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PREFACE

Contained in this report is the theoretical methodology used in developing an analysis for the response of blades subjected to soft-body impacts and a description of the computer program that was developed using the theory as its basis. This work was conducted at Hamilton Standard, Division of United Technologies Corporation, Windsor Locks, Connecticut, under NASA Lewis Research Center Contract No. NAS3-20091. The analysis was based upon three fields of study. The development of the modal equations was carried out by Messrs. W. W. Westervelt and N. E. Houtz. The development of the equations used for the missile model, based on studies of 2-dimensional and 3-dimensional fluid jets, was carried out by Dr. R. W. Cornell. The development of the interactive equations, geometry, general methodology and computer program was carried out by Mr. A. Alexander.

This program is an outgrowth of two analyses that were previously developed for the purpose of studying problems of a similar nature: a 3-mode beam impact analysis and a multi-mode beam impact analysis. The program utilizes an improved missile model that is interactively coupled with blade motion, which is more consistent with observation. It takes into account local deformation at the impact area, blade camber effects and the spreading of the impacted missile mass on the blade surface. In addition, it accomodates plate-type mode shapes. The analysis represents a significant improvement in the development of the methodology for evaluating potential fan blade materials with regard to foreign object impact resistance.

The work was monitored by Dr. C. C. Chamis of NASA Lewis Research Center and was conducted during the periods January 1976 to August 1977 and February 1978 to July 1978.

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NOMENCLATURE

IP - Refers to the in-plane direction.

OOP - Refers to the out-of-plane direction.

$\vec{V}_n$ - Directional vector on blade in the IP-OOP system. (length)

A_n - Scalar length between nodes n and n+1 on the blade. (length)

x_n, y_n - IP and OOP coordinates of a node on the blade. (length)

θ_n - Angle between the IP axis and vector $\vec{V}_n$. (radians)

$\vec{U}_\kappa$ - Directional vector along the missile length in the IP-OOP system. (length)

B_κ - Scalar length of vector $\vec{U}_\kappa$. (length)

x_κ, y_κ - IP and OOP coordinates of a point of the missile. (length)

α_o - Initial impact angle between the missile and blade chord. (radians)

β - Angle between the vector $\vec{U}_\kappa$ and the IP axis. (radians)

ν_n - Magnitude of the velocity at node n of the blade. (length/time)

ω_n - Magnitude of angular velocity of blade segment n about node n. (radians/time)

v_n - Magnitude of relative missile velocity in the direction of $\vec{V}_n$. (length/time)

v_κ - Magnitude of relative missile velocity in the direction of $\vec{U}_\kappa$. (length/time)

ν_i - Magnitude of relative impact velocity. (length/time)

x_i, y_i - IP and OOP coordinates of the center of impact on the blade. (length)

v_o - Magnitude of missile velcoity relative to the IP-OOP system. (length/time)

α_κ - Relative impact angle between missile and blade. (radians)

ℓ - Distance measured from the location of the center of force of the impact to the point on the blade where the stream flow can be considered to be parallel to the surface of the blade. (length)

f - Distance between the stagnation pressure point and the location of the center of force of impact. (length)

g - Distance between the point of intersection of the missile center-line and the blade and the stagnation point. (length)

a - Thickness of the missile. (length)

λ_1 - Distance between the center of force of the impact and the initial position of the boundary defining the void formed on the positive side of the flow stream. (length)

λ_2 - Distance between the center of force of the impact and the initial position of the boundary defining the void formed on the negative side of the flow stream. (length)

P_o - Stagnation pressure = $\frac{1}{2}\rho V^2$ (force/(length)^2)

ρ - Mass density of the missile. (mass/(length)^3)

γ_1 - Pressure decay constant in the positive side of the flow stream.

γ_2 - Pressure decay constant in the negative side of the flow stream.

P_1 - Pressure in the positive side of the flow stream. (force/(length)^2)

P_2 - Pressure in the negative side of the flow stream. (force/(length)^2)

$\{\phi\}_i$ - Displacement vector describing the i^{th} mode shape. (length)

$\{S\}_i$ - Stress vector containing the chordwise, radial and shear components of stress for the i^{th} mode shape. (force/length)^2)

m_i - i^{th} modal mass (mass)

β_i - Critical damping ratio associated with the i^{th} mode.

q_i - Generalized coordinate associated with the i^{th} mode.

ω_{oi} - Characteristic natural frequency of the i^{th} mode. (radians/time)

ω - Damped natural frequency for the i^{th} mode. (radians/time)

SECTION I

INTRODUCTION AND SUMMARY

1.1 BACKGROUND

The availability of an accurate and reliable method for the impact analysis of aircraft engine fan blades can play a major part in designing these blades for FOD (Foreign Object Damage) resistance and in assessing new materials for blade applications. Over the past several years Hamilton Standard has developed under company funding two modal analysis methods based upon beam models. Improvements and extensions of these computerized methods, one of which is a Three Mode Model and the other a more sophisticated and comprehensive Multi-Mode Model, provide the basis for the present program.

1.2 OBJECTIVES AND APPROACH

The purpose of the Multi-Mode Blade Impact (MMBI) computer program described herein is to provide the analyst with a tool that enables him to study the transient effects of soft body impacts on blades exhibiting characteristic coupled modes. Included within this purpose are three major objectives:

a) The development of a consistent missile model

b) The ability of the program to model the spreading impacted missile mass with respect to time.

c) To provide information on deformations, pressure distribution and stresses at the impact region of the blade, as well as over the entire blade.

The approach used in developing a missile model was based upon theoretical and experimental information associated with incident fluid jets on surfaces. The model is a general, symmetrical 3-dimensional fluid jet which is approximated by taking into account the combined effects of 2-dimensional and 3-dimensional fluid jets.

The spreading missile mass is modeled as an expanding oval consisting of a 2-dimensional streamform at its center and a 3-dimensional streamform at its outer limits.

With respect to the blade the program utilizes a 2-dimensional surface with mode shapes consisting of the coupled plate modes of vibration associated with the blade. By including the higher modes of the blade in the program, local deformations and stresses can be determined in the impact area.

1.3 SUMMARY AND CONCLUSIONS

The MMBI program is based upon a theoretical and experimental analysis of incident 2-dimensional and 3-dimensional fluid jets combined with the methods of modal response analysis. The geometrical representation of the problem is based upon 2 right-handed systems of reference. The entire surface of the blade is represented on a 2-dimensional planform model of the blade face upon which the pressure and impacted missile mass distribution is mapped out. The interaction between the missile and blade is represented in a 2-dimensional reference frame defined by the rotational axis of the blade and an axis lying in the plane of rotation. For consistency the program uses the methods of vector analysis to determine the missile and blade locations throughout the duration of the problem. The solution for blade response during each time step interval is obtained from a closed form solution of the uncoupled modal equations of the system, using the results of the previous time step as initial conditions.

During the impact event the blade and missile interaction program accounts for the following effects:

a) local perturbations on relative impact angle and velocity due to blade response

b) initial and ending effects of the missile forward and aft shape

c) pressure variations due to the blade face curvature.

The program provides an efficient method of analyzing the response of blades subjected to soft body impacts at a minimal cost to the user. Such problems as time step size, missile size variation, blade load variation and the spreading of the missile mass on the blade surface with time are handled as entirely internal problems to the program. The outputs available to the user include:

1) Pressure distribution variation with respect to time.
2) Gross blade displacements with respect to time.
3) Local deformations of the blade surface at the impact area.
4) Gross blade stresses with respect to time.
5) Local stresses at the impact area.

Detailed verification of the program is described in Sections 5.1 and 5.2 where results are presented for several cases that were analyzed using the MMBI program and compared with test data. The program was first used to analyze impacts of cylindrical missiles on rigid plates for 25, 45 and 90-degree impact angles. These runs were primarily a check on the computed pressure distribution and the spreading of the missile with respect to time. Within the accuracy of the test data, the program was able to predict both the shape and magnitude of the pressure distribution, corresponding to the three angles and, in general, showed good correlation with test.

The program was then used to analyze the response of a simulated blade subjected to a 600 ft/sec, 30-degree leading edge impact by a 1 pound, 3.75 inch diameter spherical missile. The blade consisted of a rigid,steel plate bolted onto a titanium spar. Comparison with test results obtained for the same problem show good correlation for the displacement of the blade. With respect to the blade twist, test data was available for angular motion at the blade tip while the MMBI program outputs this data at the impact radius of the blade. A direct correlation for response of the blade in twist was therefore difficult, however a comparison of the response duration showed good agreement with test. In addition, by considering the modal aspects of the blade, the differences between test data at the blade tip versus calculated results at the impact radius are readily explained.

The results obtained for the demonstration problems presented in this report are encouraging. However, a full evaluation of the capabilities of the program should include a case which involves the effects of blade camber and local deformations at the impact area. Data for this case is available from tests performed by Hamilton Standard on missile impacts of the 3A Q-Fan Demo Blade under NASA Contract No. NAS3-17837.

SECTION II

THEORY AND MATHEMATICAL FORMULATION

The problem of multi-mode blade impact analysis can be organized into three separate phases:

1. - Definition of missile and blade geometry
2. - Definition of missile and load distribution
3. - Modal response of the blade.

Phase 1 involves an interaction with the results of Phase 3 so that the problem geometry can be updated at the end of each time step. Phase 2 consists of a further breakdown into three subcases:

- 2a. - Definition of a fluid jet impinging on a surface at an oblique angle.
- 2b. - Distribution of pressures at the nodal points describing the blade.
- 2c. - Effect of blade camber on pressure.

In Section 2.4 is a diagram depicting the basic problem flow, the details of which are discussed below.

2.1 MISSILE AND BLADE GEOMETRY

The MMBI program uses two geometric reference frames to develop the problem geometry.

2.1.1 Planform Reference Frame

To describe the distribution of the impacted missile mass on the blade face, the three dimensional surface of the face is mapped onto a flat plane (Fig. 1). The blade is untwisted and laid out on the plane such that the curved distance between adjacent points on the three-dimensional surface is preserved. Chordwise distance along the blade is taken along the absissa and radial distance is taken along the ordinate. During each time step, the center of impact and stagnation pressure points are located on the planform representation of the blade face and the spreading missile mass is mapped out relative to these two points (Section 2.2.2).

2.1.2 In Plane (IP) / Out of Plane (OOP) Reference Frame

This reference system lies in a plane whose normal is parallel to the radial axis of the blade such that the coordinate system is a right-handed one, with the rotational axis of the blade taken as the ordinate (Out-Of-Plane or OOP axis) and the absissa lying in the plane of rotation (In-Plane or IP axis) (Fig. 2). The contour of the blade face at the impact radial station is represented in this coordinate system by straight line segments connecting the nodes that lie on the surface of the face along the impact radial station.

2.1.3 Blade and Missile Coordinates

Each blade segment n is represented by a vector $\vec{V}_n$ to establish the orientation of the surface between nodes n and n+1 relative to the IP-OOP system; see Fig. 3.

$$\vec{V}_n = A_n \left[\cos(\theta_n)\vec{ii} + \sin(\theta_n)\vec{jj}\right] \qquad 2.1.3(a)$$

where A_n is the length of segment (n, n + 1) and is given by

$$A_n = \sqrt{(x_{n+1} - x_n)^2 + (y_{n+1} - y_n)^2}$$

and

$$\cos(\theta_n) = (x_{n+1} - x_n)/A_n$$

$$\sin(\theta_n) = (y_{n+1} - y_n)/A_n$$

x represents the IP coordinate of a node

y represents the OOP coordinate of a node

$\vec{ii}$ and $\vec{jj}$ are unit vectors in the IP and OOP directions respectively.

Next, the forward and aft ends of the missile are located relative to the blade. The missile is sliced along its length into six sections (Fig. 4). Each missile section κ is described by a vector $\vec{U}_\kappa$ of length B_κ and angle β relative to the IP axis. From Fig. 4

$$\vec{U}_\kappa = B_\kappa \left[\cos(\beta)\vec{ii} + \sin(\beta)\vec{jj}\right] \qquad 2.1.3(b)$$

$$B_\kappa = \text{Length of missile section } \kappa = \sqrt{(x_\kappa - x'_\kappa)^2 + (y_\kappa - y'_\kappa)^2} \qquad 2.1.3(c)$$

$$\cos(\beta) = (x_\kappa - x'_\kappa)/B_\kappa$$

$$\sin(\beta) = (y_\kappa - y'_\kappa)/B_\kappa$$

Initially, the points (x_κ, y_κ) and (x'_κ, y'_κ) are determined from input data. Referring to Figs. 2 and 5, the user inputs the parameters:

x_o = IP coordinate of the missile centerline impact point

y_o = OOP coordinate of the missile centerline impact point

α_o = initial impact angle relative to blade chord line

R_κ = radial distance from missile centerline to centerline of missile section κ

r_κ = thickness of missile section κ

B_κ = length of missile section

D_κ = offset (toward the aft end of the missile) of the front face of missile section κ relative to the forward most point of the missile at the missile centerline

W_κ = width of missile section κ

*Note that $R_\kappa<0$ for sections to the left of the centerline.

The initial blade chord angle, θ_o, can now be calculated from the relation:

$$\theta_o = \cos^{-1}\left[\frac{(x_{t.e.} - x_{L.e.})}{\sqrt{(x_{t.e.} - x_{L.e.})^2 + (y_{t.e.} - y_{L.e.})^2}}\right] \qquad 2.1.3(d)$$

where: $x_{t.e.}$, $y_{t.e.}$ refer to the IP and OOP coordinates of the trailing edge.

and $x_{L.e.}$, $y_{L.e.}$ refer to the IP and OOP coordinates of the leading edge at the impact radial station (Fig. 6).

Note that there is a restriction that θ_o be greater than 0 degrees and less than or equal to 90 degrees.

The absolute missile angle, β, is defined by

$$\beta = \theta_o - \alpha_o \qquad 2.1.3(e)$$

For each missile section κ the coordinates, (x_κ, y_κ) and (x'_κ, y'_κ) of the forward and aft ends are given by

$$x_\kappa = x_o + R_\kappa \operatorname{Sin}(\beta) - D_\kappa \operatorname{Cos}(\beta)$$
$$y_\kappa = y_o - R_\kappa \operatorname{Cos}(\beta) - D_\kappa \operatorname{Sin}(\beta)$$

$$2.1.3(f)$$

$$x'_\kappa = x_\kappa - B_\kappa \operatorname{Cos}(\beta)$$
$$y'_\kappa = y_\kappa - B_\kappa \operatorname{Sin}(\beta)$$

For times greater than zero the points (x_κ, y_κ) and (x'_κ, y'_κ) are dependent on the missile velocity, the total time elapsed during the previous time step and the amount of missile section length that has impacted on the blade during the previous time step, Fig. 7. Assuming that at time t the forward and aft coordinates of missile section κ are given by $(x_{\kappa t}, y_{\kappa t})$ and $(x_{\kappa t}, y_{\kappa t})$, and that the missile velocity relative to the IP-OOP frame is V, the aft end of section κ moves forward by an amount $V\Delta t$, where Δt is the size of the time step. The coordinates of the aft point at time $t+\Delta t$ are given by:

$$x'_\kappa(t+\Delta t) = x'_{\kappa t} + V\Delta t \operatorname{Cos}(\beta)$$
$$y'_\kappa(t+\Delta t) = y'_{\kappa t} + V\Delta t \operatorname{Sin}(\beta) \qquad 2.1.3(g)$$

If, during the time t and $t+\Delta t$, a portion δ_κ of section κ impacted on the blade, then the length of section κ at time $t+\Delta t$ is

$$B_{\kappa(t+\Delta t)} = B_{\kappa t} - \delta_\kappa$$

and the coordinates of the forward point for section κ are given by

$$x_{\kappa(t+\Delta t)} = x_{\kappa t} + (V\Delta t - \delta_\kappa)\cos(\beta) \qquad 2.1.3(h)$$
$$y_{\kappa(t+\Delta t)} = y_{\kappa t} + (V\Delta t - \delta_\kappa)\sin(\beta)$$

By updating the length of missile section κ at the end of each time step, in the same manner described above, the missile size can be continuously reduced throughout the duration of impact.

Once the locations of the forward and aft points of missile section κ are established, the blade segment that is impacted by section κ can be determined as well as the IP and OOP coordinates of the impact. From Fig. 8 define the vectors

$$\begin{aligned}
\vec{A}_{\kappa} &= (X_{n+1} - X'_{\kappa})\vec{ii} + (Y_{n+1} - Y'_{\kappa})\vec{JJ} \\
\vec{A}'_{\kappa} &= (X_{n} - X'_{\kappa})\vec{ii} + (Y_{n} - Y_{\kappa})\vec{JJ} \\
\vec{B}_{\kappa} &= (X_{\kappa} - X_{n+1})\vec{ii} + (Y_{\kappa} - Y_{n+1})\vec{JJ} \\
\vec{B}'_{\kappa} &= (X_{\kappa} - X_{n})\vec{ii} + (Y_{\kappa} - Y_{n})\vec{JJ}
\end{aligned} \qquad 2.1.3(i)$$

Using the expression 2.1.3(b) for $\vec{U}_{\kappa}$ the following cross products are performed:

$$\begin{aligned}
\vec{U}_{\kappa} \times \vec{A} &= C_{\kappa}\vec{zz} \\
\vec{A}'_{\kappa} \times \vec{U}_{\kappa} &= C'_{\kappa}\vec{zz}
\end{aligned} \qquad 2.1.3(j)$$

where C_{κ} and C'_{κ} are scalar quantities and $\vec{zz}$ is a unit vector perpendicular to the IP-OOP plane. Observing the right-hand rule for cross products and referring to Fig. 8, it can be seen that a line passing through the points (x_{κ}, y_{κ}) and $(x'_{\kappa}, y'_{\kappa})$ will also pass between the nodes n and n+1 if both C_{κ} and C'_{κ} are greater than or equal to zero. This criterion is used to establish the blade segment that will be hit by missile section κ during a time step.

Furthermore, from the cross product:

$$\vec{B}_{\kappa} \times \vec{B}'_{\kappa} = D_{\kappa}\, \vec{zz} \qquad 2.1.3(k)$$

(where D_{κ} is a scalar), it is seen that for:

$D_K>0$: point (x_γ, y_γ) is behind the blade and the missile position will have to be adjusted by moving it aft along its centerline.

$D_K=0$: point (x_γ, y_γ) is in contact with the blade.

$D_K<0$: point (x_γ, y_γ) is in front of the blade and the missile position will have to be adjusted by moving it forward along its centerline.

2.1.4 Impact Coordinates

The location of the impact point for each missile section is determined by performing cross-products on vectors lying along the missile length and blade segment direction, respectively. A unit vector lying in the direction of the missile length is given by

$$\vec{K}_K = \text{Cos}(\beta)i\vec{i} + \text{Sin}(\beta)j\vec{j} \tag{2.1.4(a)}$$

The vector $\vec{L}_K$ which lies in the direction of the missile length between the point (x_K, y_K) and the impact point $(x_i, y_i)_K$ is given by

$$\vec{L}_K = (x_K - x_{iK})i\vec{i} + (y_K - y_{iK})j\vec{j} \tag{2.1.4(b)}$$

Performing the cross-product between $\vec{L}_K$ and $\vec{K}_K$ and noting that the two vectors are colinear results in the expression

$$(x_K - x_{iK})\text{Sin}(\beta) - (y_K - y_{iK})\text{Cos}(\beta) = 0 \tag{2.1.4(c)}$$

In a similar manner consider the unit vector $\vec{N}_n$ and the vector $\vec{R}_n$ where

$$\vec{N}_n = \cos(\theta_n)\vec{ii} + \sin(\theta_n)\vec{JJ}$$
$$\vec{R}_n = (X_{i\gamma} - X_n)\vec{ii} + (Y_{i\gamma} - Y_n)\vec{JJ} \tag{2.1.4(d)}$$

Both of these vectors lie in the direction of blade segment n. Performing the cross-product between $\vec{R}_n$ and $\vec{N}_n$ results in the second expression involving (x_{iK}, y_{iK}), i.e.

$$(x_{iK} - x_n)\text{Sin}(\theta_n) - (y_{iK} - y_n)\text{Cos}(\theta_n) = 0 \tag{2.1.4(e)}$$

Solving equations 2.1.4(c) and (e) for x_{iK} and performing some trigonometric manipulations results in

$$x_{iK} = \frac{[(y_K-y_n)\text{Cos}(\beta)-x_K\text{Sin}(\beta)]\ \text{Cos}(\theta_n) + x_n\text{Sin}(\theta_n)\text{Cos}(\beta)}{\text{Sin}\ (\theta_n-\beta)} \qquad 2.1.4(f)$$

Substitution of the result from 2.1.4(f) into either 2.1.4(c) or 2.1.4(e) will yield the value for y_{iK}.

2.1.5 Relative Velocity Impact and Angle

Consider the blade segment n with velocity vectors $\vec{v}_n$ at node n and $\vec{v}_{n+1}$ at node n+1 given by

$$\vec{V}_n = \dot{X}_n \vec{ii} + \dot{Y}_n \vec{JJ}$$
$$\vec{V}_{n+1} = \dot{X}_{n+1} \vec{ii} + \dot{Y}_{n+1} \vec{JJ} \qquad 2.1.5(a)$$

where the dot signifies the first derivative with respect to time. The angular velocity ω_n of blade segment n about node n is given by

$$\omega_n = \frac{\dot{X}_{n+1}-\dot{X}_n}{Y_{n+1}-Y_n} = \frac{\dot{Y}_{n+1}-\dot{Y}_n}{X_{n+1}-X_n} \qquad 2.1.5(b)$$

The IP and OOP velocity components for a point (x_i,y_i) lying on blade segment n between nodes n and n+1, are given by

$$\dot{X}_i = \dot{X}_n - (Y_i - Y_n)\omega_n$$
$$\dot{Y}_i = \dot{Y}_n + (X_i - X_n)\omega_n \qquad 2.1.5(c)$$

or

$$\vec{V}_i = \dot{X}_i \vec{ii} + \dot{Y}_i \vec{JJ} \qquad 2.1.5(d)$$

where $\vec{v}_i$ is the velocity vector of point (x_i,y_i). The component of $\vec{v}_i$ in the direction of the missile length is determined from the dot product of 2.1.5(d) with the unit vector given by 2.1.4(a), i.e.

$$v_K = \dot{x}_i\text{Cos}(\beta) + \dot{y}_i\text{Sin}(\beta) \qquad 2.1.5(e)$$

Similarly, using the first of the expressions 2.1.4(d), the magnitude of the velocity for point (x_i,y_i) in the direction of blade segment n is given by:

$$V_n = \dot{x}_i \cos(\theta_n) + \dot{y}_i \sin(\theta_n) \qquad 2.1.5(f)$$

The components of the relative impact velocity for missile section κ impacting at point (x_i,y_i) are therefore given by

$$\dot{X}_\kappa = (V_0 - V_\kappa)\cos(\beta) - V_n \cos(\theta_n) \qquad 2.1.5(g)$$
$$\dot{Y}_\kappa = (V_0 - V_\kappa)\sin(\beta) - V_n \sin(\theta_n)$$

where V_0 is the velocity of the missile relative to the IP-OOP frame.

From the dot product of the vector with components given by 2.1.5(g) and the unit vector in the direction of blade segment n, the relative impact angle, α_κ, is given by:

$$\alpha_\kappa = \cos^{-1}\left[\frac{\dot{X}_\kappa \cos(\theta_n) + \dot{Y}_\kappa \sin(\theta_n)}{\sqrt{(\dot{X}_\kappa)^2 + (\dot{Y}_\kappa)^2}}\right] \qquad 2.1.5(h)$$

where the quantity $\sqrt{(\dot{x}_\kappa)^2 + (\dot{y}_\kappa)^2}$ is the magnitude of the relative impact velocity.

2.2 DEVELOPMENT OF AN IMPROVED MISSILE MODEL

Experimental impact tests using birds show that they behave essentially as a fluid during impact; see Reference 4. However, in view of the short length of the missile, it would also be desirable for the model to account for the transient effects caused by the beginning and ending of the missile.

A literature search was conducted with the hope that an existing solution could be found for one or both of the above problems; see references and bibliography. Analytical solutions for the steady state, cylindrical case of a 90^o jet and near 90^o jet impinging on a flat surface and for the steady state two-dimensional case of an angled jet impinging on a flat surface, were found in the literature; see References 5 and 6 and Reference 7, respectively. Several papers were found on the numerical solution of the transient/steady state case for cylinders and spheres impacting rigid plates at 90°; see References 8 and 9. However, no solution was found for either the general case of a steady state or the transient/steady state fluid missile impacting obliquely on a flat plate. Several papers actually commented about the lack of such a general solution; see for example References 10 and 11. Numerous papers and reports were found dealing with both steady state transient oblique incidence of fluid jets, which could be used for a data base and for evaluating any analytical results; see References 6, 7 and 11 through 16. A summary of the scope and information available from these tests is given in Table I.

Because no general solution of the jet impact problem was found, the following five possible approaches for developing a missile model were considered:

1. Develop an empirical model based on available test data
2. Develop a three-dimensional analysis of an incompressible inviscid jet of fluid
3. Develop a finite element transient/steady state solution
4. Develop a finite difference transient/steady state analysis of liquid droplets
5. Develop a transient/steady state analysis based on a spring-mass model

The first approach was considered one of last resort and would be difficult to do without a theoretical basis. The development of a rigouous hydrodynamic model of an incompressible jet impinging on a flat plate did not appear feasible considering the comments in the literature. The labor and coding complexity required to develop a finite element solution was beyond the scope of the present program ; see Reference 17. The finite difference program COMCAM for the impact of liquid droplets looked promising, see Reference 14; however, at present the program handles only normal impacts and, therefore, would have to be generalized for the oblique impacts analyzed by the MMBI program. The fifth approach of developing a three-dimensional transient/steady state analysis of a compressible, inviscid liquid slug using a spring-mass model appeared to be the most amenable approach and, therefore, was pursued.

The development of the analysis of the spring-beam missile model was performed by Dr. Brice N. Cassenti of UTRC and is given in Appendix A. In this approach the finite fluid slug of arbitrary configuration is broken into discrete blocks. The pressure, volume, and position of each block is tracked as a function of time. The momentum equations are satisfied by summing the forces acting on each face and the conservation of mass is enforced by making the mass of each block a constant function of time. The analysis was programmed, and several two-dimensional impact cases with various degrees of grid fineness and various impact angles were run. The initial results from this approach look very promising, giving reasonable values of the back flow, the initial uniaxial impact pressure peak ($\rho_0 C_0 V_0$ - Hugoniot), and the later steady state flow pressure. However, during the period of steady pressure the solution tends to be unstable. To rectify this stability problem and to improve the accuracy of the model required time and funding beyond the scope of the initial contract. A planning document to cover this additional effort as a supplement to the present contract was sent to NASA-Lewis in early February, 1977.

In the meantime, some approximate steady state two and three-dimensional fluid jet missile models were developed. Both of these crude models assumed a constant pressure of $1/2\ V^2 \sin^2$ over the effective impact area, which was based on the low angle test results given in Reference 4. The derivations of these two approximate analyses are given in Appendix B. Later, it was discovered that the test results in Reference 4 were in error even for low impingement angles, so that the assumption of a constant pressure over the impact area was not a good approximation and resulted in poor correlation with test results; see Figure 11.

In January 1977, two German papers by Schach, References 5 & 7, were obtained which pertained to the two-dimensional oblique impacting jet and the three-dimensional cylindrical oblique impacting jet. The former case was solved by conformal transformation and the latter case, although not solved, was shown to have certain characteristics which agreed with experimental test results. Based on these two papers and References 5, 7 and 12, approximate analyses were developed which agreed well with the available test data. Originally it was planned to use these more rigorous analytical models in place of the above crude models for only the 3D Blade Impact Analysis (References 1 and 2), but because the supplemental funding for completing the spring-mass model did not materialize, it was decided to use it also for the MMBI analysis.

Two-Dimensional Oblique Impacting Jet

Although many papers and texts, for example Reference 18, give the elementary hydrodynamic solution for the flow split and center of force for a two-dimensional jet obliquely impinging on a flat plate, Schach's solution, Reference 7, is the only known general solution from which the complete boundary, pressure and velocity distributions can be calculated.

Figure 9 summarizes Schach's expressions for calculating the pressure and velocity distribution, and the locations of center of force and stagnation pressure for a two-dimensional jet missile. The calculated streamform and pressure distributions for various impingement angles are given in Figures 10 and 11. For very small impingement angles α_o, which are of prime importance, Schach's solution places the location of the stagnation pressure point outside of the jet envelope. Also, the total impringement load on the plate appears to be greater than it should be for small impingement angles; see Figure 13. It is believed this is a result of his approach of deriving the location of the stagnation point based upon points on the jet boundary for which the value of the conjugate velocity vector is $w=Exp_e(-i\alpha_o/2)$. Because of these apparent deficiencies in Schach's solution, an approximate model was developed based on an exponential pressure distribution; see Appendix C. This model satisfies all the hydrodynamic load and moment criteria, but places the stagnation pressure location at the edge of the jet for very small impingement angles.

Figure 11 compares the pressure distributions derived by Schach, the original crude constant pressure approximation given in Appendix B, and the exponential approximation given in Appendix C. Figure 12 presents a comparison of pressure and velocity distributions given by Schach's solution and the two approximations for a 60^o impingement angle, and shows the exponential approximation correlates very well. Figure 13 presents a comparison between the Schach's solution and the exponential approximation for a 15^o impingement angle, and shows reasonable agreement except for the location of the stagnation pressure. Figure 14 presents a comparison of the centers of force, e/a, and stagnation pressure, g/a, for both analyses. For small impingement angles the center of force occurs at the edge of the jet; however, for Schach's solution the distance of the stagnation pressure point to the center of force, f/a, goes to $(\ln 4)/\pi$ rather than zero, so that the stagnation pressure occurs outside the jet. Figure 14 shows this does not occur for the approximate solution. It is possible to make the location of the stagnation pressure for the exponential approximation match Schach's values; however, the resulting exponential coefficients below 22^o become illogical. It is also possible to define the exponential approximation so that it fits Schach's solution more exactly for the higher impingement angles; see Appendix C and Figure 14. However, because the improvement is minor, the extra complication of the more refined approximation was not deemed worth it.

Three-Dimensional Oblique Impacting Jet

There appears to be no general solution for a cylindrical jet obliquely impinging on a flat plate. However, a solution by Schach was found for 90° impingement; see Reference 7. Reference 5 by Schach presents some concepts and test results which could be used to develop an approximate analysis for the general case of a cylindrical jet obliquely impinging on a flat plate. This concept follows the same general approach given in Appendix B, but assumes a more realistic form of pressure distribution rather than a constant pressure distribution. Appendix D gives the development of this approximate 3D jet analysis, which assumes that the flow is radial from the stagnation point. This assumption has been essentially substantiated by tests; see Reference 5. Figure 15 depicts the nomenclature for a cylindrical jet impinging at an angle on a flat plate. Schach solves for the squashing and spreading of the jet based on the assumption that the fluid in each sector of the jet remains in the deflected sector.

Figure 16 gives a comparison between the measured pressure distribution given in Reference 5 for a 60° impingement angle and that given by the approximate theory developed in Appendix D. The theory matches the test results extremely well for all azimuth positions. The theory was checked by applying it to the normal or 90° impingement case for which there is a theoretical solution, see Reference 7, and test measurements, see Reference 12. Figure 17 compares the results from the approximate theory given herein and the results in these two references with regard to squashing thickness, velocity, and pressure distributions. Again, the approximate theory is found to agree very well with measurement and the formal theory. Figure 18 presents a comparison of the centers of force, e/r, and stagnation pressure, g/r, for both test and the approximate analysis. The correlation is excellent as far as there are test results, i.e. 30° up to 90°.

General Three-Dimensional Oblique Impacting Jet

Although missiles impacting blades are of arbitrary shape, they can be usually depicted approximately as either an ellipsoid or a cylinder. However, because of the impacting angle, the finite length, and the orientation of the missile with respect to the impacted airfoil surface of the blade, the simple 3D jet representation given above cannot be used directly to represent the missile. Instead the missile must be approximated by a combination of a 2D jet and a 3D jet; see Appendix E. The shape, and therefore, combination of 2 and 3D jets will vary with time because of the end effects of the missile; see Figure 19.

For the MMBI Analysis the impacting section of the missile is assumed to consist of a 2D jet in the center bounded by halves of a 3D jet; see Figure 20. As the front of the missile progressively impinges on the airfoil the impacting area and shape grows and changes. For a cylindrical missile, the approximation given in Figure 20 degenerates to a cylinder once the end effect is passed. If the missile is a slice of a cylinder or bird, the approximation requires that the spanwise width be a constant, so that the spanwise planform of each parallel division must be a rectangle; see Figure 20.

The location of the impact force and stagnation centers are assumed to be the weighted average of those for the 2D and 3D jets making up the particular cross-section. The resulting pressure loading and squashing thickness distributions are modified values of the corresponding 2D and 3D jet results, so that there is no discontinuity between the two; see Appendix E. The former is done on an incremental load basis, whereas the latter is done on an incremental fluid area basis. Because of the tying together of the 2D and 3D jet results in the analysis, the squashing and spreading action of the 3D jet with distance from the stagnation point will force the 2D deflected thickness to decrease and spread with distance. However, the simple approach given in Appendix E for tying the 2D and 3D jets together assumes a constant modified thickness and pressure spanwise across the 2D jet, which is probably not correct; however, it is doubtful that the error introduced by this assumption is significant. Table II summarizes the expressions for defining the general jet missile based on those for the 2D and 3D jet missiles.

2.2.1 Definition of an Oblique Angle Impact of a Fluid Jet on a Surface

In order to use the equations developed in Appendices C, D and E and listed in Table II it is necessary to locate the frontal flow area faces of the 2-D jet in both the positive and negative sides of the fluid jet split (Fig. 21). This first requires a knowledge of the curved surfaces formed by the portions of the incident jet during their transitions onto the impacted surface. The approximation made here is that the curvatures take the form of a portion of a circular cylindrical surface.

From Fig. 21, define the radii:

R_1 = Radius of the arc drawn from the point of flow separation, O, to the point A_+ tangent to the impacted surface on the positive side of the jet split.

R_2 = Radius of the arc drawn from the point of flow separation to the point A_-, tangent to the impacted surface on the negative side of the jet split.

R = Radius of the arc drawn from the point of flow separation to the stagnation point, S.P., on the impacted surface. Note that the center of this arc lies on the plane of the impacted surface.

It is also noted that the arcs defined by radii R_1, R_2 and R are tangent to the line O-F drawn through the point of flow separation parallel to the jet centerline. The angle subtended by the arc defined by R_1 is equal to α, the impact angle, and the bisector of this angle passes through the point F. From Fig.21

$$\ell = R_1 \tan(\alpha/2) = R_2 \cot(\alpha/2)$$
$$R = R_2\left(1 + \frac{1}{\cos\alpha}\right) \qquad 2.2.1(a)$$
$$R\sin\alpha + \ell\cos\alpha = R + g - \frac{a}{2}\cot\alpha$$

From Table II, equation 8, the distance g, between the impact center point C and the stagnation point is given by

$$g = \frac{a}{2}\left[\cot(\alpha) + \frac{2\ell}{9}\left(1 - \frac{2\alpha}{\pi}\right)\sin(\alpha)\right] \qquad 2.2.1(b)$$

where a is the jet thickness.

Substitution of the right-hand side of the second of expressions 2.2.1(a) and the right-hand side of 2.2.1(b) into the third expression of 2.2.1(a) and collecting terms yields

$$\ell\cos(\alpha) + \ell\left[\sin(\alpha) - 1\right]\left[1 + \frac{1}{\cos(\alpha)}\right]\tan\left(\frac{\alpha}{2}\right) = \frac{14a}{9}\left(1 - \frac{2\alpha}{\pi}\right)\sin(\alpha) \qquad 2.2.1(c)$$

Using the trigonometric identities

$$\tan\left(\frac{\alpha}{2}\right)=\frac{\sin(\alpha)}{1+\cos(\alpha)}=\frac{1-\cos(\alpha)}{\sin(\alpha)}$$

$$\sin^2(\alpha)+\cos^2(\alpha)=1$$

$$\cos(\alpha)=\sin\left(\frac{\pi}{2}-\alpha\right)$$

in 2.2.1(c) yields for ℓ

$$\ell=\frac{28a}{9\pi}\left(\frac{\pi}{2}-\alpha\right)\frac{\sin(\alpha)\left[1+\sin(\alpha)\right]}{\sin\left(\frac{\pi}{2}-\alpha\right)} \qquad 2.2.1(d)$$

Note that $\lim_{\alpha\to\frac{\pi}{2}}\left[\frac{(\pi/2-\alpha)}{\sin\left(\frac{\pi}{2}-\alpha\right)}\right]=1$

Using 2.2.1(d) in 2.2.1(a), expressions for R_1 and R_2 in terms of the initial incident jet thickness, a, and the impact angle α, can be obtained. Assuming now that the incident jet velocity is V_o and referring to Fig. 22, it is observed that an elemental volume located at point P, which lies on the positive portion of the fluid jet along the line Q-F, will travel a distance $d=V_ot$ during the time interval t. However, once the elemental volume has passed the point of flow separation, it will travel a distance S along the arc defined by radius R_1. The angle subtended by S is given by

$$\phi=\frac{S}{R_1} \qquad 2.2.1(e)$$

where

$$S=\ell+\frac{a}{2}\frac{\cos^2(\alpha)}{\sin(\alpha)} \qquad 2.2.1(f)$$

The location of the elemental volume after time t, relative to the position of the point F is calculated from:

$$\lambda_1=\ell-R_1\sin(\alpha-\phi) \qquad 2.2.1(g)$$

It is important to note that the location of the center of force of the impact is at the point F.

2.2.2 Location of Forward and Backwash Flow Area Faces

It has been assumed throughout the development of the relations in Section 2.2.1, that the flow conditions are steady state and that the incident jet stream is continuous. In the MMBI program the missile is portioned into streams of finite lengths $V_I \Delta t_I$ where:

V_I = Incident stream velocity

Δt_I = Time step length

From Fig. 23 note that the point P_t, located at the backstream face of the jet, a distance $V_I \Delta T_I$ from the incident face at the beginning of the time increment, will travel to the point $P_{t+\Delta t_I}$ at the end of the time interval. The location on the positive flow side of $P_{t+\Delta t}$, relative to the center of force F, is obtained from 2.2.1(g). In order to locate at time $t+\Delta t_I$ the elemental volume that originated on the negative side of the flow at point P_t in the beginning of the time interval, the moment of forces about the point F is calculated. Since F is the location of the center of force, the moment about this point must be zero and an expression can be derived for λ_2, the distance between the center of force and the position on the negative flow side, of the elemental volume at time $t+\Delta t_I$. From the summary of equations listed in Table II:

Pressure on the positive side of the flow

$$P_1 = P_0 \, e^{-(X/\gamma_1)} \left(2 - e^{-(X/\gamma_1)}\right) \qquad 2.2.2(a)$$

Pressure on the negative side of the flow

$$P_2 = P_0 \, e^{(X/\gamma_2)} \left(2 - e^{(X/\gamma_2)}\right) \qquad 2.2.2(b)$$

where P_0 is the stagnation pressure, and γ_1 and γ_2 are decay constants in the positive and negative sides of the flow, respectively. Note that since x is measured from the stagnation point it is necessary to use the value

$$\lambda_1' = \lambda_1 + f \qquad 2.2.2(c)$$

where f is the distance between the stagnation point and the center of force. From Table II

$$f = \frac{14a}{9}\left(1 - \frac{2\alpha}{\pi}\right)\sin(\alpha) \qquad 2.2.2(d)$$

Integrating the moment due to P_1 between the limits λ_1' and $\lambda_1' + V_I \Delta t_I$ gives:

$$\frac{M(\lambda_1')}{P_o b} = \frac{\gamma_1}{4} e^{-\left(\frac{2\lambda_1'}{\gamma_1}\right)} \left\{ e^{-2\left(\frac{\delta_I}{\gamma_1}\right)} \left[2(\lambda_1' + \delta_I) + \gamma_1\right] - 2\lambda_1' + \gamma_1 \right\}$$
$$+ 2\gamma_1 e^{-\left(\frac{\lambda_1'}{\gamma_1}\right)} \left[(\lambda_1' + \gamma_1)\left(1 - e^{-\left(\frac{\delta_I}{\gamma_1}\right)}\right) - \delta_I e^{-\left(\frac{\delta_I}{\gamma_1}\right)}\right] + 2f\gamma_1 \left[e^{-\left(\frac{\lambda_1'}{\gamma_1}\right)}\left(e^{-\left(\frac{\delta_I}{\gamma_1}\right)} - 1\right) - \frac{1}{4} e^{-2\left(\frac{\lambda_1'}{\gamma_1}\right)}\left(e^{-2\left(\frac{\delta_I}{\gamma_1}\right)} - 1\right)\right] \qquad 2.2.2(e)$$

where $\delta_I = V_I \Delta t_I$

P_o = stagnation pressure

b = width of flow

Similarly, for P_2

$$\frac{M(\lambda_2')}{P_o b} = \frac{\gamma_2}{4} e^{-2\left(\frac{\lambda_2'}{\gamma_2}\right)} \left\{ e^{-2\left(\frac{\delta_I}{\gamma_2}\right)} \left[2(\lambda_2' + \delta_I) + \gamma_2\right] - (2\lambda_2' + \gamma_2) \right\}$$
$$+ 2\gamma_2 e^{-\left(\frac{\lambda_2'}{\gamma_2}\right)} \left[(\lambda_2' + \gamma_2)\left(1 - e^{-\left(\frac{\delta_I}{\gamma_2}\right)}\right) - \delta_I e^{-\left(\frac{\delta_I}{\gamma_2}\right)}\right] - 2f\gamma_2 \left[e^{-\left(\frac{\lambda_2'}{\gamma_2}\right)}\left(e^{-\left(\frac{\delta_I}{\gamma_2}\right)} - 1\right) - \frac{1}{4} e^{-2\left(\frac{\lambda_2'}{\gamma_2}\right)}\left(e^{-2\left(\frac{\delta_I}{\gamma_2}\right)} - 1\right)\right] \qquad 2.2.2(f)$$

where $\lambda_2' = \lambda_2 - f$

Equating the right-hand sides of 2.2.2(e) and 2.2.2(f) will yield an expression in terms of λ_2'. The MMBI program uses the Newton-Raphson numerical iteration method to obtain a solution for λ_2'. Consider the function $F(\lambda_2')$ defined by

$$F(\lambda_2') = M(\lambda_2') - M(\lambda_1') = 0 \qquad 2.2.2(g)$$

As a first approximation assume F is a linear function such that

$$\frac{dF(p_1)}{d\lambda_2'} = \frac{F(p_1)}{p_1 - p_2} \qquad 2.2.2(h)$$

where p_1 is an initial first guess for λ_2' and p_2 is the desired value necessary to make F equal to zero. Solving for p_2

$$p_2 = p_1 - \frac{F(p_1)}{\frac{dF(p_1)}{d\lambda_2'}} \qquad 2.2.2(i)$$

If p_2 is indeed the solution for which F=0 then a second trial, p_3 in the equation

$$p_3 = p_2 - \frac{F(p_2)}{\frac{dF(p_2)}{d\lambda_2'}}$$

yield a value that is equal to p_2. In general this is not the case since F is not truly linear. However, p_3 will be a better approximation for λ_2' (i.e., p_3 will make $F(p_3)$ closer to zero than $F(p_2)$). By successively applying the above technique the solution for 2.2.2(g) can be obtained to any desired accuracy.

2.2.3 Pressure Distribution

As described in Appendix E an impacting missile is composed of 2 subdivisions, a 2-D and 3-D fluid jet. Figure 24 depicts the general model with the 2-D uniform flow spreading outward from the point lying a distance $\frac{\lambda_2'-\lambda_1'}{2}$ from the stagnation point and the 3-D portion of the flow spreading radially outward from points A and B. The location of the points A and B is determined by a consideration of Fig. 24. Since the impact is assumed to be symmetrical about the impact centerline, the points A and B are located a distance $\frac{w-a}{2}$ above and below the impact centerline where

w = total missile portion width

and $\frac{a}{2}$= the radius of the outer extremes of the missile portion which is equal to one half the missile portion thickness.

The rate of spreading of the forward and backwash flow area faces is taken equal to the impact velocity. Figure 25 illustrates the scheme used in depicting the spread of the impacted missile mass with time. Note that at the instant the aft end of the missile portion reaches the impacted surface, a void of width $\lambda_1' - \lambda_2'$ occurs, centered about the point $\frac{\lambda_1' - \lambda_2'}{2}$ from the stagnation point. For times after the void appears the spreading mass takes the form of an oval ring expanding with time at the rate of the impact velocity. The pressure distribution is obtained from equations 2.2.2(a) and (b) for the 2-D portion of the spreading mass. The pressure distribution for the 3-D portion of the mass distribution is determined from the pressure relation in Table II for a 3-D jet.

$$P_3 = P_o\, e^{-(r/\gamma_3)^2}\left[2 - e^{-(r/\gamma_3)^2}\right]$$

where γ_3 is a decay coefficient associated with the 3D jet. The MMBI program determines the load on the blade at any instant in two ways. At the instant of impact the initial force is calculated by integrating the pressure over the oval area defined by the 2-D boundaries

(S.P.$-\lambda_2'$) (negative flow side)

and (S.P.$+\lambda_1'$) (positive flow side)

where S.P. is the location of the stagnation pressure point, and the 3-D boundaries defined by the radius

$$\frac{\lambda_1' + \lambda_2'}{2} \quad \text{(See Fig. 24)}$$

For time increments after the initial impact of the missile portion, the blade loads are determined by multiplying the pressure over each node of the blade by an effective nodal area as described in Section 3.1.11.

2.2.4 Effect of Blade Camber on Pressure

As the spreading impacted missile mass traverses the blade it encounters an additional acceleration due to the curvature of the surface. The effect of this acceleration is to produce an additional pressure normal to the blade surface. Consider an elemental volume of mass traveling across the blade with velocity V_M (Fig. 26). If the instantaneous radius of curvature is R, then the force on the center of gravity of the mass is

$$F_{c.g.} = \frac{M\ V_M^2}{R} \qquad 2.2.4(a)$$

where M = total mass of the elemental volume. Assuming that the mass has a thickness T_M, length dL_M, density ρ_M and is of unit width, the mass of the element can be expressed as

$$M = \rho_M t_M dL_M \qquad 2.2.4(b)$$

Substituting 2.2.4(b) into 2.2.4(a) and dividing through by dL_M results in an expression for the pressure on the blade:

$$P_{camber} = \frac{F_{c.g.}}{dL_M} = \frac{M t_M V_M^2}{R} \qquad 2.2.4(c)$$

In order to determine the radius of curvature, the MMBI program divides the blade surface into discreet regions of curvature along the chordwise direction. Referring to the description of blade geometry in Section 2.1.3 and to Fig. 27, the midpoints of the blade segments are calculated and then used to establish the bounds of each curvature region. For the blade segments at the leading and trailing edges the program uses the leading and trailing edge node points rather than the midpoints of the segments. Given blade segments n and n+1 with nodes n and n+1 for segment n, and nodes n+1 and n+2 for blade segment n+1, the midpoint coordinates are determined from

$$\begin{aligned} x_m &= x_n + [A_n \text{ Cos } (\theta_n)]/2 \\ y_m &= y_n + [A_n \text{ Sin } (\theta_n)]/2 \\ x_{m+1} &= x_{n+1} + [A_{n+1} \text{ Cos } (\theta_{n+1})]/2 \\ y_{m+1} &= y_{n+1} + [A_{n+1} \text{ Sin } (\theta_{n+1})]/2 \end{aligned} \qquad 2.2.4(d)$$

where x_n, y_n, x_{n+1}, y_{n+1}, A_n, A_{n+1}, θ_n and θ_{n+1} are as defined in Section 2.1.3. Considering a circular arc that passes through the points m and m+1 such that it is tangent to the blade segments passing through these midpoints, the chordal length of the arc is

$$D_{chord} = \sqrt{(x_m - x_{m+1})^2 + (y_m - y_{m+1})^2} \qquad 2.2.4(e)$$

The angle subtended by the arc is equal to the difference of the blade segment angles, i.e.

$$\Delta\phi = \theta_{n+1} - \theta_n$$

The radius of curvature is therefore given by

$$R = \frac{D_{chord}}{2\ \mathrm{Sin}(\Delta\phi/2)} \qquad 2.2.4(f)$$

Substitution of this value in 2.2.4(c) gives the pressure at node n+1 due to the mass passing over it.

2.3 MODAL ANALYSIS

Consider a representation of the blade with n nodes such that the vector

$$V(\chi) = \{V\} = [V_1\ V_2\ V_3\ \ldots\ V_n] \qquad 2.3.1(a)$$

contains the out-of-plane displacements as represented by a lumped mass model of n masses. Similarly, the in-plane displacements can be represented by W. The total displacement vector can be represented by the function

$$\{\phi\}_i = \begin{Bmatrix} V_i \\ W_i \\ \theta_i \end{Bmatrix} \qquad 2.3.1(b)$$

where ϕ is a 2n vector. Thus ϕ represents the mode shape of the blade and if this mode shape corresponds to the eigenvector of the system for mode i and they are normalized to a maximum of unity for the highest component, the function is denoted ϕ_i .

Corresponding to each displacement mode shape eigenvector is a stress mode shape eigenvector, $\{S\}_i$, which represents the chordwise, radial and shear stress components at the location of each node for mode i.

The modal mass m_i is defined as

$$m_i = \{\phi_i\}^T [M_p] \{\phi_i\} \qquad 2.3.1(c)$$

where the superscript T refers to the transpose matrix operation and M_p represents the mass matrix of the structure. The subscript p refers to the system physical points used to simulate a given property. The mass matrix $[M_p]$ is

$$[M_p] = \begin{bmatrix} \ddots_{m} & & \\ & \ddots_{m} & \\ \hline & & I\ddots \end{bmatrix}$$

If the mass matrix is diagonal, then Equation (3) becomes

$$\{m_i\} = [M_p]\{\phi_i\}^2 \qquad 2.3.1(d)$$

The loads must be transformed from physical points to the generalized coordinates corresponding to the mode shapes. This is accomplsihed by the equation

$$\{P_i\} = \{\phi_i\}^T\{P_p\}$$

and

$$\{P_p\} = [P_{iv} \quad P_{iw} \quad P_{i\theta}]^T \qquad 2.3.1(e)$$

The use of normal modes provides an uncoupled set of differential equations for each mode. This is because the modes are orthogonal. The equations of motion for the i^{th} mode are

$$m_i\ddot{q}_i + b_i\dot{q}_i + k_i q_i = P_i(t)$$

or

$$\ddot{q}_i + 2\beta_i\dot{q}_i + \omega_{oi}^2 q_i = \frac{1}{m_i}P_i \qquad 2.3.1(f)$$

where q_i is the generalized coordinate and

$$\beta_i = \frac{b_i}{2m_i}, \qquad \omega_{oi}^2 = \frac{k_i}{m_i}$$

The dots refer to time derivatives of the generalized coordinate. The general solution of Equation (7) is

$$q_i = F q_{i_o} + G \dot{q}_{i_o} + \frac{1}{m_i}\int_{t_n}^{t} G(t-\tau)\, P_i(\tau)\, d\tau \qquad 2.3.1(g)$$

The functions F and G are combinations of the homogeneous solution

$$q_i(t) = e^{\left(-\beta_i \pm \sqrt{\beta_i^2 - \omega_{oi}^2}\right)(t-t_n)} \qquad 2.3.1(h)$$

which satisfy the initial conditions for unit values of the displacement and velocity. For the case of underdamped oscillations, F and G can be calculated by the equations

$$F = e^{-\beta_i h}\left(\cos \omega h + \frac{\beta_i}{\omega} \sin \omega h\right)$$
$$G = \frac{1}{\omega} e^{-\beta_i h} \sin \omega h \qquad 2.3.1(i)$$

where $\omega^2 = \left(\omega_{oi}^2 - \beta_i^2\right)$ and h is the time increment defined by $(t-t_n)$. The velocities are also required and are given by the expressions

$$F' = -\frac{\omega_{oi}^2}{\omega} e^{-\beta_i h} \sin \omega h$$
$$G' = e^{-\beta_i h}\left(\cos \omega h - \frac{\beta_i}{\omega} \sin \omega h\right) \qquad 2.3.1(j)$$

The remaining term of Equation 2.3.1(g) is a convolution or Duhammel integral, the solution of which, assuming P_i varies linearly with time, can be evaluated by the expressions

$$q_i = A P_{i,n} + B P_{i,n+1}$$

2.3.1(k)

$$\dot{q}_i = A' P_{i,n} + B' P_{i,n+1}$$

The values of the coefficients of Equations 2.3.1(k) are given by the expressions

$$A = \frac{1}{hK_i\omega}\left\{e^{-\beta_i h}\left[\left(\frac{\omega^2-\beta^2}{\omega_{oi}^2} - h\beta_i\right)\sin\omega h - \left(\frac{2\omega\beta_i}{\omega_{oi}^2} + h\omega\right)\cos\omega h\right] + \frac{2\beta_i\omega}{\omega_{oi}^2}\right\}$$

2.3.1(l)

$$B = \frac{1}{hK_i\omega}\left\{e^{-\beta_i h}\left[-\left(\frac{\omega_i^2-\beta_i^2}{\omega_{oi}^2}\right)\sin\omega h + \frac{2\omega\beta_i}{\omega_{oi}^2}\cos\omega h\right] + \omega h - \frac{2\beta_i\omega}{\omega_{oi}^2}\right\}$$

2.3.1(m)

$$A' = \frac{1}{hK\omega}\left\{e^{-\beta h}\left[(\beta + h\omega_o^2)\sin\omega h + \omega\cos\omega h\right] - \omega\right\}$$

2.3.1(n)

$$B' = \frac{1}{hK\omega}\left\{-e^{-\beta h}\left[\beta\sin\omega h + \omega\cos\omega h\right] + \omega\right\}$$

where $K = \omega_o^2 M_i$

If the generalized force is constant over the time interval h, the generalized displacement and velocity as given by Equations 2.3.1(k) reduce to,

$$q_i = \bar{A}\,P_{i,n} \quad \text{and} \quad \dot{q}_i = \bar{B}\,P_{i,n}$$

2.3.1(o)

where

$$\bar{A} = \frac{1}{K\omega}\left\{e^{-\beta h}\left[-\beta\sin\omega h \mp \omega\cos\omega h\right] + \omega\right\}$$

$$\bar{B} = \frac{1}{K\omega}\,e^{-\beta h}\,\omega_o^2\sin\omega h$$

Thus if $P_{i,n} = P_{i,\,n+1}$ the total solution at the end of the time period is

$$q_{i,n+1} = F q_{i,n} + G\dot{q}_{i,n} + \bar{A}\,P_{i,n}$$

2.3.1(p)

$$\dot{q}_{i,n+1} = F' q_{i,n} + G'\dot{q}_{i,n} + \bar{B}\,P_{i,n}$$

and the coefficients are given by Equations 2.3.1 (i), (j), and (o).

Assuming that at time zero the in-plane and out-of-plane coordinates of the nodes are contained in the 2n vector

$$\{X_o\} = \begin{Bmatrix} X_1 & X_2 & X_3 & \text{------} X_n \\ Y_1 & Y_2 & Y_3 & \text{------} Y_n \end{Bmatrix}$$

and the initial chordwise, radial and shear stress components at the nodes are contained in the 3n vector

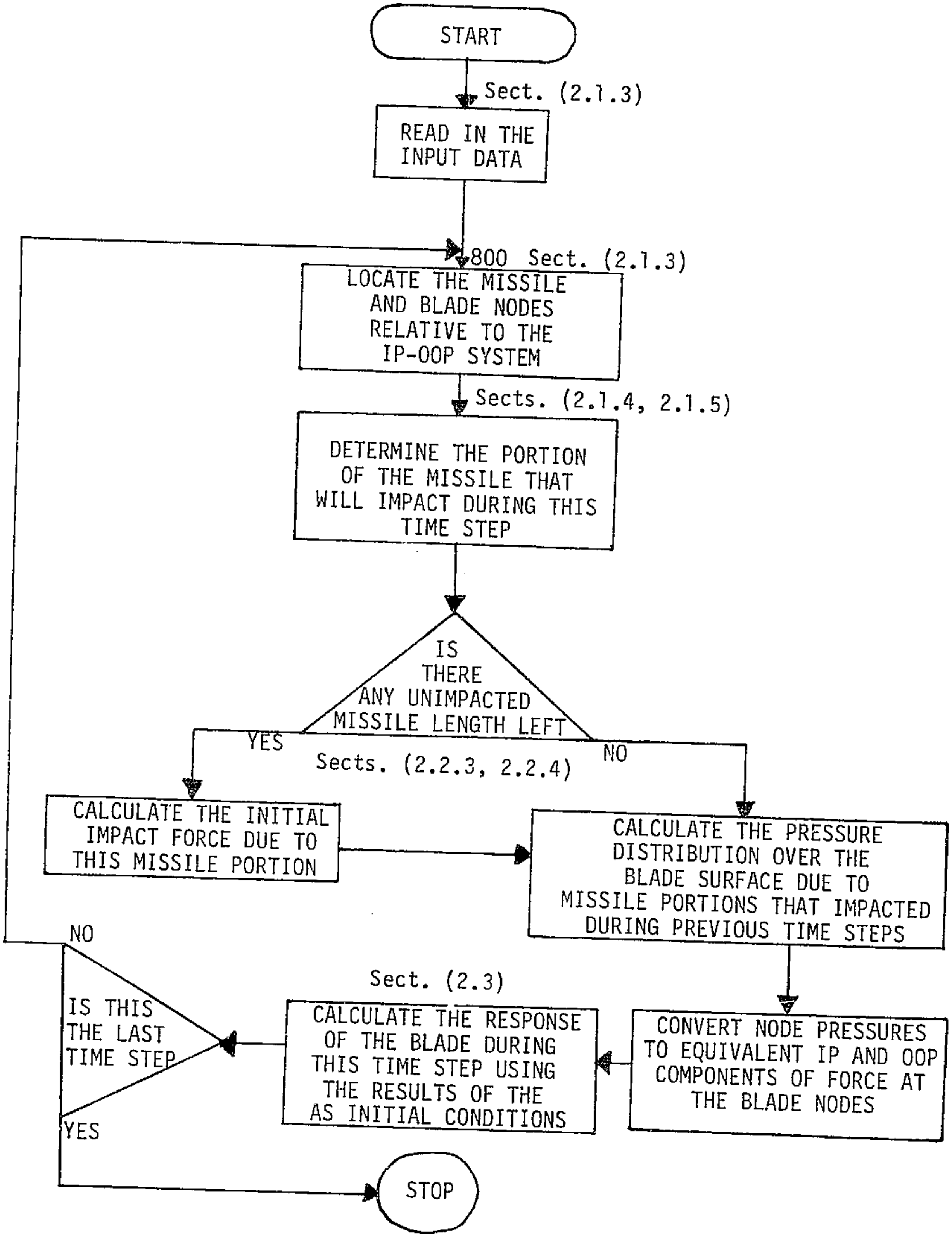
$$\{\sigma_o\} = \begin{Bmatrix} \sigma_{c1} & \sigma_{c2} & \sigma_{c3} \text{------} \sigma_{cn} \\ \sigma_{r1} & \sigma_{r2} & \sigma_{r3} \text{------} \sigma_{rn} \\ \tau_1 & \tau_2 & \tau_3 \text{------} \tau_n \end{Bmatrix}$$

the coordinates and stress components at the end of the time period are given by

$$\{X\} = \{X_o\} + \sum_i q_i \{\phi\}_i \qquad 2.3.1 \text{ (q)}$$

$$\{\sigma\} = \{\sigma_o\} + \sum_i q_i \{S\}_i \qquad 2.3.1 \text{ (r)}$$

2.4 BASIC PROBLEM FLOW DIAGRAM



SECTION III

COMPUTER PROGRAM DESCRIPTION

The MMBI program consists of a main routine and eleven subroutines. In Section 3.13 are the flow diagrams associated with each routine which are summarized below and discussed in detail in the following sections.

MAIN - Input data is read in; initial conditions for the problem are calculated; the geometrical position and shape of the missile and blade are determined; the length of the time step is determined; the total force on the blade during each time step is distributed among the nodes; and the position is determined for the nodes describing the blade cross section in the in-plane out-of-plane reference frame at the end of each time step.

P3D - Calculates the instantaneous force imparted to the blade by the 3-D jet part of the missile portion that impacts during a particular time step.

LAMBDA - Calculates the distance between the stagnation point and the boundary of the void formed on the backwash side of the fluid flow at the end of the time step during which the missile portion impacted.

CAMBER - Calculates the thickness of the impacted missile mass passing over a node on the blade and the pressure effect due to the curved surface at the node.

REGION - Determines which radius of curvature is to be used for the calculation of pressure effects due to camber.

INCURV - Calculates the inverse of the radius of curvature at a particular node located on the blade surface.

PRESUR - Maps the pressure distribution on the blade and calculates the pressure over each node of the blade during every time step.

MØDAL - Calculates the modal coefficients during each time step, the total displacement at every node relative to its position at time zero, and the three components of stress at every node.

PRINTP - Prints the pressures at the nodes falling within the impacted mass distribution during a particular time step.

PRINTV - Sets up the format for, and stores the displacement and stress output data to be printed at the end of the run.

PRINTR - Prints the displacements and stresses at the nodes chosen by the user for the time steps chosen by the user.

PINIT - Calculates the combined shape of the missile portion impacting during a time step, the impact parameters associated with the missile portion, the combined instantaneous impact force due to the 2-D and 3-D parts of the model, and distributes the force as equivalent pressures at the nearest two nodes to the center of force of the impact.

CORRELATION BETWEEN THEORETICAL AND CODED VARIABLES

Equation	Computer	Units
x_n	XO	length
y_n	YO	length
θ_n	THETA	radians
x_K	X	length
y_K	Y	length
α_o	THETAO	radians
β	BETA	radians
ν_n	VEL	length/time
ω_n	ØMEGA	radians/time
V_n	VB	length/time
V_K	VI	length/time
ν	VR	length/time
x_i	XI	length
y_i	YI	length
v_o	V	length/time
α_K	ALPHA	radians
ℓ	AL	length
f	F	length
g	G1J	length
a	RM	length
λ_1	LAND11	length
λ_2	LAND21	length
P_o	PO	force/(length)^2
ρ	DEN	mass/(length)^3
γ_1	GAMMA1	-----
γ_2	GAMMA2	-----
P_1, P_2	PRSS	force/(length)^2
$\{\phi\}$	PH2	length
$\{S\}$	SH2	force/(length)^2
m_i	VMI	mass
β_i	BET	-----
q_i	QI	-----
ω_{oi}	WØ	radians/time
ω	WI	radians/time

3.1 MAIN

3.1.1 Input Variables

a) V - Missile velocity relative to in plane-out of plane reference frame.

b) RIMP - Radius of blade at which impact occurs.

c) TSTØP - Total time duration for which the analysis is to be performed.

d) ALPHAO - Initial angle between missile and blade chord. This angle is measured positive counterclockwise in the in plane-out of plane reference frame from the centerline of the missile to the blade chord.

e) XOCL, YOCL - In plane and out of plane coordinates for the intersection of the forward point of the missile at its centerline and the blade face.

f) NR - Total number of radial stations describing the blade.

g) NN - Total number of nodes describing the blade.

h) NM - Total number of blade modes used in the analysis.

i) NVA - Total number of sections dividing up the missile along its length.

j) IPDEL - Number of time steps between each printout of deflections and stresses. Once the missile is entirely on the blade (i.e., there is no more unimpacted missile length) the pressures at the blade nodes are printed only every IPDEL time step. While there is still unimpacted missile length, the node pressures are printed during each time step.

k) DEN - Mass density of missile.

l) ISYM - Flag to signal whether missile is symmetric$^{(0)}$or unsymmetric$^{(1)}$

m) RL(M) - Radial distance between missile centerline and centerline of missile section M.

n) RM(M) - Thickness of missile section M.

o) CL(M) - Length of missile section M.

p) DELTL(M) - Offset from forward point of the missile at the centerline to the forward point of missile section M (positive toward rear of missile).

q) WM(M) - Width of missile section M.

r) MAX(I3) - Total number of nodes at radial station I3.

s) NJ3(I3) - Index of chordwise node at each radial station I3 where deflection and stress output is desired. The program automatically outputs deflections and stresses at the leading edge and trailing edge nodes of each radial station. The number NJ3 may be anything from 1 to MAX of each radial station.

t) VM(I6) - Modal mass associated with each mode I6.

u) DR(I6) - Modal damping ratio associated with each mode I6.

v) WØ(I6) - Modal frequency associated with each mode I6 (radians/second).

w) PH2(J6, K6, I6) - In-plane (J6 = 1) and Out-of-plane (J6 = 2) displacements associated with each node K6 for each mode I6.

x) SH2(J6, K6, I6) - Extensional (J6 = 1, 2) and shear (J6 - 3) stresses associated with each node (K6) for each mode I6.

y) YNØDE(I3), XNØDE(I3, J3) - Radial coordinate and chordwise coordinate at radial station I3 of node J3 describing the blade geometry in the planform reference frame.

z) XØ(JC), YØ(JC) - Initial in-plane and out-of-plane coordinates of nodes JC describing the blade face curvature at the impact radial station in the in-plane/out-of-plane reference frame. The number of XØ, YØ pairs must be the same as the value for MAX at the corresponding radial station.

3.1.2 Problem Initialization

a) Modal Parameters:

The modal coefficients, Q and QD, for each mode I6, for example, are set to zero. The program then sets the numerically highest modal frequency into array element HIMØDE(NM) and the lowest modal frequency into array element HIMØDE(1).

From the modal mass, VMI(I6) the modal stiffness VKI(I6) can be calculated as

$$VKI(I6) = [VMI(I6)] \times [WØ(I6)]^2 \qquad 3.1.2\ (a)$$

Furthermore, the modal decay constant is given by

$$BET(I6) = [DR(I6)] \times [W\emptyset(I6)] \quad 3.1.2\ (b)$$

and the effective damped modal frequency, WI(I6), is calculated from

$$WI(I6) = \sqrt{[W\emptyset(I6)]^2 - [BET(I6)]^2} \quad 3.1.2\ (c)$$

b) Effective Pressure Area at Nodes:

For each node at radial station I3 and chordwise station J3, for example, the chordwise distance between the two closest neighboring nodes on the same radial station is given by

$$XR - XL = [XN\emptyset DE(I3, J3 + 1)] - [XN\emptyset DE(I3, J3 - 1)]$$

and for the radial distance between the two closest neighboring nodes above and below radial station I3

$$RA - RB = [YN\emptyset DE(I3 + 1)] - [YN\emptyset DE(I3 - 1)]$$

The area AANØDE(I3, J3) is thus given by

$$AAN\emptyset DE(I3, J3) = [XR - XL] \times [RA - RB]/4$$

If the node should lie on either the lowest radial station or the highest radial station, then the value of YNØDE(I3) is used instead of YNØDE(I3-1) or YNØDE(I3 + 1) respectively. Similarly, if the node lies on one of the blade edges, then the value of YNØDE(I3, J3) is substituted for XNØDE(I3, J3 -1) in the case of the leading edge and for XNØDE(I3, J3 + 1) in the case of the trailing edge.

c) Correspondence between planform and in-plane/out-of-plane geometry.

The program sets variables NSTAT and NSTAF equal to the number of nodes at the impact radial station and the number of blade segments at the impact radial station respectively. Array XM is then set up with its elements equal to the XNØDE(I7, J3) values corresponding to the nodes at the impact radial station, I7. Thus, XM(1) is the chordwise coordinate on the planform geometry corresponding to the leading edge node at the impact radial station, with coordinates XØ(1), YØ(1) in the in-plane/out-of-plane reference frame. Using the values of XM, the blade is now divided up into NSTAF-1 regions of curvature. The bounds of each curvature region are uefined by the mid-points between adjacent chordwise points X_M. Thus, the first curvature region will lie between XM(1) and the mid-point of XM(2) and XM(3). The second curvature region lies between the mid-point of XM(2) and XM(3) and the mid-point of XM(3) and XM(4). The last curvature region lies between the mid-point of XM(NSTAT-2) and XM(NSTAT-1) and the point XM(NSTAT). The values of these mid-points are stored in arrays XCEN1 and XCEN2 where XCEN1(JC) is the beginning of curvature region JC and XCEN2(JC) marks the end of curvature region JC and the beginning of curvature region (JC + 1).

d) In-plane/out-of-plane blade coordinates XO, YO:
The elements of arrays XO and YO are assigned the corresponding values of the elements in arrays XØ and YØ. The program updates the blade coordinates in arrays XO and YO at the end of each time step.

e) Time step index I is set equal to zero and absolute TIME is set equal to zero. These variables are updated after every time step.

f) Displacement and stress print flag - ITPRNT:
ITPRNT is initially set equal to one. Further on in the program, a comparison is made between the values of I and ITPRNT. If they are equal, then the program stores the displacement and stress output data for time step I. ITPRNT is then incremented by IPDEL (see 3.1.1(k) and 3.10.2).

g) IFV - Free vibration flag:
Initially IFV is set equal to zero. When the blade is no longer in contact with any missile mass (i.e., all node pressures are zero), IFV will be set to 1. This will trigger the program to alter its normal solution run in order to save time as will be discussed further on in the narrative. (Sect. 3.1.15)

h) IFSLD - Shallow impact angle flag:

Normally IFSLD is set to zero. If during a particular time step the impact angle is less than one tenth of a degree, IFSLD is set to 1. The remainder of the unimpacted missile length is assumed to slide onto the blade and no further impact analysis will be performed.

i) IIFLG - Zero impact length flag:

IIFLG is initially set to zero. When the length of the missile has reduced to zero during the impact stage of the program, IIFLG is set to 1. This will cause the program to skip calculations involving initial impact.

3.1.3 Printout of Initial Conditions

The program prints the following data:

a) Initial planform and in-plane/out-of-plane blade geometry.

b) Initial thickness, length, width and offset of each missile section.

c) The modal frequency, modal mass, modal stiffness and modal damping ratio for each mode to be used in the analysis.

d) Missile velocity, initial impact angle, missile density, in plane and out of plane coordinates of the center of impact and the impact radius.

3.1.4 Time Step Increment Entry Point

The point of the program where time stepping begins is denoted by statement number 800. Each time the program returns to this point, the index I is incremented by 1.

3.1.5 Blade Chord Angle, Missile Angle and Blade Segment Angles

The blade chord angle THETAO and missile angle BETA are calculated using the relations 2.1.3(d) and 2.1.3(e). For each blade segment JC, in the in-plane/out-of-plane reference frame, the angle with respect to the in-plane axis is determined by using the expressions 2.1.3(a). The sign of the angle is determined by comparing the difference [YO(JC + 1) - YO(JC)] with zero. If the difference is negative, then THETA(JC) is negative.

3.1.6 Forward and Aft Points of Missile Sections

Using the value of BETA and the relations 2.1.3(f), the coordinates of the forward and aft points of each missile section L are calculated for the first time step. For I greater than 1, the relations 2.1.3(g) and 2.1.3(h) are used. The X and Y coordinates of the forward point of missile section L are assigned respectively to array elements X(L) and Y(L). Similarly, for the aft point of missile section L, the X and Y coordinates are assigned to array elements X1(L) and Y1(L) respectively.

The remaining unimpacted length of each missile section L is calculated for I greater than 1. Assigned to array element VDT(L, I-1) is the amount of length of missile section L that impacted on the blade during time step I-1. The remaining unimpacted length (CL(L)) is obtained by subtracting the value of VDT(L, I-1) from the length of missile section L. When the remaining length is less than or equal to one percent of the length at the beginning of time step I-1 the program considers this length to be effectively zero. This is necessary in order to avoid infinite looping due to computer roundoff error in the calculation of VDT. When CL(L) is zero, an array flag, II(L) is set to a value of 2 signaling the program that missile section L will no longer be involved in the impact calculations.

3.1.7 Missile - Blade Contact Points

To find the blade segment that is impacted by missile section L during time step I, the program uses the relations 2.1.3(j). If the missile section is not aiming at any blade segments during a time step, then a flag IHIT(L) is set to zero and the program moves to the next missile section. When a blade segment JC is established as the one to be impacted by missile section L, the program then uses equation 2.1.3(k) to determine where the forward point of the section is relative to the blade. Furthermore, IHIT(L) is assigned the value JC and a flag IBACK(L) is established such that its value is zero if the missile section is in front of the blade and 1 if the missile section is in back of the blade.

