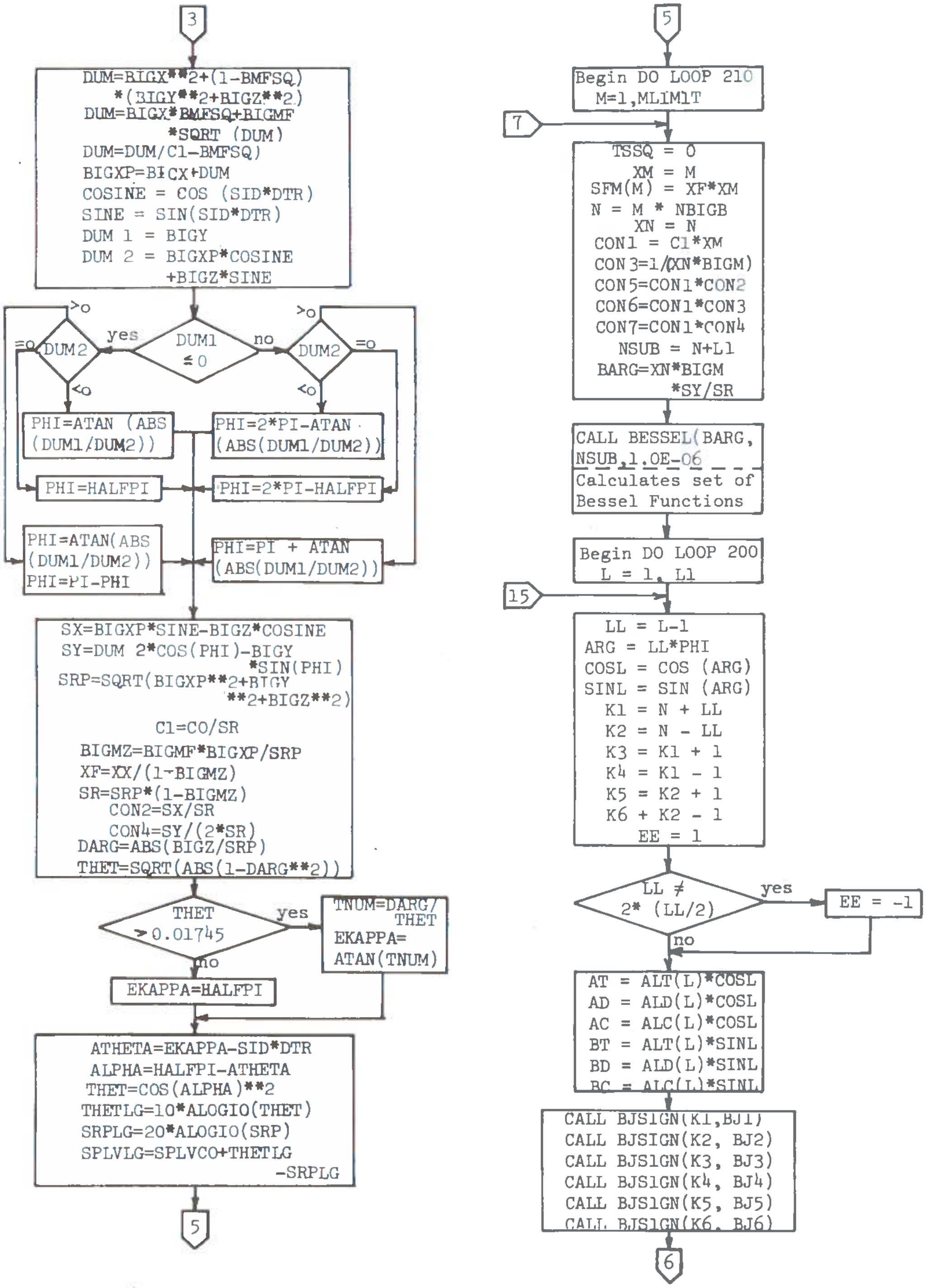
Subroutine PNL



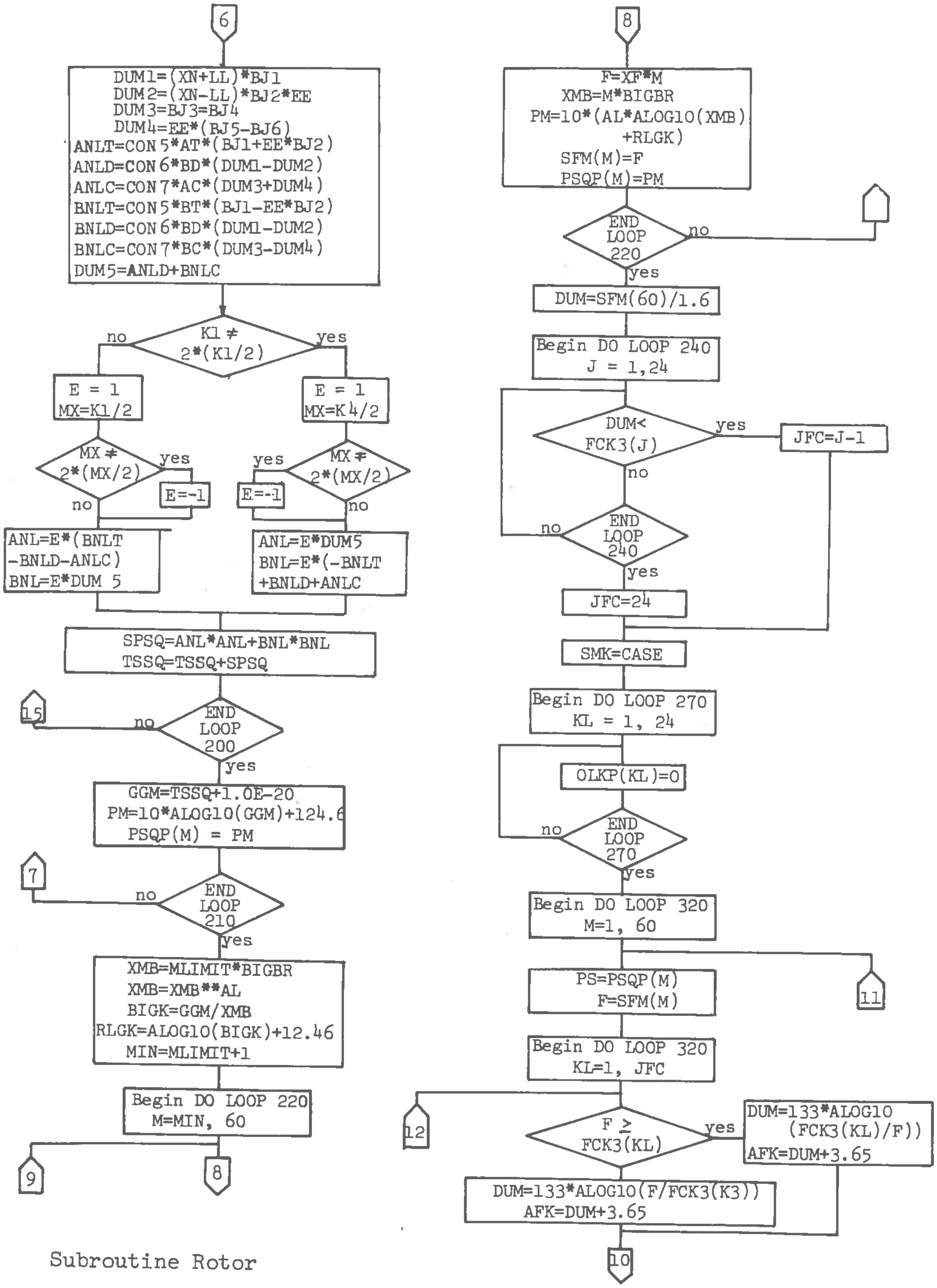
Subroutine DELTA Flow Chart



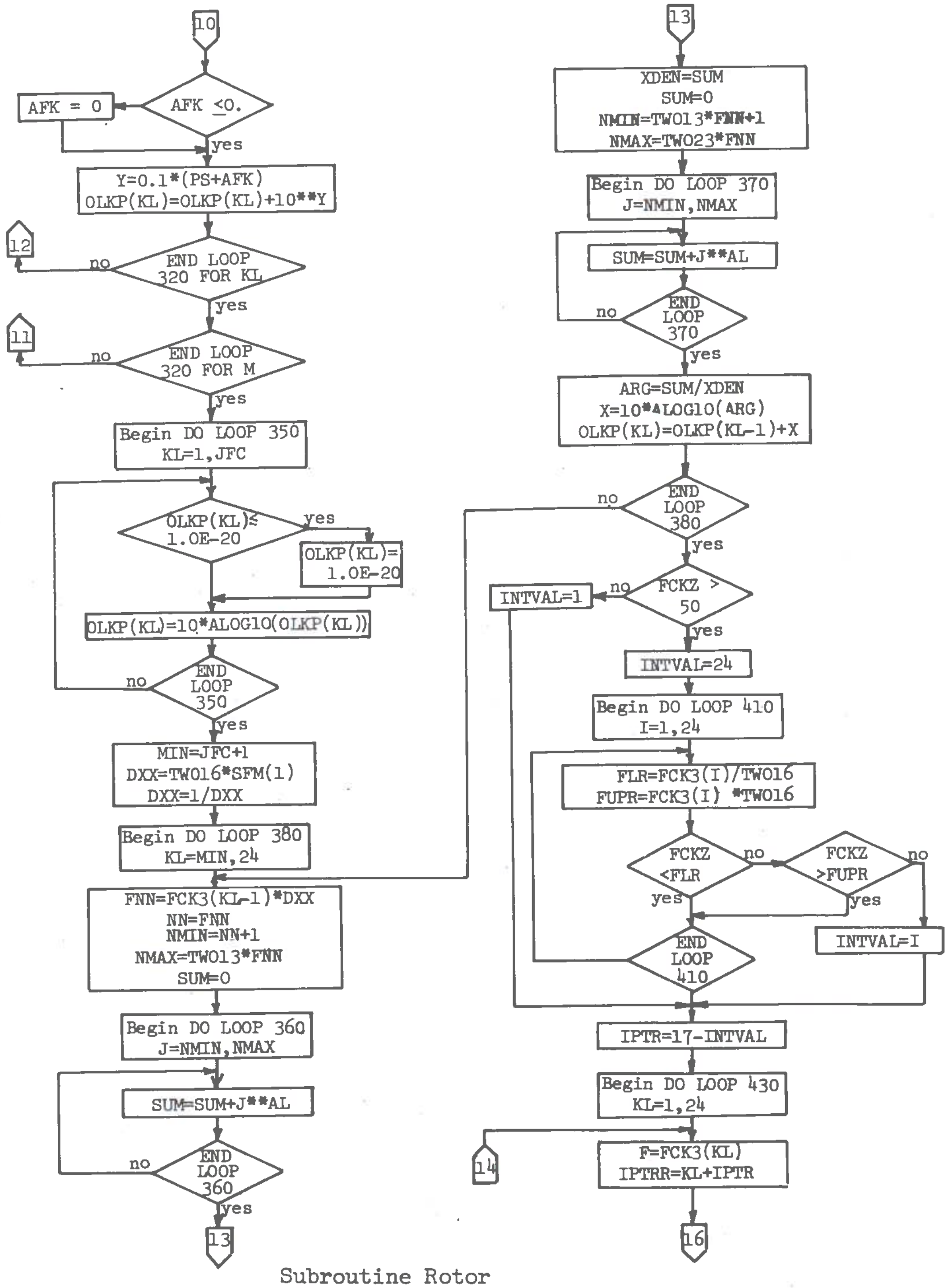
Subroutine Rotor Flow Chart



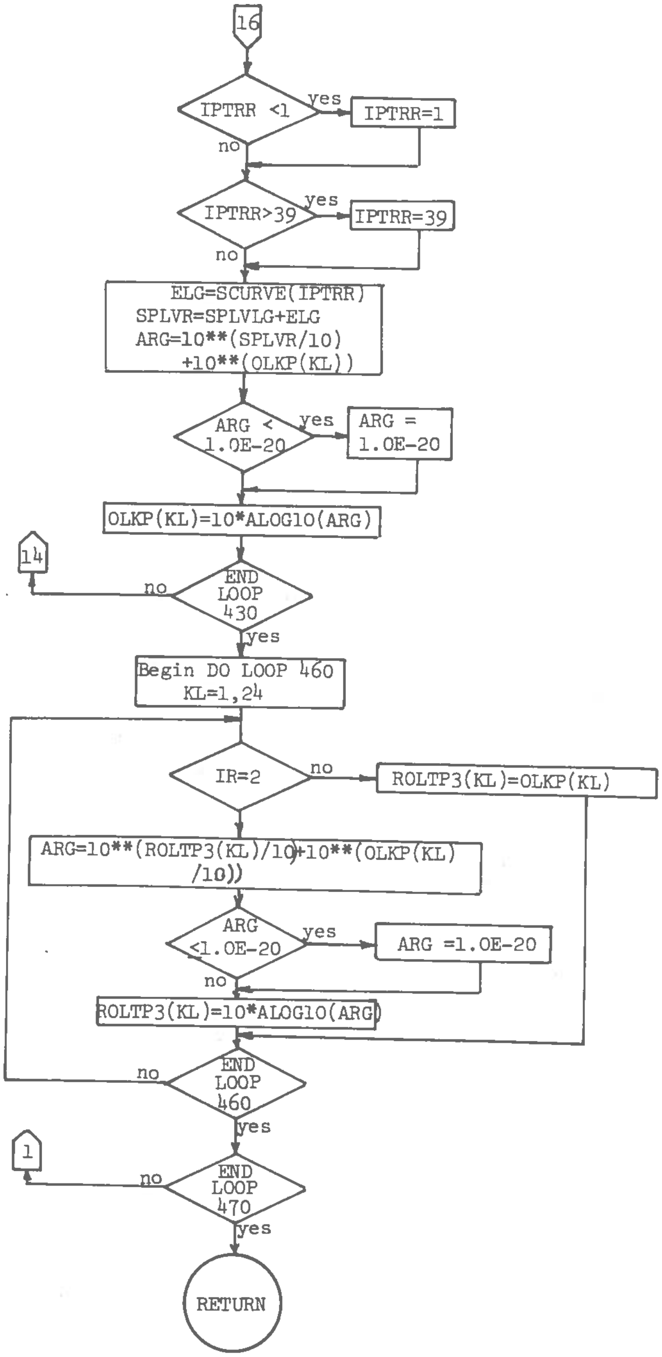
Subroutine Rotor



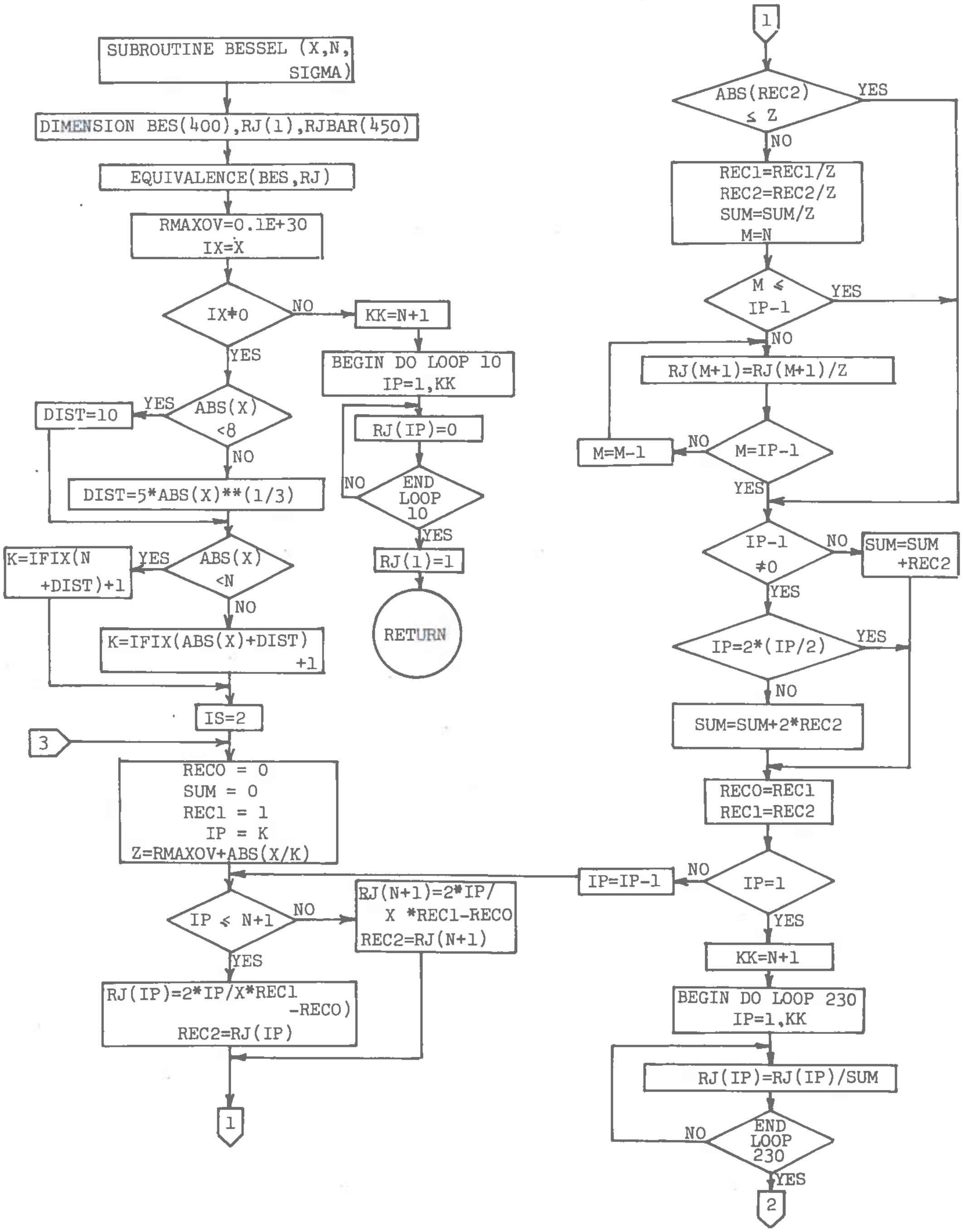
Subroutine Rotor



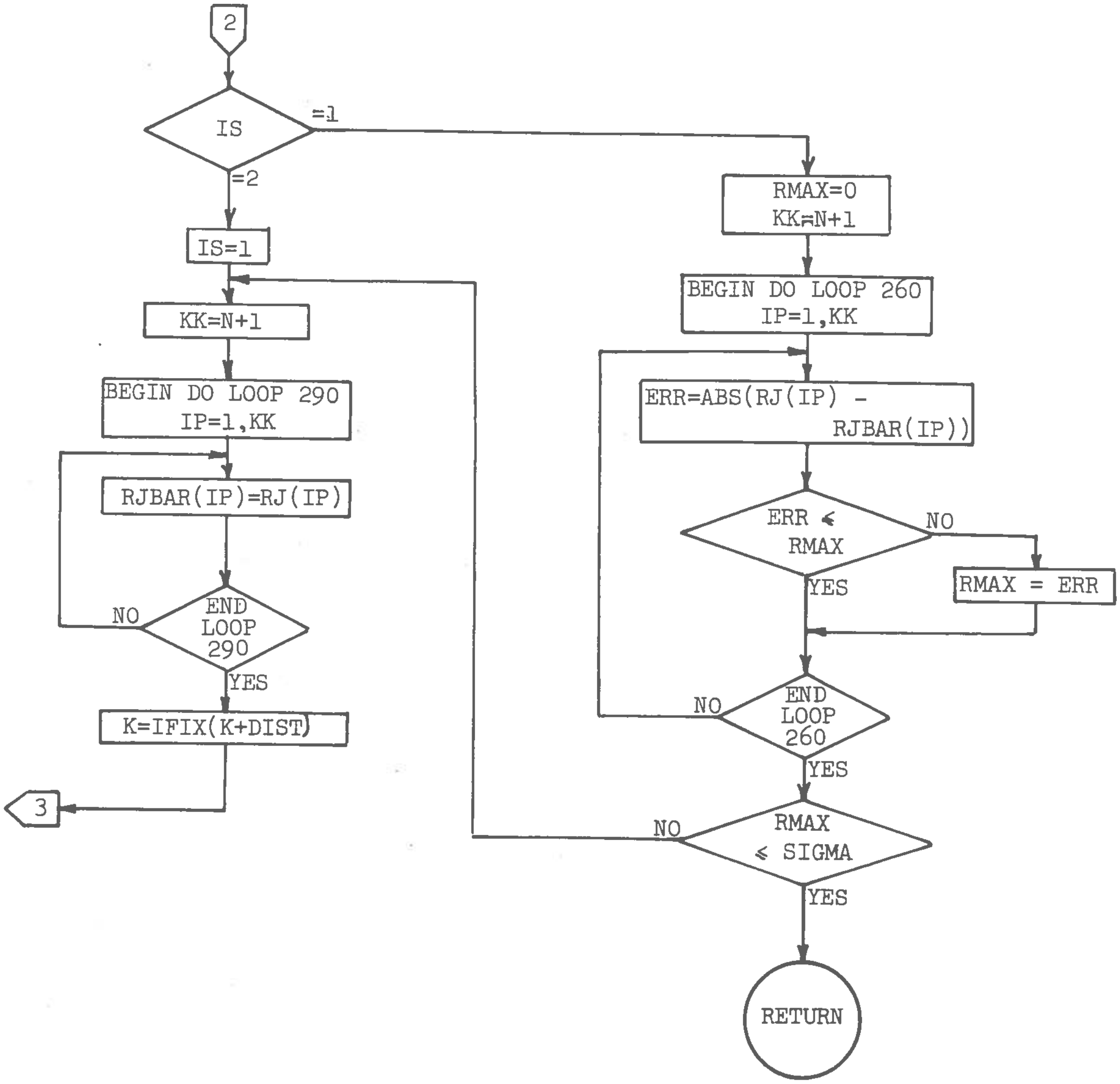
Subroutine Rotor



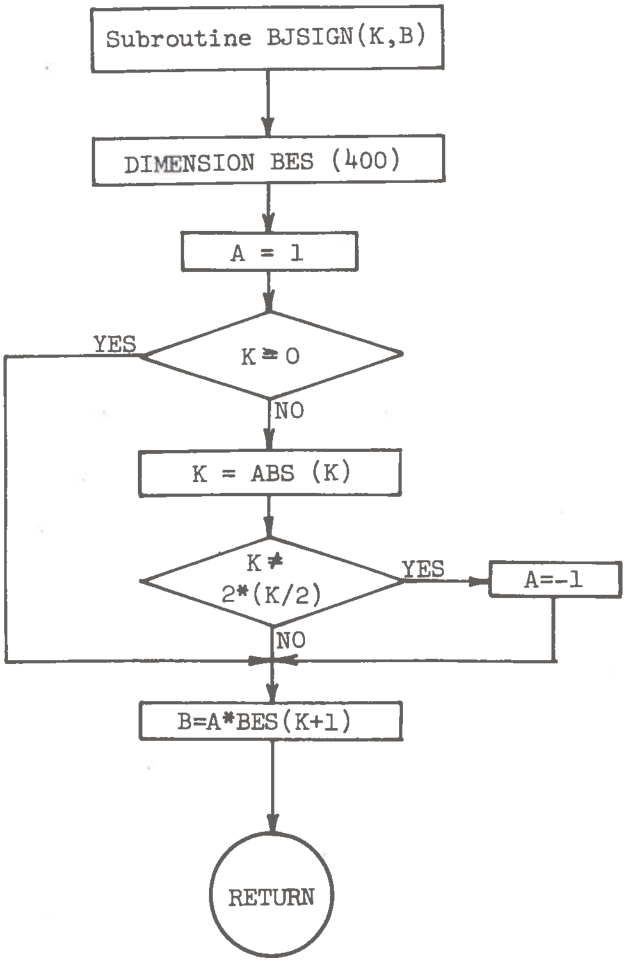
Subroutine Rotor



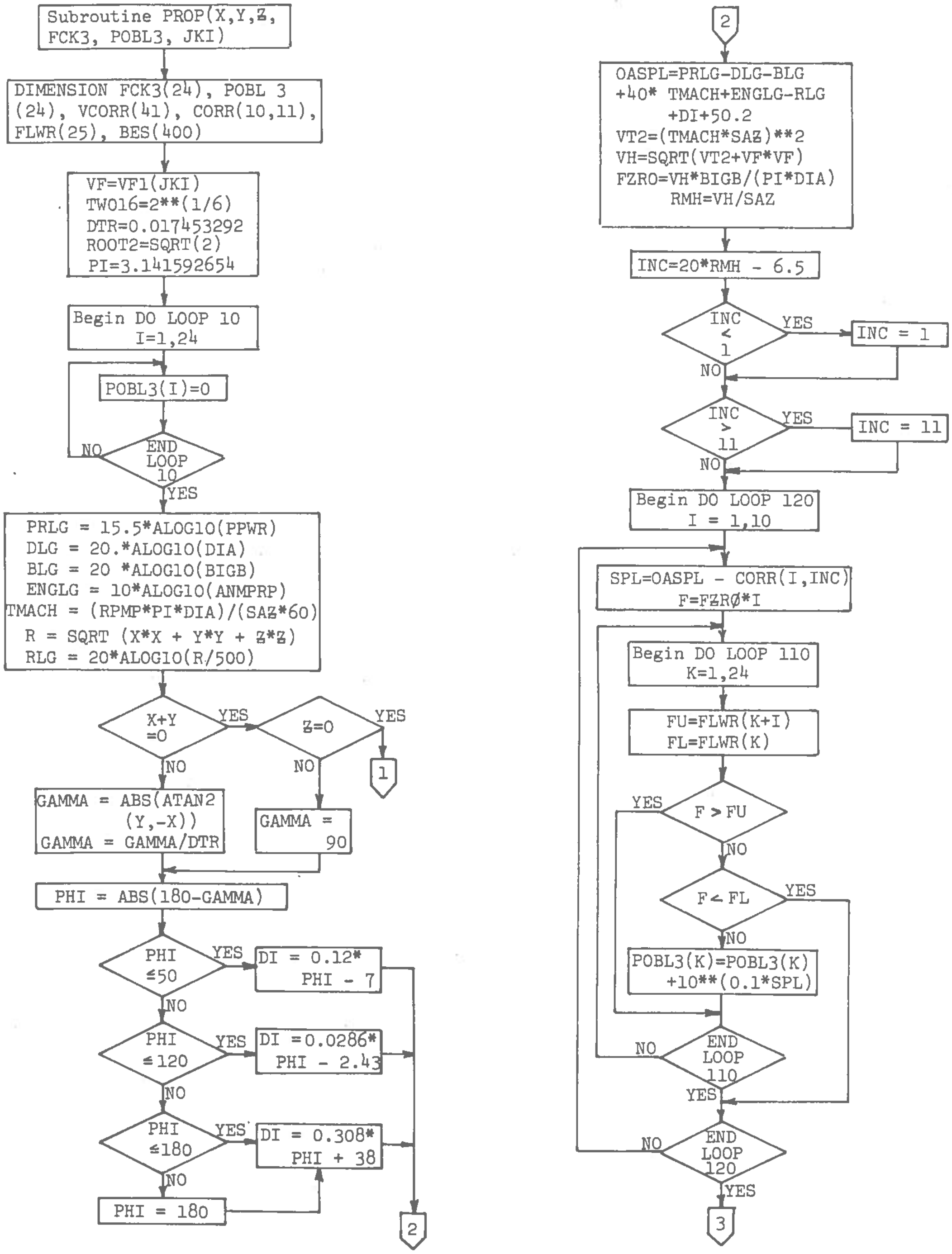
Subroutine Bessel Flow Chart



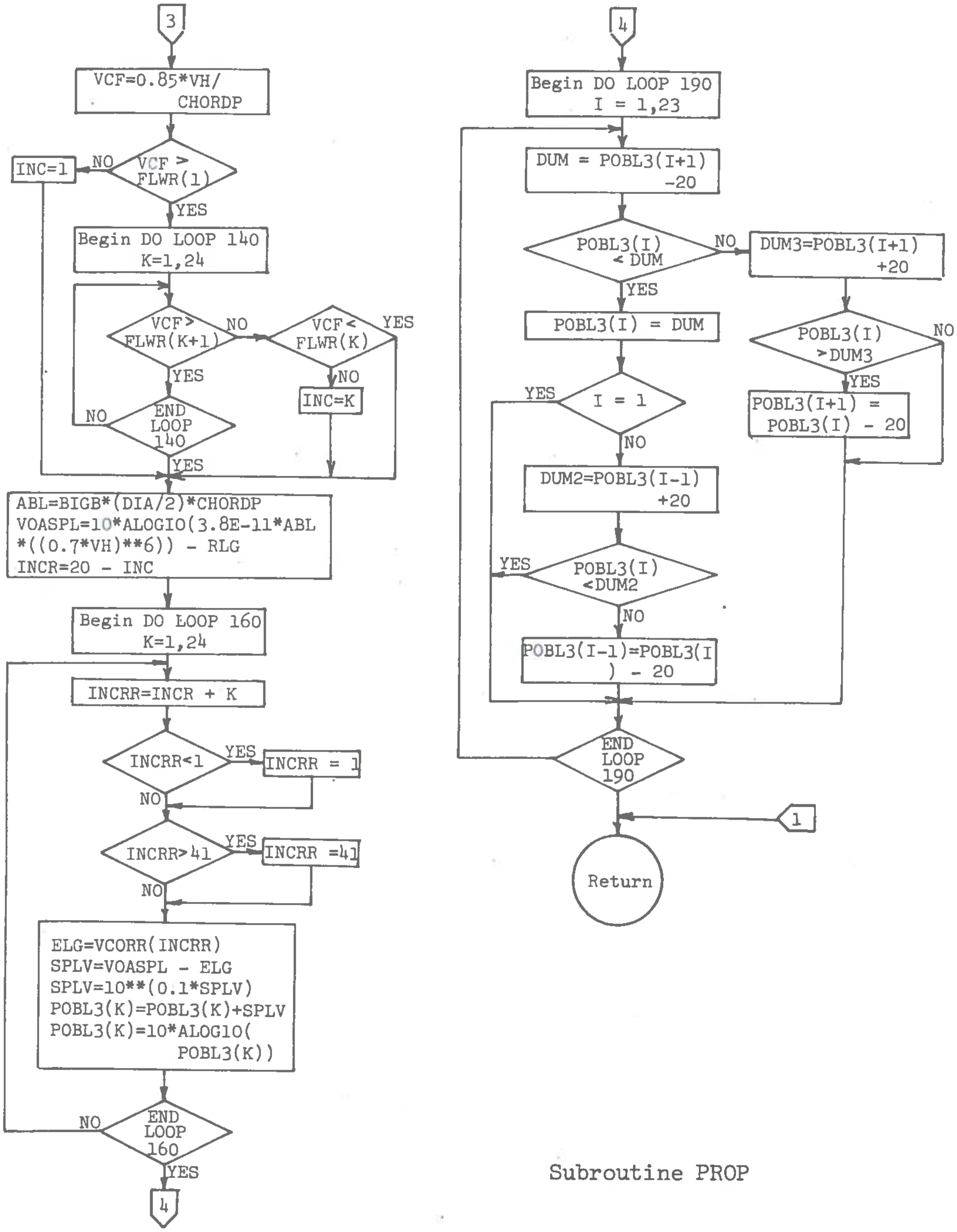
Subroutine Bessel



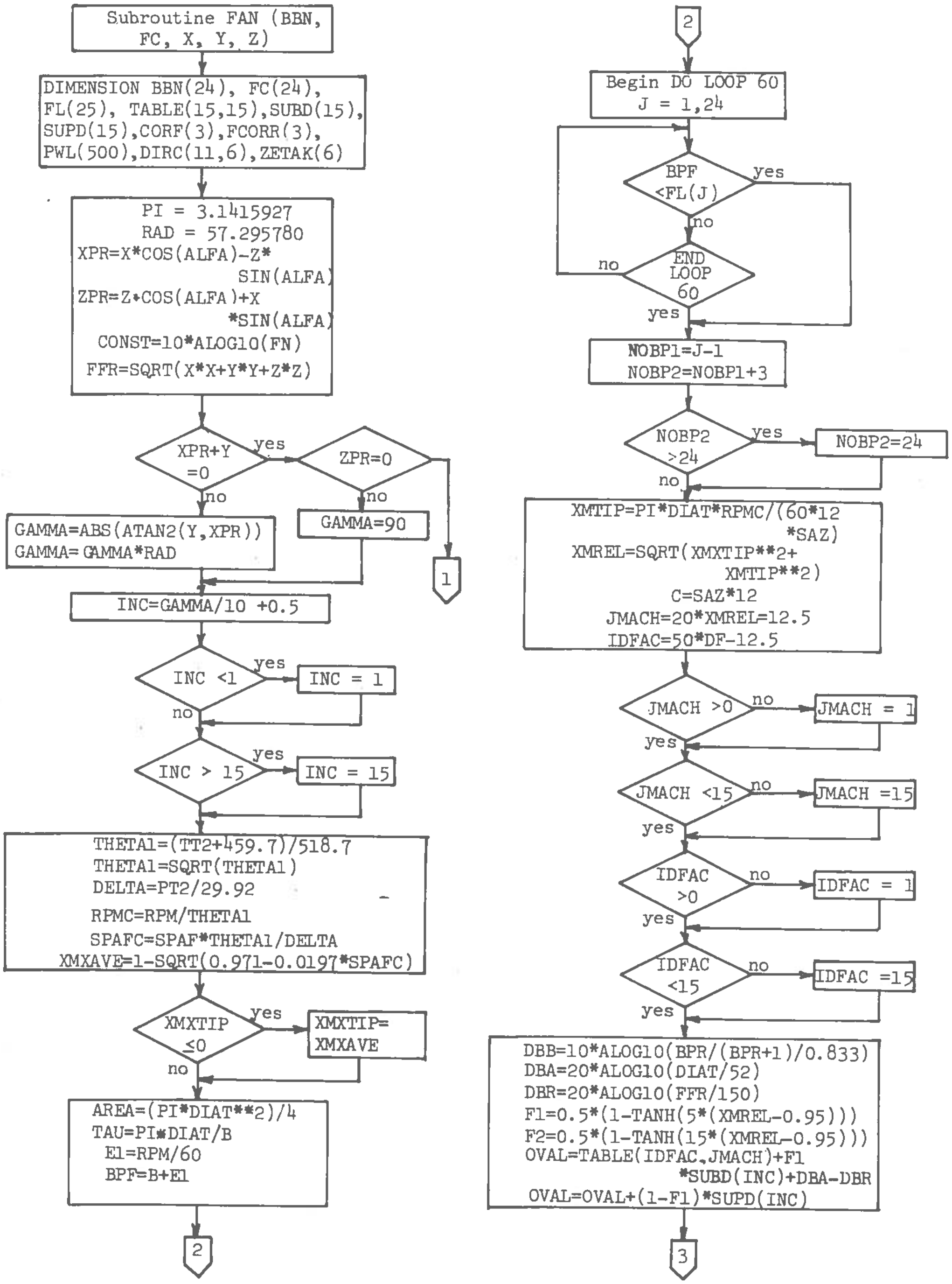
Subroutine BJSIEN Flow Chart



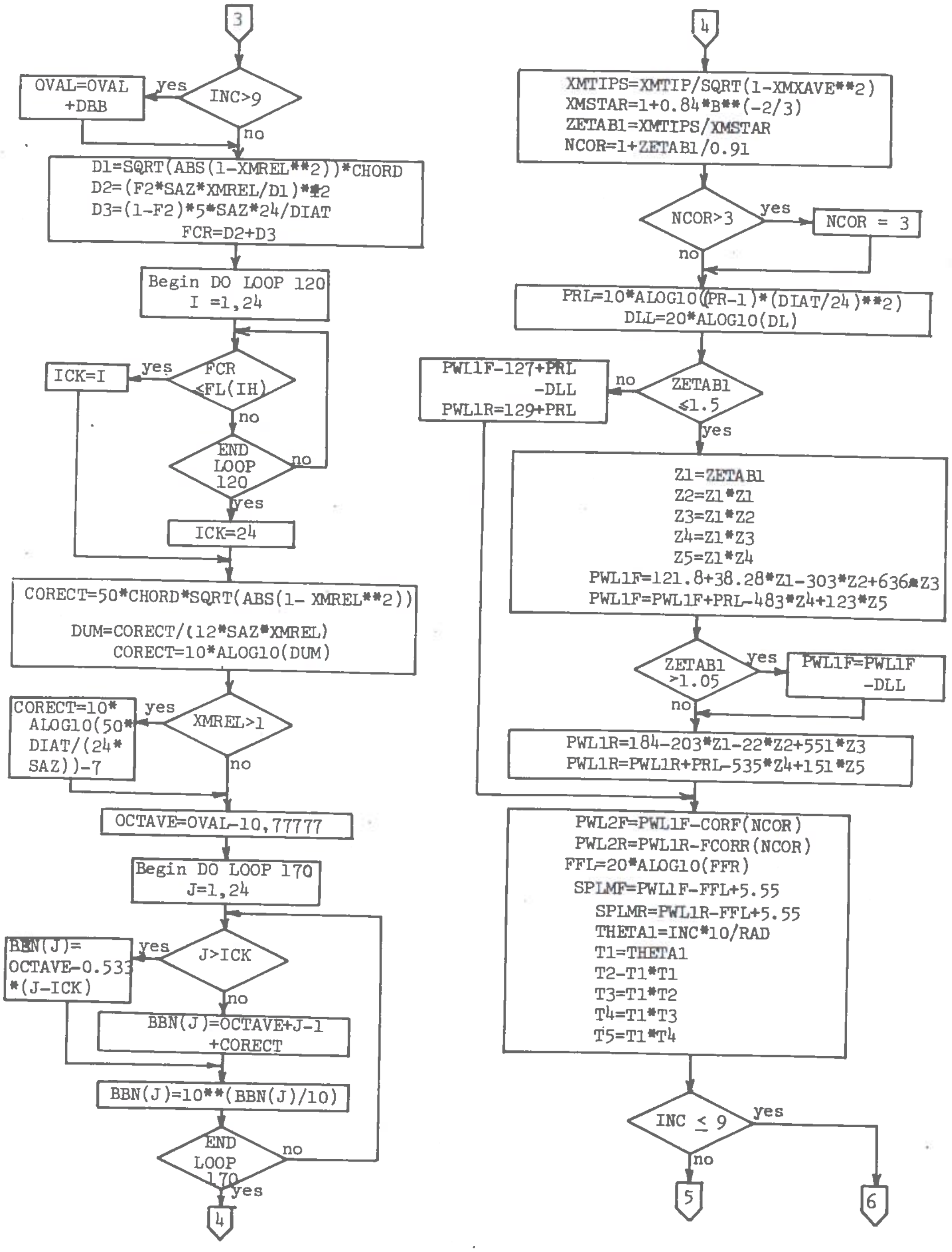
Subroutine PROP Flow Chart



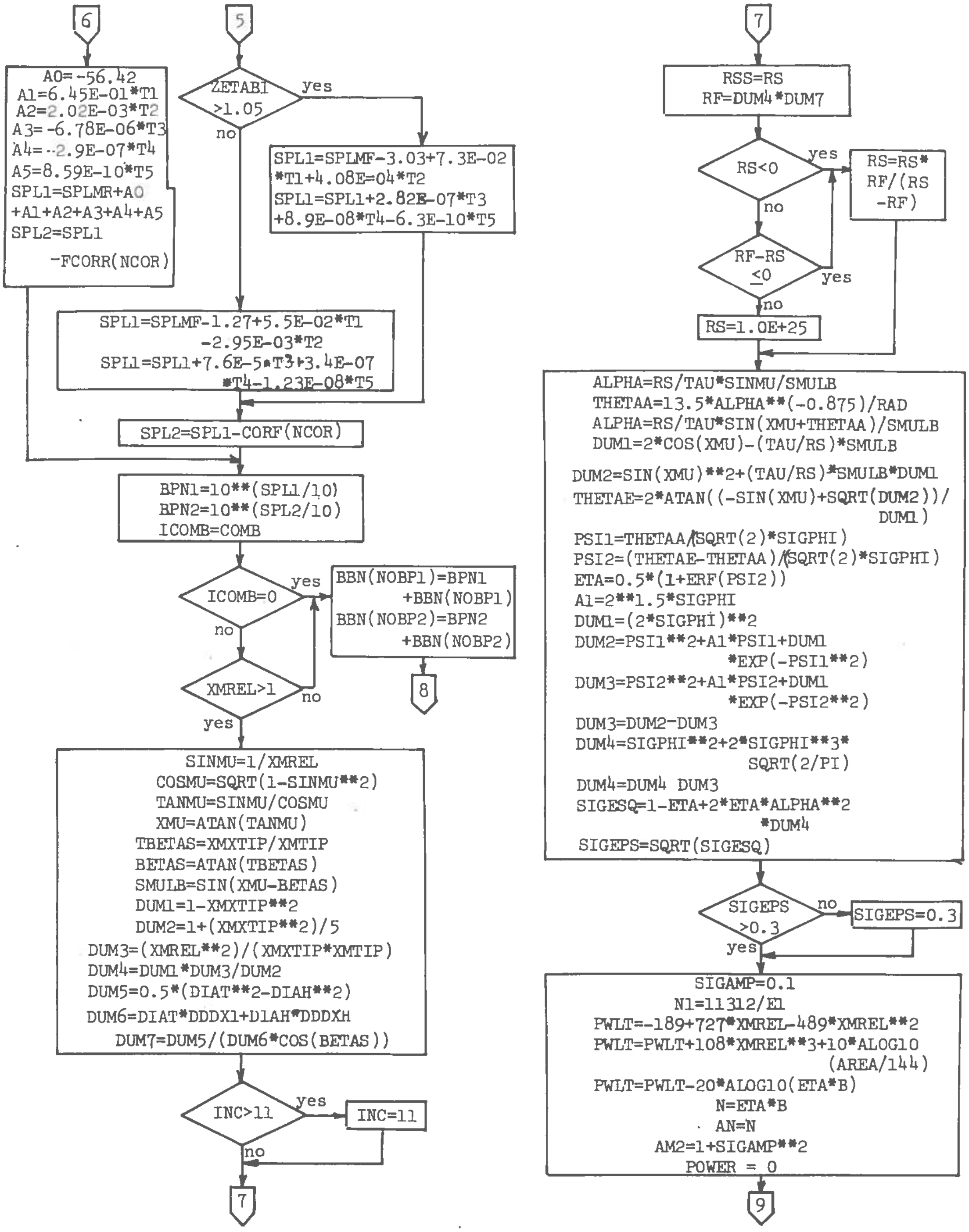
Subroutine PROP



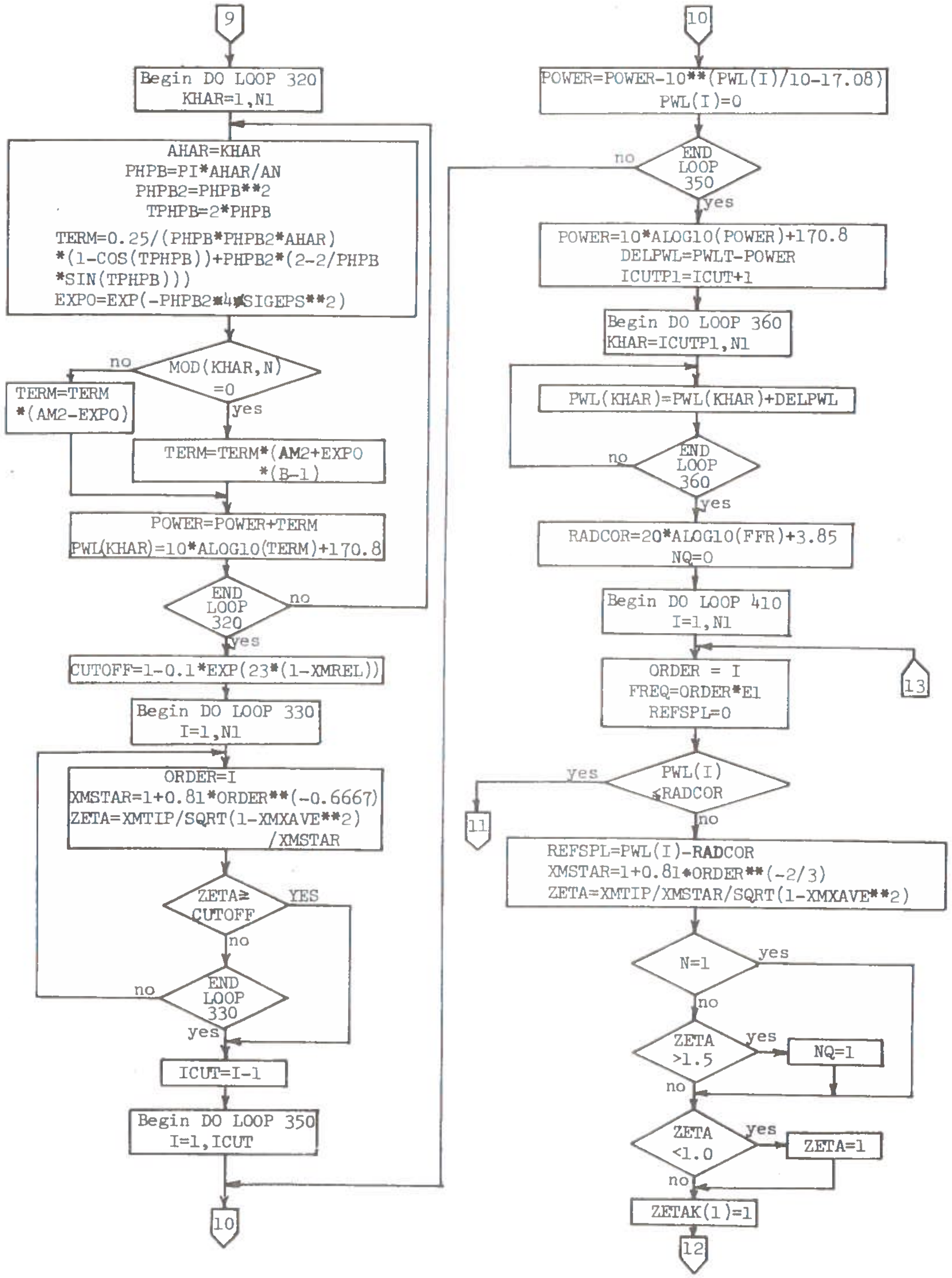
Subroutine FAN Flow Chart



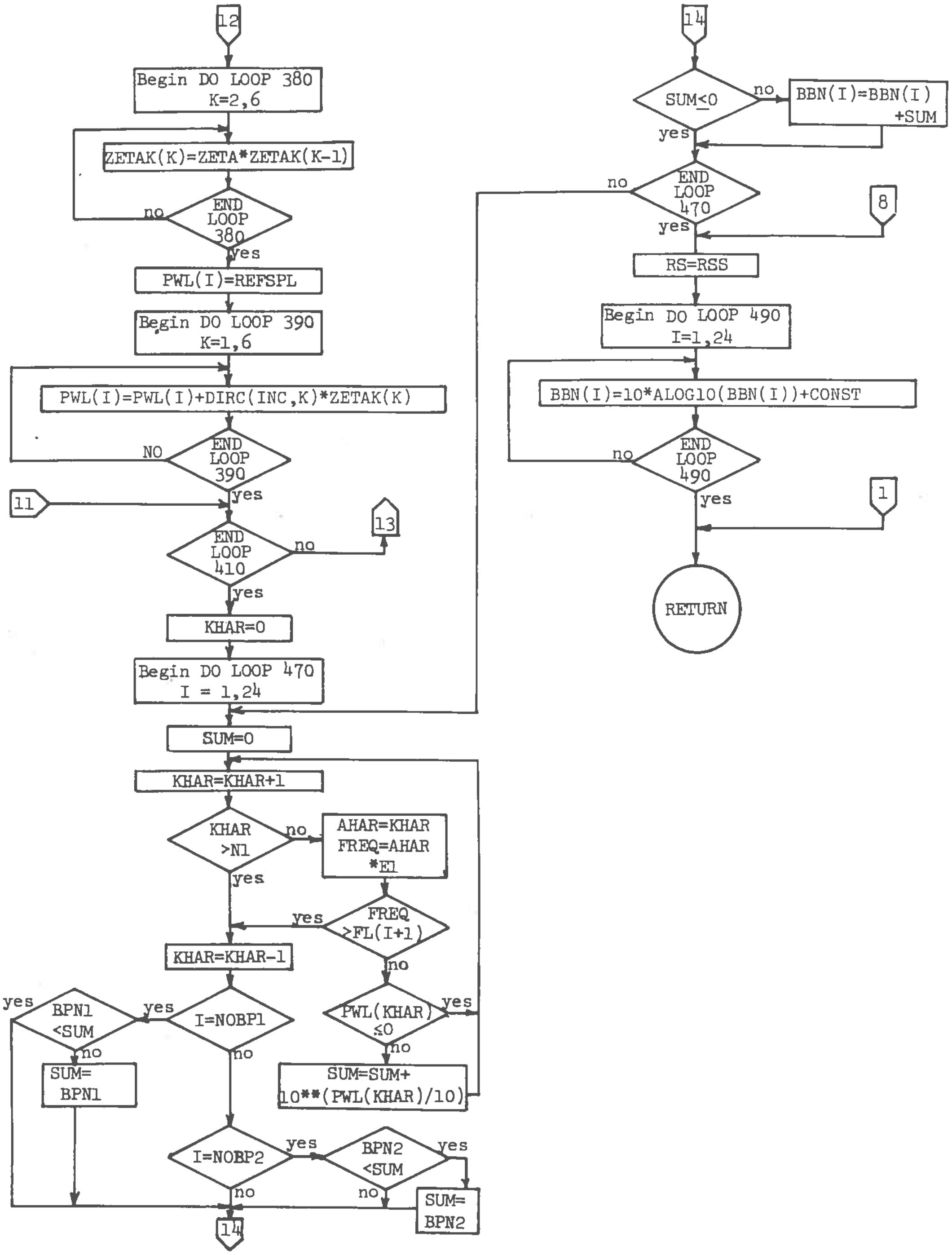
Subroutine FAN



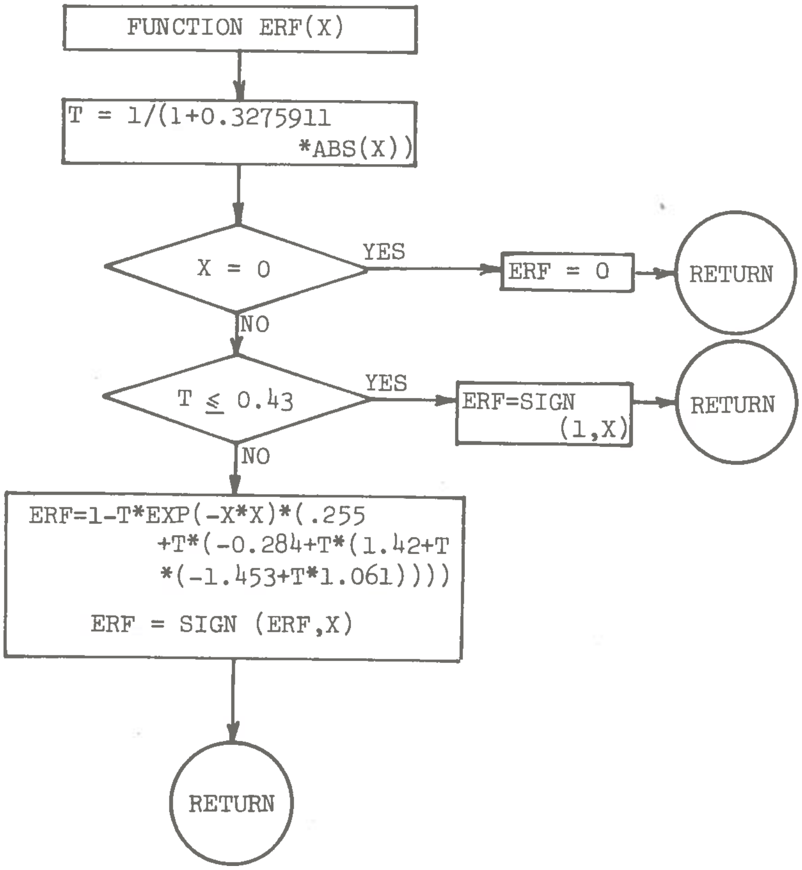
Subroutine FAN



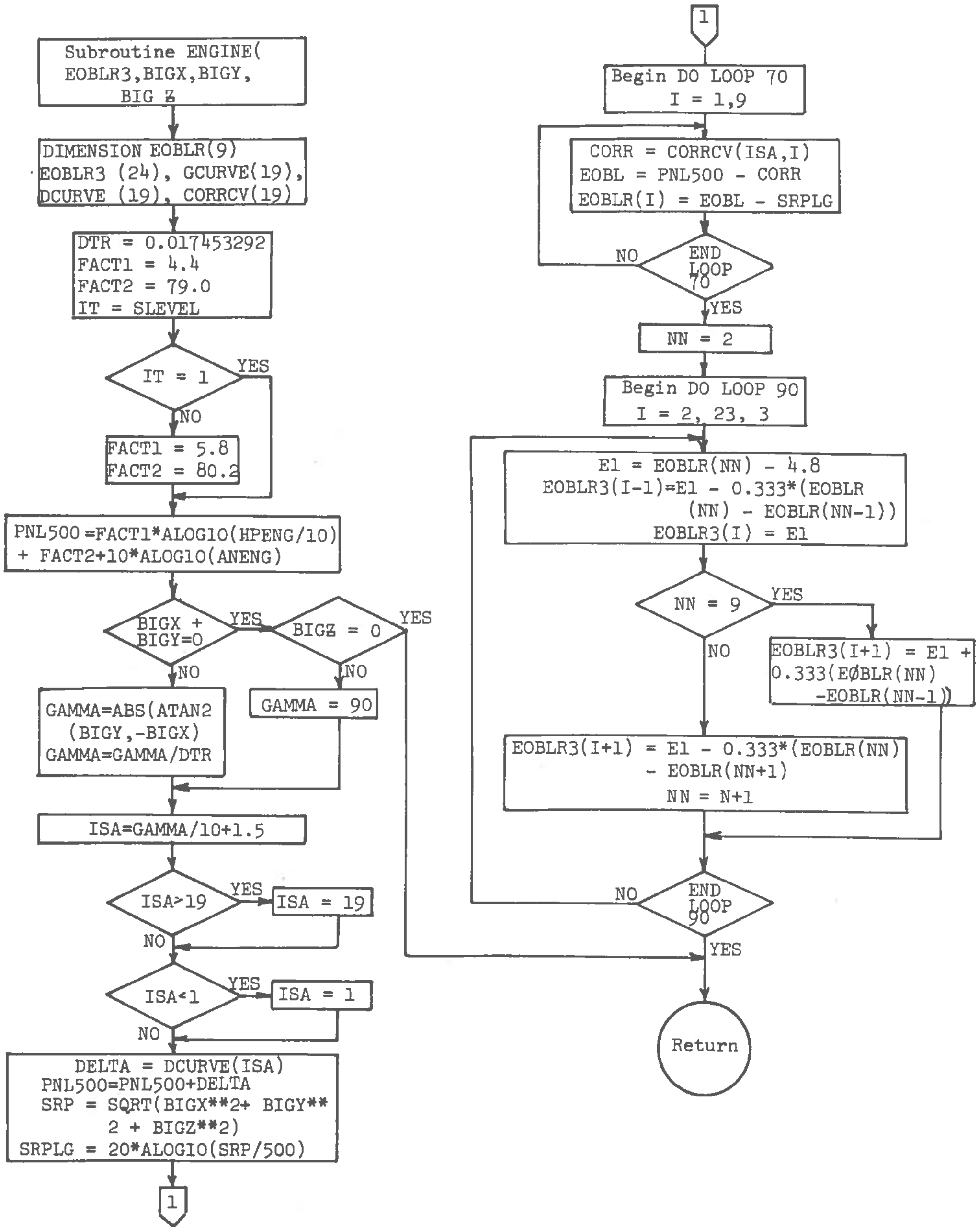
Subroutine FAN



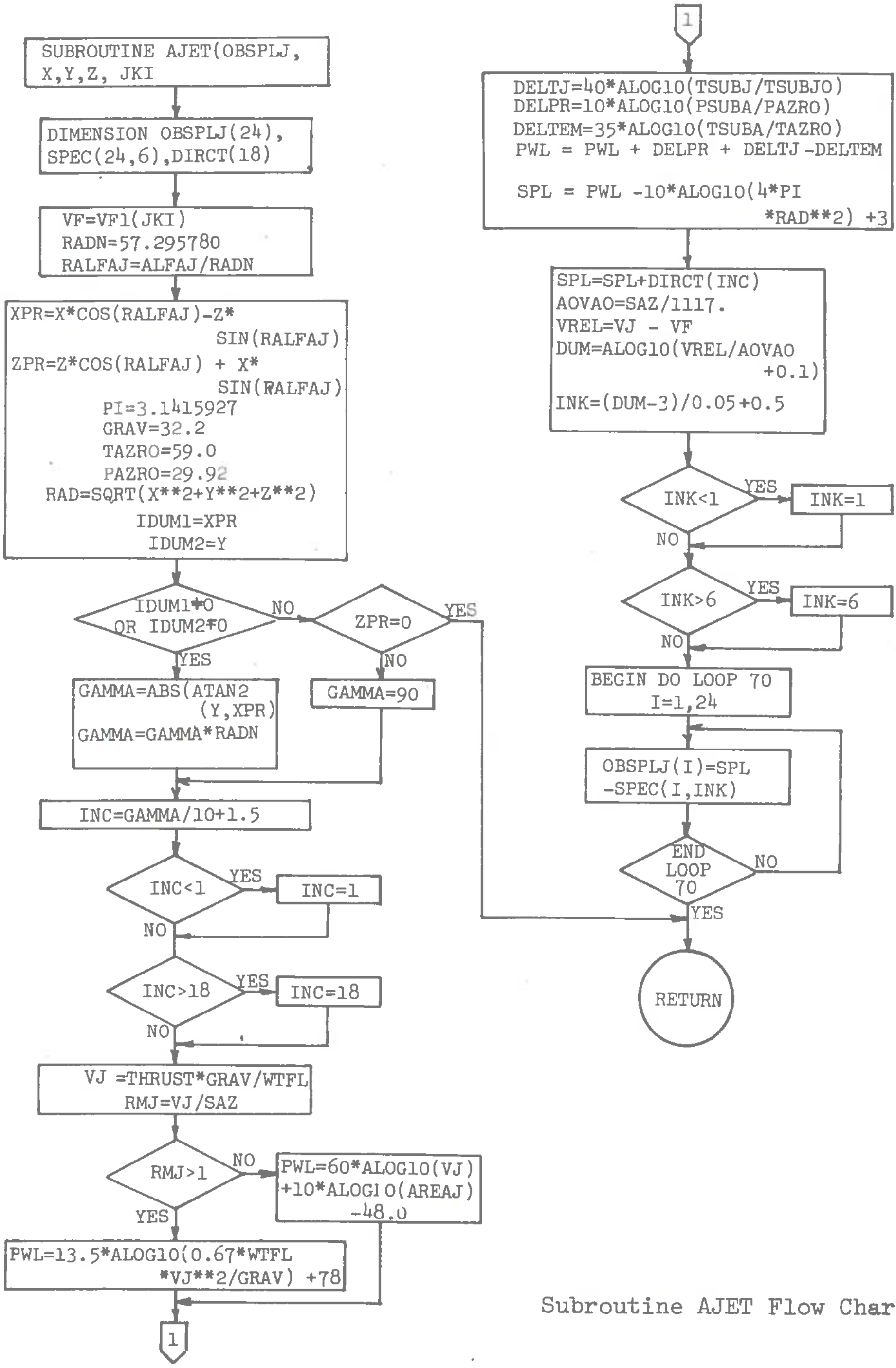
Subroutine FAN



Function ERF Flow Chart



Subroutine ENGINE Flow Chart



Subroutine AJET Flow Chart

APPENDIX D

V/STOL NOISE MODEL PROGRAM LISTING

The folowing pages contain the comilation listing and cross reference maps for the V/STOL Noise Model on an IBM 360/50 computer.

```
/*
//LKED.SYSLMOD DD DSN>A.AXX.Y080B2.LOAD.MODULE[Y080B2],
//    DISP>[NEW,KEEP,DELETE],UNIT>2314,VOL>SER>PACK07,
//    SPACE>[TRK,[5,1,1],RLSE],
//    DCB>[RECFM>U,BLKSIZE>7294]
/*
//Y080B2   EXEC  PGM>Y080B2
//STEPLIB  DD    DSN>A.AXX.Y080B2.LOAD.MODULE,UNIT>2314,VOL>SER>PACK07,
//         DISP>SHR
//FT05F001 DD    DDNAME>SYSIN
//FT06F001 DD    SYSOUT>A
//FT33F001 DD UNIT>SCRATCH,SPACE>[TRK,1],DCB>[RECFM>F,BLKSIZE>80]
//SYSIN    DD    *
C V/STOL VEHICLE NOISE PREDICTION PROGRAM   ---   DECK  Y080B
C
C PROGRAMMED IN FORTRAN IV BY C.L. MUNCH    ---   DECEMBER 1, 1972
C
C THIS PROGRAM WAS WRITTEN FOR THE TRANSPORTATION SYSTEMS CENTER OF THE
C DEPARTMENT OF TRANSPORTATION, 55 BROADWAY, CAMBRIDGE, MASSACHUSETTS.
C IT COMPUTES THE EPNL AND THE TIME HISTORIES OF PNL, PNLT, AND DBA AT
C UP TO 10 FIELD POINTS FOR A V/STOL VEHICLE DURING TAKEOFF, LANDING,
C OR CRUISE ALONG A SPECIFIED FLIGHT PATH.  THE FLIGHT PATH CONSISTS OF
C UP TO 50 STRAIGHT LINE OR HELICAL SEGMENTS.  AIRCRAFT OPERATING PARA-
C METERS ARE CONSTANT ALONG A FLIGHT SEGMENT, HOWEVER SOME OR ALL MAY
C CHANGE FROM SEGMENT TO SEGMENT.  NOISE SOURCES WHICH MAY BE INCLUDED
C ARE MAIN ROTORS, TAIL ROTORS, TURBOSHAFT ENGINES, PROPELLERS, LIFT AND
C CRUISE FANS, AND LIFT JETS.  SUBROUTINES INCLUDED ARE THE FOLLOWING:
C
C  ACPNLT      FLDPT       ADDER       ATTEN      PNL      DELTA    AJET
C  PROP        FAN         ENGINE      ROTOR      BJSIGN   BESSEL
C
C ALL INPUT IS ENTERED USING THE LOADER SUBROUTINE AND LABELED COMMON
C
      DIMENSION DBA[10,100],PN[10,100],PNLT[10,100],X[10,100],Y[10,100],Y0800110
     1Z[100],PNMAX[10],DBMAX[10],PMAX[10],FR[10],EPNL[10],XP[10]          Y0800120
     2,BES[400]                                                           Y0800130
```

```
      COMMON /B1/ BES,INCMAX[50]                                        Y0800140
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID, Y0800150
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,     Y0800160
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,       Y0800170
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50],  Y0800180
     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,   Y0800190
     5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,  Y0800200
     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,  Y0800210
     7ALFAJ,ROTR,RP,FANS,RJ,E                                           Y0800220
      COMMON /B2/ XP                                                    Y0800230
C
      EQUIVALENCE( LO, SAZ )
      DIMENSION    LO(421)
C                                                                       Y0800240
C
C  INITIAIZE LOADER VARIABLES TO ZERO   FIRST TIME THROUGH
C
      DO 5 I =1,421
 5    LO(I) = 0
C
C  INITIALIZE OUTPUT ARRAYS
C
      DO  2 J=1,100
      DO  2 I=1,10
      DBA(I,J) = 0.
      PN(I,J) = 0.
      PNLT(I,J) = 0.
 2    CONTINUE
C
C  INITIALIZE COMMON /B1/ TO ZERO
C
      DO 3 I=1,450
 3    BES(I) = 0.
      CALL LOADER[SAZ]                                                  Y0800280
C                                                                       Y0800290
C CALCULATE FIELD POINT VALUES                                          Y0800300
C                                                                       Y0800310
      CALL FLDPT[X,Y,Z,FR,INCZRO]                                       Y0800320
C                                                                       Y0800330
      IS > SEG < 0.00001                                                Y0800340
      N > 1                                                             Y0800350
      K > 1                                                             Y0800360
      IFPT > ANMFPT < 0.00001                                           Y0800370
      IK > INCMAX[1]                                                    Y0800380
      DO 10 L>1,IFPT                                                    Y0800390
      PNMAX[L] > 0.                                                     Y0800400
      DBMAX[L] > 0.                                                     Y0800410
   10 PMAX[L]  > 0.                                                     Y0800420
      L > 1                                                             Y0800430
   20 CONTINUE                                                          Y0800440
```

```
      WRITE [6,240]N,SAZ,SEG,ROTR,RP,FANS,RJ,E,ANMFPT                   Y0800450
      WRITE [6,250]RCASE,RBIGB,RBIGR,ROMEGN,RTHRUS,RETA,RBETA,RCHORD,RSIY0800460
     1D,RTORQ                                                           Y0800470
      WRITE [6,260]                                                     Y0800480
      WRITE [6,250]TCASE,TBIGB,TBIGR,TOMEGN,TTHRUS,TETA,TBETA,TCHORD,TSIY0800490
     1D,TTORQ                                                           Y0800500
      WRITE [6,270]PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP                     Y0800510
      WRITE [6,280]HPENG,SLEVEL,ANENG                                   Y0800520
      WRITE [6,290]DIAT,B,DDDXT,RS,TT2,DF,SIGPHI,RPM                    Y0800530
      WRITE [6,300]DIAH,BPR,DDDXH,DL,PT2,PR,XMXTIP,SPAF,CHORD,COMB,ALFA,Y0800540
     1FN                                                                Y0800550
      WRITE [6,310]THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,ALFA      Y0800560
      WRITE [6,320]AZERO,XPRZRO,YPRZRO,TINC                             Y0800570
      DO 30 I>1,IS                                                      Y0800580
   30 WRITE [6,330]I,ALF[I],VF1[I],XMAX[I],YMAX[I],INCMAX[I]            Y0800590
   40 RAD > SQRT[X[L,K]**2 < Y[L,K]**2 < Z[K]**2]                       Y0800600
C                                                                       Y0800610
C USE SUBROUTINE ACPNLT TO RETURN VALUES OF PNL, PNLT, AND DBA FOR EACH Y0800620
C VALUE OF K                                                            Y0800630
C                                                                       Y0800640
      CALL ACPNLT[RAD,N,X[L,K],Y[L,K],Z[K],DB,P,PNT]                    Y0800650
      PNLT[L,K] > PNT                                                   Y0800660
      DBA[L,K]  > DB                                                    Y0800670
      PN[L,K]   > P                                                     Y0800680
      IF[PNT .GT. PNMAX[L]] PNMAX[L] > PNT                              Y0800690
      IF[ DB .GT. DBMAX[L]] DBMAX[L] > DB                               Y0800700
      IF[  P .GT.  PMAX[L]]  PMAX[L] > P                                Y0800710
      IF [L.EQ.IFPT] GO TO 50                                           Y0800720
      L>L<1                                                             Y0800730
      GO TO 40                                                          Y0800740
   50 L > 1                                                             Y0800750
      K > K < 1                                                         Y0800760
      DUM > PNMAX[IFPT] - 10.0                                          Y0800770
      IF [PNT.GE.DUM] GO TO 60                                          Y0800780
      IF [K.GT.INCZRO] GO TO 80                                         Y0800790
   60 IF [K.LE.IK] GO TO 40                                             Y0800800
      N > N < 1                                                         Y0800810
      IF [N.GT.IS] GO TO 70                                             Y0800820
      CALL LOADER[SAZ]                                                  Y0800830
      IK > INCMAX[N]                                                    Y0800840
      GO TO 20                                                          Y0800850
   70 IF [K.GT.100] GO TO 100                                           Y0800860
      N > N - 1                                                         Y0800870
      GO TO 40                                                          Y0800880
   80 CONTINUE                                                          Y0800890
      IF [IFPT.EQ.1] GO TO 100                                          Y0800900
      IL > IFPT - 1                                                     Y0800910
      DO 90 I>1,IL                                                      Y0800920
      DUM > PNMAX[I] - 10.0                                             Y0800930
      IF [PNLT[I,K-1].GT.DUM] GO TO 60                                  Y0800940
```

```
   90 CONTINUE                                                          Y0800950
  100 CONTINUE                                                          Y0800960
      DO 120 L>1,IFPT                                                   Y0800970
      DUM > PNMAX[L] - 10.50001                                         Y0800980
      SUM > 0.                                                          Y0800990
      KK > K - 1                                                        Y0801000
      DO 110 I>1,KK                                                     Y0801010
      PNDB > PNLT[L,I]                                                  Y0801020
      IF [PNDB.LT.DUM] GO TO 110                                        Y0801030
      YY > 10.0 ** [PNDB/10.0]                                          Y0801040
      SUM > SUM < YY                                                    Y0801050
  110 CONTINUE                                                          Y0801060
      DURCOR> 10.0 * ALOG10[SUM * TINC/10.0 < 0.1] - PNMAX[L]           Y0801070
      EPNL[L] > PNMAX[L] < DURCOR                                       Y0801080
  120 CONTINUE                                                          Y0801090
C                                                                       Y0801100
C END CALCULATION OF VEHICLE EPNL. AT THIS POINT AVAILABLE QUANTITIES   Y0801110
C ARE THE FOLLOWING :                                                   Y0801120
C            * VEHICLE EPNL                                             Y0801130
C            * SLANT RANGE                                              Y0801140
C            * DBA TIME HISTORY AND MAXIMUM DBA                         Y0801150
C            * PNL TIME HISTORY AND MAXIMUM PNL                         Y0801160
C            * PNLT TIME HISTORY AND MAXIMUM PNLT                       Y0801170
C            * DURATION CORRECTION                                      Y0801180
C            * INPUT VARIABLES                                          Y0801190
C                                                                       Y0801200
C THE FOLLOWING WRITE STATEMENTS ARE USED IN DEBUG STAGE ONLY           Y0801210
C                                                                       Y0801220
C                                                                       Y0801230
      WRITE [6,130]                                                     Y0801240
  130 FORMAT[1H1,25X,39H CHECKOUT CASE FOR V/STOL VEHICLE NOISE,        Y0801250
     119H PREDICTION PROGRAM,/,26X,57[1H-]]                             Y0801260
      WRITE [6,140]TINC,XPRZRO,YPRZRO,AZERO,THMAXO                      Y0801270
  140 FORMAT[//,: TINC>:,F5.2,2X,:XPRZRO>:,F10.2,2X,:YPRZRO>:,F7.2,2X,  Y0801280
     1:AZERO>:,F7.2,2X,:THMAXO>:,F7.2,//,3X,:SEG:,4X,:PATH:,3X,:ALFN:,3XY0801290
     2,:VF1:,4X,:XMAX:,3X,:YMAX:,2X,:RADIUS:,2X,:PHIMAX:,/,57[1H-]]     Y0801300
      DO 150 L>1,IS                                                     Y0801310
  150 WRITE [6,160]L,PATH[L],ALF[L],VF1[L],XMAX[L],YMAX[L],RADIUS[L],PHMY0801320
     1AX[L]                                                             Y0801330
  160 FORMAT[1X,I5,2X,7F7.1]                                            Y0801340
      WRITE [6,180]                                                     Y0801350
      DO 170 L>1,IFPT                                                   Y0801360
  170 WRITE [6,190]FR[L],EPNL[L],PNMAX[L],PMAX[L],DBMAX[L],XP[L]        Y0801370
      WRITE [6,210]TINC,IFPT                                            Y0801380
      WRITE [6,200][[PNLT[L;K],K>1,100],L>1,IFPT]                       Y0801390
      WRITE [6,220]TINC,IFPT                                            Y0801400
      WRITE [6,200][[PN[L,K],K>1,100],L>1,IFPT]                         Y0801410
      WRITE [6,230]TINC,IFPT                                            Y0801420
      WRITE [6,200][[DBA[L,K],K>1,100],L>1,IFPT]                        Y0801430
  180 FORMAT[///,3X,:RANGE:,3X,:EPNL:,4X,:PNLTM:,4X,:PNL:,5X,:DBA:,7X,  Y0801480
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     1:XPR:,/,1X,49[1H-]]                                               Y0801490
 190 FORMAT[1X,F7.2,4F8.2,F10.1]                                        Y0801500
 200 FORMAT[10F10.2]                                                    Y0801510
 210 FORMAT[///,1X,:PNLT TIME HISTORY IN:,F4.1,: SECOND INCREMENTS FOR:,Y0801520
     1,I3,: FIELD POINTS:]                                              Y0801530
 220 FORMAT[///,1X,:PNL TIME HISTORY IN:,F4.1,: SECOND INCREMENTS FOR:,Y0801540
     1I3,: FIELD POINTS:]                                               Y0801550
 230 FORMAT[///,1X,:DBA TIME HISTORY IN:,F4.1,: SECOND INCREMENTS FOR:,Y0801560
     1I3,: FIELD POINTS:]                                               Y0801570
 240 FORMAT[////,25[1H*],:INPUT VARIABLES:,25[1H*],/,24[1H*],           Y0801580
     1:FLIGHT SEGMENT:,I3,24[1H*],//,: COMMON:,                         Y0801590
     2: VARIABLES &:,/,16[1H-],/,: SAZ >:,F9.2,:  SEG >:,F6.2,          Y0801600
     3:  ROTR >:,F4.1,: RP >:,F4.1,: FANS >:,F4.1,: RJ >:,F4.1,: E >:,  Y0801610
     4F4.1,: ANMFPT >:,F5.1,//,: MAIN ROTOR VARIABLES &:,/,21[1H-]]     Y0801620
 250 FORMAT[:  SM-K >:,F5.2,3X,:BIGB >:,F6.2,3X,:BIGR >:,F7.2,3X,       Y0801630
     1:OMEGN >:,F8.2,3X,:THRUS >:,F9.1,/,:  ETA >:,F5.2,3X,:BETA >:,    Y0801640
     2F6.2,3X,:CHORD >:,F7.2,3X,:SID   >:,F8.2,3X,:TORQ  >:,F9.1]       Y0801650
 260 FORMAT[/,: TAIL ROTOR VARIABLES &:,/,21[1H-]]                      Y0801660
 270 FORMAT[/,: PROPELLER VARIABLES &:,/,20[1H-],/,: POWER >:,F7.1,     Y0801670
     1:  DIA >:,F7.2,:  BIGB >:,F5.1,:  RPM >:,F8.2,:  NUMPRP >:,F5.1,  Y0801680
     2:  CHORD >:,F7.2]                                                 Y0801690
 280 FORMAT[/,: ENGINE VARIABLES &:,/,17[1H-],/,:  POWER >:,F7.1,       Y0801700
     1:  SLEVEL >:,F4.1,:  NUMENG >:,F4.1]                              Y0801710
 290 FORMAT[/,: FAN VARIABLES &:,/,14[1H-],/,:  DIAT >:,F6.2,:  B   >:,Y0801720
     1F6.2,:  DDDXT >:,F7.2,:  RS >:,F8.2,:  TT2 >:,F6.2,:  DF >:,F6.2, Y0801730
     2:  SIGPHI >:,F5.2,:  RPM >:,F7.2]                                 Y0801740
 300 FORMAT[:  DIAH >:,F6.2,:  BPR >:,F6.2,:  DDDXH >:,F7.2,:  DL >:,   Y0801750
     1F8.2,:  PT2 >:,F6.2,:  PR >:,F6.2,:  XMXTIP >:,F5.2,:  SPAF >:,   Y0801760
     2F7.2,/,:  CHORD>:,F6.2,:  COMR>:,F6.2,:  ALFA >:,F7.2,            Y0801770
     3:  FN >:,F8.2]                                                    Y0801780
 310 FORMAT[/,: JET VARIABLES &:,/,14[1H-],/,:  THRUST >:,F8.1,         Y0801790
     1:  WTFL >:,F7.2,:  AREAJ >:,F7.2,:  PSUBA >:,F6.2,:  TSUBA >:,    Y0801800
     2F6.2,:  TSUBJ >:,F6.1,:  TSUBJO >:,F6.1,: ALFA>:,F5.1]            Y0801810
 320 FORMAT[/,: FIELD POINT VARIALBES &:,/,22[1H-],/,:  AZERO >:,F8.2, Y0801820
     1:  XPRZRO >:,F8.1,:  ZPRZRO >:,F8.1,:  TINC >:,F5.2,//,:  SEG:,   Y0801830
     23X,:THETA:,3X,:SPEED:,3X,:XBREAK:,3X,!YBREAK:,3X,:INCMAX:,/,2X,   Y0801840
     33[1H-],2X,6[1H-],2X,6[1H-],2X,8[1H-],2X,8[1H-],2X,6[1H-]]         Y0801850
 330 FORMAT[I5,2F8.2,2F10.2,I6]                                         Y0801860
      END                                                               Y0801890
      SUBROUTINE FLDPT[FX,FY,FZ,FR,INCZRO]                              FLDP0010
C                                                                       FLDP0020
C  TITLE:    FIELD POINT
C
C  PURPOSE   TO CALCULATE THE X,Y,Z COORDINATES OF THE AIRCRAFT RELATIVE
C            TO THE OBSERVER ON THE GROUND.
C
C
C  ABSTRACT: THE POSITION OF THE AIRCRAFT AT GIVEN INSTANTS OF TIME IS
C            CALCULATED IN COORDINATES X',Y',Z' WHICH ARE STATIONARY
C            WITH THE ORIGIN LOCATED AT THE TAKEOFF POINT.  THESE POINTS
C            ARE THEN TRANSFORMED INTO THE X,Y,Z SYSTEM WHOSE ORIGIN IS
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C           AT THE AIRCRAFT.  THE X-AXIS IS IN THE DIRECTION OF FLIGHT,
C           THE Z-AXIS IS POSITIVE DOWNWARD, AND THE Y-AXIS IS TO THE
C           RIGHT.  ALL REQUIRED INPUT IS ENTERED VIA THE LABELED
C           COMMON BLOCK 'INPUT'.  THE REQUIRED INPUT IS THE FOLLOWING:
C
C             FLTYPE..........FLIGHT TYPE, 1=TAKEOFF, 2=LANDING
C             PATH(I).........FLIGHT PATH SEGMENT TYPE  1=HELICAL
C                                                       2=STRAIGHT
C             XMAX(I).........END POINT COORDINATES OF EACH
C             YMAX(I)         STRAIGHT LINE FLIGHT SEGMENT
C             PHMAX(I)........MAXIMUM ANGLE THROUGH WHICH AIRCRAFT
C                             TURNS ON HELICAL FLIGHT SEGMENT 'I' (DEG)
C                             POSITIVE FOR LEFT TURNS AND NEGATIVE
C                             FOR RIGHT TURNS.
C             RADIUS(I).......TURNING.RADIUS OF HELICAL SEGMENT 'I'
C             VF1(I)..........SPEED ALONG FLIGHT SEGMENT 'I'
C             ALF(I)..........ANGLE OF CLIMB OR DESCENT ALONG SEGMENT I
C             XPRZRO..........COORDINATE LOCATION
C             YPRZRO          OF THE OBSERVER
C             THMAXO..........ANGLE BETWEEN FLIGHT SEGMENT I AND X AXIS