The program now checks the shallowness of the impact angle. If the impact angle is less than 1.7×10^{-3} radians (approximately one tenth of a degree) the missile section is considered to be sliding on the blade.

a) Sliding - If missile section L is sliding, then a flag ISLIDE(L) is set equal to 1. The program now determines whether the blade segment angle THETA(JC) is close to 90 degrees. If THETA(JC) is within $\pm 1.7 \times 10^{-3}$ radians of $\pi/2$ then the out of plane coordinate of the impact point YI(L) is set equal to the out of plane coordinate Y(L) and the in plane coordinate oɪ the impact point is calculated from

$$XI(L) = [Y(L) - YO(JC)] \times ctn^{-1} [THETA(JC)] + XO(JC) \qquad 3.1.7 \text{ (a)}$$

If THETA(JC) is not close to $\pi/2$, then the program sets the in plane coordinate of the impact point XI(L) equal to X(L) and determines the out-of-plane coordinate of the impact point from

$$YI(L) = [X(L) - XO(JC)] \times \tan^{-1} [THETA(JC)] + YO(JC) \qquad 3.1.7 \text{ (b)}$$

The parameter XNEAR(L) is now assigned the value of XM(JC) in order to establish the location of the impact on the planform geometry. In addition, since the missile section is sliding on the blade, the distance between the forward point of section L and its impact point is set equal to zero in array element DFB(L). The chordwise distance DELTA(L) from the node corresponding to XM(JC) to the impact point is now calculated from

$$DELTA(L) - [XI(L) - XO(JC)]^2 + [YI(L) - YO(JC)]^2$$

Because of the arbitrary manner of assigning the value of Y(L) to YI(L) or X(L) to XI(L) it is possible that the impact point can be close enough to node (JC + 1) so that the impact can be considered to occur on blade segment JC + 1 rather than JC. This condition is indicated, for THETA(JC) less than zero when YI(L) is less than YO(JC + 1), and for THETA(JC) greater than zero when YI(L) is greater than YO(JC + 1). If either of these conditions occurs, the program assigns:

$$XI(L) = XO(JC + 1)$$

$$YI(L) = YO(JC + 1)$$

$$XNEAR(L) = XM(JC + 1)$$

$$IHIT(L) = (JC + 1)$$

$$ISLIDE(L) = 0$$

and $$DELTA(L) = 0.$$

Note that in this case, the impact point does not lie exactly on the centerline connecting the forward and aft points of missile section L. Instead of using the distance between the points [X(L), Y(L)] and [XI(L), YI(L)] for DFB(L), the program calculates the projected distance in the direction of the missile centerline, i.e.

$$DFB(L) = [X(L) - XI(L)]^2 + [Y(L) - YI(L)]^2 \qquad 3.1.7\ (c)$$

Now the angle between the missile centerline and the line joining the impact point and forward point is calculated:

$$DALPHA = COS^{-1}\ [X(L) - XI(L)]/DFB(L) \qquad 3.1.7\ (d)$$

The projected distance is then given by

$$DFB(L) = [DFB(L)]\ X\ Cos\ [BETA - DALPHA] \qquad 3.1.7\ (e)$$

However, if DFB(L), as calculated in equation 3.1.7 (c), is less than 1×10^{-5}, the program arbitrarily assigns DFB(L) a value of zero. In order to locate the center of impact of missile section L on the planform geometry, one more parameter, GAMMA(L), must be calculated. This is the chordwise location of the impact point on the planform geometry, i.e.,

$$GAMMA(L) = XNEAR(L) + DELTA(L) \qquad 3.1.7\ (f)$$

b) Impact angle is not shallow

In this case, the program uses the relation 2.1.3 (f) to calculate the impact coordinate XI(L). If THETA(JC) is within $\pm 1.7 \times 10^3$ of $\pi/2$ then YI(L) is determined by equation 2.1.3 (c). Otherwise, YI(L) is calculated by equation 2.1.3 (e).

In addition, the program calculates

$$XNEAR(L) = XM(JC)$$

$$DELTA(L) = [XO(JC) - XI(L)]^2 + [YO(JC) - YI(L)]^2$$

$$DFB(L) = [XI(L) - X(L)]^2 + [YI(L) - Y(L)]^2$$

and $GAMMA(L) = XNEAR(L) + DELTA(L)$

After all missile sections have been analyzed, the program examines Flag IT to determine the direction that the missile will have to be moved in order to locate the initial contact points between the missile and blade for time step I. If it is greater than zero then the program is signaled to move the missile rearward so that all forward points of the missile sections are in front of the blade. In addition, stored in array element DMAX(IT) is the distance that the missile will have to be moved back.

If IT is equal to zero then the program is signaled that all forward points are in front of the blade and the smallest distance, DFB, is stored in array element SDFB(NVA). Thus, depending on the value of IT, for each missile section

if IT>0

$$X(L)=X(L)-[DMAX(IT)]\ [Cos(BETA)]$$

$$Y(L)=Y(L)-[DMAX(IT)]\ [Sin(BETA)]$$

if IT=0

$$X(L)=X(L)+[SDFB(NVA)]\ [Cos(BETA)]$$

$$Y(L)=Y(L)+[SDFB(NVA)]\ [Sin(BETA)]$$

The adjusted values of the elements of DFB are now recalculated using the relation 3.1.7 (c). As a final step, the program assigns to the Flag II(L) for each missile section L a value of 1 or 0 depending upon whether the forward point is in contact with the blade (DFB(L)=0.) or not (DFB(L)=0.).

3.1.8 Time Step Size

Using the values assigned to the elements of HIMØDE (Section 3.1.2A), an initial time step size CØNST is calculated. If IFV is equal to 1, (Section 3.1.2G) then the program calculates a time step that is one tenth the period associated with HIMØDE(NM), i.e.

$$CØNST=2\pi/(10x[HIMØDE(NM)]) \qquad 3.1.8\ (a)$$

If IFB is equal to 0 (free vibration), then

$$CØNST=2\pi/(10x[HIMØDE(I)]) \qquad 3.1.8\ (b)$$

The value of CØNST is assigned to variable DT.

3.1.9 Relative Impact Velocity and Angle, and Adjusted Time Step Size

Using the relations in Section 2.1.4 the relative impact velocity VR(L,I) and relative impact angle ALPHA(L) are calculated for missile section L. By dividing the remaining unimpacted section length CL(L), for sections with II(L)=1, by the corresponding relative impact velocity VR(L,I), the time that it would take to impact the remaining length, DT1, is determined. Comparing DT1 to DT, if DT1 is smaller than DT, then DT is assigned the value DT1.

If II(L)=0, the program calculates the time that it would take missile section L to traverse the distance DFB(L) and assigns this value to DT1. If DT1 is less than DT but greater than DT/2, then DT is assigned the value DT1. If DT1 is less than DT/2, then the program assumes that section L will impact during this time step and sets II(L)=1. Note that the length of the time step will remain unchanged for this case.

3.1.10 Impacting Missile Section Length

The length of the missile section L that will impact during the time step I, VDT(L,I), is now calculated. For missile sections having IHIT(L)=0 (section 3.1.7) or II(L)=2 (missile section has completely impacted already) or II(L)=0, VDT(L,I) is assigned a value of zero. Otherwise VDT is calculated from

$$VDT(L,I)=[VR(L,I)]\times[DT]-DFB(L) \qquad 3.1.9\ (a)$$

3.1.11 Node Pressures Due to Initial Impact

The program checks the values assigned to flags IFSLD and IIFLG (items H and I of 3.1.2). If either of these flags has a value of 1, the program will skip this calculation. If both IFSLD and IIFLG are different from 1, the program calls subroutine PINIT to calculate the initial impact parameters and forces associated with the impact of the missile sections hitting the blade during time step I. Among the variables outputed by subroutine PINIT are arrays NA(I) and ITSLD(I), which are used as signals by MAIN in determining the values of IFSLD and IIFLG. The value of NA(I) corresponds to the number of missile sections impacting the blade during time step I. If the value of ITSLD(I) is other than 7, then the program is signaled that the remainder of the missile is sliding on the blade. When NA(I)=0 and ITSLD(I)=7, the program sets IIFLG=1 and assigns variable KFIN the value I-1 meaning that the last impact occurred during the previous time step. When NA(I)=0 and ITSLD(I) is less than 7, the program sets IFSLD=1 and variable KFIN=I-1. For time steps with NA(I) greater than zero the program sets KFIN=I. Until either IFSLD or IIFLG are set equal to 1 each time step has associated with it impact parameters describing the size and shape of the portion of the missile that impacted during that time step. KFIN is used as in index for the array parameters associated with impacts from time steps 1 through KFIN.

3.1.12 Node Pressures Resulting from Impacts that Occurred During Previous Time Steps

As described in Section 3.2.3 the distribution of an impacted portion of the missile takes the form of an expanding oval ring. For missile portions that have impacted the blade during a previous time step the program calculates the average size of the ring during the present time step. For the 2-D portion of the ring the location of the inner boundaries of the distributed mass in the negative and positive sides of the flow, relative to the centerline of the expanding ring, is calculated by adding half the amount of expansion during this time step (impact velocity times half the time step) to the location of these inner boundaries as of the end of the previous time step. This value is assigned to variable DIST(K) for the missile portion that impacted during a previous time step K. For the 3-D portion of the distribution the value of DIST(K) will be used as the average position of the inner radius during this time step. The program now calls subroutine PRESUR to distribute the pressure at the blade nodes that lie within the distribution.

For a missile portion that has impacted on the blade during the present time step the program calculates the initial size of the oval ring but does not call subroutine PRESUR since the node pressures have already been calculated in subroutine PINIT.

3.1.13 In-Plane and Out-of-Plane Node Forces

The pressures distributed among the nodes are now converted to in-plane and out-of-plane components of the equivalent forces at the nodes. The elements of array PRSS contain the values of the pressures at the nodes. For example, PRSS(I3,J3) represents the pressure at the J3 node along the row located at the radial station I3. From Section 3.1.2B the elements of array AANØDE(I3,J3) contain the effective areas of the nodes. The components of the force at a particular node are evaluated by using the blade segment angles in array THETA (Section 3.1.5). Since the blade segment angle of blade segment (JC) at the impact radial station (I7) is contained in array element THETA(JC), the relative angle of the blade segment containing a particular node (J3) at any other radial station (I3) is calculated as follows:

At the impact radi station, segment (JC) represents a portion of the blade chord equal to [XM(JC+1) - XM(JC)]/[XM(NSTAT) - XM(1)]. For the radial station (I3) a corresponding width is equal to the above ratio times the total chord width at radial station (I3), or

$$\text{WIDTH} = \frac{[\text{XM(JC+1)} - \text{XM(JC)}] \cdot [\text{XNØDE(I3,LIM)} - \text{XNØDE(I3,1)}]}{[\text{XM(NSTAT)} - \text{XM(1)}]}$$

The program now assigns to variable CAMLIM an initial value equal to the chordwise coordinate of the leading edge node at radial station (I3), i.e.

CAMLIM = XNØDE(I3,1)

Next, variable WIDTH is calculated using

XM(JC) = XM(1)

and XM(JC+1) = XM(2)

If node (I3,J3) falls within the range CAMLIM and (CAMLIM + WIDTH), then THETA(JC) is assigned to variable ANGLE which is used to calculate the components of force. If node (I3,J3) does not fall within the range, CAMLIM is increased by WIDTH and the process is repeated with

XM(2) = XM(JC)

and XM(3) = XM(JC+1) in 3.1.11(a)

When the range CAMLIM and (CAMLIM + WIDTH) is found to contain node (I3,J3), the program now calculates the components of force at the node from the equations:

PIFØRC(I3,J3) = [PRSS(I3,J3)] · [AANØDE(I3,J3)] · [Sin(ANGLE)]
PØFØRC(I3,J3) = −[PRSS(I3,J3)] · [AANØDE(I3,J3) · [Cos(ANGLE)]

where

PIFØRC(I3,J3) is the in-plane force component

and PØFØRCE(I3,J3) is the out-of-plane force component at node (I3,J3).

Referring to items W and X in section (3.1.1), note that the modal displacements and stresses at the nodes are stored in arrays that have a different method of indexing nodes and components. In order to achieve consistency between the arrays PH2, SH2 and the node forces the program assigns the in-plane and out-of-plane components of force to array PP(I5,1) and PP(I5,2) such that (I5) corresponds to the node being referred by (I5) in PH2(J6,I5,M) and SH2(J6,I5,7). The index (J6) = 1 refers to in-plane and (J6) = 2 refers to out-of-plane components. In addition, the value of the index in array (PP) referring to the leading edge node at the impact radial station is assigned to variable (I8) so that the velocities and displacements of the nodes at this radial station can be readily referenced. The program also algebraically sums the values of the elements of (PP) and assigns the total to variable (FV). (FV) will be used as a flag to determine when to set IFV equal to 1 (see item G under section 3.1.2).

3.1.14 Modal Analysis

The modal analysis that determines the response of the blade to the force distribution at the nodes is performed by calling subroutine MØDAL. Among the variables output by subroutine MØDAL is the array DEF(J6,K6) containing the in-plane (J6 = 1) and out-of-plane (J6 = 2) displacements of the nodes relative to their coordinates at time zero. Using the value of (I8) referred to in section (3.1.12) the program calculates the in-plane and out-of-plane coordinates of the blade nodes along the impact centerline from the relations

XO(JB) = XØ(JB) + DEF(1,I9)

YO(JB) = YØ(JB) + DEF(2,I9)

where (JB) refers to the chordwise index of the node at the impact radial station and (I9) is the corresponding index relative to variable (I8).

3.1.15 Time Update, Data Output, Return to 800 for Next Time Step

The program now calculates the total elapsed time by adding the value of (DT) (sections 3.1.8 and 3.1.9) to the previous value in variable TIME. In order to determine whether the entire length of the missile has impacted, the total number of missile sections having either (II) = 2 (section 3.1.6) or IHIT = 0 (section 3.1.7) are summed, and the value assigned to variable (III). The program now calls subroutine PRINTV to store the displacement and stress output data for this time step if any of the following conditions are satisfied.

A - This is the first time step (I = 1)

B - TIME is greater than TSTØP (item C of section 3.1.1)

C - I equals ITPRNT (section 3.1.2F)

In addition, if the value of (III) is equal to the total number of missile sections, the program will call subroutine PRINTP to print the pressure distribution for this time step. If (III) is less than the total number of missile sections (NVA), the program calls PRINTP whether the conditions A, B or C are satisfied or not. Next, the value assigned to variable (FV) (section 3.1.13) is compared to zero. If (FV) = 0 the program is triggered to set (IFV) = 1. The value assigned to variable TIME is now compared to TSTØP. If time is less than TSTØP the program returns to statement 800 to start a new time step. If TIME is greater than or equal to TSTØP the program calls subroutine PRINTR as a final step. PRINTR prints the displacement and stress output data for time steps selected by the user.

3.2 P3D - 3D PRESSURE DISTRIBUTION INTEGRATION

3.2.1 Input Variables

a) A - Thickness of the missile portion impacting the blade.

b) ALPHA - Impact angle

c) PØ - Stagnation pressure

d) GAMDA1, GAMDA2 - Parameters used to define the limits of the 3D pressure distribution. (See discussion on the variables λ_1' and λ_2' in Sections 2.2.2 and 2.2.3)

3.2.2 Discussion

This subroutine performs a numerical integration of the pressure distribution associated with the 3D portion of the distributed impacted missile mass. The shape of the distribution is formed by a semi-circle of radius [GAMDA1 + GAMDA2]/2. The routine arbitrarily sets the number of integration points to 1352, and evaluates the integral using a 2-dimensional grid formed by these points.

Given a rhombic area with corners at points (x, y), (x+Δx,y), (x,y+Δy) and (x+Δx, y+Δy), the integral of the pressure over this area is given by

$$\int P da = \frac{\Delta x \Delta y}{6}\left[P(x,y) + 2P(x+\Delta x, y) + 2P(x, y+\Delta y) + P(x+\Delta x, y+\Delta y)\right] \tag{3.2.2(a)}$$

where P is the pressure distribution. The value of the integral for the entire semi-circular region is approximated by summing the integrals of the individual discreet areas over the entire system.
The value of the integral is assigned to variable TLØAD.

3.3 LAMBDA - ITERATION SOLUTION FOR λ_2'

3.3.1 Input variables

a) GAMDA1 - Variable λ_1' in Section 2.2.2

b) DEL - Amount of missile portion impacting the blade during the time step of interest.

c) G1, G2 - 2D jet pressure distribution decay parameters in the positive and negative sides of the flow separation respectively.

d) F - Distance between the stagnation pressure point and the location of the center of force.

e) I - Time step increment number.

f) ALPHA - Impact angle

g) ISPLT - Flag determining the impact direction. If ISPLT=1 the flow in the positive side is toward the trailing edge. If ISPLT=-1 the flow is in the direction of the leading edge.

h) SP - Location of the stagnation pressure point relative to the planform geometry coordinate system.

i) X1,X2 - Location of the leading edge and trailing edge nodes, respectively, relative to the planform geometry system.

3.3.2 Iteration Solution for λ_2'

The methodology used to obtain a value for λ_2' is described in Section 2.2.2. The routine attempts to solve for λ_2' in 200 iteration steps using the Newton Raphson Method. If after that point, convergence to one-tenth of a percent accuracy for the solution has not been achieved, the routine prints a warning message to the user and returns to the calling program. Since the equations used by the routine involve exponential terms, the program is instructed to skip the analysis if the absolute value of the argument is greater than 20. In addition, the value of λ_2' for this case is arbitrarily set equal to zero. This approximation is not inconsistent since large absolute values of the arguments in the exponential functions represents a shallow impact angle such that the majority of the flow will be in the positive direction of the stream separation.

The value for λ_2' is assigned to variable BESTL.

3.4 CAMBER - CALCULATION OF PRESSURE EFFECTS DUE TO BLADE CURVATURE

3.4.1 Input Variables

a) XNØDE,YNØDE - Planform geometry coordinates of a node.

b) A,B - Radial coordinate of the limiting bounds for the 2-D portion of the spreading missile mass in the planform geometry system

c) ISPLIT - see 3.3.1(g)

d) RM - Thickness of the impacted missile portion that is associated with this portion of mass distribution.

e) ALPHA - Impact angle

f) SPP - (See 3.3.1(h))

g) VDT - See 3.1.6

h) CØSFEE - Angle with respect to x axis, defined by a line connecting a node at coordinates (XNØDE,YNØDE) and the point located at coordinates x = SPP and

$$y = \begin{cases} A \text{ if YNØDE } \geq A \\ B \text{ if YNØDE } \leq B \end{cases}$$

in the planform geometry system.

i) VR - Relative impact velocity

j) DEN - Missile density

k) NSTAT - Number of chordwise stations at the impact radial station.

l) DIST - See Section 3.1.11.

3.4.2 Discussion

This subroutine calculates the average thickness of mass traversing the node located at planform coordinates (XNØDE,YNØDE), and, through subroutines REGIØN and INCURV, it calculates the pressure over the node due to blade curvature. For a mass element in the negative side of the flow separation, the thickness for the 2D portion is approximated by

$$\text{THICK} = \text{RM*} \; [1-\text{Cos(ALPHA)}] \; /2 \qquad 3.4.2(a)$$

and in the positive side by

$$THICK = RM* \left[1+Cos(ALPHA)\right] /2 \qquad 3.4.2(b)$$

For the 3D flow portion the mass thickness is determined from the assumption that the average thickness varies inversely with the ratio of the cross sectional area of the 3D portion of the unimpacted missile to the area of the distributed 3D impacted mass, i.e.

$$H3D = \frac{(THICK_{3D})_{IMPACTED}}{VDT} = \frac{\pi(RM)^2}{\pi\ [(DIST+VDT)^2 - (DIST)^2]} \qquad 3.4.2(c)$$

Assuming now that the thickness varies linearly with angle along the mean radius of the distribution, an expression for the thickness of mass over a node lying within the 3D portion of the distribution is written as

$$THICK = (H3D) \left[1+Cos\ (ALPHA) - \frac{2Cos\,(ALPHA)}{\pi}\ Cos^{-1}\ (CØSFEE)\right] \qquad 3.4.2(d)$$

Referring to the discussion in Section 2.2.4, the routine now calls subroutine REGION to determine which curvature region of the blade the node with coordinates (XNØDE,YNØDE) lies within. Assigning this value to variable (JC1), subroutine INCURV is called to determine the value of the inverse of the radius of curvature for the curvature region corresponding to (JC1). Using this value in variable (P1)the pressure due to blade curvature is calculated using equation 2.2.4(c) and assigned to variable PRESSC.

3.5 REGIØN - DETERMINATION OF BLADE CURVATURE REGION

3.5.1 Input variables

a) XNØDE - See 3.4.1(a)

b) NSTAT - See 3.4.1(a)

c) XCEN1, XCEN2 - Arrays containing the planform x-coordinates of the bounds of the discreet curvature regions (see 2.2.4 and 3.1.2(c)).

3.5.2 Discussion

This subroutine determines which blade curvature region, as defined by XCEN1 and XCEN2, the coordinate XNØDE of a node lies within. The index of the correct region is assigned to variable JC1.

3.6 INCURV - CALCULATION OF THE INVERSE OF THE CURVATURE RADIUS CORRESPONDING TO REGION JC1

3.6.1 Input Variables -

a) JC1 - see 3.4.2

b) XO,YO - Arrays containing the in-plane and out-of-plane coordinates of the blade cross section nodes during the time step of interest

c) THETA - Array containing the relative angles between the blade segments and the in-plane axis during the time step of interest.

3.6.2 Discussion

Using the equations and methodology described in Section 2.2.4, the inverse of the blade curvature radius is calculated and assigned to variable P1.

3.7 PRESUR - PRESSURE OVER A NODE

3.7.1 Input variables -

a) NR - Number of radial stations

b) A,B - see 3.4.1(b)

c) DIST - see Section 3.1.11

d) ISPLIT - see 3.3.1(g)

e) SPP - see 3.3.1(h)

f) SPP1 - Planform x coordinate for the center of the oval distribution of mass associated with this impacted portion of the missile.

g) VDT - see 3.1.6

h) GAMMA1, GAMMA2 - Exponential decay constants in the positive and negative flow directions respectively.

i) PO – Stagnation Pressure

j) RM – see 3.4.1(d)

k) ALPHA – Impact angle associated with this missile portion.

l) VR – Impact velocity associated with this missile portion

m) DEN – Missile density

n) NSTAT – see 3.4.1(k)

o) IIFLG – see 3.1.2(I)

p) XNØDE, YNØDE – see 3.4.1(a)

q) MAX – Array containing the number of chordwise nodes at each radial station

3.7.2 2D Pressure

The 2D pressure region associated with an impacted missile portion is bounded chordwise by the planform coordinates:

SPP1 – (DIST + VDT) for the negative flow side

and SPP1 + (DIST + VDT) for the positive flow side.

For the radial bounds, the 2-D portion extends between planform radial coordinates B and A. In addition, for the distribution consisting of a void (see Section 2.2.3) the inner chordwise bounds of the distribution are SPP1-DIST in the negative side and SPP1 + DIST in the positive side of the flow. Having located the boundaries of the 2-D portion of the impacted mass the routine determines which nodes fall within this region and calculates the pressure accordingly. The value of this pressure is assigned to array element PRESS(I3, J3) corresponding to the node located in radial station I3 and chordwise station J3.

3.7.3 3D Pressure

The bounds of the 3D portion of the distributed mass are determined by semicircles of radius (DIST + VDT) centered about the coordinates

(SPP1, B) for the portion below the centerline

and (SPP1, A) for the portion above the centerline, For the inner bound due to the formation of a void, the radius is taken as DIST. Similar to the 2D portion described in 3.7.2, the pressure is determined for nodes falling within the bound of the 3D distribution and the value assigned to array element PRESS (I3, J3).

3.7.4 Camber Effects

The routine now calls subroutine CAMBER to calculate the additional pressure over a node due to blade curvature. The output value of the camber pressure, stored in variable PRESSC, is added to the value in PRESS (I3, J3). Array PRESS will be used in subroutine PRINTP further on in the program to print the pressure distribution. For use in the calculation of nodal loads as described in Section 3.1.12, the program assigns the values in PRESS to corresponding elements in array PRSS. However, for nodes I3, J3 corresponding to the void of a mass distribution, the element PRSS (I3, J3) maintains a value of zero.

3.8 MØDAL - CALCULATION OF THE BLADE RESPONSE TO THE LOADS ON THE BLADE DURING A TIME STEP

3.8.1 Input variables

a) NM - Number of modes to be used

b) NSTAT - see 3.4.1(k)

c) NN - Total number of nodes describing the blade

d) I8 - see 3.1.13

e) FV - see 3.1.12

f) T - Time step size

3.8.2 Discussion

The methodology used in determining the displacement, velocity, and stress response at the nodes of the blade is described in Section 2.3. The coefficients in equations 2.3.1(p) are first calculated using the time step length T. The generalized displacement and velocity coordinates, QI and QDI, are now calculated and their values set to Q and QD respectively. Q and QD will be used in the next time step as initial conditions for the calculation of QI and QDI.

The displacement, velocity, and stress components for each node JB, relative to their values at time zero, are now calculated, based on equations 2.3.1 (q) and (r), as follows:

in-plane displacement at node JB	$DEF(1,JB) = \sum_{\#\ of\ modes} [PH2(1,JB,I6)][QI(I6)]$
out of plane displacment at node JB	$DEF(2,JB) = \sum_{\#\ of\ modes} [PH2(2,JB,I6)][QI(I6)]$
in-plane velocity at node JB	$VEL(1,JB) = \sum_{\#\ of\ modes} [PH2(1,JB,I6)][QDI(I6)]$
out of plane velocity at node JB	$VEL(2,JB) = \sum_{\#\ of\ modes} [PH2(2,JB,I6)][QDI(I6)]$
chordwise stress at node JB	$STRSS(1,JB) = \sum_{\#\ of\ modes} [SH2(1,JB,I6)][QI(I6)]$
radial stress at node JB	$STRSS(2,JB) = \sum_{\#\ of\ modes} [SH2(2,JB,I6)][QI(I6)]$
shear stress at node JB	$STRSS(3,JB) = \sum_{\#\ of\ modes} [SH2(3,JB,I6)][QI(I6)]$

The index I6 corresponds to mode number.

3.9 PRINTP - PRESSURE DISTRIBUTION PRINTOUT

3.9.1 Input variables

a) I - Time step increment

b) TIME - Absolute time at which these pressures are recorded.

c) NR - Number of radial stations

3.9.2 Discussion

In order to minimize the amount of printout, this subroutine determines the number of radial stations that contain nodes which lie within the pressure distribution during a particular time step. Only the radial stations lying within the upper and lower radial bounds of the pressure distribution will have the pressures at their corresponding nodes printed. In addition, for time steps during which the pressure on the blade is zero, the routine instructs the computer to print a message to the user accordingly.

3.10 PRINTV - DISPLACEMENT AND STRESS OUTPUT DATA ARRANGEMENT AND STORAGE

3.10.1 Input variables

a) I - Time step increment

b) TIME - Absolute time

c) IPDEL - see 3.1.1(k)

d) ITPRNT - see 3.1.2(f)

e) NR - Number of radial stations

f) I7 - Index of the impact radial station

g) DEF, VEL, STRSS - see 3.8.2

h) XNØDE, YNØDE - see 3.4.1(a)

i) MAX - see 3.7.1(q)

3.10.2 Discussion

At the user's request the MMBI program will print the nodal displacements and stresses for every IPDEL time step. The variable ITPRNT is updated each time this routine is entered by incrementing it with the value assigned to IPDEL as described in Section 3.1.2(f). Two formats of data printout are arranged by the routine. First, the in-plane and out-of-plane displacements and the radial stress at the leading edge, trailing edge and node NJ3(I3) (see 3.1.1(s)) for each radial station I3, are arranged in order to print them according to their radial location. Second, in order to obtain information about the variation of stress and displacement at the impact radius of the blade, the stresses and displacements at the chordwise nodes of the impact radial station and those of the nearest radial stations below and above the impact centerline-are arranged for their printout vs. the planform chordwise coordinates of the nodes along the impact radial station. The information for output printout set IJPRNT is stored in arrays:

DEFBI (IJPRNT, I3) - In-plane displacement at node NJ3 (I3)
DEFBØ (IJPRNT, I3) - Out-of-plane displacement at node NJ3 (I3)
SIGMB1 (IJPRNT, I3, 1) - Radial stress at leading edge node
SIGMB1 (IJPRNT, I3, 2) - Radial stress at node NJ3 (I3)
SIGMB1 (IJPRNT, I3, 3) - Radial stress at trailing edge node
CØDI (IJPRNT, J3) - In-plane displacement at node J3 of impact radial station
CØDØ (IJPRNT, J3) - Out-of-plane displacement at node J3 of impact radial station

SIGMA1 (IJPRNT, I4, J3)
SIGMA2 (IJPRNT, I4, J3)
SIGMB2 (IJPRNT, J3 I4)

Three components of stress at node J3 of radial station:

I4 = 1 radial station below impact radius
I4 = 2 Impact radial station
I4 = 3 radial station above impact radius

3.11 PRINTR - DISPLACEMENT AND STRESS PRINTOUT

3.11.1 Input variables

a) I7 - see 3.10.1(f)

b) NSTAT - see 3.4.1(k)

c) NR - see 3.8.1(a)

d) IJPRNT - Total number of sets of displacement and stress printouts

e) XNØDE, YNØDE - see 3.4.1(a)

f) MAX - see 3.7.1(q)

g) DEFBI, DEFBØ, CØDI, CØDØ, SIGMA1, SIGMA2, SIGMB1, SIGMB2 - see Section 3.10.1

3.11.2 Discussion

This subroutine is called by the main program (Section 3.1.14) after all time steps are completed. The routine will printout the data stored by subroutine PRINTV in the arrays listed in 3.11.1(g).

3.12 PINIT - INITIAL IMPACT FORCE

3.12.1 Input variables

a) NVA - Number of sections describing the missile (see 3.1.1(j))

b) BETA - see equation 3.1.2A(c)

c) I8 - see Section 3.1.13

d) NSTAF - Number of blade segments at the impact radial station

e) PPII - Numerical value of π = 3.141592654

f) DEN - Missile density

g) I - Time step index

h) V - Initial impact velocity of missile

i) I7 - Impact radial station index

j) DT - Time step size

k) RIMP - Radial coordinate of impact station in planform system

l) NSTAT - see 3.4.1(k)

m) RM, XI, YI, IHIT, RL, X, Y, WM - Missile parameters (see Sections 3.1.1 and 3.1.6

n) XO, YO, THETA, XM - see Sections 3.1.26, 3.1.2E and 3.1.5

o) VEL - See Section 3.8.2

3.12.2 Formation of Impacting Missile Portion

As noted in Section 3.1.9 each missile section that will impact the blade during a particular time step has associated with it an array element II(L) that is set equal to 1. Subroutine PINIT initially sums the thicknesses of these missile sections, contained in the elements of RM, and assigns the value to variable RM1. In addition, the number of missile sections making up RM1 is stored in variable NA. The width of the missile section associated with the greatest value WM is used as the width of this missile portion and the value is assigned to variable WM1. Thus, similar to the missile sections described in Section 2.1.3, the impacting missile portion is described with a thickness equal to RM1 and a width equal to WM1. The missile portion consists of a 2-D portion of width WM1-RM1 and a 3-D portion of radius RM1/2.

3.12.3 Impact location, relative velocity and relative incident angle

Analogous to the methodology described in Sections 3.1.7 and 3.1.9, associated with the impacting missile portion are the parameters:

XI1, YI1 - In-plane and out-of-plane impact coordinates

XNERL1 -Nearest chordwise node to the impact point.

DLTAL1 - Distance between node located at XNERL1 and the impact point.

GMAL1 - Planform x coordinate of impact point

DFBL1 - Distance between the impact point and the centerline of the missile portion.

VRL1 - Relative impact velocity

ALPL1 - Relative impact angle

VDTL1 - Impact length of missile portion

3.12.4 Coefficients Associated with the Fluid Jet Model

As described in Sections 2.2.1 and 2.2.2, the parameters defining the shape of the impacting fluid jet are calculated. The location of the stagnation point is assigned to variable SPP and the parameter λ_1' is calculated using equations 2.2.1(g) and 2.2.2(c). The routine now calls subroutine LAMBDA to calculate the value for λ_2' which is assigned to variable LAMDL1.

3.12.5 Impact Force and Equivalent Pressure

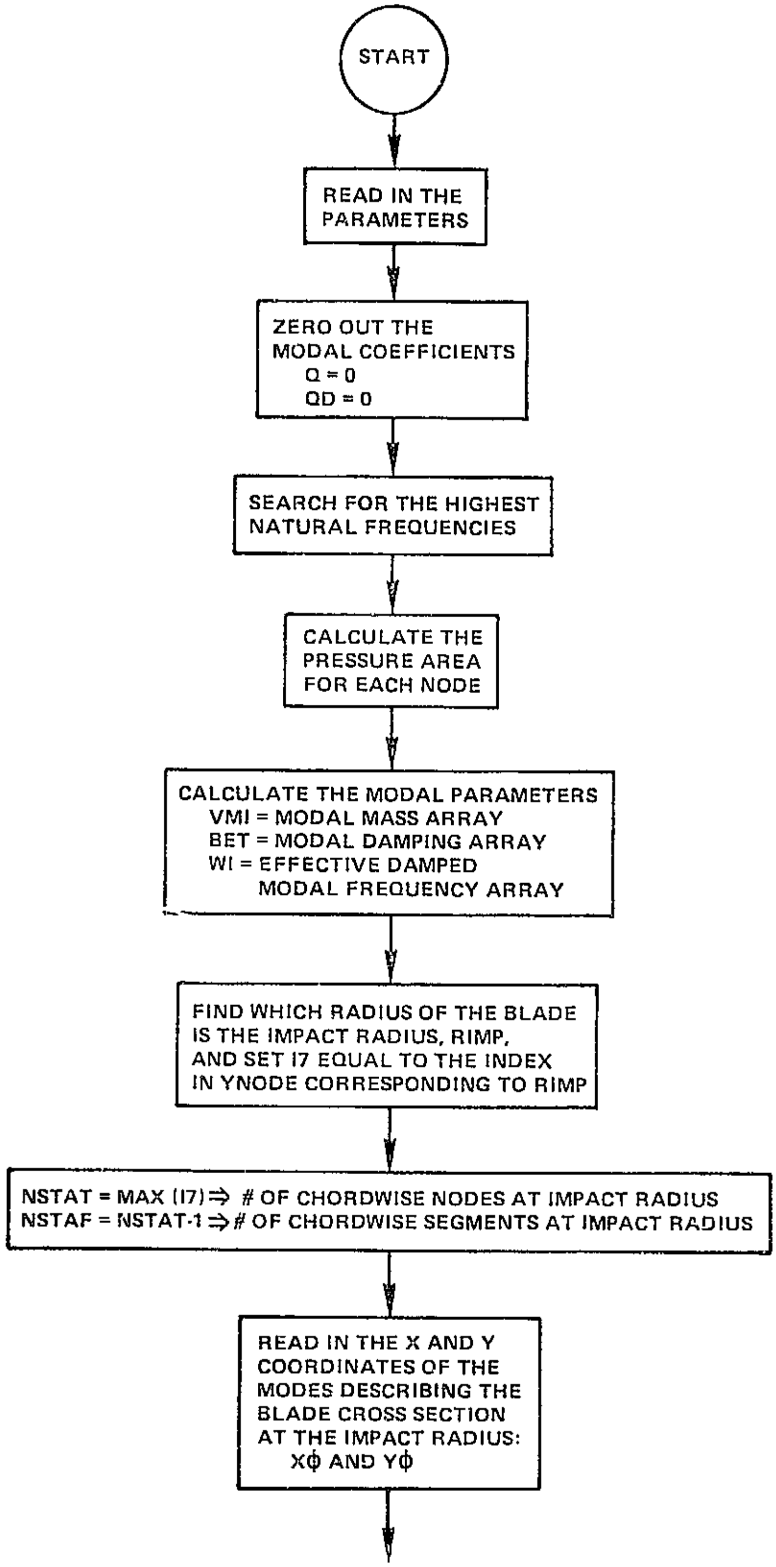
The initial impact force due to the 2-D portion of the pressure distribution is calculated and assigned to variable FIMP2D. For the impact force due the 3-D portion of the jet the routine calls subroutine P3D and assigns the value to variable FIMP3D. The total impact force is thus

$$FIMP = FIMP2D + FIMP3D$$

As a final step the routine distributes the total impact force as equivalent pressures located over the two closest nodes bounding the blade segment upon which the center of force is located.

3.13 DETAILED FLOW DIAGRAMS

MAIN


START
READ IN THE PARAMETERS
ZERO OUT THE MODAL COEFFICIENTS Q = 0 QD = 0
SEARCH FOR THE HIGHEST NATURAL FREQUENCIES
CALCULATE THE PRESSURE AREA FOR EACH NODE
CALCULATE THE MODAL PARAMETERS VMI = MODAL MASS ARRAY BET = MODAL DAMPING ARRAY WI = EFFECTIVE DAMPED MODAL FREQUENCY ARRAY
FIND WHICH RADIUS OF THE BLADE IS THE IMPACT RADIUS, RIMP, AND SET I7 EQUAL TO THE INDEX IN YNODE CORRESPONDING TO RIMP
NSTAT = MAX (I7) ⇒ # OF CHORDWISE NODES AT IMPACT RADIUS
NSTAF = NSTAT-1 ⇒ # OF CHORDWISE SEGMENTS AT IMPACT RADIUS
READ IN THE X AND Y COORDINATES OF THE MODES DESCRIBING THE BLADE CROSS SECTION AT THE IMPACT RADIUS: Xϕ AND Yϕ

SET THE ELEMENTS OF THE ARRAY XM EQUAL TO THE X COORDINATES OF THE MODES DESCRIBING THE PLANFORM GEOMETRY AT THE IMPACT RADIUS

↓

FIND THE MID-POINTS OF THE SEGMENTS OF THE BLADE AT IMPACT RADIUS

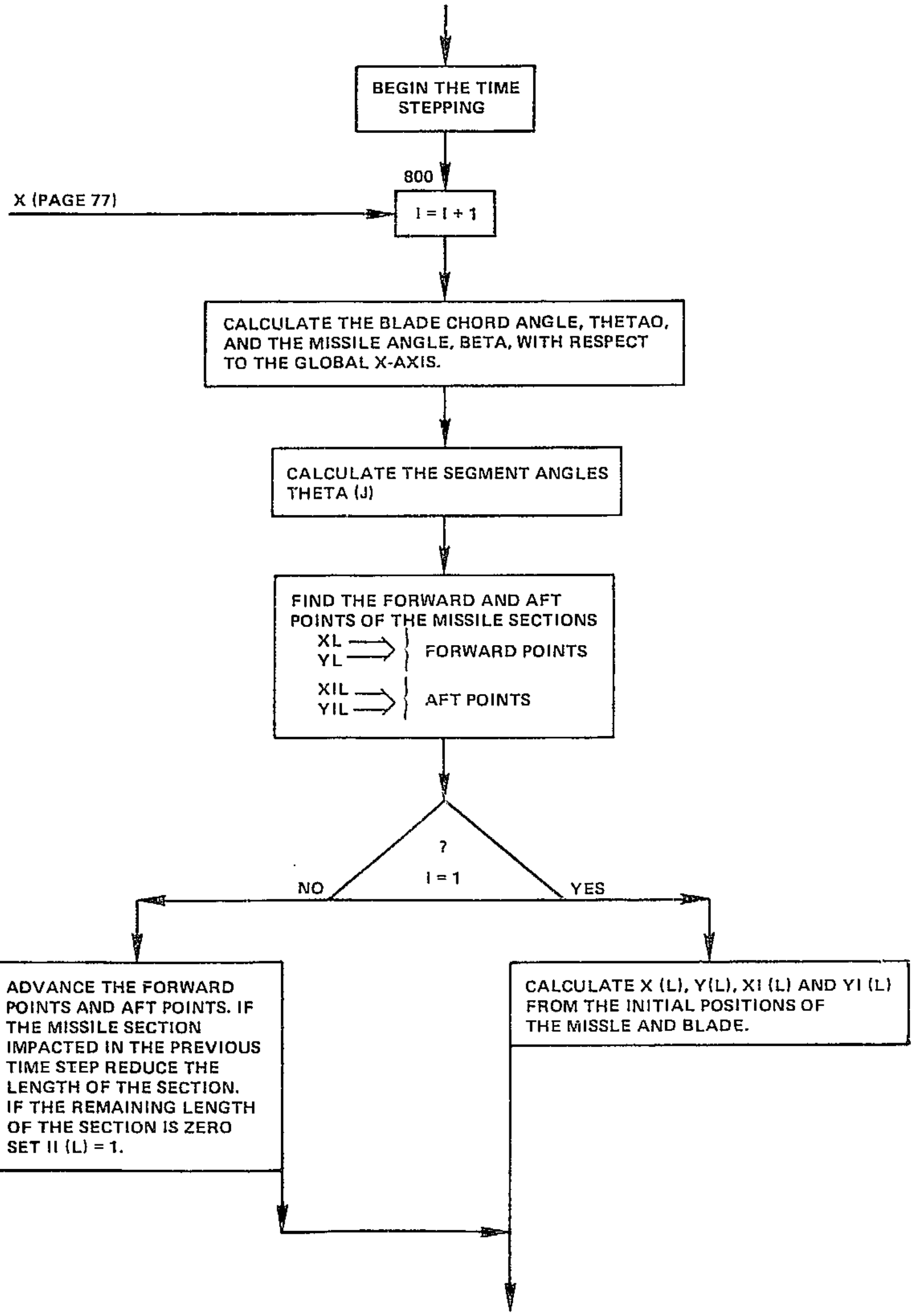
↓

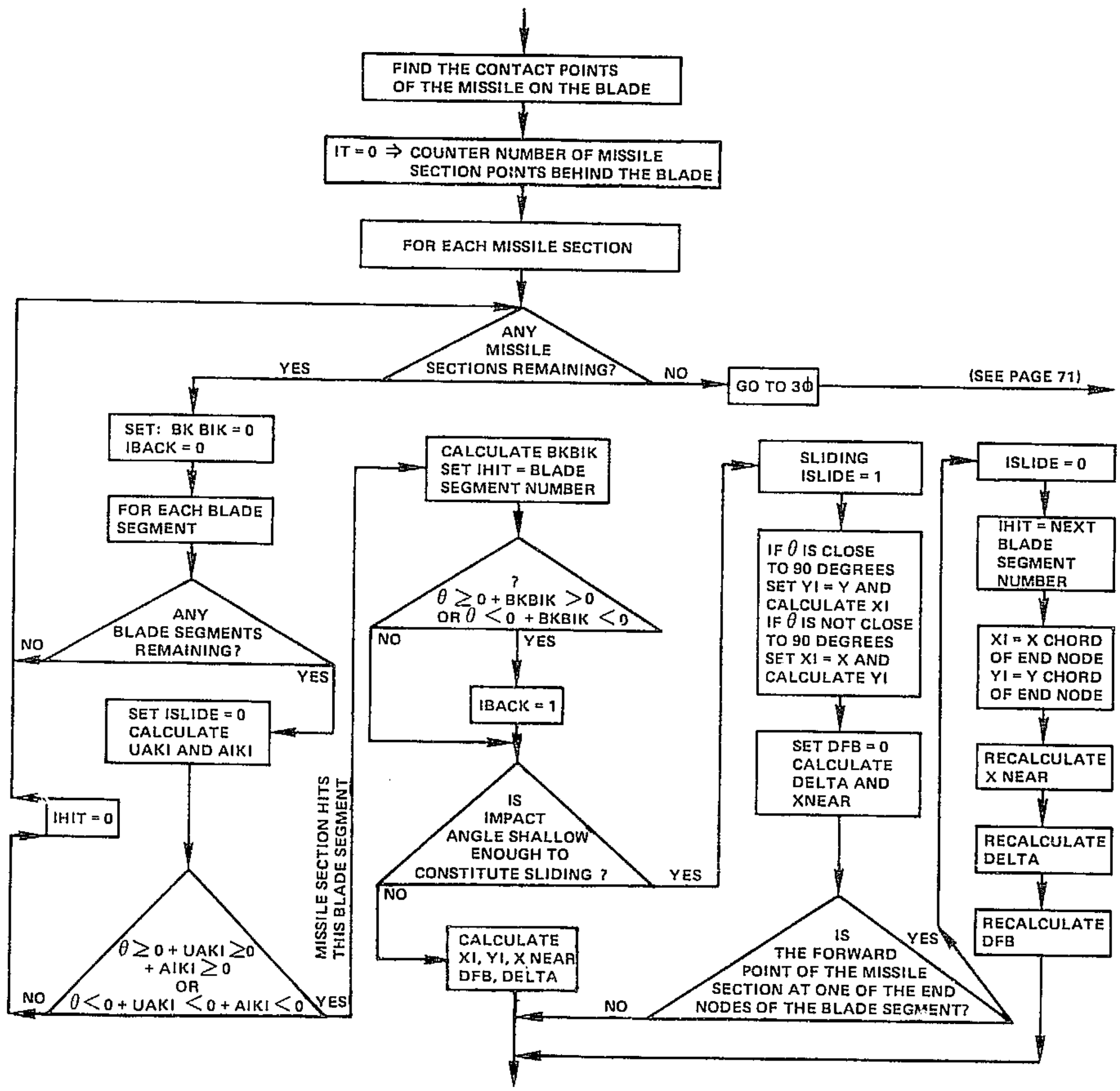
XO = Xϕ
YO = Yϕ ⇒ INITIAL BLADE CROSS SECTION SHAPE

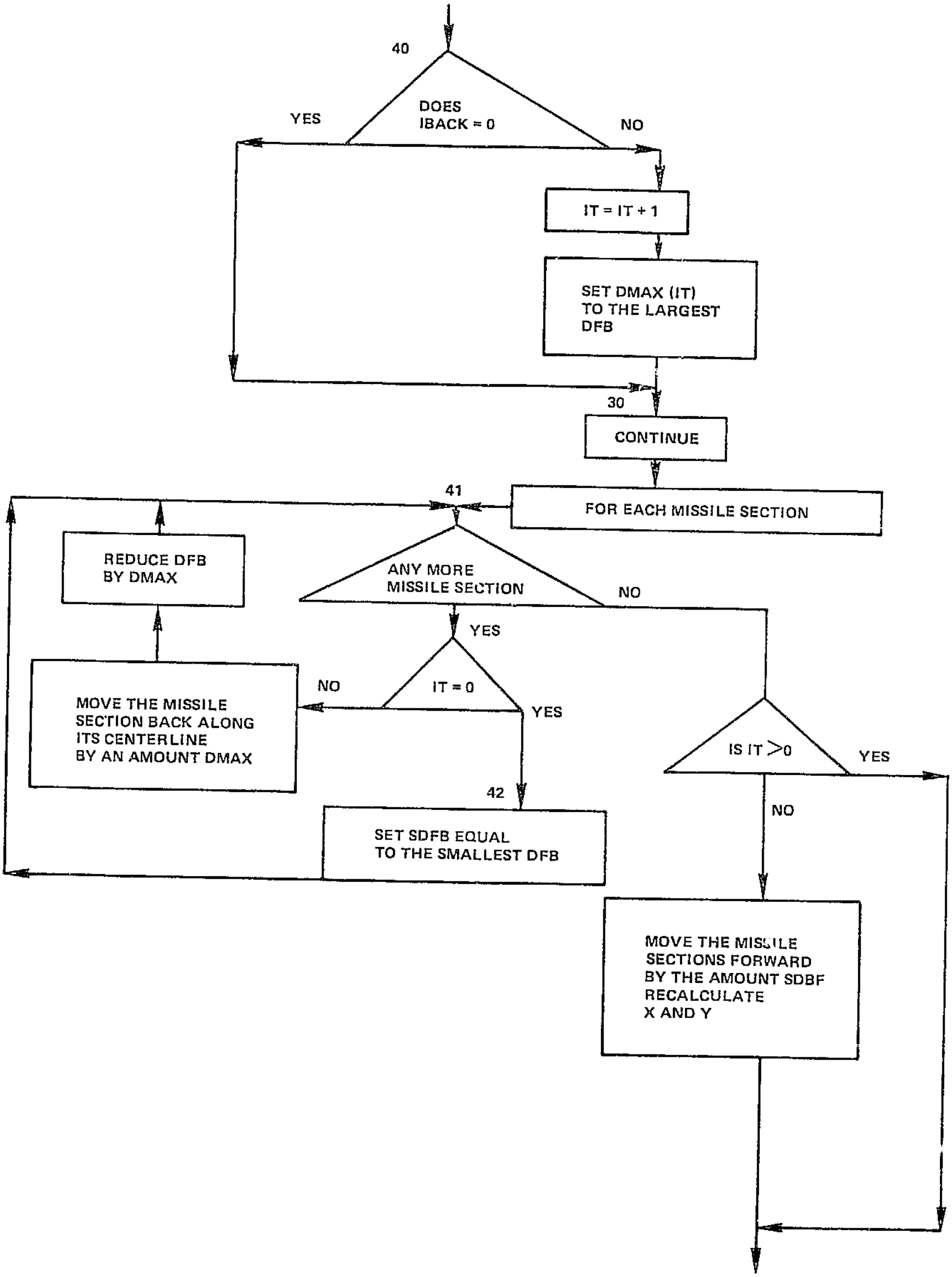
↓

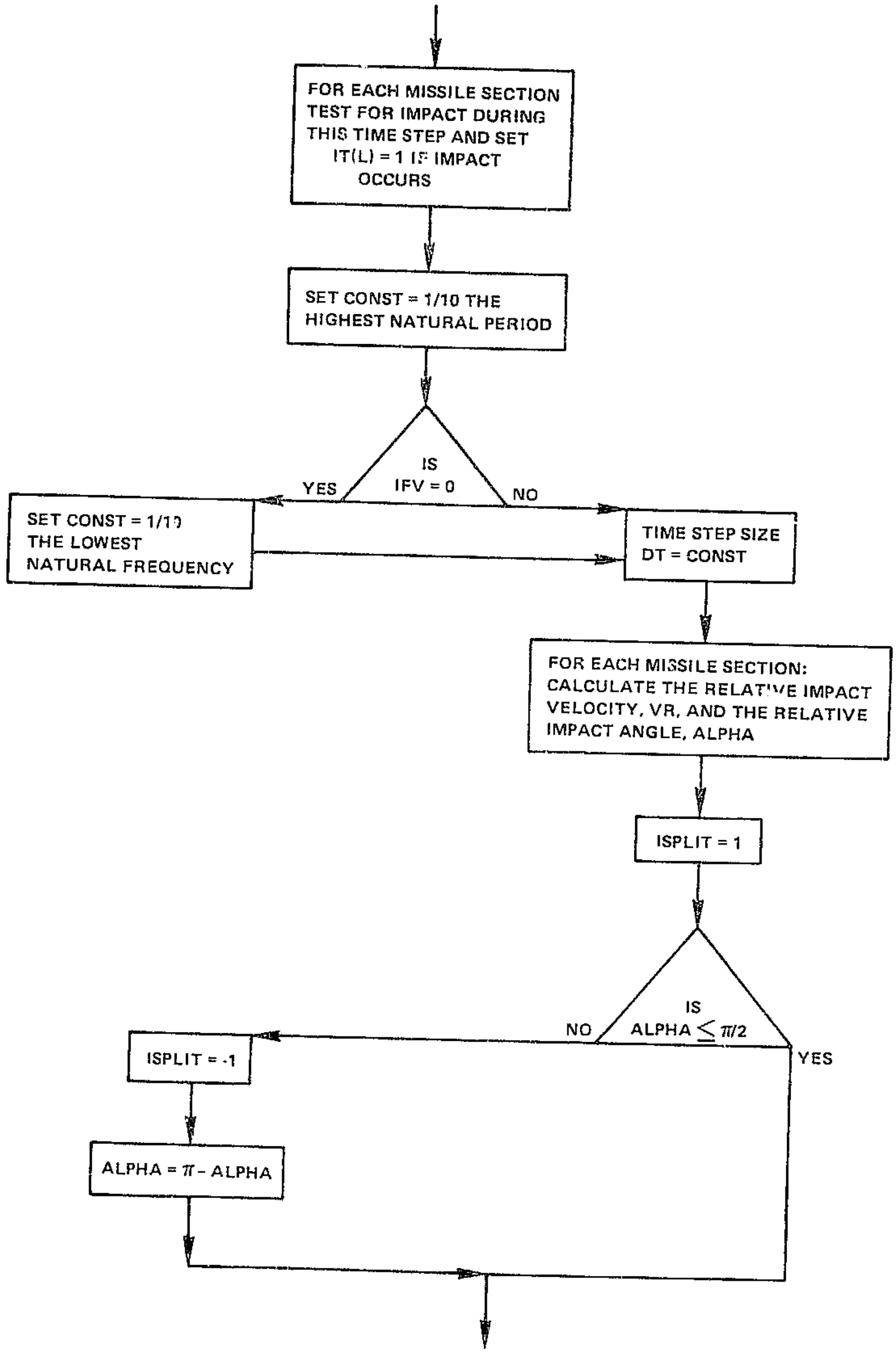
I = 0	⇒	TIME STEP
ITPRNT = 1	⇒	PRINTOUT PARAMETER (PROGRAM WILL PRINT DISPLACEMENTS AND STRESS WHEN I EQUALS ITPRINT)
TIME = 0		
IFV = 0	⇒	IFV WILL BE SET TO 1 WHEN THE MISSILE HAS COMPLETELY IMPACTED
IFSLD = 0	⇒	FLAG TO DETERMINE WHETHER THE IMPACT ANGLE IS SHALLOW ENOUGH TO CAUSE SLIDING OF THE MISSILE ALONG THE BLADE IF IFSLD = 1 THE PROGRAM WILL STOP
IIFLG = 0	⇒	FLAG TO DETERMINE WHETHER ALL MISSILE SLICES HAVE COMPLETELY IMPACTED ON THE BLADE. IF IIFLG = 1 THE MISSILE IS COMPLETELY ON THE BLADE.

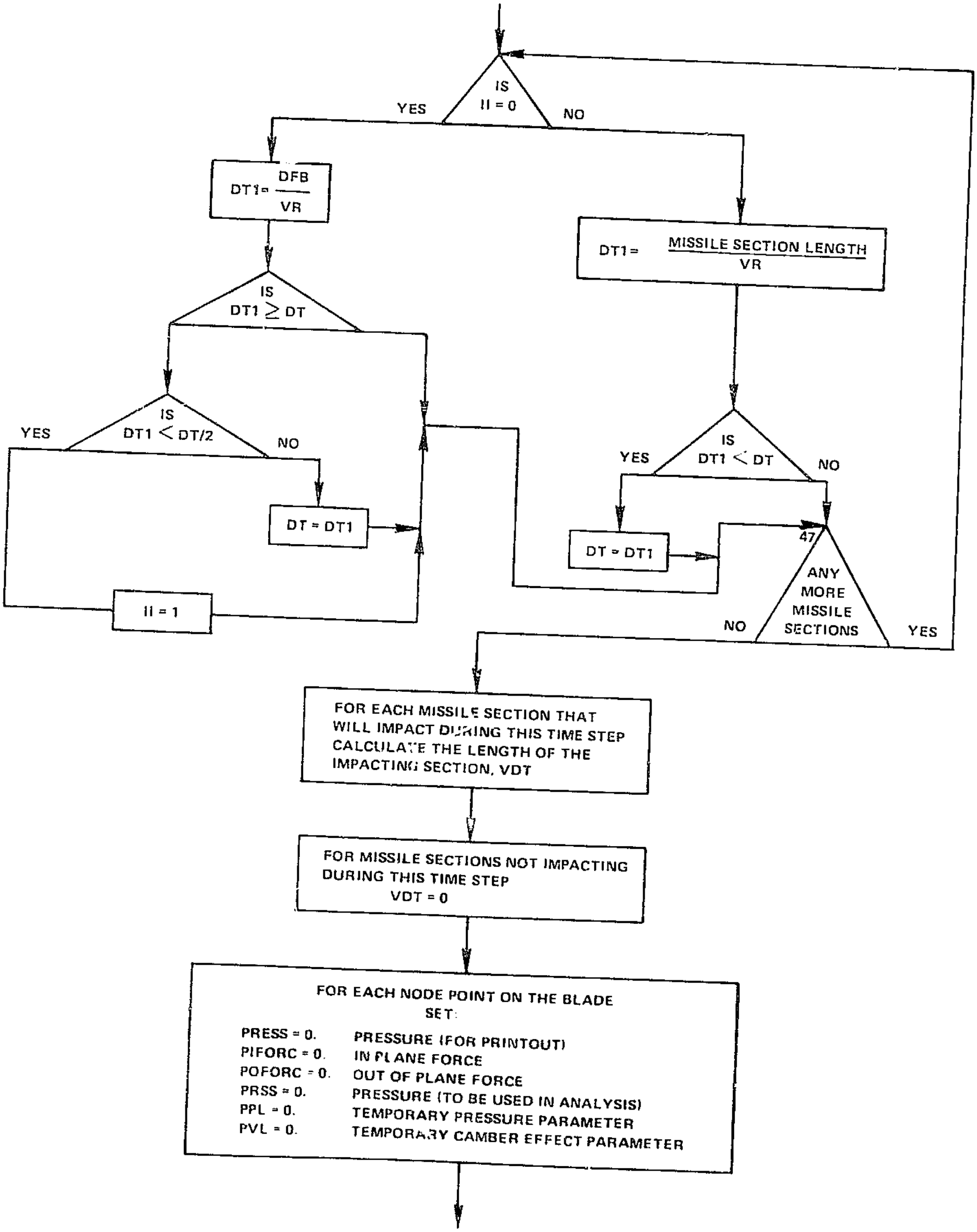
↓

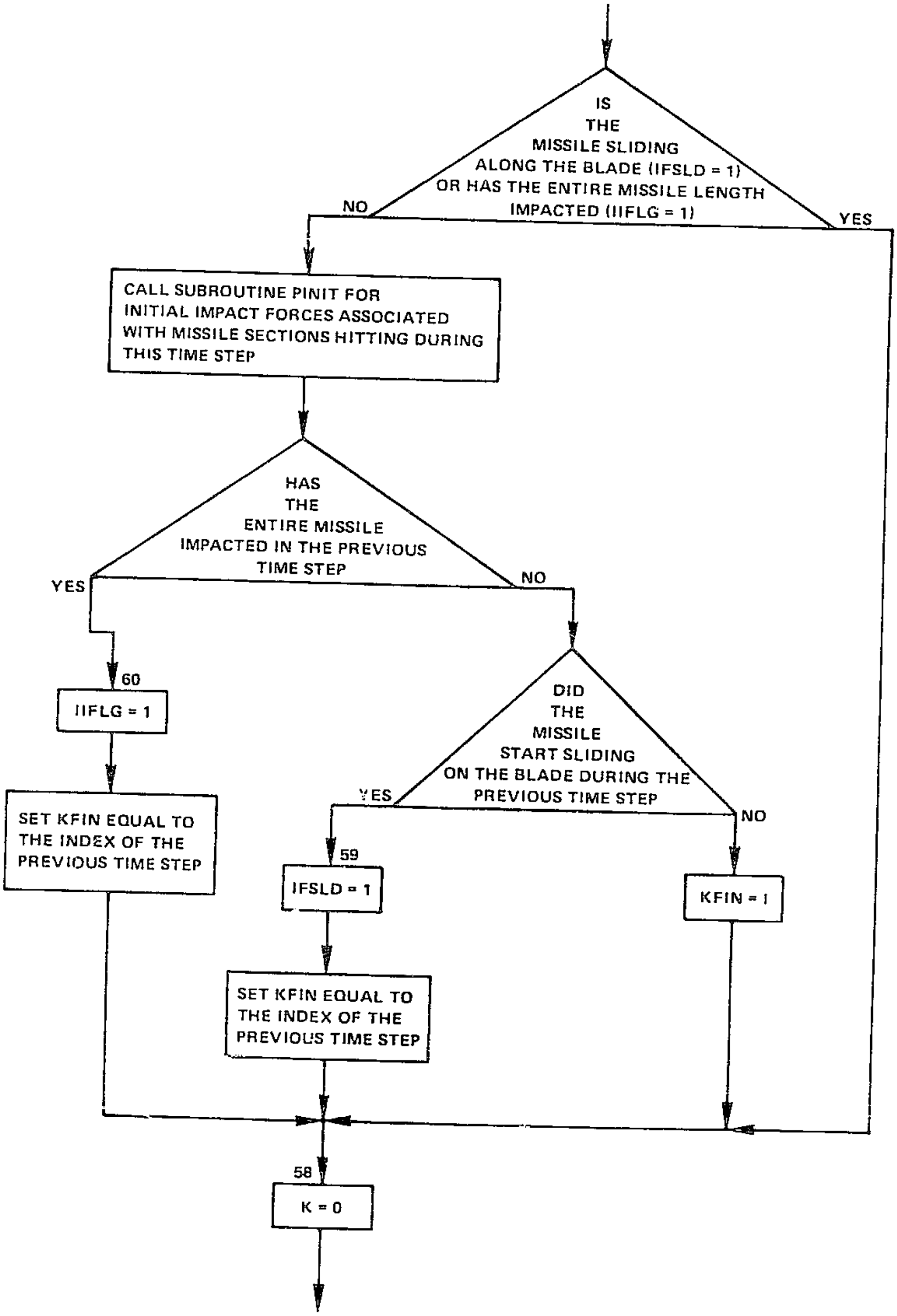

BEGIN THE TIME STEPPING
800
X (PAGE 77)
I = I + 1
CALCULATE THE BLADE CHORD ANGLE, THETAO, AND THE MISSILE ANGLE, BETA, WITH RESPECT TO THE GLOBAL X-AXIS.
CALCULATE THE SEGMENT ANGLES THETA (J)
FIND THE FORWARD AND AFT POINTS OF THE MISSILE SECTIONS
XL
YL
FORWARD POINTS
XIL
YIL
AFT POINTS
?
I = 1
NO
YES
ADVANCE THE FORWARD POINTS AND AFT POINTS. IF THE MISSILE SECTION IMPACTED IN THE PREVIOUS TIME STEP REDUCE THE LENGTH OF THE SECTION. IF THE REMAINING LENGTH OF THE SECTION IS ZERO SET II (L) = 1.
CALCULATE X (L), Y(L), XI (L) AND YI (L) FROM THE INITIAL POSITIONS OF THE MISSLE AND BLADE.