C             AZERO...........ALTITUDE AT START OF FLIGHT
C             TINC............TIME INCREMENT BETWEEN CALCULATIONS
C             ANMFPT..........NUMBER OF OBSERVER LOCATIONS
C
C USAGE:     FLDPT(FX,FY,FZ,FR,INCZRO)
C            FX
C            FY.....FIELD POINT COORDINATES FOR UP TO 100 LOCATIONS
C            FZ     RETURNED TO MAIN PROGRAM
C            FR.....CALCULATED SLANT RANGE FOR UP TO 10 OBSERVER POINTS
C            INCZRO.CALCULATED INCREMENT NUMBER (TIME) WHEN AIRCRAFT
C                   PASSES CLOSEST TO OBSERVER POINT XPRZRO,YPRZRO
C LABELED
C   COMMON: /B1/  /INPUT/  /B2/
C           /B1/ CONTAINS UP TO 50 VALUES OF INCMAX WHICH ARE INCREMENT
C                NUMBERS FOR THE END POINTS OF EACH FLIGHT SEGMENT
C           /INPUT/ CONTAINS INPUT DATA FROM LOADER
C           /B2/ CONTAINS UP TO 10 VALUES OF XP..CALCULATED X-AXIS
C                COORDINATES OF 10 OBSERVER LOCATIONS
C
C SUBROUTINES CALLED......NONE
C
      DIMENSION FX[10,100],FY[10,100],FZ[100],XP[10],FR[10]            FLDP0030
     1,BES[400]                                                        FLDP0040
      COMMON /B1/ BES,INCMAX[50]                                       FLDP0050
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID, FLDP0060
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,     FLDP0070
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,       FLDP0080
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50],  FLDP0090
     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,   FLDP0100
     5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,  FLDP0110
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     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,  FLDP0120   01151
     7ALFAJ,ROTR,RP,FANS,RJ,E                                            FLDP0130   01152
      COMMON /B2/ XP                                                     FLDP0140   01153
C                                                                        FLDP0150   01154
      DTR > 0.017453925                                                  FLDP0180   01155
      IFTYPE > FLTYPE < 0.00001                                          FLDP0190   01156
      N  > 1                                                             FLDP0200   01157
      ISEG > SEG < 0.0001                                                FLDP0210   01158
      INCZRO > 100                                                       FLDP0220   01159
      IFPT > ANMFPT < 0.0001                                             FLDP0230   01160
      DUD  > XPRZRO / IFPT                                               FLDP0240   01161
      TMAX1 > 0.                                                         FLDP0250   01162
      XMAX1 > 0.                                                         FLDP0260   01163
      YMAX1 > 0.                                                         FLDP0270   01164
      ZMAX1 > AZERO                                                      FLDP0280   01165
      ALFN  > ALF[1] * DTR                                               FLDP0290   01166
      PHMAXN > PHMAX[1] * DTR                                            FLDP0300   01167
      THMAX1 > THMAX0 * DTR                                              FLDP0310   01168
C                                                                        Y0800070   01169
C CALCULATE COORDINATES FOR IFPT OBSERVERS                                          01170
C                                                                                   01171
      DO 10 II>1,IFPT                                                    FLDP0320   01172
   10 XP[II] > II * DUD                                                  FLDP0330   01173
      IF [ISEG.NE.1] GO TO 20                                            FLDP0340   01174
      TMAX > 100.0 * TINC < 1.0                                          FLDP0350   01175
      GO TO 60                                                           FLDP0360   01176
   20 IPTH  >  PATH[1] < 0.0001                                          FLDP0370   01177
      IPTH > PATH[1] < 0.0001                                            FLDP0380   01178
      IF [IPTH.EQ.1] GO TO 50                                            FLDP0390   01179
C                                                                                   01180
C CALCULATE END POINTS AND TMAX FOR SEGMENT 1 IF STRAIGHT LINE                      01181
C                                                                                   01182
      IDM > ABS[THMAX0] < 0.0001                                         FLDP0400   01183
      IF [IDM.EQ.90] GO TO 30                                            FLDP0410   01184
      IF [IDM.EQ.270] GO TO 30                                           FLDP0420   01185
      TMAX > ABS[XMAX[1]] / ABS[VF1[1]*COS[THMAX1]*COS[ALFN]]            FLDP0430   01186
      YMAX[1] > VF1[1] * TMAX * COS[ALFN] * SIN[THMAX1]                  FLDP0440   01187
      GO TO 40                                                           FLDP0450   01188
   30 TMAX > ABS[YMAX[1]] / ABS[VF1[1] * COS[ALFN]]                      FLDP0460   01189
      XMAX[1] > VF1[1] * TMAX * COS[ALFN] * COS[THMAX1]                  FLDP0470   01190
   40 ZMAX > VF1[1] * TMAX * SIN[ALFN]                                   FLDP0480   01191
      THMAX > THMAX1                                                     FLDP0490   01192
      GO TO 60                                                           FLDP0500   01193
C                                                                                   01194
C CALCULATE END POINTS AND TMAX FOR SEGMENT 1 IF HELICAL                            01195
C                                                                                   01196
   50 APHMAX > ABS[PHMAXN]                                               FLDP0510   01197
      SPHMAX > SIN[APHMAX/2]                                             FLDP0520   01198
      SUMANG > THMAX1 < 0.5 * PHMAXN                                     FLDP0530   01199
      TMAX > RADIUS[1] * APHMAX / ABS[ VF1[1] * COS[ALFN]]               FLDP0540   01200
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      DUMMY   > 2.0 * RADIUS[1] * SPHMAX                                 FLDP0550
      XMAX[1] > DUMMY * COS[SUMANG]                                      FLDP0560
      YMAX[1] > DUMMY * SIN[SUMANG]                                      FLDP0570
      ZMAX > AZERO < RADIUS[1] * APHMAX * TAN[ALFN]                      FLDP0580
      THMAX > THMAX1 < PHMAXN                                            FLDP0590
   60 CONTINUE                                                           FLDP0600
C                                                                        FLDP0610
C BEGIN LOOP TO CALCULATE POINTS ALONG FLIGHT PATH                       FLDP0620
C                                                                        FLDP0630
      DO 240 K>1,100                                                     FLDP0640
      T > K * TINC                                                       FLDP0650
      IF [T.LT.TMAX] GO TO 160                                           FLDP0660
      INCMAX[N] > K-1                                                    FLDP0670
      N > N < 1                                                          FLDP0680
      TMAX1 > TMAX                                                       FLDP0690
      XMAX1 > XMAX[N-1]                                                  FLDP0700
      YMAX1 > YMAX[N-1]                                                  FLDP0710
      ZMAX1 > ZMAX                                                       FLDP0720
      THMAX1 > THMAX                                                     FLDP0730
      ALFN > ALF[N] * DTR                                                FLDP0740
      IF [N.LT.ISEG] GO TO 70                                            FLDP0750
      TMAX > 100. * TINC < 1.0                                           FLDP0760
      IPATH > PATH[N] < 0.0001                                           FLDP0770
      IF [IPATH.EQ.1] GO TO 180                                          FLDP0780
      GO TO 150                                                          FLDP0790
C
C CALCULATION FOR STRAIGHT LINE SEGMENTS
C
   70 IF [THMAX1.LT.0.] GO TO 90                                         FLDP0800
   80 IF [THMAX1.LT.6.28319] GO TO 100                                   FLDP0810
      THMAX1 > THMAX1 - 6.28319                                          FLDP0820
      GO TO 80                                                           FLDP0830
   90 IF [THMAX.GT.-6.28319] GO TO 100                                   FLDP0840
      THMAX1 > THMAX1 < 6.28319                                          FLDP0850
      GO TO 90                                                           FLDP0860
  100 CONTINUE                                                           FLDP0870
      IPATH > PATH[N] < 0.00001                                          FLDP0880
      IF [IPATH.EQ.1] GO TO 170                                          FLDP0890
      IDUM > ABS[THMAX1 / DTR]                                           FLDP0900
      IF [IDUM.EQ.90] GO TO 110                                          FLDP0910
      IF [IDUM.EQ.270] GO TO 110                                         FLDP0920
      TMAX > TMAX1 < ABS[[XMAX[N] - XMAX1] / [VF1[N]*COS[ALFN]           FLDP0930
     1 * COS[THMAX1]]]                                                   FLDP0940
      GO TO 120                                                          FLDP0950
  110 TMAX > TMAX1 < ABS[[YMAX[N] - YMAX1] / [VF1[N]*COS[ALFN]]]         FLDP0960
  120 THMAX > THMAX1                                                     FLDP0970
      T1 > TMAX - TMAX1                                                  FLDP0980
      DXMAX > XMAX1 < VF1[N] * T1 * COS[ALFN] * COS[THMAX]               FLDP0990
      DYMAX > YMAX1 < VF1[N] * T1 * COS[ALFN] * SIN[THMAX]               FLDP1000
      ZMAX  > ZMAX1 < VF1[N] * T1 * SIN[ALFN]                            FLDP1010
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      DELX > ABS[ XMAX[N] - DXMAX ]                                     FLDP1020
      DELY > ABS[ YMAX[N] - DYMAX ]                                     FLDP1030
      ERRX > DELX / XMAX[N]                                             FLDP1040
      ERRY > DELY / YMAX[N]                                             FLDP1050
      IF [ERRX.LE.0.1] GO TO 140                                        FLDP1060
      IF [ERRY.LE.0.1] GO TO 140                                        FLDP1070
C
C WRITE WARNING MESSAGE IF CALCULATED END POINTS OF STRAIGHT LINE
C SEGMENT DISAGREE WITH INPUT VALUES BY MORE THAN 10 PER-CENT
C
      WRITE [6,130]N,DXMAX,DYMAX,XMAX[N],YMAX[N],K                      FLDP1080
  130 FORMAT[//,: CALCULATED END POINTS FOR SEGMENT:,I3,: DO NOT AGREE:,FLDP1090
     1: WITH INPUT.  CALCULATION PROCEEDING WITH NEW END POINTS.:,//,   FLDP1100
     2: X CALCULATED>:,F8.1,:  Y CALCULATED>:,F8.1,:  X INPUT>:,F8.1,   FLDP1110
     3:  Y INPUT>:,F8.1,/,: OCCURED AT INCREMENT NUMBER:,I3]            FLDP1120
  140 XMAX[N] > DXMAX                                                   FLDP1130
      YMAX[N] > DYMAX                                                   FLDP1140
      TMAX > TMAX1 < ABS[[XMAX[N]-XMAX1]/[VF1[N]*COS[ALFN]*COS[THMAX1]]]FLDP1150
      ZMAX > ZMAX1 < VF1[N]*[TMAX-TMAX1]* SIN[ALFN]                     FLDP1160
  150 DUM1 > VF1[N] * [T - TMAX1] * COS[ALFN]                           FLDP1170
      XPR > XMAX1 < DUM1 * COS[THMAX]                                   FLDP1180
      YPR > YMAX1 < DUM1 * SIN[THMAX]                                   FLDP1190
      ZPR > ZMAX1 < VF1[N] * [T - TMAX1] * SIN[ALFN]                    FLDP1200
      DUMANG > THMAX1                                                   FLDP1210
      GO TO 190                                                         FLDP1220
  160 IPATH > PATH[N] < 0.00001                                         FLDP1230
      IF [IPATH.EQ.1] GO TO 180                                         FLDP1240
      GO TO 150                                                         FLDP1250
C
C CALCULATION FOR HELICAL SEGMENTS
C
  170 PHMAXN > PHMAX[N] * DTR                                           FLDP1260
      APHMAX > ABS[PHMAXN]                                              FLDP1270
      SPHMAX > SIN[APHMAX/2]                                            FLDP1280
      SUMANG > THMAX1 < PHMAXN/2                                        FLDP1290
      TMAX > TMAX1 < RADIUS[N] * APHMAX / [COS[ALFN] * VF1[N]]          FLDP1300
      XMAX[N] > XMAX1 < 2. * RADIUS[N] * SPHMAX * COS[SUMANG]           FLDP1310
      YMAX[N] > YMAX1 < 2. * RADIUS[N] * SPHMAX * SIN[SUMANG]           FLDP1320
      ZMAX > ZMAX1 < RADIUS[N] * APHMAX * TAN[ALFN]                     FLDP1330
      THMAX > THMAX1 < PHMAXN                                           FLDP1340
  180 CONTINUE                                                          FLDP1350
      PHISK > VF1[N] * [T - TMAX1] * COS[ALFN] / RADIUS[N]              FLDP1360
      APHMAX > ABS[PHISK]                                               FLDP1370
      DUM1 > 2.0 * RADIUS[N] * SIN[APHMAX/2]                            FLDP1380
      SUMANG > THMAX1 < PHISK/2.                                        FLDP1390
      XPR > XMAX1 < DUM1 * COS[SUMANG]                                  FLDP1400
      YPR > YMAX1 < DUM1 * SIN[SUMANG]                                  FLDP1410
      ZPR > ZMAX1 < RADIUS[N] * APHMAX *TAN[ALFN]                       FLDP1420
      DUMANG > PHISK < THMAX1                                           FLDP1430
  190 CONTINUE                                                          FLDP1440
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      IF [IFTYPE.EQ.1] GO TO 200                                        FLDP1450
      DUMANG > DUMANG < 1.5707963                                       FLDP1460
  200 COSTHK > COS[DUMANG]                                              FLDP1470
      SINTHK > SIN[DUMANG]                                              FLDP1480
C
C CALCULATE X,Y,Z FIELD POINTS FOR EACH OF IFPT OBSERVERS
C
      DO 220 L>1,IFPT                                                   FLDP1490
      FX[L,K] >[XP[L]-XPR]*COSTHK < [YPRZRO-YPR]*SINTHK                 FLDP1500
      FY[L,K] >-[YPRZRO-YPR]*COSTHK <[XP[L]-XPR]*SINTHK                 FLDP1510
      DUM1 > [XPR - XP[L]]**2                                           FLDP1520
      DUM2 > [YPR - YPRZRO]**2                                          FLDP1530
      FRD > SQRT[DUM1 < DUM2 < ZPR**2]                                  FLDP1540
      IF [K.EQ.1] GO TO 210                                             FLDP1550
      IF [FRD.GE.FR[L]] GO TO 220                                       FLDP1560
  210 FR[L] > FRD                                                       FLDP1570
      INCZRO > K                                                        FLDP1580
  220 CONTINUE                                                          FLDP1590
  230 FZ[K] > ZPR                                                       FLDP1600
  240 CONTINUE                                                          FLDP1610
      RETURN                                                            FLDP1620
      END                                                               FLDP1630
      SUBROUTINE ACPNLT[RAD,JI,X,Y,Z,DB,PN,PNT]                         ACPN0010
C                                                                       ACPN0020
C  TITLE:     SUBROUTINE ACPNLT
C
C  PURPOSE:   TO CALCULATE THE TOTAL VEHICE ONE-THIRD OCTAVE BAND NOISE
C             SPECTRUM AT A SPECIFIED OBSERVER FOR A GIVEN AIRCRAFT
C             POSITION ON THE FLIGHT PATH, TO APPLY THE NECESSARY
C             ATMOSPHERIC ABSORPTION TO THE SPECTRUM, AND CALCULATE THE
C             RESULTING PNL, PNLT, AND DBA OF THE SPECTRUM.
C
C  ABSTRACT:  THE SUBROUTINE IS CALLED BY THE MAIN PROGRAM. IT CALLS THE
C             NECESSARY COMPONENT NOISE PREDICTION ROUTINES AND FORMS A
C             VEHICLE SPECTRUM BY ENERGY SUMMING THE COMPONENT SPECTRA.
C             THE VEHICLE SPECTRUM IS CORRECTED FOR ATMOSPHERIC ABSORPTION
C             AND THE PERCEIVED NOISE LEVEL, TONE CORRECTED PERCEIVED
C             NOISE LEVEL, AND A-WEIGHTED SOUND LEVEL.
C
C  USAGE:     ......(RAD,JI,X,Y,Z,DB,PN,PNT)
C             RAD....DISTANCE FROM OBSERVER TO AIRCRAFT
C             JI.....FLIGHT PATH SEGMENT NUMBER
C             X
C             Y......COORDINATES OF OBSERVER RELATIVE TO AIRCRAFT
C             Z
C             DB.....DBA VALUE RETURNED TO MAIN
C             PN.....PNL VALUE RETURNED TO MAIN
C             PNT....PNLT VALUE RETURNED TO MAIN
C  LABELED
C    COMMON:  /B1/, /INPUT/, /B2/
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```
C
C           /B1/  SEE SUBROUTINE FLDPT
C           /INPUT/ CONTAINS INPUT DATA FROM LOADER
C
C  SUBROUTINES CALLED:  ROTOR, ADDER, PROP, FAN, AJET, ENGINE, ATTEN,
C                       PNL
C
      DIMENSION FCF[24],TEMP1[24],TEMP2[24]                             ACPN0070
     1,BES[400]                                                         ACPN0080
      COMMON /B1/ BES,INCMAX[50]                                        ACPN0090
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIRGR,ROMEGN,RSID,ACPN0100
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,     ACPN0110
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,       ACPN0120
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VFI[50],ALF[50],  ACPN0130
     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,   ACPN0140
     5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,  ACPN0150
     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,  ACPN0160
     7ALFAJ,ROTR,RP,FANS,RJ,E                                           ACPN0170
C
C THE ARRAY FCF CONTAINS THE ONE-THIRD OCTAVE CENTER FREQUENCIES
C
C
                                                                        ACPN0180
      DATA FCF             / 50.,63., 80., 100., 125., 160., 200., 250., ACPN0190
     1315., 400., 500., 630., 800., 1000., 1250., 1600., 2000., 2500.,  ACPN0200
     23150., 4000., 5000., 6300., 8000., 10000. /                       ACPN0210
C                                                                       ACPN0220
      FC > 1.0 / 37400.0                                                ACPN0230
C
C INITIALIZE DUMMY ARRAYS TEMP1 AND TEMP2.  TEMP2 WILL
C CONTAIN THE VEHICLE SPECTRUM.
C
      DO 10 I>1,24                                                      ACPN0240
      TEMP1[I] > 0.                                                     ACPN0250
   10 TEMP2[I]> 0.                                                      ACPN0260
      IR > ROTR                                                         ACPN0270