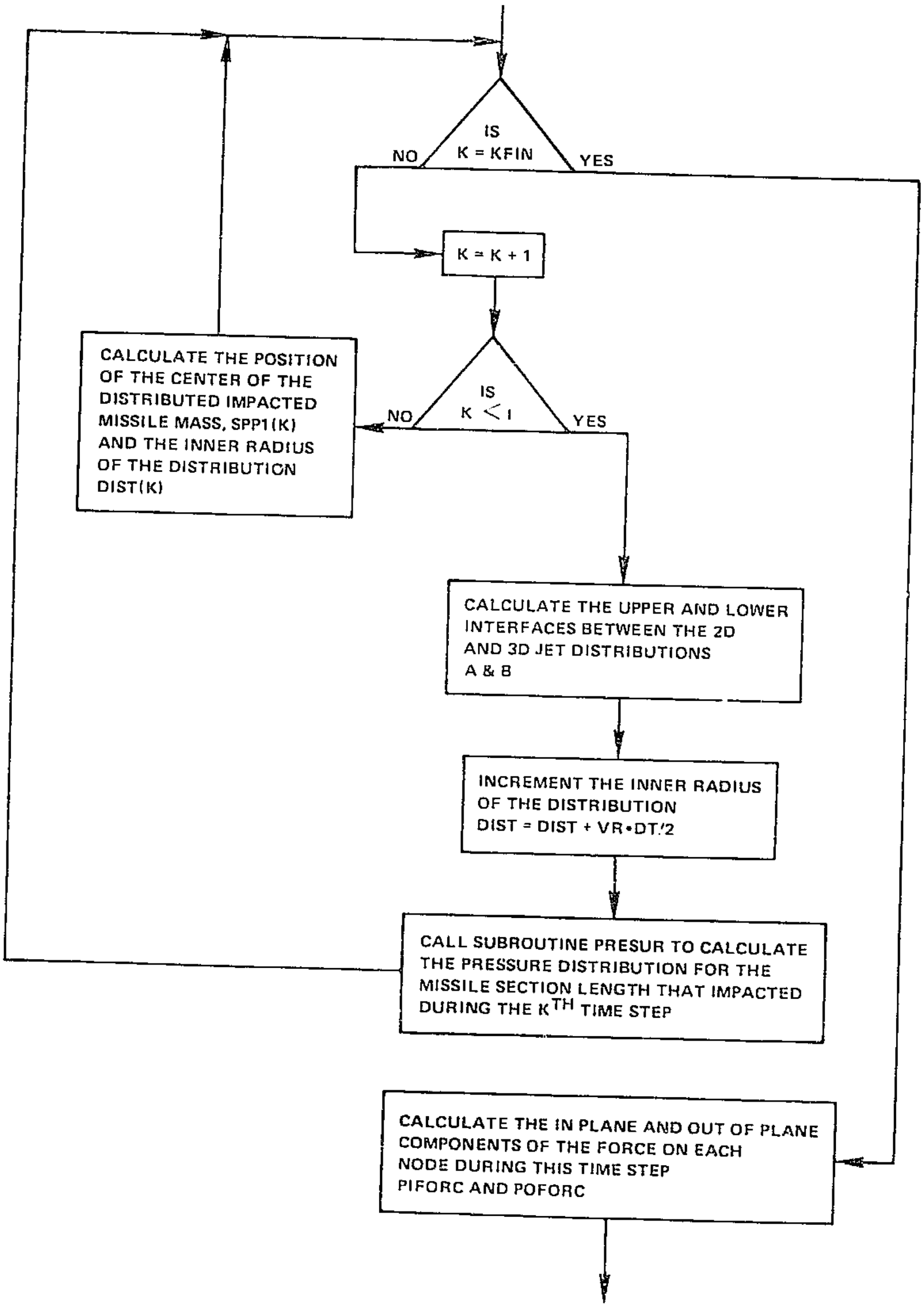

FIND THE CONTACT POINTS OF THE MISSILE ON THE BLADE
IT = 0 ⇒ COUNTER NUMBER OF MISSILE SECTION POINTS BEHIND THE BLADE
FOR EACH MISSILE SECTION
ANY MISSILE SECTIONS REMAINING?
YES
NO
GO TO 3Φ
(SEE PAGE 71)
SET: BK BIK = 0 IBACK = 0
FOR EACH BLADE SEGMENT
ANY BLADE SEGMENTS REMAINING?
NO
YES
SET ISLIDE = 0 CALCULATE UAKI AND AIKI
IHIT = 0
θ ≥ 0 + UAKI ≥ 0 + AIKI ≥ 0 OR θ < 0 + UAKI < 0 + AIKI < 0
NO
YES
MISSILE SECTION HITS THIS BLADE SEGMENT
CALCULATE BKBIK SET IHIT = BLADE SEGMENT NUMBER
? θ ≥ 0 + BKBIK > 0 OR θ < 0 + BKBIK < 0
NO
YES
IBACK = 1
IS IMPACT ANGLE SHALLOW ENOUGH TO CONSTITUTE SLIDING ?
NO
YES
CALCULATE XI, YI, X NEAR DFB, DELTA
SLIDING ISLIDE = 1
IF θ IS CLOSE TO 90 DEGREES SET YI = Y AND CALCULATE XI IF θ IS NOT CLOSE TO 90 DEGREES SET XI = X AND CALCULATE YI
SET DFB = 0 CALCULATE DELTA AND XNEAR
IS THE FORWARD POINT OF THE MISSILE SECTION AT ONE OF THE END NODES OF THE BLADE SEGMENT?
NO
YES
ISLIDE = 0
IHIT = NEXT BLADE SEGMENT NUMBER
XI = X CHORD OF END NODE YI = Y CHORD OF END NODE
RECALCULATE X NEAR
RECALCULATE DELTA
RECALCULATE DFB

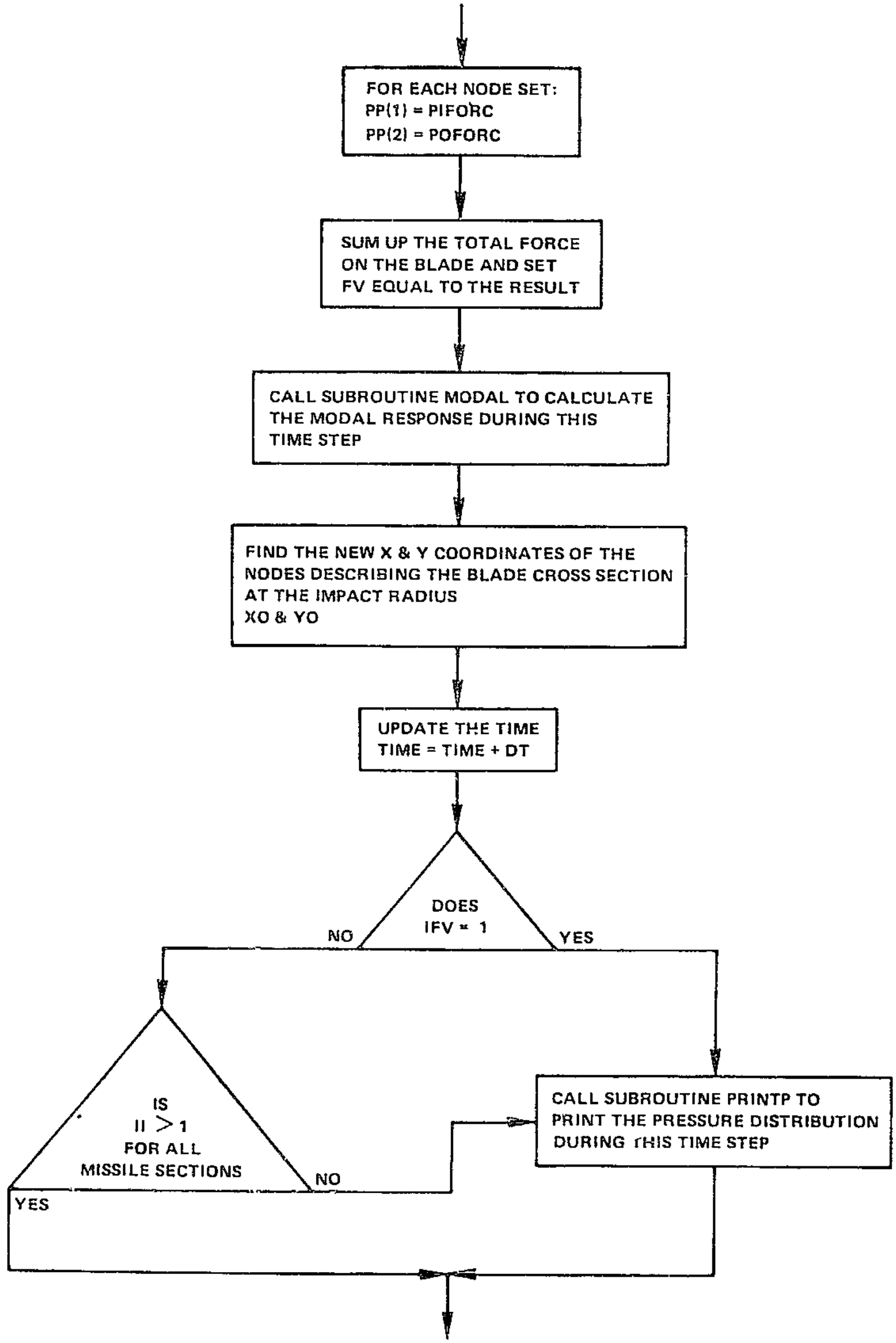

40
DOES
IBACK = 0
YES
NO
IT = IT + 1
SET DMAX (IT)
TO THE LARGEST
DFB
30
CONTINUE
41
FOR EACH MISSILE SECTION
REDUCE DFB
BY DMAX
ANY MORE
MISSILE SECTION
NO
YES
NO
IT = 0
YES
MOVE THE MISSILE
SECTION BACK ALONG
ITS CENTERLINE
BY AN AMOUNT DMAX
IS IT >0
YES
42
NO
SET SDFB EQUAL
TO THE SMALLEST DFB
MOVE THE MISSILE
SECTIONS FORWARD
BY THE AMOUNT SDBF
RECALCULATE
X AND Y

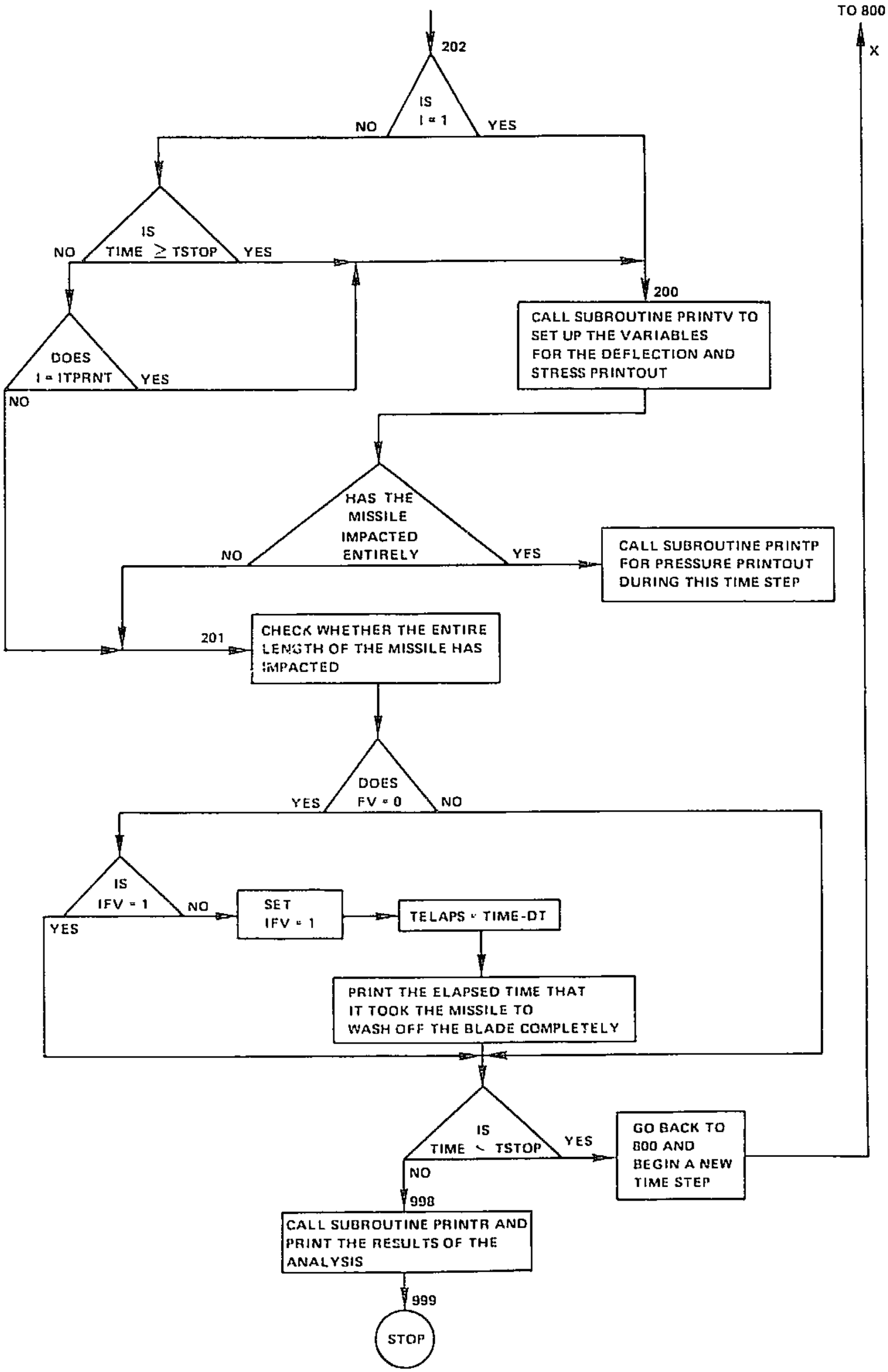

FOR EACH MISSILE SECTION TEST FOR IMPACT DURING THIS TIME STEP AND SET IT(L) = 1 IF IMPACT OCCURS
SET CONST = 1/10 THE HIGHEST NATURAL PERIOD
IS IFV = 0
YES
NO
SET CONST = 1/10 THE LOWEST NATURAL FREQUENCY
TIME STEP SIZE DT = CONST
FOR EACH MISSILE SECTION: CALCULATE THE RELATIVE IMPACT VELOCITY, VR, AND THE RELATIVE IMPACT ANGLE, ALPHA
ISPLIT = 1
IS ALPHA ≤ π/2
NO
YES
ISPLIT = -1
ALPHA = π - ALPHA


IS
II = 0
YES
NO
DT1 = DFB / VR
DT1 = MISSILE SECTION LENGTH / VR
IS
DT1 ≥ DT
IS
DT1 < DT/2
YES
NO
DT = DT1
II = 1
IS
DT1 < DT
YES
NO
DT = DT1
47
ANY
MORE
MISSILE
SECTIONS
NO
YES
FOR EACH MISSILE SECTION THAT WILL IMPACT DURING THIS TIME STEP CALCULATE THE LENGTH OF THE IMPACTING SECTION, VDT
FOR MISSILE SECTIONS NOT IMPACTING DURING THIS TIME STEP
VDT = 0
FOR EACH NODE POINT ON THE BLADE SET:
PRESS = 0. PRESSURE (FOR PRINTOUT)
PIFORC = 0. IN PLANE FORCE
POFORC = 0. OUT OF PLANE FORCE
PRSS = 0. PRESSURE (TO BE USED IN ANALYSIS)
PPL = 0. TEMPORARY PRESSURE PARAMETER
PVL = 0. TEMPORARY CAMBER EFFECT PARAMETER

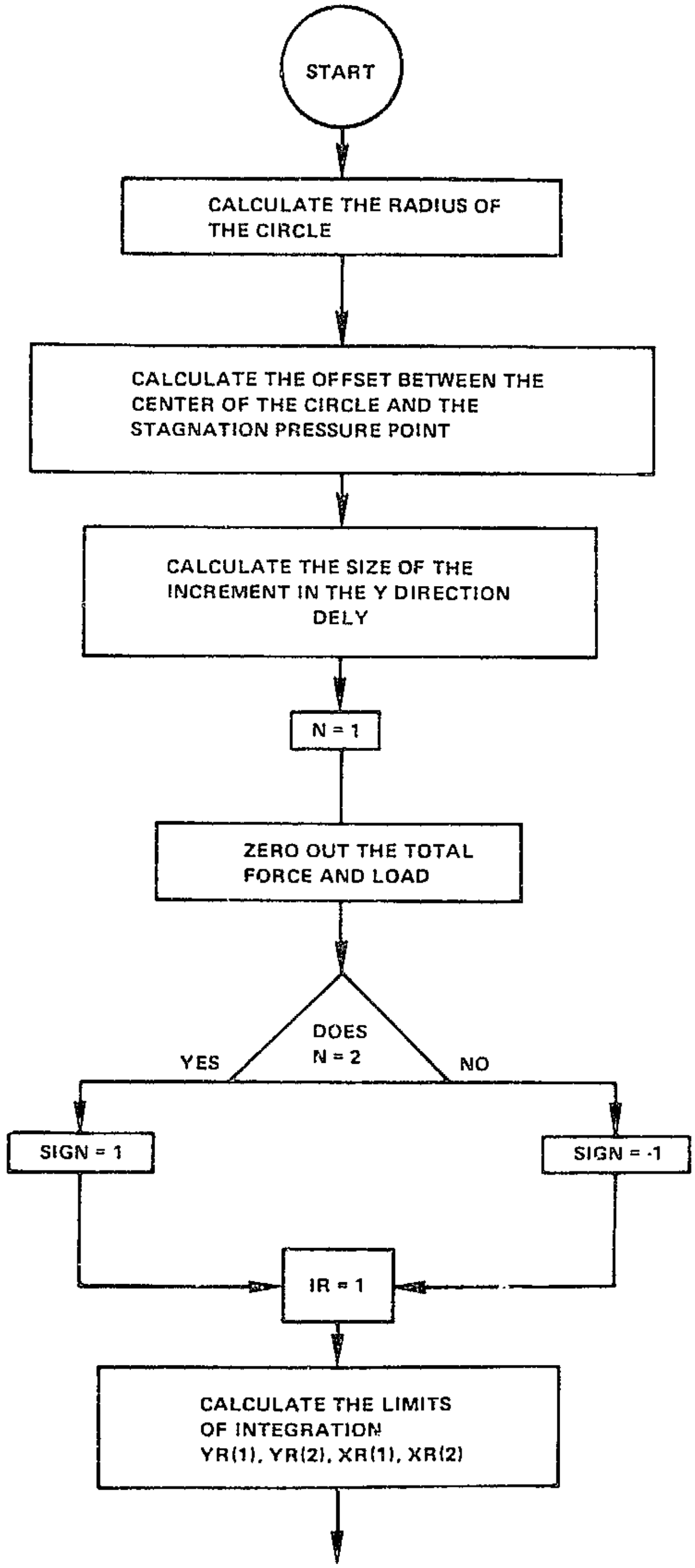

IS THE MISSILE SLIDING ALONG THE BLADE (IFSLD = 1) OR HAS THE ENTIRE MISSILE LENGTH IMPACTED (IIFLG = 1)
NO
YES
CALL SUBROUTINE PINIT FOR INITIAL IMPACT FORCES ASSOCIATED WITH MISSILE SECTIONS HITTING DURING THIS TIME STEP
HAS THE ENTIRE MISSILE IMPACTED IN THE PREVIOUS TIME STEP
YES
NO
60
IIFLG = 1
SET KFIN EQUAL TO THE INDEX OF THE PREVIOUS TIME STEP
DID THE MISSILE START SLIDING ON THE BLADE DURING THE PREVIOUS TIME STEP
YES
NO
59
IFSLD = 1
KFIN = I
SET KFIN EQUAL TO THE INDEX OF THE PREVIOUS TIME STEP
58
K = 0

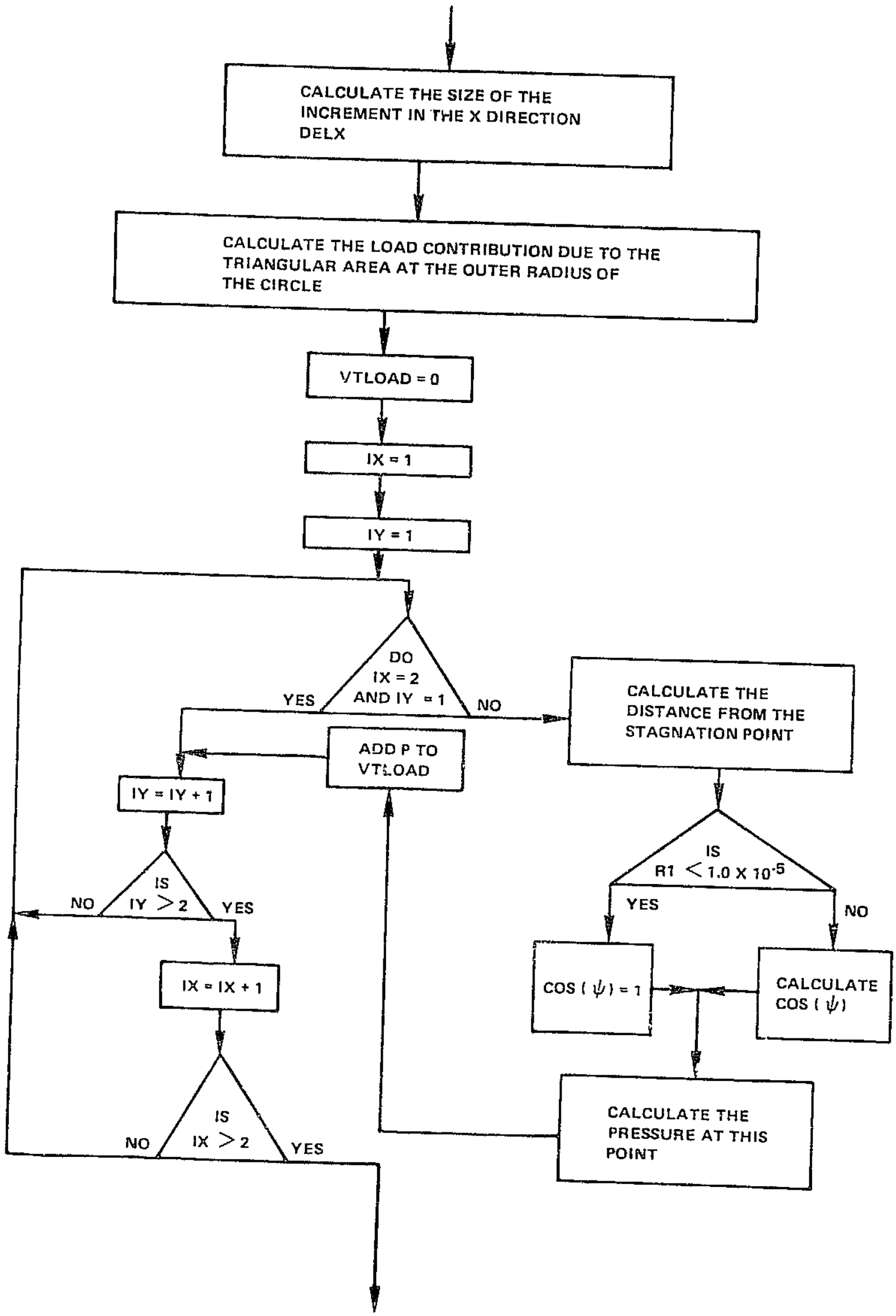

IS
K = KFIN
NO
YES
K = K + 1
IS
K < I
NO
YES
CALCULATE THE POSITION OF THE CENTER OF THE DISTRIBUTED IMPACTED MISSILE MASS, SPP1(K) AND THE INNER RADIUS OF THE DISTRIBUTION DIST(K)
CALCULATE THE UPPER AND LOWER INTERFACES BETWEEN THE 2D AND 3D JET DISTRIBUTIONS A & B
INCREMENT THE INNER RADIUS OF THE DISTRIBUTION DIST = DIST + VR•DT/2
CALL SUBROUTINE PRESUR TO CALCULATE THE PRESSURE DISTRIBUTION FOR THE MISSILE SECTION LENGTH THAT IMPACTED DURING THE K TH TIME STEP
CALCULATE THE IN PLANE AND OUT OF PLANE COMPONENTS OF THE FORCE ON EACH NODE DURING THIS TIME STEP PIFORC AND POFORC

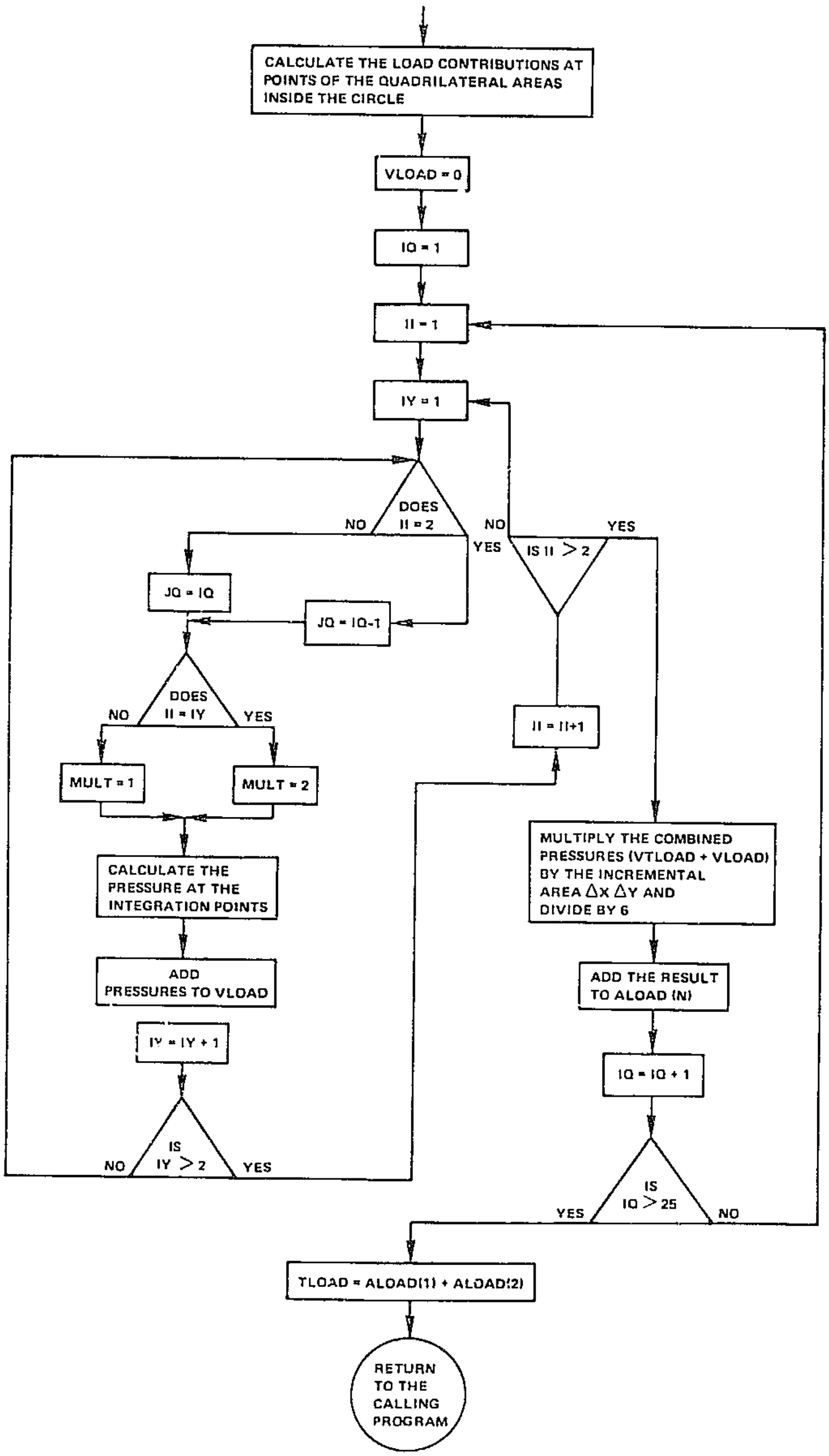

FOR EACH NODE SET:
PP(1) = PIFORC
PP(2) = POFORC
SUM UP THE TOTAL FORCE ON THE BLADE AND SET FV EQUAL TO THE RESULT
CALL SUBROUTINE MODAL TO CALCULATE THE MODAL RESPONSE DURING THIS TIME STEP
FIND THE NEW X & Y COORDINATES OF THE NODES DESCRIBING THE BLADE CROSS SECTION AT THE IMPACT RADIUS
XO & YO
UPDATE THE TIME
TIME = TIME + DT
DOES IFV = 1
NO
YES
IS II > 1 FOR ALL MISSILE SECTIONS
NO
YES
CALL SUBROUTINE PRINTP TO PRINT THE PRESSURE DISTRIBUTION DURING THIS TIME STEP


TO 800
X
202
IS
I = 1
NO
YES
IS
TIME ≥ TSTOP
NO
YES
200
CALL SUBROUTINE PRINTV TO SET UP THE VARIABLES FOR THE DEFLECTION AND STRESS PRINTOUT
DOES
I = ITPRNT
YES
NO
HAS THE MISSILE IMPACTED ENTIRELY
NO
YES
CALL SUBROUTINE PRINTP FOR PRESSURE PRINTOUT DURING THIS TIME STEP
201
CHECK WHETHER THE ENTIRE LENGTH OF THE MISSILE HAS IMPACTED
DOES
FV = 0
YES
NO
IS
IFV = 1
NO
YES
SET
IFV = 1
TELAPS = TIME-DT
PRINT THE ELAPSED TIME THAT IT TOOK THE MISSILE TO WASH OFF THE BLADE COMPLETELY
IS
TIME < TSTOP
YES
NO
GO BACK TO 800 AND BEGIN A NEW TIME STEP
998
CALL SUBROUTINE PRINTR AND PRINT THE RESULTS OF THE ANALYSIS
999
STOP

P3D

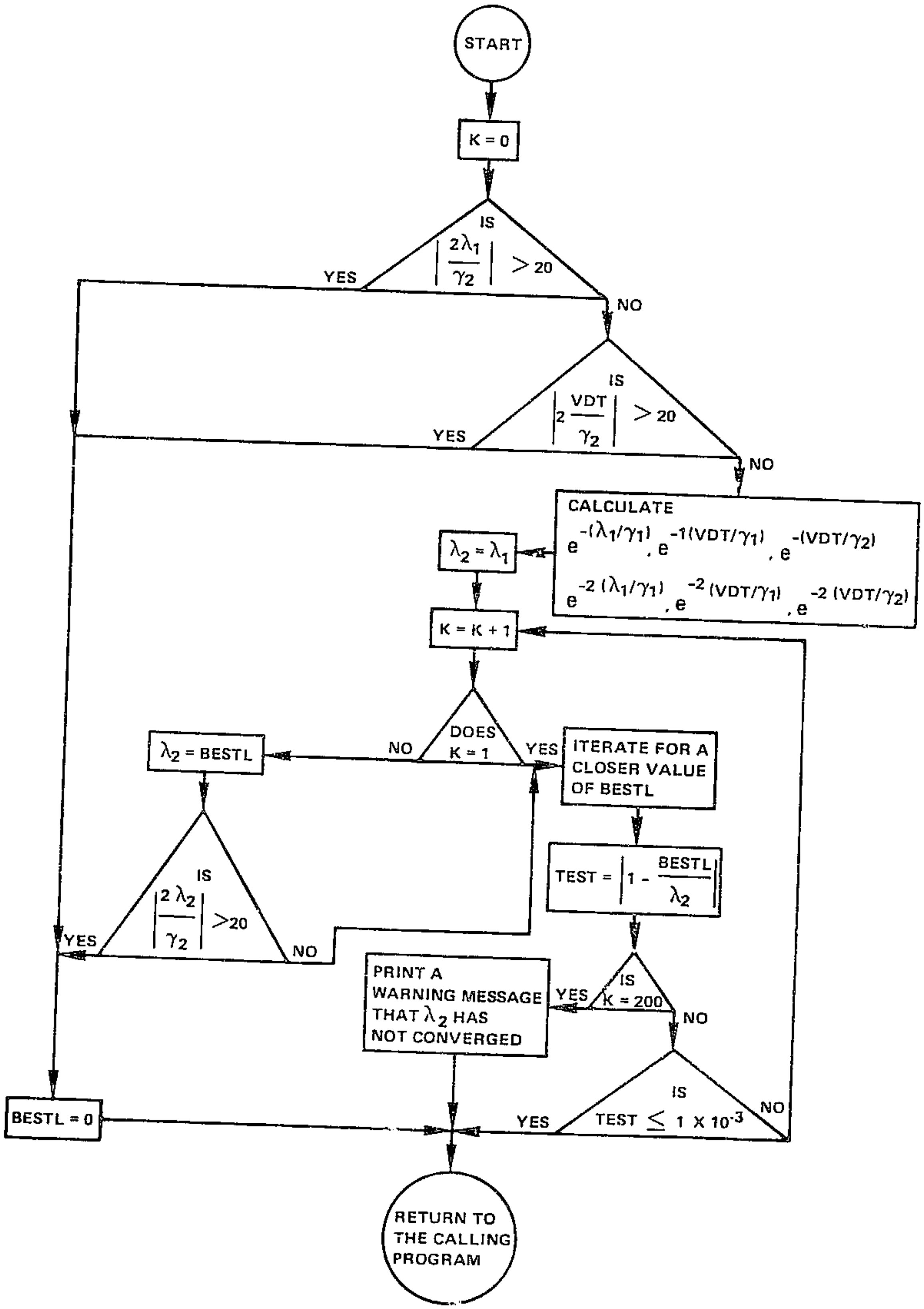

START
CALCULATE THE RADIUS OF THE CIRCLE
CALCULATE THE OFFSET BETWEEN THE CENTER OF THE CIRCLE AND THE STAGNATION PRESSURE POINT
CALCULATE THE SIZE OF THE INCREMENT IN THE Y DIRECTION DELY
N = 1
ZERO OUT THE TOTAL FORCE AND LOAD
DOES N = 2
YES
NO
SIGN = 1
SIGN = -1
IR = 1
CALCULATE THE LIMITS OF INTEGRATION YR(1), YR(2), XR(1), XR(2)


CALCULATE THE SIZE OF THE INCREMENT IN THE X DIRECTION DELX
CALCULATE THE LOAD CONTRIBUTION DUE TO THE TRIANGULAR AREA AT THE OUTER RADIUS OF THE CIRCLE
VTLOAD = 0
IX = 1
IY = 1
DO IX = 2 AND IY = 1
YES
NO
CALCULATE THE DISTANCE FROM THE STAGNATION POINT
ADD P TO VTLOAD
IY = IY + 1
IS IY > 2
NO
YES
IS R1 < 1.0 X 10-5
YES
NO
IX = IX + 1
COS (ψ) = 1
CALCULATE COS (ψ)
IS IX > 2
NO
YES
CALCULATE THE PRESSURE AT THIS POINT

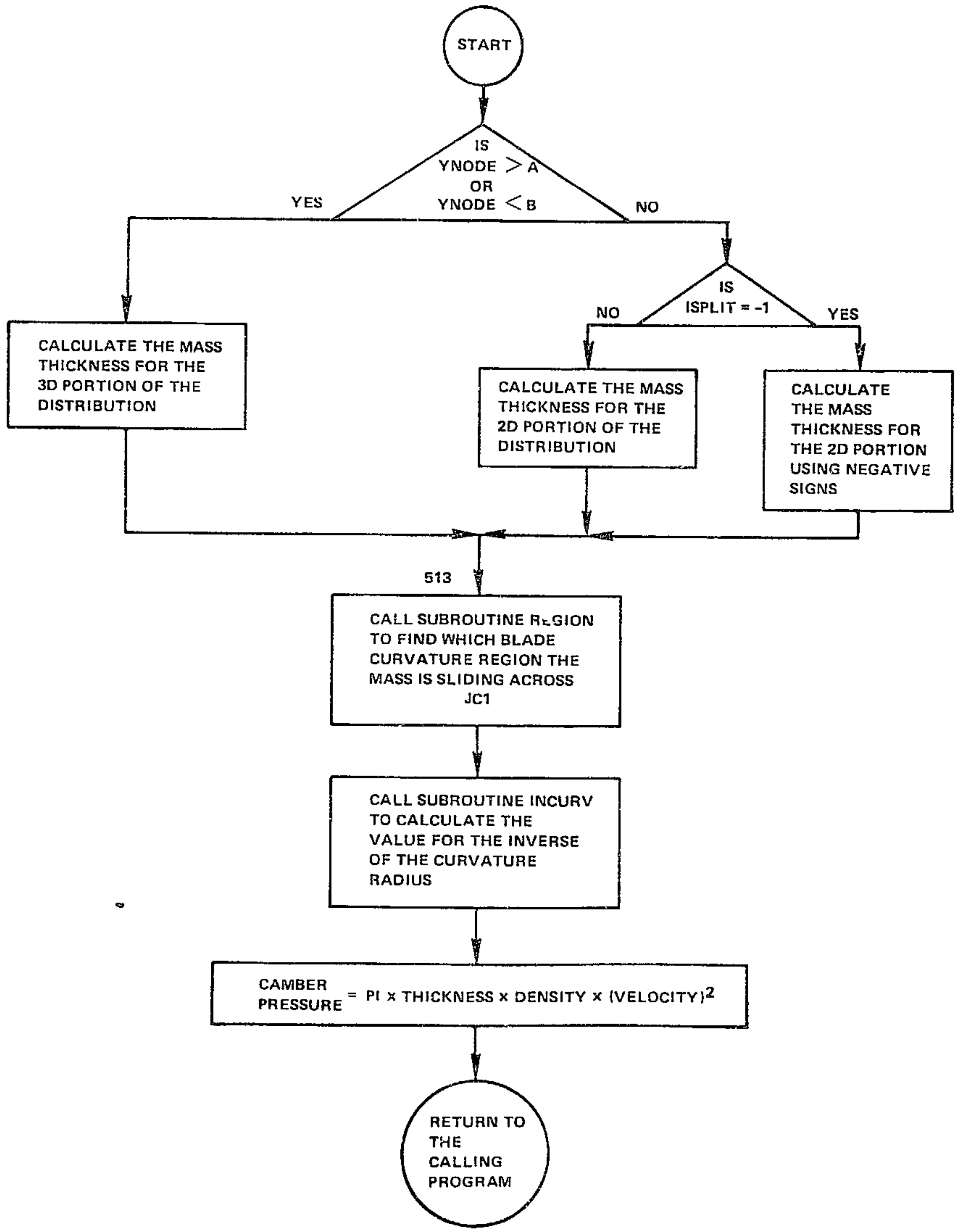


CALCULATE THE LOAD CONTRIBUTIONS AT POINTS OF THE QUADRILATERAL AREAS INSIDE THE CIRCLE
VLOAD = 0
IQ = 1
II = 1
IY = 1
DOES II = 2
NO
YES
JQ = IQ
JQ = IQ-1
DOES II = IY
NO
YES
MULT = 1
MULT = 2
CALCULATE THE PRESSURE AT THE INTEGRATION POINTS
ADD PRESSURES TO VLOAD
IY = IY + 1
IS IY > 2
NO
YES
IS II > 2
NO
YES
II = II+1
MULTIPLY THE COMBINED PRESSURES (VTLOAD + VLOAD) BY THE INCREMENTAL AREA ΔX ΔY AND DIVIDE BY 6
ADD THE RESULT TO ALOAD (N)
IQ = IQ + 1
IS IQ > 25
YES
NO
TLOAD = ALOAD(1) + ALOAD(2)
RETURN TO THE CALLING PROGRAM

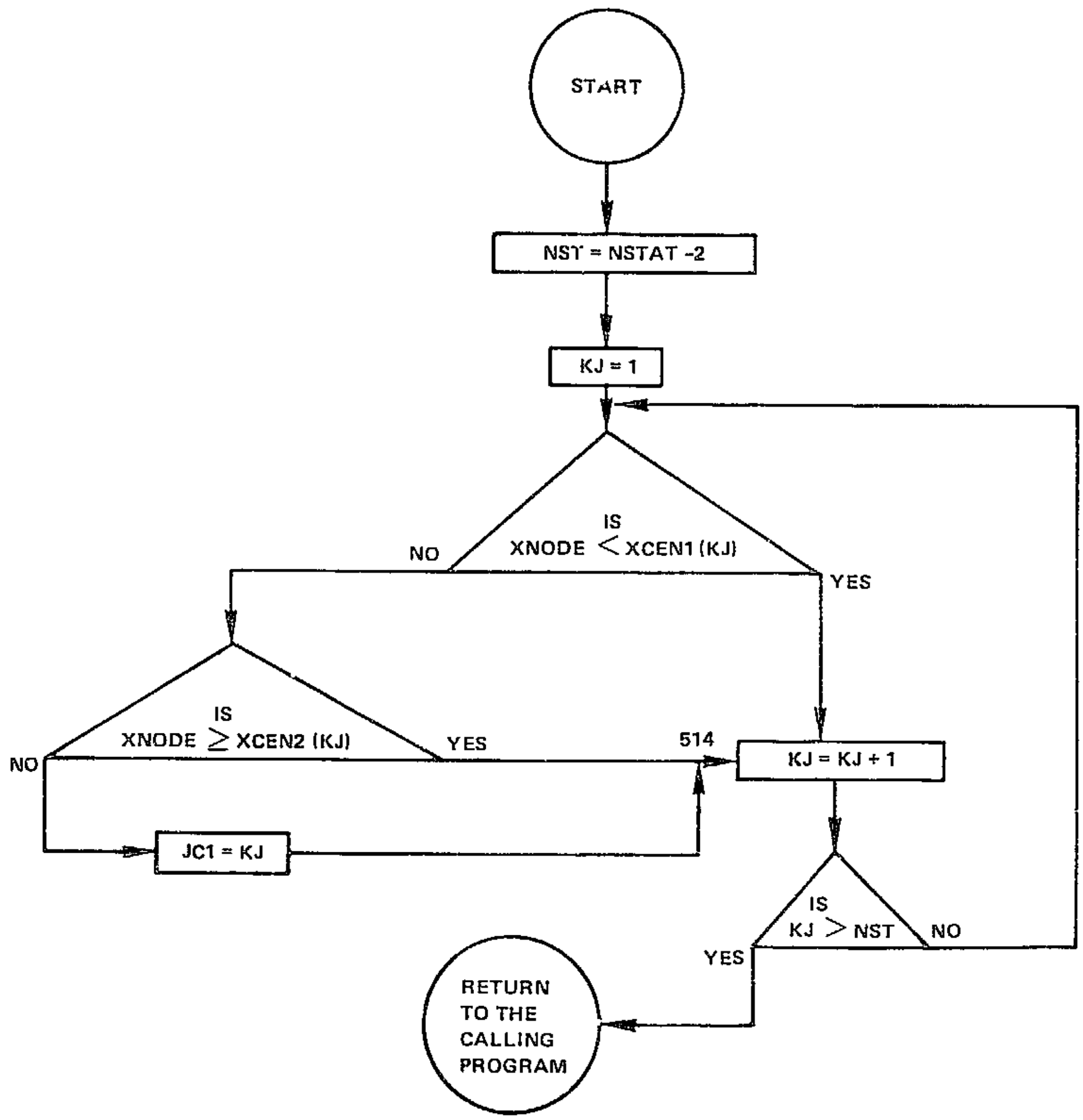
LAMBDA


START
K = 0
IS $\left|\frac{2\lambda_1}{\gamma_2}\right| > 20$
YES
NO
IS $\left|2\frac{VDT}{\gamma_2}\right| > 20$
YES
NO
CALCULATE
$e^{-(\lambda_1/\gamma_1)}, e^{-1(VDT/\gamma_1)}, e^{-(VDT/\gamma_2)}$
$e^{-2(\lambda_1/\gamma_1)}, e^{-2(VDT/\gamma_1)}, e^{-2(VDT/\gamma_2)}$
$\lambda_2 = \lambda_1$
K = K + 1
DOES K = 1
NO
YES
λ_2 = BESTL
ITERATE FOR A CLOSER VALUE OF BESTL
IS $\left|\frac{2\lambda_2}{\gamma_2}\right| > 20$
YES
NO
TEST = $\left|1 - \frac{BESTL}{\lambda_2}\right|$
IS K = 200
YES
NO
PRINT A WARNING MESSAGE THAT λ_2 HAS NOT CONVERGED
IS TEST $\leq 1 \times 10^{-3}$
YES
NO
BESTL = 0
RETURN TO THE CALLING PROGRAM

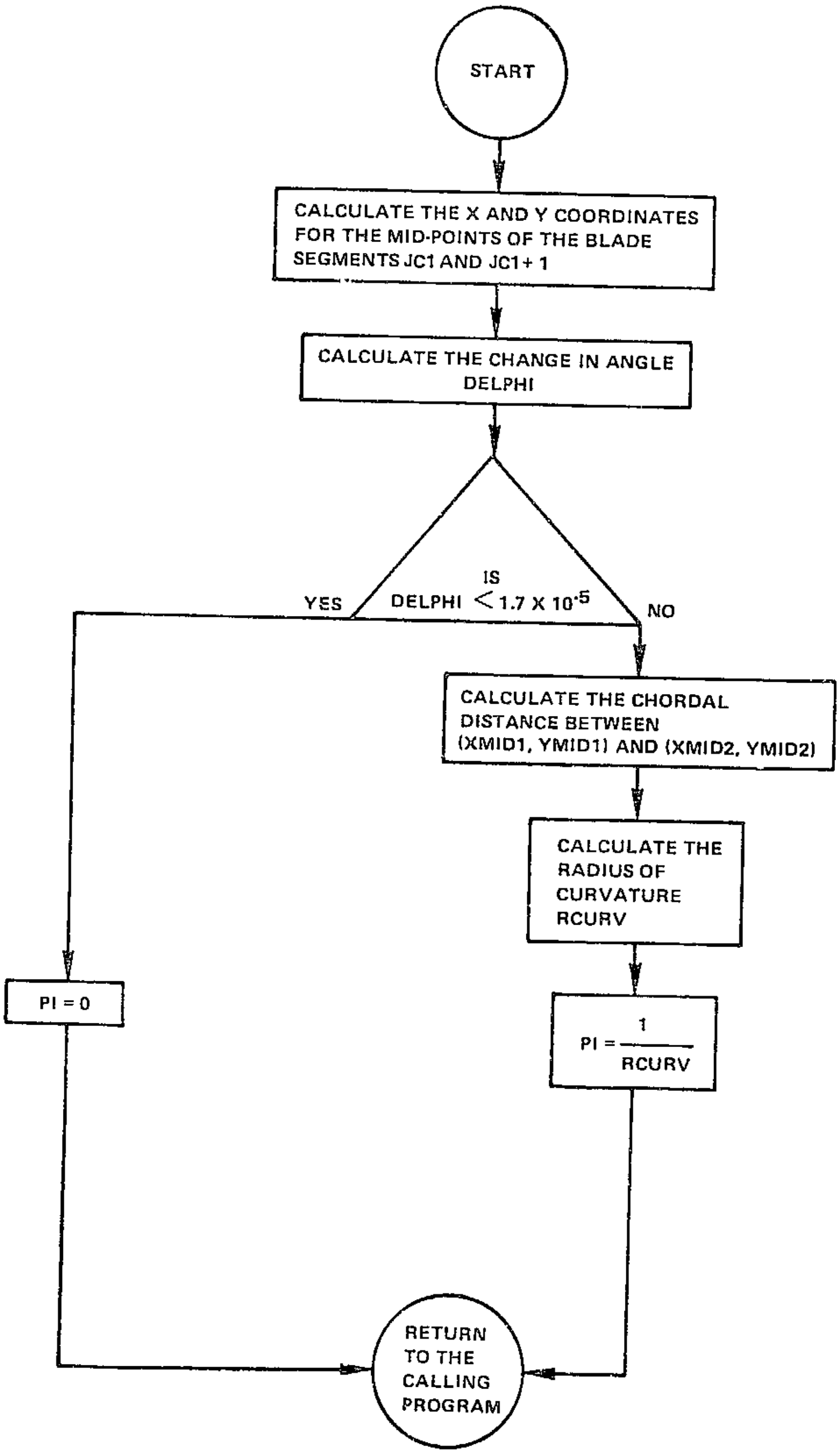
CAMBER


START
IS YNODE > A OR YNODE < B
YES
NO
CALCULATE THE MASS THICKNESS FOR THE 3D PORTION OF THE DISTRIBUTION
IS ISPLIT = -1
NO
YES
CALCULATE THE MASS THICKNESS FOR THE 2D PORTION OF THE DISTRIBUTION
CALCULATE THE MASS THICKNESS FOR THE 2D PORTION USING NEGATIVE SIGNS
513
CALL SUBROUTINE REGION TO FIND WHICH BLADE CURVATURE REGION THE MASS IS SLIDING ACROSS JC1
CALL SUBROUTINE INCURV TO CALCULATE THE VALUE FOR THE INVERSE OF THE CURVATURE RADIUS
CAMBER PRESSURE = PI x THICKNESS x DENSITY x (VELOCITY)^2
RETURN TO THE CALLING PROGRAM

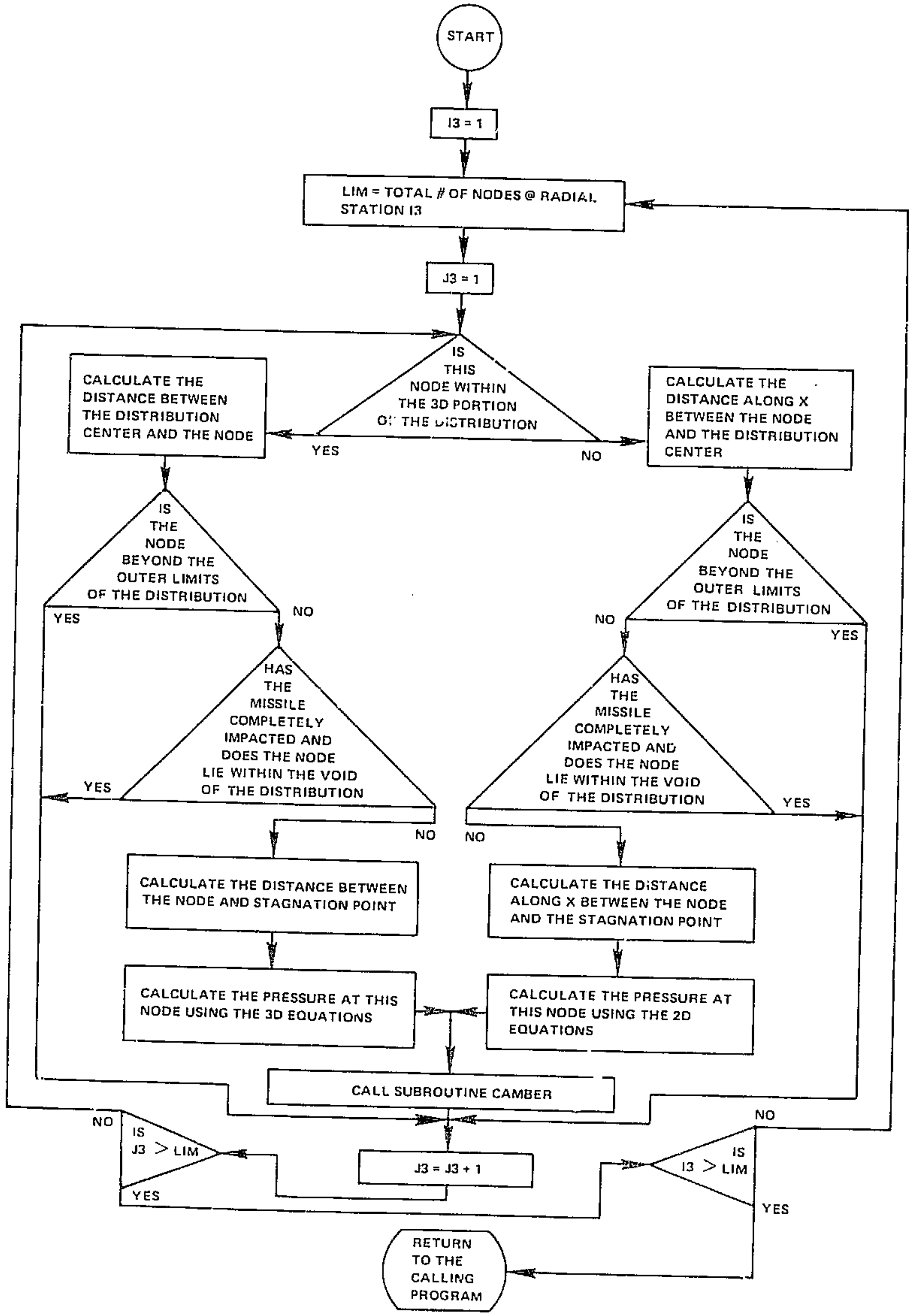
REGION


START
NST = NSTAT -2
KJ = 1
IS
XNODE < XCEN1 (KJ)
NO
YES
IS
XNODE ≥ XCEN2 (KJ)
NO
YES
514
KJ = KJ + 1
JC1 = KJ
IS
KJ > NST
NO
YES
RETURN
TO THE
CALLING
PROGRAM

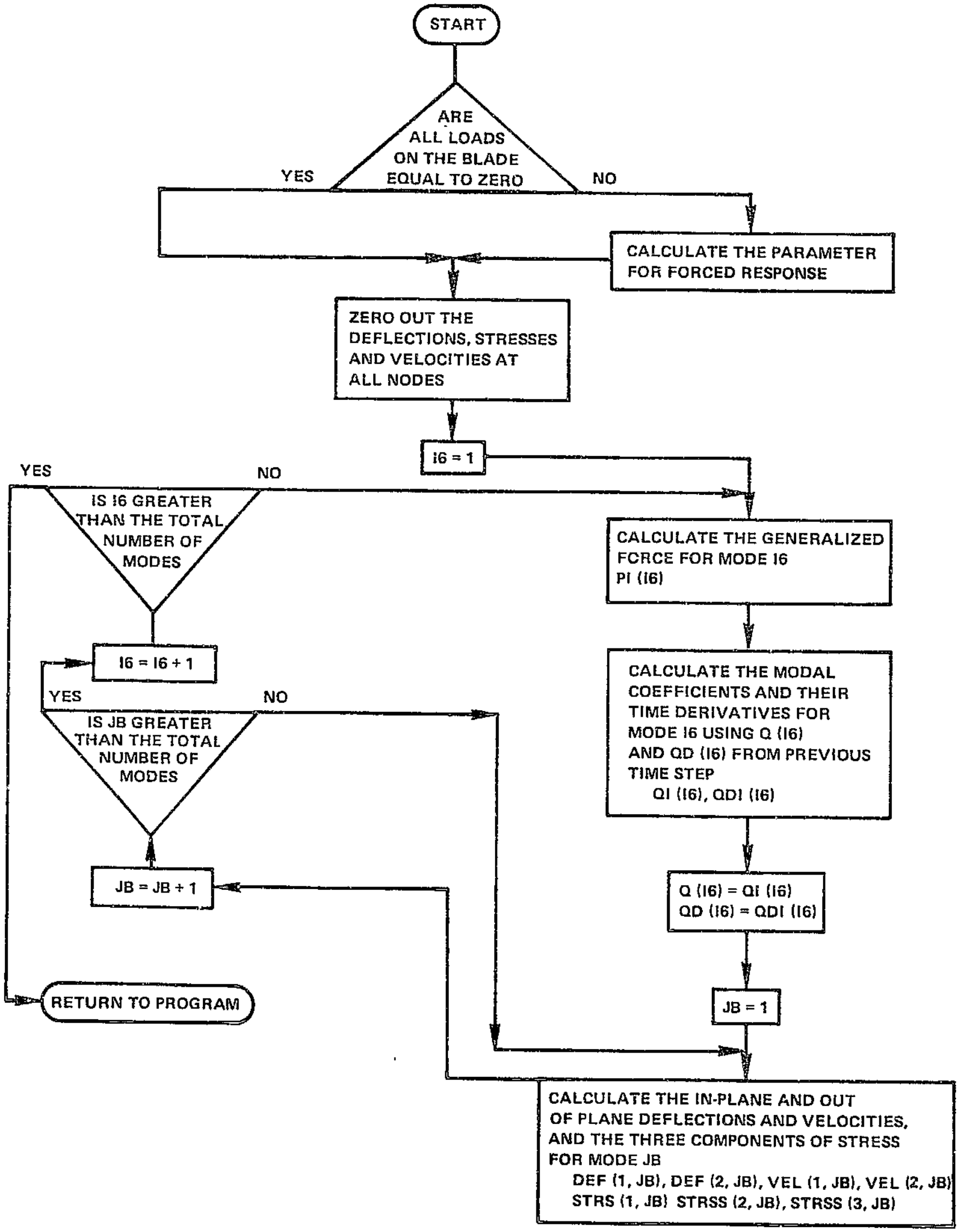
INCURV


START
CALCULATE THE X AND Y COORDINATES FOR THE MID-POINTS OF THE BLADE SEGMENTS JC1 AND JC1+1
CALCULATE THE CHANGE IN ANGLE DELPHI
IS DELPHI < 1.7 X 10-5
YES
NO
CALCULATE THE CHORDAL DISTANCE BETWEEN (XMID1, YMID1) AND (XMID2, YMID2)
CALCULATE THE RADIUS OF CURVATURE RCURV
PI = 0
PI = 1/RCURV
RETURN TO THE CALLING PROGRAM

PRESUR


START
I3 = 1
LIM = TOTAL # OF NODES @ RADIAL STATION I3
J3 = 1
IS THIS NODE WITHIN THE 3D PORTION OF THE DISTRIBUTION
YES
NO
CALCULATE THE DISTANCE BETWEEN THE DISTRIBUTION CENTER AND THE NODE
CALCULATE THE DISTANCE ALONG X BETWEEN THE NODE AND THE DISTRIBUTION CENTER
IS THE NODE BEYOND THE OUTER LIMITS OF THE DISTRIBUTION
YES
NO
IS THE NODE BEYOND THE OUTER LIMITS OF THE DISTRIBUTION
NO
YES
HAS THE MISSILE COMPLETELY IMPACTED AND DOES THE NODE LIE WITHIN THE VOID OF THE DISTRIBUTION
YES
NO
HAS THE MISSILE COMPLETELY IMPACTED AND DOES THE NODE LIE WITHIN THE VOID OF THE DISTRIBUTION
YES
NO
CALCULATE THE DISTANCE BETWEEN THE NODE AND STAGNATION POINT
CALCULATE THE DISTANCE ALONG X BETWEEN THE NODE AND THE STAGNATION POINT
CALCULATE THE PRESSURE AT THIS NODE USING THE 3D EQUATIONS
CALCULATE THE PRESSURE AT THIS NODE USING THE 2D EQUATIONS
CALL SUBROUTINE CAMBER
NO
IS J3 > LIM
YES
J3 = J3 + 1
NO
IS I3 > LIM
YES
RETURN TO THE CALLING PROGRAM

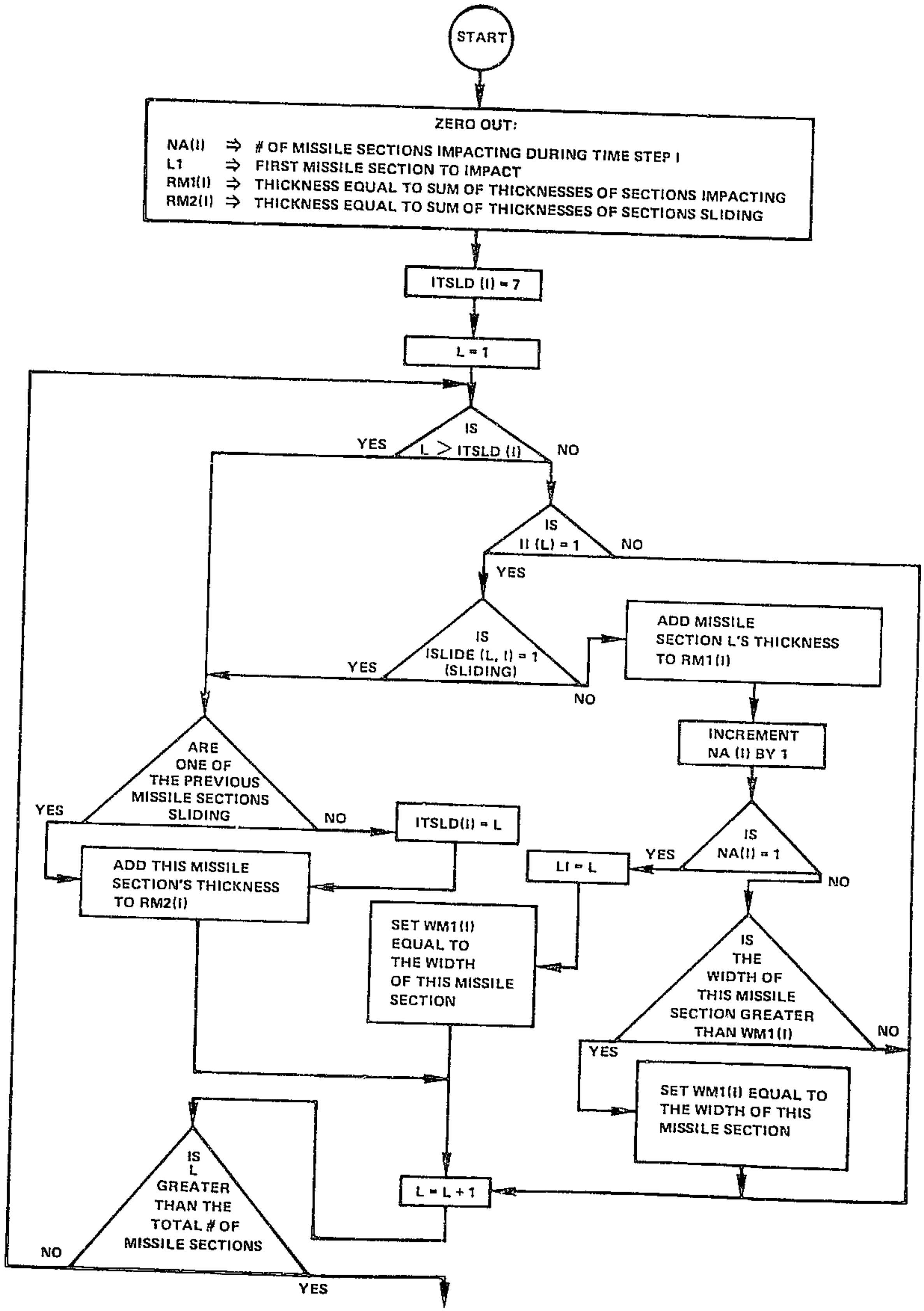
MODAL

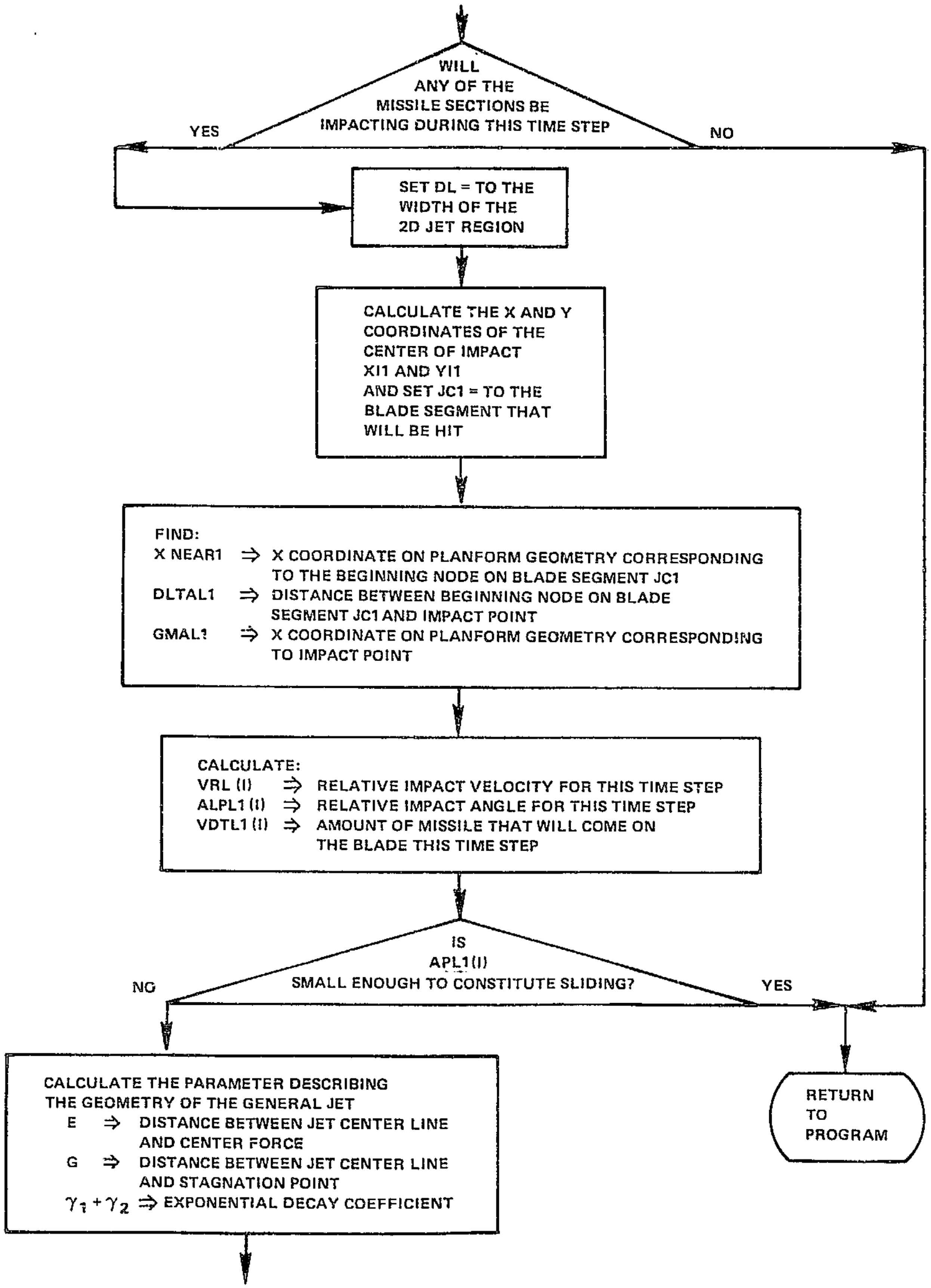


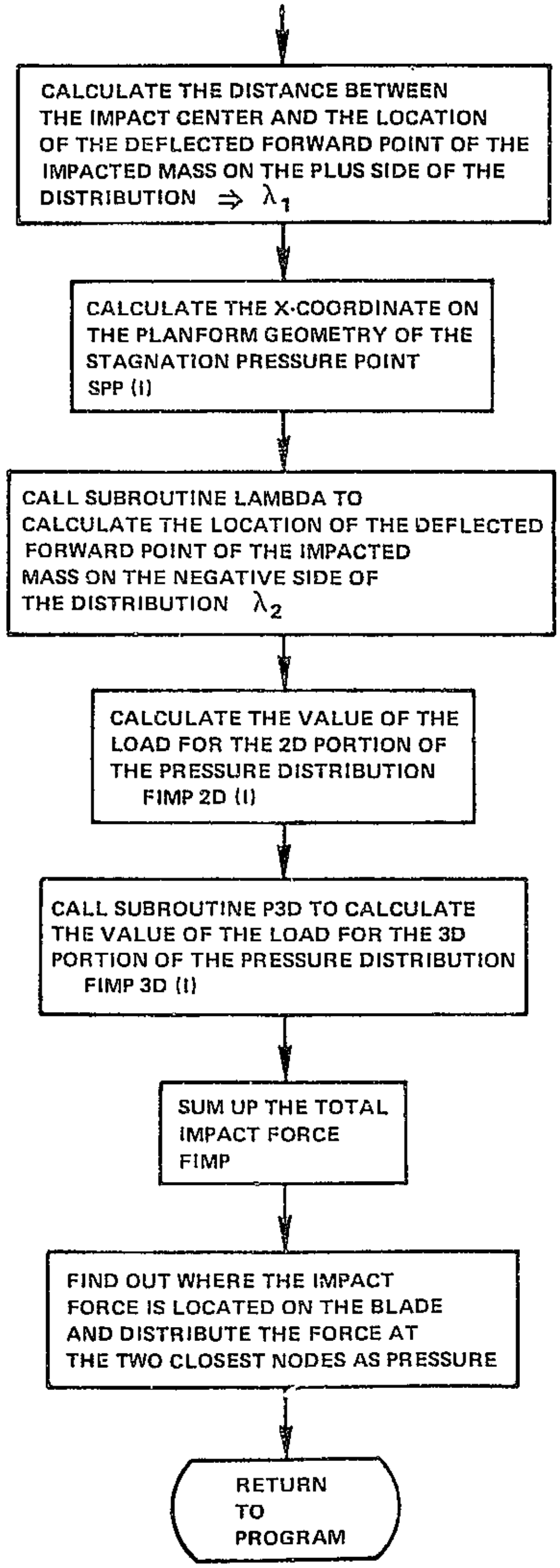
START
ARE ALL LOADS ON THE BLADE EQUAL TO ZERO
YES
NO
CALCULATE THE PARAMETER FOR FORCED RESPONSE
ZERO OUT THE DEFLECTIONS, STRESSES AND VELOCITIES AT ALL NODES
I6 = 1
YES
NO
IS I6 GREATER THAN THE TOTAL NUMBER OF MODES
CALCULATE THE GENERALIZED FORCE FOR MODE I6
PI (I6)
I6 = I6 + 1
YES
NO
IS JB GREATER THAN THE TOTAL NUMBER OF MODES
CALCULATE THE MODAL COEFFICIENTS AND THEIR TIME DERIVATIVES FOR MODE I6 USING Q (I6) AND QD (I6) FROM PREVIOUS TIME STEP
QI (I6), QDI (I6)
JB = JB + 1
Q (I6) = QI (I6)
QD (I6) = QDI (I6)
RETURN TO PROGRAM
JB = 1
CALCULATE THE IN-PLANE AND OUT OF PLANE DEFLECTIONS AND VELOCITIES, AND THE THREE COMPONENTS OF STRESS FOR MODE JB
DEF (1, JB), DEF (2, JB), VEL (1, JB), VEL (2, JB)
STRS (1, JB) STRSS (2, JB), STRSS (3, JB)

A-2

PINIT


START
ZERO OUT:
NA(I) ⇒ # OF MISSILE SECTIONS IMPACTING DURING TIME STEP I
L1 ⇒ FIRST MISSILE SECTION TO IMPACT
RM1(I) ⇒ THICKNESS EQUAL TO SUM OF THICKNESSES OF SECTIONS IMPACTING
RM2(I) ⇒ THICKNESS EQUAL TO SUM OF THICKNESSES OF SECTIONS SLIDING
ITSLD (I) = 7
L = 1
IS L > ITSLD (I)
YES
NO
IS II (L) = 1
YES
NO
IS ISLIDE (L, I) = 1 (SLIDING)
YES
NO
ADD MISSILE SECTION L'S THICKNESS TO RM1(I)
INCREMENT NA (I) BY 1
IS NA(I) = 1
YES
NO
LI = L
ARE ONE OF THE PREVIOUS MISSILE SECTIONS SLIDING
YES
NO
ITSLD(I) = L
ADD THIS MISSILE SECTION'S THICKNESS TO RM2(I)
SET WM1(I) EQUAL TO THE WIDTH OF THIS MISSILE SECTION
IS THE WIDTH OF THIS MISSILE SECTION GREATER THAN WM1(I)
YES
NO
SET WM1(I) EQUAL TO THE WIDTH OF THIS MISSILE SECTION
L = L + 1
IS L GREATER THAN THE TOTAL # OF MISSILE SECTIONS
NO
YES


WILL ANY OF THE MISSILE SECTIONS BE IMPACTING DURING THIS TIME STEP
YES
NO
SET DL = TO THE WIDTH OF THE 2D JET REGION
CALCULATE THE X AND Y COORDINATES OF THE CENTER OF IMPACT XI1 AND YI1 AND SET JC1 = TO THE BLADE SEGMENT THAT WILL BE HIT
FIND:
X NEAR1 ⇒ X COORDINATE ON PLANFORM GEOMETRY CORRESPONDING TO THE BEGINNING NODE ON BLADE SEGMENT JC1
DLTAL1 ⇒ DISTANCE BETWEEN BEGINNING NODE ON BLADE SEGMENT JC1 AND IMPACT POINT
GMAL1 ⇒ X COORDINATE ON PLANFORM GEOMETRY CORRESPONDING TO IMPACT POINT
CALCULATE:
VRL (I) ⇒ RELATIVE IMPACT VELOCITY FOR THIS TIME STEP
ALPL1 (I) ⇒ RELATIVE IMPACT ANGLE FOR THIS TIME STEP
VDTL1 (I) ⇒ AMOUNT OF MISSILE THAT WILL COME ON THE BLADE THIS TIME STEP
IS APL1(I) SMALL ENOUGH TO CONSTITUTE SLIDING?
NO
YES
CALCULATE THE PARAMETER DESCRIBING THE GEOMETRY OF THE GENERAL JET
E ⇒ DISTANCE BETWEEN JET CENTER LINE AND CENTER FORCE
G ⇒ DISTANCE BETWEEN JET CENTER LINE AND STAGNATION POINT
$\gamma_1 + \gamma_2$ ⇒ EXPONENTIAL DECAY COEFFICIENT
RETURN TO PROGRAM


CALCULATE THE DISTANCE BETWEEN THE IMPACT CENTER AND THE LOCATION OF THE DEFLECTED FORWARD POINT OF THE IMPACTED MASS ON THE PLUS SIDE OF THE DISTRIBUTION ⇒ λ_1
CALCULATE THE X-COORDINATE ON THE PLANFORM GEOMETRY OF THE STAGNATION PRESSURE POINT SPP (I)
CALL SUBROUTINE LAMBDA TO CALCULATE THE LOCATION OF THE DEFLECTED FORWARD POINT OF THE IMPACTED MASS ON THE NEGATIVE SIDE OF THE DISTRIBUTION λ_2
CALCULATE THE VALUE OF THE LOAD FOR THE 2D PORTION OF THE PRESSURE DISTRIBUTION FIMP 2D (I)
CALL SUBROUTINE P3D TO CALCULATE THE VALUE OF THE LOAD FOR THE 3D PORTION OF THE PRESSURE DISTRIBUTION FIMP 3D (I)
SUM UP THE TOTAL IMPACT FORCE FIMP
FIND OUT WHERE THE IMPACT FORCE IS LOCATED ON THE BLADE AND DISTRIBUTE THE FORCE AT THE TWO CLOSEST NODES AS PRESSURE
RETURN TO PROGRAM

SECTION IV

INSTRUCTIONS ON THE USE OF THE PROGRAM

The MMBI program uses an unformatted method of data input. Individual items of data need only to be separated by a comma or blank. However, it is recommended that sets of data be grouped together in a manner that allows the user to keep track of the number of data points being input per set since a missing data item or a misplaced comma (or blank) may result in gross errors in the analysis. The inputs to the FOD Impact program are grouped into four categories:

1) Problem definition
2) Missile description
3) Modal data
4) Blade description

4.1 PROBLEM DEFINITION

```
V,RIMP,TSTØP,ALPHAO,XOCL,YOCL,NR,NN,NM,NVA,IPDEL,DEN,ISYM
```

1) V - Initial missile impact velocity (in/sec) [REAL]
2) RIMP - Impact radius (in.) [REAL]
3) TSTØP- Total length of time representing the duration of the analysis. It is recommended that on the first trial run, the user input a time length equal to the blade cord width times the inverse of the cosine of the impact angle, divided by the initial impact velocity. If this run is successful the time length for subsequent runs should be of a duration sufficient to include the impact stage of the problem and the length of time necessary to pass through one complete cycle of vibration at the lowest mode of the blade. (sec.) [REAL]
4) ALPHAO - Initial impact angle. Fig. 6 illustrates the sign convention for angles. This angle must be input with a value between 0 and $\frac{\pi}{2}$ radians such

that the blade chord angle, determined with a vector drawn from the leading edge to the trailing edge, must lie between 0 and $\frac{\pi}{2}$ radians (see Section 2.1.3). (radians) [REAL]

5) XOCL, YOCL - In-plane, out-of-plane coordinates for the intersection of the missile centerline and the blade (see Section 2.1.3). (in.) [REAL]

6) NR - Total number of radial stations defining the blade. [INTEGER]

7) NN - Total number of nodes describing the blade. [INTEGER]

8) NM - Total number of nodes to be used in the problem. [INTEGER]

9) NVA - Total number of lengthwise sections defining the missile. [INTEGER]

10) IPDEL - Number of time steps between each printout of displacements and stresses. [INTEGER]

11) DEN - Missile density. Note that the value input for this item must be such that the mass of the missile will be consistent. Thus, if a one-pound spherical missile is being modeled the density must be such that when it is multiplied by the volume of the modeled missile it will yield one pound.

$$\frac{LBS\text{-}SEC^2}{in^4}$$ [REAL]

12) ISYM - Flag indicating whether items input in section 4.2 describe a symmetric (ISYM=0) or unsymmetric (ISYM=1) missile. If ISYM=0 NVA (see 4.1.9) must be equal to 6. [INTEGER]

4.2 MISSILE DESCRIPTION (Fig. 5)

```
RL(1),RL(2),RL(3),RL(4),RL(5),RL(6)
```

```
RM(1),RM(2),RM(3),RM(4),RM(5),RM(6)
```

```
CL(1),CL(2),CL(3),CL(4),CL(5),CL(6)
```

```
DELTL(1),DELTL(2),DELTL(3),DELTL(4),DELTL(5),DELTL(6)
```

```
WM(1),WM(2),WM(3),WM(4),WM(5),WM(6)
```

1) RL(1), RL(2), RL(3), [RL(4), RL(5), RL(6)]*** - Radial distance from missile centerline to centerline of corresponding missile section. Note the sense of positive values of radius. (*The number of input items must be equal to NVA and the numbering order must be from right to left as per Fig. 5.) (in.) [REAL]

   (** If ISYM=0 there must be <u>three</u> entries input for this variable.)

2) [RM(1), RM(2), RM(3), RM(4), RM(5), RM(6)]*** - Thickness of missile sections. (in). [REAL] (see starred note 4.2.1)

3) CL(1), CL(2), CL(3), [CL(4), CL(5), CL(6)]*** - Length of missile sections - (in.) [REAL] (see starred notes 4.2.1)

4) [DELTL(1), DELTL(2), DELTL(3), DELTL(4), DELTL(5), DELTL(6)]***- Offset of each missile section towards aft end from missile center at forward end. (in.) [REAL] (see starred note 4.2.1)

5) WM(1), WM(2), WM(3), WM(4), WM(5), WM(6) - Width of missile sections including both the 2-D and 3-D portions. (see section 2.2.3) (in.) [REAL] (see starred notes 4.2.1)

*** Needed only if ISYM=1 and NVA>3.

4.3 MODAL DATA

```
MAX(1),MAX(2),MAX(3),MAX(4),------MAX(NR)

NJ3(1),NJ3(2),NJ3(3),NJ3(4),------NJ3(NR)

VMI(1),VMI(2),VMI(3),VMI(4),------VMI(NM)

DR(1),DR(2),DR(3),DR(4),DR(5),------DR(NM)

WØ(1),WØ(2),WØ(3),WØ(4),------WØ(NM)

PH2(1,1,1),PH2(1,2,1),PH2(1,3,1),------,PH2(1,NN,1),

PH2(2,1,1),PH2(2,2,1),PH2(2,3,1),------,PH2(2,NN,1),

PH2(1,1,2),PH2(1,2,2),PH2(1,3,2),------,PH2(1,NN,2),

PH2(2,1,2),PH2(2,2,2),------PH2(2,NN,2)

PH2(1,1,3),PH2(1,2,3),------PH2(1,NN,3),------PH2(2,NN,3),------

PH2(1,1,NM),------PH2(1,NN,NM),------PH2(2,NN,NM)

SH2(1,1,1),------SH2(1,NN,1),------SH2(2,NN,1),------SH2(3,NN,1),

SH2(1,1,2),------SH2(1,NN,2),------SH2(2,NN,2),------SH2(3,NN,2),------

SH2(1,1,NM),------SH2(1,NN,NM),------SH2(2,NN,NM),------SH2(3,NN,NM)
```

1) MAX(1), MAX(2), ---MAX(NR) - Number of nodes at each radial station of the blade. [INTEGER]

   MAX ≤ 25

2) NJ3(1), NJ3(2), ---NJ3(NR) - Index corresponding to the chordwise node at each radial station for which the user wishes to obtain displacement and

stress output results. (e.g. if radial station 6 of the blade has its center of twist located at node 7 from the leading edge, the user may wish to input NJ3(6) = 7). [INTEGER]

3) VMI(1), VMI(2), ---VMI(NM) - Modal mass corresponding to the first, second --- NM modes of the blade. (1≤NM≤10) [REAL]

4) DR(1), DR(2), --- DR(NM) - Critical damping ratio associated with each mode. (1≤NM≤10) [REAL]

5) WØ(1), WØ(2), --- WØ(NM) - Modal frequency associated with each mode. (1≤NM≤10) (Radians/sec) [REAL]

6) PH2(1, 1, 1), PH2(1, 2, 1), PH2(1, 3, 1) --- PH2(1, NN, 1) - In-plane displacement components for the first mode at each node of the blade. (*The numbering of nodes is row by row from the leading edge node to the trailing edge node. Thus the data will be composed of displacements corresponding to the nodes of the lowest radial station, then the nodes of the next radial station, etc.) [REAL]

7) PH2 (2, 1, 1), PH2 (2, 2, 1), PH2 (2, 3, 1) --- PH2 (2, NN, 1) - Out-of-plane displacement components for the first mode at each node of the blade. [REAL] (see starred note 4.3.6)

8) PH2(1, 1,2), PH2(1, 2,2), PH2(1, 3, 2) --- PH2(1, NN, 2) - In-plane displacement components for the second mode at each node of the blade. [REAL] (see starred note 4.3.6)

9) PH2(2, 1, 2), PH2(2, 2, 2), PH2(2, 3, 2) --- PH2(2, NN, 2) - Out-of-plane displacement components for the second mode at each node of the blade. [REAL] (see starred note 4.3.6).