      IF [IR.NE.1] GO TO 30                                             ACPN0280
      CALL ROTOR[FCF,TEMP1,X,Y,Z,JI]                                    ACPN0290
   20 FORMAT[///,2[12E10.4,/]]                                          ACPN0300
      CALL ADDER[TEMP1,TEMP2]                                           ACPN0310
   30 IRP > RP                                                          ACPN0320
      IF [IRP.NE.1] GO TO 40                                            ACPN0330
      CALL PROP[X,Y,Z,FCF,TEMP1,JI]                                     ACPN0340
      CALL ADDER[TEMP1,TEMP2]                                           ACPN0350
   40 IRF > FANS                                                        ACPN0360
      IF [IRF.NE.1] GO TO 50                                            ACPN0370
      CALL FAN[TEMP1,FCF,X,Y,Z]                                         ACPN0380
      CALL ADDER[TEMP1,TEMP2]                                           ACPN0390
   50 IRJ > RJ                                                          ACPN0400
      IF [IRJ.NE.1] GO TO 60                                            ACPN0410
      CALL AJET[TEMP1,X,Y,Z,JI]                                         ACPN0420
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      CALL ADDER[TEMP1,TEMP2]                                           ACPN0430
   60 IE > E                                                            ACPN0440
      IF [IE.NE.1] GO TO 70                                             ACPN0450
      CALL ENGINE[TEMP1,X,Y,Z]                                          ACPN0460
      CALL ADDER[TEMP1,TEMP2]                                           ACPN0470
   70 CONTINUE                                                          ACPN0480
C                                                                       ACPN0490
C VEHICLE SPECTRUM COMPLETE.  BEGIN CONVERSION FROM SOUND PRESSURE TO   ACPN0500
C SOUND PRESSURE LEVEL AND APPLY ATMOSPHERIC ABSORPTION CORRECTION      ACPN0510
C                                                                       ACPN0520
      DO 80 I>1,24                                                      ACPN0530
      F > FCF[I]                                                        ACPN0540
      TEMP2[I] > 10.0 * ALOG10[ TEMP2[I] < 0.1 ]                        ACPN0550
      CALL ATTEN[F,RAD,FC,AM]                                           ACPN0560
      TEMP2[I] > TEMP2[I] - AM                                          ACPN0570
   80 CONTINUE                                                          ACPN0580
C
C CALCULATE DBA, PNL, AND PNLT
C
      CALL PNL[TEMP2,DB,PN,PNT]                                         ACPN0590
      RETURN                                                            ACPN0600
      END                                                               ACPN0610
      SUBROUTINE ATTEN[F,R,FC,AM]                                       ATTE0010
C  TITLE:    SUBROUTINE ATTEN
C
C  PURPOSE:  TO CALCULATE ATMOSPHERIC ATTENUATION OF SOUND IN DB
C
C  ABSTRACT: ATMOSPHERIC ABSORPTION IS CALCULATED FOR A GIVEN
C            PROPAGATION DISTANCE FOR STANDARD CONDITIONS OF 14.7
C            PSI BAROMETRIC PRESSURE, 59 DEGREES FARENHEIT, AND 50 PER-
C            CENT RELATIVE HUMIDITY.  THIS IS ADEQUATE FOR ALL BUT
C            EXTREME CONDITIONS.  THE EQUATIONS ARE FROM WORK DONE BY
C            L.C. SUTHERLAND AT WYLE LABORATORIES (REFERENCE 1).
C
C  USAGE:    .....(F,R,FC,AM)
C            F.....FREQUENCY FOR WHICH ATTENUATION IS CALCULATED (HZ)
C            R.....PROPAGATION DISTANCE (FT)
C            FC....A CONSTANT BASED ON ATMOSPHERIC CONDITIONS (FOR
C                  STANDARD CONDITIONS FC = 1.0 / 37,400.
C            AM....ATMOSPHERIC ABSORPTION VALUE (DB) RETURNED
C  LABELED
C    COMMON: NONE
C
C  SUBROUTINES CALLED:  NONE
C
C  REFERENCES:     1. SUTHERLAND,L.C.,''SONIC AND VIBRATION ENVIRONMENTS
C                     FOR GROUND FACILITIES - A DESIGN MANUAL'',WYLE
C                     LABS RESEARCH STAFF REPORT WR68-2, MARCH 1968,
C                     FINAL REPORT FOR CONTRACT NAS8-11217
C
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      F2>F*FC*F*FC                                                      ATTE0150
      DUM>2.0*F2/[1.0<F2]                                               ATTE0160
      DUM>0.0324*F2<DUM*DUM                                             ATTE0170
      AM>0.292*R*SQRT[DUM]                                              ATTE0180
      RETURN                                                            ATTE0190
      END                                                               ATTE0200
      SUBROUTINE ADDER[T1,T2]                                           ADDE0010
C                                                                       Y0800010
C  TITLE:    SUBROUTINE ADDER
C
C  PURPOSE:  TO ADD SOUND PRESSURE LEVELS
C
C  ABSTRACT: TWO ONE-THIRD OCTAVE BAND SPECTRA ARE ENERGY SUMMED BAND
C            BY BAND TO PRODUCE A TOTAL SPECTRUM.  THE SPECTRUM IN ARRAY
C            T1 IS ADDED TO THE SPECTRUM IN ARRAY T2 AND THE TOTAL
C            SPECTRUM IS RETURNED IN ARRAY T2.
C
C  USAGE:    .....(T1,T2)
C            T1....A 24 ELEMENT ARRAY CONTAINING THE SPECTRUM TO BE
C                  ADDED TO THE T2 SPECTRUM
C            T2....A 24 ELEMENT ARRAY CONTAINING THE SPECTRUM TO WHICH
C                  THE T1 SPECTRUM IS ADDED.  THE'TOTAL SPECTRUM IS
C                  RETURNED IN ARRAY T2.
C 'LABELED
C    COMMON: NONE
C
C  SUBROUTINES CALLED: NONE
C
C
      DIMENSION T1[24],T2[24]                                           ADDE0020
      DO 10 I>1,24                                                      ADDE0030
      T1[I] > 10.0 ** [T1[I]/10.0]                                      ADDE0040
      T2[I] > T2[I] < T1[I]                                             ADDE0050
      T1[I] > 0.                                                        ADDE0060
   10 CONTINUE                                                          ADDE0070
      RETURN                                                            ADDE0080
      END                                                               ADDE0090
      SUBROUTINE PNL[TEMP,DBA,PN,PNT]                                   PNL 0010
C                                                                       PNL 0020
C  TITLE:    PNL
C
C  PURPOSE:  TO CALCULATE THE PERCEIVED NOISE LEVEL, THE TONE CORRECTED
C            PERCEIVED NOISE LEVEL, AND THE A-WEIGHTED SOUND LEVEL FOR
C            A ONE-THIRD OCTAVE SOUND SPECTRUM
C
C  ABSTRACT: THE 1/3-OCTAVE SPECTRUM CONTAINED IN ARRAY TEMP IS
C            CONVERTED TO NOY VALUES USING PINKER'S FORMULATION OF THE
C            NOY TABLES (REF. 1).  THE PNL IS CALCULATED FROM THE NOY
C            VALUES AND THE TONE CORRECTED PNL IS COMPUTED USING THE
C            REFERENCE 2 TONE CORRECTION PROCEDURE.  THE A-WEIGHTED
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C             SOUND LEVEL IS COMPUTED BY APPLYING THE A-WEIGHTING
C             CORRECTION NUMBERS TO THE SPECTRUM AND THEN PERFORMING A
C             BAND BY BAND ENERGY SUMMATION.
C
C  USAGE:     ...(TEMP,DBA,PN,PNT)
C             TEMP...24 ELEMENT ARRAY CONTAINIG THE NOISE SPECTRUM
C             DBA....A-WEIGHTED SOUND LEVEL RETURNED
C             PN.....PERCEIVED NOISE LEVEL RETURNED
C             PNT....TONE CORRECTED PNL RETURNED
C
C  LABELED
C    COMMON: NONE
C
C  SUBROUTINES CALLED:  DELTA(X,MOP,SLOPE)
C
C  REFERENCES:  1. R.A.PINKER, ''MATHEMATICAL FORMULATION OF THE
C                  NOY TABLES'', JL. SOUND VIB.,VOL 8, NO 3, 1968,
C                  PP. 488-493
C               2. W.C.SPERRY, ''AIRCRAFT NOISE EVALUATION'', REPORT
C                  FAA-NO-68-34, SEPTEMBER 1968
C
      DIMENSION TEMP[24],AM1[24],S1[24],S2[24],DBACR[24]                PNL 0080
     1,SLOPE[25],SPLP[24],NFLAG[24],NFP[24]                             PNL 0090
C                                                                       PNL 0100
C THE ARRAY DBACR CONTAINS CORRECTIONS TO BE APPLIED TO THE SPL IN      PNL 0110
C BANDS 50 HZ TO 10000 HZ TO PROVIDE THE A-WEIGHTED SPECTRUM FROM       PNL 0120
C WHICH THE A-WEIGHTED SOUND LEVEL IS CALCULATED.  CORRECTION NUMBERS   PNL 0130
C ARE FROM USA STANDARD S1.4-1961, ::SPECIFICATION FOR GENERAL PURPOSE  PNL 0140
C SOUND LEVEL METERS::, DATED JAN 1,1961                                PNL 0150
C                                                                       PNL 0160
      DATA DBACR/ -30.2, -26.1, -22.3, -19.1, -16.2, -13.2, -10.8,      PNL 0170
     1-8.6, -6.5, -4.8, -3.3, -1.9, -0.8, 0.0, 0.5, 1.0, 1.2, 1.2,      PNL 0180
     2 1.2, 1.0, 0.5, -0.2, -1.1, -2.3/                                 PNL 0190
C
C ARRAYS AM1, S1, AND S2 ARE THE CONSTANTS REQUIRED IN THE
C MATHEMATICAL FORMULATION OF THE NOY TABLES.
C
      DATA AM1/0.043478,0.04057,0.036831,0.036831,0.035336,0.033333,    PNL 0280
     1 0.033333,0.032051,0.030675,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,  PNL 0290
     2 0.0,0.0,0.0,0.0,0.042285,0.042285/                               PNL 0300
      DATA S1/64.,60.,56.,53.,51.,48.,46.,44.,42.,0.0,0.0,0.0,0.0,0.0,  PNL 0310
     1 0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,37.,41./                         PNL 0320
      DATA S2/52.,51.,49.,47.,46.,45.,43.,42.,41.,40.0,40.,40.,40.,40., PNL 0330
     1 38.,34.,32.,30.,29.,29.,30.,31.,34.,35./                         PNL 0340
      CON1>0.030103                                                     PNL 0350
      CON2>0.029960                                                     PNL 0360
C                                                                       PNL 0370
C BEGIN CALCULATION OF PNDB AND DBA                                     PNL 0380
C THE TERM  SUM  WILL CONTAIN THE A-WEIGHTED SOUND LEVEL.               PNL 0390
C                                                                       PNL 0400
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      TOT>0.                                                          PNL 0410    01551
      RMAX>0.                                                         PNL 0420    01552
      SUM>0.                                                          PNL 0430    01553
      DO 70 L>1,24                                                    PNL 0440    01554
      Y > 0.1 * [TEMP[L] < DBACR[L]]                                  PNL 0450    01555
      Y > 10.0 ** Y                                                   PNL 0460    01556
      SUM>SUM<Y                                                       PNL 0470    01557
      IF [L.GT.9] GO TO 50                                            PNL 0480    01558
   10 AM2>CON1                                                        PNL 0490    01559
      IF[L .GT. 15] AM2 > CON2                                        PNL 0500    01560
      AL > [AM1[L]*S1[L] - AM2*S2[L]]/[AM1[L]-AM2]                    PNL 0510    01561
      IF [TEMP[L].GE.S1[L]] GO TO 20                                  PNL 0520    01562
      ANOY>0.0                                                        PNL 0530    01563
      GO TO 40                                                        PNL 0540    01564
   20 IF [TEMP[L].GT.AL] GO TO 30                                     PNL 0550    01565
      ANOY > AM1[L] * [TEMP[L] - S1[L]]                               PNL 0560    01566
      ANOY>10.0**ANOY                                                 PNL 0570    01567
      GO TO 40                                                        PNL 0580    01568
   30 ANOY > AM2 * [TEMP[L] - S2[L]]                                  PNL 0590    01569
      ANOY>10.0**ANOY                                                 PNL 0600    01570
   40 IF[ANOY .GT. RMAX]RMAX>ANOY                                     PNL 0610    01571
      TOT>TOT<ANOY                                                    PNL 0620    01572
      GO TO 70                                                        PNL 0630    01573
   50 IF [L.GE.23] GO TO 10                                           PNL 0640    01574
      IF [TEMP[L].GE.S2[L]] GO TO 60                                  PNL 0650    01575
      ANOY>0.                                                         PNL 0660    01576
      GO TO 40                                                        PNL 0670    01577
   60 ANOY > AM2 * [TEMP[L] - S2[L]]                                  PNL 0680    01578
      ANOY>10.0**ANOY                                                 PNL 0690    01579
      GO TO 40                                                        PNL 0700    01580
   70 CONTINUE                                                        PNL 0710    01581
      ANMAX>0.15*TOT<0.85*RMAX                                        PNL 0720    01582
      IF [ANMAX.GT.0.] GO TO 80                                       PNL 0730    01583
      PN>0.0                                                          PNL 0740    01584
      GO TO 90                                                        PNL 0750    01585
   80 PN>40.0<[ALOG10[ANMAX]]/0.03                                    PNL 0760    01586
   90 DBA > 10.0 * ALOG10[SUM]                                        PNL 0770    01587
C                                                                     PNL 0780    01588
C END CALCULATION OF PERCEIVED NOISE LEVEL AND DBA.                   PNL 0790    01589
C                                                                     PNL 0800    01590
C BEGIN CALCULATION OF TONE CORRECTION                                PNL 0810    01591
C                                                                     PNL 0820    01592
      SLOPE[25] > 0.0                                                 PNL 0830    01593
      DO 100 I>1,24                                                   PNL 0840    01594
      SLOPE[I] > 0.0                                                  PNL 0850    01595
      SPLP[I] > 0.0                                                   PNL 0860    01596
      NFLAG[I] > 0                                                    PNL 0870    01597
  100 NFP[I] > 0                                                      PNL 0880    01598
C                                                                     PNL 0890    01599
C FAA-NO-68-34.....STEP 1                                             PNL 0900    01600
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C                                                                       PNL 0910
      CALL DELTAC TEMP, 1, SLOPE]                                       PNL 0920
C                                                                       PNL 0930
C FAA-NO-68-34.....STEP 2                                               PNL 0940
C                                                                       PNL 0950
      DO 120 I>4,24                                                     PNL 0960
      IF [ABS[SLOPE[I]-SLOPE[I-1]]-5.0]120,120,110                      PNL 0970
  110 NFLAG[I] > I                                                      PNL 0980
  120 CONTINUE                                                          PNL 0990
C                                                                       PNL 1000
C  FLAG BANDS                                                           PNL 1010
C                                                                       PNL 1020
C FAA-NO-68-34.....STEP 3                                               PNL 1030
C                                                                       PNL 1040
      DO 170 I>4,24                                                     PNL 1050
      NF > NFLAG[I]                                                     PNL 1060
      IF [SLOPE[NF]]140,140,130                                         PNL 1070
  130 IF [SLOPE[NF]-SLOPE[NF-1]]170,170,160                             PNL 1080
  140 IF [SLOPE[NF-1]]170,170,150                                       PNL 1090
  150 NFP[I-1] > I-1                                                    PNL 1100
      GO TO 170                                                         PNL 1110
  160 NFP[I] > I                                                        PNL 1120
  170 CONTINUE                                                          PNL 1130
C                                                                       PNL 1140
C ADJUST SPECTRUM USING SPERRY:S FAA METHOD                             PNL 1150
C                                                                       PNL 1160
C FAA-NO-68-34.....STEP 4                                               PNL 1170
C                                                                       PNL 1180
      DO 200 I>3,24                                                     PNL 1190
      IF [I.EQ.NFP[I]] GO TO 180                                        PNL 1200
      SPLP[I] > TEMP[I]                                                 PNL 1210
      GO TO 190                                                         PNL 1220
  180 SPLP[I] > 0.5 * [TEMP[I-1] < TEMP[I<1]]                           PNL 1230
  190 IF[ NFP[I] .EQ. 24 ] SPLP[24] > TEMP[23] < SLOPE[24]              PNL 1240
  200 CONTINUE                                                          PNL 1250
C                                                                       PNL 1260
C FAA-NO-68-34.....STEP 5                                               PNL 1270
C                                                                       PNL 1280
      CALL DELTAC SPLP, 2, SLOPE ]                                      PNL 1290
C                                                                       PNL 1300
C CALC AVG SLOPE                                                        PNL 1310
C                                                                       PNL 1320
C FAA-NO-68-34.....STEP 6                                               PNL 1330
C                                                                       PNL 1340
      DO 210 I>3,23                                                     PNL 1350
  210 SLOPE[I] > 0.33333 * [SLOPE[I] < SLOPE[I<1] < SLOPE[I<2] ]        PNL 1360
C                                                                       PNL 1370
C FAA-NO-68-34.....STEP 7                                               PNL 1380
C                                                                       PNL 1390
      SPLP[3] > TEMP[3]                                                 PNL 1400
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      DO 220 I>4,24                                                      PNL 1410     01651
  220 SPLP[I] > SPLP[I-1] < SLOPE[I-1]                                   PNL 1420     01652
C                                                                        PNL 1430     01653
C CALC FINAL DIFFERENCES                                                 PNL 1440     01654
C                                                                        PNL 1450     01655