10) PH2(1, 1, 3) --- PH2(1, NN, 3), PH2(2, 1, 3), --- PH2(2, NN, 3), ---, PH2(1, 1, NM), PH2(1, 2, NM), ---, PH2(1, NN, NM), PH2(2, 1, NM), PH2(2, 2, NM), --- PH2(2, NN, NM) - In-plane and out-of-plane displacement components corresponding to each mode at the nodes of the blade. The order of

input follows the same as in 4.3.6 thru 4.3.9, i.e. first the in-plane components at each node, then the out-of-plane components at each node, etc., etc. for each mode. [REAL] (see starred note 4.3.6).

11) SH2(1, 1, 1), SH2(1, 2, 1), --- SH2(1, NN, 1), SH2(2, 1, 1), --- SH2(2, NN, 1), SH2(3, 1, 1), SH2(3, 2, 1), --- SH2(3, NN, 1), SH2(1, 1, 2), SH2(1, 2, 2), --- SH2(1, NN, 2), SH2(2, 1, 2), SH2(2, 2, 2), --- SH2(2, NN, 2), SH2(3, 1, 2), SH2(3, 2, 2), --- SH2(3, NN, 2), ---SH2(1, 1, NM), SH2(1, 2, NM), ---SH2(1, NN, NM), SH2(2, 1, NM), SH2(2, 2, NM), --- SH2(2, NN, NM), SH2(3, 1, NM), SH2(3, 2, NM) --- SH2(3, NN, NM) - Three components of stress at each node, for each mode. The order of input consists of first inputting the first component (usually chordwise) at each node, then the second component (usually radial) at each node, then the third component (usually shear) at each node, then repeating for the next mode until all modes have been input. [REAL] (see starred note 4.3.6).

4.4 BLADE DESCRIPTION (Figs 1 and 2)

```
YNØDE(1)

XNØDE(1,1),XNØDE(1,2),XNØDE(1,3),-----XNØDE(1,MAX(1)),

YNØDE(2)

XNØDE(2,1),XNØDE(2,2),XNØDE(2,3),-----XNØDE(2,MAX(2)),

YNØDE(NR)

XNØDE(NR,1),XNØDE(NR,2),XNØDE(NR,3),-----XNØDE(NR,MAX(NR))

XØ(1), XØ(2), XØ(3), ---- XØ(MAX(impact radial station))

YØ(1), YØ(2), YØ(3), ---- YØ(MAX(impact radial station))
```

1) YNØDE(1) - Radius of the first radial station. (in.) [REAL]

2) XNØDE(1, 1), XNØDE(1, 2), ---XNØDE(1,MAX(1)) - Chordwise coordinates of the nodes lying on radial station 1.(* Input order is from the leading edge to the trailing edge.) (in.) [REAL]

3) YNØDE(2) - Radius of the second radial station. (in.) [REAL]

4) XNODE(2, 1), XNODE(2, 2), --- XNODE(2, MAX(2)) - Chordwise coordinates of the nodes lying on the second radial station. (in.) [REAL] (See starred note 4.4.2)

5) YNØDE(3), XNØDE(3, 1), --- XNØDE(3, MAX(3)), YNØDE(4), XNØDE(4, 1), --- XNØDE(4, MAX(4), --- YNØDE(NR), XNØDE(NR, 1), --- XNØDE(NR, MAX(NR)) - Radial coordinate of radial stations and chordwise coordinate of nodes corresponding to each radial station. Order of inputs is as shown. NR≤25.

6) XØ(1), XØ(2), XØ(3), --- XØ(MAX(impact radial station)) - In-plane coordinates of nodes segmenting the blade chord at the impact radial station. (see starred note below). Input order is from the leading edge to trailing edge. (in.) [REAL]

7) YØ(1), YØ(2), YØ(3), --- YØ(MAX(impact radial station)) - Out-of-plane coordinates of nodes segmenting the blade chord at the impact radial station. Input order is from the leading edge to the trailing edge. (in.) [REAL]

*NOTE: The coordinates XØ(J), YØ(J) must be such that

$$0 \le \cos^{-1} \frac{XØ(J+1)-XØ(J)}{\sqrt{[XØ(J+1)-XØ(J)]^2 + [YØ(J+1)-YØ(J)]^2}} \le \frac{\pi}{2}$$

4.5 OUTPUT

4.5.1 Pressure Distribution

During the time in which there remains a portion of unimpacted missile length the MMBI program prints out the pressure distribution for each time step. When the entire length of missile has impacted the blade, pressure printout is performed for every IPDEL time step until the final TSTØP is reached. In addition, when the pressures on the blade have reduced to a negligible amount, the program prints out a message to the user indicating the time elapsed to complete the impact phase of the problem. If the value of TSTØP is reached before the pressures on the blade have reduced to negligible values, the program prints out a message informing the user that the length of time allotted to solve the problem is too short.

4.5.2 Poor Convergence in Subroutine LAMBDA

As mentioned in Section 3.3.2, the program is instructed to print a warning message informing the user that it was unable to converge to a one percent accuracy for the definition of the impacted missile mass shape. The best accuracy achieved is printed and the program will continue with the analysis. Generally, accuracies within 5 percent are acceptable, and accuracies greater than 5 percent are indicative of an error in the inputs with respect to missile shape (see 4.2).

4.5.3 Displacement and Stress

In addition to printing out the displacement and stress output for each IPDEL time step, the program will print the displacements and stresses for the first and last time steps of the problem. Displacement and stress output is printed in two configurations. The in-plane and out-of-plane displacements at the node NJ3 (see 4.3.2) of each radial station are printed out vs. the radial coordinate of the radial station. In addition, the stresses in the radial direction at the leading edge node, node NJ3, and trailing edge node of each radial station are printed out vs. the corresponding radial coordinates. Note that in order for this printout to be successful the user must input the proper component of stress as mentioned in 4.3.11. The second configuration of displacement and stress printout consists of tabulating this data with respect to the chordwise distance relative to the leading edge at the impact radial station. The in-plane and out-of-plane displacements at the nodes lying on the impact radial station are printed out versus their chordwise distance from the leading edge. The program then prints out the chordwise (STRESS-X), radial (STRESS-Y), and shear (SHEAR-XY) stress components at the nearest radial station below the impact radius, the impact radial station, and the nearest radial station above the impact radius, for chordwise distances relative to the leading edge.

SECTION V

DEMONSTRATION PROBLEMS

As noted in the introduction to Section II, the MMBI program solves the problem of missile impacts on blades in three separate phases. The demonstration problems presented in this section illustrate the program's ability to handle the missile and blade geometry and its analysis of the pressure distribution associated with the impacting missile. Presented in Section 5.2 is a complete modal response analysis of a soft body impact on a blade.

5.1 Impacts on Rigid Plates

The impacting missile used in these analyses is a 600 gram, cylindrically shaped mass with a 2 to 1 length to diameter ratio, impacting the target at a velocity of 7800 in/sec. Specifically, the length of the missile is 5.8 in., making the density $8.89\text{x}10^{-5}$ $\frac{\text{lb-sec}^2}{\text{in}^4}$. Fig. 28 illustrates the parameters used in modeling the missile for the program.

Since the target is rigid, the modal displacements are set to zero. In addition, only one mode need be used, with a frequency chosen such that the time step sizes calculated by the program will be sufficient to illustrate the variation of the pressure distribution with respect to time and target surface. Since the length of the missile is 5.8 in., the frequency is chosen as 8449.8 rad/sec. The program will calculate a time step from

$$\Delta t = \frac{2\pi}{10\text{x}8449.8} = 7.4359\text{x}10^{-4} \text{ sec}$$

(see Section 3.1.8)

The length of missile that will impact during each time step will then be

$$V\Delta T = 7800\text{x}7.4359\text{x}10^{-4} = .58 \text{ in.}$$

It will therefore take 10 time steps for the missile to impact the blade at an impact angle of 90 degrees.

The program was run using impact angles of 25°, 45° and 90°. The results were then compared to experimental data reported in Ref. [20] on similar impacts. Table III summarizes the results which are plotted in Figs. 29, 30 and 31. Generally, the data points are shifted toward the stagnation pressure point by .75 inches. The general shape of the distributions for both the calculated and observed results are similar. In the case of the 25 degree impact the correlation is poor for points near the center of impact lying along the minor axis. However, the relative values for the data points located at the center of impact and at a radius of .46 inches in this case

from the center to the outer point. This result is contrary to both theory and to the results for the 45 and 90-degree cases, indicating that the test data for pressure ratios along the minor axis in the 25-degree case is questionable.

5.2 <u>30-DEGREE IMPACT OF A 1 LB. SPHERE ON A FLAT PLATE SIMULATED Q-FAN BLADE</u>

Fig. 32 depicts the model used in performing this analysis. The blade consists of rigid steel plate bolted on a titanium spar between the 26-inch and 33.75-inch radial stations. The plate measures 10 inches between the leading edge and trailing edge, is flat on the impact face, and tapers on the rear (or spar) face from a nominal thickness of .31 inches at the center of twist to a thickness of .14 inches at the leading edge and .080 inches at the trailing edge. The leading edge is located a distance of 4.6 inches from the center of twist and is parallel to the spar's twist axis.

The missile is a 3.75-inch diameter sphere weighing 1 lb. and impacting the plate with a velocity of 600 ft/sec. at a 30° angle to the plane of the plate. Figs. 33 and 34 show the dimensions of the model depicting the missile.

The modal data used in the problem includes the first five modes of the blade. Since the plate is relatively rigid it was felt that these lower modes (i.e. the first three bending and the first two twisting modes) would be sufficient to obtain the data necessary for comparison with test results. Due to the lack of a good finite element model for the blade, consisting of a dimensional plate element, the modal data was obtained from a beam analysis eigenvalue solution. The results of this normal modes analysis was then used to determine the displacements of the plate nodes relative to the point of the plate located at the impact radius and the center of twist. Since the plate is relatively rigid this approximation should not impose any gross errors. In addition, the loads calculated by the program are maximum along the impact centerline and decay rapidly with distance from the impact centerline, thus reducing the effects of errors in the mode shapes with respect to the blade response. Below is a summary of the modal data.

MODE	SHAPE	FREQ.(HZ)	*DISPLACEMENTS		TWIST	
			IP	OOP	IMPACT STATION	BLADE TIP
1	1st BENDING	69	.383	.310	-.0407	-.108
2	2nd BENDING	139	-.205	-.116	-.0169	-.231
3	3rd BENDING	231	.375	-.515	.0237	-.191
4	1st TWIST	244	.0131	.129	.297	.0861
5	2nd TWIST	360	-.269	-.624	.217	.514

*At the impact radial station and center of twist

The impact station is at the 30-in. radius and the center of the missile impact is .6 inches off the center of twist towards the leading edge. A listing of the input data is presented in Table IV and the output results of the program are presented in Appendix G. Presented in Fig. 35 is a plot of the calculated flatwise displacement response at the blade tip and the corresponding test data. The test data indicates the presence of higher mode contributions to the displacement response of the blade, however, these contributions are minimal. With respect to the duration of the response and the general shape of the curve, the correlation between calculated and test results is very good. The peak displacement predicted by the MMBI program is within 6.7% of the test results.

Fig. 36 shows the calculated response of the blade in twist at the impact radius and the test data for twist response of the blade at the blade tip. Although the two sets of data cannot be directly compared, several encouraging conclusions can be drawn from their relative shapes. First, note that for the initial rise of the response and for the fall off after the peak, there is good correlation. This is consistent with the fact that the blade response during these time intervals is mostly due to the lower twist modes. The break away of test results from the calculated curve indicates, as with the displacement response, the presence of higher modes. Furthermore, noting that the modal data input to the program is based upon a rigid body transformation of the plate with respect to a point at the impact radius, and considering the summarized modal data, it can be seen that there is a sharp transition in the twist mode shapes between the impact radius and the tip radius. The MMBI program predicted that the missile mass washes off the blade 1 millisecond after the initiation of impact. It would therefore be expected that the blade twist response will include the higher modes after this time as is illustrated by the test data.

It should be noted that the effects of blade camber on pressures are not present in this analysis since the plate motion is virtually rigid. However, the significance of this demonstration problem lies in the ability of the MMBI program to couple the effects of a variable sized and shaped missile with the modal characteristics of the impacted blade. The program was able to predict within acceptable accuracy, the response of the blade subjected to a nonlinear load.

5.3 RECOMMENDATIONS

In its present form, the MMBI Impact program combines the effects of coupled modal response with a time variable missile model. Although the demonstration problems presented in Sections 5.1 and 5.2 provide an insight to the capabilities of the program, it must be pointed out that a thorough evaluation of the program is still warranted.

As a first step, it is recommended that the results from available test data on missile impacts of real fan blades be compared to corresponding analyses performed with the program, e.g. missile impacts of the 3A Q-Fan Demo Blade performed for NASA Lewis by Hamilton Standard under Contract No. NAS3-17837.

Second, since successful design techniques require the analyst to conduct parametric studies on proposed designs, the evaluation of the program with respect to parametric applications is of importance.

As an outgrowth of these studies, improvements on the present modelling could be accomplished, such as:

1) The development of a technique for integrating the pressure distribution over the surface of the blade. Such a method has already been partially developed.
2) The inclusion of Hugonoit pressure for the initial shock force developed prior to steady flow.
3) The inclusion of an internal preprocessor for extracting the eigenvalues and eigenvectors associated with the blade. The procedure for inputing the modal data into the program is a cumbersome task due to the large volume of data that is associated with most blades. Errors in transmitting the data from an external modal preprocessor to the MMBI program can be incurred if extreme caution by the user is not exercised.

It is to be noted that the present version of the program does not account for the non-linear behavior of blades subjected to impacts. The expansion of the program to include the effects of large deformation, non-linear elastic-plastic material behavior, and as a final step, inhomogeneity, would be a significant improvement. The methodology used to determine the variation of impact load with respect to time and blade surface would be analogous to that used by the present version of the program. However, rather than purely time stepping through the problem with a single solution set for the modal response, a time step integration technique can be developed such that the generalized coordinates corresponding to the modes of the system are solved for during each time step. This releases the constraints that the transient forcing function on the system, and that the material and stiffness properties of the system, be relatively smooth functions with time. A similar method is presented in Ref. 21.

An additional area of interest, in which the FOD Impact program could be a useful tool, concerns the subject of failure analysis. The development of the program's capability to handle delamination and fracture damage could be implemented using the methodology described above. These developments would necessitate further efforts in the improvement of the missile model. Since fracture damage constitutes discontinuities in the surface of the blade, the improved missile model would be required to respond to these discontinuities. Such a model can be developed by using a non-linear, semi-solid, theoretical substance such as Mooney-Rivlin material.

The improvements mentioned above cover a very broad and general scope of developmental work. Certainly, the area of program evaluation is a task which should be afforded immediate attention. The remainder of the recommendations constitute multiple task efforts that can be expended as longer range developments.

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TABLE I. EXPERIMENTAL IMPACT DATA

AUTHORS	MEDIUM	DESCRIPTION	IMPACT ANGLES, α°
W. SCHACH REFERENCES 5 & 7	LIQUID	2D AND 3D OBLIQUE JETS IMPINGING PLANE	30, 45, 60, 75, 90
J.F. FOSS & S.J. KLEIS REFERENCES 13, 14, 15	AIR	3D OBLIQUE JETS IMPINGING PLANE	3, 6, 9, 12, 15, 30, 45, 60
A. LECLERC REFERENCE 12	LIQUID	3D NORMAL JET IMPINGING PLANE	90
G. TAYLOR REFERENCE II	LIQUID	3D COLLIDING OBLIQUE JETS	30, 45, 60
T. STRAND REFERENCES 5, 16	LIQUID	3D NEAR NORMAL JETS IMPINGING PLANE	80 & 90
R.L. PETERSON & J.P. BARBER REFERENCE 4	BIRD	BIRDS OBLIQUELY IMPINGING PLANE	25, 45, 90
J.P. BARBER & J.S. WILBECK REFERENCE 19	BIRD	BIRDS OBLIQUELY IMPINGING PLANE	25, 45

TABLE II

REL[illegible]SHIPS FOR 2D, 3D, AND GENERAL SYMMETRICAL MISSILE MODELS

1. FORWARD FLOW AREA	$A^F{}_2 = \frac{wa}{2}(1+\cos\alpha)$	$A^F{}_3 = \frac{\pi a^2}{4}\left(1-\frac{\alpha}{\pi}+\frac{\sin 2\alpha}{2\pi}\right)$	$\overline{A}^F = A^F{}_2 + A^F{}_3$
2. PRESSURE DISTRIBUTION $P_o = \frac{1}{2}\rho V_o^2$	$(P/P_o) = e^{-(x/\lambda)}\,[2-e^{-(x/\lambda)}]$	$(P/P_o)_3 = e^{-(x/\lambda)^2}\,[2-e^{-(x/\lambda)^2}]$	$\overline{P}/P_o = r_3\,(P/P_o)_3 + r_2\,(P/P_o)_2$ *
3. DECAY COEFFICIENTS	$\lambda_1/a = \frac{1}{3}\left(1-\frac{\alpha}{\pi}\right)\sin\alpha$ $\lambda_2/a = \frac{\alpha}{3\pi}\sin\alpha$	$(\lambda/a)^2 = \frac{4}{3}\,\frac{\sin^3\alpha}{(1-\cos\psi\cos\alpha)^2}\sqrt{1-(\cos\psi\cos\alpha)^2}$	———
4. DEFLECTED THICKNESS	$(\delta/a)_2 = \frac{1}{2}(1\pm\cos\alpha)$	$(\delta/a)_3 = \frac{a}{2X}\left(\frac{\sin\alpha}{1-\cos\psi\cos\alpha}\right)^2\sin\alpha$	$(\overline{\delta}/a) = \mu_3\,(\delta/a)_3 + \mu_2\,(\delta/a)_2$ +
5. FORCE FROM JET ℄	$(e/a)_2 = \frac{1}{2}\cot\alpha$	$(e/a)_3 = \frac{4\cot\alpha}{3\pi(1+\sqrt{\sin\alpha})}$	$(\overline{e}/a) = \frac{A_2\,(e/a)_2 + A_3\,(e/a)_3}{A_2+A_3}$
6. STAG. PRESSURE FROM FORCE	$(f/a)_2 = \frac{14}{9}\left(1-\frac{2\alpha}{\pi}\right)\sin\alpha$	$(f/a)_3 = \frac{2.3}{2}\left(1-\frac{2\alpha}{\pi}\right)\left[1-\left(1-\frac{2\alpha}{\pi}\right)^{27}\right] + \frac{0.1\sin 2\alpha}{2}$	———
7. STAG. PRESSURE FROM JET ℄	$(g/a)_2 = \frac{1}{2}\left[\cot\alpha + \frac{28}{9}\left(1-\frac{2\alpha}{\pi}\right)\sin\alpha\right]$	$(g/a)_3 = (e/a)_3 + (f/a)_3$	$(\overline{g}/a) = \frac{(g/a)_3\,A_3 + (g/a)_2\,A_2}{A_3+A_2}$

$$*\,r_2 = \frac{1+[wP_2/(dL/dX)_3]}{(P_2/P_3)+[wP_3/(dL/dX)_3]} \quad ; \quad r_3 = \frac{1+[(dL/dX)_3/wP_2]}{(P_3/P_2)+[(dL/dX)_3/wP_2]}$$

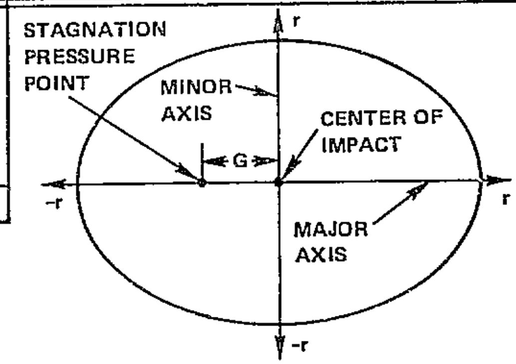
$$+\,\mu_2 = \frac{1+A_2/A_3}{[(\overline{\delta}/a)_2/(\overline{\delta}/a)_3]+A_2/A_3} \quad ; \quad \mu_3 = \frac{1+A_3/A_2}{[(\overline{\delta}/a)_3/(\delta/a)_2]+A_3/A_2}$$

NOTE: $\overline{P}_3$ & $\overline{\delta}_3$ ARE VALUES FOR $\psi = 0$

$$(dL/dX)_3 \approx 2\int_0^{\pi/2} x\,P_3\,d\psi$$

TABLE III. PRESSURE RATIOS FOR 25, 45 AND 90 DEGREE IMPACTS OF CYLINDRICAL MISSILES ON RIGID PLATES

	25° IMPACT G = 4.12 IN.				45° IMPACT G = 2.48 IN.				90° IMPACT G = 0.00 IN.			
		P/P_o				P/P_o				P/P_o		
	r	TEST**	THEORY	Δ*	r	TEST**	THEORY	Δ*	r	TEST**	THEORY	Δ*
MAJOR AXIS	-0.804	0.50	0.56	0.20	-1.19	0.93	0.96	0.25	0.0	0.924	1.0	0.95
	0.0	0.140	0.34	1.05	-0.60	0.76	0.87	0.45	0.47	0.847	0.99	0.70
	0.24	0.130	0.29	0.90	0.00	0.54	0.72	0.55	1.45	0.42	0.72	0.55
	0.64	0.093	0.21	0.85	0.38	0.38	0.60	0.70	1.92	0.15	0.46	0.62
	1.07	0.060	0.14	0.75	0.59	0.30	0.53	0.78				
					1.05	0.12	0.38	1.5				
	AVG. SHIFT OF STAG. PT. = 0.76				AVG. SHIFT OF STAG. PT. = 0.71				AVG. SHIFT OF STAG. PT = 0.75			
MINOR AXIS	0.0	0.13	0.34	1.05	0.0	0.53	0.72	1.02				
	0.46	0.16	0.29	0.5	0.47	0.42	0.67	0.87				
	1.45	0.13	0.05	-0.2	1.44	0.22	0.36	0.37				
	1.91	0.05	0.01	-0.45								
	2.43	0.02	0.	-0.75								
	AVG. SHIFT OF STAG. PT. = 0.03				AVG. SHIFT OF STAG. PT. = 0.75							



* Δ IS THE SHIFT ALONG THE AXIS FROM THE OBSERVED VALUE TO THE EQUIVALENT P/P_o ON THE CURVE.

**FROM REF. 2.

TABLE IV

INPUT DATA TO MMBI PROGRAM FOR ANALYSIS OF A 30 DEGREE IMPACT OF A 1 LB. SPHERICAL MISSILE

```
         **** TSO FOREGROUND HARDCOPY ****
         DSNAME=TSOG02I.DEMO7.DATA
           V  |RIMP|TSTOP|ALPHAO|XDCL|YDCL|NR|NN|NM|NVA|IPDEL|DEN
        7260.0,30.0,.0500, .5236,4.5460,3.7705,8, 120, 5,  6,   2,  9.888-5,1
     RL 1.5625,.95,.325,-.325,-.95,-1.5625,
     RM .625,.60,.65,.65,.60,.625
     CL 2.10,3.26,3.75,3.75,3.26,2.10,
  DELTL .825,.245,0.0,0.0,.245,.825,
     WM 2.10,3.26,3.75,3.75,3.26,2.10
    MAX 8*15
    NJ3 8*9
    VMI .0098558,.0042763,.009889,.0102230,.02334
     DR .035,.035,.035,.035,.035
     WΦ 433.500,873.3900,1445.0,1533.100,2262.0
```

IP DISPLACEMENT	1	0.470906E-01	0.603713E-01	0.771465E-01	0.939220E-01	0.110697E+00	MODE # 1
		0.127473E+00	0.144248E+00	0.161024E+00	0.177799E+00	0.194575E+00	
		0.218340E+00	0.246299E+00	0.274258E+00	0.302217E+00	0.326681E+00	
	2	0.122718E+00	0.135999E+00	0.152774E+00	0.169550E+00	0.186325E+00	
		0.203100E+00	0.219876E+00	0.236651E+00	0.253427E+00	0.270202E+00	
		0.293967E+00	0.321926E+00	0.349886E+00	0.377845E+00	0.402308E+00	
	3	0.198346E+00	0.211627E+00	0.228402E+00	0.245177E+00	0.261953E+00	
		0.278728E+00	0.295503E+00	0.312279E+00	0.329054E+00	0.345830E+00	
		0.369595E+00	0.397554E+00	0.425513E+00	0.453472E+00	0.477936E+00	
	4	0.273574E+00	0.287254E+00	0.304030E+00	0.320805E+00	0.337580E+00	
		0.354356E+00	0.371131E+00	0.387907E+00	0.404682E+00	0.421457E+00	
		0.445223E+00	0.473182E+00	0.501141E+00	0.529100E+00	0.553564E+00	
	5	0.330694E+00	0.343975E+00	0.360750E+00	0.377526E+00	0.394301E+00	
		0.411077E+00	0.427852E+00	0.444627E+00	0.461403E+00	0.478178E+00	
		0.501943E+00	0.529903E+00	0.557862E+00	0.585821E+00	0.610285E+00	
	6	0.406322E+00	0.419603E+00	0.436378E+00	0.453153E+00	0.469929E+00	
		0.486704E+00	0.503479E+00	0.520255E+00	0.537030E+00	0.553806E+00	
		0.577571E+00	0.605530E+00	0.633489E+00	0.661448E+00	0.685913E+00	
	7	0.481949E+00	0.495230E+00	0.512005E+00	0.528781E+00	0.545556E+00	
		0.562330E+00	0.579107E+00	0.595883E+00	0.612658E+00	0.629433E+00	
		0.653199E+00	0.681258E+00	0.709117E+00	0.737076E+00	0.761540E+00	
	8	0.557577E+00	0.570858E+00	0.587633E+00	0.604409E+00	0.621184E+00	
		0.637959E+00	0.654735E+00	0.671510E+00	0.668286E+00	0.705061E+00	
		0.722826E+00	0.756785E+00	0.784745E+00	0.812704E+00	0.837168E+00	
OOP DISPLACEMENT	1	0.526383E-01	0.383952E-01	0.204040E-01	0.241280E-02	-.155785E-01	
		-.335697E-01	-.515609E-01	-.695521E-01	-.875432E-01	-.105534E+00	
		-.131022E+00	-.161007E+00	-.190993E+00	-.220978E+00	-.247215E+00	
	2	-.187010E-01	-.329440E-01	-.509353E-01	-.689265E-01	-.869179E-01	
		-.104909E+00	-.122900E+00	-.140891E+00	-.158883E+00	-.176874E+00	
		-.202361E+00	-.232346E+00	-.262332E+00	-.292317E+00	-.318554E+00	
	3	-.900402E-01	-.104283E+00	-.122275E+00	-.140266E+00	-.158257E+00	
		-.176248E+00	-.194239E+00	-.212231E+00	-.230222E+00	-.248213E+00	
		-.273700E+00	-.303686E+00	-.333671E+00	-.363656E+00	-.389894E+00	
	4	-.161380E+00	-.175623E+00	-.193614E+00	-.211605E+00	-.229596E+00	
		-.247587E+00	-.265579E+00	-.283570E+00	-.301561E+00	-.319552E+00	
		-.345040E+00	-.375025E+00	-.405011E+00	-.434996E+00	-.461233E+00	
	5	-.214884E+00	-.229127E+00	-.247118E+00	-.265109E+00	-.283101E+00	
		-.301092E+00	-.319083E+00	-.337074E+00	-.355066E+00	-.373057E+00	
		-.398544E+00	-.420530E+00	-.458515E+00	-.488500E+00	-.514738E+00	
	6	-.286223E+00	-.300466E+00	-.318458E+00	-.336449E+00	-.354440E+00	
		-.372431E+00	-.390422E+00	-.408414E+00	-.426405E+00	-.444396E+00	
		-.469804E+00	-.499869E+00	-.529854E+00	-.559840E+00	-.586077E+00	
	7	-.357563E+00	-.371806E+00	-.389797E+00	-.407788E+00	-.425779E+00	
		-.443770E+00	-.461762E+00	-.479753E+00	-.497744E+00	-.515735E+00	
		-.541223E+00	-.571208E+00	-.601194E+00	-.631179E+00	-.657416E+00	

TABLE IV (CONTINUED)

Mode	Displacement						
MODE # 1 (CONT)		8	-.428902E+00	-.443145E+00	-.461136E+00	-.479127E+00	-.497119E+00
			-.515110E+00	-.533101E+00	-.551092E+00	-.569083E+00	-.587075E+00
			-.612562E+00	-.642547E+00	-.672533E+00	-.702518E+00	-.728755E+00
MODE # 2	IP DISPLACEMENT	1	-.213493E+00	-.208445E+00	-.202068E+00	-.195692E+00	-.189315E+00
			-.182938E+00	-.176562E+00	-.170185E+00	-.163808E+00	-.157432E+00
			-.148398E+00	-.137770E+00	-.127142E+00	-.116515E+00	-.107215E+00
		2	-.224593E+00	-.219545E+00	-.213168E+00	-.206791E+00	-.200415E+00
			-.194038E+00	-.187661E+00	-.181285E+00	-.174908E+00	-.168531E+00
			-.159498E+00	-.148870E+00	-.138242E+00	-.127614E+00	-.118315E+00
		3	-.235693E+00	-.230645E+00	-.224268E+00	-.217891E+00	-.211515E+00
			-.205138E+00	-.198761E+00	-.192384E+00	-.186008E+00	-.179631E+00
			-.170598E+00	-.159970E+00	-.149342E+00	-.138714E+00	-.129415E+00
		4	-.246793E+00	-.241744E+00	-.235368E+00	-.228991E+00	-.222614E+00
			-.216238E+00	-.209861E+00	-.203484E+00	-.197108E+00	-.190731E+00
			-.181697E+00	-.171069E+00	-.160442E+00	-.149814E+00	-.140515E+00
		5	-.255117E+00	-.250069E+00	-.243692E+00	-.237316E+00	-.230939E+00
			-.224562E+00	-.218186E+00	-.211809E+00	-.205432E+00	-.199056E+00
			-.190022E+00	-.179394E+00	-.168766E+00	-.158139E+00	-.148839E+00
		6	-.266217E+00	-.261169E+00	-.254792E+00	-.248416E+00	-.242039E+00
			-.235662E+00	-.229285E+00	-.222909E+00	-.216532E+00	-.210155E+00
			-.201122E+00	-.190494E+00	-.179866E+00	-.169238E+00	-.159939E+00
		7	-.277317E+00	-.272269E+00	-.265892E+00	-.259515E+00	-.253139E+00
			-.246762E+00	-.240385E+00	-.234009E+00	-.227632E+00	-.221255E+00
			-.212222E+00	-.201594E+00	-.190966E+00	-.180338E+00	-.171039E+00
		8	-.288417E+00	-.283368E+00	-.276992E+00	-.270615E+00	-.264238E+00
			-.257862E+00	-.251485E+00	-.245108E+00	-.238732E+00	-.232355E+00
			-.223321E+00	-.212694E+00	-.202066E+00	-.191438E+00	-.182139E+00
	OOP DISPLACEMENT	1	0.187633E+00	0.181313E+00	0.173329E+00	0.165346E+00	0.157363E+00
			0.149379E+00	0.141396E+00	0.133413E+00	0.125429E+00	0.117446E+00
			0.106136E+00	0.928308E-01	0.795253E-01	0.662197E-01	0.545774E-01
		2	0.185583E+00	0.179263E+00	0.171279E+00	0.163296E+00	0.155313E+00
			0.147329E+00	0.139346E+00	0.131363E+00	0.123379E+00	0.115396E+00
			0.104086E+00	0.907609E-01	0.774753E-01	0.641698E-01	0.525275E-01
		3	0.183533E+00	0.177213E+00	0.169229E+00	0.161246E+00	0.153263E+00
			0.145279E+00	0.137296E+00	0.129313E+00	0.121329E+00	0.113346E+00
			0.102036E+00	0.887309E-01	0.754253E-01	0.621198E-01	0.504774E-01
		4	0.181483E+00	0.175163E+00	0.167179E+00	0.159196E+00	0.151213E+00
			0.143229E+00	0.135246E+00	0.127263E+00	0.119279E+00	0.111296E+00
			0.999864E-01	0.866808E-01	0.733753E-01	0.600698E-01	0.484275E-01
		5	0.179945E+00	0.173625E+00	0.165642E+00	0.157658E+00	0.149675E+00
			0.141692E+00	0.133709E+00	0.125725E+00	0.117742E+00	0.109759E+00
			0.984489E-01	0.851433E-01	0.718378E-01	0.585323E-01	0.468900E-01
		6	0.177895E+00	0.171575E+00	0.163592E+00	0.155608E+00	0.147625E+00
			0.139642E+00	0.131658E+00	0.123675E+00	0.115692E+00	0.107709E+00
			0.963989E-01	0.830933E-01	0.697878E-01	0.564823E-01	0.448400E-01
		7	0.175845E+00	0.169525E+00	0.161542E+00	0.153558E+00	0.145575E+00
			0.137592E+00	0.129609E+00	0.121625E+00	0.113642E+00	0.105659E+00
			0.943489E-01	0.810434E-01	0.677378E-01	0.544323E-01	0.427900E-01
		8	0.173795E+00	0.167475E+00	0.159492E+00	0.151508E+00	0.143525E+00
			0.135542E+00	0.127559E+00	0.119575E+00	0.111592E+00	0.103609E+00
			0.922989E-01	0.789934E-01	0.656878E-01	0.523823E-01	0.407400E-01
MODE # 3		1	-.479193E+00	-.471817E+00	-.462501E+00	-.453184E+00	-.443867E+00
			-.434550E+00	-.425233E+00	-.415917E+00	-.406600E+00	-.397283E+00
			-.384084E+00	-.368556E+00	-.353028E+00	-.337500E+00	-.323913E+00
		2	-.464694E+00	-.457318E+00	-.448001E+00	-.438684E+00	-.429368E+00
			-.420051E+00	-.410734E+00	-.401417E+00	-.392100E+00	-.382784E+00
			-.369585E+00	-.354057E+00	-.338529E+00	-.323001E+00	-.309414E+00
		3	-.450199E+00	-.442818E+00	-.433502E+00	-.424185E+00	-.414868E+00
			-.405551E+00	-.396235E+00	-.386918E+00	-.377601E+00	-.368284E+00
			-.355085E+00	-.339557E+00	-.324029E+00	-.308501E+00	-.294914E+00

TABLE IV (CONTINUED)

Mode	Displacement	Node					
MODE # 3 (CONTINUED)	IP DISPLACEMENT	4	-.435695E+00	-.428319E+00	-.419002E+00	-.409685E+00	-.400369E+00
			-.391052E+00	-.381735E+00	-.372418E+00	-.363101E+00	-.353785E+00
			-.340586E+00	-.325058E+00	-.309530E+00	-.294002E+00	-.280415E+00
		5	-.424820E+00	-.417444E+00	-.408128E+00	-.398811E+00	-.389494E+00
			-.380177E+00	-.370860E+00	-.361544E+00	-.352227E+00	-.342910E+00
			-.329711E+00	-.314183E+00	-.298655E+00	-.283127E+00	-.269540E+00
		6	-.410321E+00	-.402945E+00	-.393628E+00	-.384311E+00	-.374995E+00
			-.365678E+00	-.356361E+00	-.347044E+00	-.337727E+00	-.328411E+00
			-.315212E+00	-.299684E+00	-.284156E+00	-.268628E+00	-.255041E+00
		7	-.395621E+00	-.388445E+00	-.379129E+00	-.369812E+00	-.360495E+00
			-.351178E+00	-.341861E+00	-.332545E+00	-.323228E+00	-.313911E+00
			-.300712E+00	-.285184E+00	-.269656E+00	-.254128E+00	-.240541E+00
		8	-.381322E+00	-.373946E+00	-.364629E+00	-.355312E+00	-.345996E+00
			-.336679E+00	-.327362E+00	-.318045E+00	-.308728E+00	-.299412E+00
			-.286213E+00	-.270685E+00	-.255157E+00	-.239629E+00	-.226042E+00
	OOP DISPLACEMENT	1	-.547007E-01	-.614263E-01	-.699217E-01	-.784175E-01	-.869129E-01
			-.954084E-01	-.103904E+00	-.112399E+00	-.120895E+00	-.129390E+00
			-.141425E+00	-.155584E+00	-.169743E+00	-.183902E+00	-.196292E+00
		2	-.183343E+00	-.190069E+00	-.198564E+00	-.207060E+00	-.215555E+00
			-.224051E+00	-.232546E+00	-.241042E+00	-.249537E+00	-.258033E+00
			-.270068E+00	-.284227E+00	-.298386E+00	-.312545E+00	-.324934E+00
		3	-.311985E+00	-.318711E+00	-.327207E+00	-.335702E+00	-.344198E+00
			-.352693E+00	-.361189E+00	-.369684E+00	-.378179E+00	-.386675F+00
			-.398710E+00	-.412869E+00	-.427028E+00	-.441187E+00	-.453576E+00
		4	-.440628E+00	-.447353E+00	-.455849E+00	-.464344E+00	-.472840E+00
			-.481335E+00	-.489831E+00	-.498326E+00	-.506822E+00	-.515317E+00
			-.527352E+00	-.541511E+00	-.555671E+00	-.569830E+00	-.582219E+00
		5	-.537109E+00	-.543835E+00	-.552330E+00	-.560826E+00	-.569321E+00
			-.577817E+00	-.586312E+00	-.594808E+00	-.603303E+00	-.611799E+00
			-.623834E+00	-.637993E+00	-.652152E+00	-.666312E+00	-.678701E+00
		6	-.665752E+00	-.672477E+00	-.680973E+00	-.689468E+00	-.697964E+00
			-.706459E+00	-.714955E+00	-.723450E+00	-.731945E+00	-.740441E+00
			-.752477E+00	-.766635E+00	-.780795E+00	-.794954E+00	-.807343E+00
		7	-.794394E+00	-.801120E+00	-.809615E+00	-.818110E+00	-.826606E+00
			-.835101E+00	-.843597E+00	-.852092E+00	-.860588E+00	-.869083E+00
			-.881119E+00	-.895278E+00	-.909437E+00	-.923596E+00	-.935986E+00
		8	-.923036E+00	-.929762E+00	-.938257E+00	-.946753E+00	-.955248E+00
			-.963744E+00	-.972239E+00	-.980735E+00	-.989230E+00	-.997726E+00
			-.100976E+01	-.102392E+01	-.103808E+01	-.105224E+01	-.106463E+01
MODE # 4	IP DISPLACEMENT	1	0.779122E+00	0.711728E+00	0.626601E+00	0.541472E+00	0.456345E+00
			0.371216E+00	0.286088E+00	0.200960E+00	0.115832E+00	0.307035E-01
			-.898941E-01	-.231775E+00	-.373655E+00	-.515536E+00	-.639682E+00
		2	0.690937E+00	0.623543E+00	0.538415E+00	0.453287E+00	0.368159E+00
			0.283031E+00	0.197903E+00	0.112775E+00	0.276468E-01	-.574816E-01
			-.178079E+00	-.319961E+00	-.461841E+00	-.603721E+00	-.727866E+00
		3	0.602752E+00	0.535358E+00	0.450230E+00	0.365102E+00	0.279974E+00
			0.194846E+00	0.109718E+00	0.245897E-01	-.605383E-01	-.145667E+00
			-.266264E+00	-.408146E+00	-.550026E+00	-.691907E+00	-.816052E+00
		4	0.514566E+00	0.447172E+00	0.362045E+00	0.276917E+00	0.191789E+00
			0.106661E+00	0.215327E-01	-.635955E-01	-.148724E+00	-.233852E+00
			-.354450E+00	-.496331E+00	-.638211E+00	-.780092E+00	-.904237E+00
		5	0.448427E+00	0.381033E+00	0.295906E+00	0.210778E+00	0.125650E+00
			0.405217E-01	-.446062E-01	-.129734E+00	-.214863E+00	-.299991E+00
			-.420589E+00	-.562470E+00	-.704350E+00	-.846231E+00	-.970376E+00
		6	0.360242E+00	0.292848E+00	0.207721E+00	0.122593E+00	0.374649E-01
			-.476634E-01	-.132791E+00	-.217920E+00	-.303048E+00	-.388176E+00
			-.508774E+00	-.650655E+00	-.792535E+00	-.934416E+00	-.105856E+01
		7	0.272057E+00	0.204663E+00	0.119536E+00	0.344073E-01	-.507202E-01
			-.135848E+00	-.220976E+00	-.306105E+00	-.391233E+00	-.476361E+00
			-.596959E+00	-.738841E+00	-.860721E+00	-.102260E+01	-.114675E+01

TABLE IV (CONTINUED)

	MODE # 4 (CONTINUED)	8	0.183872E+00	0.116478E+00	0.313503E-01	-.537779E-01	-.138905E+00
			-.224034E+00	-.309162E+00	-.394290E+00	-.479418E+00	-.564547E+00
			-.685144E+00	-.827026E+00	-.968906E+00	-.111079E+01	-.123493E+01
OOP DISPLACEMENT	MODE # 4 (CONTINUED)	1	-.162351E+01	-.150096E+01	-.134617E+01	-.119138E+01	-.103658E+01
			-.881787E+00	-.726993E+00	-.572199E+00	-.417404E+00	-.262610E+00
			-.433183E-01	0.214672E+00	0.472663E+00	0.730653E+00	0.956395E+00
		2	-.153742E+01	-.141467E+01	-.126008E+01	-.110528E+01	-.950488E+00
			-.795694E+00	-.640900E+00	-.486105E+00	-.331311E+00	-.176517E+00
			0.427747E-01	0.300765E+00	0.558756E+00	0.816747E+00	0.104249E+01
		3	-.145132E+01	-.132878E+01	-.117398E+01	-.101919E+01	-.864395E+00
			-.709601E+00	-.554806E+00	-.400012E+00	-.245218E+00	-.904236E-01
			0.128868E+00	0.386858E+00	0.644849E+00	0.902839E+00	0.112856E+01
		4	-.136523E+01	-.124268E+01	-.108789E+01	-.933096E+00	-.778302E+00
			-.623507E+00	-.468713E+00	-.313919E+00	-.159125E+00	-.433034E-02
			0.214961E+00	0.472952E+00	0.730943E+00	0.988932E+00	0.121467E+01
		5	-.130066E+01	-.117811E+01	-.102332E+01	-.868526E+00	-.713732E+00
			-.558937E+00	-.404143E+00	-.249349E+00	-.945548E-01	0.602396E-01
			0.279531E+00	0.537522E+00	0.795513E+00	0.105350E+01	0.127924E+01
		6	-.121457E+01	-.109202E+01	-.937228E+00	-.782433E+00	-.627639E+00
			-.472845E+00	-.318050E+00	-.163256E+00	-.846177E-02	0.146333E+00
			0.365624E+00	0.623615E+00	0.881606E+00	0.113960E+01	0.136534E+01
		7	-.112847E+01	-.100593E+01	-.851134E+00	-.696340E+00	-.541546E+00
			-.386751E+00	-.231957E+00	-.771627E-01	0.776315E-01	0.232426E+00
			0.451718E+00	0.709708E+00	0.967699E+00	0.122569E+01	0.145143E+01
		8	-.104238E+01	-.919835E+00	-.765041E+00	-.610247E+00	-.455452E+00
			-.300658E+00	-.145864E+00	0.893062E-02	0.163725E+00	0.318519E+00
			0.537811E+00	0.795801E+00	0.105379E+01	0.131178E+01	0.153752E+01
IP DISPLACEMENT	MODE # 5	1	-.851468E+00	-.890776E+00	-.940402E+00	-.990028E+00	-.103965E+01
			-.108928E+01	-.113891E+01	-.118853E+01	-.123816E+01	-.128778E+01
			-.135809E+01	-.144080E+01	-.152351E+01	-.160622E+01	-.167859E+01
		2	-.570332E+00	-.609620E+00	-.659244E+00	-.708871E+00	-.758497E+00
			-.808123E+00	-.857750E+00	-.907376E+00	-.957002E+00	-.100663E+01
			-.107693E+01	-.115964E+01	-.124235E+01	-.132506E+01	-.139744E+01
		3	-.289174E+00	-.328462E+00	-.378088E+00	-.427714E+00	-.477340E+00
			-.526966E+00	-.576592E+00	-.626219E+00	-.675845E+00	-.725471E+00
			-.795775E+00	-.878486E+00	-.961196E+00	-.104391E+01	-.111628E+01
		4	-.801569E-02	-.473041E-01	-.969300E-01	-.146556E+00	-.196182E+00
			-.245809E+00	-.295435E+00	-.345061E+00	-.394688E+00	-.444314E+00
			-.514618E+00	-.597328E+00	-.680039E+00	-.762749E+00	-.835120E+00
		5	0.202853E+00	0.163564E+00	0.113938E+00	0.643118E-01	0.146857E-01
			-.349408E-01	-.845674E-01	-.134194E+00	-.183820E+00	-.233446E+00
			-.303750E+00	-.386460E+00	-.469171E+00	-.551881E+00	-.624253E+00
		6	0.484010E+00	0.444721E+00	0.395095E+00	0.345469E+00	0.295843E+00
			0.246216E+00	0.196590E+00	0.146964E+00	0.973374E-01	0.477108E-01
			-.225926E-01	-.105304E+00	-.188014E+00	-.270725E+00	-.343095E+00
		7	0.765165E+00	0.725878E+00	0.676252E+00	0.626626E+00	0.577000E+00
			0.527373E+00	0.477747E+00	0.428121E+00	0.378494E+00	0.328868E+00
			0.258565E+00	0.175853E+00	0.931430E-01	0.104324E-01	-.619392E-01
		8	0.104632E+01	0.100703E+01	0.957409E+00	0.907783E+00	0.858157E+00
			0.808531E+00	0.758905E+00	0.709278E+00	0.659652E+00	0.610025E+00
			0.539722E+00	0.457011E+00	0.374300E+00	0.291590E+00	0.219218E+00
		1	0.473928E+00	0.573437E+00	0.699132E+00	0.824827E+00	0.950522E+00
			0.107622E+01	0.120191E+01	0.132761E+01	0.145330E+01	0.157900E+01
			0.175706E+01	0.196656E+01	0.217605E+01	0.238554E+01	0.256885E+01
		2	0.194690E+00	0.294199E+00	0.419894E+00	0.545590E+00	0.671284E+00
			0.796980E+00	0.922675E+00	0.104837E+01	0.117406E+01	0.129976E+01
			0.147783E+01	0.168732E+01	0.189681E+01	0.210630E+01	0.228961E+01
		3	-.845468E-01	0.149618E-01	0.140656E+00	0.266352E+00	0.392047E+00
			0.517742E+00	0.643437E+00	0.769133E+00	0.894828E+00	0.102052E+01
			0.119859E+01	0.140808E+01	0.161757E+01	0.182707E+01	0.201037E+01

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TABLE IV (CONTINUED)

OOP DISPLACEMENT	4	-.363784E+00	-.264275E+00	-.138581E+00	-.128852E-01	0.112810E+00	MODE # 5 (CONTINUED)
		0.239505E+00	0.364200E+00	0.489895E+00	0.615590E+00	0.741286E+00	
		0.919353E+00	0.112885E+01	0.133834E+01	0.154783E+01	0.173113E+01	
	5	-.573212E+00	-.473703E+00	-.348009E+00	-.222313E+00	-.966182E-01	
		0.290771E-01	0.154772E+00	0.280467E+00	0.406163E+00	0.531857E+00	
		0.709925E+00	0.919418E+00	0.112891E+01	0.133840E+01	0.152170E+01	
	6	-.852450E+00	-.752940E+00	-.627246E+00	-.501550E+00	-.375855E+00	
		-.250160E+00	-.124465E+00	0.123000E-02	0.126925E+00	0.252621E+00	
		0.430688E+00	0.640180E+00	0.849671E+00	0.105916E+01	0.124247E+01	
	7	-.113169E+01	-.103216E+01	-.906483E+00	-.780788E+00	-.655092E+00	
		-.529397E+00	-.403702E+00	-.278007E+00	-.152312E+00	-.266171E-01	
		0.151451E+00	0.360942E+00	0.570434E+00	0.779926E+00	0.963231E+00	
	8	-.141092E+01	-.131141E+01	-.118572E+01	-.106002E+01	-.934330E+00	
		-.806635E+00	-.682940E+00	-.557244E+00	-.431549E+00	-.305855E+00	
		-.127786E+00	0.817063E-01	0.291196E+00	0.500688E+00	0.683995E+00	
STRESS X	1	15*1.880+4					MODE # 1
	2	15*1.662+4					
	3	15*1.515+4					
	4	15*1.422+4					
	5	15*1.352+4					
	6	15*1.134+4					
	7	15*9.170+3					
	8	15*7.024+3					
STRESS Y	1	15*-2.335+4					
	2	15*-2.066+4					
	3	15*-1.885+4					
	4	15*-1.771+4					
	5	15*-1.684+4					
	6	15*-1.416+4					
	7	15*-1.149+4					
	8	15*-8.852+3					
SHEAR XY	1	15*-6.650+2					
	2	15*-6.650+2					
	3	15*-6.649+2					
	4	15*-6.649+2					
	5	15*-6.649+2					
	6	15*-6.642+2					
	7	15*-6.626+2					
	8	15*-6.597+2					
STRESS X	1	15*-4.283+3					MODE # 2
	2	15*-3.280+3					
	3	15*-2.603+3					
	4	15*-2.177+3					
	5	15*-1.852+3					
	6	15*-8.522+2					
	7	15*1.290+2					
	8	15*1.051+3					
STRESS Y	1	15*3.062+4					
	2	15*2.661+4					
	3	15*2.390+4					
	4	15*2.220+4					
	5	15*2.089+4					
	6	15*1.689+4					
	7	15*1.294+4					
	8	15*9.094+3					
SHEAR XY	1	15*-3.072+3					
	2	15*-3.072+3					
	3	15*-3.071+3					
	4	15*-3.071+3					
	5	15*-3.071+3					

TABLE IV (CONTINUED)

	6	15*-3.072+3	MODE # 2 (CONT)
	7	15*-3.074+3	
	8	15*-3.077+3	
STRESS X	1	15*-3.134+5	MODE #3
	2	15*-2.767+5	
	3	15*-2.520+5	
	4	15*-2.365+5	
	5	15*-2.247+5	
	6	15*-1.884+5	
	7	15*-1.525+5	
	8	15*-1.172+5	
STRESS Y	1	15*-2.594+5	
	2	15*-2.277+5	
	3	15*-2.064+5	
	4	15*-1.930+5	
	5	15*-1.828+5	
	6	15*-1.514+5	
	7	15*-1.207+5	
	8	15*-9.099+4	
SHEAR XY	1	15*-3.610+3	
	2	15*-3.609+3	
	3	15*-3.608+3	
	4	15*-3.608+3	
	5	15*-3.607+3	
	6	15*-3.592+3	
	7	15*-3.564+3	
	8	15*-3.527+3	
STRESS X	1	15*1.378+5	MODE #4
	2	15*1.194+5	
	3	15*1.070+5	
	4	15*9.921+4	
	5	15*9.329+4	
	6	15*7.520+4	
	7	15*5.754+4	
	8	15*4.084+4	
STRESS Y	1	15*2.036+3	
	2	15*5.077+2	
	3	15*2.225+3	
	4	15*3.304+3	
	5	15*4.128+3	
	6	15*6.655+3	
	7	15*9.017+3	
	8	15*1.084+4	
SHEAR XY	1	15*5.286+4	
	2	15*5.284+4	
	3	15*5.281+4	
	4	15*5.280+4	
	5	15*5.279+4	
	6	15*5.272+4	
	7	15*5.256+4	
	8	15*5.225+4	
STRESS X	1	15*-4.971+5	MODE #5
	2	15*-4.174+5	
	3	15*-3.637+5	
	4	15*-3.301+5	
	5	15*-3.045+5	
	6	15*-2.263+5	
	7	15*-1.506+5	
	8	15*-8.069+4	
	1	15*-1.718+3	

TABLE IV (CONTINUED)

STRESS Y	2	15*-2.115+4	MODE #5 (CONTINUED)
	3	15*-3.426+4	
	4	15*-4.251+4	
	5	15*-4.882+4	
	6	15*-6.822+4	
	7	15*-8.642+4	
	8	15*-1.009+5	
SHEAR XY	1	15*9.835+4	
	2	15*9.828+4	
	3	15*9.821+4	
	4	15*9.817+4	
	5	15*9.814+4	
	6	15*9.780+4	
	7	15*9.704+4	
	8	15*9.570+4	

YNODE(1) 27.0
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(2) 28.0
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(3) 29.0
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(4) 30.0
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(5) 30.75
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(6) 31.75
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(7) 32.75
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
YNODE(8) 33.75
XNODE { 11.0,11.6,12.2,12.8,13.4,14.0,14.6,15.2,15.8,16.4,17.25,
18.25,19.25,20.25,21.00
X Φ { 1.0,1.473,1.946,2.418,2.891,3.364,3.837,4.310,4.782,5.255,5.925,6.713,
7.501,8.289,8.860
Y Φ { 1.0,1.369,1.739,2.108,2.478,2.847,3.216,3.586,3.955,4.325,4.848,5.463,
6.079,6.695,7.141

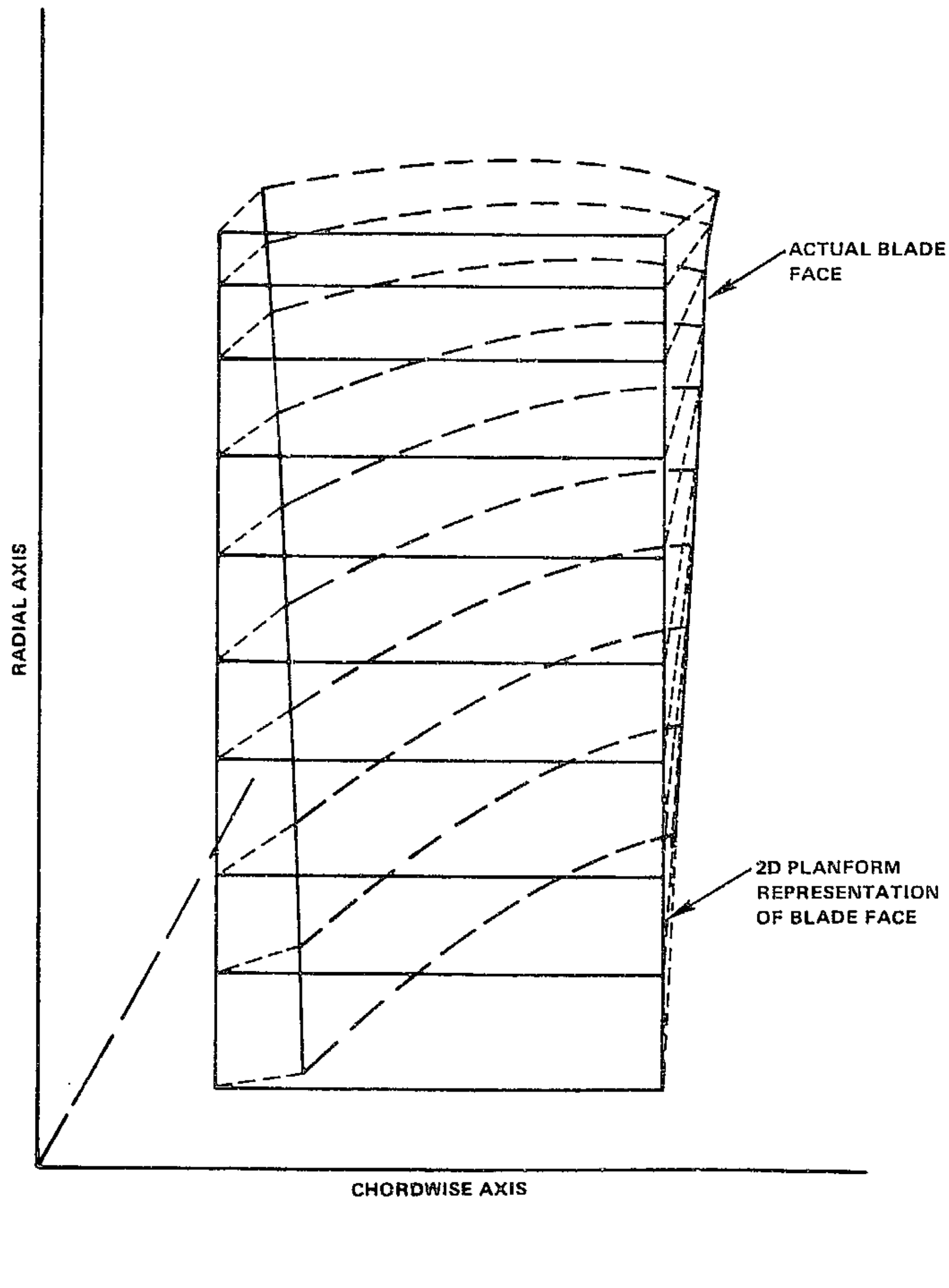


FIGURE 1. BLADE FACE MAPPED OUT ON PLANFORM PLANE

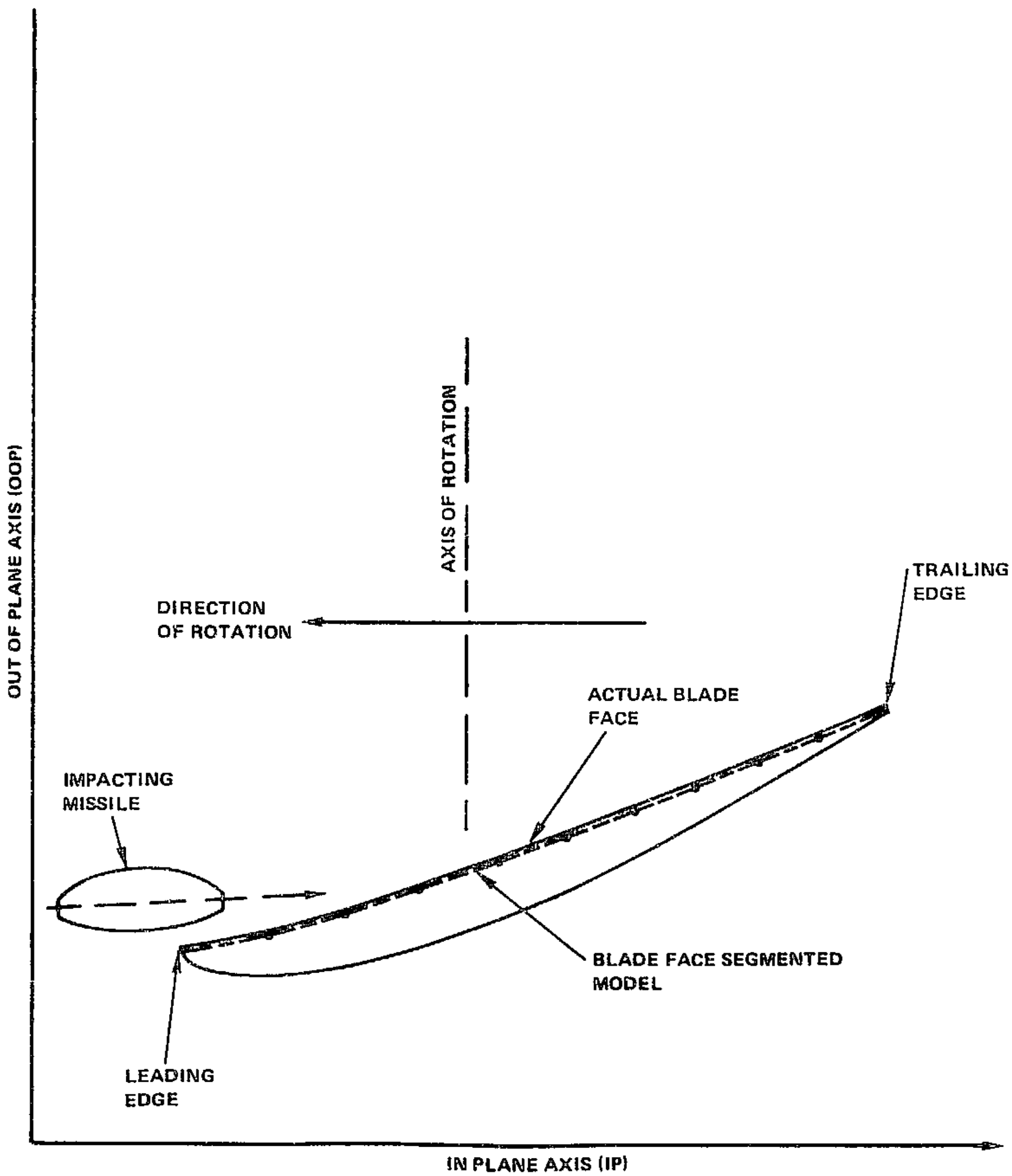


FIGURE 2. BLADE CROSS SECTION IN IP-OOP FRAME

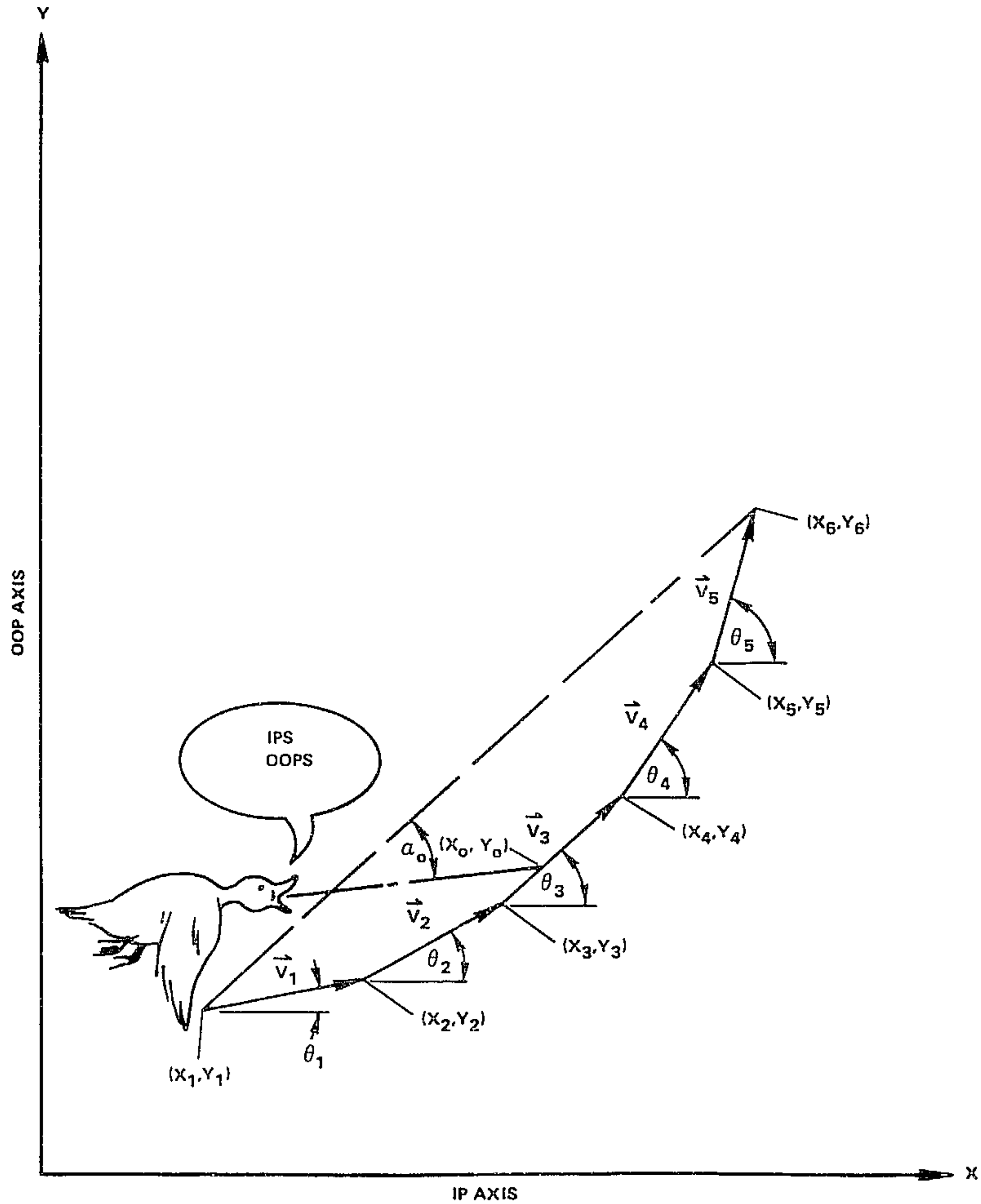


FIGURE 3. BLADE SEGMENTS IN IP-OOP FRAME

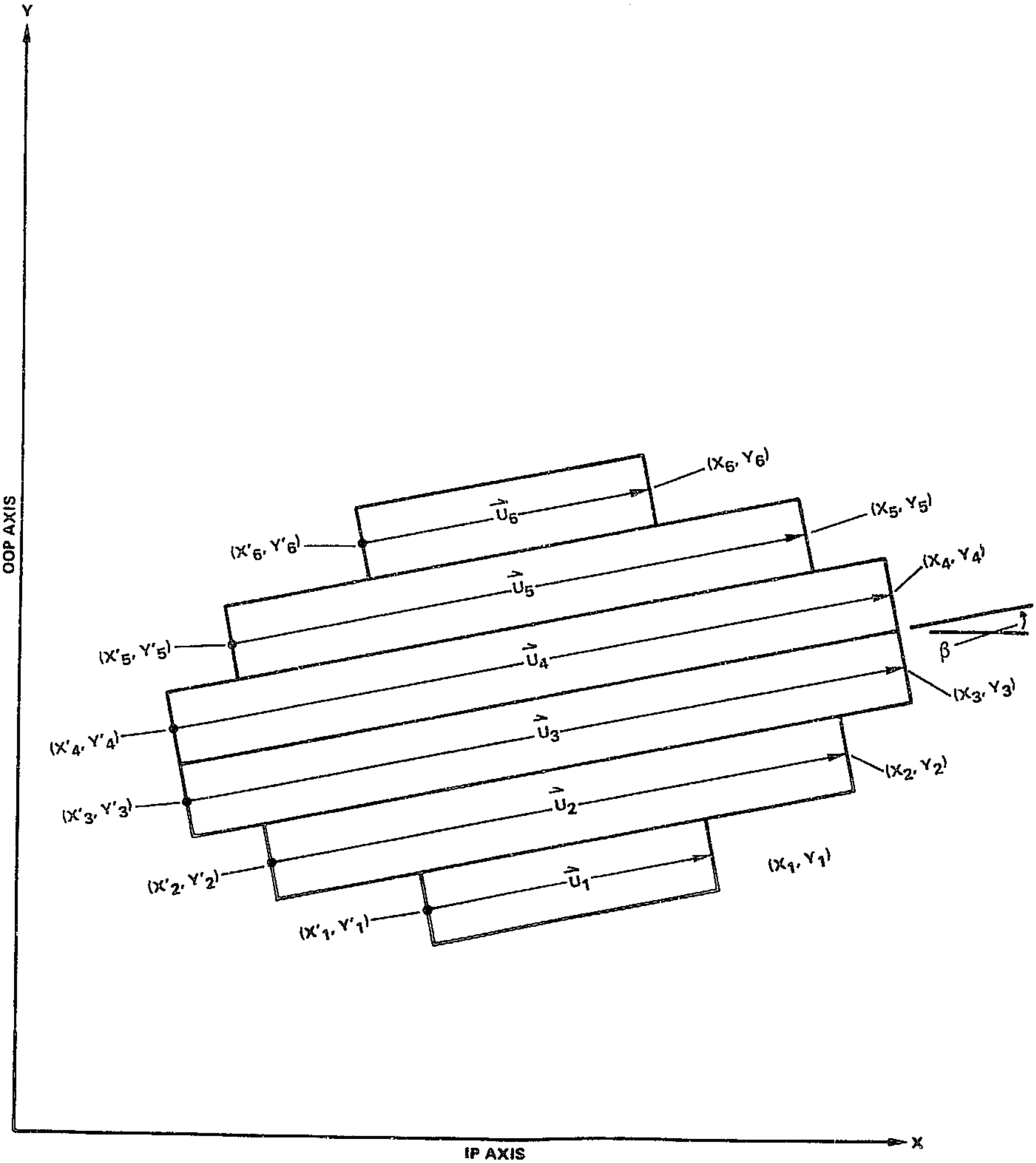


FIGURE 4. MISSILE SECTIONS IN IP-OOP FRAME

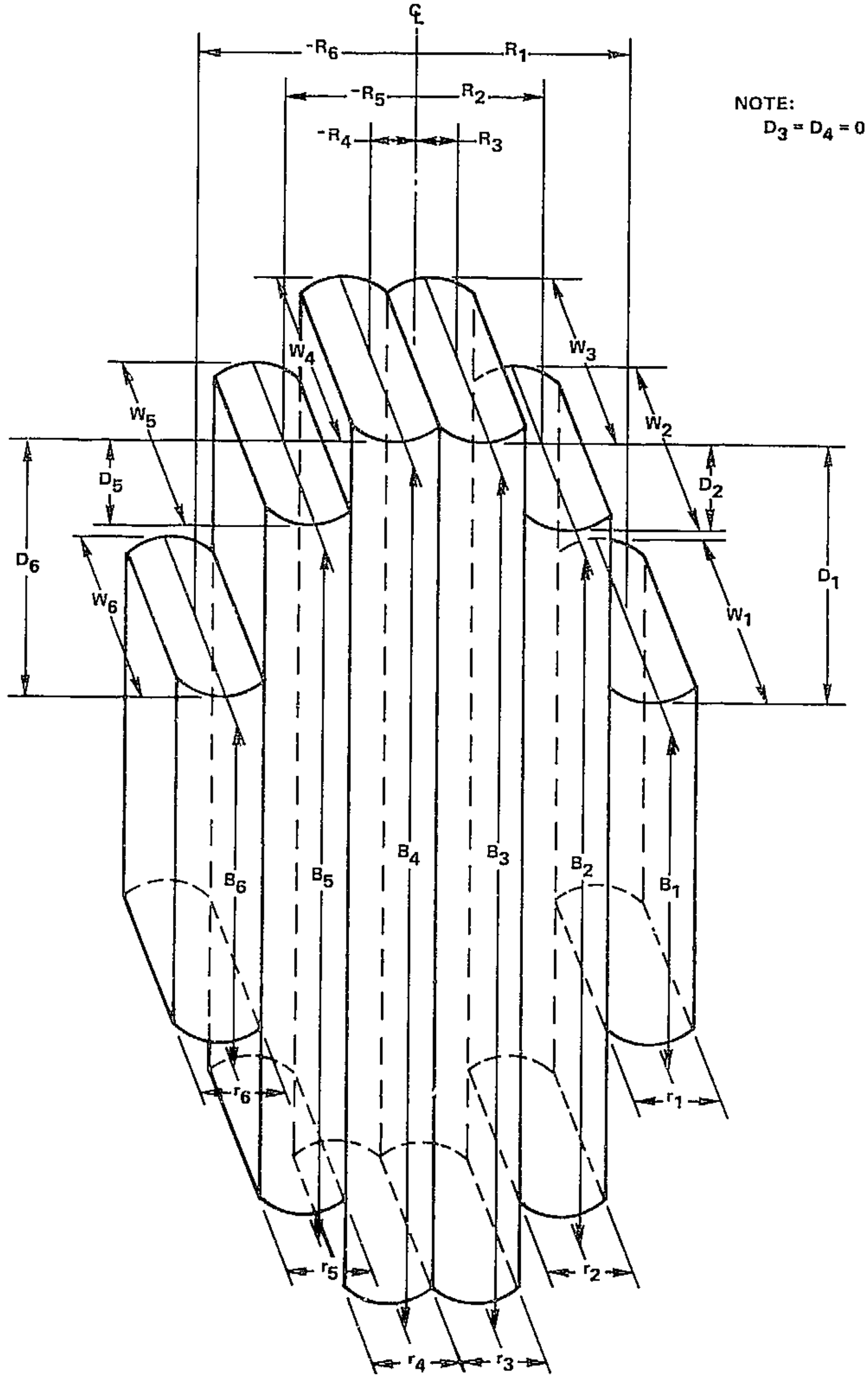


FIGURE 5. MISSILE DEFINITION

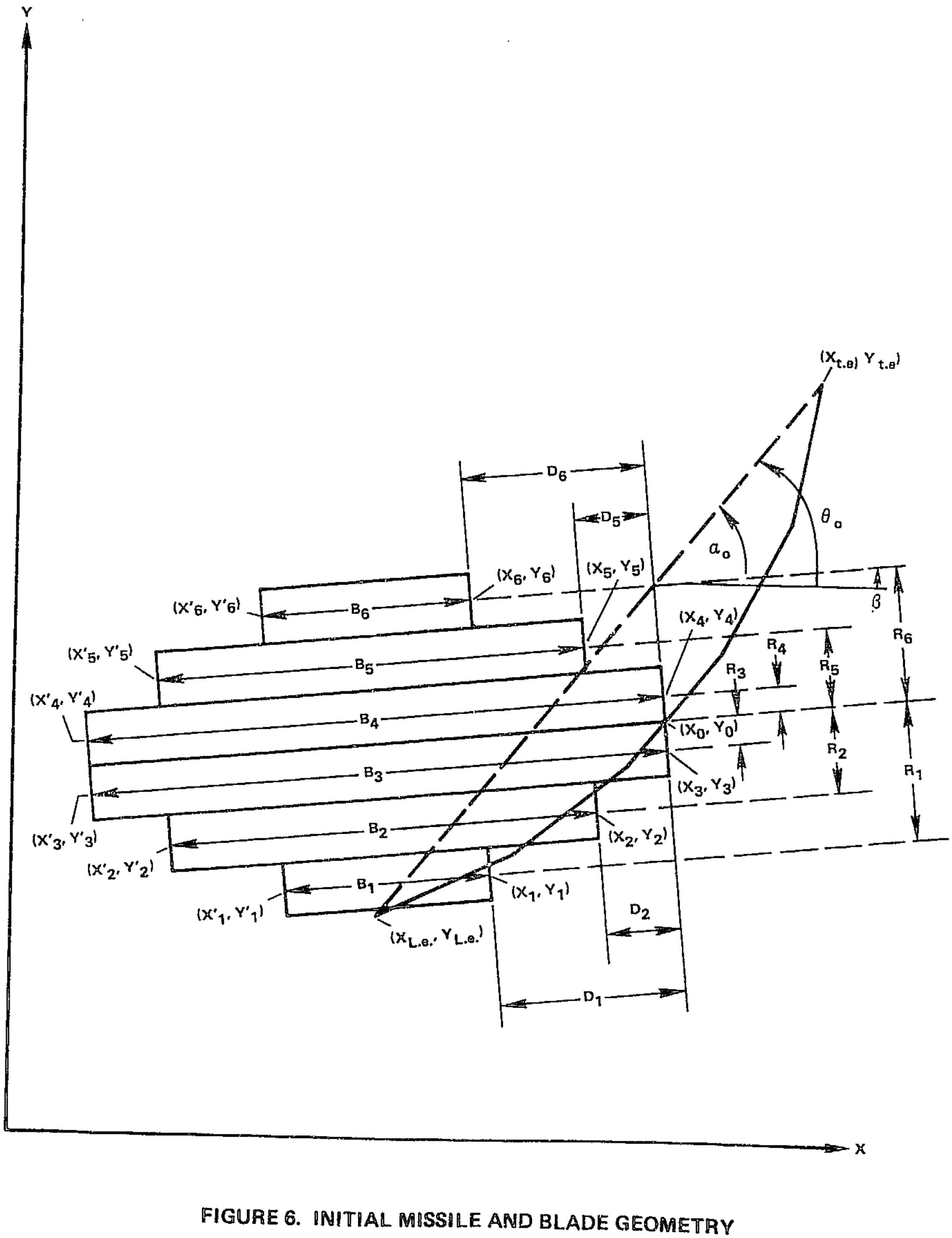


FIGURE 6. INITIAL MISSILE AND BLADE GEOMETRY

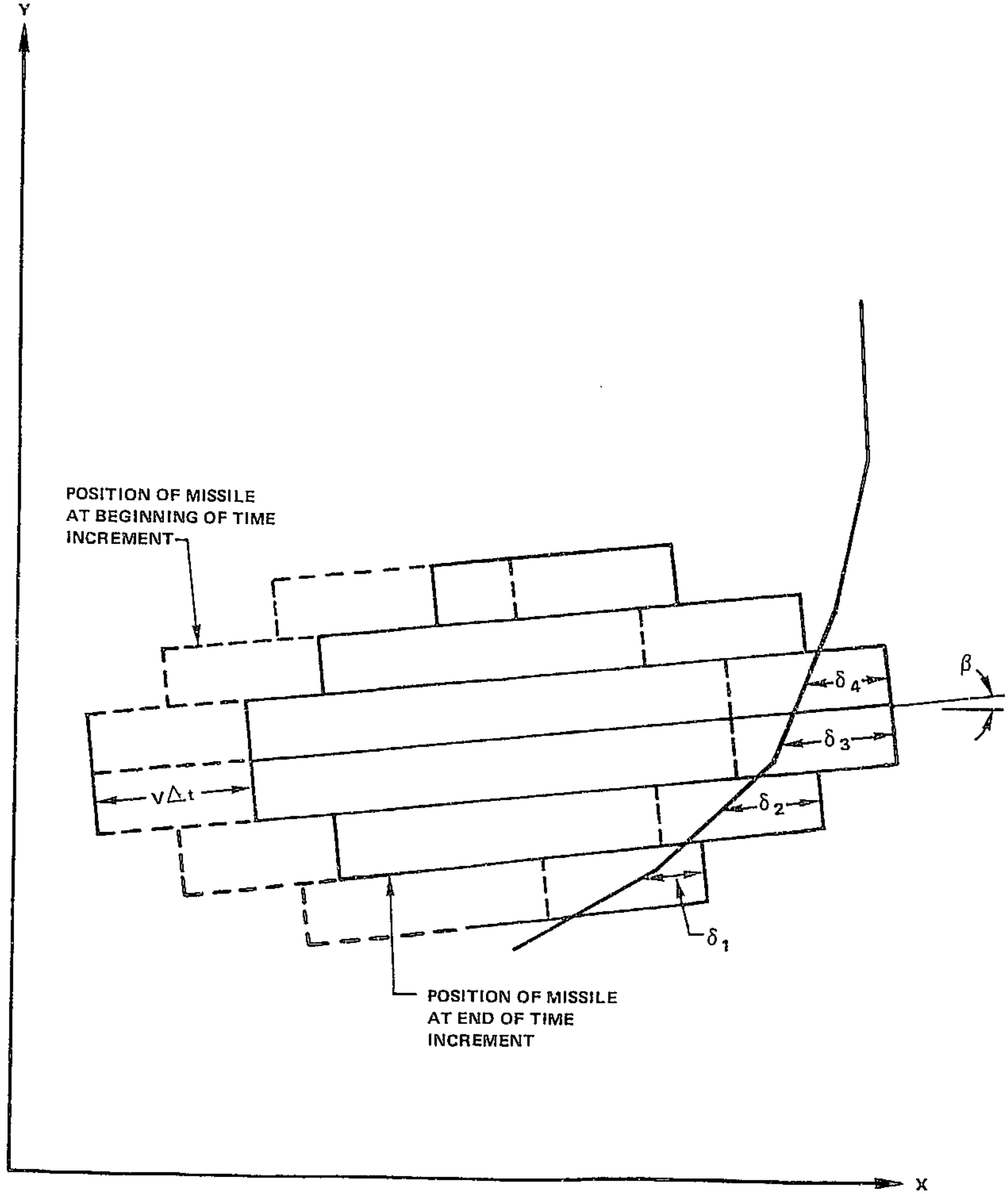


FIGURE 7. MISSILE AND BLADE GEOMETRY DURING TIMES OF IMPACT

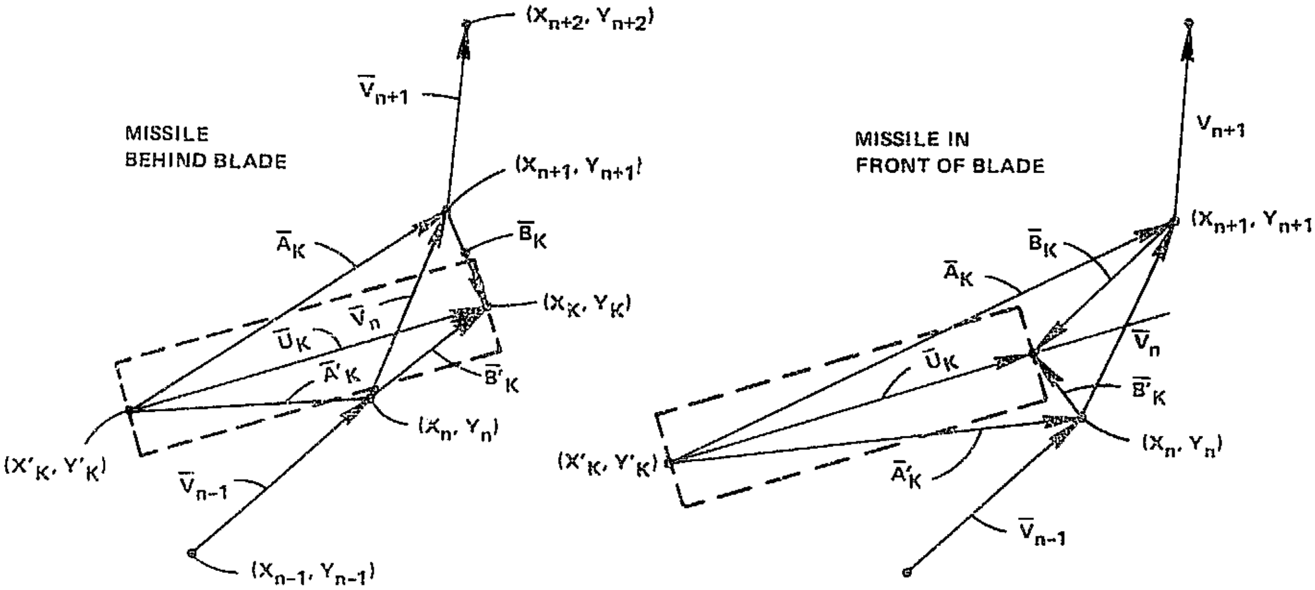
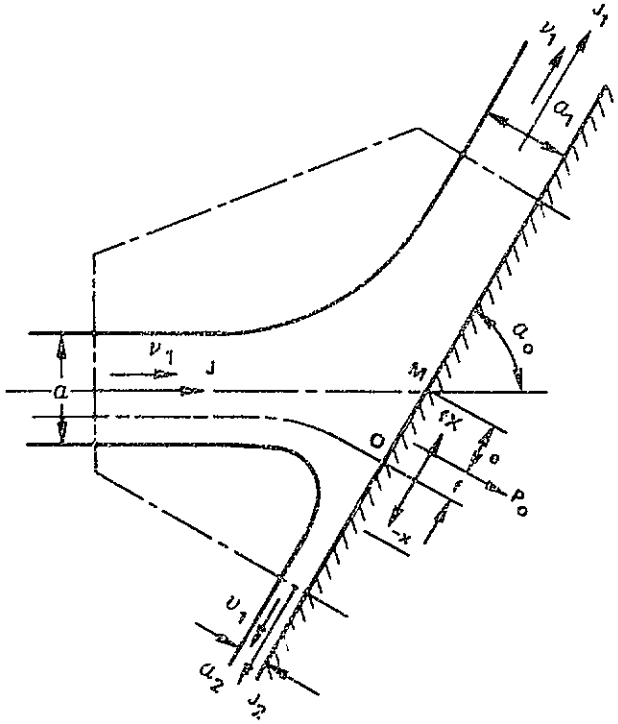


FIGURE 8. DETERMINATION OF BLADE SEGMENT TO BE HIT



$$a_1/a = \cos^2 \alpha_o/2 \; ; \; a_2/a = \sin^2 \alpha_o/2$$

$$e/a = 1/2 \cot \alpha_o$$

$$f/a = \frac{1}{\pi}\left[\cos \alpha_o \ln (2 \sin \alpha_o) + \ln \cot \frac{\alpha_o}{2} + \left(\frac{\pi}{2} - \alpha_o\right) \sin \alpha_o\right]$$

$$P_o = \rho v_1^2 \sin \alpha_o$$

$$x/a = \frac{1}{\pi}\left[\cos \alpha_o \ln \left\{\left(\frac{1}{1-r^2}\right)\left(\frac{\sin \alpha_o}{\sin \gamma}\right)^2\right\} + \ln \left(\frac{1+r}{1-r}\right) + 2(\pi - \alpha_o - \gamma) \sin \alpha_o\right]$$

$$P = P_o (1-r^2)$$

$$r = v/v_1 ; \; \tan \gamma^{1 \text{ OR } 2} = \left(\frac{\sin \alpha_o}{r - \cos \alpha_o}\right) \; ; \; P_o = 1/2 \rho v_1^2$$

FIGURE 9. TWO DIMENSIONAL JET MISSILE - SCHACH

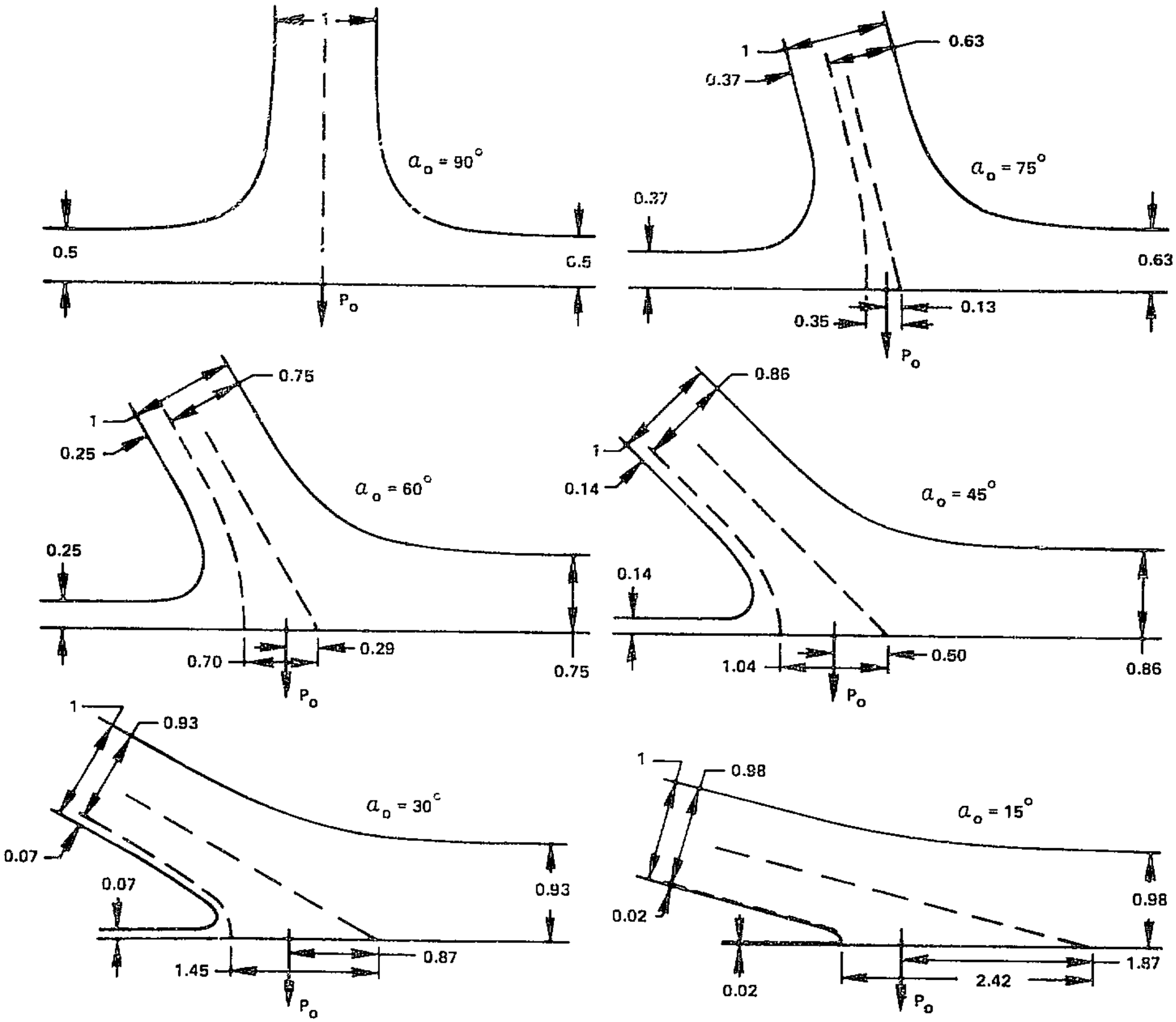


FIGURE 10. STREAMFORM FOR 2D JET – SCHACH

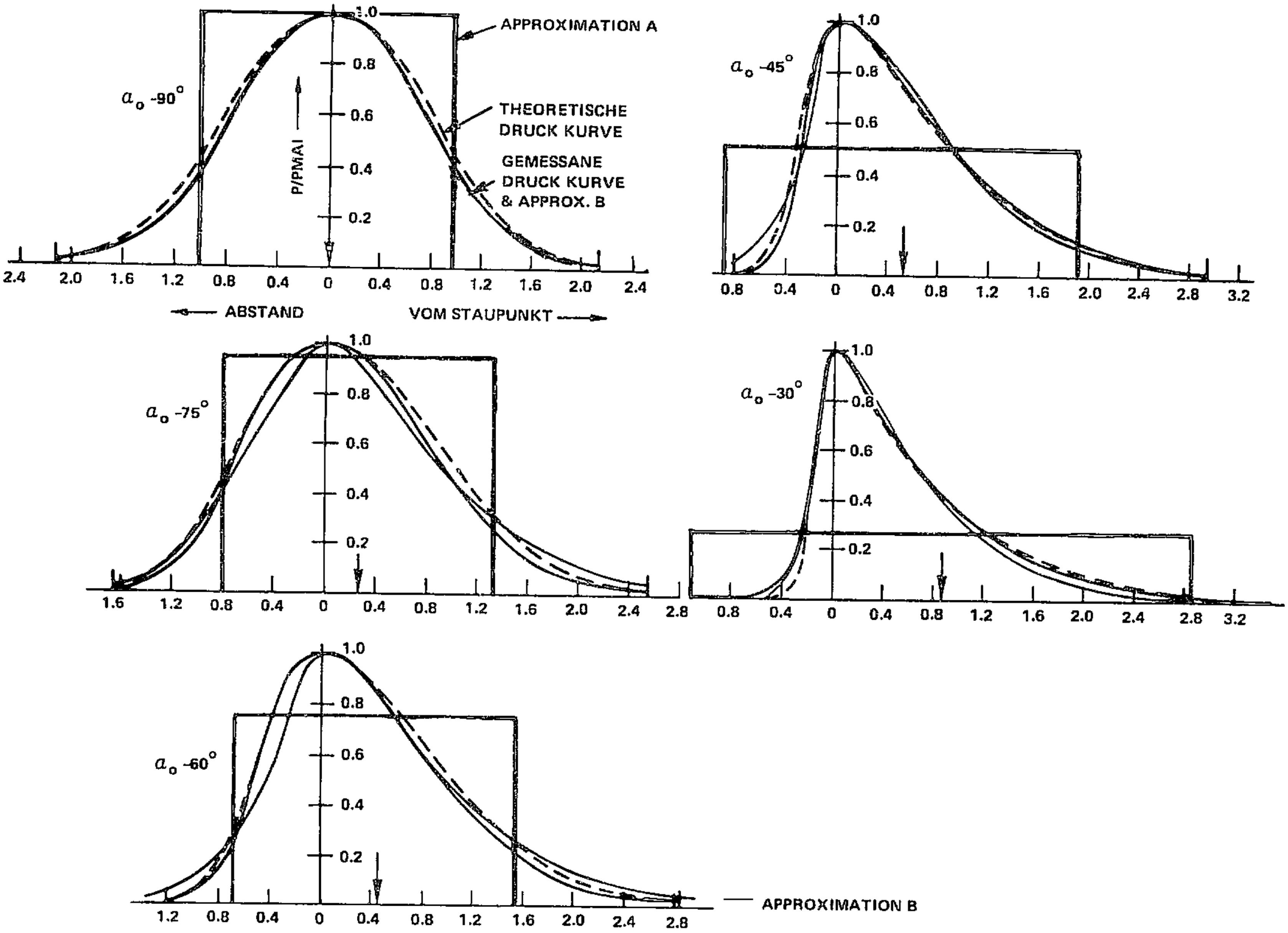


FIGURE 11. PRESSURE DISTRIBUTIONS FOR 2D JET MEASURED, SCHACH & APPROXIMATIONS

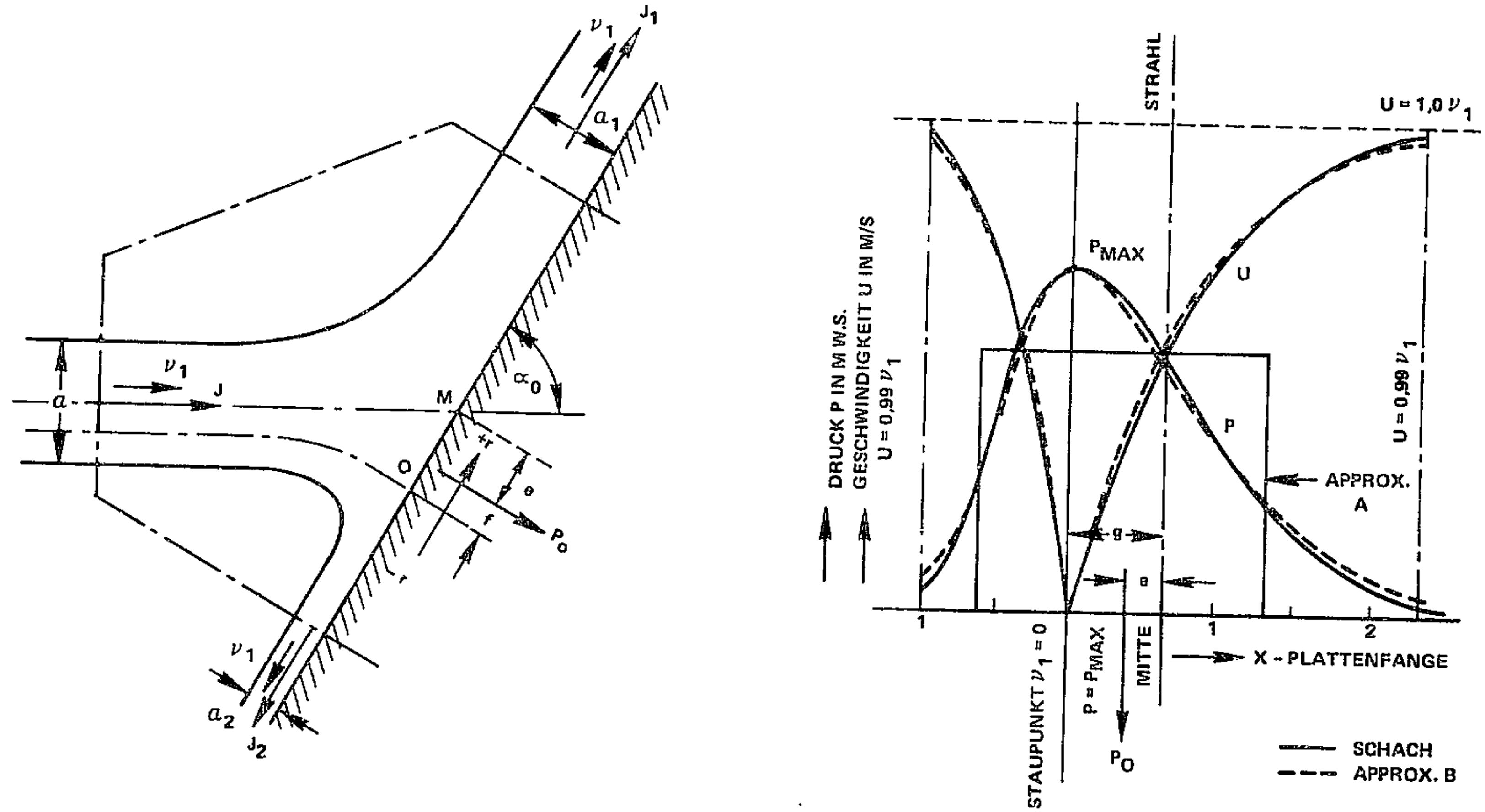


FIGURE 12. PRESSURE & VELOCITY DISTRIBUTIONS FOR 60° IMPINGEMENT OF 2D JET SCHACH & APPROXIMATIONS

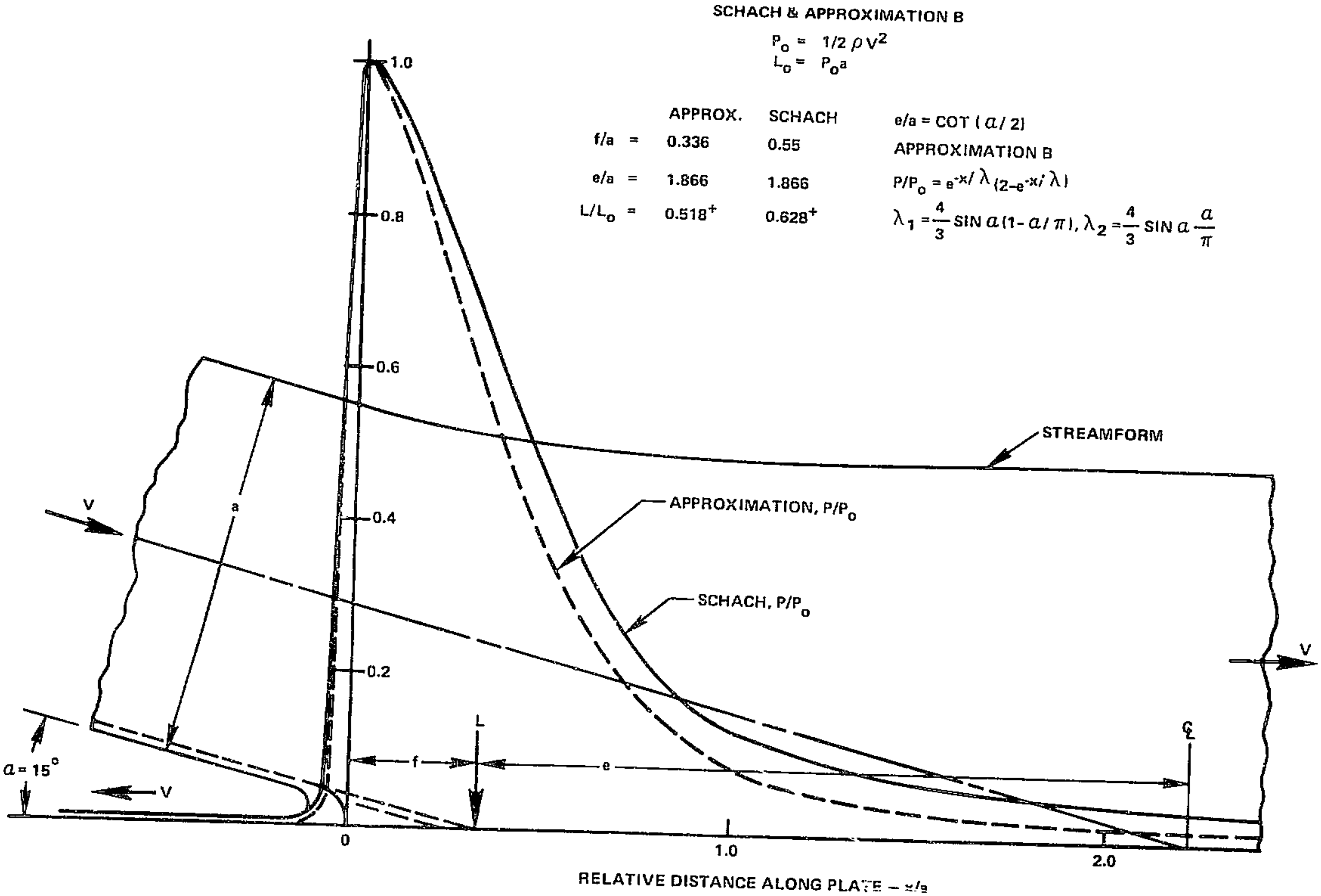


FIGURE 13. PRESSURE DISTRIBUTIONS FOR 15° 2D JET

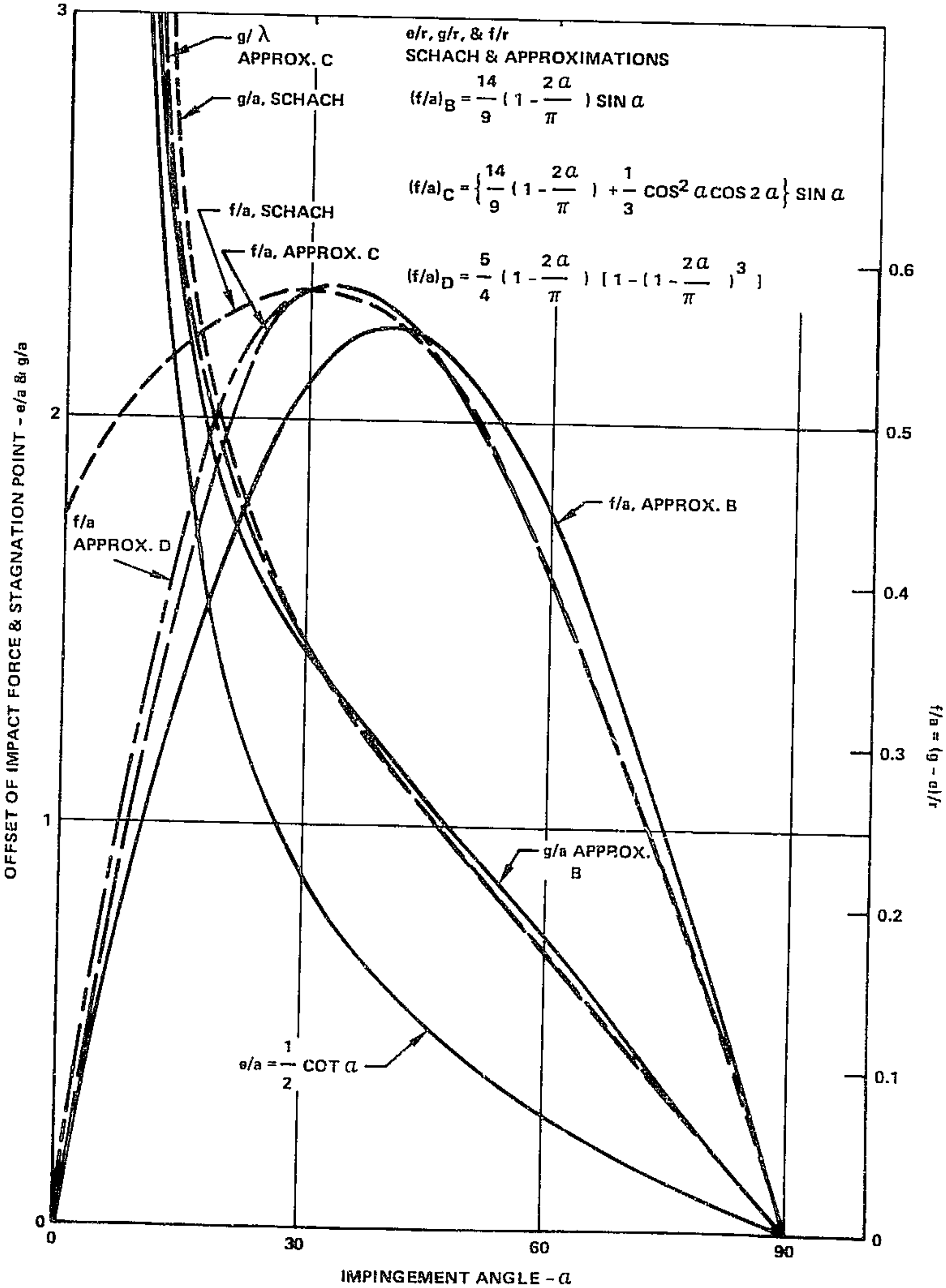


FIGURE 14. LOCATIONS FOR 2D JET OF IMPACT FORCE & STAGNATION POINT

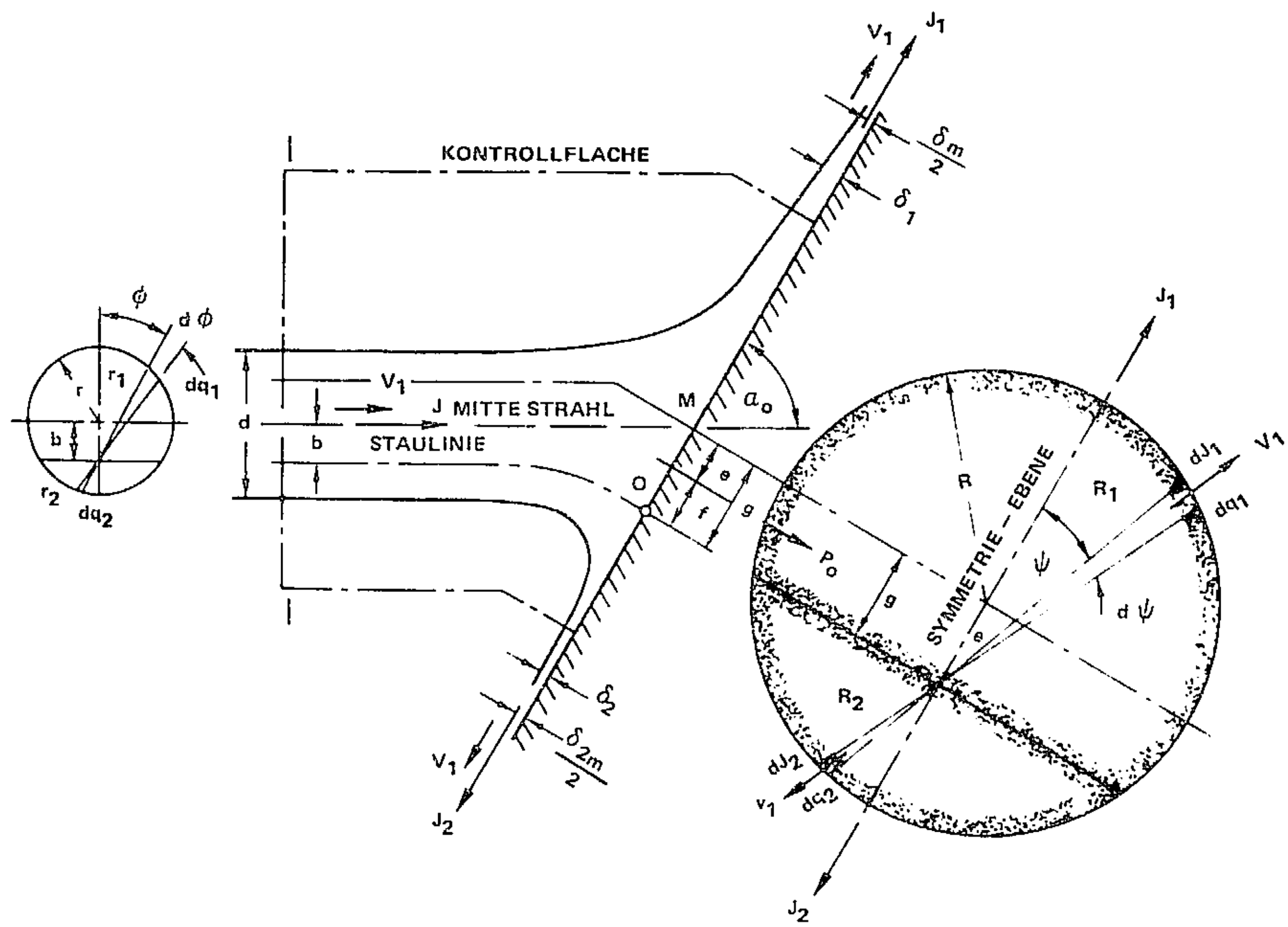


FIGURE 15. 3D JET MISSILE MODEL PER SCHACH

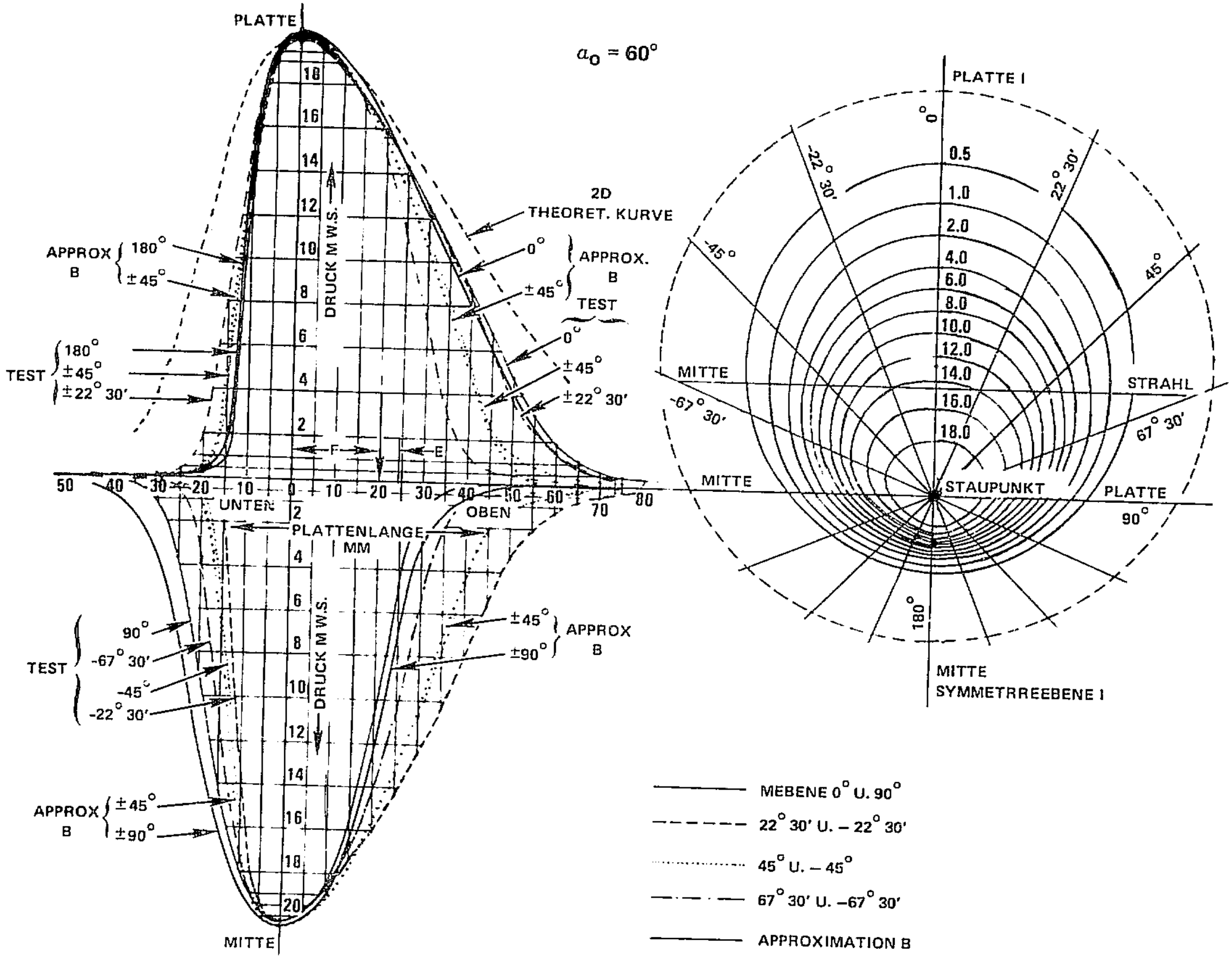


FIGURE 16. PRESSURE DISTRIBUTION FOR 3D JET MEASURED & SCHACH'S THEORY

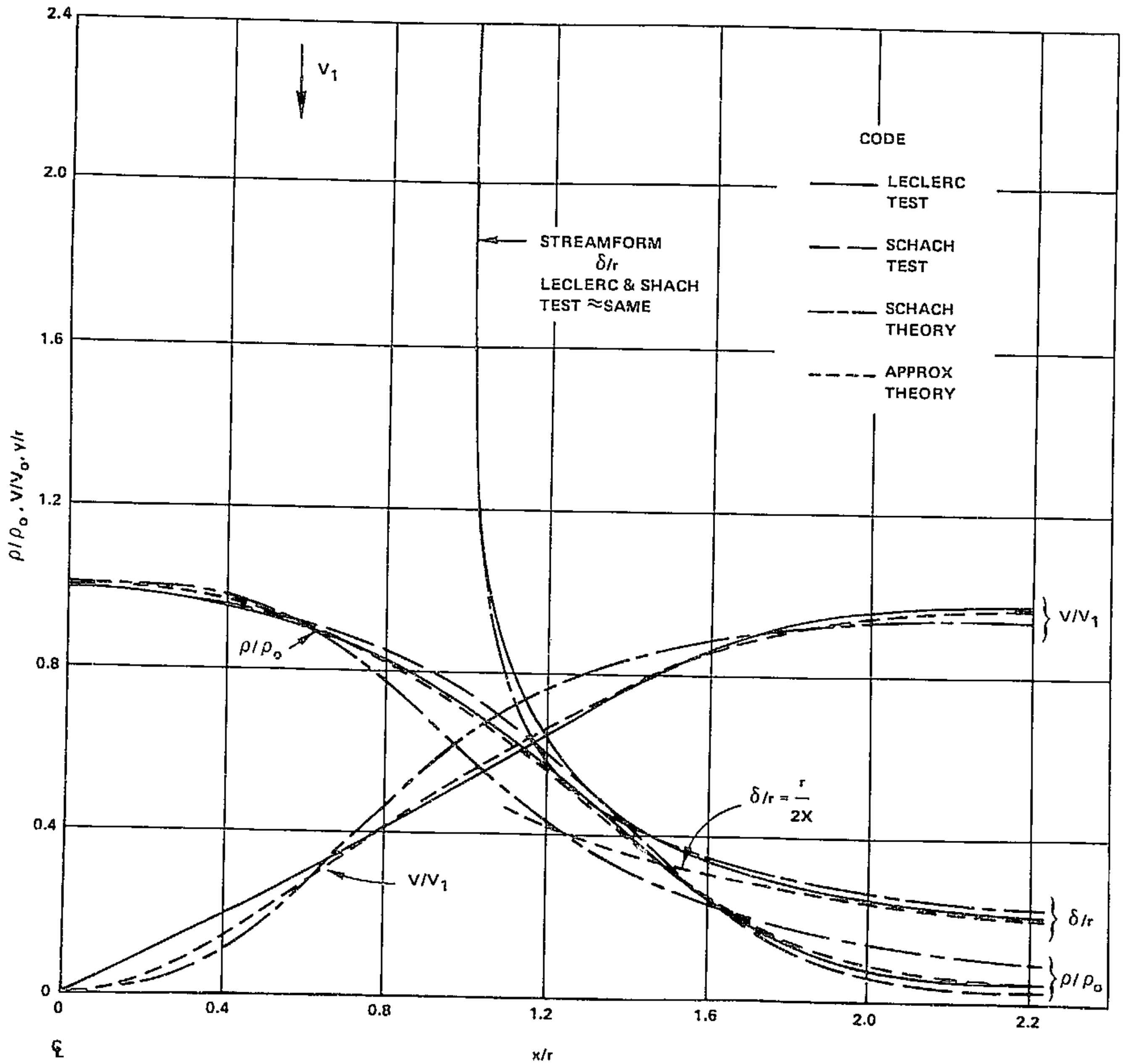


FIGURE 17. NORMAL IMPINGEMENT OF 3D JET PRESSURE, STREAMFORM & VELOCITY DISTRIBUTIONS – THEORY & TEST

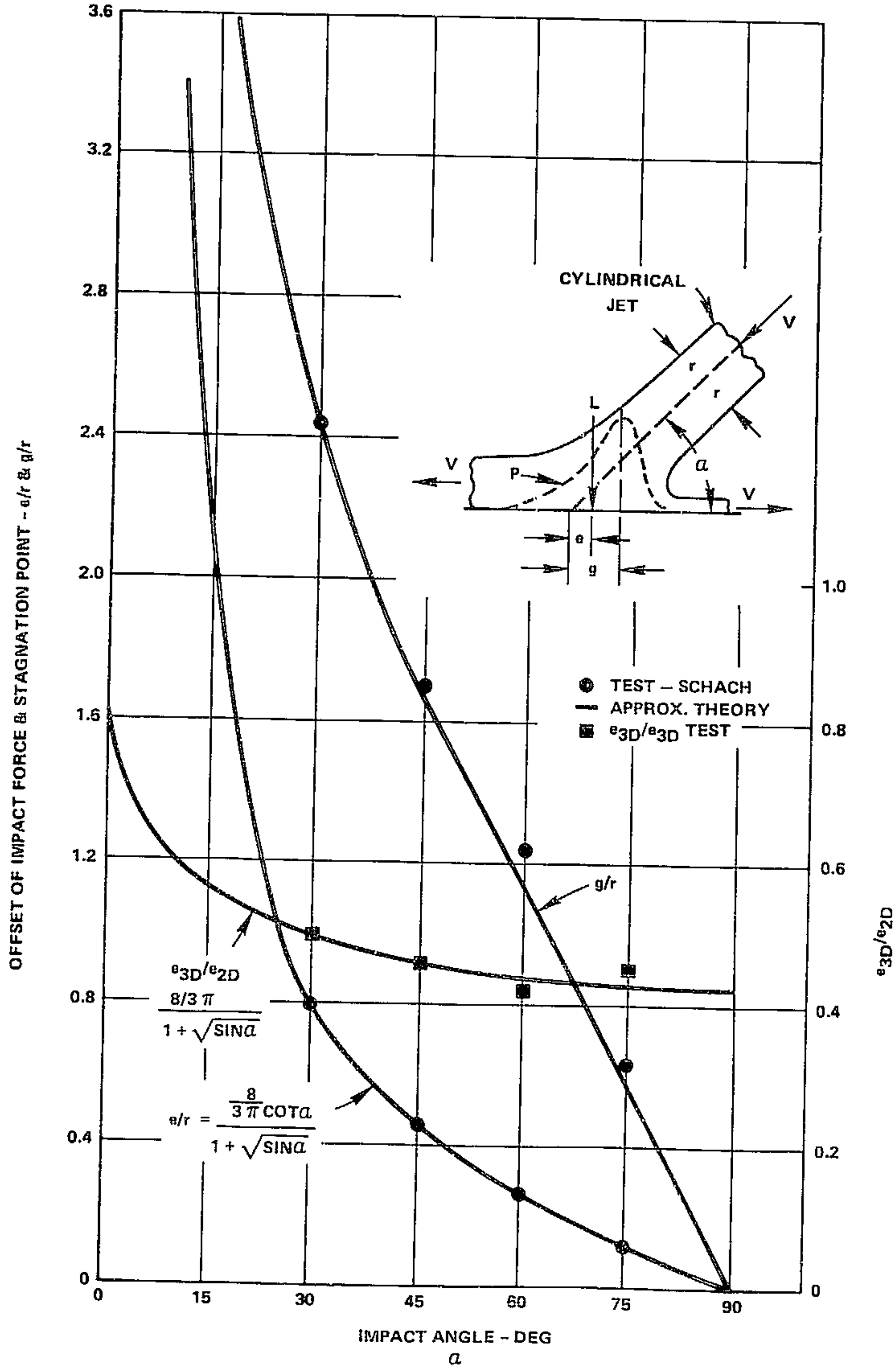


FIGURE 18. 3D JET LOCATIONS OF IMPACT FORCE & STAGNATION POINT e/r & g/r

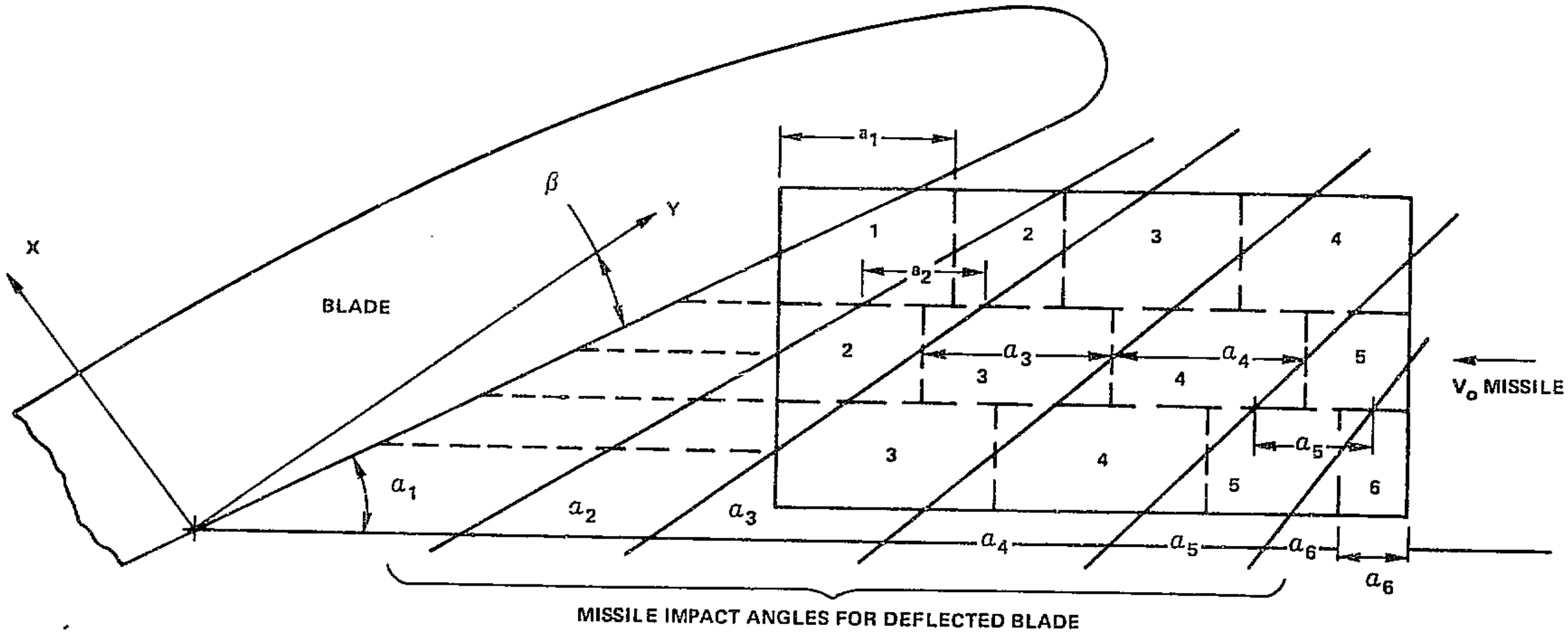
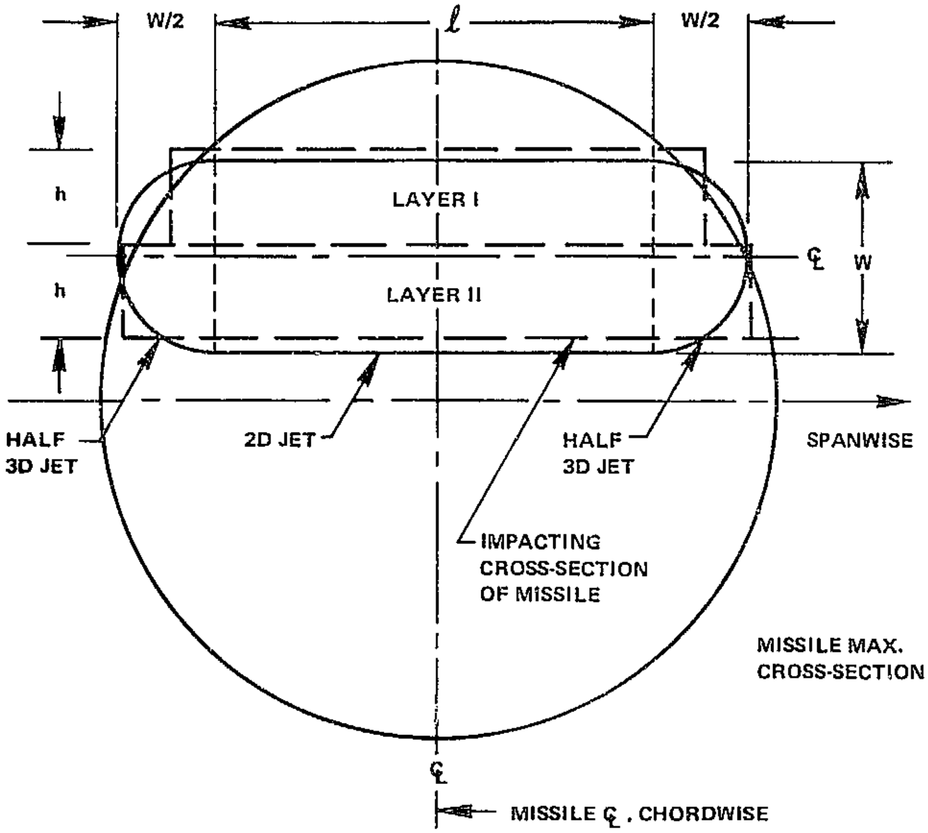