C FAA-NO-68-34.....STEP 8                                                PNL 1460     01656
C                                                                        PNL 1470     01657
      DO 230 I>3,24                                                      PNL 1480     01658
  230 SPLP[I] > TEMP[I] - SPLP[I]                                        PNL 1490     01659
C                                                                        PNL 1500     01660
C FAA-NO-68-34.....STEP 9 AND 10                                         PNL 1510     01661
C                                                                        PNL 1520     01662
      CMAX > 0.0                                                         PNL 1530     01663
      NCMAX > 0                                                          PNL 1540     01664
      DO 320 M>4,24                                                      PNL 1550     01665
      IF [M.GE.11.AND.M.LE.21] GO TO 270                                 PNL 1560     01666
      IF [SPLP[M]-3.0]320,250,240                                        PNL 1570     01667
  240 IF [SPLP[M]-20.0]250,260,260                                       PNL 1580     01668
  250 CMAX1 > SPLP[M]/6.0                                                PNL 1590     01669
      IF [CMAX-CMAX1]310,320,320                                         PNL 1600     01670
  260 CMAX1 > 3.3333                                                     PNL 1610     01671
      IF [CMAX-CMAX1]310,320,320                                         PNL 1620     01672
  270 IF [SPLP[M]-3.0]320,290,280                                        PNL 1630     01673
  280 IF [SPLP[M]-20.0]290,300,300                                       PNL 1640     01674
  290 CMAX1 > SPLP[M]/3.0                                                PNL 1650     01675
      IF [CMAX-CMAX1]310,320,320                                         PNL 1660     01676
  300 CMAX1 > 6.66667                                                    PNL 1670     01677
      IF [CMAX-CMAX1]310,320,320                                         PNL 1680     01678
  310 CMAX > CMAX1                                                       PNL 1690     01679
      NCMAX > M                                                          PNL 1700     01680
  320 CONTINUE                                                           PNL 1710     01681
C                                                                        PNL 1720     01682
C CALCULATE PNLT                                                         PNL 1730     01683
C                                                                        PNL 1740     01684
      PNT > PN < CMAX                                                    PNL 1750     01685
      RETURN                                                             PNL 1760     01686
      END                                                                PNL 1770     01687
      SUBROUTINE DELTA[X, MOP, SLOPE]                                    DELT0010     01688
C                                                                                     01689
C  TITLE:    DELTA                                                                    01690
C                                                                                     01691
C  PURPOSE:  TO CALCULATE THE SLOPES REQUIRED IN THE CALCULATION                      01692
C            OF THE TONE CORRECTION IN SUBROUTINE PNL                                 01693
C                                                                                     01694
C  ABSTRACT: THE SLOPE,  OR CHANGE IN LEVEL FROM THIRD OCTAVE BAND 'I'                01695
C            TO BAND 'I+1' IS CALCULATED FOR THE ENTIRE 24 BAND                       01696
C            SPECTRUM.  IF THE VALUE OF 'MOP' IS NOT 1 THE SLOPE FOR                  01697
C            BAND 3 AND FOR IMAGINARY BAND 25 IS CALCULATED.                          01698
C                                                                                     01699
C  USAGE:    .....(X,MOP,SLOPE)                                                       01700
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C            X......A 24 ELEMENT ARRAY CONTAINING THE THIRD OCTAVE
C                   SPECTRUM
C            MOP....CONTROL VARIABLE TO PREVENT CALCULATION OF EXTENDED
C                   SLOPES (BANDS 3 AND 25). NO = 1
C            SLOPE..A 25 ELEMENT ARRAY CONTAINING THE CALCULATED SLOPES
C
C LABELED
C   COMMON..NONE
C
C SUBROUTINES CALLED: NONE
C
     DIMENSION X[24], SLOPE[25]                                        
     DO 10 I>4,24                                                       DELT0020
  10 SLOPE[I] > X[I] - X[I-1]                                           DELT0030
     IF[ MOP  .EQ. 1]RETURN                                             DELT0040
     SLOPE[3] > SLOPE[4]                                                DELT0050
     SLOPE[25] > SLOPE[24]                                              DELT0060
     RETURN                                                             DELT0070
     END                                                                DELT0080
     SUBROUTINE PROP[X,Y,Z,FCK3,POBL3,JKI]                              DELT0090
C                                                                       PROP0010
C                                                                       PROP0020
C TITLE:     PROP
C
C PURPOSE:   TO CALCULATE THE 1/3-OCTAVE BAND NOISE SPECTRUM OF A
C            PROPELLER(S) AT A SPECIFIED POINT.
C
C ABSTRACT:  USING EMPIRICAL MEANS THE FIRST 10 HARMONICS OF ROTATIONAL
C            NOISE ARE CALCULATED AND CONVERTED TO A THIRD OCTAVE
C            SPECTRUM.  VORTEX NOISE IS CALCULATED FROM HUBBARD'S (REF
C            2) THEORETICAL EQUATION, CONVERTED TO A THIRD OCTAVE
C            SPECTRUM USING THE REFERENCE 3 SPECTRUM SHAPE, AND ADDED
C            TO THE ROTATIONAL SPECTRUM TO PRODUCE A COMPLETE SPECTRUM.
C            REQUIRED PARAMETERS (INPUT VIA COMMON):
C              PPWR....POWER INPUT TO PROPELLER (HP)
C              DIA ....DIAMETER (FT)
C              BIGB....NUMBER OF BLADES
C              RPMP....ROTATIONAL SPEED (RPM)
C              ANMPRP..NUMBER OF PROPELLERS
C              CHORDP..MEAN BLADE CHORD (FT)
C              VF(I)...FLIGHT SPEED ON FLIGHT SEGMENT I (FPS)
C USAGE:     ....(X,Y,Z,FCK3,POBL3,JKI)
C            X
C            Y......FIELD POINT COORDINATES (INPUT)
C            Z
C            FCK3...A 24 ELEMENT ARRAY CONTAINING THE 1/3-OCTAVE
C                   BAND CENTER FREQUENCIES (INPUT)
C            JKI....FLIGHT PATH SEGMENT NUMBER
C            POBL3..A 24 ELEMENT ARRAY IN WHICH THE CALCULATED SPECTRUM
C                   IS RETURNED
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```
C
C  LABELED
C    COMMON: /B1/   /INPUT/
C
C  SUBROUTINES CALLED: NONE
C
C  REFERENCE:1. HAMILTON STANDARD, ''A STUDY OF PROPELLER NOISE
C               RESEARCH'', HAMILTON STANDARD SP-67148 REV A, 1967
C
C            2. H.H.HUBBARD,''PROPELLER-NOISE CHARTS FOR TRANSPORT
C               AIRPLANES'', NACA TN-2968, JUNE 1953
C
C            3. L.L.BERANEK(ED),  NOISE REDUCTION , MCGRAW-HILL BOOK
C                                 ---------------
C               CO., NEW YORK, NY, CHAPTER 25
C
       DIMENSION FCK3[24],POBL3[24],VCORR[41],CORR[10,11],FLWR[25]      PROP0060
      1,BES[400]                                                        PROP0070
       COMMON /B1/ BES,INCMAX[50]                                       PROP0080
       COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID, PROP0090
      1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,    PROP0100
      2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,      PROP0110
      3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50], PROP0120
      4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,  PROP0130
      5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF, PROP0140
      6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO, PROP0150
      7ALFAJ,ROTR,RP,FANS,RJ,E                                          PROP0160
C
C ARRAY CORR(I,J) CONTAINS CORRECTION NUMBERS TO CALCULATE 10 (J=1,10)
C ROTATIONAL HARMONICS FOR 11 (I=1,11) TIP MACH NUMBERS FROM THE
C CALCULATED OVERALL LEVEL.  I REPRESENTS MACH NUMBERS FROM 0.40 TO
C 0.90 IN STEPS OF 0.05
C
       DATA CORR /
      1 0.6, 14.0, 18.0, 19.8, 21.8, 23.1, 24.0, 25.2, 26.9, 28.8 ,     PROP0180
C                                                                       PROP0190
      1 0.6, 13.7, 17.6, 19.7, 21.7, 23.0, 23.9, 25.1, 26.8, 28.7 ,     PROP0210
C                                                                       PROP0220
      1 0.6, 13.0, 17.2, 19.5, 21.5, 23.0, 23.9, 25.0, 26.8, 28.7 ,     PROP0240
C                                                                       PROP0250
      1 0.6, 12.0, 16.7, 19.3, 21.3, 22.8, 23.7, 25.0, 26.6, 28.6 ,     PROP0270
C                                                                       PROP0280
      1 0.7, 11.0, 16.2, 19.0, 21.0, 22.6, 23.5, 24.8, 26.5, 28.5 ,     PROP0300
C                                                                       PROP0310
      1 0.9,  9.7, 15.5, 18.6, 20.6, 22.4, 23.4, 24.6, 26.2, 28.2 ,     PROP0330
C                                                                       PROP0340
      1 1.1,  8.4, 14.6, 18.2, 20.1, 22.0, 23.0, 24.2, 25.8, 27.8 ,     PROP0360
C                                                                       PROP0370
      1 1.6,  7.1, 13.7, 17.6, 19.5, 21.4, 22.4, 23.7, 25.3, 27.2 ,     PROP0390
C                                                                       PROP0400
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     1 2.6,  6.2, 12.4, 16.6, 18.6, 20.3, 21.5, 23.0, 24.4, 26.2 ,        PROP0420
C                                                                          PROP0430
     1 3.9,  5.8, 10.5, 15.0, 17.0, 18.5, 20.0, 21.5, 24.4, 26.2 ,        PROP0450
C                                                                          PROP0460
     1 5.5,  5.9,  8.0, 10.5, 12.5, 14.5,16.5,  18.0, 19.5, 21.4 /        PROP0480
C                                                                          PROP0490
C
C ARRAY VCORR(I) CONTAINS CORRECTIONS TO CALCULATE THE 1/3-OCTAVE
C SPECTRUM FROM THE COMPUTED OVERALL VORTEX NOISE LEVEL
C
      DATA VCORR              /64.,61.,58.,55.,52.,49.,46.,43.,40.,37.,  PROP0500
     134.,31.,28.,25.,22.,19.,16.,14.,12.,10.,11.,12.,13.,15.,17.,19.,   PROP0510
     221.,23.,25.,27.,29.,31.,33.,35.,37.,39.,41.,43.,45.,47.,49. /     PROP0520
C                                                                          PROP0530
C
C ARRAY FLWR(I) CONTAINS LOWER CUTOFF FREQUENCIES FOR THE 1/3-OCTAVE
C BANDS FROM 50 HZ TO 12,500 HZ
C
      DATA FLWR             /44.4,55.8,70.5,88.9,111.5,140.,177.,221.,   PROP0540
     1280.,354.,445.,561.,707.,891.,1122.,1414.,1782.,2242.,2828.,3565.,PROP0550
     24488.,5656.,7127.,8980.,11312. /                                    PROP0560
C                                                                          PROP0570
      VF > VF1[JK]                                                         PROP0600
C                                                                          PROP0610
C SET CONSTANTS                                                            PROP0620
C                                                                          PROP0630
      TWO16 > 2.0 ** [1.0/6.0]                                             PROP0640
      DTR > 0.0174532925                                                   PROP0650
      ROOT2 > SQRT[2.0]                                                    PROP0660
      PI > 3.1415926536                                                    PROP0670
C                                                                          PROP0680
C INITIALIZE POBL3 ARRAY AND CALCULATE TERMS FOR OASPL EQUATION           PROP0690
C                                                                          PROP0700
      DO 10 I>1,24                                                         PROP0710
   10 POBL3[I] > 0.                                                        PROP0720
      PRLG > 15.5 * ALOG10[PPWR]                                           PROP0730
      DLG  > 20.0 * ALOG10[DIA]                                            PROP0740
      BLG  > 20.0 * ALOG10[BIGB]                                           PROP0750
      ENGLG> 10.0 * ALOG10[ANMPRP]                                         PROP0760
      TMACH > [RPMP * PI * DIA] / [ SAZ * 60.0 ]                           PROP0770
      R > SQRT[ X*X < Y*Y < Z*Z ]                                          PROP0780
      RLG > 20.0 * ALOG10[R/500.]                                          PROP0790
C                                                                          PROP0800
C CALCULATE AZIMUTH ANGLE GAMMA                                            PROP0810
C                                                                          PROP0820
      IF [X<Y]40,20,40                                                     PROP0830
   20 IF [Z]30,200,30                                                      PROP0840
   30 GAMMA > 90.                                                          PROP0850
      GO TO 50                                                             PROP0860
   40 GAMMA > ABS[ATAN2[Y,-X]]                                             PROP0870
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      GAMMA > GAMMA / DTR                                               PROP0880
   50 CONTINUE                                                          PROP0890
C                                                                       PROP0900
C CALCULATE DIRECTIVITY ANGLE PHI AND DIRECTIVITY INDEX                 PROP0910
C                                                                       PROP0920
      PHI > ABS[180.0 - GAMMA]                                          PROP0930
      IF [PHI.LE.50.0] GO TO 60                                         PROP0940
      IF [PHI.LE.120.0] GO TO 70                                        PROP0950
      IF [PHI.LE.180.0] GO TO 80                                        PROP0960
      PHI > 180.                                                        PROP0970
      GO TO 80                                                          PROP0980
   60 DI > 0.120 * PHI - 7.0                                            PROP0990
      GO TO 90                                                          PROP1000
   70 DI > 0.0286 * PHI - 2.43                                          PROP1010
      GO TO 90                                                          PROP1020
   80 DI > -0.308 * PHI < 38.0                                          PROP1030
   90 CONTINUE                                                          PROP1040
C                                                                       PROP1050
C CALCULATE OASPL AT R AND GAMMA                                        PROP1060
C                                                                       PROP1070
      OASPL > PRLG - DLG - BLG < [40. * TMACH] < ENGLG - RLG < DI < 50.2PROP1080
C                                                                       PROP1090
C CALCULATE FUNDAMENTAL ROTATIONAL FREQUENCY                            PROP1100
C                                                                       PROP1110
      VT2 > [TMACH * SAZ]**2                                            PROP1120
      VH > SQRT[ VT2 < VF*VF ]                                          PROP1130
      FZRO > VH * BIGB / [PI * DIA]                                     PROP1140
      RMH > VH / SAZ                                                    PROP1150
C                                                                       PROP1160
C DETERMINE WHICH SET OF CORRECTION NUMBERS TO USE                      PROP1170
C BASED ON HELICAL TIP MACH NUMBER                                      PROP1180
C                                                                       PROP1190
      INC > 20.0 * RMH - 6.500001                                       PROP1200
      IF[INC .LT. 1] INC >1                                             PROP1210
      IF[INC .GT. 11] INC > 11                                          PROP1220
C                                                                       PROP1230
C BEGIN CALCULATION OF 1/3-OCTAVE BAND LEVELS FOR ROTATIONAL NOISE      PROP1240
C                                                                       PROP1250
C DETERMINE WHICH 1/3-OCTAVE VCF FALLS IN                               PROP1260
C                                                                       PROP1270
      DO 120 I>1,10                                                     PROP1280
      SPL > OASPL - CORR[I,INC]                                         PROP1290
      F > FZRO * I                                                      PROP1300
      DO 110 K>1,24                                                     PROP1310
      FU > FLWR[K<1]                                                    PROP1320
      FL > FLWR[K]                                                      PROP1330
  100 IF [F.GT.FU] GO TO 110                                            PROP1340
      IF [F.LT.FL] GO TO 120                                            PROP1350
      POBL3[K] > POBL3[K] < 10.0 ** [0.1 * SPL]                         PROP1360
  110 CONTINUE                                                          PROP1370
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  120 CONTINUE
C
C CALCULATE VORTEX AND TOTAL NOISE
C
      VCF > 0.85 * VH / CHORDP
      IF [VCF.GT.FLWR[1]] GO TO 130
      INC > 1
      GO TO 150
  130 CONTINUE
      DO 140 K>1,24
      IF [VCF.GT.FLWR[K<1]] GO TO 140
      IF [VCF.LT.FLWR[K]] GO TO 150
      INC > K
      GO TO 150
  140 CONTINUE
  150 CONTINUE
      ABL > BIGB * [DIA / 2. ] * CHORDP
      VOASPL > 10. * ALOG10[3.8E-11 * ABL *[[0.7 * VH]**6]] - RLG
      INCR > 20 - INC
      DO 160 K>1,24
      INCRR > INCR < K
      IF[INCRR .LT. 1] INCRR > 1
      IF[INCRR .GT. 41] INCRR>41
      ELG > VCORR[ INCRR ]
      SPLV > VOASPL - ELG
      SPLV > 10.0 ** [ 0.1 * SPLV ]
      POBL3[K] > POBL3[K] < SPLV
      POBL3[K] > 10.0 * ALOG10[ POBL3[K] ]
  160 CONTINUE
C
C CORRECT SPECTRUM TO ASSURE NO MORE THAN 20 DB DIFFERENCE BETWEEN
C ADJACENT BANDS
C
      DO 190 I>1,23
      DUM > POBL3[I<1] - 20.
      IF [POBL3[I].LT.DUM] GO TO 170
      DUM3 > POBL3[I<1] < 20.
      IF [POBL3[I].GT.DUM3] GO TO 180
      GO TO 190
  170 POBL3[I] > DUM
      IF [I.EQ.1] GO TO 190
      DUM2 > POBL3[I-1] < 20
      IF [POBL3[I].LT.DUM2] GO TO 190
      POBL3[I-1] > POBL3[I] - 20.
      GO TO 190
  180 POBL3[I<1] > POBL3[I] - 20.
  190 CONTINUE
  200 CONTINUE
      RETURN
      END
```

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      SUBROUTINE FAN[BBN,FC,X,Y,Z]                                       FAN 0010
C                                                                        FAN 0020
C  TITLE:    FAN
C
C  PURPOSE:  TO CALCULATE THE NOISE RADIATED BY LIFT AND CRUISE FANS
C
C  ABSTRACT: THE DISCRETE FREQUENCY (BLADE PASSAGE) NOISE, BROADBAND
C            NOISE, AND COMBINATION TONE NOISE ARE CALCULATED AND
C            CONVERTED TO A 1/3-OCTAVE BAND SPECTRUM USING THE
C            METHODS OF REFERENCE 1.  THE METHOD CANNOT CALCULATE
C            INTERACTION TONE NOISE BECAUSE IT WAS DERIVED FROM NOISE
C            DATA OF ENGINES THAT HAVE NO PROPAGATING INTERACTION TONES.
C            REQUIRED PARAMETERS (INPUT VIA COMMON):
C              DIAT....TIP DIAMETER (INCHES)
C              DIAH....HUB DIAMETER (INCHES)
C              B.......NUMBER OF BLADES
C              BPR.....BY-PASS RATIO
C              CHORD...BLADE  TIP CHORD (INCHES)
C            * DDDXT...TIP DIAMETER GRADIENT (IN/IN)
C            * DDDXH...HUB DIAMETER GRADIENT (IN/IN)
C            * RS......BLADE SUCTION SURFACE RADIUS OF CURVATURE (IN)
C            * SIGPHI..STANDARD DEVIATION OF BLADE TIP METAL ANGLE (RAD)
C              DL......INLET DUCT LENGTH (FT)
C              RPM.....ROTATIONAL SPEED (RPM)
C              SPAF....SPECIFIC AIRFLOW RATE (LB/SEC/SQ FT)
C              XMXTIP..TIP AXIAL MACH NUMBER
C              PR......PRESSURE RATIO
C              DF......DIFFUSION FACTOR
C              TT2.....AMBIENT INLET TEMPERATURE (DEGREES F)
C              PT2.....AMBIENT INLET PRESSURE (INCHES HG)
C              ALFA....INCLINATION OF INLET TO HORIZONTAL (+90 DEG
C                      IS VERTICAL).
C              FN......NUMBER OF FANS
C              COMB....CONTROL FACTOR TO EXCLUDE CALCULATION OF
C                      COMBINATION TONE NOISE (0=NO)
C
C            * - THESE VALUES REQUIRED ONLY IN THE CALCULATION OF
C                COMBINATION TONE NOISE.
C
C  USAGE:    ...(BBN,FC,X,Y,Z)
C            BBN....A 24 ELEMENT ARRAY IN WHICH THE CALCULATED FAN
C                   1/3-OCTAVE BAND SPECTRUM IS RETURNED
C            FC.....A 24 ELEMENT ARRAY CONTAINING THE 1/3 OCTAVE
C                   BAND CENTER FREQUENCIES FROM 50 TO 10,000 HZ.
C            X
C            Y......COORDINATES OF THE OBSERVER RELATIVE TO THE VEHICLE
C            Z
C
C  LABELED
C    COMMON: /B1/   /INPUT/
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C
C  SUBROUTINE CALLED:  NONE
C
C  REFERENCE 1:  E.A.BURDSALL AND R.H.URBAN,''FAN-COMPRESSOR NOISE:
C                PREDICTION, RESEARCH, AND REDUCTION STUDIES'', FAA
C                REPORT FAA-RD-71-73, FEBRUARY 1971
C
      DIMENSION BBN[24],FC[24],FL[25],TABLE[15,15],SUBD[15],SUPD[15],
     1CORF[3],FCORR[3],PWL[500],DIRC[11,6],ZETAK[6]
     2,BES[400]
      EQUIVALENCE [TABLE[151],XTAB]
      DIMENSION XTAB[75]
C
      COMMON /B1/ BES,INCMAX[50]
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID,
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50],
     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,
     5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,
     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,
     7ALFAJ,ROTR,RP,FANS,RJ,E
C
C
C ARRAY FL CONTAINS LOWER AND UPPER CUTOFF FREQUENCIES FOR THE THIRD
C OCTAVES FROM 50 TO 10,000 HZ.
C
      DATA FL          / 44.4, 55.8, 70.5, 88.9, 111.5, 140.0, 177.0,
     1221.0, 280., 354., 445., 561., 707., 891., 1122., 1414., 1782.,
     22242., 2828., 3565., 4488., 5656., 7127., 8980., 11312. /
C
C ARRAY SUBD CONTAINS THE SUBSONIC DIRECTIVITY INDICIES
C
      DATA SUBD          / -0.5, 0.9, 1.4, 0.7, 1.0, 0.0, -0.6, -2.5,
     1-3.7, -0.9, 1.7, 2.5, 2.2, -1.0, -2.2 /
C
C ARRAY SUPD CONTAINS THE SUPERSONIC DIRECTIVITY INDICIES
C
      DATA SUPD          / -0.6, -0.5, -0.4, -0.3, -0.2, 0.0, 0.2,
     10.3, 0.7, 4.0, 4.7, 4.9, 4.8, 2.5, 1.4 /
C
C ARRAY TABLE CONTAINS THE BROADBAND OVERALL SPL AT AN AZIMUTH ANGLE
C OF 60 DEGREES FROM THE INLET AS A FUNCTION OF TIP MACH NUMBER AND
C DIFFUSION FACTOR.  TABLE(I,J)  J=1,15 REPRESENTING DIFFUSION FACTORS
C                                FROM 0.28 TO 0.56 IN STEPS OF 0.02
C                                I=1,15 REPRESENTING MACH NUMBERS FROM
C                                0.7 TO 1.40 IN STEPS OF 0.05
C
      DATA TABLE           / 87.2, 87.4, 87.6, 88.1, 88.9, 89.7,
     190.9, 92.0, 92.8, 93.4, 93.6, 93.7, 94.1, 94.4, 94.7 ,
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C                                                                FAN 0320     02051
     *                      2*88.4, 88.7, 89.2, 89.9, 90.8, 92.0,    FAN 0330     02052
     193.1,94.0, 94.6, 95.1, 95.4, 95.8, 96.0, 96.2 ,               FAN 0340     02053
C                                                                FAN 0350     02054
     *                        89.5, 89.6, 89.9, 90.5, 91.4, 92.7,    FAN 0360     02055
     193.8, 94.8, 95.8, 96.5, 97.0, 97.3, 97.4, 97.5, 97.6 ,         FAN 0370     02056
C                                                                FAN 0380     02057
     *                      2*90.6, 90.8, 91.3, 92.0, 92.9, 94.1,    FAN 0390     02058
     195.3, 96.4, 97.2, 98.2, 98.4, 98.7, 2*98.9 ,                   FAN 0400     02059
C                                                                FAN 0410     02060
     *                        91.6, 91.7, 91.8, 92.2, 92.8, 93.8,    FAN 0420     02061
     195.0, 96.4, 97.7, 98.7, 99.4, 99.9, 100.1, 100.3, 100.4 ,      FAN 0430     02062
C                                                                FAN 0440     02063
     *                        92.6, 92.8, 93.0, 93.3, 93.9, 94.8,    FAN 0450     02064
     195.9, 97.2, 98.4, 99.4, 100.2, 100.8, 101.1, 101.4, 101.5 ,    FAN 0460     02065
C                                                                FAN 0470     02066
     *                        93.7, 93.9, 94.1, 94.5, 95., 95.7, 96.8,FAN 0480    02067
     198., 99.2, 100.2, 101., 101.7, 102.1, 102.4, 102.6 ,           FAN 0490     02068
C                                                                FAN 0500     02069
     *                        94.8, 95.1, 95.3, 95.6, 96.1, 96.8,    FAN 0510     02070
     197.8, 98.9, 100.1, 101., 101.8, 102.4, 102.8, 103.3, 103.7 ,   FAN 0520     02071
C                                                                FAN 0530     02072
     *                        96., 96.2, 96.4, 96.8, 97.2, 97.8, 98.7,FAN 0540    02073
     199.9, 101., 101.9, 102.7, 103.3, 103.8, 104.4, 104.7 ,         FAN 0550     02074
C                                                                FAN 0560     02075
     *                        96.9, 97., 97.3, 97.7, 98.1, 98.7, 99.5,FAN 0570    02076
     1100.5, 101.7, 102.7, 103.4, 104., 104.5, 105., 105.3 /         FAN 0580     02077
C                                                                FAN 0590     02078
      DATA XTAB /                                                               02079
     *                        97.9, 98.1, 98.3, 98.6, 98.9, 99.5,    FAN 0600     02080
     1100.2, 101.3, 102.4, 103.4, 104.1, 104.7, 105.2, 105.6, 106. , FAN 0610     02081
C                                                                FAN 0620     02082
     *                      2*98.7, 99., 99.2, 99.6, 100., 100.8,    FAN 0630     02083
     1101.9, 103., 103.9, 104.5, 105.1, 105.6, 105.9, 106.2 ,        FAN 0640     02084
C                                                                FAN 0650     02085
     *                      2*99.5, 99.6, 99.7, 100., 100.5, 101.4,  FAN 0660     02086
     1102.5, 103.5, 104.4, 105., 105.5, 105.9, 106.2, 106.4 ,        FAN 0670     02087
C                                                                FAN 0680     02088
     *                      2*100.1, 100.2,100.3,100.6, 101.2, 102., FAN 0690     02089
     1103., 103.8, 104.7, 105.3, 105.7, 106.1, 106.4, 106.6 ,        FAN 0700     02090
C                                                                FAN 0710     02091
     *                      2*100.7, 100.8, 100.9, 101.3, 101.8,     FAN 0720     02092
     1102.5,103.3, 104.2, 105., 105.2, 105.9, 106.3, 106.5, 106.7 /  FAN 0730     02093
C                                                                FAN 0740     02094
C ARRAY CORF CONTAINS CORRECTION FACTORS TO CALCULATE THE SECOND                  02095
C HARMONIC OF FORWARD RADIATED DISCRETE FREQUENCY NOISE FROM THE FIRST            02096
C HARMONIC.                                                                       02097
C                                                                                 02098
      DATA CORF / 3.3, 7.5, 6.8 /                                    FAN 0750     02099
C                                                                FAN 0760     02100
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C ARRAY FCORR CONTAINS CORRECTION FACTORS TO CALCULATE THE SECOND
C HARMONIC OF AFT RADIATED DISCRETE FREQUENCY NOISE FROM THE FIRST
C HARMONIC
C
      DATA FCORR / 3.2, 3.5, 2.5 /                                      FAN 0770
C                                                                       FAN 0780
C THE ARRAY DIRC CONTAINS THE CORRECTION NUMBERS USED IN COMPUTING THE
C SPL OF THE COMBINATION TONES FROM THE PWL
C
      DATA  DIRC /
     1   -475.92   ,-488.88  ,-491.57  ,-14.22   ,419.53   ,12.96
     1  ,-286.74   , 181.25  ,1618.24  , 4033.55 ,6613.32
     2  ,1088.41   ,1164.19  ,1202.70  , 7.71    ,-1046.58 ,-43.78
     2  ,635.16    ,-411.47  ,-3933.70 ,-9869.94 ,-16167.2
     3  ,-832.01   ,-929.26  ,-987.87  , 2.85    ,867.72   ,53.02
     3  ,-432.44   ,295.32   ,3133.88  , 7937.61 ,12994.70
     4  ,207.78    ,244.73   ,269.86   , 0.      ,-238.17  ,-20.72
     4  ,105.71    ,-67.81    ,-821.89   ,-2104.66 ,-3443.76
     5  ,6*0.
     5  ,-48.7     , 4*0.
     6  ,6*0.
     6  ,26.11     , 4*0.
     $                            /
C
      PI > 3.1415927                                                    FAN 0930
      RAD > 57.295780                                                   FAN 0940
      XPR > X * COS[ ALFA ] - Z * SIN[ ALFA ]                           FAN 0950
      ZPR > Z * COS[ ALFA ] < X * SIN[ ALFA ]                           FAN 0960
      CONST > 10.0 * ALOG10[ FN ]                                       FAN 0970
      FFR > SQRT[X*X < Y*Y < Z*Z]                                       FAN 0980
C                                                                       FAN 0990
C CALCULATE GAMMA - DIRECTIVITY ANGLE - AND INTERVAL IN WHICH IT FALLS  FAN 1000
C                                                                       FAN 1010
      IF [XPR<Y]30,10,30                                                FAN 1020
   10 IF [ZPR]20,500,20                                                 FAN 1030
   20 GAMMA > 90.                                                       FAN 1040
      GO TO 40                                                          FAN 1050
   30 GAMMA > ABS[ ATAN2[ Y,XPR ]]                                      FAN 1060
      GAMMA > GAMMA * RAD                                               FAN 1070
   40 CONTINUE                                                          FAN 1080
      INC > GAMMA / 10.0 < 0.50001                                      FAN 1090
      IF[ INC .LT.  1 ] INC > 1                                         FAN 1100
      IF[ INC .GT. 15 ] INC >15                                         FAN 1110
   50 CONTINUE                                                          FAN 1120
C                                                                       FAN 1130
C CALCULATE PROGRAM PARAMETERS                                          FAN 1140
C                                                                       FAN 1150