FIGURE 19. VARYING MULTI-SEGMENT MISSILE



$$W = 2h \text{ OR } mh$$

$$A_{sect} = A_3 + A_2 = \sum_{Impact}^{m} A_{Layers}$$

$$A_3 = \frac{\pi}{4} W^2$$

$$A_2 = \ell W$$

m = NUMBER OF RECTANGULAR LAYERS h THICK SIMULATING MISSILE

FIGURE 20. APPROXIMATION OF GENERAL SHAPED MISSILE FROM 2D AND 3D JETS

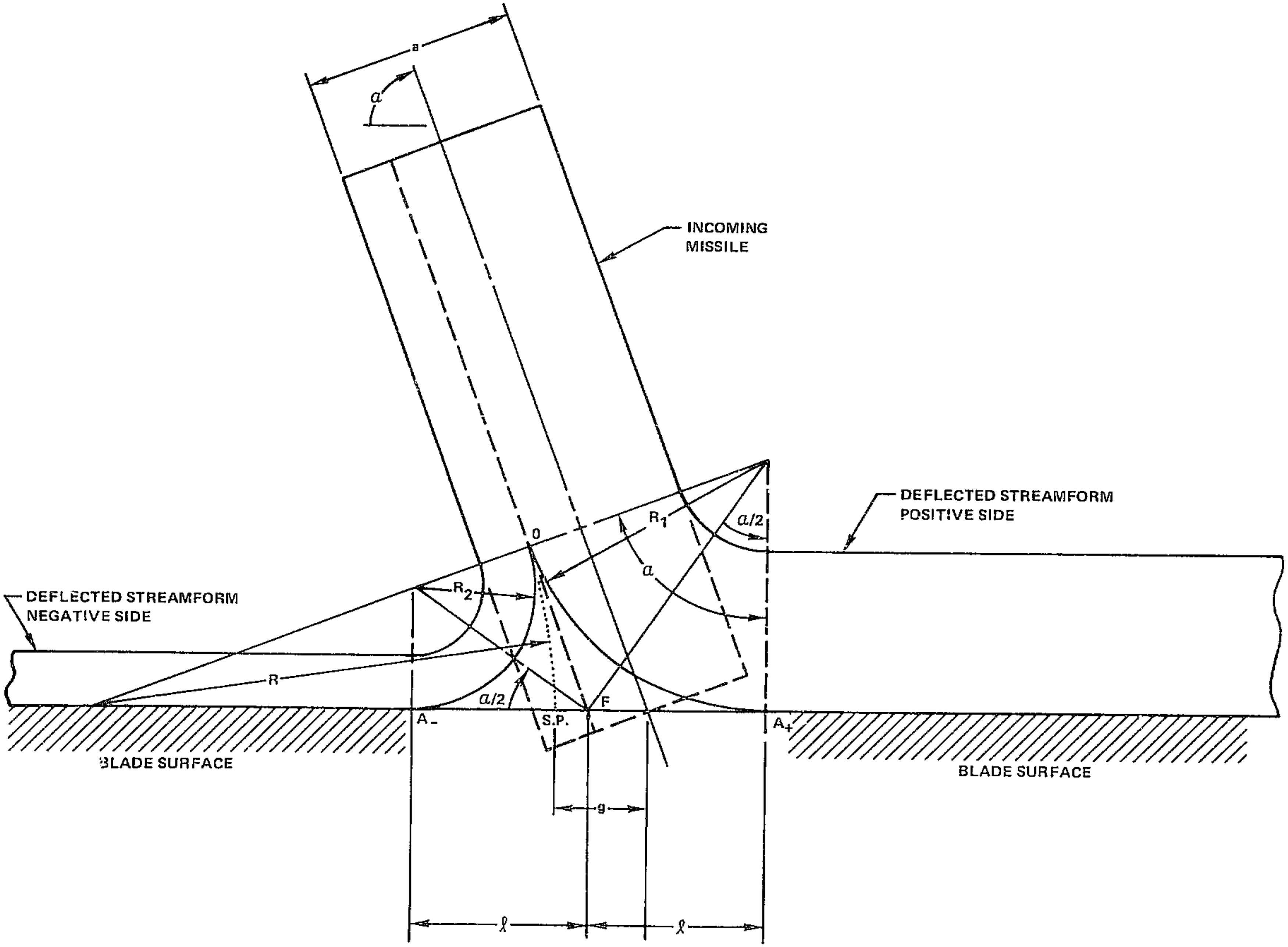


FIGURE 21. APPROXIMATED STREAMFORM PARAMETERS

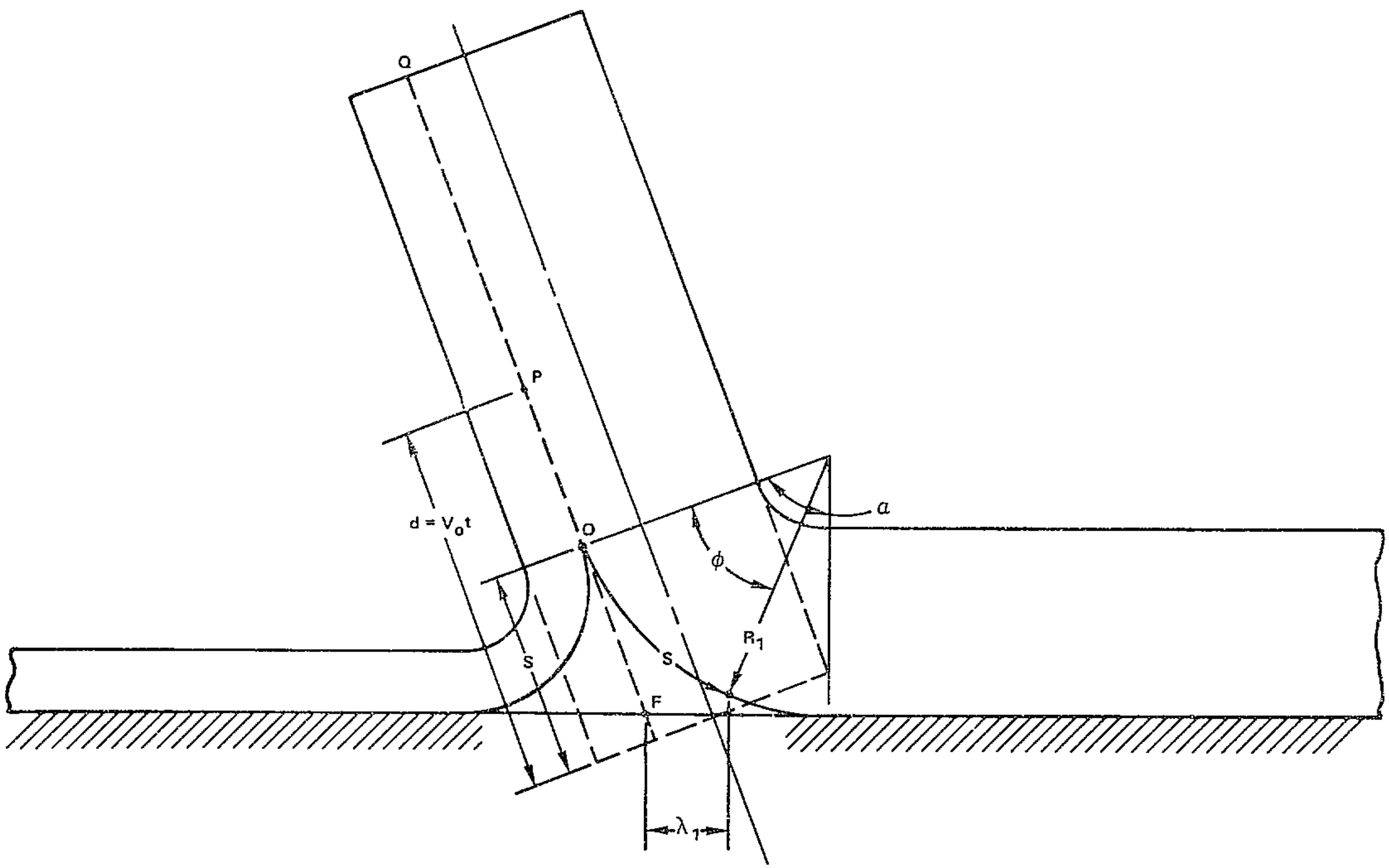


FIGURE 22. PATH AND LOCATION OF AN ELEMENTAL VOLUME OF FLUID

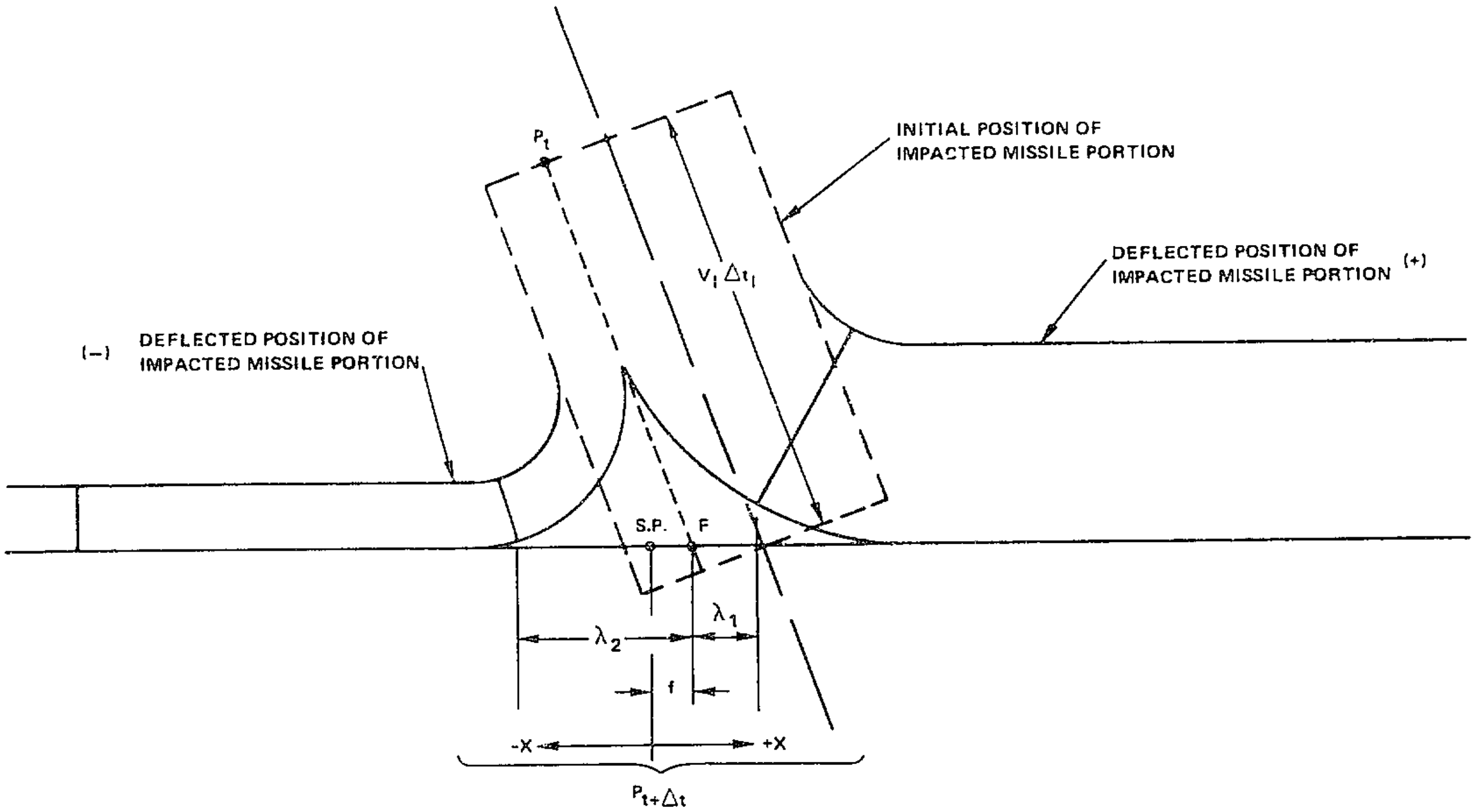


FIGURE 23. INITIAL AND FINAL FORM OF AN IMPACTING MISSILE PORTION

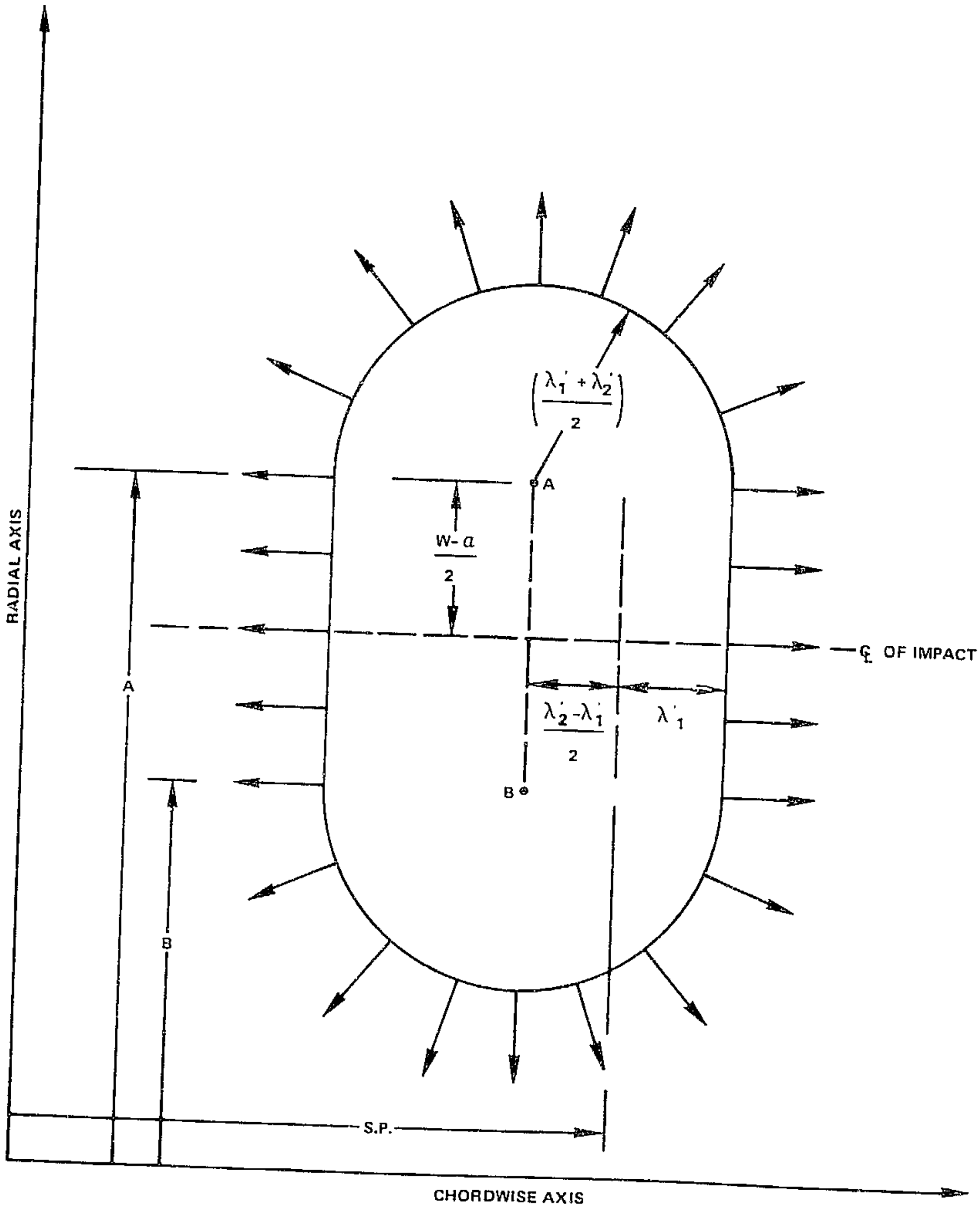


FIGURE 24. GENERAL IMPACTED MISSILE MASS DISTRIBUTION

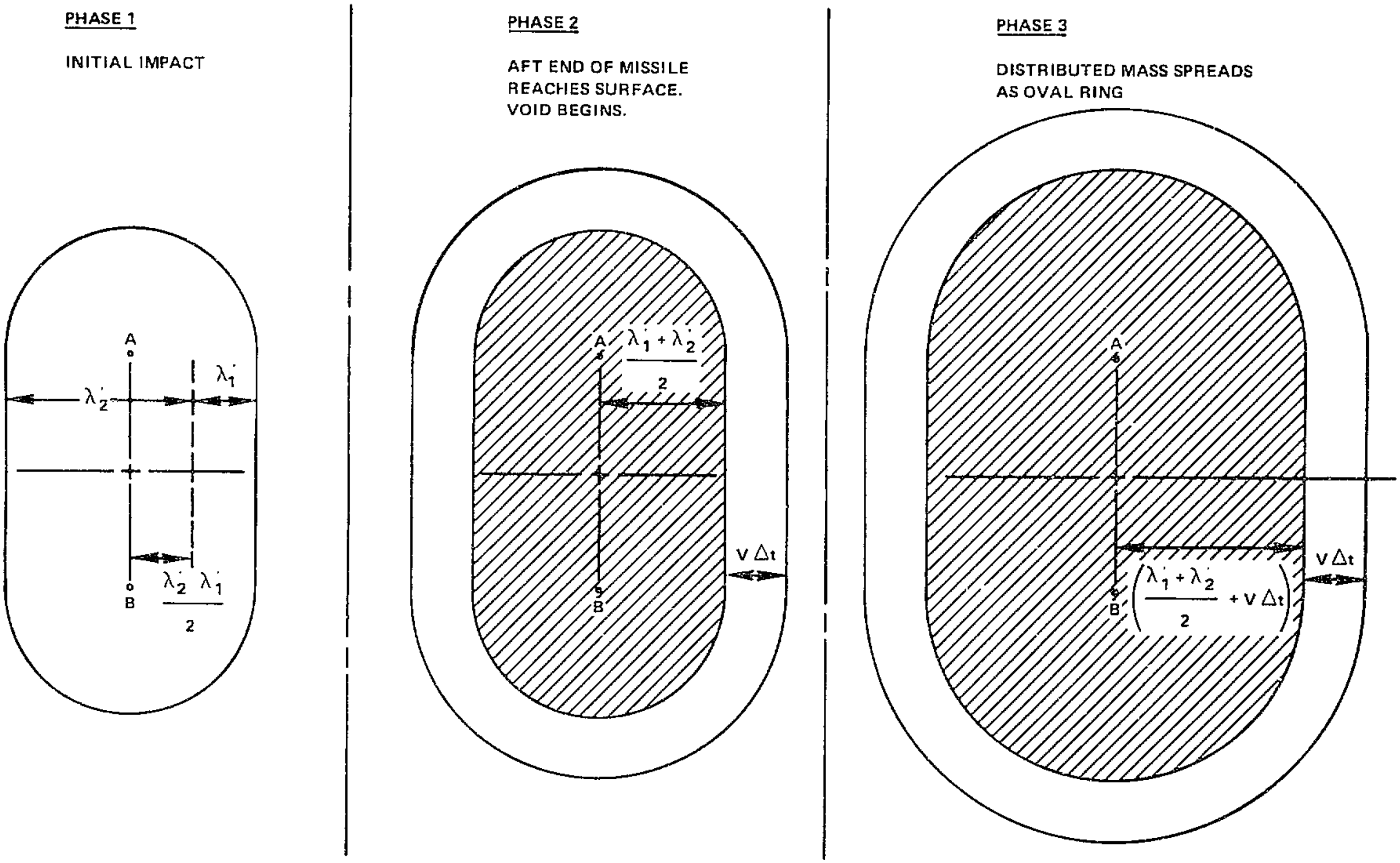


FIGURE 25. SPREAD OF IMPACTED MISSILE MASS DISTRIBUTION WITH TIME

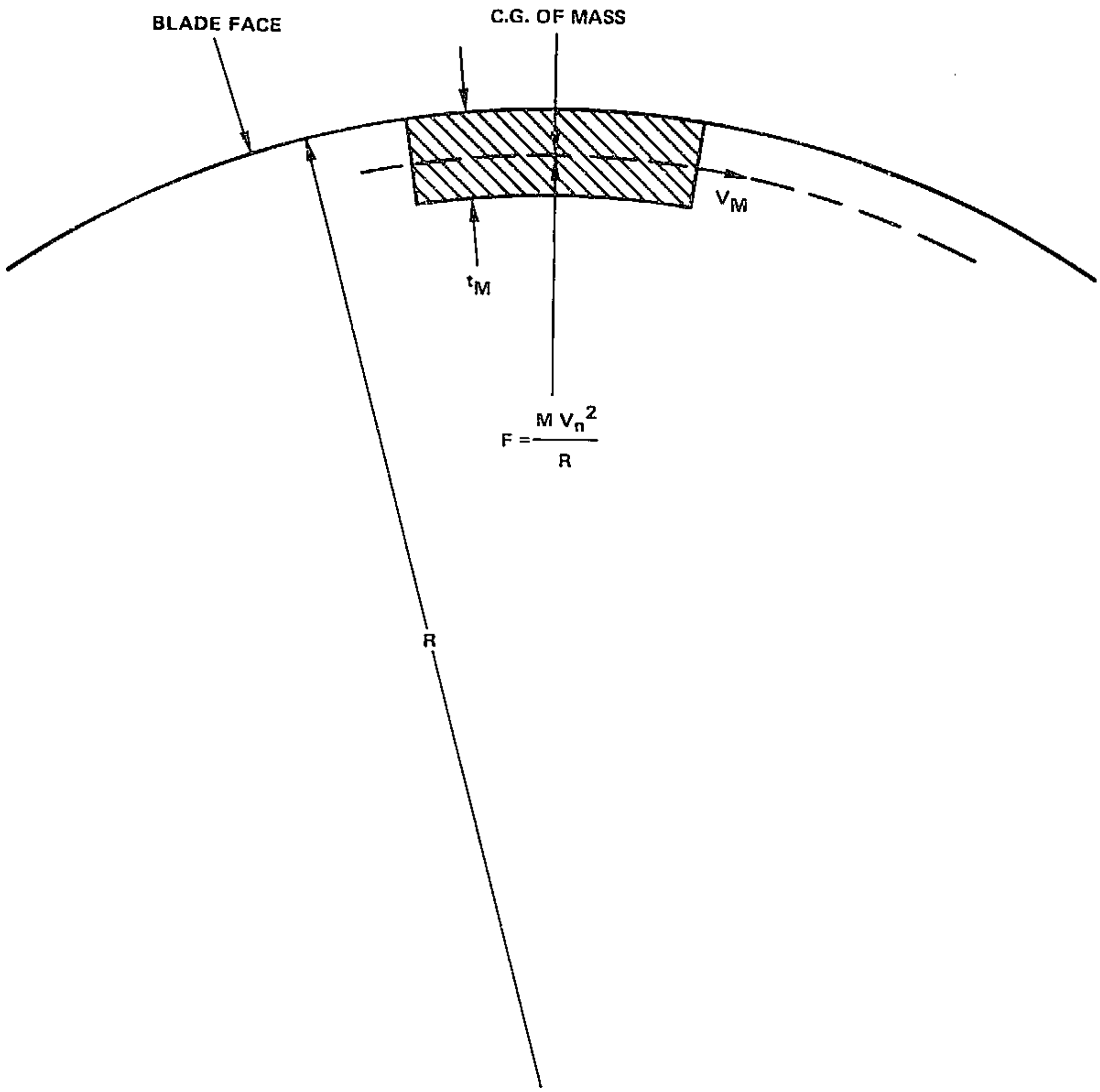


FIGURE 26. ELEMENTAL MASS VOLUME TRAVERSING A CURVED SURFACE

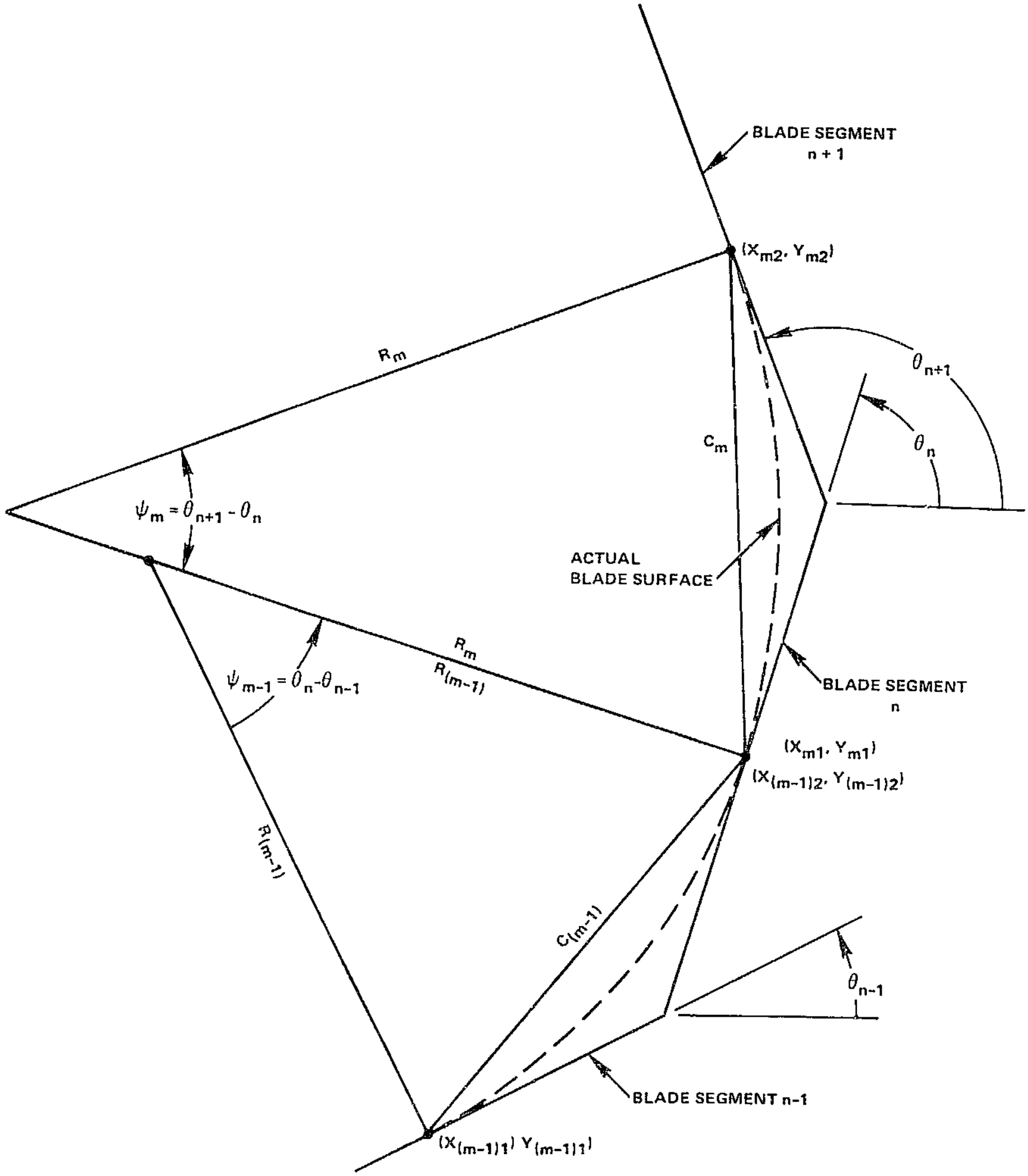
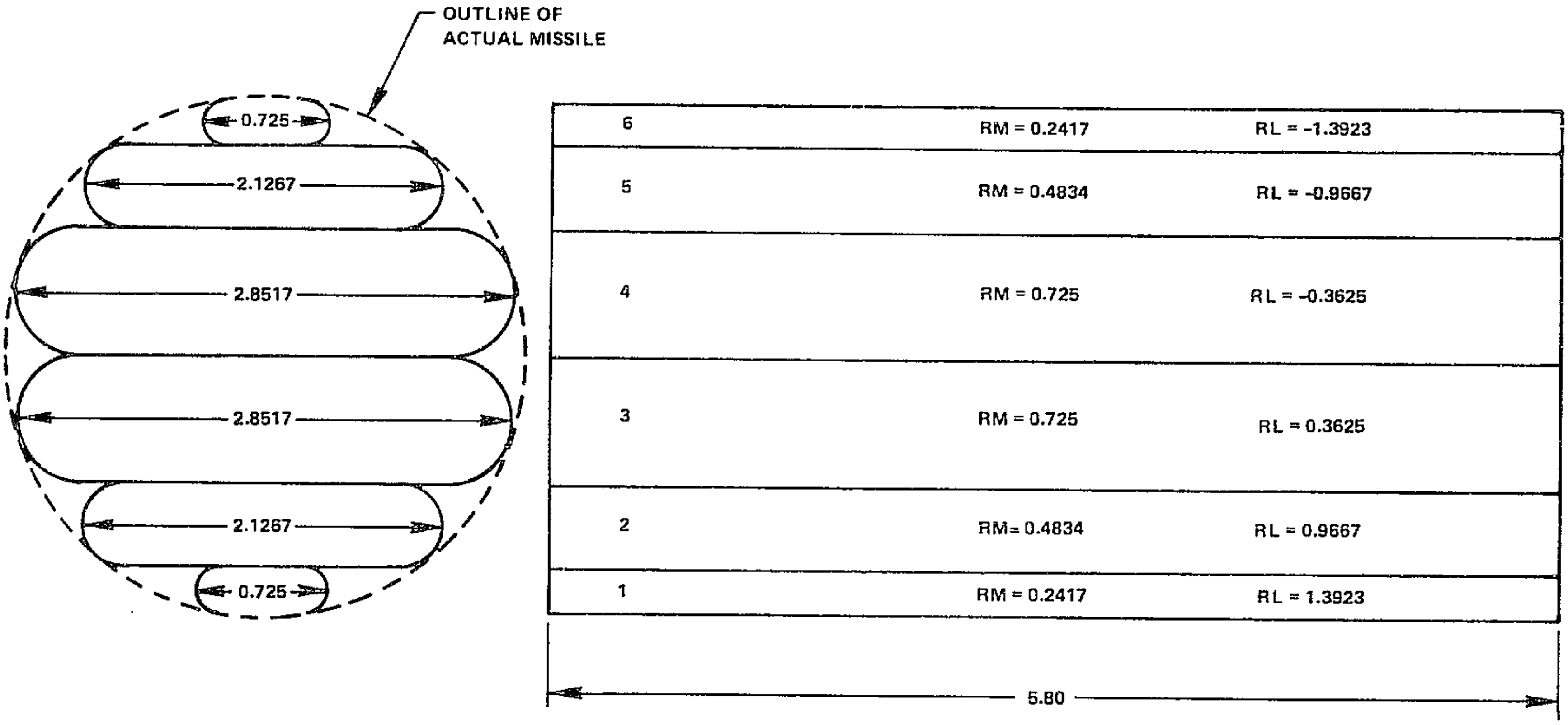


FIGURE 27. BLADE CAMBER CURVATURE GEOMETRY



*ALL DELTL = 0

FIGURE 28. MISSILE MODEL USED FOR IMPACTS ON RIGID TARGETS

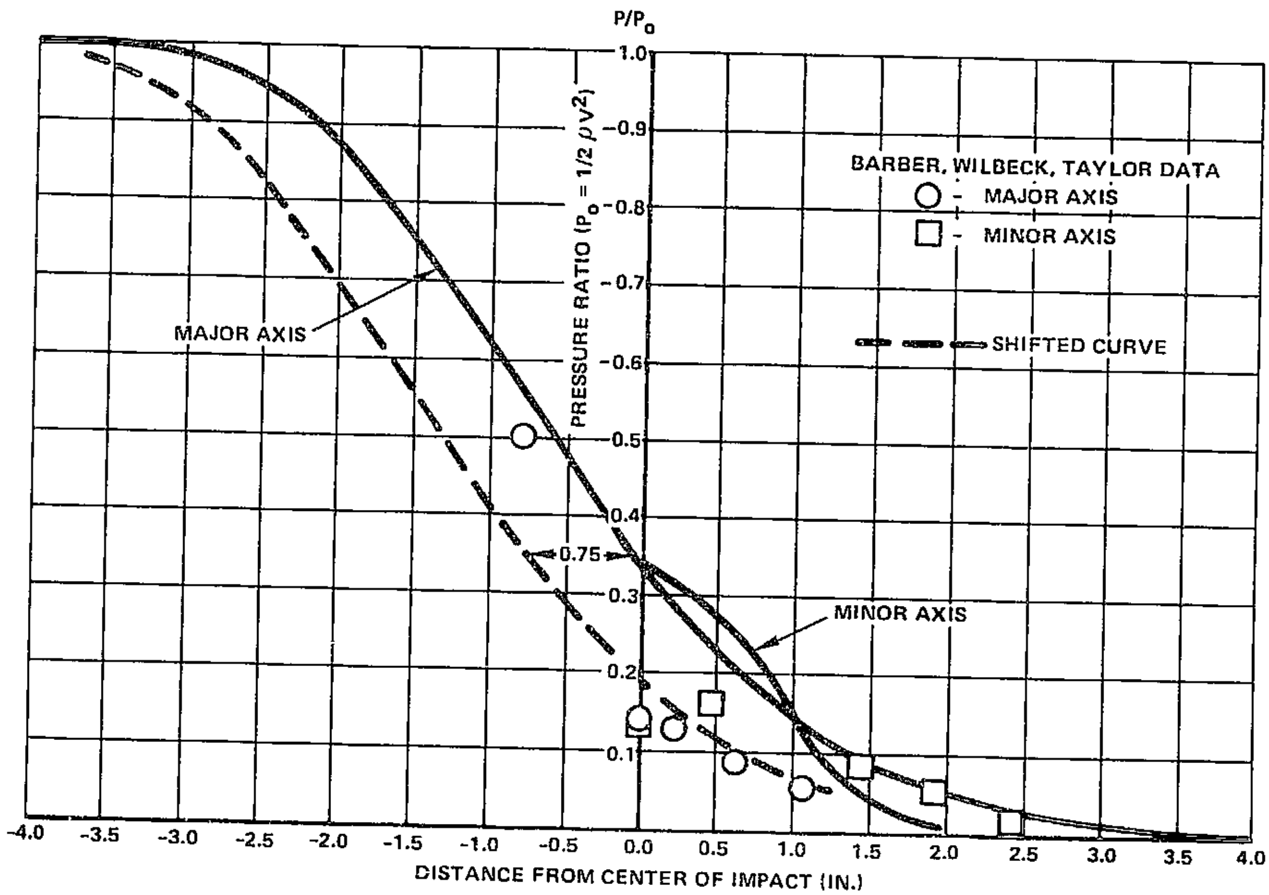


FIGURE 29. 25° IMPACT ON RIGID PLATE

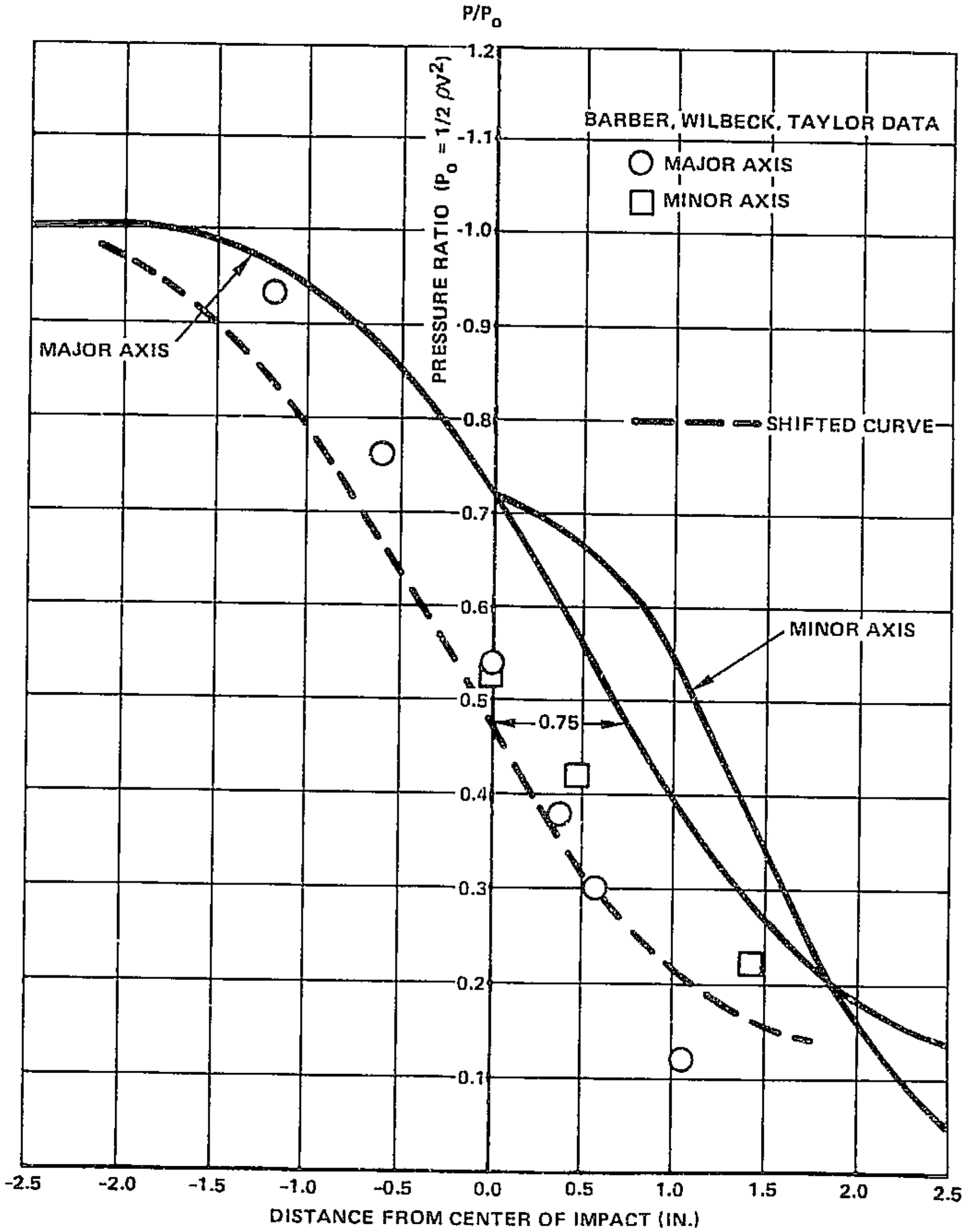


FIGURE 30. 45° IMPACT ON RIGID PLATE

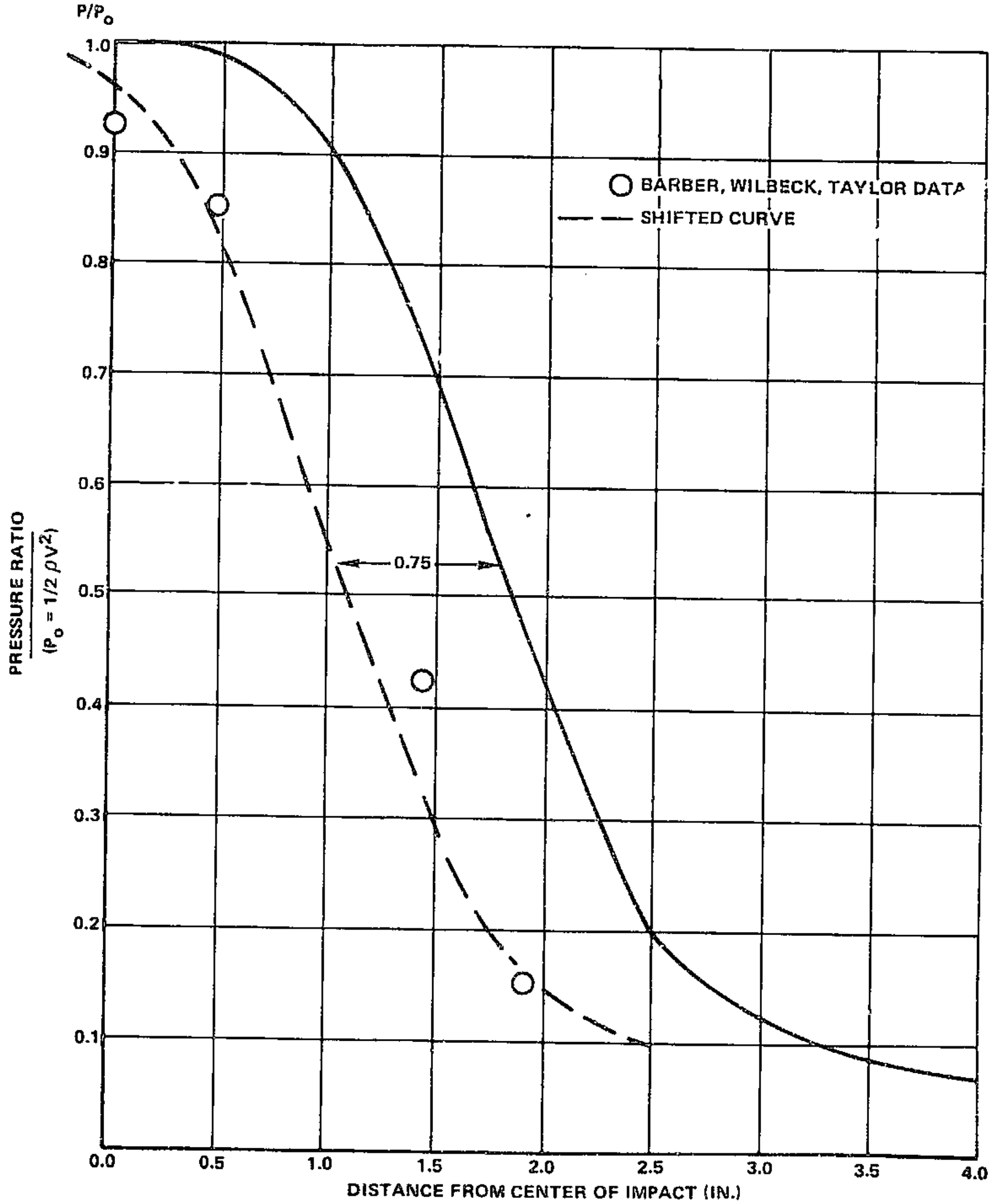


FIGURE 31. 90° IMPACT ON RIGID PLATE

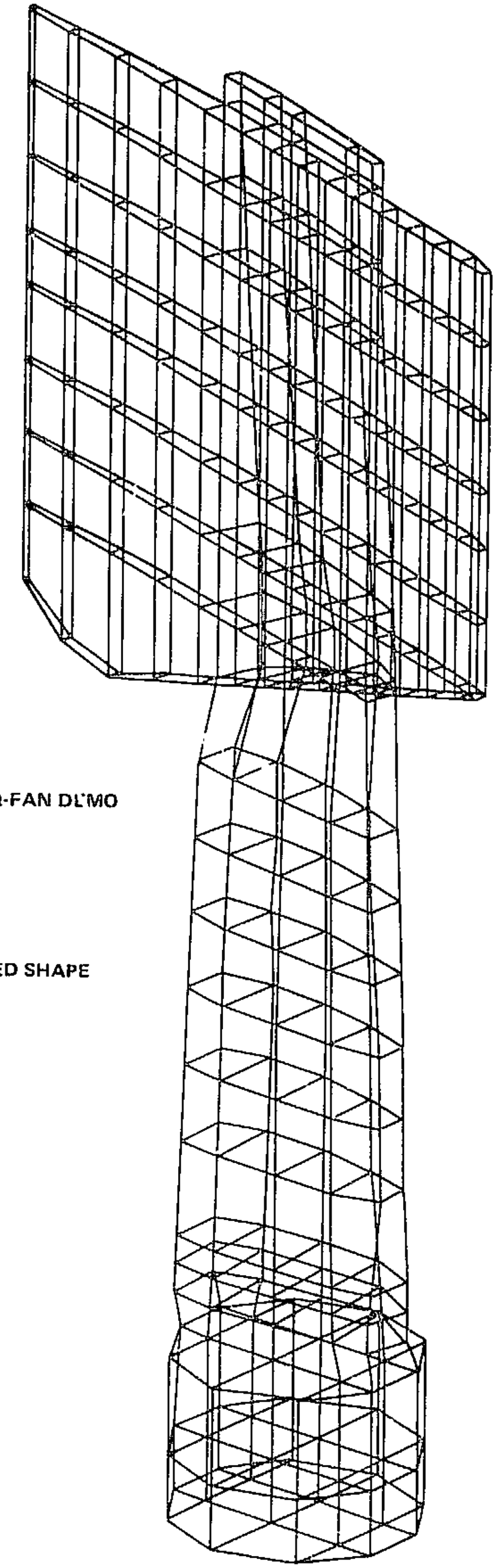
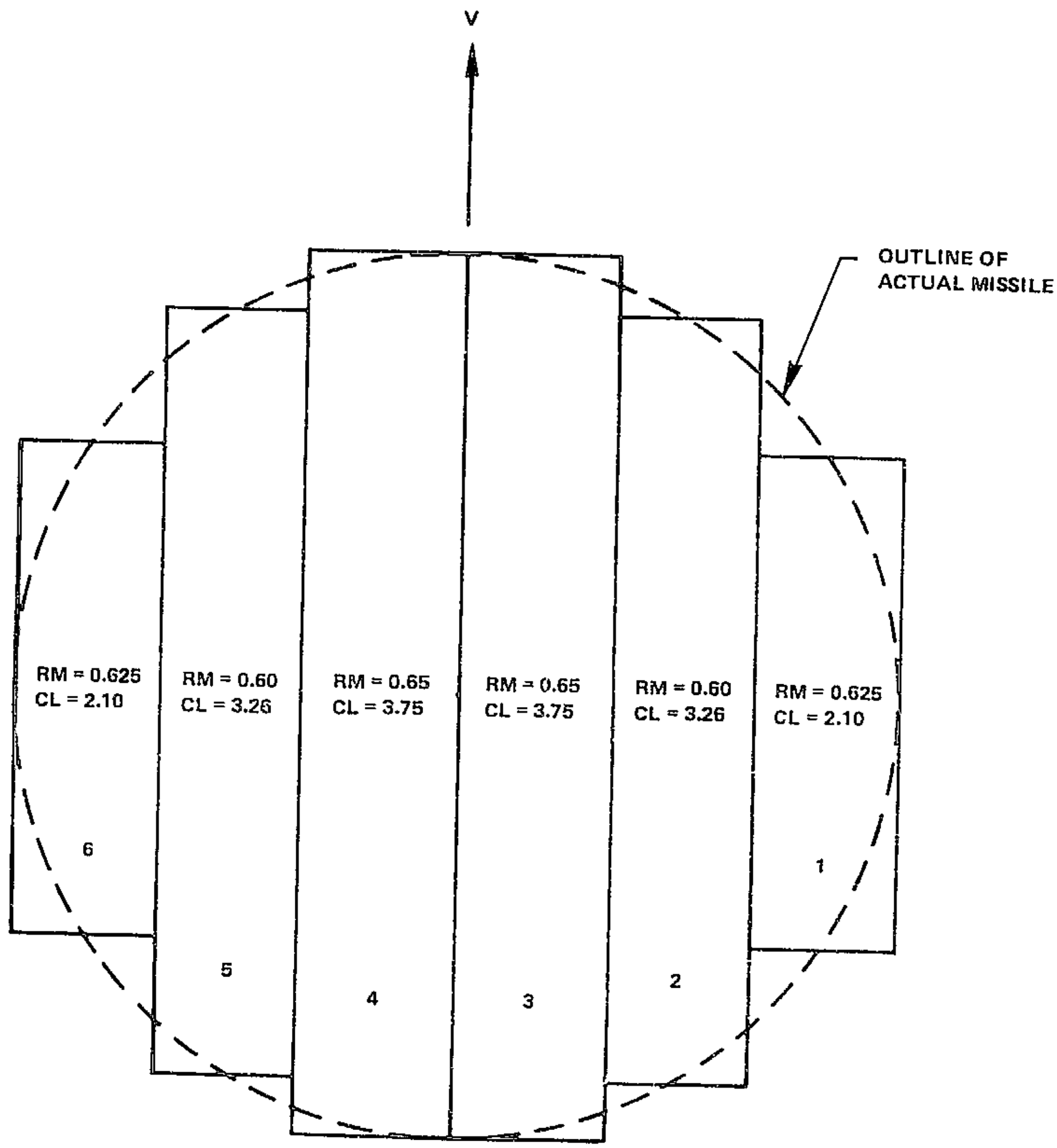


FIGURE 32. FLAT PLATE SIMULATED Q-FAN BLADE MODEL



RL(1) = 1.5625
RL(2) = 0.95
RL(3) = 0.325
RL(4) = -0.325
RL(5) = -0.95
RL(6) = -1.5625

DELTL(1) = 0.825
DELTL(2) = 0.245
DELTL(3) = 0.0
DELTL(4) = 0.0
DELTL(5) = 0.245
DELTL(6) = 0.825

FIGURE 33. SIDE VIEW OF SPHERICAL MISSILE MODEL

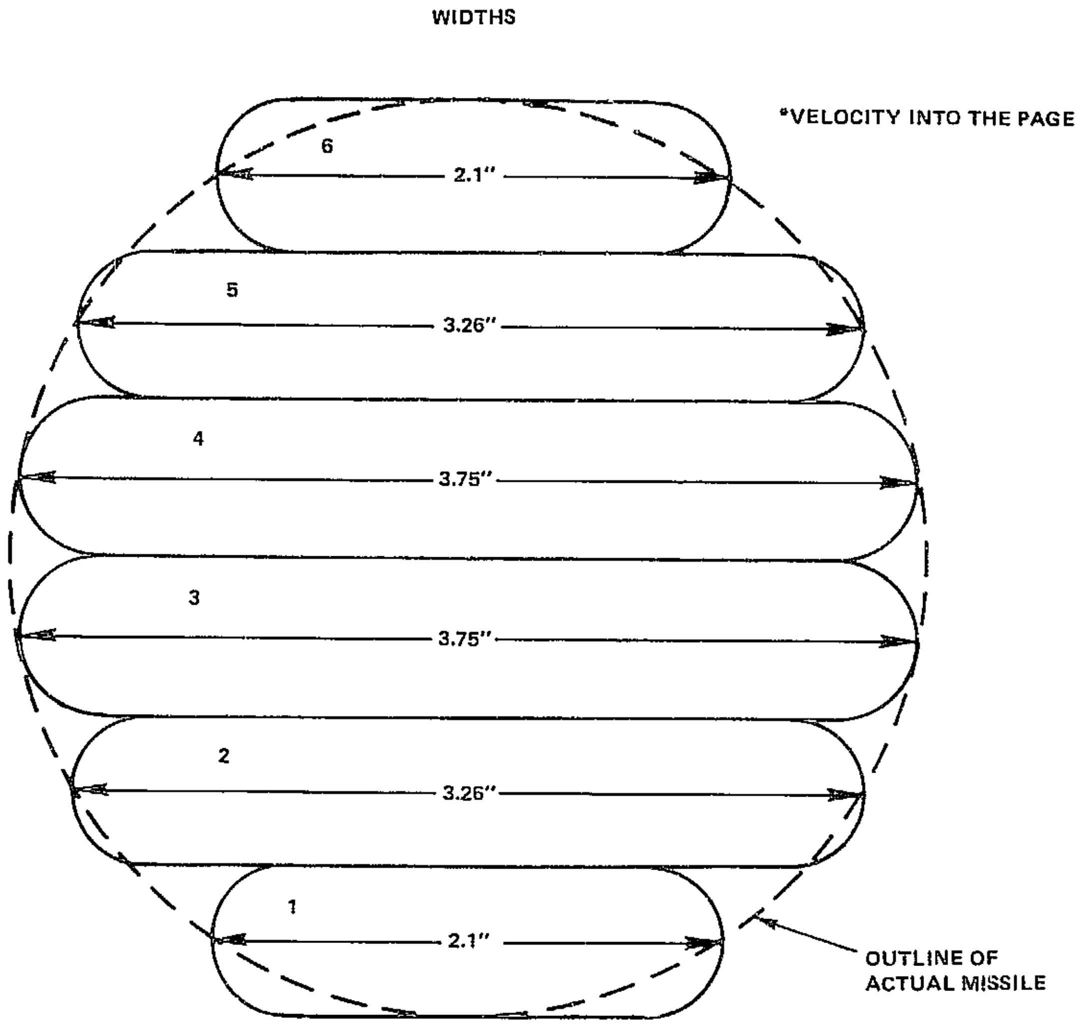


FIGURE 34. CROSS SECTION OF SPHERICAL MISSILE MODEL

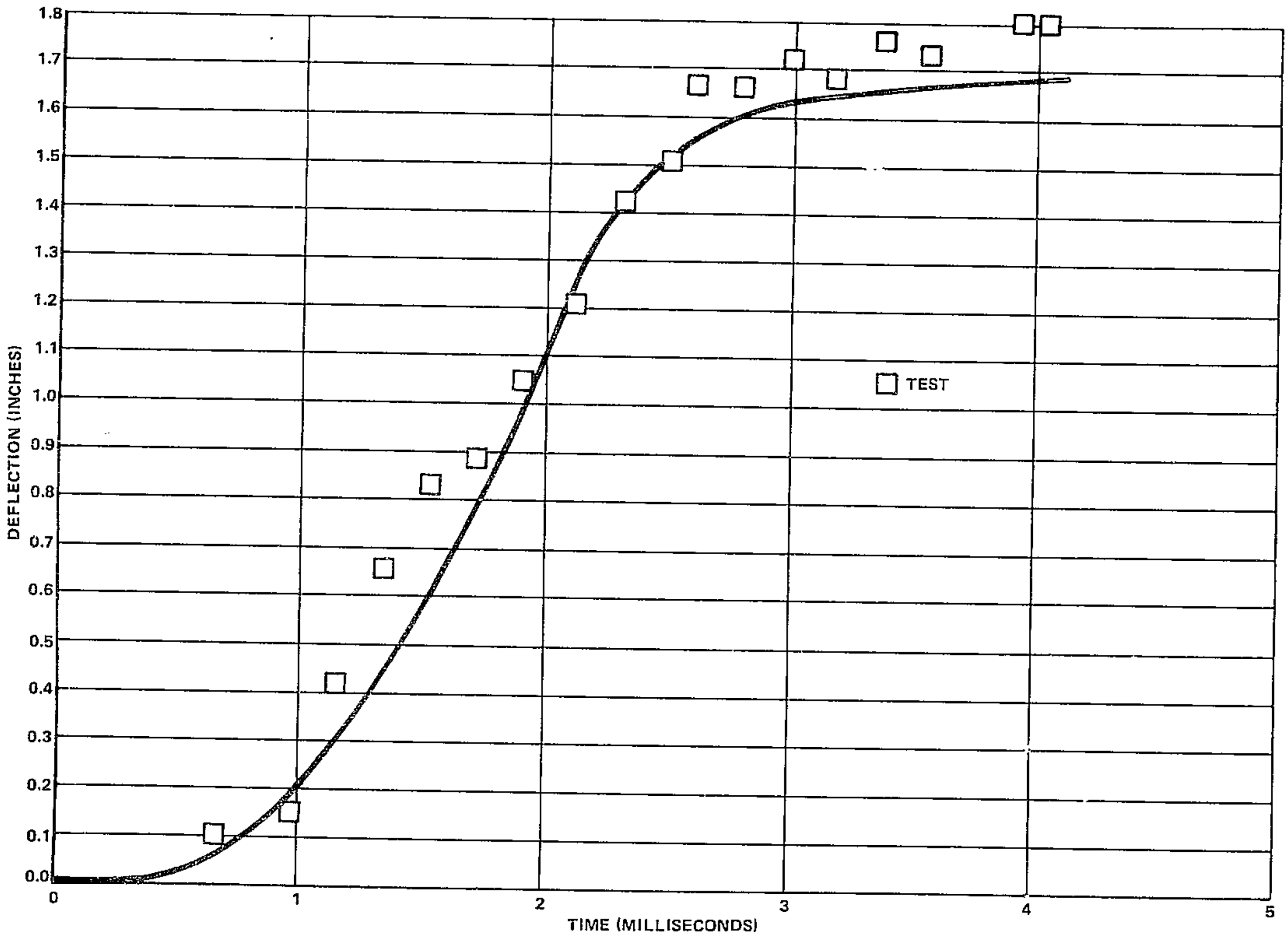


FIGURE 35. FLATWISE DISPLACEMENT RESPONSE OF SIMULATED Q-FAN BLADE SUBJECTED TO A 30° IMPACT OF A 1 LB. SPHERE AT 600 FT/SEC.

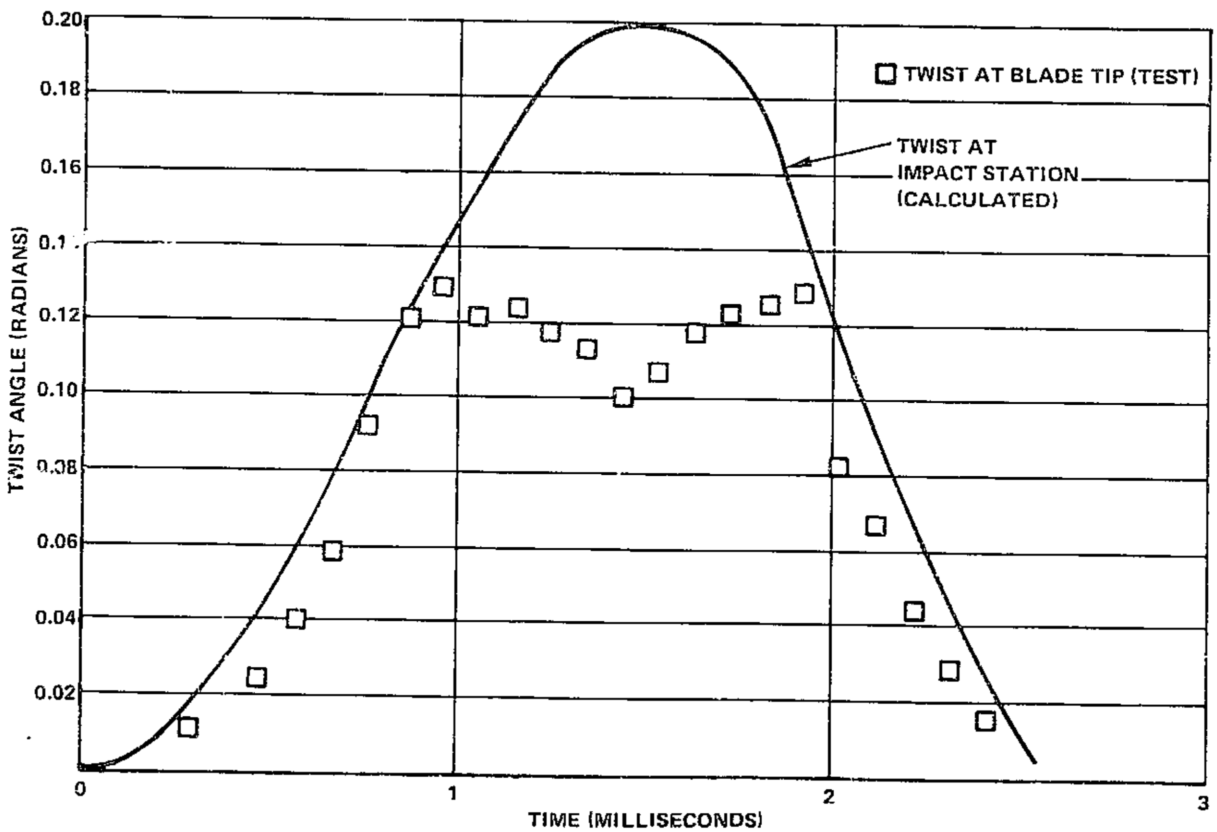


FIGURE 36. TWIST RESPONSE OF SIMULATED Q-FAN BLADE SUBJECTED TO A 30° IMPACT OF A 1 LB. SPHERE AT 600 FT/SEC.

APPENDIX A

SPRING-MASS ELEMENTAL MISSILE MODEL

Approach

This spring-mass elemental analysis approach is analogous to a finite element analysis but simpler in execution. In this analysis the missile is analyzed as a finite slug of fluid impacting an inclined surface and includes all the six requirements defined by the contract and listed in the Introduction. In this approach the fluid slug is divided into a finite number of mass blocks as shown in Fig. 1A. The mass of each block is concentrated at the center of the block and these masses are connected to the neighboring masses sharing a common surface. The volume enclosing the mass of each fluid slug can be calculated by summing the triple vector products of the relative position by computing the appropriate cross-products. Once the volume of the block is known the density can be calculated from

$$\rho_i = m_i/V_i \qquad (1A)$$

where:

m_i is the mass of block i,

V_i is the volume of block i, and

ρ_i is the density of block i.

The pressure at the center of block i can be found from a constitutive relation. In the present analysis the pressure, P, is computed as

$$P = \frac{\rho_o C_o^2}{\gamma + 1}\left[\left(\frac{\rho}{\rho_o}\right)^{\gamma + 1} - 1\right] + P_a \qquad (2A)$$

when $P \geq -P_T$

and as

$$P = -P_T \qquad (3A)$$

if

$$P < -P_T \qquad (4A)$$

where:

ρ_o is the nominal density,

C_o is the speed of sound at $P = P_o$,

γ is a material parameter,

P_a is the ambient pressure, and

P_T is the tensile pressure failure load.

These constitutive relations are similar to those used in Ref. 8. The interface pressures can be computed as the average of the pressures at two connected masses. The forces on the masses can then be evaluated by using the calculated interface areas. The position of the particles at the end of the time increment can now be found from Newton's second law of motion. Presently the integration in time is done using the Runge-Kutta method.

Status & Results

Using the scheme just described, the two-dimensional model in Fig. 1A was examined at various angles of attack. As the angle of attack is increased, the analysis showed that backflow (i.e., reverse flow up the plane in Fig. 1A) was initiated at the angle of attack for which it was expected. This angle depends upon whether the flow is two- or three-dimensional and the fineness of the grid.

Table IA presents the peak pressure that occurred for the model in Fig. 2A and the elapsed time when the peak pressure was reached. Cases 1 and 2 in Table IA are for arbitrary material properties, while Case 3 uses the material properties of water given in Ref. 8. The results for Case 3 are comparable to the results in Ref. 8 where the normal impact of water droplets was examined.

Figure 2A presents the average pressure over the blocks intersecting the surface as a function of time for Case 1 of Table IA. Note that there is a high initial peak response followed by a relatively steady portion. As shown in Fig. 2A this steady portion actually has a great deal of noise resulting from numerical instabilities.

The time domain integration algorithm and the finite grid are contributing to the numerical instabilities. In addition to this the model does not include any cushioning for the leading masses, which could also be contributing to the numerical instability.

Improvements

Without adding to the complexity, an improved representation of the missile could be obtained by: (1) adding zero masses to the outside surface which will allow the program to track the surface of the missile in order to obtain the cushioning effect, and (2) moving the pressure calculation points to the element interfaces instead of placing them at the lumped masses. The numerical stability in the time domain could be improved by: (1) using an implicit integration scheme in time or (2) evaluating the stability criteria, and if necessary, (3) updating the grid periodically. Concurrently with this effort it might be advantageous to undertake to obtain, test, and evaluate the COMCAM program, the code used in Ref. 8. For the angles of attack of interest ($\alpha \lesssim 30$ deg), the total impact force and center of pressure would be presented as a function of time. In addition, the force distribution for each time increment required by the Multi-Mode Blade Impact Program would be evaluated. These improvements to the present model should result in an improved, but relatively simple, technique to predict the pressure loading due to foreign object impacts.

TABLE 1A
PEAK PRESSURE AND ELAPSED TIME AT PEAK PRESSURE

NOTE 1. PARAMETER DEFINITIONS:

$H = 10$ CM
$D = 4$ CM
$V_o = 20 \times 10^3$ CM/SEC
$\alpha = 30$ DEG
$\theta = 0$
$P_o = 0$
$P_t = 0$

NOTE 2. CASE 3 IS FOR WATER

CASE NO.	ρ_o (G/CM^3)	C_o (CM/SEC)	γ	$\rho_o C_o V_o$ (DYNES/CM^2)	$\frac{P_{MAX}}{\rho_o C_o V_o}$	t^* (μSEC)	$\frac{C_o t^*}{D}$
1	1.0	250×10^3	-0.78	0.5×10^9	2.58	250	1.56
2	1.0	150×10^3	-0.78	3.0×10^9	1.23	16.7	0.626
3	1.0	150×10^3	6.15	3.0×10^9	1.98	13.3	0.499

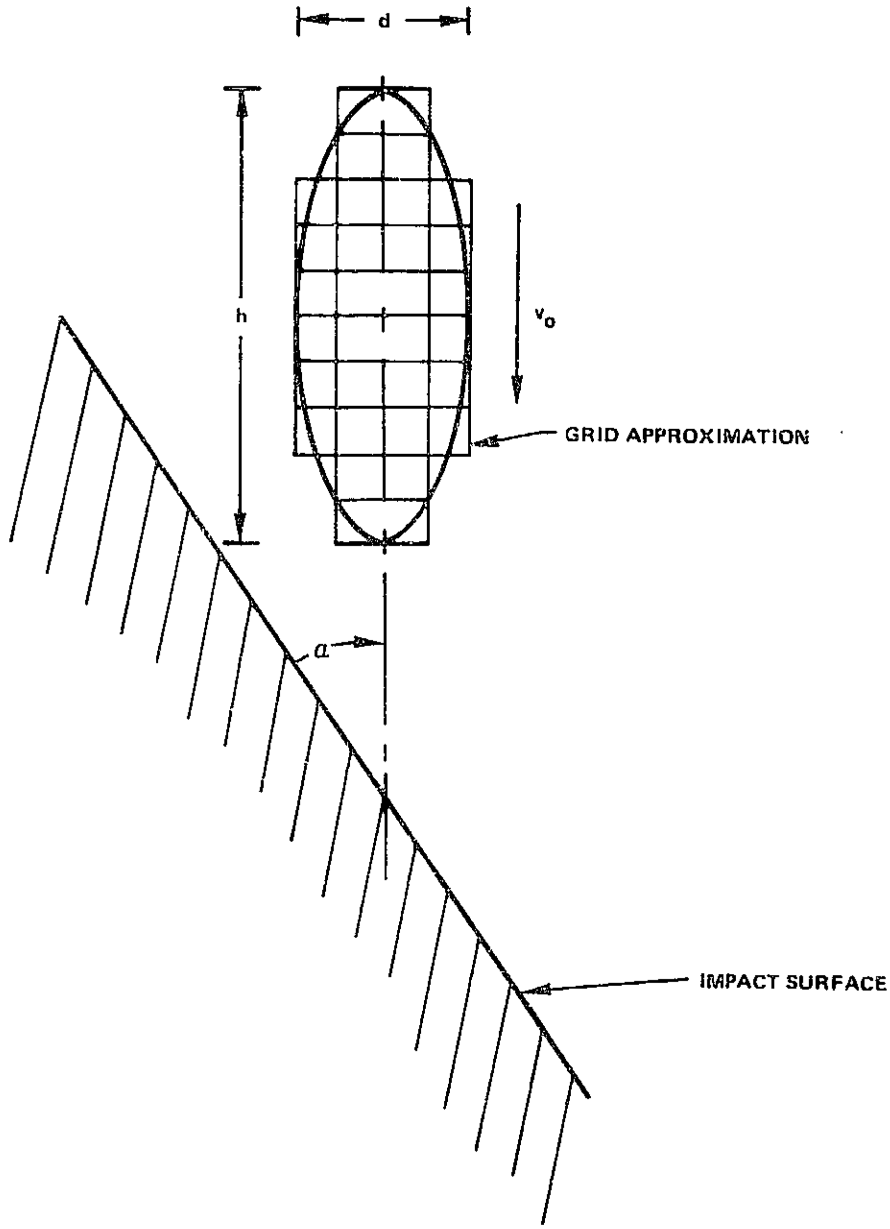


FIGURE 1A. MODEL DESCRETIZATION FOR A TWO DIMENSIONAL ELLIPTICAL FLUID MISSILE INTERSECTING A RIGID FLAT SURFACE

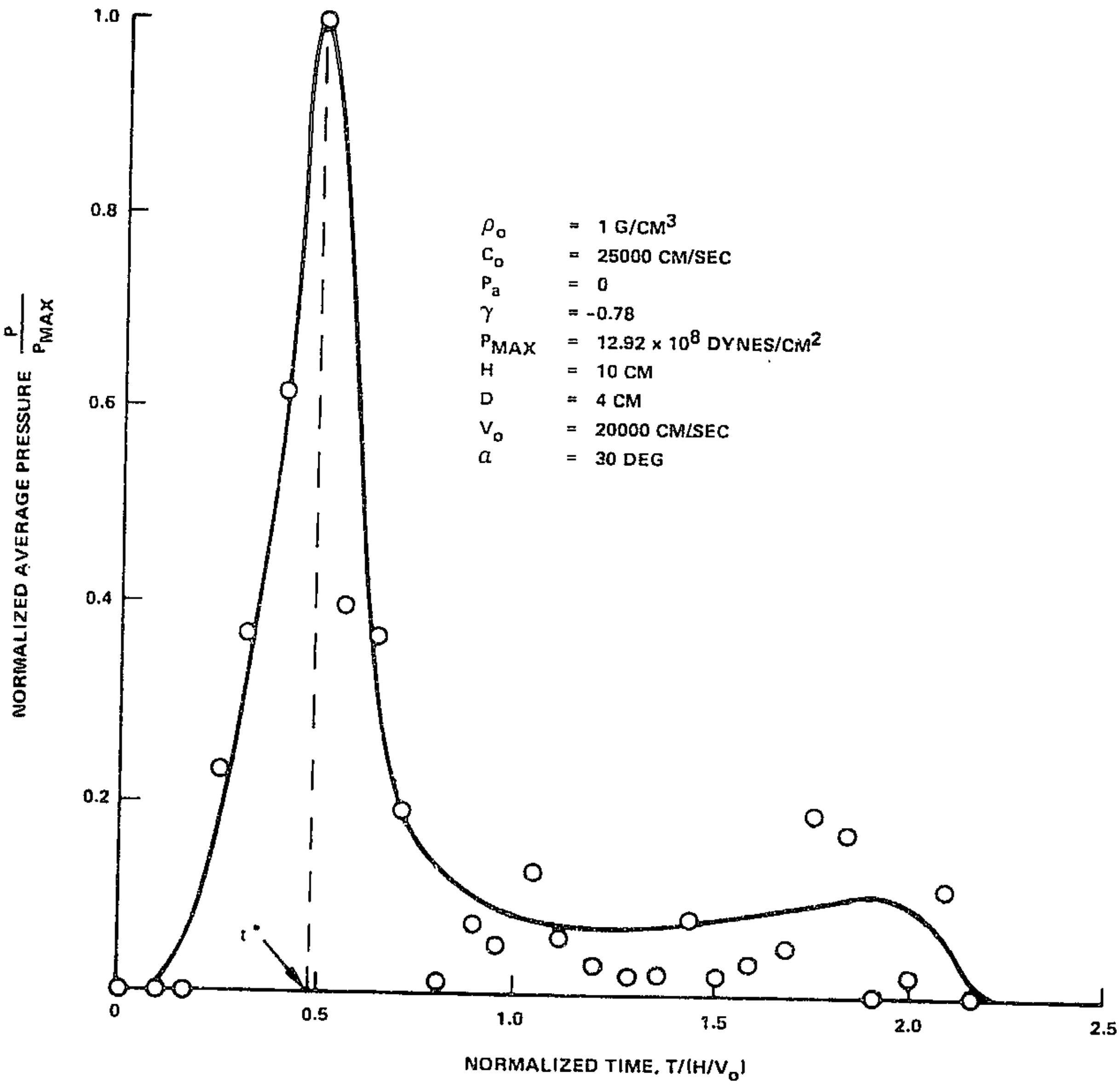


FIGURE 2A. AVERAGE IMPACT PRESSURE OVER THE IMPACTED SURFACE VS TIME FOR CASE 1 OF TABLE I

APPENDIX B

UNIFORM PRESSURE, 2D & 3D OBLIQUE IMPACTING JET MISSILES

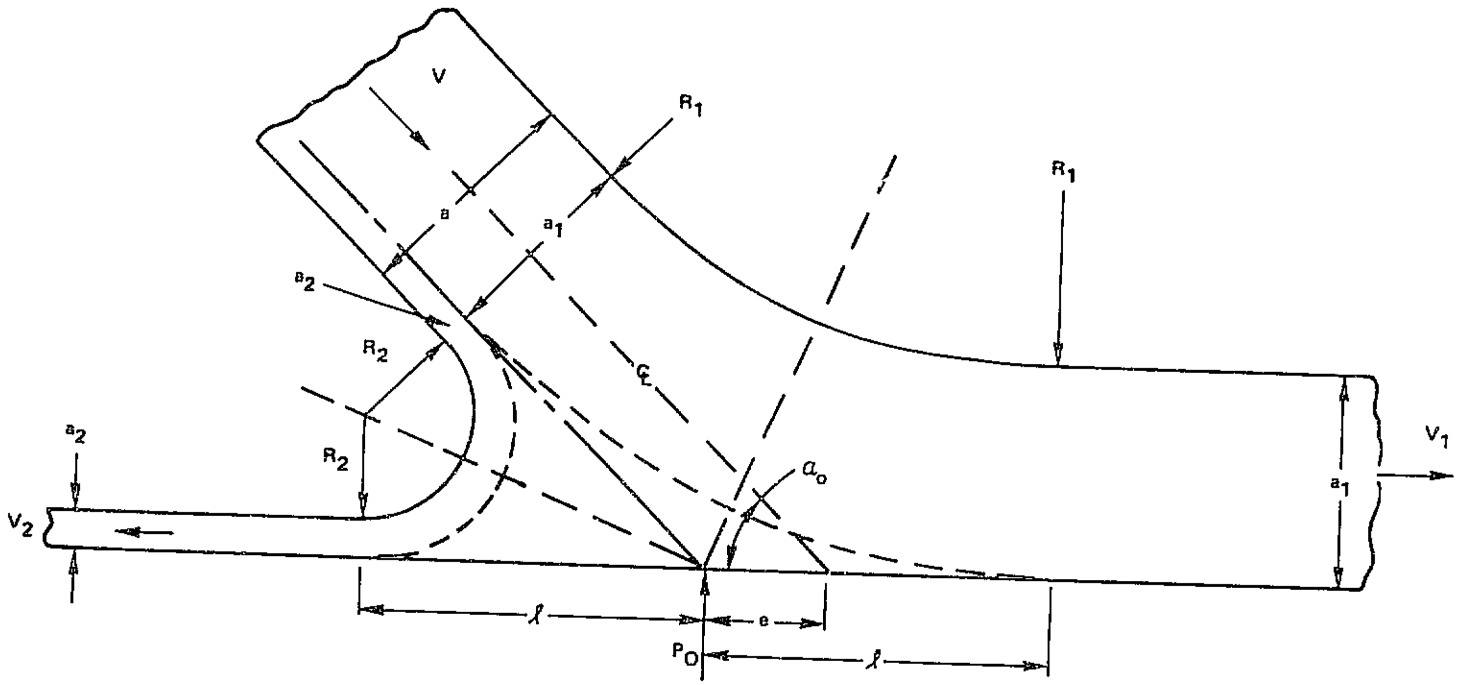
Reference 4 presents test results which show that birds behave as a fluid during impact at high speeds and that the maximum steady impact pressure for low impact angles is proportional to $p_o(\text{Sin}\ \alpha)^2$, where p_o is the stagnation pressure and α the impact angle. The test results also show that there is a critical impingement angle between 25^o and 45^o below which a relatively uniform impact pressure of this magnitude occurs over the impacted area. The approximate analyses developed below were based on this test information. More recently it was learned by Reference 19 that the test results were not fully evaluated and, therefore, in error. Because of this and the acquisition of References 5 and 7, which permitted the development of a better missile model, the simplistic, uniform pressure missile developed herein was abandoned in favor of the missiles developed in Appendices C, D, and E.

2D Oblique Impacting Jet Missile

Numerous texts and articles give the solution for the splitting of the 2D jet and the magnitude and position of the impulse load on the plate; see for example Reference 18. These quantities plus the fact that the magnitude of the fluid velocity is maintained can be derived using the theories of continuity, momentum, and energy; see Figure 1B. However, there is no simple way of arriving at the pressure loading distribution on the plate. Because originally no known solution was found in the literature (later Reference 5 was found), an approximate analysis was developed based on the uniform pressure test finding reported in Reference 4. In this analysis the deflected streamform is assumed to be given by circular arcs which result in a core of uniform pressure over a length, ℓ, either side of the impulse load point; see Figure 1B.

3D Oblique Impacting Jet Missile

The same uniform pressure and constant radius streamform assumptions were used for the approximate 3D analysis as for the above 2D analysis. However, in this case the jet is split into radial sectors in which the fluid is assumed to flow. Thus, the radius of the streamform is a continuous function of the azimuthal angle and is symmetrical about the line of impingement of the jet. The derivation of the approximate 3D jet analysis assuming a uniform pressure is given in Figure 2B. Note that centerline of the split is the same as that for the two dimensional jet – i.e., $b = r\ \text{Cos}\ \alpha$ and $\Delta = r\ \text{Cot}\ \alpha$. For this analysis the resultant impulse force is located a distance $e/r \approx (.265-.022\ \text{Cos}\ \alpha)\ \text{Cot}\ \alpha$ aft of the impingement center of the jet, and the uniform pressure area is centered about this location. The separation line for forward and rearward flow is a distance $f/r = \sqrt{2}\ \text{Cot}\ \alpha$ aft of the load center e/r. Figure 3B presents the variation of the envelope dimensions of the uniform elliptic pressure distribution with impingement angle, and the location of the resultant impact force from the jet centerline.



CONTINUITY: $V_1 a_1 + V_2 a_2 = Va$

MOMENTUM: $Va \cos \alpha_o = V_1 a_1 - V_2 a_2$

$P_o = \rho a V^2 \sin \alpha_o$

ENERGY: $V_1^2 a_1 + V_2^2 a_2 = V^2 a$

PRESSURE: (UNIFORM) $p = \frac{a_2 V_2}{R_2 + a_2} = \frac{a_1 V_1}{R_1 + a_1}$

$= 1/2\, \rho V^2 \sin^2 \alpha_o$

RESULTS: $V_1 = V_2 = V$

$a_1/a = \cos^2 \frac{\alpha_o}{2}$

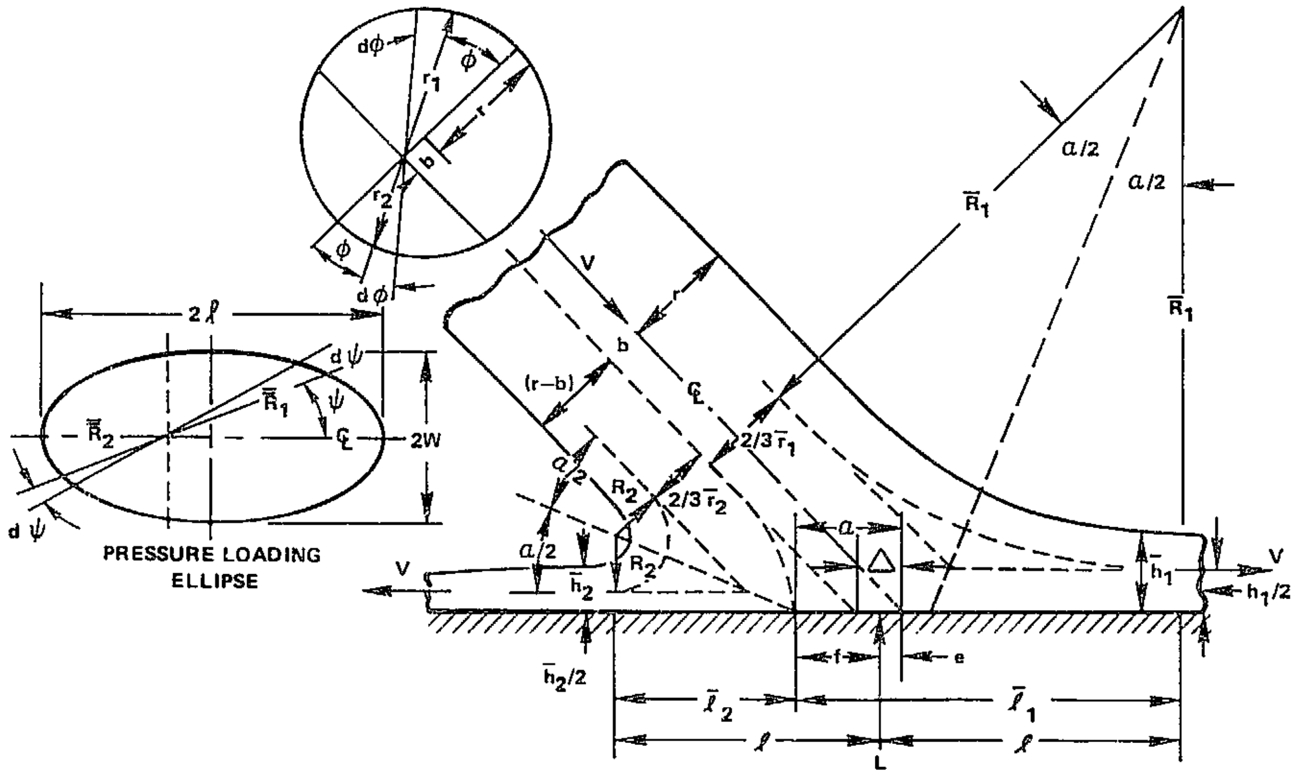
$a_2/a = \sin^2 \frac{\alpha_o}{2}$

$(a_1 + R_1)/a = 1/2 \sin^2 \alpha_o/2$

$(a_2 + R_2)/a = 1/2 \cos^2 \alpha_o/2$

$\ell/a = 1/\sin \alpha_o$

FIGURE 1B. APPROXIMATE 2D JET MISSILE



CONTINUITY:

$$\frac{1}{2}\, r_1^2\, d\phi = \ell_1 h_1 d\psi \;\&\; \frac{1}{2}\, r_2^2\, d\phi = \ell_2 h_2 d\psi$$

$$\text{TAN}\,\psi = \text{TAN}\,\phi\,\text{SIN}\,\alpha$$

$$d\psi/\text{COS}^2\psi = d\phi\,\text{SIN}\,\alpha/\text{COS}^2\phi$$

MOMENTUM:

(HORIZ)

$$\pi r^2 \rho V^2 \cos\alpha = 2\rho V^2 \left[\int_0^{\pi/2} \frac{1}{2} r_1^2 \cos\psi\, d\phi - \int_0^{\pi/2} \frac{1}{2} r_2^2 \cos\psi\, d\phi\right]$$

$$= \rho V^2 \int_0^{\pi/2} (r_1^2 - r_2^2) \cos\psi\, d\phi$$

AND

$$(r_1^2 - r_2^2) = 4\,br\,\text{COS}\,\phi \sqrt{1 - \frac{b^2 \text{SIN}^2\phi}{r^2}}$$

$$\text{TAN}\,\psi = \text{TAN}\,\phi\,\text{SIN}\,\alpha \quad \text{OR} \quad \text{COS}\,\psi = 1/\sqrt{1 + \text{TAN}^2\phi\,\text{SIN}^2\alpha}$$

FIGURE 2B. APPROXIMATE 3D JET MISSILE

MOMENTUM:

$$\pi \cos \alpha = 4 \frac{b}{r} \int_0^{\pi/2} \frac{\cos\phi \sqrt{1 - b^2 \sin^2 \phi / r^2}}{\sqrt{1 + \tan^2 \phi \sin^2 \alpha}} \, d\phi$$

⟶ IF $b/r = \cos\alpha$, THIS EQUALITY EQUATION IS MET.

THUS, $\Delta/r = \cot \alpha$ AND

⟶ $\bar{r}_r/r = (1 + \cos\alpha)$ & $\bar{r}_2/r = (1 - \cos\alpha)$

(VERT.) ASSUME $p = \frac{1}{2} \rho V^2 \sin^2 \alpha = \bar{p}_1 = \bar{p}_2$

$$\bar{p}_1 = \frac{1/2\, \bar{r}_1^2\, \rho V^2 \sin\alpha\, d\phi}{1/2\, \bar{\ell}_1^2\, d\psi} \quad \& \quad \bar{p}_2 = \frac{1/2\, \bar{r}_2^2\, \rho V^2 \sin\alpha\, d\phi}{1/2\, \bar{\ell}_2^2\, d\psi}$$

THUS,

⟶ $\bar{\ell}_1/r = \sqrt{2}/\tan\alpha/2$ & $\bar{\ell}_2/r = \sqrt{2}\tan\alpha/2$

AND

⟶ $\bar{h}_1/r = (1 + \cos\alpha)/2\sqrt{2}$ & $\bar{h}_2/r = (1 - \cos\alpha)/2\sqrt{2}$

⟶ $\ell/r = 1/2\, (\frac{\bar{\ell}_1 + \bar{\ell}_2}{r}) = \sqrt{2}/\sin\alpha$

⟶ $f/r = (\frac{\bar{\ell}_1 - \ell}{r}) = \sqrt{2}\cot\alpha$ (FLOW DIVISION LINE)

EQUILIBRIUM:

$$L = \rho \pi r^2 V^2 \sin\alpha = \pi r^2 (\frac{\ell}{r})(\frac{w}{r})\, p$$

⟶ $w/r = 2/(\ell/r)\sin\alpha = \sqrt{2}$

⟶ $$e/r = \frac{\sqrt{2}\cot\alpha}{4\pi} \int_0^{\pi/2} [3 + \cos^2\alpha - 4\sin^2\phi\cos^2\alpha]\, [1 - \sin^2\phi\cos^2\alpha]^{1/4} \cos^2\phi\, d\phi$$

$$\approx (0.265 - 0.022\cos\alpha)\cot\alpha$$

FIGURE 2B. APPROXIMATE 3D JET MISSILE (CONTINUED)

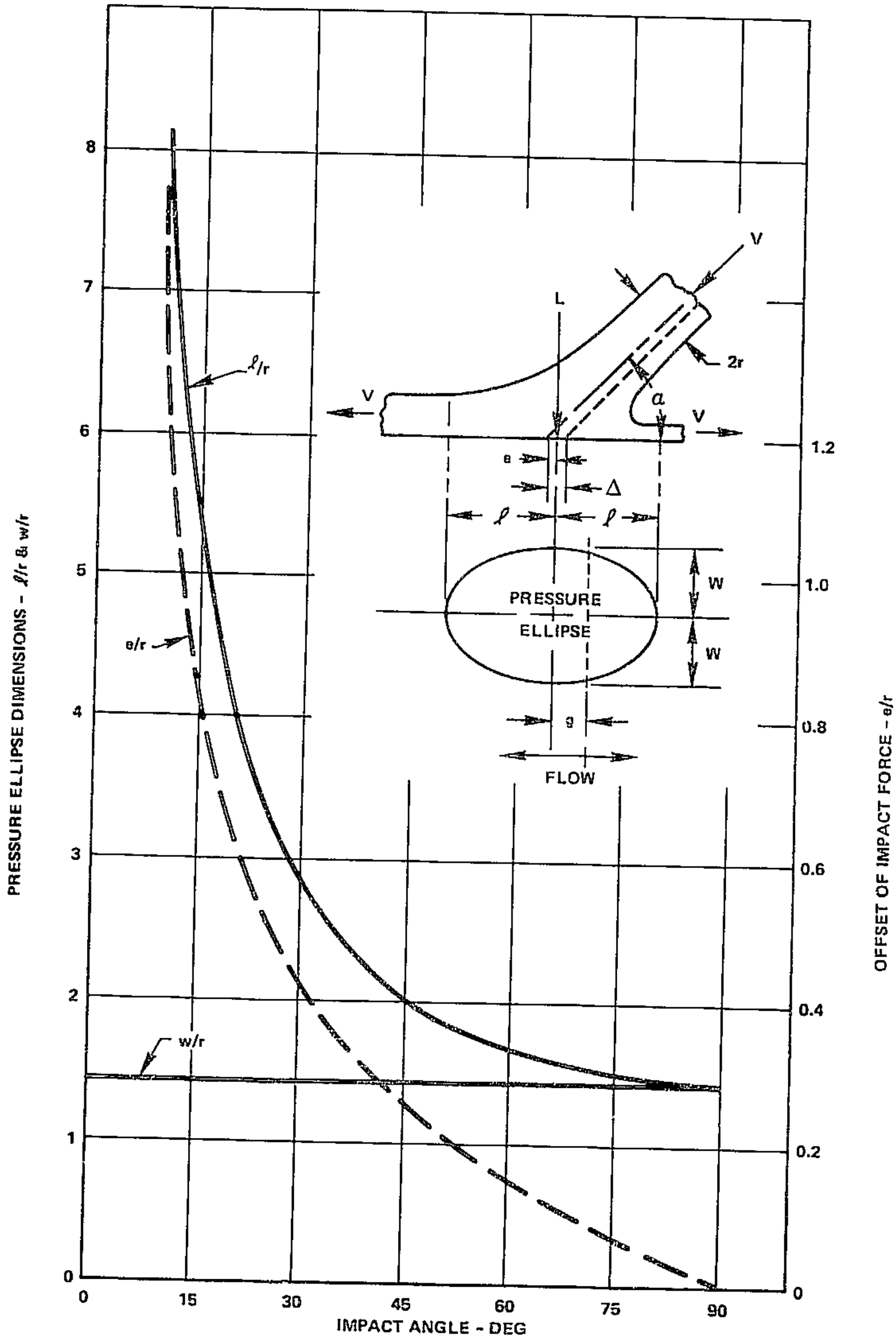


FIGURE 3B. PRESSURE ELLIPSE DIMENSIONS AND OFFSET OF IMPACT FORCE FOR APPROXIMATE 3D JET IMPACT $\Delta/r = \text{Cot}\ a$

APPENDIX C

APPROXIMATION FOR 2D OBLIQUE IMPACTING JET MISSILE

The conformal transformation solution for the steady state, oblique, impingement of a 2D jet on a flat plate given in Reference 5 and recent test results given in Reference 19 show that the pressure distribution on the plate is not uniform for low impingement angles as originally reported in Reference 4 and assumed in Appendix B. Therefore, a new representation of a 2D jet missile was developed. To facilitate computations and to alleviate some anomalies in the solution given in Reference 5 for low impingement angles, an approximate analysis was developed based on the analysis and test results given by Schach in Reference 5. The approximate analysis is based on the assumption that the velocity distribution along the plate can be represented by the expression $V/V_o=(1-e^{-x/\lambda})$. Because the pressure on the plate surface is equal to $P_o=1-(V/V_o)^2$, the resulting pressure distribution will have the form $P/Po = e^{-x/\lambda}(2 - e^{-x/\lambda})$. Figure 4 shows that such expressions for V/V_o and P/Po fit the experimental and Schach's results very well. Thus, the only requirement is to determine the decay parameters λ_1 and λ_2 for each side.