      THETA1 > [TT2 < 459.688] / 518.688                                FAN 1170
      THETA1 > SQRT[THETA1]                                             FAN 1180
      DELTA > PT2/29.92                                                 FAN 1190
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      RPMC > RPM / THETA1                                               FAN 1200    02151
      SPAFC > SPAF * THETA1 / DELTA                                     FAN 1210    02152
      XMXAVE > 1.0 - SQRT[ 0.9708126 - 0.0196508 * SPAFC ]              FAN 1220    02153
      IF[XMXTIP .LE. 0.]XMXTIP > XMXAVE                                 FAN 1230    02154
      AREA > PI * DIAT ** 2 / 4.                                        FAN 1240    02155
      TAU > PI * DIAT / B                                               FAN 1250    02156
      E1 > RPM / 60.0                                                   FAN 1260    02157
      BPF > B * E1                                                      FAN 1270    02158
C                                                                                   02159
C DETERMINE THE 1/3-OCTAVE BANDS IN WHICH THE BLADE PASSAGE TONE AND                02160
C ITS FIRST HARMONIC FALL                                                           02161
C                                                                                   02162
      DO 60 J>1,24                                                      FAN 1280    02163
      IF [BPF.LT.FL[J]] GO TO 70                                        FAN 1290    02164
   60 CONTINUE                                                                      02165
   70 NOBP1 > J-1                                                       FAN 1300    02166
      NOBP2 > NOBP1 <3                                                  FAN 1310    02167
      IF[NOBP2 .GT.24] NOBP2 > 24                                       FAN 1320    02168
      XMTIP > PI * DIAT * RPMC / [ 60. * 12. * SAZ]                     FAN 1330    02169
      XMREL > SQRT[XMXTIP**2 < XMTIP**2]                                FAN 1340    02170
      C > SAZ * 12.                                                     FAN 1350    02171
C                                                                       FAN 1360    02172
C * * * BEGIN CALCULATION OF BROADBAND NOISE * * *                                  02173
C                                                                       FAN 1380    02174
      JMACH > 20.0 * XMREL - 12.50001                                   FAN 1390    02175
      IDFAC > 50.0 * DF - 12.50001                                      FAN 1400    02176
      IF [JMACH.GT.0] GO TO 80                                          FAN 1410    02177
      JMACH > 1                                                         FAN 1420    02178
   80 IF [JMACH.LE.15] GO TO 90                                         FAN 1430    02179
      JMACH > 15                                                        FAN 1440    02180
   90 IF [IDFAC.GT.0] GO TO 100                                         FAN 1450    02181
      IDFAC > 1                                                         FAN 1460    02182
  100 IF [IDFAC.LE.15] GO TO 110                                        FAN 1470    02183
      IDFAC > 15                                                        FAN 1480    02184
  110 CONTINUE                                                          FAN 1490    02185
C                                                                       FAN 1500    02186
C CALCULATE CONSTANT TERMS AND OVERALL LEVEL                            FAN 1510    02187
C                                                                       FAN 1520    02188
      DBB > 10.0 * ALOG10[ BPR/[BPR < 1.0]/0.833 ]                      FAN 1530    02189
      DBA > 20.0 * ALOG10[ DIAT/52.0]                                   FAN 1540    02190
      DBR > 20.0 * ALOG10[ FFR / 150.0 ]                                FAN 1550    02191
      F1  > 0.5 * [ 1.0 - TANH[ 5.0 * [XMREL - 0.95]]]                  FAN 1560    02192
      F2  > 0.5 * [ 1.0 - TANH[15.0 * [XMREL - 0.95]]]                  FAN 1570    02193
C                                                                       FAN 1580    02194
      OVAL > TABLE[IDFAC, JMACH] < F1 * SUBD[INC] < DBA - DBR           FAN 1590    02195
      OVAL > OVAL < [ 1.0 - F1 ] * SUPD[INC]                            FAN 1600    02196
      IF[ INC .GT. 9 ] OVAL > OVAL < DBB                                FAN 1610    02197
C                                                                       FAN 1620    02198
C SPECTRAL DISTRIBUTION                                                 FAN 1630    02199
C                                                                       FAN 1640    02200
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      D1 > SQRT[ABS[1.00 - XMREL**2]] * CHORD                           FAN 1650
      D2 >[F2 * SAZ * XMREL / D1]* 12.0                                 FAN 1660
      D3 >[1.00-F2]* 5.00 * SAZ * 24.00 / DIAT                          FAN 1670
      FCR > D2 < D3                                                     FAN 1680
      DO 120 I>1,24                                                     FAN 1690
      IF [FCR.LE.FL[I<1]] GO TO 130                                     FAN 1700
  120 CONTINUE                                                          FAN 1710
      ICK > 24                                                          FAN 1720
      GO TO 140                                                         FAN 1730
  130 ICK > I                                                           FAN 1740
  140 CORECT > 50.0 * CHORD * SQRT[ABS[ 1.00 - XMREL ** 2]]             FAN 1750
      DUM > CORECT / [12.0/* SAZ * XMREL]                               FAN 1760
      CORECT > 10.0 *ALOG10[DUM]                                        FAN 1770
      IF[XMREL .GT. 1.0]CORECT>10.0*ALOG10[50.0*DIAT/[24.0*SAZ]] - 7.00 FAN 1780
      OCTAVE > OVAL - 10.7777                                           FAN 1790
      DO 170 J>1,24                                                     FAN 1800
      IF [J.GT.ICK] GO TO 150                                           FAN 1810
      BBN[J] > OCTAVE < CORECT < J - 1.0                                FAN 1820
      GO TO 160                                                         FAN 1830
  150 BBN[J] > OCTAVE - 0.5333*[J - ICK]                                FAN 1840
  160 BBN[J] > 10.0**[BBN[J]/10.0]                                      FAN 1850
  170 CONTINUE                                                          FAN 1860
C                                                                       FAN 1870
C *** END BROADBAND NOISE ***
C                                                                       FAN 1890
C * * * BEGIN CALCULATION OF DISCRETE TONE NOISE * * *
C
      XMTIPS > XMTIP / SQRT[ 1.0 - XMXAVE**2]                           FAN 1910
      XMSTAR > 1.0 < 0.84*B**[-0.6666667]                               FAN 1920
      ZETAB1 > XMTIPS / XMSTAR                                          FAN 1930
      NCOR   > 1.0 < ZETAB1 / 0.91                                      FAN 1940
      IF[ NCOR .GT. 3 ] NCOR > 3                                        FAN 1950
C                                                                       FAN 1960
C CALCULATE POWER LEVELS                                                FAN 1970
C                                                                       FAN 1980
      PRL > 10.0 * ALOG10[[PR-1.0] * [DIAT/24.0]**2]                    FAN 1990
      DLL > 20.0 * ALOG10[DL]                                           FAN 2000
      IF [ZETAB1.LE.1.5] GO TO 180                                      FAN 2010
      PWL1F > 127.0 < PRL - DLL                                         FAN 2020
      PWL1R > 129.0 < PRL                                               FAN 2030
      GO TO 190                                                         FAN 2040
  180 Z1 > ZETAB1                                                       FAN 2050
      Z2 > Z1 * Z1                                                      FAN 2060
      Z3 > Z1 * Z2                                                      FAN 2070
      Z4 > Z1 * Z3                                                      FAN 2080
      Z5 > Z1 * Z4                                                      FAN 2090
      PWL1F > 121.84 < 38.28*Z1 - 303.79*Z2 < 635.85*Z3                 FAN 2100
      PWL1F > PRL < PWL1F - 483.36*Z4 < 122.80* Z5                      FAN 2110
      IF[ ZETAB1 .GT. 1.05] PWL1F > PWL1F - DLL                         FAN 2120
      PWL1R > 184. - 203.18*Z1 - 21.98*Z2 < 550.99*Z3                   FAN 2130
                                                                        FAN 2140
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      PWL1R > PWL1R < PRL - 534.97*Z4 < 151.26*Z5                       FAN 2150    02251
  190 PWL2F > PWL1F - CORF[NCOR]                                        FAN 2160    02252
      PWL2R > PWL1R - FCORR[NCOR]                                       FAN 2170    02253
C                                                                       FAN 2180    02254
C DIRECTIVITY AND SPL                                                               02255
C                                                                       FAN 2200    02256
      FFL > 20.0 * ALOG10[FFR]                                          FAN 2210    02257
      SPLMF > PWL1F - FFL < 5.55                                        FAN 2220    02258
      SPLMR > PWL1R - FFL < 5.55                                        FAN 2230    02259
      THETA1 > INC * 10. / RAD                                          FAN 2240    02260
      T1 > THETA1                                                       FAN 2250    02261
      T2 > T1 * T1                                                      FAN 2260    02262
      T3 > T1 * T2                                                      FAN 2270    02263
      T4 > T1 * T3                                                      FAN 2280    02264
      T5 > T1 * T4                                                      FAN 2290    02265
      IF [INC.GE.9] GO TO 220                                           FAN 2300    02266
      IF [ZETAB1.GT.1.05] GO TO 200                                     FAN 2310    02267
      SPL1 > SPLMF -1.26688 < 5.49633E-02*T1 - 2.949127E-03*T2          FAN 2320    02268
      SPL1 > SPL1 < 7.628378E-05*T3 < 3.44868E-07*T4 - 1.232265E-08*T5  FAN 2330    02269
      GO TO 210                                                         FAN 2340    02270
  200 SPL1 > SPLMF - 3.03392 < 7.285306E-02*T1 < 4.082438E-04*T2        FAN 2350    02271
      SPL1 > SPL1 < 2.823003E-07*T3 < 8.859138E-08*T4 - 6.314598E-10*T5 FAN 2360    02272
  210 SPL2 > SPL1 - CORF[NCOR]                                          FAN 2370    02273
      GO TO 230                                                         FAN 2380    02274
  220 A0 > -56.418                                                      FAN 2390    02275
      A1 >    6.450250E-01 * T1                                         FAN 2400    02276
      A2 >    2.096982E-03 * T2                                         FAN 2410    02277
      A3 >   -6.778207E-06 * T3                                         FAN 2420    02278
      A4 >   -2.895571E-07 * T4                                         FAN 2430    02279
      A5 >    8.594444E-10 * T5                                         FAN 2440    02280
C                                                                       FAN 2450    02281
      SPL1 > SPLMR < A0 < A1 < A2 < A3 < A4 < A5                        FAN 2460    02282
      SPL2 > SPL1 - FCORR[NCOR]                                         FAN 2470    02283
  230 CONTINUE                                                          FAN 2480    02284
C                                                                       FAN 2490    02285
      BPN1 > 10.0 ** [SPL1/10.]                                         FAN 2500    02286
      BPN2 > 10.0 ** [SPL2/10.]                                         FAN 2510    02287
      ICOMB > COMB < 0.00001                                            FAN 2570    02288
      IF [ICOMB.EQ.0] GO TO 240                                         FAN 2580    02289
C                                                                       FAN 2520    02290
C IF CALCULATION IS DESIRED FOR COMBINATION TONES AND IF RELATIVE TIP   FAN 2530    02291
C MACH NUMBER IS OVER 1 NEXT THREE STATEMENTS ARE SKIPPED AND           FAN 2540    02292
C CALCULATION FOR COMBINATION TONES BEGINS                              FAN 2550    02293
C                                                                       FAN 2560    02294
      IF [XMREL.GT.1.0] GO TO 250                                       FAN 2590    02295
  240 BBN[NOBP1] > BPN1 < BBN[NOBP1]                                    FAN 2600    02296
      BBN[NOBP2] > BPN2 < BBN[NOBP2]                                    FAN 2610    02297
      GO TO 480                                                         FAN 2620    02298
C                                                                       FAN 2630    02299
C BEGIN CALCULATION OF COMBINATION TONE NOISE                           FAN 2640    02300
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C                                                                          FAN 2650    02301
  250 SINMU > 1.0 / XMREL                                                  FAN 2660    02302
      COSMU > SQRT[1.0 - SINMU**2 ]                                        FAN 2670    02303
      TANMU > SINMU / COSMU                                                FAN 2680    02304
      XMU > ATAN[TANMU]                                                    FAN 2690    02305
      TBETAS > XMXTIP /XMTIP                                               FAN 2700    02306
      BETAS  > ATAN[ TBETAS ]                                              FAN 2710    02307
      SMULB  > SIN[ XMU - BETAS ]                                          FAN 2720    02308
      DUM1 > 1.0 - XMXTIP ** 2                                             FAN 2730    02309
      DUM2 > 1.0 < XMXTIP ** 2 / 5.0                                       FAN 2740    02310
      DUM3 > XMREL ** 2 /[XMXTIP * XMTIP]                                  FAN 2750    02311
      DUM4 > DUM1 * DUM3 / DUM2                                            FAN 2760    02312
      DUM5 > 0.5 * [DIAT ** 2 - DIAH ** 2]                                 FAN 2770    02313
      DUM6 > DIAT*DDDXT < DIAH * DDDXH                                     FAN 2780    02314
      DUM7 > DUM5 /[DUM6 * COS[BETAS]]                                     FAN 2790    02315
C                                                                                      02316
C  IF AZIMUTH ANGLE .GT. 110 DEG., SET TO MAXIMUM                                      02317
C                                                                                      02318
                                                                                       02319
      IF [INC .GT. 11 ] INC > 11                                           FAN 2810    02320
      RF > DUM4 * DUM7                                                     FAN 2820    02321
      IF [RS.LT.0.0] GO TO 260                                             FAN 2830    02322
      IF [RF-RS]260,260,270                                                FAN 2840    02323
  260 RS > 1.0E<25                                                         FAN 2850    02324
      GO TO 280                                                            FAN 2860    02325
  270 RS > RS * RF / [RF - RS ]                                            FAN 2870    02326
  280 CONTINUE                                                             FAN 2880    02327
      ALPHA > RS/TAU * SINMU/SMULB                                         FAN 2890    02328
      THETAA > 13.5 * ALPHA**[-0.875] / RAD                                FAN 2900    02329
      ALPHA > RS/TAU * SIN[XMU < THETAA] / SMULB                           FAN 2910    02330
      DUM1 > 2.0 * COS[XMU] - [TAU/RS] * SMULB                             FAN 2920    02331
      DUM2 > SIN[XMU]**2 < [TAU/RS] * SMULB * DUM1                         FAN 2930    02332
      THETAE > 2.0 * ATAN[[-SIN[XMU] < SQRT[DUM2]] / DUM1 ]                FAN 2940    02333
      PSI1 > THETAA / [SQRT[2.0] * SIGPHI ]                                FAN 2950    02334
      PSI2 > [THETAE - THETAA] / [SQRT[2.0] * SIGPHI]                      FAN 2960    02335
      ETA > 0.5 * [1.0 < ERF[PSI2] ]                                       FAN 2970    02336
      A1 > 2.0 ** 1.5 * SIGPHI                                             FAN 2980    02337
      DUM1 > [2.0 * SIGPHI]**2                                             FAN 2990    02338
      DUM2 > PSI1**2 < A1*PSI1 < DUM1*EXP[-PSI1**2]                        FAN 3000    02339
      DUM3 > PSI2 < A1*PSI2 < DUM1**EXP[-PSI2**2]                          FAN 3010    02340
      DUM3 > DUM2 - DUM3                                                   FAN 3020    02341
      DUM4 > SIGPHI**2 < 2.0*SIGPHI**3*SQRT[2.0 / PI ]                     FAN 3030    02342
      DUM4 > DUM4 * DUM3                                                   FAN 3040    02343
      SIGESQ > 1.0 - ETA < 2.0*ETA*ALPHA**2 * DUM4                         FAN 3050    02344
      SIGEPS > SQRT[SIGESQ]                                                FAN 3060    02345
      IF[ SIGEPS .GT. 0.3] SIGEPS > 0.3                                    FAN 3070    02346
      SIGAMP > 0.1                                                         FAN 3080    02347
      N1 > 11312.0 / E1                                                    FAN 3090    02348
C                                                                          FAN 3100    02349
C CALCULATE SOUND POWER                                                    FAN 3110    02350
C
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      PWLT > -189.16 < 727.24 * XMREL - 488.93 * XMREL**2               FAN 3120
      PWLT > PWLT < 107.69 * XMREL**3 < 10.0*ALOG10[AREA / 144.0]       FAN 3130
      PWLT > PWLT - 20.0 * ALOG10[ETA * B ]                             FAN 3140
C                                                                       FAN 3150
C SPECTRAL DISTRIBUTION                                                 FAN 3160
C                                                                       FAN 3170
      N > ETA * B                                                       FAN 3180
      AN > N                                                            FAN 3190
      AM2 > 1.0 < SIGAMP**2                                             FAN 3200
      POWER > 0.0                                                       FAN 3210
      DO 320 KHAR>1,N1                                                  FAN 3220
      AHAR > KHAR                                                       FAN 3230
      PHPB > PI * AHAR / AN                                             FAN 3240
      PHPB2 > PHPB ** 2                                                 FAN 3250
      TPHPB > 2.0 * PHPB                                                FAN 3260
      TERM > 0.25 / [PHPB * PHPB2 * AHAR ] * [1.0 - COS[TPHPB]          FAN 3270
     1 < PHPB2 * [2.0 - 2.0 / PHPB * SIN[TPHPB] ] ]                     FAN 3280
      EXPO > EXP[-PHPB2 * 4.0 * SIGEPS ** 2]                            FAN 3290
      IF [MOD[KHAR,N]]300,290,300                                       FAN 3300
  290 TERM > TERM * [ AM2 < EXPO * [ B - 1.0 ] ]                        FAN 3310
      GO TO 310                                                         FAN 3320
  300 TERM > TERM * [AM2 - EXPO]                                        FAN 3330
  310 POWER > POWER < TERM                                              FAN 3340
  320 PWL[KHAR] > 10.0 * ALOG10[TERM] < 170.8                           FAN 3350
C                                                                       FAN 3360
C DUCT PROPAGATION                                                      FAN 3370
C                                                                       FAN 3380
      CUTOFF > 1.0 - 0.1 * EXP[23.0259 * [1.0 - XMREL] ]                FAN 3390
      DO 330 I>1,N1                                                     FAN 3400
      ORDER > I                                                         FAN 3410
      XMSTAR > 1.0 < 0.81 * ORDER ** [-0.6666667]                       FAN 3420
      ZETA > XMTIP / SQRT[1.0 - XMXAVE ** 2] / XMSTAR                   FAN 3430
      IF [ZETA.GE.CUTOFF] GO TO 340                                     FAN 3440
  330 CONTINUE                                                          FAN 3450
  340 ICUT > I - 1                                                      FAN 3460
C
C CALCULATE TOTAL PWL CONTAINED IN HARMONICS BELOW CUTOFF AND SET PWL
C OF ALL THESE HARMONICS TO ZERO
C
      DO 350 I>1,ICUT                                                   FAN 3470
      POWER > POWER - 10.0**[ PWL[I]/10.0 - 17.08]                      FAN 3480
  350 PWL[I] > 0.                                                       FAN 3490
      POWER > 10.0 * ALOG10[POWER] < 170.8                              FAN 3500
      DELPWL > PWLT - POWER                                             FAN 3510
      ICUTP1 > ICUT < 1                                                 FAN 3520
C
C INCREASE THE PWL OF HARMONICS ABOVE CUTOFF TO ACCOUNT FOR PWL
C SUBTRACTED BECAUSE OF HARMONICS BELOW CUTOFF.
C
      DO 360 KHAR>ICUTP1,N1                                             FAN 3530
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  360 PWL[KHAR] > PWL[KHAR] < DELPWL                                    FAN 3540
C                                                                       FAN 3550
C DIRECTIVITY                                                           FAN 3560
C                                                                       FAN 3570
      RADCOR > 20.0 * ALOG10[FFR] - 3.85                                FAN 3580
      NQ > 0                                                            FAN 3590
      DO 410 I>1,N1                                                     FAN 3600
      ORDER > I                                                         FAN 3610
      FREQ > ORDER * E1                                                 FAN 3620
      REFSPL > 0.                                                       FAN 3630
      IF [PWL[I].LE.RADCOR] GO TO 400                                   FAN 3640
      REFSPL > PWL[I] - RADCOR                                          FAN 3650
      XMSTAR > 1.0 < 0.81 * ORDER ** [-2/3]                             FAN 3660
      ZETA > XMTIP / XMSTAR / SQRT[1.0 - XMXAVE ** 2]                   FAN 3670
      IF [NQ.EQ.1] GO TO 370                                            FAN 3680
      IF[ ZETA .GT. 1.5 ] NQ > 1                                        FAN 3690
  370 IF[ ZETA .LT. 1.0 ] ZETA > 1.0                                    FAN 3700
      ZETAK[1] > 1.0                                                    FAN 3710
      DO 380 K>2,6                                                      FAN 3720
  380 ZETAK[K] > ZETA * ZETAK[K-1]                                      FAN 3730
      PWL[I] > REFSPL                                                   FAN 3740
      DO 390 K>1,6                                                      FAN 3750
  390 PWL[I] > PWL[I] < DIRC[INC,K] * ZETAK[K]                          FAN 3760
  400 CONTINUE                                                          FAN 3770
  410 CONTINUE                                                          FAN 3780
C                                                                       FAN 3790
C THIRD OCTAVE SYNTHESIS                                                FAN 3800
C                                                                       FAN 3810
      KHAR > 0                                                          FAN 3820
      DO 470 I>1,24                                                     FAN 3830
      SUM > 0.                                                          FAN 3840
  420 KHAR > KHAR < 1                                                   FAN 3850
      IF [KHAR.GT.N1] GO TO 430                                         FAN 3860
      AHAR > KHAR                                                       FAN 3870
      FREQ > AHAR * E1                                                  FAN 3880
      IF [FREQ.GT.FL[I<1]] GO TO 430                                    FAN 3890
      IF [PWL[KHAR].LE.0.0] GO TO 420                                   FAN 3900
      SUM > SUM < 10.0 ** [PWL[KHAR]/10.0]                              FAN 3910
      GO TO 420                                                         FAN 3920
  430 KHAR > KHAR - 1                                                   FAN 3930
      IF [I.EQ.NOBP1] GO TO 450                                         FAN 3940
      IF [I.EG.NOBP2] GO TO 460                                         FAN 3950
  440 IF [SUM.LE.0.0] GO TO 470                                         FAN 3960
      BBN[I] > BBN[I] < SUM                                             FAN 3970
      GO TO 470                                                         FAN 3980
C
C FOR THIRD OCTAVES CONTAINING THE DISCRETE FREQUENCY (BLADE PASSAGE)
C NOISE THE SPL IS EQUAL TO THE LARGER OF BLADE PASSAGE NOISE OR
C COMBINATION TONE NOISE
C
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  450 IF [BPN1.LT.SUM] GO TO 440                                    FAN 3990
      SUM > BPN1                                                    FAN 4000
      GO TO 440                                                     FAN 4010
  460 IF [BPN2.LT.SUM] GO TO 440                                    FAN 4020
      SUM > BPN2                                                    FAN 4030
      GO TO 440                                                     FAN 4040
  470 CONTINUE                                                      FAN 4050
C                                                                   FAN 4060
C END OF COMBINATION TONE NOISE CALCULATION                          FAN 4070
C                                                                   FAN 4080
C ARRAY BBN NOW CONTAINS THE SOUND PRESSURE OF THE TOTAL OF BROADBAND,
C DISCRETE FREQUENCY TONE, AND COMBINATION TONE NOISE
C
  480 CONTINUE                                                      FAN 4090
C
C CONVERT SOUND PRESSURE TO SPL
C
      DO 490 I>1,24                                                 FAN 4100
  490 BBN[I] > 10.0 * ALOG10[BBN[I]] < CONST                        FAN 4110
  500 CONTINUE                                                      FAN 4120
      RETURN                                                        FAN 4130
      END                                                           FAN 4140
      FUNCTION ERF[X]                                               ERF 0010
C                                                                   ERF 0020
C  TITLE:    FUNCTION ERF
C
C  PURPOSE:  TO CALCULATE THE VALUE OF ERF(PSI(2)) REQUIRED BY
C            SUBROUTINE FAN IN THE CALCULATION OF COMBINATION TONES
C
C  ABSTRACT: ERF CAN TAKE ON 5 DIFFERENT VALUES DEPENDING ON THE VALUES
C            OF THE ARGUMENT PSI(2) AND A VARIABLE T GIVEN BY:
C                   T = 1/(1 - 0.328*ABS(PSI(2) ) )
C            ERF =  0     FOR PSI(2) EQ 0
C            ERF =  1     FOR PSI(2) GT 0  AND  T LE 0.43
C            ERF = -1     FOR PSI(2) LT 0  AND  T LE 0.43
C            ERF = +Q     FOR PSI(2) GT 0  AND  T GT 0.43
C            ERF = -Q     FOR PSI(2) LT 0  AND  T GT 0.43 .
C            WHERE Q IS GIVEN BY:
C                   Q = 1 - T*CXP(-PSI(2)**2)*(1.061*T**4 - 1.43*T**3
C                      + 1.42*T**2 - 0.248* T + 0.255)
C
C USAGE:     ...(X)
C            X.....INPUT VALUE OF PSI(2)
C
C LABELED
C   COMMON:  NONE
C
C SUBROUTINES CALLED:  FUNCTION SIGN(X,Y)
C
      T > 1.0 / [1.0 < 0.3275911 * ABS[X]]                          ERF 0030
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```
      IF [X]20,10,20                                                    ERF 0040
   10 ERF > 0.                                                          ERF 0050
      RETURN                                                            ERF 0060
   20 IF [T-0.43]30,30,40                                               ERF 0070
   30 ERF > SIGN[1.0,X]                                                 ERF 0080
      RETURN                                                            ERF 0090
   40 ERF > 1.0 - T * EXP[-X*X]*[0.254829592 < T * [-0.284496736 <      ERF 0100
     1  T * [1.42141374 < T * [-1.45315203 < T * 1.06140543]]]]         ERF 0110
      ERF > SIGN[ERF,X]                                                 ERF 0120
      RETURN                                                            ERF 0130
      END                                                               ERF 0140
      SUBROUTINE ENGINE[EOBLR3,BIGX,BIGY,BIGZ]                          ENGI0010
C                                                                       ENGI0020
C  TITLE:    ENGINE
C
C  PURPOSE:  TO CALCULATE THE 1/3-OCTAVE BAND SPL SPECTRUM FOR TURBO-
C            SHAFT ENGINES
C
C  ABSTRACT: AN EMPIRICAL TECHNIQUE BASED ON NOISE DATA MEASURED FOR
C            SEVERAL ENGINE IS USED.  THE SIDELINE PNL IS CALCULATED,
C            CORRECTED TO THE OBSERVER'S AZIMUTH LOCATION, CONVERTED
C            TO AN OCTAVE SPECTRUM, AND,FINALLY,CONVERTED TO A 1/3-
C            OCTAVE SPECTRUM. REQUIRED INPUT (VIA COMMON):
C               HPENG....ENGINE POWER OUTPUT
C               SLEVEL...ESTIMATED ENGINE SOUND LEVEL, EITHER AVERAGE
C                        OR LOUD (SEE REPORT FOR DETAILS)
C               ANENG....NUMBER OF ENGINES
C
C  USAGE:    ......(EOBLR3,BIGX,BIGY,BIGZ)
C            EOBLR3...A 24 ELEMENT ARRAY COUNTAINING THE CALCULATED
C                     1/3-OCTAVE NOISE SPECTRUM
C            BIGX
C            BIGY......COORDINATES OF OBSERVER RELATIVE TO VEHICLE
C            BIGZ                                         (INPUT)
C
C  LABELED
C    COMMON: /B1/   /INPUT/
C
C  SUBROUTINES CALLED:  NONE
C
      DIMENSION EOBLR[9],EOBLR3[24],GCURVE[19],DCURVE[19],CORRCV[19,9]  ENGI0170
     1,BES[400]                                                         ENGI0180
      COMMON /B1/ BES,INCMAX[50]                                        ENGI0190
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID, ENGI0200
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,     ENGI0210
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,       ENGI0220
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50],  ENGI0230
     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,   ENGI0240
     5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,  ENGI0250
     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,  ENGI0260
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      7ALFAJ,ROTR,RP,FANS,RJ,E
C                                                                       ENGI0270
C THE GCURVE ARRAY CONTAINS THE AZIMUTH ANGLES FROM 0 TO 180 DEGREES IN ENGI0280
C INCREMENTS OF 10 DEGREES.                                             ENGI0290
C                                                                       ENGI0300
       DATA  GCURVE /0.,  10.,  20., 30., 40., 50., 60., 70., 80., 90., ENGI0310
     1              100.,110.,120.,130.,140.,150.,160.,170.,180.       /ENGI0320
C                                                                       ENGI0330
C THE DCURVE ARRAY CONTAINS DIRECTIVITY CORRECTION FACTORS TO BE APPLIEDENGI0340
C TO THE CALCULATED TOTAL LEVEL                                         ENGI0350
C                                                                       ENGI0360
       DATA DCURVE /-4.3,-3.6,-2.5,-1.8,-1.2,-0.8,-.6,-0.4,-0.2,0.0, 0.2,ENGI0370
     1              0.4, 0.6, 0.9, 1.0, 0.9, 0.5, 0.0, -0.5            /ENGI0380
C                                                                       ENGI0390
C THE CORRCV ARRAY CONTAINS CORRECTION FACTORS TO PRODUCE A 9 ELEMENT   ENGI0400
C OCTAVE BAND SPECTRUM FOR EACH OF 19 AZIMUTH LOCATIONS [0 TO 180 DEG.] ENGI0410
C                                                                       ENGI0420
       DATA CORRCV               / 24.8, 25.0, 25.8, 26.0, 27.2, 30.0,  ENGI0430
     1 32.0, 34.0, 37.0, 39.5, 41.0, 43.0, 43.6, 44.6, 44.5, 43.4, 41.8,ENGI0440
     * 40.5,39.6,                 24.6, 24.8, 25.2, 25.8, 26.5, 28.0,   ENGI0450
     1 29.6, 31.0, 34.0, 36.7, 38.5, 40.6, 41.6, 42.8, 42.8, 41.0, 39.5,ENGI0480
     * 37.7,36.6,                 26.6, 26.7, 26.8, 27.0, 27.5, 28.7,   ENGI0490
     1 30.3, 31.5, 34.2, 36.6, 38.5, 40.6, 41.6, 42.8, 42.8, 41.0, 39.5,ENGI0520
     * 37.7,36.6,                 29.6, 29.8, 30.0, 30.4, 31.0, 32.3,   ENGI0530
     1 33.5, 34.7, 37.0, 39.6, 41.0, 43.0, 43.9, 45.0, 45.0, 44.0, 42.2,ENGI0560
     * 40.5,39.6,                 30.6, 30.7, 30.8, 31.3, 31.8, 32.9,   ENGI0570
     1 34.3, 34.9, 36.8, 38.6, 39.5, 41.4, 42.3, 43.8, 43.8, 42.2, 41.0,ENGI0600
     * 39.3,38.6,                 19.6, 20.2, 21.6, 23.4, 25.0, 27.3,   ENGI0610
     1 29.2, 30.4, 32.6, 33.6, 33.4, 33.7, 32.9, 33.2, 33.0, 32.8, 33.4,ENGI0640
     * 33.7,33.6,                 19.6, 19.6, 19.8, 19.9, 20.0, 20.7,   ENGI0650
     1 21.3, 21.5, 22.8, 23.6, 23.4, 23.7, 22.9, 23.0, 22.9, 22.6, 23.4,ENGI0680
     * 23.7,23.6,                 19.6, 19.4, 19.2, 19.0, 18.8, 18.2,   ENGI0690
     1 17.6, 16.6, 16.4, 16.4, 16.6, 17.0, 16.6, 17.2, 17.2, 16.7, 16.6,ENGI0720
     * 16.4,16.4,                 19.6, 19.6, 19.6, 19.4, 19.2, 19.3,   ENGI0730
     1 19.1, 18.4, 18.6, 18.0, 16.5, 15.7, 14.0, 13.7, 13.8, 14.2, 16.0,ENGI0760
     2 17.3, 18.0 /                                                     ENGI0770
C                                                                       ENGI0780
       DTR > 0.0174532925                                               ENGI0790
C                                                                       ENGI0800
C                              AVERAGE ENGINE FACTORS                   ENGI0810
C                                                                       ENGI0820
       FACT1 > 4.4                                                      ENGI0830
       FACT2 > 79.0                                                     ENGI0840
C                                                                       ENGI0850
C                               LOUD ENGINE FACTORS                     ENGI0860
C                                                                       ENGI0870
       IT > SLEVEL                                                      ENGI0880
       IF [IT.EQ.1] GO TO 10                                            ENGI0890
       FACT1 > 5.8                                                      ENGI0900
       FACT2 > 80.2                                                     ENGI0910
                                                                        ENGI0920
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   10 CONTINUE                                                          ENGI0930
      PNL500 > FACT1 * ALOG10[HPENG/10.]< FACT2<                        ENGI0940
     1 10.0*ALOG10[ANENG]                                               ENGI0950
C                                                                       ENGI0960
C COMPUTE GAMMA, IF X AND Y ARE BOTH ZERO SET GAMMA TO  90 DEG.         ENGI0970
C IF GAMMA IS NEGATIVE, SET POSITIVE                                    ENGI0980
C GAMMA IS THE OBSERVER AZIMUTHAL LOCATION.  180 DEGREES IS IN FRONT.   ENGI0990
C                                                                       ENGI1000
      IF [BIGY<BIGX]40,20,40                                            ENGI1010
   20 IF [BIGZ]30,100,30                                                ENGI1020
   30 GAMMA >  90.                                                      ENGI1030
      GO TO 50                                                          ENGI1040
   40 GAMMA >  ABS[ ATAN2[ BIGY, -BIGX ] ]                              ENGI1050
      GAMMA >  GAMMA / DTR                                              ENGI1060
   50 CONTINUE                                                          ENGI1070
C                                                                       ENGI1080
C CORRECT SIDELINE PNL TO AZIMUTH GAMMA USING ARRAY DCURVE              ENGI1090
C                                                                       ENGI1100
C FIND INTERVAL IN WHICH GAMMA LIES AND APPLY CORRECTION                ENGI1110
C                                                                       ENGI1120
      ISA > GAMMA / 10.0 < 1.5                                          ENGI1130
      IF[ ISA .GT. 19 ] ISA > 19                                        ENGI1140
      IF[ ISA .LT.  1 ] ISA >  1                                        ENGI1150
      DELTA > DCURVE[ISA]                                               ENGI1160
   60 PNL500 > PNL500 < DELTA                                           ENGI1170
      SRP > SQRT[BIGX**2 < BIGY**2 < BIGZ**2]                           ENGI1180
C                                                                       ENGI1190
C CORRECTION FOR SPHERICAL EXPANSION TO DISTANCES OTHER THAN 500 FEET.  ENGI1200
C                                                                       ENGI1210
      SRPLG > 20.0 * ALOG10[SRP/500.]                                   ENGI1220
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C                                                                          ENGI1230    02631
C CALCULATE ENGINE OCTAVE BAND SPECTRUM                                    ENGI1240    02632
C                                                                          ENGI1250    02633
      DO 70 I>1,9                                                          ENGI1260    02634
      CORR > CORRCV[ISA,I]                                                 ENGI1270    02635
      EOBL > PNL500 - CORR                                                 ENGI1280    02636
      EOBLR[I]> EOBL - SRPLG                                               ENGI1290    02637
   70 CONTINUE                                                             ENGI1300    02638
      NN > 2                                                               ENGI1310    02639
C                                                                          ENGI1320    02640
C CALCULATE ENGINE 1/3-OCTAVE BAND SPECTRUM                                ENGI1330    02641
C                                                                          ENGI1340    02642
      DO 90 I>2,23,3                                                       ENGI1350    02643
      E1 > EOBLR[NN] - 4.8                                                 ENGI1360    02644
      EOBLR3[I-1] > E1 - 0.333 * [ EOBLR[NN] - EOBLR[NN-1] ]               ENGI1370    02645
      EOBLR3[I]   > E1                                                     ENGI1380    02646
      IF [NN.EQ.9] GO TO 80                                                ENGI1390    02647
      EOBLR3[I<1] > E1 - 0.333 * [ EOBLR[NN] - EOBLR[NN<1] ]               ENGI1400    02648
      NN > NN < 1                                                          ENGI1410    02649
      GO TO 90                                                             ENGI1420    02650
   80 EOBLR3[I<1] > E1 < 0.333 * [ EOBLR[NN] - EOBLR[NN-1] ]               ENGI1430    02651
   90 CONTINUE                                                             ENGI1440    02652
C                                                                          ENGI1450    02653
C END OF ENGINE 1/3-OCTAVE NOISE SPECTRUM                                  ENGI1460    02654
C                                                                          ENGI1470    02655
  100 CONTINUE                                                             ENGI1480    02656
      RETURN                                                               ENGI1490    02657
      END                                                                  ENGI1500    02658
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      SUBROUTINE ROTOR[FCK3,ROLTP3,RX,RY,RZ,JKI]                        ROT00010
C
C  TITLE:    ROTOR
C
C  PURPOSE:  TO CALCULATE THE ONE-THIRD OCTAVE NOISE SPECTRUM GENERATED
C            BY A HELICOPTER MAIN AND TAIL ROTOR
C
C  ABSTRACT: ROTOR ROTATIONAL NOISE IS CALCULATED USING THE CLOSED-FORM
C            SOLUTION MENTIONED BY LOWSON AND OLLERHEAD IN REFERENCE 1.
C            THIS IS COMBINED WITH A BROADBAND NOISE SPECTRUM THAT IS
C            CALCULATED FROM THE EMPIRICAL EQUATION PRESENTED IN REF. 2
C            BUT CORRECTED TO ACCOUNT FOR DIRECTIVITY.  SPECTRA ARE
C            CALCULATED FOR THE MAIN ROTOR AND TAIL ROTOR THEN COMBINED
C            TO PRODUCE THE TOTAL SPECTRUM.
C            REQUIRED INPUT (VIA COMMON):
C              RCASE (TCASE)....MAIN (TAIL) ROTOR AIRLOADING K FACTOR
C              RETA  (TETA).....MAIN (TAIL) ROTOR RADIAL LOADING STATION
C              RBIGB (TBIGB)....NUMBER OF MAIN (TAIL) ROTOR BLADES
C              RBIGR (TBIGR)....MAIN (TAIL) ROTOR RADIUS
C              ROMEGN(TOMEGN)...MAIN (TAIL) ROTOR ROTATIONAL SPEED
C              RSID  (TSID).....MAIN (TAIL) ROTOR DISK INCIDENCE ANGLE
C              RCHORD(TCHORD)...MAIN (TAIL) ROTOR BLADE CHORD
C              RTHRUS(TTHRUS)...MAIN (TAIL) ROTOR THRUST
C              RTORQ (TTORQ)....MAIN (TAIL) ROTOR TORQUE
C              RBETA (TBETA)....MAIN (TAIL) ROTOR CONING ANGLE
C              VF1..............FLIGHT SPEED
C  USAGE:    .....(FCK3,ROLTP3,RX,RY,RZ,JKI)
C            ROLTP3...THE 24 ELEMENT ARRAY CONTAINING THE CALCULATED
C                     ONE-THIRD OCTAVE NOISE SPECTRUM
C            FCK3.....A 24 ELEMENT ARRAY CONTAINING THE 1/3-OCTAVE
C                     CENTER FREQUENCIES FROM 50 TO 10,000 HZ (INPUT)
C            JKI......FLIGHT SEGMENT NUMBER (INPUT)
C            RX....
C            RY.......COORDINATES OF OBSERVER RELATIVE TO VEHICLE
C            RZ                                               (INPUT)
C
C  LABELED
C    COMMON: /B1/   /INPUT/
C
C  SUBROUTINES CALLED:  BJSIGN   BESSEL
C
      DIMENSION BES[400],OLKP[24],PSQP[60],SFM[60],FCK3[24],            ROT00060
     1ROLTP3[24],ALT[61],ALD[61],ALC[61],SCURVE[39]                     ROT00070
C
      COMMON /B1/ BES,INCMAX[50]                                        ROT00080
C
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID, ROT00090
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,     ROT00100
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,       ROT00110
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50],  ROT00120
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     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,     ROTO0130
     5UIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,   ROTO0140
     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,   ROTO0150
     7ALFAJ,ROTR,RP,FANS,RJ,E                                            ROTO0160
C                                                                        ROTO0170
C THE ARRAY SCURVE CONTAINS THE CORRECTION NUMBERS TO CALCULATE THE
C BROADBAND NOISE SPECTRUM FROM THE CALCULATED OVERALL LEVEL
C
      DATASCURVE/
     1-29.1,    -28.0,    -26.5,    -25.1,    -24.0,    -22.5,    -21.1, ROTO0190
     2-20.0,    -18.4,    -17.1,    -15.9,    -14.5,    -13.1,    -12.0, ROTO0200
     3-10.8,    -9.1,     -8.0,     -9.1,     -10.9,    -12.0,    -12.1, ROTO0210
     4-12.3,    -12.5,    -14.0,    -15.4,    -17.0,    -17.3,    -17.7, ROTO0220
     5-18.0,    -19.3,    -20.7,    -22.0,    -23.3,    -24.7,    -26.0, ROTO0230
     6-27.3,    -28.7,    -30.0,    -31.3  /                             ROTO0240
C                                                                        ROTO0250
      BIGV > VF1[JKI]                                                    ROTO0260
C                                                                        ROTO0270
C SET PROGRAM CONSTANTS                                                  ROTO0280
C                                                                        ROTO0290
      DTR>0.0174532925                                                   ROTO0300
      PI>3.1415926536                                                    ROTO0310
      HALFPI>PI/2.0                                                      ROTO0320
      ROOT2>SQRT[2.0]                                                    ROTO0330
      NPP>1                                                              ROTO0340
      TWO16>2.0**[1.0/6.0]                                               ROTO0350
      TWO13>2.0**[1.0/3.0]                                               ROTO0360
      TWO23>2.0**[2.0/3.0]                                               ROTO0370
      MLIMIT > 20                                                        ROTO0380
      IJK>TCASE                                                          ROTO0390
      XML>FLOAT[MLIMIT]                                                  ROTO0400
      BIGMF>BIGV/SAZ                                                     ROTO0410
      BMFSQ>BIGMF*BIGMF                                                  ROTO0420
      BIGX > RX                                                          ROTO0430
      BIGY > RY                                                          ROTO0440
      BIGZ > RZ                                                          ROTO0450
      IF [IJK.EQ.-10] GO TO 10                                           ROTO0460
      TBIGX > BIGX                                                       ROTO0470
      TBIGY > BIGZ                                                       ROTO0480
      TBIGZ >-BIGY                                                       ROTO0490
   10 CONTINUE                                                           ROTO0500
      CONLC > 0.7                                                        ROTO0540
C                                                                        ROTO0510
C BEGIN LOOP FOR TWO ROTORS                                              ROTO0520
C                                                                        ROTO0530
      DO 470 IR>1,2                                                      ROTO0550
      IF [IR.EQ.1] GO TO 30                                              ROTO0560
C
C IF IJK IS -10 CALCULATION FOR TAIL ROTOR IS SUPRESSED
C
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      IF [IJK.NE.-10] GO TO 20                                          ROT00570
      III>2                                                             ROT00580
      GO TO 470                                                         ROT00590
   20 CASE>TCASE                                                        ROT00600
      ETA>TETA                                                          ROT00610
      BIGBR > TBIGB                                                     ROT00620
      BIGR>TBIGR                                                        ROT00630
      OMEGN>TOMEGN                                                      ROT00640
      SID>TSID                                                          ROT00650
      CHORDR > TCHORD                                                   ROT00660
      THRUSR > TTHRUS                                                   ROT00670
      TORQUE>TTORQ                                                      ROT00680
      BETA>TBETA                                                        ROT00690
      BIGY>TBIGY                                                        ROT00700
      BIGX>TBIGX                                                        ROT00710
      BIGZ>TBIGZ                                                        ROT00720
      GO TO 40                                                          ROT00730
   30 CASE>RCASE                                                        ROT00740
      ETA>RETA                                                          ROT00750
      BIGBR > RBIGB                                                     ROT00760
      BIGR>RBIGR                                                        ROT00770
      OMEGN>ROMEGN                                                      ROT00780
      SID>RSID                                                          ROT00790
      CHORDR > RCHORD                                                   ROT00800
      THRUSR > RTHRUS                                                   ROT00810
      TORQUE>RTORQ                                                      ROT00820
      BETA>RBETA                                                        ROT00830
   40 BIGM>OMEGN*ETA*PI*BIGR/[SAZ*30.]                                  ROT00840
C
C CALCULATE THE MAXIMUM NUMBER OF SOUND HARMONICS THAT CAN BE CALCULATED
C FROM 60 LOADING HARMONICS
C
      LLIMIT > XML * BIGBR * [1.0 < BIGM] < 0.5                         ROT00850
      IF [LLIMIT.LT.60] GO TO 50                                        ROT00860
      LLIMIT>60                                                         ROT00870
      MLIMIT > LLIMIT / [ BIGBR * [1.0 < BIGM] < 0.5]                   ROT00880
   50 L1>LLIMIT<1                                                       ROT00890
      XLL>LLIMIT                                                        ROT00900
      K>1                                                               ROT00910
      ETARN>1.0/[ETA*BIGR]                                              ROT00920
C                                                                       ROT00930
C CALCULATE STEADY AND FIRST HARMONIC LOADING                           ROT00940
C                                                                       ROT00950
      ALT[1] > THRUSR                                                   ROT00960
      ALD[1]>TORQUE*ETARN                                               ROT00970
      ALC[1] > THRUSR * SIN[BETA * DTR]                                 ROT00980
      ALT[2] > ALT[1]/4.0                                               ROT00990
      ALD[2] > ALD[1]/4.0                                               ROT01000
      ALC[2] > ALC[1] / 4.0                                             ROT01010
      DO 60 LK>3,61                                                     ROT01020
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      PWRK>CONLC/[[LK-1]**CASE]
      ALT[LK]>ALT[1]*PWRK
      ALD[LK]>ALD[1]*PWRK
   60 ALC[LK]>ALC[1]*PWRK
      OMEGA>[PI*OMEGN]/30.
      XX > 0.5 * OMEGA * BIGBR / PI
      OMEGR>OMEGA*BIGR
      CO > OMEGA * BIGBR / [4. * PI * SAZ]
      EXPK>2.0*CASE
      AL>2.0-EXPK
C
C CALCULATE VORTEX NOISE CONSTANT TERMS
C
      VTLG>20.0*ALOG10[OMEGR]
      TLG > 20. * ALOG10[THRUSR]
      BLG > 10. * ALOG10[BIGBR]
      RLG>10.0*ALOG10[BIGR]
      CLG > 10. * ALOG10[CHORDR/12.]
      FCKZ > 0.764 * OMEGR - 240. * ALOG10[THRUSR] < 786.0
       FCKZ1 > 1.0/[TWO16 * FCKZ]
       FCKZ2 > TWO16 / FCKZ
      RMT>OMEGR/SAZ
      XMACH>[1.0<RMT]**2
      XMACHM>[1.0-RMT]**2
      SPLVCO>VTLG<TLG-BLG-RLG-CLG<17.4
      NBIGB > BIGBR < 0.0001
C
C CALCULATE SMALL-X, SMALL-Y, PHI, X-PRIME, R-PRIME, AND SAMLL-R1
C
      DUM>BIGX**2<[1.0-BMFSQ]*[BIGY**2<BIGZ**2]
      DUM>BIGX*BMFSQ<BIGMF*SQRT[DUM]
      DUM>DUM/[1.0-BMFSQ]
      BIGXP>BIGX<DUM
      COSINE>COS[SID*DTR]
      SINE>SIN[SID*DTR]
      DUM1>BIGY
      DUM2>BIGXP*COSINE<BIGZ*SINE
      IF [DUM1]70,70,110
   70 IF [DUM2]80,90,100
   80 PHI>ATAN[ABS[DUM1/DUM2]]
      GO TO 150
   90 PHI>HALFPI
      GO TO 150
  100 PHI>ATAN[ABS[DUM1/DUM2]]
      PHI>PI-PHI
      GO TO 150
  110 IF [DUM2]120,130,140
  120 PHI>2.0*PI-ATAN[ABS[DUM1/DUM2]]
      GO TO 150
  130 PHI>2.0*PI-HALFPI
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      GO TO 150                                                         ROTO1530
  140 PHI>PI<ATAN[ABS[DUM1/DUM2]]                                       ROTO1540
  150 CONTINUE                                                          ROTO1550
      SX>BIGXP*SINE-BIGZ*COSINE                                         ROTO1560
      SY>-DUM2*COS[PHI]-BIGY*SIN[PHI]                                   ROTO1570
      SRP>SQRT[BIGXP**2<BIGY**2<BIGZ**2]                                ROTO1580
      BIGMZ>BIGMF*BIGXP/[SRP]                                           ROTO1590
      XF>XX/[1.0-BIGMZ]                                                 ROTO1600
      SR>SRP*[1.0-BIGMZ]                                                ROTO1610
      C1>C0/SR                                                          ROTO1620
      CON2>SX/SR                                                        ROTO1630
      CON4>SY/[2.0*SR]                                                  ROTO1640
      DARG>ABS[BIGZ/SRP]                                                ROTO1650
C                                                                       ROTO1660
C CALCULATE VORTEX DIRECTIVITY ANGLE AND CONSTANT TERMS                 ROTO1670
C                                                                       ROTO1680
      THET > ABS[1.0 - DARG**2]                                         ROTO1690
      THET > SQRT[THET]                                                 ROTO1700
      IF [THET.GT.0.01745] GO TO 160                                    ROTO1710
      EKAPPA>HALFPI                                                     ROTO1720
      GO TO 170                                                         ROTO1730
  160 TNUM > DARG / THET                                                ROTO1740
      EKAPPA>ATAN[TNUM]                                                 ROTO1750
  170 ATHETA>EKAPPA-SID*DTR                                             ROTO1760
      ALPHA>HALFPI-ATHETA                                               ROTO1770
      THET > COS[ALPHA]**2 < 0.1                                        ROTO1780
      THETLG > 10.0 * ALOG10[THET]                                      ROTO1790
      SRPLG>20.0*ALOG10[SRP]                                            ROTO1800
      SPLVLG>SPLVCO<THETLG-SRPLG                                        ROTO1810
C                                                                       ROTO1820
C START SOUND HARMONIC LOOP
C                                                                       ROTO1840
      DO 210 M>1,MLIMIT                                                 ROTO1850
      TSSQ>0.                                                           ROTO1860
      XM>FLOAT[M]                                                       ROTO1870
      SFM[M]>XF*XM                                                      ROTO1880
      N>M*NBIGB                                                         ROTO1890
      XN>FLOAT[N]                                                       ROTO1900
      L11 = XN * (1.0 + BIGM) + 0.5
      CON1>C1*XM                                                        ROTO1910
      CON3>1.0/[XN*BIGM]                                                ROTO1920
      CON5>CON1*CON2                                                    ROTO1930
      CON6>CON1*CON3                                                    ROTO1940
      CON7>CON1*CON4                                                    ROTO1950
      NSUB=N+L11+1
      BARG>XN*BIGM*SY/SR                                                ROTO1970
      CALL BESSEL[BARG,NSUB,1.0E-06]                                    ROTO1980
C                                                                       ROTO1990
C BEGIN LOADING HARMONIC LOOP                                           ROTO2000
C                                                                       ROTO2010
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      DO 200 L>1,L11                                                    ROTO2020
      LL>L-1                                                            ROTO2030
      ARG>LL*PHI                                                        ROTO2040
      COSL>COS[ARG]                                                     ROTO2050
      SINL>SIN[ARG]                                                     ROTO2060
      K1>N<LL                                                           ROTO2070
      K2>N-LL                                                           ROTO2080
      K3>K1<1                                                           ROTO2090
      K4>K1-1                                                           ROTO2100
      K5>K2<1                                                           ROTO2110
      K6>K2-1                                                           ROTO2120
      EE>1.0                                                            ROTO2130
      IF[LL .NE. 2*[LL/2]]EE>-1.0                                       ROTO2140
C                                                                       ROTO2150
C TRANSFORM LOADINGS FROM X,Y,Z SYSTEM TO SX,SY SYSTEM
C                                                                       ROTO2170
      AT>ALT[L]*COSL                                                    ROTO2180
      AD>ALD[L]*COSL                                                    ROTO2190
      AC>ALC[L]*COSL                                                    ROTO2200
      BT>ALT[L]*SINL                                                    ROTO2210
      BD>ALD[L]*SINL                                                    ROTO2220
      BC>ALC[L]*SINL                                                    ROTO2230
C                                                                       ROTO2240
C CALCULATE REQUIRED BESSEL FUNCTION VALUES                             ROTO2250
C                                                                       ROTO2260
      CALL BJSIGN[K1,BJ1]                                               ROTO2270
      CALL BJSIGN[K2,BJ2]                                               ROTO2280
      CALL BJSIGN[K3,BJ3]                                               ROTO2290
      CALL BJSIGN[K4,BJ4]                                               ROTO2300
      CALL BJSIGN[K5,BJ5]                                               ROTO2310
      CALL BJSIGN[K6,BJ6]                                               ROTO2320
C                                                                       ROTO2330
C CALCULATE TERM VALUES                                                 ROTO2340
C                                                                       ROTO2350
      DUM1>[XN<LL]*BJ1                                                  ROTO2360
      DUM2>[XN-LL]*BJ2*EE                                               ROTO2370
      DUM3>BJ3-BJ4                                                      ROTO2380
      DUM4>EE*[BJ5-BJ6]                                                 ROTO2390
      ANLT>CON5*AT*[BJ1<EE*BJ2]                                         ROTO2400
      ANLD>CON6*AD*[DUM1<DUM2]                                          ROTO2410
      ANLC>CON7*AC*[DUM3<DUM4]                                          ROTO2420
      BNLT>CON5*BT*[BJ1-EE*BJ2]                                         ROTO2430
      BNLD>CON6*BD*[DUM1-DUM2]                                          ROTO2440
      BNLC>CON7*BC*[DUM3-DUM4]                                          ROTO2450
      DUM5>ANLT-ANLD<BNLC                                               ROTO2460
C                                                                       ROTO2470
C DETERMINE IF N<LL IS ODD OR EVEN                                      ROTO2480
C                                                                       ROTO2490
      IF [K1.NE.2*[K1/2]] GO TO 180                                     ROTO2500
C                                                                       ROTO2510
```

```
C N<LL IS EVEN                                                          ROTO02520
C                                                                       ROTO02530
      E1>1.0                                                              ROTO254
      MX>K1/2                                                           ROTO02550
      IF[MX .NE. 2*[MX/2]]E1>-1.0
      ANL>E1*[BNLT-BNLD-ANLC]
      BNL>E1*DUM5
      GO TO 190                                                         ROTO02590
  180 CONTINUE                                                          ROTO02600
C                                                                       ROTO02610
C N<LL IS ODD                                                           ROTO02620
C                                                                       ROTO02630
      E1 > 1.0
      MK>K4/2                                                           ROTO02650
      IF[MK .NE. 2*[MK/2]]E1>-1.0
      ANL>E1*DUM5
      BNL>E1*[-BNLT<BNLD<ANLC]
  190 SPSQ>ANL*ANL<BNL*BNL                                              ROTO02690
      TSSQ>TSSQ<SPSQ                                                    ROTO02700
  200 CONTINUE                                                          ROTO02710
C                                                                       ROTO02720
C END LOADING HARMONIC LOOP                                             ROTO02730
C                                                                       ROTO02740
      GGM>TSSQ<1.0E-20                                                  ROTO02750
      PM > 10.0 * ALOG10[GGM] < 124.58                                  ROTO02760
      PSQP[M] > PM                                                      ROTO02770
  210 CONTINUE                                                          ROTO02780
C
C END OF SOUND HARMONIC LOOP                                            ROTO02790
C
C CALCULATE BIG K FOR HIGHER HARMONICS                                  ROTO02800
C
      XMB > MLIMIT * BIGBR                                              ROTO02810
      XMB>XMB**AL                                                       ROTO02820
      BIGK > GGM/XMB                                                    ROTO02830
C
C CALCULATE SOUND HARMONICS FROM MLIMIT TO 60                           ROTO02840
C
      RLGK>ALOG10[BIGK]<12.458                                          ROTO02850
      MIN>MLIMIT<1                                                      ROTO02860
      DO 220 M>MIN,60                                                   ROTO02870
      F>XF*M                                                            ROTO02880
      XMB > M * BIGBR                                                   ROTO02890
      PM>10.0*[AL*ALOG10[XMB]<RLGK]                                     ROTO02900
      SFM[M]>F                                                          ROTO02910
      PSQP[M] > PM                                                      ROTO02920
  220 CONTINUE                                                          ROTO02930
  230 CONTINUE                                                          ROTO02940
C
C END OF SOUND HARMONIC CALCULATION                                     ROTO02950
```

```
C
C BEGIN CALCULATION OF ONE-THIRD OCTAVES OF ROTATIONAL NOISE BY
C COMPARING FREQUENCY OF THE 60-TH HARMONIC TO THE 1/3-OCTAVE CENTER
C FREQUENCIES TO DETERMINE THE BAND THAT CAN BE CALCULATED BY
C SUMMING HARMONIC LEVELS.  THE CENTER FREQUENCY OF THIS BAND IS
C CALLED FCC AND THE BAND NUMBER IS JFC.
C
      DUM > SFM[60] / 1.6
      DO 240 J>1,24
      IF [DUM.LT.FCK3[J]] GO TO 250
  240 CONTINUE
      JFC > 24
      GO TO 260
  250 JFC > J - 1
  260 CONTINUE
      SMK>CASE
      DO 270 KL>1,24
  270 OLKP[KL]>0.0
C
C CALCULATE 1/3-OCTAVE LEVELS UP TO BAND JFC BY SUMMING HARMONICS.
C AFK VALUES ARE ATTENUATIONS DUE TO FILTER SHAPE ASSUMED
C
      DO 320 M>1,60
      PS>PSQP[M]
      F>SFM[M]
      DO 320 KL>1,JFC
      IF [F.GE.FCK3[KL]] GO TO 280
      DUM>133.0*ALOG10[F/FCK3[KL]]
      AFK>DUM<3.65
      GO TO 290
  280 DUM>133.0*ALOG10[FCK3[KL]/F]
      AFK>DUM<3.65
  290 IF [AFK.LE.0] GO TO 310
  300 AFK>0.
  310 CONTINUE
      Y>0.1*[PS<AFK]
      OLKP[KL]>OLKP[KL]<10.0**Y
      GO TO 320
  320 CONTINUE
  330 CONTINUE
C
C CALCULATE SPL:S FOR BANDS UP TO FCC
C
      DO 350 KL>1,JFC
      IF[OLKP[KL] .LE. 1.0E-20] OLKP[KL]>1.0E-20
  340 OLKP[KL]>10.0*ALOG10[OLKP[KL]]
  350 CONTINUE
      MIN>JFC<1
      DXX>TWO16*SFM[1]
      DXX>1.0/DXX
```

```
C
C CALCULATE 1/3-OCTAVE BANDS ABOVE ONE AT FCC                                    ROTO3370
C
      DO 380 KL>MIN,24                                                          ROTO3380
      FNN > FCK3[KL-1] * DXX                                                    ROTO3390
      NN > FNN                                                                  ROTO3400
      NMIN>NN<1                                                                 ROTO3410
      NMAX > TWO13 * FNN                                                        ROTO3420
      SUM>0.0                                                                   ROTO3430
      DO 360 J>NMIN,NMAX                                                        ROTO3440
  360 SUM>SUM<J**AL                                                             ROTO3450
      XDEN > SUM                                                                ROTO3460
      SUM>0.0                                                                   ROTO3470
      NMIN > TWO13 * FNN < 1.0001                                               ROTO3480
      NMAX > TWO23 * FNN                                                        ROTO3490
      DO 370 J>NMIN,NMAX                                                        ROTO3500
  370 SUM>SUM<J**AL                                                             ROTO3510
      ARG > SUM/XDEN                                                            ROTO3520
      X>10.0*ALOG10[ARG]                                                        ROTO3530
      OLKP[KL] > OLKP[KL - 1] < X                                               ROTO3540
  380 CONTINUE                                                                  ROTO3550
  390 CONTINUE                                                                  ROTO3560
C
C END CALCULATION OF 1/3-OCTAVE BANDS OF ROTATIONAL NOISE                        ROTO3570
C
C BEGIN CALCULATION OF VORTEX NOISE                                              ROTO3580
C
      IF [FCKZ.GT.50] GO TO 400                                                 ROTO3590
      INTVAL > 1                                                                ROTO3600
      GO TO 420                                                                 ROTO3610
  400 CONTINUE                                                                  ROTO3620
      INTVAL > 24                                                               ROTO3630
      DO 410 I>1,24                                                             ROTO3640
      FLR > FCK3[I] / TWO16                                                     ROTO3650
      FUPR > FCK3[I] * TWO16                                                    ROTO3660
      IF [FCKZ.LT.FLR] GO TO 410                                                ROTO3670
      IF [FCKZ.GT.FUPR] GO TO 410                                               ROTO3680
      INTVAL > I                                                                ROTO3690
      GO TO 420                                                                 ROTO3700
  410 CONTINUE                                                                  ROTO3710
  420 CONTINUE                                                                  ROTO3720
      IPTR > 17 - INTVAL                                                        ROTO3730
      DO 430 KL>1,24                                                            ROTO3740
      F>FCK3[KL]                                                                ROTO3750
      IPTRR > KL < IPTR                                                         ROTO3760
      IF[IPTRR.LT.1]IPTRR>1                                                     ROTO3770
      IF[ IPTRR .GT. 39 ] IPTRR > 39                                            ROTO3780
      ELG > SCURVE[IPTRR]                                                       ROTO3790
      SPLVR>SPLVLG<ELG                                                          ROTO3800
      ARG > 10.0 **[0.1 * SPLVR] < 10.0 ** [0.1 * OLKP[KL]]                     ROTO3810
```