The results given in Figure 1B for the splitting of the jet is still valid, being based on momentum, energy, and continuity, i.e,

$$V_1 = V_2 = V_o$$
$$a_1/a = \cos^2 \alpha/2$$
$$a_2/a = \sin^2 \alpha/2$$

and $e/a = 1/2 \cot \alpha$. The decay parameters must be such as to satisfy the force and its position on the plate recognizing the pressure distributions are based on the stagnation point. Thus

Force $$\int_0^\infty P_1/P_o \, dx_1 + \int_0^\infty P_2/P_o \, dx_2 = 2a \sin \alpha$$

$$\text{or} \quad \lambda_1 + \lambda_2 = \frac{4}{3} a \sin \alpha \qquad (1C)$$

and

Position $$\int_0^\infty P_1/P_o \, x_1 \, dx_1 - \int_0^\infty P_2/P_o \, x_2 \, dx_2 = 2 f a \sin \alpha$$

$$\text{or} \quad \lambda_1^{\,2} - \lambda_2^{\,2} = \frac{8}{7} f a \sin \alpha \qquad (2C)$$

Solving Equations (1C) and (2C) we find that

$$\lambda_1 = \frac{2}{3} a \operatorname{Sin} \alpha + \frac{3}{7} f$$

$$\lambda_2 = \frac{2}{3} a \operatorname{Sin} \alpha - \frac{3}{7} f \tag{3C}$$

Now evaluation of test and analysis results, see Reference 5, show that f can be approximated to varying degrees of accuracy by the following expressions:

$$f_1/a = \frac{14}{9} \left(1 - \frac{2\alpha}{\pi}\right) \operatorname{Sin} \alpha \tag{4C}$$

$$f_2/a = \left[\frac{14}{9} \left(1 - \frac{2\alpha}{\pi}\right) + \frac{1}{3} \operatorname{Cos}^2 \alpha \operatorname{Cos} 2\alpha\right] \operatorname{Sin} \alpha \tag{5C}$$

$$f_4/a = 1.25(1- \frac{2\alpha}{\pi} \quad 1-(1- \frac{2\alpha}{\pi} \quad ^3 \tag{6C}$$

$$f_3/a = \frac{\ln 4}{\pi} \operatorname{Cos} \alpha \left(1 + \operatorname{Sin}\alpha\right) \tag{7C}$$

Although Equation (7C) matches the load position given by Schach's solution, the rearward decay constant, λ_2, becomes negative for impingement angles less than 22°, which is impossible. This is the result of the anomaly in Schach's solution which has the stagnation center outside of the jet for small impingement angles. Although Equation (5C) and (6C) fit the test and analysis results slightly better than Equation (4C), the extra complication did not seem warranted; see Figure 6. Thus, substituting Equation (4C) into (3C) we find

$$\lambda_1 = \frac{4}{3} \left(1 - \frac{\alpha}{\pi}\right) \operatorname{Sin} \alpha$$

$$\lambda_2 = \frac{4}{3} \left(\frac{\alpha}{\pi}\right) \operatorname{Sin} \alpha \tag{7C}$$

APPENDIX D

APPROXIMATE 3D OBLIQUE IMPACTING JET MISSILE

The assumption of a constant pressure distribution over the impingement area used in the development of the 3D missile model in Appendix B was found to be unrealistic, even for shallow angles; see References 5 and 19. Therefore a new representation of a 3D jet missile was developed based on the concepts and test information given in Reference 5. This new, approximate analysis assumes the fluid in the impacting jet is split into and remains in radial sectors after being deflected by the plate. This assumption is the same as used in Appendix B. Thus, the derivation of the splitting of the jet presented in Figure 2B applies to this analysis, i.e. $b/r = \text{Cos}\ \alpha$; see Figure 15. This split of the jet was found to correlate very well with test results; see Reference 5.

The approximate 3D Jet Missile analysis is based on the assumption that the velocity distribution along the plate can be represented by the expression $V/V_o = \left(1 - e^{-(x/\lambda)^2}\right)$, where x is the radial distance from the stagnation point and λ is a decay parameter that is a function of Cos ψ; see Figure 15. The resulting pressure distribution is given by the expression

$$P/P_o = 1 - (V/V_o)^2 = e^{-(x/\lambda)^2}\left[2 - e^{-(x/\lambda)^2}\right] \qquad (1D)$$

It was found that these expressions for V/V_o and P/P_o fitted the experimental data quite well; see Figures 16 and 17.

The expression for the decay parameter, λ, is derived so that the pressure distribution gives the proper normal impulse force and its location. The development of the differential loading for each sector requires considerable trigonometric manipulations as given below:

$$dL/P_o = \frac{1}{2} \cdot 2\ \bar{r}^2\ \text{Sin}\bar{\alpha}d\theta = 2\delta x\ \text{Sin}\bar{\alpha}d\psi \qquad (2D)$$

Now

$$\bar{r}/r = \text{Cos}\phi\text{Cos}\alpha + \sqrt{1-\text{Sin}^2\phi\text{Cos}^2\alpha}$$
$$\text{Tan}\psi = \text{Tan}\phi\text{Sin}\alpha$$
$$\text{Sin}\phi = \text{Sin}\psi/\sqrt{1-\cos^2\psi\ \text{Cos}^2\alpha}$$
$$\text{Cos}\ d = \text{Sin}\alpha\ \text{Cos}\psi/\sqrt{1-\text{Cos}^2\psi\ \text{Cos}^2\alpha}$$
$$d\phi/d\psi = \text{Sin}\alpha/(1-\text{Cos}^2\psi\ \text{Cos}^2\alpha)$$
$$\text{Cos}\bar{\alpha} = \text{Cos}\phi\ \text{Cos}\alpha$$
$$\text{Sin}\bar{\alpha} = \text{Sin}\alpha/\sqrt{1-\text{Sin}^2\phi\ \text{Cos}^2\alpha} = \sqrt{1-\text{Cos}^2\psi\ \text{Cos}^2\alpha}$$

so that

$$(\bar{r}/r)^2 = \text{Sin}^2\alpha\left(\frac{1 + \text{Cos}\alpha\ \ \text{Cos}\psi}{1 - \text{Cos}\alpha\ \ \text{Cos}\psi}\right) \qquad (3D)$$

Thus,

$$dL/P_o = r^2\ \text{Sin}^3\alpha\left(\frac{1 + \text{Cos}\alpha\ \text{Cos}\psi}{1 - \text{Cos}\alpha\ \text{Cos}\psi}\right)\frac{d\psi}{\sqrt{1 - \text{Cos}^2\psi\ \text{Cos}^2\alpha}}$$

or

$$dL/P_o = r^2\ \text{Sin}^3\alpha\sqrt{\frac{1 + \text{Cos}\alpha\ \text{Cos}\psi}{(1 - \text{Cos}\alpha\ \text{Cos}\psi)^3}}\quad d\psi \qquad (4D)$$

Assuming $P/P_o = 2e^{-\left(\frac{x}{\lambda}\right)^2} - e^{-2\left(\frac{x}{\lambda}\right)^2}$, we find that

$$dL/P_o = \int_o^{\infty} P/P_o x dx d\psi = \frac{3}{4}\lambda^2 d\psi \qquad (5D)$$

The decay parameter is obtained by equating Equations (4D) and (5D) giving

$$\lambda^2 = \frac{4}{3} r^2 \mathrm{Sin}^3\alpha \sqrt{\frac{(1 + \mathrm{Cos}\psi\ \mathrm{Cos}\alpha)}{(1 - \mathrm{Cos}\psi\ \mathrm{Cos}\alpha)^3}} \qquad (6D)$$

The location of the resultant load from the stagnation point, f, can be obtained by including the moment arm when integrating over the pressure area, i.e.

$$fL/p_o = 2\int_o^{\pi}\int_o^{\infty} \left(2x^2 \mathrm{Cos}\psi e^{-\left(\frac{x}{\lambda}\right)^2} - x^2 \mathrm{Cos}\psi\ e^{-2\left(\frac{x}{\lambda}\right)^2}\right) dx d\psi$$

$$= \sqrt{\pi}\left(1 - \frac{1}{4\sqrt{2}}\right)\int_o^{\pi} \lambda^3 \mathrm{Cos}\psi d\psi \qquad (7D)$$

Now, $L/p_o = 2\pi r^2 \mathrm{Sin}\alpha$, and λ is given by Equation 6D, so that

$$f/r = \frac{4}{3}\sqrt{\frac{1}{6\pi}}\left(\sqrt{2} - \frac{1}{4}\right) \mathrm{Sin}^{\frac{7}{2}}\alpha \int_o^{\pi}\left[\frac{1 + \mathrm{Cos}\psi\ \mathrm{Cos}\alpha}{(1 - \mathrm{Cos}\psi\ \mathrm{Cos}\alpha)^3}\right]^{3/4} \mathrm{Cos}\psi d\psi$$

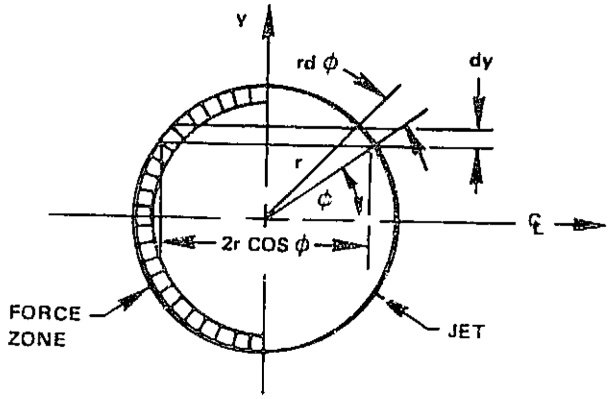
$$= .35754\ \mathrm{Sin}^{\frac{7}{2}}\alpha \int_o^{\pi} \frac{(1 - \mathrm{Cos}^2\psi\ \mathrm{Cos}^2\alpha)^{3/4}}{(1 - \mathrm{Cos}\psi\ \mathrm{Cos}\alpha)^3} \mathrm{Cos}\psi d\psi \qquad (8D)$$

There appears to be no closed form solution of the integral in Equation (8D). However, integrating it graphically results in the following values of f/r (See Figure 1D):

α	o	7.5°	15°	30°	45°	60°	75°	90°
f/r	o	1.94	1.98	1.62	1.23	.87	.44	0
e/r	α	4.71	2.09	.80	.44	.25	.11	0
g/r	∞	6.65	4.07	2.42	1.67	1.12	.55	0

Reference 5 points out that there is no corresponding simple way to determine the location of the resulting load from the center of the 3D jet as there was for a 2D jet. Thus, one must resort to using the test results given in Reference 5. These results are plotted in Figure 18 and show that for high impingement angles the load position from the jet centerline is about .43 of that found for the 2D jet. Although the test results indicate this value increases as the impingement angle decreases, the question arises as to what value it goes to as $\alpha \rightarrow o$.

The limiting value of the coefficient was obtained by assuming that as $\alpha \rightarrow o$, the 3D jet acts like a series of parallel, 2D jets as depicted below. The analysis in Appendix C for the 2D jet shows that the resultant load ends at



$$dL = 2r\cos\phi\, dy\, \rho V^2 \sin\alpha$$

$$dM = r\cos\phi \cot\alpha\, d\psi\, \rho V^2 \qquad (9D)$$

$$dM/P_o = 4r^3\cos^3\phi \cot\alpha \sin\alpha\, d\phi$$

(SMALL α)

the edge of the jet as the impingement angle approaches zero. The magnitude of the resultant load is proportional to its deflected area. Based on the above relationships, Equations (9D), we find for small impingement angles, i.e. $\alpha \rightarrow o$,

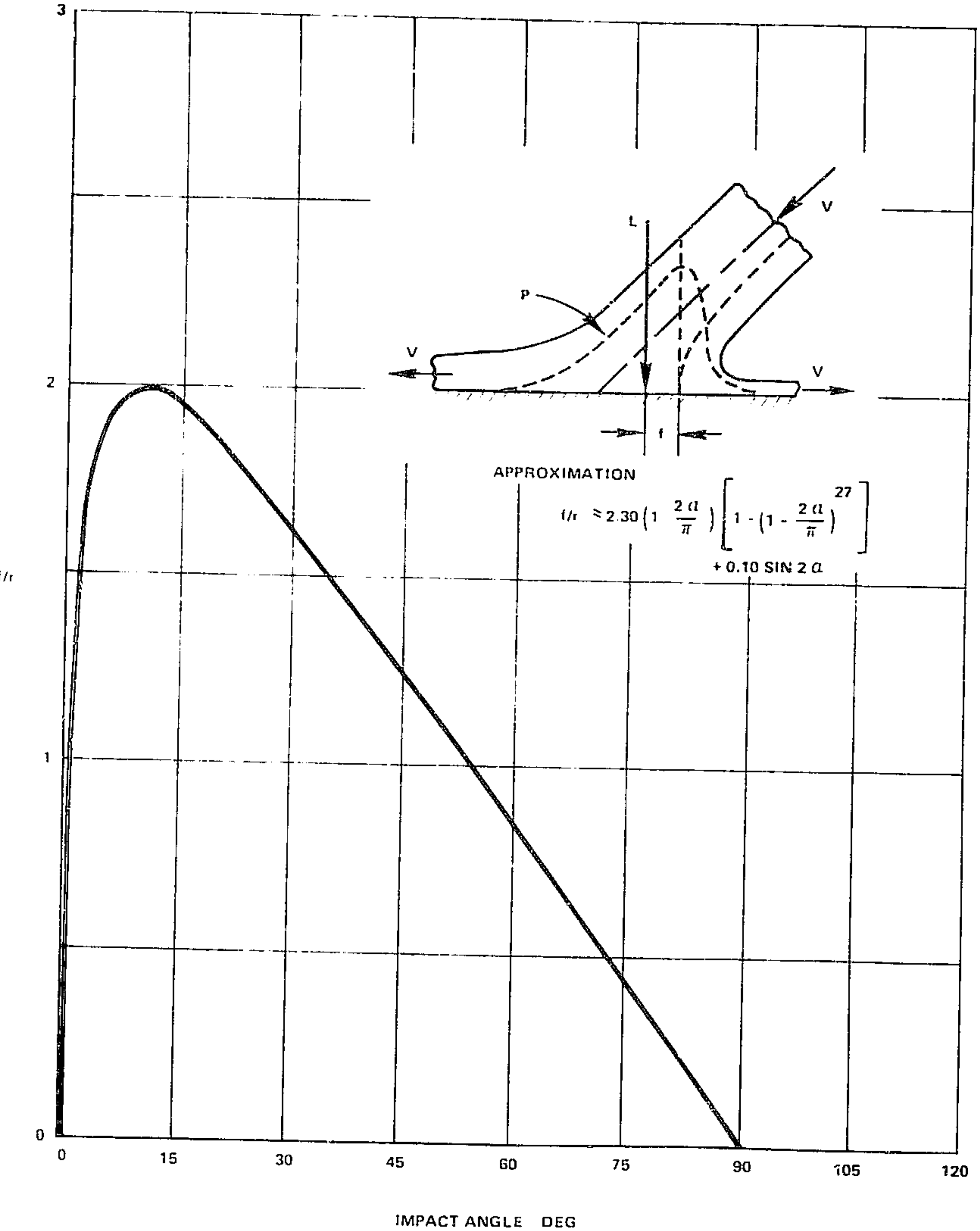
$$M/P_o = 8r^3\cot\alpha\sin\alpha \int_o^{\pi/2} \cos^3\phi\, d\phi = \frac{16}{3} r^3 \sin\alpha\cot\alpha \qquad (10D)$$

Dividing Equation (10D) by $L/P_o = 2\pi r^2 \sin\alpha$ we find

$$g/r = \frac{M}{Lr} = \frac{8}{3\pi}\cot\alpha \qquad (11D)$$

Using this value for $\alpha \rightarrow o$ and the test value of about $4/3\pi$ for the large impingement angles, we find that the following expression for the normal load position from the jet centerline e/r fits the test data very well; see Figure 18:

$$e/r = \frac{8\cot\alpha/3\pi}{1+\sqrt{\sin\alpha}} \qquad (12D)$$



$$f/r \approx 2.30\left(1 - \frac{2\alpha}{\pi}\right)\left[1 - \left(1 - \frac{2\alpha}{\pi}\right)^{27}\right] + 0.10 \sin 2\alpha$$

FIGURE 1D. DISTANCE OF RESULTANT LOAD FROM STAGNATION POINT FOR 3D OBLIQUE IMPACTING JET MISSILE

APPENDIX E

GENERAL, SYMMETRICAL 3D, OBLIQUE IMPINGING JET MISSILE

To model a general, symmetrical shaped missile using oblique impinging jet theory, the 2D and 3D jet models, developed in Appendices C and D, are combined as shown in Figure 20. The resulting model has the center section depicted by the 2D jet and the two sides are depicted by halves of a 3D jet. As such an oblong jet becomes a square or round jet, the equivalent model degenerates into an equivalent pure, round jet. Such a model composed of 2D and 3D jets appears appropriate because the dividing lines for forward and rearward flow for oblique impinging 2D and 3D jets are the same, i.e. $\Delta/r = \text{Cot}\ \alpha$. The assumptions and relationships needed for simulating a general, symmetrical 3D jet missile by a combination of 2D and 3D jets are given below.

The impacting missile is assumed to be symmetrical about the blade chordwise impact centerline; see Figure 20. It is also assumed that the missile impacting cross-section is depicted by a number of rectangular sections parallel to the velocity axis of the missile. First, the n rectangular impinging layers h thick are approximated by a combination of 2D and 3D jets as shown in Figure 20. Naturally the total cross-sectioned areas must be the same. For simplicity the width, W, of the approximate model is made the same as the original, rectangular layered missile, i.e. W = nh. Although this assumption for W introduces a slight error in approximating the layered missile, an evaluation of the error for typical missiles showed it to be small.

The centerline position of the approximate missile is such that its center of gravity is consistent with the original, layered missile. The position of the centerline of the approximate missile relative to the centerline of the first rectangular layer of the original missile is given by the expression

$$\Delta \mathcal{C}_{1-AM} = \sum_{j=2}^{n} A_j (n-1) h \Big/ \sum_{j=1}^{n} A_j \qquad (1E)$$

where

$$A_{AM} = A_2 + A_3 = (1 + \frac{\pi}{4} W) W = \sum_{j=1}^{n} A_j \qquad (2E)$$

Although the dividing lines for forward and rearward flow for the 2D and 3D jets are the same, the positions of their resultant forces are not. Because of the sideward spreading action of the 3D jet its resultant force is not displaced as far aft of the jet centerline as that for the 2D jet; see Figures 14 & 18. Since their impingement forces are proportional to their respective areas, A_3 and A_2, the effective resultant position is represented by the weighted average based on area, i.e. -

$$\bar{e}/r = \frac{A_2 (e/r)_2 + A_3 (e/r)_3}{A_2 + A_3} \qquad (3E)$$

where $r = W/2$.

The resulting pressure distribution decay and spreading action of the 2D and 3D jets are different, which result in discontinuities at their common boundaries. To prevent these discontinuities from occurring, correction factors are applied to the 2D and 3D results such that the total incremental load and flow area at a given radius from the pressure stagnation point and flow dividing line, respectively, are maintained. For the flow area this poses no problem because the flow dividing lines for the 2D and 3D jets are the same; see Figure 1E. In general, for shallow impingement angles, α, almost all of the fluid is deflected forward, for

$$A_3^{Fwd} = \pi r^2\left(1-\frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}\right) \approx \pi r^2, \text{if } \alpha < 45^\circ \ (<9\% \text{ error})$$

$$A_2^{Fwd} = \ell r \ (1 + \cos \alpha) \simeq 2 l r, \text{if } \alpha < 45^\circ \ (<15\% \text{ error}) \qquad (4E)$$

Thus, for simplicity the rearward flow can be neglected and the correction factors μ_3 and μ_2 for the 3D and 2D spreading thicknesses are approximated as follows:

$$(\delta/r)_3^c = \mu_3(\delta/r)_3 \ \& \ (\delta/r)_2^c = \mu_2(\delta/r)_2 \ (c = \text{corrected}) \qquad (5E)$$

$$\mu_3 A_3^{Fwd} + \mu_2 A_2^{Fwd} = A_3^{Fwd} + A_2^{Fwd}$$

or

approx. $\mu_3 A_3 + \mu_2 A_2 = A_3 + A_2$ (6E)

$$(\bar{\delta}/r)_3\mu_3 = (\delta/r)_2 \mu_2 \ (\text{Junction}) \left[\bar{\delta}_3 = \delta_2 (\sim \text{Junction})\right] \qquad (7E)$$

Thus,

$$\mu_3 = \left[\frac{1 + A_3/A_2}{\frac{(\bar{\delta}/r)_3}{(\delta/r)_2} + \frac{A_3}{A_2}}\right] \ \& \ \mu_2 = \left[\frac{1 + A_2/A_3}{\frac{(\bar{\delta}/r)_2}{(\bar{\delta}/r)_3} + \frac{A_2}{A_3}}\right] \qquad (8E)$$

For the uniform thickness region the spreading thickness is given by combining Equations (5E) and (8E) or

$$(\delta/r)_2^c = (\bar{\delta}/r)_3^c = \left[\frac{A_2 + A_3}{\frac{A_3}{(\delta/r)_3} \ \frac{A_2}{(\delta/r)_2}}\right] \qquad (9E)$$

A more sophisticated approximation can be made if both the forward and rearward discontinuities are to be prevented. This can be done by using a linearly changing correction factor for the 3D side jet results and front and rear correction factors for the 2D center jet. Considering the other approximations in the analysis, such additional complexity did not appear justified initially.

The location of the stagnation pressure points for the 2D and 3D jets from the missile centerline differ slightly. Also, their respective decay rates differ. The simplest way to tie the two pressure distributions together without any discontinuities is to assume they both have a common pressure stagnation point relative to the missile centerline. Because the pressure loadings of the 2D and 3D jets are proportional to their respective areas, the weighted average position of the stagnation point from the missile centerline can be expressed as follows:

$$\bar{g}/r = \frac{(g/r)_3 A_3 + (g/r)_2 A_2}{A_3 + A_2} \qquad (10E)$$

Even though the pressure distributions for the 2D and 3D jets are made to start at a common stagnation point given by Equation (10E), pressure discontinuities will occur at their junctions because of their different pressure decay expressions. To rectify this situation the magnitudes of the pressures can be modified by factors γ_3 and γ_2 so as to satisfy equilibrium and alleviate the pressure discontinuity at the junctions. These pressure correction factors are obtained in a manner similar to that done for the flow spreading correction factors. As for the flow case, the pressure load due to the rearward flow is assumed small and neglected for simplicity. Then, referring to Figure 1E, vertical equilibrium incremental loading gives

$$\left.\begin{aligned} (dL/dx)_3 &\simeq 2\int_0^{\pi/2} x\, P_3 d\psi \quad \text{where } P_3 = f(\psi) \\ (dL/dx)_2 &\simeq \ell P_2 \end{aligned}\right\} \qquad (11E)$$

so that

$$\gamma_3 (dL/dx)_3 + \gamma_2 (dL/dx)_2 = (dL/dx)_3 + (dL/dx)_2 \qquad (12E)$$

and

$$\gamma_3 \bar{P}_3 = \gamma_2 P_2 \quad \text{(Junction)} \left[\bar{P}_3 - P_3 \text{ @ Junction}\right] \qquad (13E)$$

Thus,

$$\gamma_3 = \left[\frac{1 + (dL/dx)_3/\ell P_2}{\bar{P}_3/P_2 + (dL/dx)_3/\ell P_2}\right]$$

and (14E)

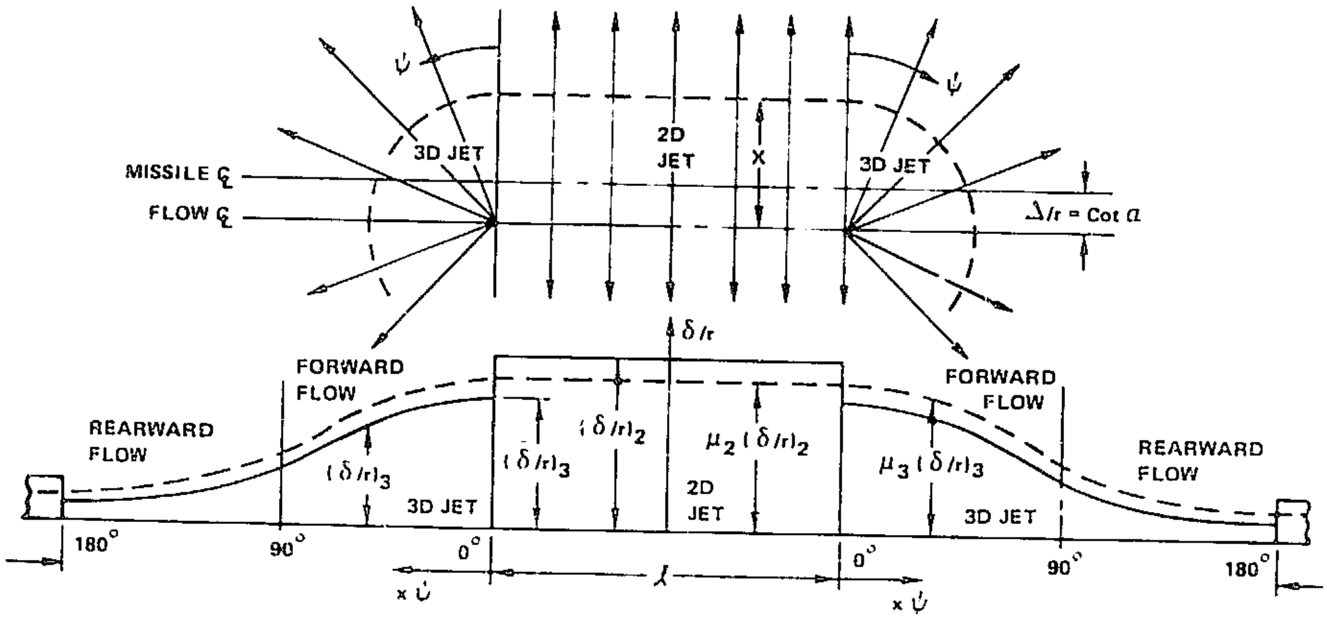
$$\gamma_2 = \left[\frac{1 + \ell P_2/(dl/dx)_3}{P_2/\bar{P}_3 + \ell P_2/(dL/dx)_3}\right]$$

where P_3/P_0 is given by Equations (1D) and (6D). For the uniform pressure region the pressure is given by combining Equations (13E) and (14E) or

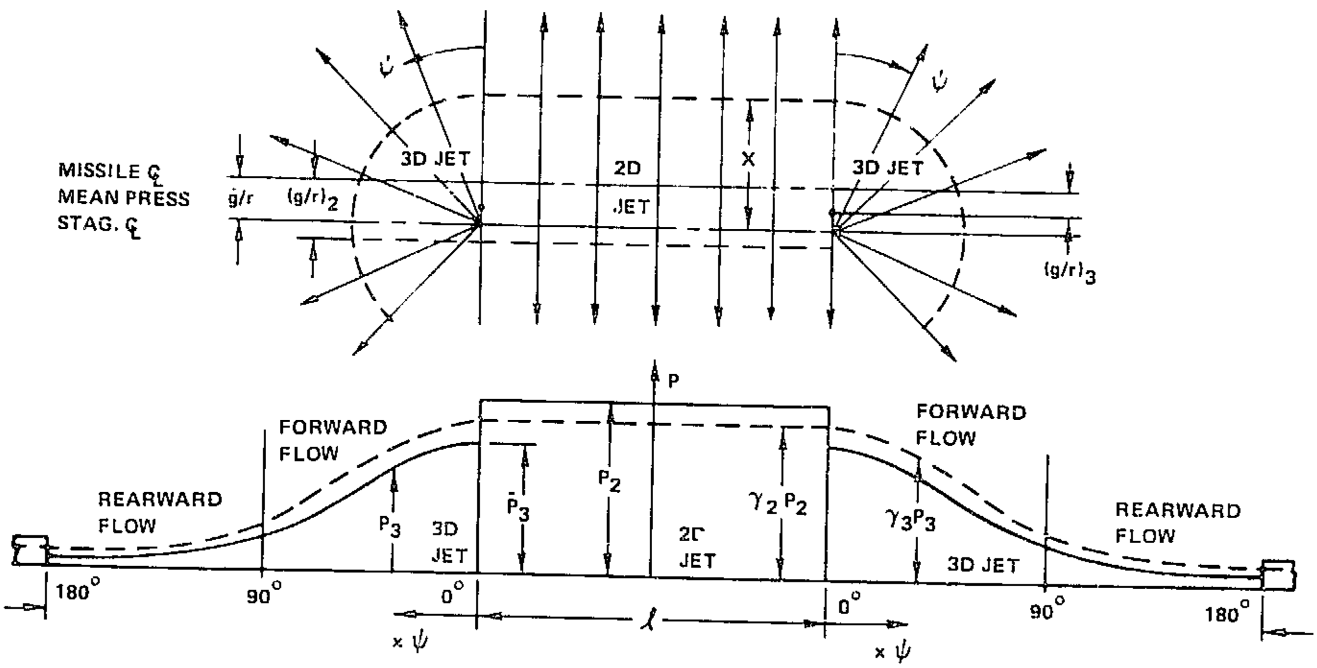
$$P_3^c = P_2^c = \left[\frac{\ell P_2 + (dL/dx)_3}{\ell + \dfrac{(dL/dx)_3}{\bar{P}_3}} \right] \qquad (15E)$$

Just as for the spreading thickness case, a more exact but more sophisticated approach could be used to smooth out the pressure distribution of the 2D and 3D jets, but it did not appear warranted initially.

Table II summarizes the pertinent equations for modeling and analyzing a general, symmetrical 3D oblique impinging jet missile. Appendix F gives a procedure for modifying the 2D and 3D jet pressure and thickness distribution results for the entire jet, not just for the forward deflected portion. To do this requires three correction factors, rather than two, so that no discontinuity occurs between the junction of the 3D side jet and the 2D rearward jet as well as between the 2D forward jet.



SPREADING CORRECTION FACTORS



PRESSURE LOADING CORRECTION FACTORS

FIGURE 1E. CORRECTION FACTORS FOR SPREADING & PRESSURE LOADING FOR GENERAL, SYMMETRICAL JET MISSILE

APPENDIX F

SUPPLEMENTARY RELATIONSHIPS FOR GENERAL MISSILE MODEL

Appendix E gives relationships for defining the general missile model assuming most of the flow is diverted towards the direction of impact, thus simplifying the corrections necessary to tie together the 2D and 3D jet models that make up the general missile. Because of the desire to have the computer program plot pressure contour lines, a more elaborate correction is necessary to prevent any discontinuities in pressure in the rearward flow. This is also true of the squashing or thickness expressions. This Appendix presents a more exact modifying procedure, so that there will be no discontinuities in the pressure or squashing contour distributions in any direction.

Appendix E suggests that all the pressure discontinuities could be eliminated by using a linearly changing correction factor for the 3D jets; i.e. $\gamma_3 = \bar{\gamma}_3 + \bar{\bar{\gamma}}_3 \psi/\pi$. However, such a correction function is inconsistent with the 3D pressure distribution, so that, although the junction discontinuities are eliminated, a distorted unrealistic pressure distribution can result between $\psi=0$ and $180°$. In order to circumvent this problem and still eliminate the discontinuities between the 2D and 3D jets, it is proposed to perturbate the 3D pressure distribution using the following relationship:

$$\bar{P}_3 = P_3 + \left(\frac{P_3 - P_3^{180°}}{P_3^{o} - P_3^{180°}}\right)\gamma_3^1 + \left(\frac{P_3^{o} - P_3}{P_3^{o} - P_3^{180°}}\right)\gamma_3^2 \qquad (1F)$$

A similar perturbation expression can be used for smoothing of the spreading/thickness of the jet; i.e.

$$\bar{\delta}_3 = \delta_3 + \left(\frac{\delta_3 - \delta_3^{180°}}{\delta_3^{o} - \delta_3^{180°}}\right)\mu_3^1 + \left(\frac{\delta_3^{o} - \delta_3}{\delta_3^{o} - \delta_3^{180°}}\right)\mu_3^2 \qquad (2F)$$

In order to satisfy the force equilibrium or continuity, moment equilibrium or flow split, and avoid discontinuities in the pressure or thickness for both rearward and forward flows of the 2D jet and 3D jet, four correction factors are needed. Two of these correction factors are in the perturbation of the pressure or thickness for the side 3D jets, whereas the other two correction factors apply to the front and rear 2D jets. The expressions for the necessary four correction factors for both the pressure and thickness distributions are derived below:

<u>Pressure Distribution:</u> Expressions for P_2 and P_3 are given in Table II. The location of the pressures is based on the stagnation point defined by g; see Table II.

<u>Load Equilibrium:</u> (Correction Factors γ_2^1, γ_2^2, γ_3^1, & γ_3^2)

$$(P_2^1 + P_2^2)\ell + 2X\int_0^{\pi} P_3 \, d\psi = (\gamma_2^1 P_2^1 + \gamma_2^2 P_2^2)\ell + 2X\int_0^{\pi} \bar{P}_3 \, d\psi \qquad (3F)$$

Moment Equilibrium:

$$(P_2^1+P_2^2)\,\ell\, X+2X^2\int_0^\pi P_3\cos\psi d\psi=(\gamma_2^1P_2^1+\gamma_2^2P_2^2)\,\ell\, X+2X^2\int_0^\pi \bar{P}_3\cos\psi d\psi \qquad (4F)$$

Boundary Conditions:

$$\bar{P}_3^{o}=\gamma_2^1P_2^1 \text{ and } \bar{P}_3^{180^\circ}=\gamma_2^2P_2^2 \qquad (5F)$$

Substituting Equations (1F) and (5F) into Equations (3F) and (4F) we find

$$(P_2^1+P_2^2)\,\ell = (\bar{P}_3^{o}+P_3^{180^\circ})\,\ell + 2X\left[\gamma_3^1\int_0^\pi\left(\frac{P_3-P_3^{180^\circ}}{P_3^{o}-P_3^{180^\circ}}\right)d\psi_3+\gamma_3^2\int_0^\pi\left(\frac{P_3^{o}-P_3}{P_3^{o}-P_3^{180^\circ}}\right)d\psi\right]$$

or

$$\left[P_2^1+P_2^2-(P_3^{o}+P_3^{180^\circ})\right] = \left[\gamma_3^1+\gamma_3^2\right]\ell + 2X\left[\gamma_3^1\int_0^\pi\left(\frac{P_3-P_3^{180^\circ}}{P_3^{o}-P_3^{180^\circ}}\right)d\psi+\gamma_3^2\int_0^\pi\left(\frac{P_3^{o}-P_3}{P_3^{o}-P_3^{180^\circ}}\right)d\psi\right] \qquad (6F)$$

and

$$\left[P_2^1-P_2^2\right]\ell = (\bar{P}_3^{o}-P_3^{180^\circ})\,\ell + 2X\int_0^\pi\left[\left(\frac{P_3-P_3^{180^\circ}}{P_3^{o}-P_3^{180^\circ}}\right)\gamma_3^1+\left(\frac{P_3^{o}-P_3}{P_0^{o}-P_3^{180^\circ}}\right)\gamma_3^2\right]\cos\psi d\psi$$

or

$$\left[(P_2^1-P_2^2)-(P_3^{o}-P_3^{180^\circ})\right]\ell = \left[\gamma_3^1-\gamma_3^2\right]\ell + 2X\int_0^\pi\left[\left(\frac{P_3-P_3^{180^\circ}}{P_3^{o}-P_3^{180^\circ}}\right)\gamma_3^1+\left(\frac{P_3^{o}-P_3}{P_0^{2}-P_3^{180^\circ}}\right)\gamma_3^2\right]\cos\psi d\psi \qquad (7F)$$

After integrating the integral quantities in Equations (6F) and (7F) one obtains two equations in two unknowns, γ_3^1 and γ_3^2. Once γ_3^1 and γ_3^2 are determined from Equations (6F) and (7F), γ_2^1 and γ_2^2 can be solved for using Equations (5F). Knowing all four correction factors, the pressure distribution is then defined everywhere for that particular value of X.

Thickness Distribution: Expressions for δ_2 and δ_3 are given in Table II. The location of the thicknesses is based on the stagnation point defined by g; see Table II. The thickness distribution is only valid for $X/r \gg 1/\sin\alpha$.

Flow Continuity: (Correction Factors μ_2^1, μ_2^2, μ_3^1, & μ_3^2)

$$\mu_2^1 A_2^1 + \mu_2^1 A_2^2 + 2X \int_0^{\pi} \bar{\delta}_3 d\psi = A_2^1 + A_2^2 + A_3 = A_T$$

or (8F)

$$\ell(\mu_2^1 \delta_2^1 + \mu_2^1 \delta_2^2) + 2X \int_0^{\pi} \bar{\delta}_3 d\psi = (2\,\ell\, r \cdot \pi r^2) = A_T$$

Flow Split:

$$\mu_2^1 A_2^1 + 2X \int_0^{\pi/2} \bar{\delta}_3 d\psi = A_2^1 + 2X \int_0^{\pi/2} \delta_3 d\psi$$

or (9F)

$$\mu_2^1 \delta_2^1\, \ell + 2X \int_0^{\pi/2} \bar{\delta}_3 d\psi = \ell\, \delta_2^1 + 2X \int_0^{\pi/2} \delta_3 d\psi$$

Boundary Conditions:

$$\mu_2^1 \delta_2^1 = \bar{\delta}_3^{o} \text{ and } \mu_2^2 \delta_2^2 = \bar{\delta}_3{}^{180^o} \quad (10F)$$

Substituting Equations (2F) and (10F) into Equations (8F) and (9F) we find

$$\ell(\bar{\delta}_3^{o} + \bar{\delta}_3{}^{180^o}) + 2X \int_0^{\pi} \bar{\delta}_3 d\psi = (2\,\ell\, r + \pi r^2) = A_T$$

or

$$\ell(\mu_3^1 + \mu_3^2 + \delta_3^{0^o} + \delta_3{}^{180^o}) + 2X \left[\mu_3^1 \int_0^{\pi} \left(\frac{\delta_3 - \delta_3{}^{180^o}}{\delta_3^{o^o}\ \delta_3{}^{180^o}}\right) d\psi + \mu_3^2 \int_0^{\pi} \left(\frac{\delta_3^{o^o}\ \delta_3}{\delta_3^{o^o}\ \delta_3{}^{180}}\right) d\psi\right] = 2\,\ell\, r \quad (11F)$$

and

$$\ell(\mu_3^1 + \delta_3^{0^o}) + 2X \left[\mu_3^1 \int_0^{\pi/2} \left(\frac{\delta_3 - \delta_3{}^{180^o}}{\delta_3^{o^o} - \delta_3{}^{180^o}}\right) d\psi + \mu_3^2 \int_0^{\pi/2} \left(\frac{\delta_3^{o} - \delta_3}{\delta_3^{o^o} - \delta_3{}^{180^o}}\right) d\psi\right] = \ell\, \delta_2^1 \quad (12F)$$

After integrating the integral quantities in Equations (11F) and (12F) one obtains two equations in two unknowns, μ_3^1 and μ_3^2. Once μ_3^1 and μ_3^2 are determined from Equations (11F) and (12F), μ_2^1 and μ_2^2 can be solved for using Equations (10F). Knowing all four correction factors, the thickness distribution is then defined everywhere for that particular value of X.

Because of the form of the expression for δ_3 the bracketed quantities under the integral signs in Equations (11F) and (12F) are the same for all values of X/r. Thus, the respective values of the integrals remain the same for all X's for a given impact configuration. Specifically, the first and second integral take the form, see Table II,

$$\int\left(\frac{\delta_3-\delta_3^{180°}}{\delta_3^{0°}-\delta_3^{180°}}\right)d\psi=\left[\frac{1}{\left(\frac{1+\cos\alpha}{1-\cos\alpha}\right)^2-1}\right]\int\left[\left(\frac{1+\cos\alpha}{1-\cos\alpha\cos\psi}\right)^2-1\right]d\psi$$

and

$$\int\left(\frac{\delta_3^{0°}-\delta_3}{\delta_3^{0°}-\delta_3^{180°}}\right)d\psi=\left[\frac{1}{\left(\frac{1+\cos\alpha}{1-\cos\alpha}\right)^2-1}\right]\int\left[\left(\frac{1+\cos\alpha}{1-\cos\alpha}\right)^2-\left(\frac{1+\cos\alpha}{1-\cos\alpha\cos\psi}\right)^2\right]d\psi$$

Thus, only the integral $\int[(1+\cos\alpha)^2/(1-\cos\alpha\cos\psi)^2]d\psi$ needs to be evaluated numerically once for all the thickness distributions for the particular impact configuration.

APPENDIX G

LISTING OF COMPUTER OUTPUT RESULTS FOR DEMONSTRATION PROBLEM 5.2

(PAGES 180–251)

```
V,RIMP,TSTOP,ALPHA0,XOCL,YOCL,NR,NN,NM,NVA,IPDEL,DEN,ISYM
0.726000E+04,0.300000E+02,0.500000E-01,0.523600E+00,0.454600E+01,0.377050E+01,  8,120,  5,  6,  2,0.988800E-04,  1

RL  1, 2, 3, 4, 5, 6,
0.156250E+01,0.950000E+00,0.325000E+00,-.325000E+00,-.950000E+00,-.156250E+01,

RM  1, 2, 3, 4, 5, 6,
0.625000E+00,0.600000E+00,0.650000E+00,0.650000E+00,0.600000E+00,0.625000E+00,

CL  1, 2, 3, 4, 5, 6,
0.210000E+01,0.326000E+01,0.375000E+01,0.375000E+01,0.326000E+01,0.210000E+01,

DELTL  1, 2, 3, 4, 5, 6,
0.825000E+00,0.245000E+00,0.0         ,0.0         ,0.245000E+00,0.825000E+00,

WM  1, 2, 3, 4, 5, 6,
0.210000E+01,0.326000E+01,0.375000E+01,0.375000E+01,0.326000E+01,0.210000E+01,

MAX  1, 2, 3, 4, 5, 6, 7, 8,
 15, 15, 15, 15, 15, 15, 15, 15,

NJ3  1, 2, 3, 4, 5, 6, 7, 8,
  9,  9,  9, [illegible]  9,  9,  9,  9,

VMI  1, 2, 3, 4, 5,
0.98558E-02,0.42763E-02,0.98890E-02,0.10223E-01,0.23340E-01,

DR  1, 2, 3, 4, 5,
0.35000E-01,0.35000E-01,0.35000E-01,0.35000E-01,0.35000E-01,

WO  1, 2, 3, 4, 5,
0.43350E+03,0.87339E+03,0.14450E+04,0.15331E+04,0.22620E+04,

PH2( 1,1, 1) THRU PH2( 1,120, 1)

0.47091E-01,0.60371E-01,0.77146E-01,0.93922E-01,0.11070E+00,0.12747E+00,0.14425E+00,0.16102E+00,0.17780E+00,0.19458E+00,
0.21834E+00,0.24630E+00,0.27426E+00,0.30222E+00,0.32668E+00,0.12272E+00,0.13600E+00,0.15277E+00,0.16955E+00,0.18633E+00,
0.20310E+00,0.21988E+00,0.23665E+00,0.25343E+00,0.27020E+00,0.29397E+00,0.32193E+00,0.34989E+00,0.37784E+00,0.40231E+00,
0.19835E+00,0.21163E+00,0.22840E+00,0.24518E+00,0.26195E+00,0.27873E+00,0.29550E+00,0.31228E+00,0.32905E+00,0.34583E+00,
0.36959E+00,0.39755E+00,0.42551E+00,0.45347E+00,0.47794E+00,0.27397E+00,0.28725E+00,0.30403E+00,0.32081E+00,0.33758E+00,
0.35436E+00,0.37113E+00,0.38791E+00,0.40468E+00,0.42146E+00,0.44522E+00,0.47318E+00,0.50114E+00,0.52910E+00,0.55356E+00,
0.33069E+00,0.34398E+00,0.36075E+00,0.37753E+00,0.39430E+00,0.41106E+00,0.42785E+00,0.44463E+00,0.46140E+00,0.47818E+00,
0.50194E+00,0.52990E+00,0.55786E+00,0.58582E+00,0.61028E+00,0.40632E+00,0.41960E+00,0.43638E+00,0.45315E+00,0.46993E+00,
0.48670E+00,0.50348E+00,0.52026E+00,0.53703E+00,0.55381E+00,0.57757E+00,0.60553E+00,0.63349E+00,0.66145E+00,0.68591E+00,
0.48195E+00,0.49523E+00,0.51200E+00,0.52878E+00,0.54556E+00,0.56233E+00,0.57911E+00,0.59588E+00,0.61266E+00,0.62943E+00,
0.65320E+00,0.68116E+00,0.70912E+00,0.73708E+00,0.76154E+00,0.55758E+00,0.57086E+00,0.58763E+00,0.60441E+00,0.62118E+00,
0.63796E+00,0.65474E+00,0.67151E+00,0.68829E+00,0.70506E+00,0.72883E+00,0.75678E+00,0.78474E+00,0.81270E+00,0.83717E+00,

PH2( 2,1, 1) THRU PH2( 2,120, 1)

0.52638E-01,0.38395E-01,0.20404E-01,0.24128E-02,-.15579E-01,-.33570E-01,-.51561E-01,-.69552E-01,-.87543E-01,-.10553E+00,
-.13102E+00,-.16101E+00,-.19099E+00,-.22098E+00,-.24721E+00,-.18701E-01,-.32944E-01,-.50935E-01,-.68927E-01,-.86918E-01,
-.10491E+00,-.12290E+00,-.14089E+00,-.15888E+00,-.17687E+00,-.20236E+00,-.23235E+00, .26233E+00,-.29232E+00,-.31855E+00,
-.90040E-01,-.10428E+00,-.12227E+00,-.14027E+00,-.15826E+00,-.17625E+00,-.19424E+00, .21223E+00,-.23022E+00,-.24821E+00,
-.27370E+00,-.30369E+00,-.33367E+00,-.36366E+00,-.38989E+00,-.16138E+00,-.17562E+00,-.19361E+00,-.21161E+00,-.22960E+00,
-.24759E+00,-.26558E+00,-.28357E+00,-.30156E+00,-.31955E+00,-.34504E+00,-.37502E+00,-.40501E+00,-.43500E+00,-.46123E+00,
-.21488E+00,-.22913E+00,-.24712E+00,-.26511E+00,-.28310E+00,-.30109E+00,-.31908E+00, .33707E+00,-.35507E+00,-.37306E+00,
```

```
-.39854E+00,-.42853E+00,-.45851E+00,-.48850E+00,-.51474E+00,-.28622E+00,-.30047E+00,-.31846E+00,-.33645E+00,-.35444E+00,
-.37243E+00,-.39042E+00,-.40841E+00,-.42641E+00,-.44440E+00,-.46988E+00,-.49987E+00,-.52985E+00,-.55984E+00,-.58608E+00,
-.35756E+00,-.37181E+00,-.38980E+00,-.40779E+00,-.42578E+00,-.44377E+00 -.46176E+00,-.47975E+00,-.49774E+00,-.51573E+00,
-.54122E+00,-.57121E+00,-.60119E+00,-.63118E+00,-.65742E+00,-.42890E+00,-.44314E+00,-.46114E+00,-.47913E+00,-.49712E+00,
-.51511E+00,-.53310E+00,-.55109E+00,-.56908E+00,-.58707E+00,-.61256E+00,-.64255E+00,-.67253E+00,-.70252E+00,-.72875E+00,

PH2( 1,1, 2) THRU PH2( 1,120, 2)

-.21349E+00,-.20845E+00,-.20207E+00,-.19569E+00,-.18932E+00,-.18294E+00,-.17656E+00,-.17019E+00,-.16381E+00,-.15743E+00,
-.14840E+00,-.13777E+00,-.12714E+00,-.11651E+00,-.10721E+00,-.22459E+00,-.21955E+00,-.21317E+00,-.20679E+00,-.20042E+00,
-.19404E+00,-.18766E+00,-.18129E+00,-.17491E+00,-.16853E+00,-.15950E+00,-.14887E+00,-.13824E+00,-.12761E+00,-.11831E+00,
-.23569E+00,-.23065E+00,-.22427E+00,-.21789E+00,-.21152E+00,-.20514E+00,-.19876E+00,-.19238E+00,-.18601E+00,-.17963E+00,
-.17060E+00,-.15997E+00,-.14934E+00,-.13871E+00,-.12941E+00,-.24679E+00,-.24174E+00,-.23537E+00,-.22899E+00,-.22261E+00,
-.21624E+00,-.20986E+00,-.20348E+00,-.19711E+00,-.19073E+00,-.18170E+00,-.17107E+00,-.16044E+00,-.14981E+00,-.14052E+00,
-.25512E+00,-.25007E+00,-.24369E+00,-.23732E+00,-.23094E+00,-.22456E+00,-.21819E+00,-.21181E+00,-.20543E+00,-.19906E+00,
-.19002E+00,-.17939E+00,-.16877E+00,-.15814E+00,-.14884E+00,-.26622E+00,-.26117E+00,-.25479E+00,-.24842E+00,-.24204E+00,
-.23566E+00,-.22929E+00,-.22291E+00,-.21653E+00,-.21016E+00,-.20112E+00,-.19049E+00,-.17987E+00,-.16924E+00,-.15994E+00,
-.27732E+00,-.27227E+00,-.26589E+00,-.25951E+00,-.25314E+00,-.24676E+00,-.24038E+00,-.23401E+00,-.22763E+00,-.22126E+00,
-.21222E+00,-.20159E+00,-.19097E+00,-.18034E+00,-.17104E+00,-.28842E+00,-.28337E+00,-.27699E+00,-.27061E+00,-.26424E+00,
-.25786E+00,-.25148E+00,-.24511E+00,-.23873E+00,-.23235E+00,-.22332E+00,-.21269E+00,-.20207E+00,-.19144E+00,-.18214E+00,

PH2( 2,1, 2) THRU PH2( 2,120, 2)

0.18763E+00,0.18131E+00,0.17333E+00,0.16535E+00,0.15736E+00,0.14938E+00,0.14140E+00,0.13341E+00,0.12543E+00,0.11745E+00,
0.10614E+00,0.92831E-01,0.79525E-01,0.66220E-01,0.54577E-01,0.18558E+00,0.17926E+00,0.17128E+00,0.16330E+00,0.15531E+00,
0.14733E+00,0.13935E+00,0.13136E+00,0.12338E+00,0.11540E+00,0.10409E+00,0.90781E-01,0.77475E-01,0.64170E-01,0.52527E-01,
0.18353E+00,0.17721E+00,0.16923E+00,0.16125E+00,0.15326E+00,0.14528E+00,0.13730E+00,0.12931E+00,0.12133E+00,0.11335E+00,
0.10204E+00,0.88731E-01,0.75425E-01,0.62120E-01,0.50477E-01,0.18148E+00,0.17516E+00,0.16718E+00,0.15920E+00,0.15121E+00,
0.14323E+00,0.13525E+00,0.12726E+00,0.11928E+00,0.11130E+00,0.99986E-01,0.86681E-01,0.73375E-01,0.60070E-01,0.48427E-01,
0.17994E+00,0.17362E+00,0.16564E+00,0.15766E+00,0.14968E+00,0.14169E+00,0.13371E+00,0.12572E+00,0.11774E+00,0.10976E+00,
0.98449E-01,0.85143E-01,0.71838E-01,0.58532E-01,0.46890E-01,0.17790E+00,0.17158E+00,0.16359E+00,0.15561E+00,0.14763E+00,
0.13964E+00,0.13166E+00,0.12367E+00,0.11569E+00,0.10771E+00,0.96399E-01,0.83093E-01,0.69788E-01,0.56482E-01,0.44840E-01,
0.17585E+00,0.16953E+00,0.16154E+00,0.15356E+00,0.14557E+00,0.13759E+00,0.12961E+00,0.12163E+00,0.11364E+00,0.10566E+00,
0.94349E-01,0.81043E-01,0.67738E-01,0.54432E-01,0.42790E-01,0.17379E+00,0.16747E+00,0.15949E+00,0.15151E+00,0.14353E+00,
0.13554E+00,0.12756E+00,0.11958E+00,0.11159E+00,0.10361E+00,0.92299E-01,0.78993E-01,0.65688E-01,0.52382E-01,0.40740E-01,

PH2( 1,1, 3) THRU PH2( 1,120, 3)

-.47919E+00,-.47182E+00,-.46250E+00,-.45318E+00,-.44387E+00,-.43455E+00,-.42523E+00,-.41592E+00,-.40660E+00,-.39728E+00,
-.38408E+00,-.36856E+00,-.35303E+00,-.33750E+00,-.32391E+00,-.46469E+00,-.45732E+00,-.44800E+00,-.43868E+00,-.42937E+00,
-.42005E+00,-.41073E+00,-.40142E+00,-.39210E+00,-.38278E+00,-.36958E+00,-.35406E+00,-.33853E+00,-.32300E+00,-.30941E+00,
-.45019E+00,-.44282E+00,-.43350E+00,-.42418E+00,-.41487E+00,-.40555E+00,-.39623E+00,-.38692E+00,-.37760E+00,-.36828E+00,
-.35509E+00,-.33956E+00,-.32403E+00,-.30850E+00,-.29491E+00,-.43569E+00,-.42832E+00,-.41900E+00,-.40969E+00,-.40037E+00,
-.39105E+00,-.38174E+00,-.37242E+00,-.36310E+00,-.35378E+00,-.34059E+00,-.32506E+00,-.30953E+00,-.29400E+00,-.28041E+00,
-.42482E+00,-.41744E+00,-.40813E+00,-.39881E+00,-.38949E+00,-.38018E+00,-.37086E+00,-.36154E+00,-.35223E+00,-.34291E+00,
-.32971E+00,-.31418E+00,-.29865E+00,-.28313E+00,-.26954E+00,-.41032E+00,-.40294E+00,-.39363E+00,-.38431E+00,-.37499E+00,
-.36568E+00,-.35636E+00,-.34704E+00,-.33773E+00,-.32841E+00,-.31521E+00,-.29968E+00,-.28416E+00,-.26863E+00,-.25504E+00,
-.39582E+00,-.38845E+00,-.37913E+00,-.36981E+00,-.36049E+00,-.35118E+00,-.34186E+00,-.33254E+00,-.32323E+00,-.31391E+00,
-.30071E+00,-.28518E+00,-.26966E+00,-.25413E+00,-.24054E+00,-.38132E+00,-.37395E+00,-.36463E+00,-.35531E+00,-.34600E+00,
-.33668E+00,-.32736E+00,-.31805E+00,-.30873E+00,-.29941E+00,-.28621E+00,-.27069E+00,-.25516E+00,-.23963E+00,-.22604E+00,

PH2( 2,1, 3) THRU PH2( 2,120, 3)
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-.54701E-01,-.61426E-01,-.69922E-01,-.78417E-01,-.86913E-01,-.95408E-01,-.10390E+00,-.11240E+00,-.12090E+00,-.12939E+00,
-.14143E+00,-.15558E+00,-.16974E+00,-.18390E+00,-.19629E+00,-.18334E+00,-.19007E+00,-.19856E+00,-.20706E+00,-.21556E+00,
-.22405E+00,-.23255E+00,-.24104E+00,-.24954E+00,-.25803E+00,-.27007E+00,-.28423E+00,-.29839E+00,-.31255E+00,-.32493E+00,
-.31199E+00,-.31871E+00,-.32721E+00,-.33570E+00,-.34420E+00,-.35269E+00,-.36119E+00,-.36968E+00,-.37818E+00,-.38668E+00,
-.39871E+00,-.41287E+00,-.42703E+00,-.44119E+00,-.45358E+00,-.44063E+00,-.44735E+00,-.45585E+00,-.46434E+00,-.47284E+00,
-.48133E+00,-.48983E+00,-.49833E+00,-.50682E+00,-.51532E+00,-.52735E+00,-.54151E+00,-.55567E+00,-.56983E+00,-.58222E+00,
-.53711E+00,-.54383E+00,-.55233E+00,-.56083E+00,-.56932E+00,-.57782E+00,-.58631E+00,-.59481E+00,-.60330E+00,-.61180E+00,
-.62383E+00,-.63799E+00,-.65215E+00,-.66631E+00,-.67870E+00,-.66575E+00,-.67248E+00,-.68097E+00,-.68947E+00,-.69796E+00,
-.70646E+00,-.71495E+00,-.72345E+00,-.73194E+00,-.74044E+00,-.75248E+00,-.76664E+00,-.78079E+00,-.79495E+00,-.80734E+00,
-.79439E+00,-.80112E+00,-.80962E+00,-.81811E+00,-.82661E+00,-.83510E+00,-.84360E+00,-.85209E+00,-.86059E+00,-.86908E+00,
-.88112E+00,-.89528E+00,-.90944E+00,-.92360E+00,-.93599E+00,-.92304E+00,-.92976E+00,-.93826E+00,-.94675E+00,-.95525E+00,
-.96374E+00,-.97224E+00,-.98074E+00,-.98923E+00,-.99773E+00,-.10098E+01,-.10239E+01,-.10381E+01,-.10522E+01,-.10646E+01,
```

PH2(1,1, 4) THRU PH2(1,120, 4)

```
0.77912E+00,0.71173E+00,0.62660E+00,0.54147E+00,0.45635E+00,0.37122E+00,0.28609E+00,0.20096E+00,0.11583E+00,0.30703E-01,
-.89894E-01,-.23177E+00,-.37366E+00,-.51554E+00,-.63968E+00,0.69094E+00,0.62354E+00,0.53842E+00,0.45329E+00,0.36816E+00,
0.28303E+00,0.19790E+00,0.11278E+00,0.27647E-01,-.57482E-01,-.17808E+00,-.31996E+00,-.46184E+00,-.60372E+00,-.72787E+00,
0.60275E+00,0.53536E+00,0.45023E+00,0.36510E+00,0.27997E+00,0.19485E+00,0.10972E+00,0.24590E-01,-.60538E-01,-.14567E+00,
-.26626E+00,-.40815E+00,-.55003E+00,-.69191E+00,-.81605E+00,0.51457E+00,0.44717E+00,0.36204E+00,0.27692E+00,0.19179E+00,
0.10666E+00,0.21533E-01,-.63595E-01,-.14872E+00,-.23385E+00,-.35445E+00,-.49633E+00,-.63821E+00,-.78009E+00,-.90424E+00,
0.44843E+00,0.38103E+00,0.29591E+00,0.21078E+00,0.12565E+00,0.40522E-01,-.44606E-01,-.12973E+00,-.21486E+00,-.29999E+00,
-.42059E+00,-.56247E+00,-.70435E+00,-.84623E+00,-.97038E+00,0.36024E+00,0.29285E+00,0.20772E+00,0.12259E+00,0.37465E-01,
-.47663E-01,-.13279E+00,-.21792E+00,-.30305E+00,-.38818E+00,-.50877E+00,-.65065E+00,-.79254E+00,-.93442E+00,-.10586E+01,
0.27206E+00,0.20466E+00,0.11954E+00,0.34407E-01,-.50720E-01,-.13585E+00,-.22098E+00,-.30611E+00,-.39123E+00,-.47636E+00,
-.59696E+00,-.73884E+00,-.88072E+00,-.10226E+01,-.11468E+01,0.18387E+00,0.11648E+00,0.31350E-01,-.53778E-01,-.13890E+00,
-.22403E+00,-.30916E+00,-.39429E+00,-.47942E+00,-.56455E+00,-.68514E+00,-.82703E+00,-.96891E+00,-.11108E+01,-.12349E+01,
```

PH2(2,1, 4) THRU PH2(2,120, 4)

```
-.16235E+01,-.15010E+01,-.13462E+01,-.11914E+01,-.10366E+01,-.88179E+00,-.72699E+00,-.57220E+00,-.41740E+00,-.26261E+00,
-.43318E-01,0.21467E+00,0.47266E+00,0.73065E+00,0.95639E+00,-.15374E+01,-.14149E+01,-.12601E+01,-.11053E+01,-.95049E+00,
-.79569E+00,-.64090E+00,-.48611E+00,-.33131E+00,-.17652E+00,0.42775E-01,0.30076E+00,0.55876E+00,0.81675E+00,0.10425E+01,
-.14513E+01,-.13288E+01,-.11740E+01,-.10192E+01,-.86440E+00,-.70960E+00,-.55481E+00,-.40001E+00,-.24522E+00,-.90424E-01,
0.12887E+00,0.38686E+00,0.64485E+00,0.90284E+00,0.11286E+01,-.13652E+01,-.12427E+01,-.10879E+01,-.93310E+00,-.77830E+00,
-.62351E+00,-.46871E+00,-.31392E+00,-.15912E+00,-.43303E-02,0.21496E+00,0.47295E+00,0.73094E+00,0.98893E+00,0.12147E+01,
-.13007E+01,-.11781E+01,-.10233E+01,-.86853E+00,-.71373E+00,-.55894E+00,-.40414E+00,-.24935E+00,-.94555E-01,0.60240E-01,
0.27953E+00,0.53752E+00,0.79551E+00,0.10535E+01,0.12792E+01,-.12146E+01,-.10920E+01,-.93723E+00,-.78243E+00,-.62764E+00,
-.47285E+00,-.31805E+00,-.16326E+00,-.84618E-02,0.14633E+00,0.36562E+00,0.62362E+00,0.88161E+00,0.11396E+01,0.13653E+01,
-.11285E+01,-.10059E+01,-.85113E+00,-.69634E+00,-.54155E+00,-.38675E+00,-.23196E+00,-.77163E-01,0.77631E-01,0.23243E+00,
0.45172E+00,0.70971E+00,0.96770E+00,0.12257E+01,0.14514E+01,-.10424E+01,-.91983E+00,-.76504E+00,-.61025E+00,-.45545E+00,
-.30066E+00,-.14586E+00,0.89306E-02,0.16373E+00,0.31852E+00,0.53781E+00,0.79580E+00,0.10538E+01,0.13118E+01,0.15375E+01,
```

PH2(1,1, 5) THRU PH2(1,120, 5)

```
-.85149E+00,-.89078E+00,-.94040E+00,-.99003E+00,-.10396E+01,-.10893E+01,-.11389E+01,-.11885E+01,-.12382E+01,-.12878E+01,
-.13581E+01,-.14408E+01,-.15235E+01,-.16062E+01,-.16726E+01,-.57033E+00,-.60962E+00,-.65924E+00,-.70887E+00,-.75850E+00,
-.80812E+00,-.85775E+00,-.90738E+00,-.95700E+00,-.10066E+01,-.10769E+01,-.11596E+01,-.12423E+01,-.13251E+01,-.13974E+01,
-.28917E+00,-.32846E+00,-.37809E+00,-.42771E+00,-.47734E+00,-.52697E+00,-.57659E+00,-.62622E+00,-.67585E+00,-.72547E+00,
-.79577E+00,-.87849E+00,-.96120E+00,-.10439E+01,-.11163E+01,-.80157E-02,-.47304E-01,-.96930E-01,-.14656E+00,-.19618E+00,
-.24581E+00,-.29544E+00,-.34506E+00,-.39469E+00,-.44431E+00,-.51462E+00,-.59733E+00,-.68004E+00,-.76275E+00,-.83512E+00,
0.20265E+00,0.16356E+00,0.11394E+00,0.64312E-01,0.14686E-01,-.34941E-01,-.84567E-01,-.13419E+00,-.18382E+00,-.23345E+00,
-.30375E+00,-.38646E+00,-.46917E+00,-.55188E+00,-.62425E+00,0.48401E+00,0.44472E+00,0.39509E+00,0.34547E+00,0.29584E+00,
```

```
0.24622E+00,0.19659E+00,0.14696E+00,0.97337E-01,0.47711E-01,-.22593E-01,-.10530E+00,-.18801E+00,-.27073E+00,-.34310E+00,
0.76516E+00,0.72588E+00,0.67625E+00,0.62663E+00,0.57700E+00,0.52737E+00,0.47775E+00,0.42812E+00,0.37849E+00,0.32887E+00,
0.25857E+00,0.17585E+00,0.93143E-01,0.10432E-01,-.61939E-01,0.10463E+01,0.10070E+01,0.95741E+00,0.90778E+00,0.85816E+00,
0.80853E+00,0.75890E+00,0.70928E+00,0.65965E+00,0.61002E+00,0.53972E+00,0.45701E+00,0.37430E+00,0.29159E+00,0.21922E+00,
```

PH2(2,1, 5) THRU PH2(2,120, 5)

```
0.47393E+00,0.57344E+00,0.69913E+00,0.82483E+00,0.95052E+00,0.10762E+01,0.12019E+01,0.13276E+01,0.14533E+01,0.15790E+01,
0.17571E+01,0.19666E+01,0.21761E+01,0.23855E+01,0.25688E+01,0.19469E+00,0.29420E+00,0.41989E+00,0.54559E+00,0.67128E+00,
0.79698E+00,0.92268E+00,0.10484E+01,0.11741E+01,0.12998E+01,0.14778E+01,0.16873E+01,0.18968E+01,0.21063E+01,0.22896E+01,
-.84547E-01,0.14962E-01,0.14066E+00,0.26635E+00,0.39205E+00,0.51774E+00,0.64344E+00,0.76913E+00,0.89483E+00,0.10205E+01,
0.11986E+01,0.14081E+01,0.16176E+01,0.18271E+01,0.20104E+01,-.36378E+00,-.26428E+00,-.13858E+00,-.12885E-01,0.11281E+00,
0.23851E+00,0.36420E+00,0.48989E+00,0.61559E+00,0.74129E+00,0.91935E+00,0.11288E+01,0.13383E+01,0.15478E+01,0.17311E+01,
-.57321E+00,-.47370E+00,-.34801E+00,-.22231E+00,-.96618E-01,0.29077E-01,0.15477E+00,0.28047E+00,0.40616E+00,0.53186E+00,
0.70992E+00,0.91942E+00,0.11289E+01,0.13384E+01,0.15217E+01,-.85245E+00,-.75294E+00,-.62725E+00,-.50155E+00,-.37586E+00,
-.25016E+00,-.12446E+00,0.12300E-02,0.12692E+00,0.25262E+00,0.43069E+00,0.64018E+00,0.84967E+00,0.10592E+01,0.12425E+01,
-.11317E+01,-.10322E+01,-.90648E+00,-.78079E+00,-.65509E+00,-.52940E+00,-.40370E+00,-.27801E+00,-.15231E+00,-.26617E-01,
0.15145E+00,0.36094E+00,0.57043E+00,0.77993E+00,0.96323E+00,-.14109E+01,-.13114E+01,-.11857E+01,-.10600E+01,-.93433E+00,
-.80863E+00,-.68294E+00,-.55724E+00,-.43155E+00,-.30585E+00,-.12779E+00,0.81706E-01,0.29120E+00,0.50069E+00,0.68400E+00,
```

SH2(1,1, 1) THRU SH2(1,120, 1)

```
0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,
0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.18800E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,
0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,0.16620E+05,
0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,
0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.15150E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,
0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,0.14220E+05,
0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,
0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.13520E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,
0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,0.11340E+05,
0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,
0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.91700E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,
0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,0.70240E+04,
```

SH2(2,1, 1) THRU SH2(2,120, 1)

```
-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,
-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.23350E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,
-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,-.20660E+05,
-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,
-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.18850E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,
-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,-.17710E+05,
-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,
-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.16840E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,
-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,-.14160E+05,
-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,
-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.11490E+05,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,
-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,-.88520E+04,
```

SH2(3,1, 1) THRU SH2(3,120, 1)

```
-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,
-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,
-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,-.66500E+03,
-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,
-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,
-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,
-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,
-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66490E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,
-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,-.66420E+03,
-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,
-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.66260E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,
-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,-.65970E+03,
```

SH2(1,1, 2) THRU SH2(1,120, 2)

```
-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,
-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.42830E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,
-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,-.32800E+04,
-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,
-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.26030E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,
-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,-.21770E+04,
-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,
-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.18520E+04,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,
-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,-.85220E+03,
0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,
0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.12900E+03,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,
0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,0.10510E+04,
```

SH2(2,1, 2) THRU SH2(2,120, 2)

```
0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,
0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.30620E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,
0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,0.26610E+05,
0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,
0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.23900E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,
0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,0.22200E+05,
0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,
0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.20890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,
0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,0.16890E+05,
0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,
0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.12940E+05,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,
0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,0.90940E+04,
```

SH2(3,1, 2) THRU SH2(3,120, 2)

```
-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,
-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,
-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,
-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,
-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,
-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,
-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,
-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30710E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,
-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,-.30720E+04,
```

```
-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,
-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,-.30740E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,
-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,-.30770E+04,

SH2( 1,1, 3) THRU SH2( 1,120, 3)

-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,
-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,-.31340E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,
-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,
-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,-.27670E+06,
-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,-.25200E+06,
-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,
-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,-.23650E+06,
-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,-.22470E+06,
-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,
-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,-.18840E+06,
-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,-.15250E+06,
-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,
-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,-.11720E+06,

SH2( 2,1, 3) THRU SH2( 2,120, 3)

-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,
-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,-.25940E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,
-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,
-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,-.22770E+06,
-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,-.20640E+06,
-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,
-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,-.19300E+06,
-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,-.18280E+06,
-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,
-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,-.15140E+06,
-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,-.12070E+06,
-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,
-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,-.90990E+05,

SH2( 3,1, 3) THRU SH2( 3,120, 3)

-.36100E+04,-.36100E+04,-.36100E+)4,-.36100E+04,-.36100E+04,-.36100E+04,-.36100E+04,-.36100E+04,
-.36100E+04,-.36100E+04,-.36100E+04,-.36100E+04,-.36100E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,
-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,-.36090E+04,
-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36090E+04,-.36090E+04,-.36090E+04,
-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,
-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,
-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,-.36080E+04,
-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,-.36070E+04,
-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,-.35920E+04,
-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35920E+04,-.35920E+04,-.35920E+04,
-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,-.35640E+04,
-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,
-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,-.35270E+04,

SH2( 1,1, 4) THRU SH2( 1,120, 4)

0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,
```

```
0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.13780E+06,0.11940E+06,0.11940E+06,0.11940E+06
0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,
0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,0.11940E+06,
0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,0.10700E+06,
0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,
0.93290E+05,0.93290E+05,0.93290E+05,0.93290E+05,0.93290E+05,0.93290E+05,0.99210E+05,0.99210E+05,0.99210E+05,0.99210E+05,
0.93290E+05,0.93290E+05,0.93290E+05,0.93290E+05,0.93290E+05,0.75200E+05,0.93290E+05,0.93290E+05,0.93290E+05,0.93290E+05,
0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,
0.57540E+05,0.57540E+05,0.57540E+05,0.57540E+05,0.57540E+05,0.57540E+05,0.75200E+05,0.75200E+05,0.75200E+05,0.75200E+05,
0.57540E+05,0.57540E+05,0.57540E+05,0.57540E+05,0.57540E+05,0.40840E+05,0.57540E+05,0.57540E+05,0.57540E+05,0.57540E+05,
0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,0.40840E+05,
```

SH2(2,1, 4) THRU SH2(2,120, 4)

```
0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,
0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,0.50770E+03,0.20360E+04,0.20360E+04,0.20360E+04,0.20360E+04,
0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,0.50770E+03,
0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+04,0.50770E+03,0.50770E+03,0.50770E+03,
0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+0.,0.33040E+04,0.22250E+04,0.22250E+04,0.22250E+04,0.22250E+04,
0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,0.33040E+04,
0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.33040E+04,0.33040E+04,0.33040E+04,
0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.66550E+04,0.41280E+04,0.41280E+04,0.41280E+04,0.41280E+04,
0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,0.66550E+04,
0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,0.66550E+04,0.66550E+04,0.66550E+04,
0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,0.10840E+05,0.90170E+04,0.90170E+04,0.90170E+04,0.90170E+04,
0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,0.10840E+05,
```