```
      IF[ARG .LE. 1.0E-20] ARG > 1.0E-20                                ROTO3820
      OLKP[KL] > 10.0 * ALOG10[ARG]                                     ROTO3830
  430 CONTINUE                                                          ROTO3840
C                                                                       ROTO3860
C END VORTEX NOISE CALCULATION                                          ROTO3870
C                                                                       ROTO3880
C CALCULATE SPECTRUM FOR BOTH ROTORS                                    ROTO3890
C                                                                       ROTO3900
      DO 460 KL>1,24                                                    ROTO3910
      IF [IR.EQ.2] GO TO 440                                            ROTO3920
      ROLTP3[KL] > OLKP[KL]                                             ROTO3930
      GO TO 460                                                         ROTO3940
  440 ARG > 10.0 ** [0.1 * ROLTP3[KL]] < 10.0 ** [0.1 * OLKP[KL]]       ROTO3950
      IF[ARG .LE. 1.0E-20] ARG > 1.0E-20                                ROTO3960
  450 ROLTP3[KL] > 10.0 * ALOG10[ARG]                                   ROTO3970
  460 CONTINUE                                                          ROTO3980
  470 CONTINUE                                                          ROTO3990
C                                                                       ROTO4000
C END OF ROTOR LOOP                                                     ROTO4010
C                                                                       ROTO4020
      RETURN                                                            ROTO4030
      END                                                               ROTO4040
      SUBROUTINE BJSIGN[K,B]                                            BJSI0010
C
C  TITLE:    BJSIGN
C
C  PURPOSE:  TO DETERMINE THE VALUE OF A BESSEL FUNCTION OF THE FIRST
C            KIND
C
C  ABSTRACT: THE VALUE OF THE K-TH ORDER BESSEL FUNCTION IS DETERMINED
C            FROM A PREVIOUSLY CALCULATED SET OF VALUES FOR A SPECIFIED
C            ARGUMENT.  THE ARITHMETIC SIGN OF THE FUNCTION IS
C            CALCULATED FROM THE SIGN OF THE ORDER VALUE.
C
C  USAGE:    ......(K,B)
C            K...INPUT VALUE OF THE BESSEL FUNCTION ORDER
C            B...BESSEL FUNCTION VALUE RETURNED
C
C  LABELED
C    COMMON: /B1/...CONTAINS (IN ARRAY BES) THE PREVIOUSLY CALCULATED
C                   SET OF BESSEL FUNCTIONS
C
C  SUBROUTINES CALLED:  NONE
C
      DIMENSION BES[400]                                                BJSI0020
C
      COMMON /B1/ BES,INCMAX[50]                                        BJSI0030
      A>1.0                                                             BJSI0050
      IF [K.GE.0] GO TO 10                                              BJSI0060
      K=IABS(K)
```

```
C
C IF THE ORDER (K) IS NEGATIVE AND ODD THEN THE FUNCTION VALUE IS
C MULTIPLIED BY -1.
C
      IF[K .NE. 2*[K/2]] A>-1.0                                         BJSI0080
   10 B>A*BES[K<1]                                                      BJSI0090
      RETURN                                                            BJSI0100
      END                                                               BJSI0110
      SUBROUTINE BESSEL[X,N,SIGMA]                                      BESS0010
C
C  TITLE:    BESSEL
C
C  PURPOSE:  TO CALCULATE A SET OF BESSEL FUNCTION FOR A GIVEN ARGUMENT
C
C  ABSTRACT: THE RECURSION METHOD (REF. 1) OF CALCULATING BESSEL
C            FUNCTIONS OF THE FIRST KIND IS USED TO CALCULATE FUNCTION
C            VALUES FOR ORDERS FROM 0 TO N FOR ARGUMENT X.
C
C  USAGE:    ......(X,N,SIGMA)
C            X.......ARGUMENT VALUE
C            N.......MAXIMUM ORDER FOR WHICH FUNCTION VALUES ARE
C                    REQUIRED
C            SIGMA...ACCURACY TO WHICH FUNCTION VALUES ARE CALCULATED
C
C  LABELED
C    COMMON: /B1/
C
C  SUBROUTINES CALLED: NONE
C
C REFERENCE 1.  ''HANDBOOK OF MATHEMATICAL FUNCTIONS WITH FORMULAS,
C                 GRAPSH, AND MATHEMATICAL TABLES'', NAT. BUREAU OF
C                 STANDARDS, APPLIED MATHEMATICS SERIES NO. 55, JUNE
C                 1964, CHAPTER 9, PG 385
C
C
C ARRAY BES WILL CONTAIN THE CALCULATED BESSEL FUNCTION VALUES
C
      DIMENSION BES[400]                                                BESS0020
      DIMENSION  RJ[400], RJBAR[450]
C
      COMMON /B1/ BES,INCMAX[50]                                        BESS0040
C
      EQUIVALENCE[BES,RJ]                                               BESS0050
      RMAXOV>0.1E<30                                                    BESS0060
      IX>X                                                              BESS0070
      IF [IX.NE.0] GO TO 30                                             BESS0080
      KK>N<1                                                            BESS0090
      DO 10 IP>1,KK                                                     BESS0100
   10 RJ[IP]>0.0                                                        BESS0110
      RJ[1]>1.0                                                         BESS0120
```

```
   20 RETURN                                                            BESS0130
C
C DETERMINE STARTING VALUE OF ORDER FOR RECURSION
C
   30 IF [ABS[X].LT.8.0] GO TO 40                                       BESS0140
      DIST>5.0*ABS[X]**[1.0/3.0]                                        BESS0150
      GO TO 50                                                          BESS0160
   40 DIST>10.0                                                         BESS0170
   50 IF [ABS[X].LT.FLOAT[N]] GO TO 60                                  BESS0180
      K>IFIX[ABS[X]<DIST]<1                                             BESS0190
      GO TO 70                                                          BESS0200
   60 K>IFIX[FLOAT[N]<DIST]<1                                           BESS0210
   70 IS>2                                                              BESS0220
   80 REC0>0.                                                           BESS0230
      SUM>0.                                                            BESS0240
      REC1>1.                                                           BESS0250
      Z>RMAXOV*ABS[X/FLOAT[K]]                                          BESS0260
      IP>K                                                              BESS0270
   90 IF [IP.LE.N<1] GO TO 110                                          BESS0280
  100 RJ[N<1]>2.0*FLOAT[IP]/X*REC1-REC0                                 BESS0290
      REC2>RJ[N<1]                                                      BESS0300
      GO TO 120                                                         BESS0310
  110 RJ[IP]>2.0*FLOAT[IP]/X*REC1-REC0                                  BESS0320
      REC2>RJ[IP]                                                       BESS0330
  120 IF [ABS[REC2].LE.Z] GO TO 160                                     BESS0340
C
C IF RECURSIVE VALUES BECOME TOO LARGE THEY ARE NORMALIZED BY THE
C NUMBER Z
C
  130 REC1>REC1/Z                                                       BESS0350
      REC2>REC2/Z                                                       BESS0360
      SUM>SUM/Z                                                         BESS0370
      M>N                                                               BESS0380
      IF [M.LE.IP-1] GO TO 160                                          BESS0390
  140 RJ[M<1]>RJ[M<1]/Z                                                 BESS0400
C
C  RJ HAS THE POTENTIAL OF UNDERFLOWING AT STATEMENT NUMBER 230
C  TEST RJ AGAINST A LOWER LIMIT (SAY  1.E-50) AND SET RJ TO 0. WHEN
C  RJ IS LESS THAN THE LOWER LIMIT
C
      IF ( RJ(M+1) .LT.  1.0E-50 )  RJ(M+1) = 0.
      IF [M.EQ.IP-1] GO TO 160                                          BESS0410
  150 M>M-1                                                             BESS0420
      GO TO 140                                                         BESS0430
  160 IF [IP-1.NE.0] GO TO 180                                          BESS0440
  170 SUM>SUM<REC2                                                      BESS0450
      GO TO 200                                                         BESS0460
  180 IF [IP.EQ.2*[IP/2]] GO TO 200                                     BESS0470
  190 SUM>SUM<2.0*REC2                                                  BESS0480
  200 REC0>REC1                                                         BESS0490
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      REC1>REC2                                                          BESS0500
      IF [IP.EQ.1] GO TO 220                                             BESS0510
  210 IP>IP-1                                                            BESS0520
      GO TO 90                                                           BESS0530
  220 KK>N<1                                                             BESS0540
      DO 230 IP>1,KK                                                     BESS0550
C
C CALCULATE FUNCTION VALUES BY DIVIDING BY 'SUM'
C
  230 RJ[IP]>RJ[IP]/SUM                                                  BESS0560
C
C IF THIS IS THE FIRST TIME THROUGH CALCULATE ANOTHER SET OF FUNCTION
C VALUES STARTING WITH A HIGHER ORDER
C
      GO TO [240,270],IS                                                 BESS0570
  240 RMAX>0.                                                            BESS0580
      KK>N<1                                                             BESS0590
      DO 260 IP>1,KK                                                     BESS0600
C
C COMPARE OLD AND NEW VALUES TO DETERMINE IF THEY ARE WITHIN LIMITS
C ESTABLISHED BY SIGMA
C
      ERR>ABS[RJ[IP]-RJBAR[IP]]                                          BESS0610
      IF [ERR.LE.RMAX] GO TO 260                                         BESS0620
  250 RMAX>ERR                                                           BESS0630
  260 CONTINUE                                                           BESS0640
      IF [RMAX-SIGMA]20,20,280                                           BESS0650
  270 IS>1                                                               BESS0660
  280 KK>N<1                                                             BESS0670
      DO 290 IP>1,KK                                                     BESS0680
  290 RJBAR[IP]>RJ[IP]                                                   BESS0690
      K>IFIX[FLOAT[K]<DIST]                                              BESS0700
      GO TO 80                                                           BESS0710
      END                                                                BESS0720
      SUBROUTINE AJET[OBSPLJ,X,Y,Z,JKI]                                  AJET0010
C
C  TITLE:    AJET
C
C  PURPOSE:  TO CALCULATE THE 1/3-OCTAVE NOISE SPECTRUM OF UNDEFLECTED
C            JET NOISE
C
C  ABSTRACT: THE NOISE FROM AN UNDEFLECTED JET AND ITS SPECTRUM SHAPE
C            IS CALCULATED BY METHOD GIVEN IN REFERENCE 1.  DIRECTIVITY
C            CORRECTIONS AND CORRECTION FOR NON-STANDARD ATMOSPHERIC
C            CONDITIONS ARE FROM REFERENCE 2.  REQUIRED INPUT (VIA
C            COMMON):
C              THRUST....DEVELOPED THRUST (LB)
C              WTFL......TOTAL WEIGHT FLOW(LB/SEC)
C              AREAJ.....JET NOZZLE AREA  (SQ FT)
C              PSUBA.....AMBIENT INLET PRESSURE (IN HG)
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C              TSUBA.....AMBIENT INLET TEMPERATURE (DEG F)
C              TSUBJ.....TAILPIPE TEMPERATURE (DEG F)
C              TSUBJO....TAILPIPE TEMPERATURE AT STD CONDITIONS (DEG F)
C              ALFAJ.....INCLINATION OF THRUST AXIS TO HORIZONTAL
C                        (POSITIVE FOR INLET UP  (DEG)  )
C
C  USAGE:     .....(OBSPLJ,X,Y,Z,JKI)
C             OBSPLJ...A 24 ELEMENT ARRAY CONTAINING THE CALCULATED 1/3-
C                      OCTAVE NOISE SPECTRUM
C
C  LABELED
C    COMMON: /B1/   /INPUT/
C
C  SUBROUTINES CALLED:  NONE
C
C  REFERENCE 1:  E.J.RICHARDS AND D.J.MEAD,''NOISE AND ACOUSTIC FATIGUE
C                IN AERONAUTICS'', JOHN WILEY AND SONS LTD, NEW YORK,
C                N.Y., 1968, CHAPTER 7
C
C            2   L.L.BERANEK,''NOISE REDUCTION'', MCGRAW-HILL BOOK CO.,
C                INC., NEW YORK,N.Y.,1960, CHAPTER 24
C
      DIMENSION OBSPLJ[24],SPEC[24,6],DIRCT[18]                          AJET0210
     1,BES[400]                                                          AJET0220
C                                                                        AJET0200
      COMMON /B1/ BES,INCMAX[50]                                         AJET0230
C
      COMMON /INPUT/ SAZ,SEG,FLTYPE,RCASE,RETA,RBIGB,RBIGR,ROMEGN,RSID,  AJET0240
     1RCHORD,RTHRUS,RTORQ,RBETA,TCASE,TETA,TBIGB,TBIGR,TOMEGN,TSID,      AJET0250
     2TCHORD,TTHRUS,TTORQ,TBETA,PPWR,DIA,BIGB,RPMP,ANMPRP,CHORDP,        AJET0260
     3PATH[50],XMAX[50],YMAX[50],PHMAX[50],RADIUS[50],VF1[50],ALF[50],   AJET0270
     4XPRZRO,YPRZRO,THMAXO,AZERO,TINC,ANMFPT,HPENG,SLEVEL,ANENG,DIAT,    AJET0280
     5DIAH,B,BPR,CHORD,DDDXT,DDDXH,RS,SIGPHI,DL,RPM,SPAF,XMXTIP,PR,DF,   AJET0290
     6TT2,PT2,ALFA,FN,COMB,THRUST,WTFL,AREAJ,PSUBA,TSUBA,TSUBJ,TSUBJO,   AJET0300
     7ALFAJ,ROTR,RP,FANS,RJ,E                                            AJET0310
C                                                                        AJET0320
C ARRAY SPEC[I,K] CONTAINS CORRECTIONS TO OBTAIN SPECTRUM FROM OVERALL   AJET0330
C LEVEL BASED ON RELATIVE JET VELOCITY.                                  AJET0340
C                                                                        AJET0350
      DATA SPEC            / 26.,21.5,15.,10.,11.,8.5,11.,11.,12.,       AJET0360
     112.5,14.5,14.5,17.,17.5,18.,19.5,21.5,24.5,27.,30.5,35.,44.5,      AJET0370
     249.,52. ,
C                                                                        AJET0390
     $                       25.5,22.5,16.5,11.,11.5,9.5,11.5,11.5,      AJET0400
     111.5,12.,13.,13.,15.5,16.5,17.,18.,20.5,24.,25.5,29.5,32.5,        AJET0410
     240.5,46.5,48.5 ,
C                                                                        AJET0430
     $                       28.,24.,18.,12.,11.8,10.5,12.5,11.75,10.5,AJET0440
     111.,12.,12.,14.5,15.5,16.5,17.5,20.,22.5,25.,28.,30.5,38.,43.5,    AJET0450
     246. ,
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C                                                                       AJET0470
     $                        29.5,25.5,20.,12.5,12.,11.5,13.,12.5,10., AJET0480
     110.5,10.5,11.,13.,15.,16.,17.,19.,22.,23.,26.5,28.,35.,40.,43.5 , AJET0490
C                                                                       AJET0500
     $                        31.,26.5,22.,13.,12.2,12.5,13.5,12.75,9.5,AJET0510
     110.,9.,10.,12.,14.,15.,16.5,17.5,20.,22.,25.,26.,31.5,36.5,41. ,  AJET0520
C                                                                       AJET0530
     $                        32.,27.5,22.5,13.5,12.5,13.,14.5,12.,8.5, AJET0540
     18.5,7.5,9.,11.,13.,14.5,16.,17.,19.,20.,22.5,23.,28.,31.,38. /    AJET0550
C                                                                       AJET0560
C                                                                       AJET0570
C ARRAY DIRCT[I] CONTAINS DIRECTIVITY CORRECTIONS FOR ANGLES 0 [IN      AJET0580
C FRONT] TO 170 DEGREES [BEHIND].                                       AJET0590
      DATA DIRCT              / -15.5, -15.0, -14.0, -13.5, -13., -12.5, AJET0600
     1-12., -11., -9., -7.5, -5., -2., 2., 6., 8., 6., 1., -8. /       AJET0610
CS    DEBUG[ALL]                                                        AJET0620
CS    TRACE ON                                                          AJET0630
      VF > VF1[JKI]                                                     AJET0640
      RADN > 57.295780                                                  AJET0650
      RALFAJ > ALFAJ / RADN                                             AJET0660
C                                                                       AJET0670
C CONVERT X,Z TO X-PRIME, Z-PRIME                                       AJET0680
C                                                                       AJET0690
      XPR > X * COS[RALFAJ] - Z * SIN[RALFAJ]                           AJET0700
      ZPR > Z * COS[RALFAJ] < X * SIN[RALFAJ]                           AJET0710
      PI  > 3.1415927                                                   AJET0720
      GRAV> 32.2                                                        AJET0730
      TAZRO > 59.0                                                      AJET0740
      PAZRO > 29.92                                                     AJET0750
      RAD > SQRT[ X**2 < Y**2 < Z**2 ]                                  AJET0760
C                                                                       AJET0770
C CALCULATE GAMMA - DIRECTIVITY ANGLE                                   AJET0780
C                                                                       AJET0790
      IDUM1 > XPR < 0.00001                                             AJET0800
      IDUM2 > Y < 0.00001                                               AJET0810
      IF [IDUM1.NE.0.OR.IDUM2.NE.0] GO TO 30                            AJET0820
   10 IF [ZPR]20,80,20                                                  AJET0830
   20 GAMMA > 90.                                                       AJET0840
      GO TO 40                                                          AJET0850
   30 GAMMA > ABS[ATAN2[Y,XPR] ]                                        AJET0860
      GAMMA > GAMMA * RADN                                              AJET0870
   40 INC > GAMMA/10.0 < 1.50001                                        AJET0880
      IF[ INC .LT.  1 ] INC >  1                                        AJET0890
      IF[ INC .GT. 18 ] INC > 18                                        AJET0900
C                                                                       AJET0910
C CALCULATE POWER LEVEL                                                 AJET0920
C                                                                       AJET0930
      VJ > THRUST * GRAV / WTFL                                         AJET0940
      RMJ > VJ / SAZ                                                    AJET0950
      IF [RMJ.GT.1.0] GO TO 50                                          AJET0960
```

```
      PWL > 60.0 * ALOG10[VJ] < 10.0 * ALOG10[AREAJ] - 48.0            AJET0970
      GO TO 60                                                          AJET0980
   50 PWL > 13.5 * ALOG10[ 0.67 * WTFL * VJ**2 / GRAV ] < 78.0          AJET0990
   60 CONTINUE                                                          AJET1000
C                                                                       AJET1010
C CORRECT FOR NON-STANDARD ATMOSPHERE - TEMPERATURE AND PRESSURE -      AJET1020
C AND CONVERT TO SPL FOR HEMISPHERICAL RADIATION                        AJET1030
C                                                                       AJET1040
      DELPR > 10.0*ALOG10[PSUBA / PAZRO ]                               AJET1050
      DELTJ > 40.0*ALOG10[TSUBJ / TSUBJO]                               AJET1060
      DELTEM> 35.0*ALOG10[TSUBA / TAZRO ]                               AJET1070
      PWL > PWL < DELPR < DELTJ - DELTEM                                AJET1080
      SPL > PWL - 10.0 * ALOG10[ 4.0 * PI * RAD**2 ] < 3.0              AJET1090
C                                                                       AJET1100
C DIRECTIVITY                                                           AJET1110
C                                                                       AJET1120
      SPL > SPL < DIRCT[INC]                                            AJET1130
C                                                                       AJET1140
C SPECTRUM                                                              AJET1150
C                                                                       AJET1160
      AOVAO > SAZ / 1117.0                                              AJET1170
      VREL > VJ - VF                                                    AJET1180
      DUM > ALOG10[VREL/AOVAO < 0.1]                                    AJET1190
      INK > [DUM - 3.0]/0.05 < 0.50001                                  AJET1200
      IF[INK .LT. 1] INK > 1                                            AJET1210
      IF[INK .GT. 6] INK > 6                                            AJET1220
      DO 70 I>1,24                                                      AJET1230
      OBSPLJ[I] > SPL - SPEC[I,INK]                                     AJET1240
   70 CONTINUE                                                          AJET1250
   80 CONTINUE                                                          AJET1260
      RETURN                                                            AJET1270
      END                                                               AJET1280
      SUBROUTINE LOADER [X]
      WRITE[6,70]
      WRITE[6,71]
   70 FORMAT[//,132H ***************************************************
     X******************************************************************
     X**************]
   71 FORMAT[50X,17HLOADER CARD INPUT//19X,6HCOLUMN,
     X1X,6H2 4 6 ,11X,2H19,10X,2H31,10X,2H43,10X,2H55,10X,2H67 ,
     X/26X,1H*, 3X,1H*,12X,1H*,11X,1H*,11X,1H*,11X,1H*,11X,1H*,
     X/26X,1H*, 3X,1H*,12X,1H*,11X,1H*,11X,1H*,11X,1H*,11X,1H*]
C     SUBROUTINE LOADER(DATA)
C     DESCRIPTION OF PARAMETERS
C         DATA-- VECTOR OF ANY LENGTH
C     USAGE
C        CALL LOADER(DATA)
C     SUBROUTINES REQUIRED
C        NONE
C     PURPOSE
```

```
C       SUBROUTINE LOADER(DATA) LOADS DATA INTO THE VECTOR DATA(I).
C     DATA CARDS ARE READ SUCCESSIVELY.
C     INSTRUCTIONS FOR USING LOADER
C       1) PLACE THE NUMBER OF VALUES (.LE. 5) TO BE READ INTO DATA(I).
C            IN COLUMN 2 OR 72.  COLUMN 2 OVERRIDES 72.  AN ERROR IS
C            INDICATED IF BOTH COLUMNS 2 AND 72 ARE BLANK, OR IF THE
C            VALUE IS GREATER THAN 5.  THIS NUMBER USES I FORMAT.
C      2)  PLACE THE LOCATION OF THE FIRST STORAGE SPACE ASSIGNED TO
C            DATA IN COLUMNS 3 TO 6.  THIS NUMBER MUST BE AN INTEGER
C            AND MUST BE RIGHT ADJUSTED.  THIS NUMBER MAY BE LEFT BLANK
C            ON SUCCESSIVE CARDS IF THE DATA IS CONTINUOUS.  IF THIS
C            NUMBER IS LEFT BLANK ON THE FIRST DATA CARD TO BE LOADED,
C            THE FIRST FIELD OF THE CARD IS LOADED INTO STORAGE
C            LOCATION 1.
C      3)  PLACE THE VALUES TO BE LOADED (UP TO 5 PER CARD) IN COLUMNS
C            7-66, FORMAT 5E12.4.
C      4)  FOR RETURN TO THE PROGRAM, PLACE A MINUS SIGN IN COLUMN 1 OR
C            71 OF THE LAST CARD TO BE LOADED. THIS LAST CARD IS LOADED
C            BEFORE THE RETURN.
C     THE PROGRAM USING SUBROUTINE LOADER(DATA) MUST INCLUDE
C      A) THE SYMBOL DATA WITH PROPER SUBSCRIPT IN A DIMENSION
C            STATEMENT.
C      B) AN EQUIVALENCE STATEMENT SETTING THE VARIABLE NAME OF THE
C            FIRST ITEM OF DATA LOADED EQUAL TO DATA.
C
      DIMENSION A[15], X[1]
    3 FORMAT[A2,A4,15A4,A4]
    4 FORMAT[25X,A2,A4,15A4,A4]
C   4 FORMAT[1X,A2,A4,15A4,A4]
C   4 FORMAT(1X,A2,A4,11A4)
    5 FORMAT(I2,I4,5E12.4,I6)
C
C     BEGIN LOADING DATA
C
      I=1
   10 READ(5,3)NA,NB,(A(J),J=1,15),NC
       REWIND 33
      WRITE[33,3] NA,NB,[A[J],J>1,15],NC
      WRITE[6,4] NA,NB,[A[J],J>1,15],NC
      REWIND 33
      READ[33,5] NA,NB,[A[J],J>1,5],NC
C     WRITE(6,4)NA,NB,(A(J),J=1,10),NC
C     READ(0,5)NA,NB,(A(J),J=1,5),NC
      IF(NA)6,30,6
    6 IF(IABS(NA) - 5) 412,412,41
  412 IF(NB) 999,11,8
    8 I=NB
   11 K=IABS(NA)
      DO 20 J=1,K
      X(I)=A(J)
```

```
 20 I=I+1
    IF(NA)999,57,57
 57 IF(NC)999,10,10
 30 NA=NC
    IF(NC)6,40,6
 40 IF(NB)45,41,41
 41 WRITE(6,50)
 50 FORMAT(10X,43HERROR IN DATA SETUP. SEE SUBROUTINE LOADER         )
    STOP
 45 WRITE(6,51)
 51 FORMAT(//10X,47HDO NOT USE A NEGATIVE VALUE OF NB FOR RETURN --,
   *23H SEE SUBROUTINE LOADER      //)
999 RETURN
    END
```

APPENDIX E

V/STOL Noise Subroutine For Use With NEM Mod-5 and Mod-6 Programs

During the development of the V/STOL Noise Model it became apparent that, while the program would be of great value in evaluating V/STOL systems, it was too cumbersome to be used efficiently in the Noise Exposure Model (NEM) computer program. For this reason a subroutine designed specifically for use in the NEM program was written. The subroutine accepts a slant range distance and a thrust value from the main program and returns the corresponding EPNL value for a helicopter by a table look-up procedure. The table of EPNL values for the various slant ranges and thrust values was established by using the output of the V/STOL Noise Model. The subroutine, as provided, is only for a single main rotor helicopter, however the method is completely general and can be applied to any vehicle by providing a different set of EPNL-slant range/ thrust values.

```
      SUBROUTINE VSTOLN (SR,TR,EPNL )
C
C  TITLE:      VSTOLN
C
C  PURPOSE:    TO CALCULATE THE EFFECTIVE PERCEIVED NOISE LEVEL FOR
C              A HELICOPTER TAKEOFF, LANDING, OR FLYBY AT A GIVEN SLANT
C              RANGE AND THRUST LEVEL.
C
C  ABSTRACT:   THE EPNL VALUE IS COMPUTED FROM THE EPNL-SLANT RANGE
C              CURVES REPRESENTED BY THE ARRAY ANOISE(J,K).  J=1,10
C              REPRESENTS SLANT RANGE DISTANCES FROM 1000 TO 10,000 FT
C              IN 1000 FT INCREMENTS AND K=1,9 REPRESENTS THRUST LEVELS
C              FROM 15,000 TO 55,000 LB IN 5000 LB INCREMENTS. THE ONLY
C              INPUTS REQUIRED ARE SLANT RANGE (SR) IN FEET AND THE MAIN
C              ROTOR THRUST IN POUNDS. THE PROGRAM INTERPOLATES OR
C              EXTRAPOLATES AS NECESSARY.
C                     *
C                   A *  .     .    TABLE OF EPNL VALUES
C                   N *   .     .   IN ARRAY ANOISE(J,K)
C                   O *    .     .
C                   I *     .     .
C                   S *      .     .
C                   E *       .     . K=2
C                    -*            . K=1
C                     *
C                     *********************
C                         SLANT RANGE (J)
C
C USAGE:       VSTOLN(SR,TR,EPNL)
C              SR.......SLANT RANGE IN FEET INPUT
C              TR.......THRUST LEVEL IN POUNDS INPUT
C              EPNL.....EPNL VALUE AT SR AND TR RETURNED.
C
C LABELED
C   COMMON:    NONE
C
C SUBROUTINES
C     CALLED:  NONE
C
C
      REAL LINEAR
      LINEAR(DELX,X1,Y1,Y2,X0)= Y1+(Y2-Y1)/DELX *(X0-X1)
C
      DIMENSION ANOISE(10,9)
C
      DATA (ANOISE(I,1),I=1,10) /
     $ 83.6, 75.1, 69.2, 64.1, 59.0, 55.2, 52.0, 48.0, 45.0, 43.0 /
C
      DATA (ANOISE(I,2),I=1,10) /
     $ 86.8, 78.7, 73.0, 68.0, 63.5, 60.0, 56.8, 53.3, 50.8, 48.8 /
C
      DATA (ANOISE(I,3),I=1,10) /
     $ 89.0, 81.0, 75.5, 71.0, 67.0, 63.5, 60.4, 57.4, 55.0, 53.0 /
C
      DATA (ANOISE(I,4),I=1,10) /
     $ 90.8, 83.1, 77.9, 73.3, 69.7, 66.2, 63.1, 60.5, 58.4, 55.2 /
C
      DATA (ANOISE(I,5),I=1,10) /
     $ 92.0, 84.8, 79.5, 75.2, 71.7, 68.5, 65.5, 63.0, 61.0, 59.0 /
```

```
C
      DATA (ANOISE(I,6),I=1,10) /
     $ 93.0, 86.0, 80.8, 76.7, 73.2, 70.1, 67.5, 65.1, 63.0, 61.1 /
C
      DATA (ANOISE(I,7),I=1,10) /
     $ 93.8, 86.9, 81.8, 77.8, 74.7, 71.6, 69.0, 66.8, 65.0, 63.0 /
C
      DATA (ANOISE(I,8),I=1,10) /
     $ 94.4, 87.5, 82.5, 79.5, 75.4, 72.7, 70.1, 68.0, 66.0, 64.1 /
C
      DATA (ANOISE(I,9),I=1,10) /
     $ 95.0, 88.2, 83.3, 79.5, 76.5, 73.8, 70.5, 69.1, 67.5, 65.8 /
C
      DATA SRMIN/1000./, SRMAX/10000./,SRDEL/1000./
      DATA TRMIN/15000./,TRMAX/55000./,TRDEL/5000./
      J=0
      K=0
      IF (SR .LT. SRMAX ) GO TO 5
      J=10
      GO TO 10
    5 IF (SR .GT. SRMIN ) GO TO 10
      J=2
   10 IF (TR .LT. TRMAX ) GO TO 15
      K=9
      GO TO 20
   15 IF (TR .GT. TRMIN ) GO TO 20
      K=2
   20 IF (J .EQ. 0)  J= SR/SRDEL + 1.0001
   25 IF (K .EQ. 0)  K= TR/TRDEL -  .9999
      SR1= (J-1)*SRDEL
      TR1= (K-1)*TRDEL + 10000.
      Z1   = LINEAR(SRDEL,SR1,ANOISE(J-1,K-1),ANOISE(J,K-1),SR)
      Z2   = LINEAR(SRDEL,SR1,ANOISE(J-1,K  ),ANOISE(J,K),SR)
      EPNL = LINEAR(TRDEL,TR1,Z1,Z2,           TR )
      RETURN
      END
```

APPENDIX F

REPORT OF INVENTIONS APPENDIX

In regard to the patent rights (license) clause of the contract, a review of the work performed has been made and as far as can be determined there were no subject inventions conceived or first actually reduced to practice in the course of or under the contract. There were no subcontracts awarded for the conduct of experimental, developmental or research work.