SH2(3,1, 4) THRU SH2(3,120, 4)

```
0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,
0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52840E+05,0.52860E+05,0.52860E+05,0.52860E+05,0.52860E+05,
0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,
0.52810E+05,0.52810E+05,0.52810E+05,0.52810E+05,0.52810E+05,0.52810E+05,0.52840E+05,0.52840E+05,0.52840E+05,0.52840E+05,
0.52810E+05,0.52810E+05,0.52810E+05,0.52810E+05-0.52810E+05,0.52800E+05,0.52810E+05,0.52810E+05,0.52810E+05,0.52810E+05,
0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,
0.52790E+05,0.52790E+05,0.52790E+05,0.52790E+05,0.52790E+05,0.52790E+05,0.52800E+05,0.52800E+05,0.52800E+05,0.52800E+05,
0.52790E+05,0.52790E+05,0.52790E+05,0.52790E+05,0.52790E+05,0.52720E+05,0.52790E+05,0.52790E+05,0.52790E+05,0.52790E+05,
0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,0.52720E+05,
0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52720E+05,0.52720E+05,0.52720E+05,
0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52250E+05,0.52560E+05,0.52560E+05,0.52560E+05,0.52560E+05,
0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,0.52250E+05,
```

SH2(1,1, 5) THRU SH2(1,120, 5)

```
-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06
-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.41740E+06,-.49710E+06,-.49710E+06,-.49710E+06,-.49710E+06,
-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,-.41740E+06,
-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.41740E+06,-.41740E+06,-.41740E+06,
-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.33010E+06,-.36370E+06,-.36370E+06,-.36370E+06,-.36370E+06,
-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,-.33010E+06,
-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.33010E+06,-.33010E+06,-.33010E+06,
-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.22630E+06,-.30450E+06,-.30450E+06,-.30450E+06,-.30450E+06,
-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,-.22630E+06,
-.15060E+06,-.15060E+06,-.15060E+06,-.15060E+06,-.15060E+06,-.15060E+06,-.15060E+06,-.22630E+06,-.22630E+06,-.22630E+06,
```

-.15060E+06,-.15060E+06,-.15060E+06,-.15060E+06,-.15060E+06,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,
-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,-.80690E+05,

SH2(2,1, 5) THRU SH2(2,120, 5)

-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,
-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.17180E+04,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,
-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,-.21150E+05,
-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,
-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.34260E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,
-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,-.42510E+05,
-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,
-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.48820E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,
-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,-.68220E+05,
-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,
-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.86420E+05,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,
-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,-.10090E+06,

SH2(3,1, 5) THRU SH2(3,120, 5)

0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,
0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98350E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,
0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,0.98280E+05,
0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,
0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98210E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,
0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,0.98170E+05,
0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,
0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.98140E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,
0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,0.97800E+05,
0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,
0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.97040E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,
0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,0.95700E+05,

PLANFORM GEOMETRY OF BLADE

Y= 27.0000

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000

X11	X12	X13	X14	X15	X
17.2500	18.2500	19.2500	20.2500	21.0000	

Y= 28.0000

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000

X11	X12	X13	X14	X15	X
17.2500	18.2500	19.2500	20.2500	21.0000	

Y= 29.0000

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000

X11	X12	X13	X14	X15	X
17.2500	18.2500	19.2500	20.2500	21.0000	

Y= 30.0000

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000

X11	X12	X13	X14	X15	X
17.2500	18.2500	19.2500	20.2500	21.0000	

Y= 30.7500

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000

X11	X12	X13	X14	X15	X

17.2500	18.2500	19.2500	20.2500	21.0000

****

Y= 31.7500

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000
X11	X12	X13	X14	X15	X				
17.2500	18.2500	19.2500	20.2500	21.0000					

****

Y= 32.7500

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000
X11	X12	X13	X14	X15	X				
17.2500	18.2500	19.2500	20.2500	21.0000					

****

Y= 33.7500

X 1	X 2	X 3	X 4	X 5	X 6	X 7	X 8	X 9	X10
11.0000	11.6000	12.2000	12.8000	13.4000	14.0000	14.6000	15.2000	15.8000	16.4000
X11	X12	X13	X14	X15	X				
17.2500	18.2500	19.2500	20.2500	21.0000					

INITIAL BLADE CAMBER GEOMETRY
AT IMPACT STATION

NODE	IN-PLANE COORDINATE	OUT OF PLANE COORDINATE
1	1.00000	1.00000
2	1.47300	1.36900
3	1.94600	1.73900
4	2.41600	2.10800
5	2.89100	2.47800
6	3.36400	2.84700
7	3.83700	3.21600
8	4.31000	3.58600
9	4.78200	3.95500
10	5.25500	4.32500
11	5.92500	4.84800
12	6.71300	5.46300
13	7.50100	6.07900
14	8.28900	6.69500
15	8.86000	7.14100

MISSILE GEOMETRY

SECTION	THICKNESS	WIDTH	LENGTH	OFFSET
1	0.625	2.100	2.100	0.825
2	0.600	3.260	3.260	0.245
3	0.650	3.750	3.750	0.0
4	0.650	3.750	3.750	0.0
5	0.600	3.260	3.260	0.245
6	0.625	2.100	2.100	0.825

MODAL DATA

MODE	FREQ(RAD/SEC)	MODAL MASS	MODAL STIFFNESS	DAMPING RATIO
1	0.433500E+03	0.985580E-02	0.185212E+04	0.350000E-01
2	0.873390E+03	0.427630E-02	0.326201E+04	0.350000E-01
3	0.144500E+04	0.986900E-02	0.206485E+05	0.350000E-01
4	0.153310E+04	0.102230E-01	0.240281E+05	0.350000E-01
5	0.226200E+04	0.233400E-01	0.119422E+06	0.350000E-01

IMPACT VELOCITY	IMPACT ANGLE	MISSILE DENSITY	CHORDWISE IMPACT COORDINATES IN-PLANE	CHORDWISE IMPACT COORDINATES OUT-OF-PLANE	IMPACT RADIUS
0.726000E+04	0.523600E+00	0.988800E-04	0.454600E+01	0.377050E+01	0.300000E+02

ORIGINAL PAGE IS OF POOR QUALITY

TIME STEP= 2 TIME=0.289325E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.0	0.1100E+02	0.8107E-09	0.1100E+02	0.4178E+03	0.1100E+02	0.4178E+03	0.1100E+02	0.4178E+03
0.1160E+02	0.6337E-18	0.1160E+02	0.1909E+00	0.1160E+02	0.2341E+04	0.1160E+02	0.2341E+04	0.1160E+02	0.2341E+04
0.1220E+02	0.8497E-11	0.1220E+02	0.1157E+02	0.1220E+02	0.1263E+04	0.1220E+02	0.1263E+04	0.1220E+02	0.1263E+04
0.1280E+02	0.1376E-07	0.1280E+02	0.1858E+02	0.1280E+02	0.5739E+03	0.1280E+02	0.5739E+03	0.1280E+02	0.5739E+03
0.1340E+02	0.2943E-06	0.1340E+02	0.8981E+01	0.1340E+02	0.2465E+03	0.1340E+02	0.2465E+03	0.1340E+02	0.2465E+03
0.1400E+02	0.6495E-06	0.1400E+02	0.2218E+01	0.1400E+02	0.1036E+03	0.1400E+02	0.1036E+03	0.1400E+02	0.1036E+03
0.1460E+02	0.3672E-06	0.1460E+02	0.3262E+00	0.1460E+02	0.4319E+02	0.1460E+02	0.4319E+02	0.1460E+02	0.4319E+02
0.1520E+02	0.0	0.1520E+02	0.3017E-01	0.1520E+02	0.1794E+02	0.1520E+02	0.1794E+02	0.1520E+02	0.1794E+02
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5323E-05	0.1100E+02	0.9295E-26	0.1100E+02	0.0	
0.1160E+02	0.3275E+02	0.1160E+02	0.2893E-12	0.1160E+02	0.0	
0.1220E+02	0.2198E+03	0.1220E+02	0.1278E-06	0.1220E+02	0.3203E-28	
0.1280E+02	0.1647E+03	0.1280E+02	0.2229E-04	0.1280E+02	0.1637E-21	
0.1340E+02	0.5879E+02	0.1340E+02	0.1232E-03	0.1340E+02	0.8665E-18	
0.1400E+02	0.1253E+02	0.1400E+02	0.1183E-03	0.1400E+02	0.0	
0.1460E+02	0.1697E+01	0.1460E+02	0.3928E-04	0.1460E+02	0.0	
0.1520E+02	0.1494E+00	0.1520E+02	0.0	0.1520E+02	0.0	
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 3 TIME=0.293143E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.0	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2608E+04	0.1160E+02	0.2341E+04	0.1160E+02	0.2341E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2480E+04	0.1220E+02	0.1606E+04	0.1220E+02	0.1606E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3022E+03	0.1280E+02	0.2027E+04	0.1280E+02	0.9956E+03	0.1280E+02	0.9956E+03
0.1340E+02	0.1040E+00	0.1340E+02	0.2168E+03	0.1340E+02	0.1333E+04	0.1340E+02	0.5891E+03	0.1340E+02	0.5891E+03
0.1400E+02	0.1384E+0[illegible]	0.1400E+02	0.1168E+03	0.1400E+02	0.6953E+03	0.1400E+02	0.3405E+03	0.1400E+02	0.3405E+03
0.1460E+02	0.1050E+00	0.1460E+02	0.5007E+02	0.1460E+02	0.2913E+03	0.1460E+02	0.1944E+03	0.1460E+02	0.1944E+03
0.1520E+02	0.0	0.1520E+02	0.1751E+02	0.1520E+02	0.9970E+02	0.1520E+02	0.1103E+03	0.1520E+02	0.1103E+03
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.2825E+02	0.1580E+02	0.6230E+02	0.1580E+02	0.6230E+02
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+0[illegible]	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=	
X	P	X	P	X	P		
0.1100E+02	0.5219E+01	0.1100E+02	0.9295E-26	0.1100E+02	0.0		
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.0		
0.1220E+02	0.9150E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.3203E-28		
0.1280E+02	0.7926E+03	0.1280E+02	0.7624E+00	0.1280E+02	0.1637E-21		
0.1340E+02	0.5093E+03	0.1340E+02	0.1463E+01	0.1340E+02	0.8665E-18		
0.1400E+02	0.2604E+03	0.1400E+02	0.1383E+01	0.1400E+02	0.0		
0.1460E+02	0.1083E+03	0.1460E+02	0.8385E+00	0.1460E+02	0.0		
0.1520E+02	0.3710E+02	0.1520E+02	0.0	0.1520E+02	0.0		
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0		
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0		
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0		
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0		
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0		
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0		
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0		

TIME STEP= 4 TIME=0.299168E-03 SEC

Y=0.27000E+02 X	P	Y=0.28000E+02 X	P	Y=0.29000E+02 X	P	Y=0.30000E+02 X	P	Y=0.30750E+02 X	P
0.1100E+02	0.0	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2432E+04	0.1160E+02	0.2432E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2522E+04	0.1220E+02	0.1717E+04	0.1220E+02	0.1717E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3206E+03	0.1280E+02	0.2113E+04	0.1280E+02	0.1079E+04	0.1280E+02	0.1079E+04
0.1340E+02	0.1040E+00	0.1340E+02	0.2393E+03	0.1340E+02	0.1431E+04	0.1340E+02	0.6439E+03	0.1340E+02	0.6439E+03
0.1400E+02	0.1384E+00	0.1400E+02	0.1327E+03	0.1400E+02	0.7685E+03	0.1400E+02	0.3747E+03	0.1400E+02	0.3747E+03
0.1460E+02	0.1050E+00	0.1460E+02	0.5830E+02	0.1460E+02	0.3304E+03	0.1460E+02	0.2151E+03	0.1460E+02	0.2151E+03
0.1520E+02	0.0	0.1520E+02	0.1751E+02	0.1520E+02	0.9970E+02	0.1520E+02	0.1103E+03	0.1520E+02	0.1103E+03
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.2825E+02	0.1580E+02	0.6230E+02	0.1580E+02	0.6230E+02
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02	
X	P	X	P	X	P
0.1100E+02	0.5219E+01	0.1100E+02	0.9295E-26	0.1100E+02	0.0
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.0
0.1220E+02	0.9271E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.3203E-28
0.1280E+02	0.8424E+03	0.1280E+02	0.7730E+00	0.1280E+02	0.1637E-21
0.1340E+02	0.5582E+03	0.1340E+02	0.1624E+01	0.1340E+02	0.8665E-18
0.1400E+02	0.2930E+03	0.1400E+02	0.1383E+01	0.1400E+02	0.0
0.1460E+02	0.1248E+03	0.1460E+02	0.8385E+00	0.1460E+02	0.0
0.1520E+02	0.3710E+02	0.1520E+02	0.0	0.1520E+02	0.0
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=

TIME STEP= 5 TIME=0.504719E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2117E+04	0.1280E+02	0.1083E+04	0.1280E+02	0.1083E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2405E+03	0.1340E+02	0.1436E+04	0.1340E+02	0.6467E+03	0.1340E+02	0.6467E+03
0.1400E+02	0.1653E+00	0.1400E+02	0.1335E+03	0.1400E+02	0.7721E+03	0.1400E+02	0.3764E+03	0.1400E+02	0.3764E+03
0.1460E+02	0.1308E+00	0.1460E+02	0.5873E+02	0.1460E+02	0.3324E+03	0.1460E+02	0.2162E+03	0.1460E+02	0.2162E+03
0.1520E+02	0.5361E-01	0.1520E+02	0.2103E+02	0.1520E+02	0.1166E+03	0.1520E+02	0.1232E+03	0.1520E+02	0.1232E+03
0.1580E+02	0.2013E-01	0.1580E+02	0.5056E+01	0.1580E+02	0.3379E+02	0.1580E+02	0.6994E+02	0.1580E+02	0.6994E+02
0.1640E+02	0.0	0.1640E+02	0.1213E+01	0.1640E+02	0.6674E+01	0.1640E+02	0.3513E+02	0.1640E+02	0.3513E+02
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.0	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.5607E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.1085E-05	
0.1400E+02	0.2947E+03	0.1400E+02	0.1631E+01	0.1400E+02	0.6603E-05	
0.1460E+02	0.1257E+03	0.1460E+02	0.1026E+01	0.1460E+02	0.1437E-04	
0.1520E+02	0.4408E+02	0.1520E+02	0.3679E+00	0.1520E+02	0.0	
0.1580E+02	0.1056E+02	0.1580E+02	0.1242E+00	0.1580E+02	0.0	
0.1640E+02	0.2507E+01	0.1640E+02	0.0	0.1640E+02	0.0	
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 6 TIME=0.519678E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2485E+04	0.1280E+02	0.2485E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2621E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.1785E+04	0.1340E+02	0.1785E+04
0.1400E+02	0.1653E+00	0.1400E+02	0.3385E+03	0.1400E+02	0.2173E+04	0.1400E+02	0.1138E+04	0.1400E+02	0.1138E+04
0.1460E+02	0.1508E+00	0.1460E+02	0.2594E+03	0.1460E+02	0.1505E+04	0.1460E+02	0.6884E+03	0.1460E+02	0.6884E+03
0.1520E+02	0.2171E+00	0.1520E+02	0.1478E+03	0.1520E+02	0.8313E+03	0.1520E+02	0.4054E+03	0.1520E+02	0.4054E+03
0.1580E+02	0.1753E+00	0.1580E+02	0.6698E+02	0.1580E+02	0.3692E+03	0.1580E+02	0.2354E+03	0.1580E+02	0.2354E+03
0.1640E+02	0.9495E-01	0.1640E+02	0.2479E+02	0.1640E+02	0.1340E+03	0.1640E+02	0.1357E+03	0.1640E+02	0.1357E+03
0.1725E+02	0.0	0.1725E+02	0.4395E+01	0.1725E+02	0.2318E+02	0.1725E+02	0.6171E+02	0.1725E+02	0.6171E+02
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.1085E-05	
0.1400E+02	0.8758E+03	0.1400E+02	0.1631E+01	0.1400E+02	0.6603E-05	
0.1460E+02	0.5945E+03	0.1460E+02	0.1978E+01	0.1460E+02	0.1437E-04	
0.1520E+02	0.3208E+03	0.1520E+02	0.2013E+01	0.1520E+02	0.1553E-04	
0.1580E+02	0.1409E+03	0.1580E+02	0.1298E+01	0.1580E+02	0.3368E-04	
0.1640E+02	0.5111E+02	0.1640E+02	0.6040E+00	0.1640E+02	0.0	
0.1725E+02	0.8888E+01	0.1725E+02	0.1317E+00	0.1725E+02	0.0	
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 7 TIME=0.548717E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2599E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2160E+04	0.1340E+02	0.2623E+04
0.1400E+02	0.1653E+00	0.1400E+02	0.4528E+03	0.1400E+02	0.2370E+04	0.1400E+02	0.1623E+04	0.1400E+02	0.2478E+04
0.1460E+02	0.2717E+01	0.1460E+02	0.4576E+03	0.1460E+02	0.2005E+04	0.1460E+02	0.1159E+04	0.1460E+02	0.2131E+04
0.1520E+02	0.4259E+01	0.1520E+02	0.3635E+03	0.1520E+02	0.1506E+04	0.1520E+02	0.8047E+03	0.1520E+02	0.1621E+04
0.1580E+02	0.1753E+00	0.1580E+02	0.2447E+03	0.1580E+02	0.9950E+03	0.1580E+02	0.5491E+03	0.1580E+02	0.1080E+04
0.1640E+02	0.9495E-01	0.1640E+02	0.1438E+03	0.1640E+02	0.5784E+03	0.1640E+02	0.3707E+03	0.1640E+02	0.6313E+03
0.1725E+02	0.2384E-01	0.1725E+02	0.4395E+01	0.1725E+02	0.2180E+03	0.1725E+02	0.2102E+03	0.1725E+02	0.2388E+03
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.1237E-05	
0.1400E+02	0.9746E+03	0.1400E+02	0.6915E+01	0.1400E+02	0.6603E-05	
0.1460E+02	0.8664E+03	0.1460E+02	0.1490E+02	0.1460E+02	0.1437E-04	
0.1520E+02	0.6486E+03	0.1520E+02	0.1848E+02	0.1520E+02	0.1553E-04	
0.1580E+02	0.4234E+03	0.1580E+02	0.1638E+02	0.1580E+02	0.3368E-04	
0.1640E+02	0.2442E+03	0.1640E+02	0.6040E+00	0.1640E+02	0.3832E-04	
0.1725E+02	0.8888E+01	0.1725E+02	0.1317E+00	0.1725E+02	0.0	
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 8 TIME=0.713245E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2606E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.8995E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2378E+04	0.1400E+02	0.1642E+04	0.1400E+02	0.2484E+04
0.1460E+02	0.2798E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2018E+04	0.1460E+02	0.1175E+04	0.1460E+02	0.2143E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.3704E+03	0.1520E+02	0.1521E+04	0.1520E+02	0.8171E+03	0.1520E+02	0.1637E+04
0.1580E+02	0.4596E+01	0.1580E+02	0.2502E+03	0.1580E+02	0.1009E+04	0.1580E+02	0.5583E+03	0.1580E+02	0.1094E+04
0.1640E+02	0.3608E+01	0.1640E+02	0.1474E+03	0.1640E+02	0.5883E+03	0.1640E+02	0.3774E+03	0.1640E+02	0.6417E+03
0.1725E+02	0.2384E-01	0.1725E+02	0.5653E+02	0.1725E+02	0.2226E+03	0.1725E+02	0.2143E+03	0.1725E+02	0.2437E+03
0.1825E+02	0.0	0.1825E+02	0.3616E+00	0.1825E+02	0.1867E+01	0.1825E+02	0.2431E+02	0.1825E+02	0.2431E+02
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.1237E-05	
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.8322E-05	
0.1460E+02	0.8771E+03	0.1460E+02	0.1527E+02	0.1460E+02	0.1930E-04	
0.1520E+02	0.6590E+03	0.1520E+02	0.1905E+02	0.1520E+02	0.1553E-04	
0.1580E+02	0.4316E+03	0.1580E+02	0.1695E+02	0.1580E+02	0.3368E-04	
0.1640E+02	0.2496E+03	0.1640E+02	0.1195E+02	0.1640E+02	0.3832E-04	
0.1725E+02	0.9413E+02	0.1725E+02	0.1317E+00	0.1725E+02	0.1975E-04	
0.1825E+02	0.7209E+00	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 9 TIME=0.719889E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2605E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.8995E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2656E+04	0.1400E+02	0.2626E+04	0.1400E+02	0.2626E+04
0.1460E+02	0.2798E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2613E+04	0.1460E+02	0.2051E+04	0.1460E+02	0.2143E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.4386E+03	0.1520E+02	0.2324E+04	0.1520E+02	0.1375E+04	0.1520E+02	0.1637E+04
0.1580E+02	0.4596E+01	0.1580E+02	0.3552E+03	0.1580E+02	0.1703E+04	0.1580E+02	0.8634E+03	0.1580E+02	0.1094E+04
0.1640E+02	0.3608E+01	0.1640E+02	0.2110E+03	0.1640E+02	0.9930E+03	0.1640E+02	0.5251E+03	0.1640E+02	0.6417E+03
0.1725E+02	0.3743E+00	0.1725E+02	0.6796E+02	0.1725E+02	0.3151E+03	0.1725E+02	0.2525E+03	0.1725E+02	0.2525E+03
0.1825E+02	0.0	0.1825E+02	0.1072E+02	0.1825E+02	0.4857E+02	0.1825E+02	0.1047E+03	0.1825E+02	0.1047E+03
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.1237E-05	
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.8322E-05	
0.1460E+02	0.1032E+04	0.1460E+02	0.1527E+02	0.1460E+02	0.2654E-02	
0.1520E+02	0.1049E+04	0.1520E+02	0.1905E+02	0.1520E+02	0.1067E-01	
0.1580E+02	0.7508E+03	0.1580E+02	0.1695E+02	0.1580E+02	0.3368E-04	
0.1640E+02	0.4242E+03	0.1640E+02	0.1195E+02	0.1640E+02	0.1015E-03	
0.1725E+02	0.1320E+03	0.1725E+02	0.2130E+01	0.1725E+02	0.1975E-04	
0.1825E+02	0.2035E+02	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 10 TIME=0.743553E-03 SEC

Y=0.27000E+02 X	P	Y=0.28000E+02 X	P	Y=0.29000E+02 X	P	Y=0.30000E+02 X	P	Y=0.30750E+02 X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2606E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.89[illegible]E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2656E+04	0.1400E+02	0.2626E+04	0.1400E+02	0.2626E+04
0.1460E+02	0.2799E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2613E+04	0.1460E+02	0.2302E+04	0.1460E+02	0.2613E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.5493E+03	0.1520E+02	0.2418E+04	0.1520E+02	0.1798E+04	0.1520E+02	0.2509E+04
0.1580E+02	0.4596E+01	0.1580E+02	0.5694E+03	0.1580E+02	0.2101E+04	0.1580E+02	0.1327E+04	0.1580E+02	0.2216E+04
0.1640E+02	0.3608E+01	0.1640E+02	0.4625E+03	0.1640E+02	0.1629E+04	0.1640E+02	0.9476E+03	0.1640E+02	0.1741E+04
0.1725E+02	0.3743E+00	0.1725E+02	0.2619E+03	0.1725E+02	0.9121E+03	0.1725E+02	0.5702E+03	0.1725E+02	0.9861E+03
0.1825E+02	0.0	0.1825E+02	0.1072E+02	0.1825E+02	0.3329E+03	0.1825E+02	0.3058E+03	0.1825E+02	0.3622E+03
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.1237E-05	
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.8322E-05	
0.1460E+02	0.1032E+04	0.1460E+02	0.1527E+02	0.1460E+02	0.2654E-02	
0.1520E+02	0.1098E+04	0.1520E+02	0.1905E+02	0.1520E+02	0.1067E-01	
0.1580E+02	0.1005E+04	0.1580E+02	0.2673E+02	0.1580E+02	0.3368E-04	
0.1640E+02	0.7733E+03	0.1640E+02	0.3271E+02	0.1640E+02	0.1015E-03	
0.1725E+02	0.4234E+03	0.1725E+02	0.5400E+01	0.1725E+02	0.1975E-04	
0.1825E+02	0.2035E+02	0.1825E+02	0.1255E-01	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 11 TIME=0.873301E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2606E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.8995E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2656E+04	0.1400E+02	0.2626E+04	0.1400E+02	0.2626E+04
0.1460E+02	0.2798E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2613E+04	0.1460E+02	0.2306E+04	0.1460E+02	0.2613E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.5507E+03	0.1520E+02	0.2418E+04	0.1520E+02	0.1805E+04	0.1520E+02	0.2509E+04
0.1580E+02	0.5960E+01	0.1580E+02	0.5725E+03	0.1580E+02	0.2105E+04	0.1580E+02	0.1333E+04	0.1580E+02	0.2219E+04
0.1640E+02	0.9039E+01	0.1640E+02	0.4659E+03	0.1640E+02	0.1634E+04	0.1640E+02	0.9529E+03	0.1640E+02	0.1746E+04
0.1725E+02	0.8508E+01	0.1725E+02	0.2643E+03	0.1725E+02	0.9170E+03	0.1725E+02	0.5740E+03	0.1725E+02	0.9911E+03
0.1825E+02	0.9169E-01	0.1825E+02	0.9726E+02	0.1825E+02	0.3354E+03	0.1825E+02	0.3081E+03	0.1825E+02	0.3648E+03
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02 X	P	Y=0.32750E+02 X	P	Y=0.33750E+02 X	P
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.3745E-05
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.2303E-03
0.1460E+02	0.1032E+04	0.1460E+02	0.1527E+02	0.1460E+02	0.2654E-02
0.1520E+02	0.1100E+04	0.1520E+02	0.1905E+02	0.1520E+02	0.1067E-01
0.1580E+02	0.1009E+04	0.1580E+02	0.2701E+02	0.1580E+02	0.2164E-01
0.1640E+02	0.7778E+03	0.1640E+02	0.3313E+02	0.1640E+02	0.2750E-01
0.1725E+02	0.4267E+03	0.1725E+02	0.2592E+02	0.1725E+02	0.2359E-03
0.1825E+02	0.1541E+03	0.1825E+02	0.4369E+00	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=

ORIGINAL PAGE IS
OF POOR QUALITY

TIME STEP= 12 TIME=0.962933E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2606E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.8995E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2656E+04	0.1400E+02	0.2626E+04	0.1400E+02	0.2626E+04
0.1460E+02	0.2798E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2613E+04	0.1460E+02	0.2306E+04	0.1460E+02	0.2613E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.5507E+03	0.1520E+02	0.2594E+04	0.1520E+02	0.2561E+04	0.1520E+02	0.2561E+04
0.1580E+02	0.5960E+01	0.1580E+02	0.5725E+03	0.1580E+02	0.2583E+04	0.1580E+02	0.2210E+04	0.1580E+02	0.2219E+04
0.1640E+02	0.9039E+01	0.1640E+02	0.5294E+03	0.1640E+02	0.2371E+04	0.1640E+02	0.1546E+04	0.1640E+02	0.1746E+04
0.1725E+02	0.8508E+01	0.1725E+02	0.3720E+03	0.1725E+02	0.1505E+04	0.1725E+02	0.8234E+03	0.1725E+02	0.9911E+03
0.1825E+02	0.8861E+00	0.1825E+02	0.1181E+03	0.1825E+02	0.4772E+03	0.1825E+02	0.3639E+03	0.1825E+02	0.3648E+03
0.1925E+02	0.0	0.1925E+02	0.2051E+02	0.1925E+02	0.8169E+02	0.1925E+02	0.1557E+03	0.1925E+02	0.1557E+03
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.3745E-05	
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.2303E-03	
0.1460E+02	0.1032E+04	0.1460E+02	0.1527E+02	0.1460E+02	0.2654E-02	
0.1520E+02	0.1100E+04	0.1520E+02	0.1905E+02	0.1520E+02	0.1067E-01	
0.1580E+02	0.1082E+04	0.1580E+02	0.2701E+02	0.1580E+02	0.2164E-01	
0.1640E+02	0.1184E+04	0.1640E+02	0.3313E+02	0.1640E+02	0.2750E-01	
0.1725E+02	0.7183E+03	0.1725E+02	0.2592E+02	0.1725E+02	0.2209E-01	
0.1825E+02	0.2180E+03	0.1825E+02	0.1164E+02	0.1825E+02	0.3595E-05	
0.1925E+02	0.3707E+02	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 13 TIME=0.970919E-03 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2606E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.8995E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2656E+04	0.1400E+02	0.2626E+04	0.1400E+02	0.2626E+04
0.1460E+02	0.2798E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2613E+04	0.1460E+02	0.2306E+04	0.1460E+02	0.2613E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.5507E+03	0.1520E+02	0.2594E+04	0.1520E+02	0.2561E+04	0.1520E+02	0.2561E+04
0.1580E+02	0.5960E+01	0.1580E+02	0.5725E+03	0.1580E+02	0.2583E+04	0.1580E+02	0.2210E+04	0.1580E+02	0.2219E+04
0.1640E+02	0.9039E+01	0.1640E+02	0.5294E+03	0.1640E+02	0.2371E+04	0.1640E+02	0.1546E+04	0.1640E+02	0.1746E+04
0.1725E+02	0.8508E+01	0.1725E+02	0.3720E+03	0.1725E+02	0.1864E+04	0.1725E+02	0.1864E+04	0.1725E+02	0.1864E+04
0.1825E+02	0.8861E+00	0.1825E+02	0.1181E+03	0.1825E+02	0.6178E+03	0.1825E+02	0.6178E+03	0.1825E+02	0.6178E+03
0.1925E+02	0.0	0.1925E+02	0.2051E+02	0.1925E+02	0.8169E+02	0.1925E+02	0.1557E+03	0.1925E+02	0.1557E+03
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.3745E-05	
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.2303E-03	
0.1460E+02	0.1032E+04	0.1460E+02	0.1527E+02	0.1460E+02	0.2654E-02	
0.1520E+02	0.1100E+04	0.1520E+02	0.1905E+02	0.1520E+02	0.1067E-01	
0.1580E+02	0.1082E+04	0.1580E+02	0.2701E+02	0.1580E+02	0.2164E-01	
0.1640E+02	0.1184E+04	0.1640E+02	0.3313E+02	0.1640E+02	0.2750E-01	
0.1725E+02	0.7183E+03	0.1725E+02	0.2592E+02	0.1725E+02	0.2209E-01	
0.1825E+02	0.2228E+03	0.1825E+02	0.1164E+02	0.1825E+02	0.3595E-05	
0.1925E+02	0.3707E+02	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

ORIGINAL PAGE IS OF POOR QUALITY

TIME STEP= 14 TIME=0.100438E-02 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.8094E-11	0.1100E+02	0.1259E+00	0.1100E+02	0.9760E+03	0.1100E+02	0.1688E+04	0.1100E+02	0.1688E+04
0.1160E+02	0.3641E-05	0.1160E+02	0.6397E+02	0.1160E+02	0.2620E+04	0.1160E+02	0.2436E+04	0.1160E+02	0.2436E+04
0.1220E+02	0.1799E-02	0.1220E+02	0.2621E+03	0.1220E+02	0.2524E+04	0.1220E+02	0.1722E+04	0.1220E+02	0.1722E+04
0.1280E+02	0.3144E-01	0.1280E+02	0.3215E+03	0.1280E+02	0.2644E+04	0.1280E+02	0.2606E+04	0.1280E+02	0.2649E+04
0.1340E+02	0.1162E+00	0.1340E+02	0.2780E+03	0.1340E+02	0.2557E+04	0.1340E+02	0.2178E+04	0.1340E+02	0.2624E+04
0.1400E+02	0.8995E+00	0.1400E+02	0.4566E+03	0.1400E+02	0.2656E+04	0.1400E+02	0.2626E+04	0.1400E+02	0.2626E+04
0.1460E+02	0.2798E+01	0.1460E+02	0.4644E+03	0.1460E+02	0.2613E+04	0.1460E+02	0.2306E+04	0.1460E+02	0.2613E+04
0.1520E+02	0.4415E+01	0.1520E+02	0.5507E+03	0.1520E+02	0.2594E+04	0.1520E+02	0.2561E+04	0.1520E+02	0.2561E+04
0.1580E+02	0.5960E+01	0.1580E+02	0.5725E+03	0.1580E+02	0.2583E+04	0.1580E+02	0.2210E+04	0.1580E+02	0.2219E+04
0.1640E+02	0.9039E+01	0.1640E+02	0.5294E+03	0.1640E+02	0.2371E+04	0.1640E+02	0.1546E+04	0.1640E+02	0.1746E+04
0.1725E+02	0.8508E+01	0.1725E+02	0.3720E+03	0.1725E+02	0.1974E+04	0.1725E+02	0.1974E+04	0.1725E+02	0.1974E+04
0.1825E+02	0.4323E+01	0.1825E+02	0.1181E+03	0.1825E+02	0.6836E+03	0.1825E+02	0.6836E+03	0.1825E+02	0.6836E+03
0.1925E+02	0.0	0.1925E+02	0.2051E+02	0.1925E+02	0.1767E+03	0.1925E+02	0.1767E+03	0.1925E+02	0.1767E+03
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.5219E+01	0.1100E+02	0.1028E-07	0.1100E+02	0.2379E-22	
0.1160E+02	0.5096E+03	0.1160E+02	0.8261E-03	0.1160E+02	0.1967E-14	
0.1220E+02	0.9277E+03	0.1220E+02	0.1052E+00	0.1220E+02	0.8080E-10	
0.1280E+02	0.8449E+03	0.1280E+02	0.7742E+00	0.1280E+02	0.3556E-07	
0.1340E+02	0.9385E+03	0.1340E+02	0.1634E+01	0.1340E+02	0.3745E-05	
0.1400E+02	0.9819E+03	0.1400E+02	0.7007E+01	0.1400E+02	0.2303E-03	
0.1460E+02	0.1032E+04	0.1460E+02	0.1527E+02	0.1460E+02	0.2654E-02	
0.1520E+02	0.1100E+04	0.1520E+02	0.1905E+02	0.1520E+02	0.1067E-01	
0.1580E+02	0.1082E+04	0.1580E+02	0.2701E+02	0.1580E+02	0.2164E-01	
0.1640E+02	0.1184E+04	0.1640E+02	0.3313E+02	0.1640E+02	0.4424E-01	
0.1725E+02	0.7183E+03	0.1725E+02	0.2592E+02	0.1725E+02	0.2209E-01	
0.1825E+02	0.2589E+03	0.1825E+02	0.1164E+02	0.1825E+02	0.1401E-03	
0.1925E+02	0.3707E+02	0.1925E+02	0.6936E-03	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 15 TIME=0.128215E-02 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.0	0.1100E+02	0.0	0.1100E+02	0.0	0.1100E+02	0.4596E-01	0.1100E+02	0.4596E-01
0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.5234E+00	0.1160E+02	0.5234E+00
0.1220E+02	0.0	0.1220E+02	0.3767E-16	0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0
0.1280E+02	0.0	0.1280E+02	0.0	0.1280E+02	0.0	0.1280E+02	0.0	0.1280E+02	0.0
0.1340E+02	0.0	0.1340E+02	0.0	0.1340E+02	0.0	0.1340E+02	0.6472E+01	0.1340E+02	0.6472E+01
0.1400E+02	0.6349E-22	0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0
0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0
0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.3020E+01	0.1520E+02	0.3020E+01	0.1520E+02	0.3020E+01
0.1580E+02	0.0	0.1580E+02	0.5293E-16	0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0
0.1640E+02	0.1710E-16	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.1936E-03	0.1825E+02	0.2196E-09	0.1825E+02	0.2041E+00	0.1825E+02	0.2041E+00	0.1825E+02	0.2041E+00
0.1925E+02	0.2430E+00	0.1925E+02	0.1824E-01	0.1925E+02	0.9292E-01	0.1925E+02	0.9554E+01	0.1925E+02	0.9554E+01
0.2025E+02	0.5118E-05	0.2025E+02	0.2064E+01	0.2025E+02	0.4883E+02	0.2025E+02	0.8568E+02	0.2025E+02	0.6582E+02
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.0	0.1100E+02	0.0	0.1100E+02	0.0	
0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.0	
0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0	
0.1280E+02	0.0	0.1280E+02	0.0	0.1280E+02	0.0	
0.1340E+02	0.0	0.1340E+02	0.0	0.1340E+02	0.3107E-11	
0.1400E+02	0.0	0.1400E+02	0.2398E-19	0.1400E+02	0.0	
0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.1078E-19	
0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.3154E-12	
0.1580E+02	0.0	0.1580E+02	0.8140E-27	0.1580E+02	0.0	
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.8617E-18	
0.1825E+02	0.9930E-09	0.1825E+02	0.1228E-12	0.1825E+02	0.8359E-03	
0.1925E+02	0.3604E-01	0.1925E+02	0.1044E+01	0.1925E+02	0.5668E-03	
0.2025E+02	0.3682E+01	0.2025E+02	0.1215E+00	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 17 TIME=0.183769E-02 SEC

Y=0.27000E+02		Y=0.28000E+02		Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02	
X	P	X	P	X	P	X	P	X	P
0.1100E+02	0.0	0.1100E+02	0.0	0.1100E+02	0.0	0.1100E+02	0.1034E-02	0.1100E+02	0.1034E-02
0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.9199E-02	0.1160E+02	0.9199E-02
0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0
0.1280E+02	0.0	0.1280E+02	0.0	0.1280E+02	0.1242E-04	0.1280E+02	0.1242E-04	0.1280E+02	0.1242E-04
0.1340E+02	0.0	0.1340E+02	0.0	0.1340E+02	0.2758E-03	0.1340E+02	0.2758E-03	0.1340E+02	0.2758E-03
0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0
0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0
0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.0
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0
0.2025E+02	0.6407E-22	0.2025E+02	0.2879E-17	0.2025E+02	0.1083E-01	0.2025E+02	0.1083E-01	0.2025E+02	0.1083E-01
0.2100E+02	0.2918E-06	0.2100E+02	0.5584E-07	0.2100E+02	0.3600E-02	0.2100E+02	0.4272E+00	0.2100E+02	0.4272E+00

Y=0.31750E+02		Y=0.32750E+02		Y=0.33750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.0	0.1100E+02	0.0	0.1100E+02	0.0	
0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.0	
0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0	
0.1280E+02	0.0	0.1280E+02	0.0	0.1280E+02	0.0	
0.1340E+02	0.0	0.1340E+02	0.0	0.1340E+02	0.0	
0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0	
0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0	
0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.0	
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.1280E-16	0.2025E+02	0.1975E-20	0.2025E+02	0.3391E-10	
0.2100E+02	0.1120E-06	0.2100E+02	0.1274E-05	0.2100E+02	0.2276E-04	

TIME STEP= 19 TIME=0.239324E-02 SEC

Y=0.29000E+02		Y=0.30000E+02		Y=0.30750E+02		Y=
X	P	X	P	X	P	
0.1100E+02	0.1134E-08	0.1100E+02	0.1134E-08	0.1100E+02	0.1134E-08	
0.1160E+02	0.0	0.1160E+02	0.0	0.1160E+02	0.0	
0.1220E+02	0.0	0.1220E+02	0.0	0.1220E+02	0.0	
0.1280E+02	0.0	0.1280E+02	0.1014E-16	0.1280E+02	0.0	
0.1340E+02	0.0	0.1340E+02	0.0	0.1340E+02	0.0	
0.1400E+02	0.0	0.1400E+02	0.0	0.1400E+02	0.0	
0.1460E+02	0.0	0.1460E+02	0.0	0.1460E+02	0.0	
0.1520E+02	0.0	0.1520E+02	0.0	0.1520E+02	0.0	
0.1580E+02	0.0	0.1580E+02	0.0	0.1580E+02	0.0	
0.1640E+02	0.0	0.1640E+02	0.0	0.1640E+02	0.0	
0.1725E+02	0.0	0.1725E+02	0.0	0.1725E+02	0.0	
0.1825E+02	0.0	0.1825E+02	0.0	0.1825E+02	0.0	
0.1925E+02	0.0	0.1925E+02	0.0	0.1925E+02	0.0	
0.2025E+02	0.0	0.2025E+02	0.0	0.2025E+02	0.0	
0.2100E+02	0.0	0.2100E+02	0.0	0.2100E+02	0.0	

TIME STEP= 21   TIME=0.412041E-02 SEC

ALL NODE PRESSURES ARE ZERO

TIME STEP= 53 TIME=0.505014E-01 SEC

ALL NODE PRESSURES ARE ZERO

TIME=0.181667E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	DISPLACEMENTS OUT-OF-PLANE	**	RADIAL BENDING STRESS LED-EDG	RADIAL BENDING STRESS CHD-PNT	RADIAL BENDING STRESS TRL-EDG
0.27000E+02	0.38396E-02	-.94973E-02	**	-.92376E+03	-.92376E+03	-.92376E+03
0.28000E+02	0.29056E-02	-.86260E-02	**	-.84432E+03	-.84432E+03	-.84432E+03
0.29000E+02	0.19716E-02	-.77548E-02	**	-.73765E+03	-.73765E+03	-.73765E+03
0.30000E+02	0.10377E-02	-.68835E-02	**	-.67062E+03	-.67062E+03	-.67062E+03
0.30750E+02	0.33716E-03	-.62300E-02	**	-.61936E+03	-.61936E+03	-.61936E+03
0.31750E+02	-.59680E-03	-.53588E-02	**	-.46211E+03	-.46211E+03	-.46211E+03
0.32750E+02	-.15308E-02	-.44875E-02	**	-.30928E+03	-.30928E+03	-.30928E+03
0.33750E+02	-.24647E-02	-.36162E-02	**	-.16801E+03	-.16801E+03	-.16801E+03

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.13742E-01	-.30523E-01
0.60000E+00	0.12452E-01	-.28121E-01
0.12000E+01	0.10821E-01	-.25087E-01
0.18000E+01	0.91905E-02	-.22053E-01
0.24000E+01	0.75599E-02	-.19019E-01
0.30000E+01	0.59294E-02	-.15985E-01
0.36000E+01	0.42988E-02	-.12951E-01
0.42000E+01	0.26682E-02	-.99174E-02
0.48000E+01	0.10377E-02	-.68835E-02
0.54000E+01	-.59289E-03	-.38496E-02
0.62500E+01	-.29028E-02	0.44848E-03
0.72500E+01	-.56205E-02	0.55050E-02
0.82500E+01	-.83380E-02	0.10562E-01
0.92500E+01	-.11056E-01	0.15618E-01
0.10000E+02	-.13434E-01	0.20043E-01

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	STRESS-X *R=0.3000E+02	STRESS-X *R=0.3075E+02	STRESS-Y *R=0.2900E+02	STRESS-Y *R=0.3000E+02	STRESS-Y *R=0.3075E+02	SHEAR-XY *R=0.2900E+02	SHEAR-XY *R=0.3000E+02	SHEAR-XY *R=0.3075E+02
0.0	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.6000E+00	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.1200E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.1800E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.2400E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.3000E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.3600E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.4200E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.4800E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04
0.5400E+01	* 0.1546E+04	* 0.1431E+04	* 0.1343E+04	* -.7377E+03	* -.6706E+03	* -.6194E+03	* 0.1102E+04	* 0.1102E+04	* 0.1101E+04

0.6250E+01	0.1546E+04	0.1431E+04	0.1343E+04	-.7377E+03	-.6706E+03	-.6194E+03	0.1102E+04	0.1102E+04	0.1101E+04
0.7250E+01	0.1546E+04	0.1431E+04	0.1343E+04	-.7377E+03	-.6706E+03	-.6194E+03	0.1102E+04	0.1102E+04	0.1101E+04
0.8250E+01	0.1546E+04	0.1431E+04	0.1343E+04	-.7377E+03	-.6706E+03	-.6194E+03	0.1102E+04	0.1102E+04	0.1101E+04
0.9250E+01	0.1546E+04	0.1431E+04	0.1343E+04	-.7377E+03	-.6706E+03	-.6194E+03	0.1102E+04	0.1102E+04	0.1101E+04
0.1000E+02	0.1546E+04	0.1431E+04	0.1343E+04	-.7377E+03	-.6706E+03	-.6194E+03	0.1102E+04	0.1102E+04	0.1101E+04

TIME=0.293143E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.11612E-01	-.27797E-01	-.27163E+04	-.27163E+04	-.27163E+04
0.28000E+02	0.89131E-02	-.25282E-01	-.24721E+04	-.24721E+04	-.24721E+04
0.29000E+02	0.62145E-02	-.22768E-01	-.21562E+04	-.21562E+04	-.21562E+04
0.30000E+02	0.35159E-02	-.20253E-01	-.19576E+04	-.19576E+04	-.19576E+04
0.30750E+02	0.14920E-02	-.18367E-01	-.18058E+04	-.18058E+04	-.18058E+04
0.31750E+02	-.12066E-02	-.15852E-01	-.13400E+04	-.13400E+04	-.13400E+04
0.32750E+02	-.39051E-02	-.13337E-01	-.88745E+03	-.88745E+03	-.88745E+03
0.33750E+02	-.66037E-02	-.10822E-01	-.46949E+03	-.46949E+03	-.46949E+03

DISPLACEMENTS VS. CHORDWISE LOCATION AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.39496E-01	-.87165E-01
0.60000E+00	0.35840E-01	-.80366E-01
0.12000E+01	0.31223E-01	-.71779E-01
0.18000E+01	0.26605E-01	-.63191E-01
0.24000E+01	0.21987E-01	-.54604E-01
0.30000E+01	0.17369E-01	-.46016E-01
0.36000E+01	0.12751E-01	-.37428E-01
0.42000E+01	0.81337E-02	-.28841E-01
0.48000E+01	0.35159E-02	-.20253E-01
0.54000E+01	-.11019E-02	-.11665E-01
0.62500E+01	-.76437E-02	0.50079E-03
0.72500E+01	-.15340E-01	0.14814E-01
0.82500E+01	-.23036E-01	0.29127E-01
0.92500E+01	-.30733E-01	0.43439E-01
0.10000E+02	-.37467E-01	0.55963E-01

STRESSES VS. CHORDWISE LOCATION AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	R=0.2900E+02	R=0.3000E+02	R=0.3075E+02	R=0.2900E+02	R=0.3000E+02	R=0.3075E+02	R=0.2900E+02	R=0.3000E+02	R=0.3075E+02
0.0	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.6000E+00	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.1200E+01	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.1800E+01	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.2400E+01	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.3000E+01	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.3600E+01	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04
0.4200E+01	0.4515E+04	0.4175E+04	0.3917E+04	-.2156E+04	-.1958E+04	-.1806E+04	0.3103E+04	0.3103E+04	0.3102E+04

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0.4800E+01	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04
0.5400E+01	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04
0.6250E+01	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04
0.7250E+01	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04
0.8250E+01	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04
0.9250E+01	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04
0.1000E+02	* 0.4515E+04	* 0.4175E+04	* 0.3917E+04	* -.2156E+04	* -.1958E+04	* -.1806E+04	* 0.3103E+04	* 0.3103E+04	* 0.3102E+04

TIME=0.504719E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	DISPLACEMENTS OUT-OF-PLANE	***	RADIAL BENDING STRESS LED-EDG	RADIAL BENDING STRESS CHD-PNT	RADIAL BENDING STRESS TRL-EDG
0.27000E+02	0.47263E-01	-.98679E-01	**	-.99224E+04	-.99224E+04	-.99224E+04
0.28000E+02	0.38198E-01	-.90341E-01	**	-.88456E+04	-.88456E+04	-.88456E+04
0.29000E+02	0.29132E-01	-.82003E-01	**	-.76535E+04	-.76535E+04	-.76535E+04
0.30000E+02	0.20067E-01	-.73664E-01	**	-.69043E+04	-.69043E+04	-.69043E+04
0.30750E+02	0.13268E-01	-.67411E-01	**	-.63314E+04	-.63314E+04	-.63314E+04
0.31750E+02	0.42026E-02	-.59073E-01	**	-.45733E+04	-.45733E+04	-.45733E+04
0.32750E+02	-.48626E-02	-.50735E-01	**	-.28672E+04	-.28672E+04	-.28672E+04
0.33750E+02	-.13928E-01	-.42396E-01	**	-.12980E+04	-.12980E+04	-.12980E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.12707E+00	-.27201E+00
0.60000E+00	0.11619E+00	-.25186E+00
0.12000E+01	0.10246E+00	-.22640E+00
0.18000E+01	0.88729E-01	-.20095E+00
0.24000E+01	0.74997E-01	-.17549E+00
0.30000E+01	0.61264E-01	-.15003E+00
0.36000E+01	0.47532E-01	-.12458E+00
0.42000E+01	0.33799E-01	-.99121E-01
0.48000E+01	0.20067E-01	-.73664E-01
0.54000E+01	0.63345E-02	-.48208E-01
0.62500E+01	-.13120E-01	-.12145E-01
0.72500E+01	-.36007E-01	0.30283E-01
0.82500E+01	-.58894E-01	0.72711E-01
0.92500E+01	-.81782E-01	0.11514E+00
0.10000E+02	-.10181E+00	0.15226E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	STRESS-X *R=0.3000E+02	STRESS-X *R=0.3075E+02	STRESS-Y *R=0.2900E+02	STRESS-Y *R=0.3000E+02	STRESS-Y *R=0.3075E+02	SHEAR-XY *R=0.2900E+02	SHEAR-XY *R=0.3000E+02	SHEAR-XY *R=0.3075E+02
0.0	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.6000E+00	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.1200E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.1800E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.2400E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.3000E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04

0.3600E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.4200E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.4800E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.5400E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.6250E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.7250E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.8250E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.9250E+01	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04
0.1000E+02	* 0.1577E+05	* 0.1453E+05	* 0.1358E+05	* -.7654E+04	* -.6904E+04	* -.6331E+04	* 0.8916E+04	* 0.8915E+04	* 0.8913E+04

TIME=0.548717E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-FNT	TRL-EDG
0.27000E+02	0.58903E-01	-.11976E+00	** -.12111E+05	-.12111E+05	-.12111E+05
0.28000E+02	0.48052E-01	-.10980E+00	** -.10753E+05	-.10753E+05	-.10753E+05
0.29000E+02	0.37201E-01	-.99841E-01	** -.92890E+04	-.92890E+04	-.92890E+04
0.30000E+02	0.26350E-01	-.89882E-01	** -.83690E+04	-.83690E+04	-.83690E+04
0.30750E+02	0.18211E-01	-.82413E-01	** -.76655E+04	-.76655E+04	-.76655E+04
0.31750E+02	0.73602E-02	-.72454E-01	** -.55066E+04	-.55066E+04	-.55066E+04
0.32750E+02	-.34909E-02	-.62495E-01	** -.34119E+04	-.34119E+04	-.34119E+04
0.33750E+02	-.14342E-01	-.52536E-01	** -.14868E+04	-.14868E+04	-.14868E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.15110E+00	-.32096E+00
0.60000E+00	0.13842E+00	-.29748E+00
0.12000E+01	0.12241E+00	-.26783E+00
0.18000E+01	0.10640E+00	-.23817E+00
0.24000E+01	0.90391E-01	-.20851E+00
0.30000E+01	0.74381E-01	-.17885E+00
0.36000E+01	0.58371E-01	-.14920E+00
0.42000E+01	0.42360E-01	-.11954E+00
0.48000E+01	0.26350E-01	-.89882E-01
0.54000E+01	0.10339E-01	-.60225E-01
0.62500E+01	-.12342E-01	-.18210E-01
0.72500E+01	-.39026E-01	0.31219E-01
0.82500E+01	-.65710E-01	0.80648E-01
0.92500E+01	-.92394E-01	0.13008E+00
0.10000E+02	-.11574E+00	0.17333E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.6000E+00	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.1200E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.1800E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05

0.2400E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.3000E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.3600E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.4200E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.4800E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.5400E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.6250E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.7250E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.8250E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.9250E+01	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05
0.1000E+02	* 0.1908E+05	* 0.1756E+05	* 0.1641E+05	* -.9289E+04	* -.8369E+04	* -.7666E+04	* 0.1031E+05	* 0.1030E+05	* 0.1030E+05

TIME=0.719889E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE***	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.12069E+00	-.22341E+00 **	-.23048E+05	-.23048E+05	-.23048E+05
0.28000E+02	0.10171E+00	-.20606E+00 **	-.20181E+05	-.20181E+05	-.20181E+05
0.29000E+02	0.82737E-01	-.18872E+00 **	-.17342E+05	-.17342E+05	-.17342E+05
0.30000E+02	0.63761E-01	-.17137E+00 **	-.15557E+05	-.15557E+05	-.15557E+05
0.30750E+02	0.49528E-01	-.15837E+00 **	-.14192E+05	-.14192E+05	-.14192E+05
0.31750E+02	0.30552E-01	-.14102E+00 **	-.10003E+05	-.10003E+05	-.10003E+05
0.32750E+02	0.11575E-01	-.12368E+00 **	-.59414E+04	-.59414E+04	-.59414E+04
0.33750E+02	-.74008E-02	-.10633E+00 **	-.22167E+04	-.22167E+04	-.22167E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.26268E+00	-.53888E+00
0.60000E+00	0.24247E+00	-.50153E+00
0.12000E+01	0.21694E+00	-.45437E+00
0.18000E+01	0.19141E+00	-.40720E+00
0.24000E+01	0.16588E+00	-.36004E+00
0.30000E+01	0.14035E+00	-.31287E+00
0.36000E+01	0.11482E+00	-.26571E+00
0.42000E+01	0.89290E-01	-.21854E+00
0.48000E+01	0.63761E-01	-.17137E+00
0.54000E+01	0.38231E-01	-.12421E+00
0.62500E+01	0.20643E-02	-.57390E-01
0.72500E+01	-.40485E-01	0.21220E-01
0.82500E+01	-.83034E-01	0.99830E-01
0.92500E+01	-.12558E+00	0.17844E+00
0.10000E+02	-.16281E+00	0.24722E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.6000E+00	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05

0.1200E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.1800E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.2400E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.3000E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.3600E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.4200E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.4800E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.5400E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.6250E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.7250E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.8250E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.9250E+01	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05
0.1000E+02	* 0.3524E+05	* 0.3236E+05	* 0.3017E+05	* -.1734E+05	* -.1556E+05	* -.1419E+05	* 0.1586E+05	* 0.1586E+05	* 0.1586E+05

TIME=0.873301E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS			RADIAL BENDING STRESS	
R	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.19245E+00	-.33549E+00	** -.35205E+05	-.35205E+05	-.35205E+05
0.28000E+02	0.16593E+00	-.31118E+00	** -.30595E+05	-.30595E+05	-.30595E+05
0.29000E+02	0.13941E+00	-.28687E+00	** -.26230E+05	-.26230E+05	-.26230E+05
0.30000E+02	0.11289E+00	-.26256E+00	** -.23486E+05	-.23486E+05	-.23486E+05
0.30750E+02	0.92993E-01	-.24433E+00	** -.21388E+05	-.21388E+05	-.21388E+05
0.31750E+02	0.66471E-01	-.22002E+00	** -.14946E+05	-.14946E+05	-.14946E+05
0.32750E+02	0.39948E-01	-.19572E+00	** -.87017E+04	-.87017E+04	-.87017E+04
0.33750E+02	0.13426E-01	-.17141E+00	** -.29788E+04	-.29788E+04	-.29788E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.38104E+00	-.75760E+00
0.60000E+00	0.35379E+00	-.70730E+00
0.12000E+01	0.31938E+00	-.64377E+00
0.18000E+01	0.28496E+00	-.58023E+00
0.24000E+01	0.25055E+00	-.51670E+00
0.30000E+01	0.21613E+00	-.45316E+00
0.36000E+01	0.18172E+00	-.38963E+00
0.42000E+01	0.14730E+00	-.32610E+00
0.48000E+01	0.11289E+00	-.26256E+00
0.54000E+01	0.78470E-01	-.19903E+00
0.62500E+01	0.29716E-01	-.10902E+00
0.72500E+01	-.27643E-01	-.31321E-02
0.82500E+01	-.85001E-01	0.10276E+00
0.92500E+01	-.14236E+00	0.20865E+00
0.10000E+02	-.19255E+00	0.30130E+00

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STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02

0.0	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.6000E+00	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.1200E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.1800E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.2400E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.3000E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.3600E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.4200E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.4800E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.5400E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.6250E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.7250E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.8250E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.9250E+01	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05
0.1000E+02	* 0.5257E+05	* 0.4820E+05	* 0.4488E+05	* -.2623E+05	* -.2349E+05	* -.2139E+05	* 0.2090E+05	* 0.2090E+05	* 0.2090E+05

TIME=0.970919E-03 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS			RADIAL BENDING STRESS	
R	IN-PLANE	OUT-OF-PLANE***	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.24026E+00	-.40807E+00 **	-.43256E+05	-.43256E+05	-.43256E+05
0.28000E+02	0.20970E+00	-.37987E+00 **	-.37520E+05	-.37520E+05	-.37520E+05
0.29000E+02	0.17913E+00	-.35168E+00 **	-.32166E+05	-.32166E+05	-.32166E+05
0.30000E+02	0.14857E+00	-.32349E+00 **	-.28800E+05	-.28800E+05	-.28800E+05
0.30750E+02	0.12565E+00	-.30234E+00 **	-.26227E+05	-.26227E+05	-.26227E+05
0.31750E+02	0.95091E-01	-.27415E+00 **	-.18326E+05	-.18326E+05	-.18326E+05
0.32750E+02	0.64530E-01	-.24596E+00 **	-.10665E+05	-.10665E+05	-.10665E+05
0.33750E+02	0.33969E-01	-.21777E+00 **	-.36422E+04	-.36422E+04	-.36422E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.46217E+00	-.90295E+00
0.60000E+00	0.43031E+00	-.84408E+00
0.12000E+01	0.39006E+00	-.76971E+00
0.18000E+01	0.34981E+00	-.69534E+00
0.24000E+01	0.30957E+00	-.62097E+00
0.30000E+01	0.26932E+00	-.54660E+00
0.36000E+01	0.22907E+00	-.47223E+00
0.42000E+01	0.18882E+00	-.39786E+00
0.48000E+01	0.14857E+00	-.32349E+00
0.54000E+01	0.10832E+00	-.24912E+00
0.62500E+01	0.51307E-01	-.14376E+00
0.72500E+01	-.15774E-01	-.19813E-01
0.82500E+01	-.82854E-01	0.10414E+00
0.92500E+01	-.14993E+00	0.22809E+00
0.10000E+02	-.20863E+00	0.33654E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.6000E+00	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.1200E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.1800E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.2400E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.3000E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.3600E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.4200E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.4800E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.5400E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.6250E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.7250E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.8250E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.9250E+01	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05
0.1000E+02	* 0.6376E+05	* 0.5844E+05	* 0.5440E+05	* -.3217E+05	* -.2880E+05	* -.2623E+05	* 0.2435E+05	* 0.2435E+05	* 0.2435E+05

TIME=0.128215E-02 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE	RADIAL BENDING STRESS ***LED-EDG	CHD-PNT	TRL-EDG
0.27800E+02	0.37774E+00	-.59590E+00 **	-.67170E+05	-.67170E+05	-.67170E+05
0.28000E+02	0.34467E+00	-.56435E+00 **	-.58216E+05	-.58216E+05	-.58216E+05
0.29000E+02	0.31160E+00	-.53281E+00 **	-.50137E+05	-.50137E+05	-.50137E+05
0.30000E+02	0.27853E+00	-.50126E+00 **	-.45059E+05	-.45059E+05	-.45059E+05
0.30750E+02	0.25373E+00	-.47760E+00 **	-.41174E+05	-.41174E+05	-.41174E+05
0.31750E+02	0.22066E+00	-.44606E+00 **	-.29251E+05	-.29251E+05	-.29251E+05
0.32750E+02	0.18759E+00	-.41451E+00 **	-.17674E+05	-.17674E+05	-.17674E+05
0.33750E+02	0.15452E+00	-.38297E+00 **	-.70159E+04	-.70159E+04	-.70159E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.69756E+00	-.12826E+01
0.60000E+00	0.65498E+00	-.12032E+01
0.12000E+01	0.60121E+00	-.11029E+01
0.18000E+01	0.54743E+00	-.10027E+01
0.24000E+01	0.49365E+00	-.90238E+00
0.30000E+01	0.43987E+00	-.80210E+00
0.36000E+01	0.38609E+00	-.70182E+00
0.42000E+01	0.33231E+00	-.60154E+00
0.48000E+01	0.27853E+00	-.50126E+00
0.54000E+01	0.22475E+00	-.40098E+00
0.62500E+01	0.14856E+00	-.25892E+00
0.72500E+01	0.58930E-01	-.91787E-01
0.82500E+01	-.30702E-01	0.75347E-01
0.92500E+01	-.12033E+00	0.24248E+00
0.10000E+02	-.19876E+00	0.36872E+00

STRESSES VS. CHORDWISE LOCATION

AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.6000E+00	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.1200E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.1800E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.2400E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.3000E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.3600E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.4200E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.4800E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.5400E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.6250E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.7250E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.8250E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.9250E+01	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05
0.1000E+02	* 0.9079E+05	* 0.8319E+05	* 0.7741E+05	* -.5014E+05	* -.4506E+05	* -.4117E+05	* 0.3319E+05	* 0.3319E+05	* 0.3318E+05

TIME=0.183769E-02 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE	RADIAL BENDING STRESS ***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.45261E+00	-.59108E+00	** -.89500E+05	-.89500E+05	-.89500E+05
0.28000E+02	0.47267E+00	-.60576E+00	** -.78546E+05	-.78546E+05	-.78546E+05
0.29000E+02	0.49273E+00	-.62045E+00	** -.69297E+05	-.69297E+05	-.69297E+05
0.30000E+02	0.51279E+00	-.63514E+00	** -.63483E+05	-.63483E+05	-.63483E+05
0.30750E+02	0.52783E+00	-.64616E+00	** -.59034E+05	-.59034E+05	-.59034E+05
0.31750E+02	0.54789E+00	-.66084E+00	** -.45381E+05	-.45381E+05	-.45381E+05
0.32750E+02	0.56795E+00	-.67553E+00	** -.32039E+05	-.32039E+05	-.32039E+05
0.33750E+02	0.58801E+00	-.69022E+00	** -.19473E+05	-.19473E+05	-.19473E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.87154E+00	-.13476E+01
0.60000E+00	0.83509E+00	-.12752E+01
0.12000E+01	0.78905E+00	-.11838E+01
0.18000E+01	0.74300E+00	-.10924E+01
0.24000E+01	0.69696E+00	-.10009E+01
0.30000E+01	0.65092E+00	-.90947E+00
0.36000E+01	0.60487E+00	-.81803E+00
0.42000E+01	0.55883E+00	-.72658E+00
0.48000E+01	0.51279E+00	-.63514E+00
0.54000E+01	0.46674E+00	-.54370E+00
0.62500E+01	0.40152E+00	-.41415E+00
0.72500E+01	0.32478E+00	-.26175E+00
0.82500E+01	0.24804E+00	-.10934E+00
0.92500E+01	0.17130E+00	0.43061E-01
0.10000E+02	0.10415E+00	0.17641E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	STRESS-X *R=0.3000E+02	STRESS-X *R=0.3075E+02	STRESS-Y *R=0.2900E+02	STRESS-Y *R=0.3000E+02	STRESS-Y *R=0.3075E+02	SHEAR-XY *R=0.2900E+02	SHEAR-XY *R=0.3000E+02	SHEAR-XY *R=0.3075E+02
0.0	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.6000E+00	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.1200E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.1800E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.2400E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.3000E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.3600E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.4200E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.4800E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.5400E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.6250E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.7250E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.8250E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.9250E+01	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05
0.1000E+02	* 0.7473E+05	* 0.6858E+05	* 0.6391E+05	* -.6930E+05	* -.6348E+05	* -.5903E+05	* 0.3494E+05	* 0.3493E+05	* 0.3493E+05

TIME=0.239324E-02 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	DISPLACEMENTS OUT-OF-PLANE		RADIAL BENDING STRESS LED-EDG	RADIAL BENDING STRESS CHD-PNT	RADIAL BENDING STRESS TRL-EDG
0.27000E+02	0.38976E+00	-.28413E+00	**	-.84357E+05	-.84357E+05	-.84357E+05
0.28000E+02	0.50595E+00	-.38314E+00	**	-.75138E+05	-.75138E+05	-.75138E+05
0.29000E+02	0.62215E+00	-.48216E+00	**	-.68461E+05	-.68461E+05	-.68461E+05
0.30000E+02	0.73834E+00	-.58117E+00	**	-.64266E+05	-.64266E+05	-.64266E+05
0.30750E+02	0.82549E+00	-.65543E+00	**	-.61050E+05	-.61050E+05	-.61050E+05
0.31750E+02	0.94168E+00	-.75445E+00	**	-.51190E+05	-.51190E+05	-.51190E+05
0.32750E+02	0.10579E+01	-.85346E+00	**	-.41411E+05	-.41411E+05	-.41411E+05
0.33750E+02	0.11741E+01	-.95247E+00	**	-.31760E+05	-.31760E+05	-.31760E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.75681E+00	-.72541E+00
0.60000E+00	0.75493E+00	-.71076E+00
0.12000E+01	0.75256E+00	-.69224E+00
0.18000E+01	0.75019E+00	-.67373E+00
0.24000E+01	0.74782E+00	-.65522E+00
0.30000E+01	0.74545E+00	-.63671E+00
0.36000E+01	0.74308E+00	-.61820E+00
0.42000E+01	0.74071E+00	-.59968E+00
0.48000E+01	0.73834E+00	-.58117E+00
0.54000E+01	0.73597E+00	-.56266E+00
0.62500E+01	0.73262E+00	-.53643E+00
0.72500E+01	0.72867E+00	-.50558E+00
0.82500E+01	0.72472E+00	-.47472E+00
0.92500E+01	0.72077E+00	-.44387E+00
0.10000E+02	0.71731E+00	-.41687E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	STRESS-X *R=0.3000E+02	STRESS-X *R=0.3075E+02	STRESS-Y *R=0.2900E+02	STRESS-Y *R=0.3000E+02	STRESS-Y *R=0.3075E+02	SHEAR-XY *R=0.2900E+02	SHEAR-XY *R=0.3000E+02	SHEAR-XY *R=0.3075E+02
0.0	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.6000E+00	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.1200E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.1800E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.2400E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.3000E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.3600E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.4200E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.4800E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.5400E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.6250E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.7250E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.8250E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.9250E+01	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05
0.1000E+02	* 0.1039E+05	* 0.9781E+04	* 0.9327E+04	* -.6846E+05	* -.6427E+05	* -.6105E+05	* 0.1691E+05	* 0.1690E+05	* 0.1690E+05

TIME=0.412041E-02 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	DISPLACEMENTS OUT-OF-PLANE	RADIAL BENDING STRESS ***LED-EDG	RADIAL BENDING STRESS CHD-PNT	RADIAL BENDING STRESS TRL-EDG
0.27000E+02	0.39630E+00	-.57051E-01 **	-.18851E+05	-.18851E+05	-.18851E+05
0.28000E+02	0.55482E+00	-.19548E+00 **	-.14989E+05	-.14989E+05	-.14989E+05
0.29000E+02	0.71334E+00	-.33391E+00 **	-.13623E+05	-.13623E+05	-.13623E+05
0.30000E+02	0.87186E+00	-.47234E+00 **	-.12761E+05	-.12761E+05	-.12761E+05
0.30750E+02	0.99075E+00	-.57616E+00 **	-.12099E+05	-.12099E+05	-.12099E+05
0.31750E+02	0.11493E+01	-.71459E+00 **	-.10057E+05	-.10057E+05	-.10057E+05
0.32750E+02	0.13078E+01	-.85301E+00 **	-.79688E+04	-.79688E+04	-.79688E+04
0.33750E+02	0.14663E+01	-.99144E+00 **	-.58435E+04	-.58435E+04	-.58435E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.31715E+00	0.38321E+00
0.60000E+00	0.37351E+00	0.29628E+00
0.12000E+01	0.44470E+00	0.18648E+00
0.18000E+01	0.51589E+00	0.76681E-01
0.24000E+01	0.58709E+00	-.33122E-01
0.30000E+01	0.65828E+00	-.14293E+00
0.36000E+01	0.72947E+00	-.25273E+00
0.42000E+01	0.80067E+00	-.36253E+00
0.48000E+01	0.87186E+00	-.47234E+00
0.54000E+01	0.94305E+00	-.58214E+00
0.62500E+01	0.10439E+01	-.73769E+00
0.72500E+01	0.11626E+01	-.92070E+00
0.82500E+01	0.12812E+01	-.11037E+01
0.92500E+01	0.13999E+01	-.12867E+01

0.10000E+02 0.15037E+01 -.14468E+01

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.6000E+00	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.1200E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.1800E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.2400E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.3000E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.3600E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.4200E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.4800E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.5400E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.6250E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.7250E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.8250E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.9250E+01	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05
0.1000E+02	* 0.2767E+05	* 0.2578E+05	* 0.2435E+05	* -.1362E+05	* -.1276E+05	* -.1210E+05	* -.3097E+05	* -.3097E+05	* -.3096E+05

TIME=0.701923E-02 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE		RADIAL BENDING STRESS LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.18350E-01	0.93241E-01	**	0.57434E+04	0.57434E+04	0.57434E+04
0.28000E+02	0.69533E-01	0.35989E-01	**	0.61610E+04	0.61610E+04	0.61610E+04
0.29000E+02	0.12072E+00	-.21263E-01	**	0.55578E+04	0.55578E+04	0.55578E+04
0.30000E+02	0.17190E+00	-.78515E-01	**	0.51831E+04	0.51831E+04	0.51831E+04
0.30750E+02	0.21029E+00	-.12145E+00	**	0.48889E+04	0.48889E+04	0.48889E+04
0.31750E+02	0.26147E+00	-.17871E+00	**	0.40085E+04	0.40085E+04	0.40085E+04
0.32750E+02	0.31265E+00	-.23596E+00	**	0.31468E+04	0.31468E+04	0.31468E+04
0.33750E+02	0.36384E+00	-.29321E+00	**	0.23192E+04	0.23192E+04	0.23192E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	-.17049E+00	0.48128E+00
0.60000E+00	-.13570E+00	0.42440E+00
0.12000E+01	-.91758E-01	0.35255E+00
0.18000E+01	-.47815E-01	0.28071E+00
0.24000E+01	-.38722E-02	0.20886E+00
0.30000E+01	0.40071E-01	0.13702E+00
0.36000E+01	0.84014E-01	0.65174E-01
0.42000E+01	0.12796E+00	-.66700E-02
0.48000E+01	0.17190E+00	-.78515E-01
0.54000E+01	0.21584E+00	-.15036E+00
0.62500E+01	0.27810E+00	-.25214E+00
0.72500E+01	0.35133E+00	-.37188E+00

0.82500E+01	0.42457E+00	-.49162E+00
0.92500E+01	0.49781E+00	-.61136E+00
0.10000E+02	0.56189E+00	-.71614E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.6000E+00	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.1200E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.1800E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.2400E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.3000E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.3600E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.4200E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.4800E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.5400E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.6250E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.7250E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.8250E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.9250E+01	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05
0.1000E+02	* -.9349E+04	* -.8771E+04	* -.8331E+04	* 0.5558E+04	* 0.5183E+04	* 0.4889E+04	* -.2430E+05	* -.2430E+05	* -.2429E+05

TIME=0.991804E-02 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE***	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	-.11660E-02	-.26894E+00 **	-.16854E+05	-.16854E+05	-.16854E+05
0.28000E+02	-.14138E+00	-.13046E+00 **	-.14213E+05	-.14213E+05	-.14213E+05
0.29000E+02	-.28159E+00	0.80197E-02 **	-.11115E+05	-.11115E+05	-.11115E+05
0.30000E+02	-.42180E+00	0.14650E+00 **	-.91737E+04	-.91737E+04	-.91737E+04
0.30750E+02	-.52696E+00	0.25036E+00 **	-.76805E+04	-.76805E+04	-.76805E+04
0.31750E+02	-.66717E+00	0.38884E+00 **	-.31242E+04	-.31242E+04	-.31242E+04
0.32750E+02	-.80738E+00	0.52732E+00 **	0.12241E+04	0.12241E+04	0.12241E+04
0.33750E+02	-.94759E+00	0.66580E+00 **	0.50500E+04	0.50500E+04	0.50500E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.97765E-01	-.63594E+00
0.60000E+00	0.44975E-01	-.55644E+00
0.12000E+01	-.21707E-01	-.45602E+00
0.18000E+01	-.88389E-01	-.35560E+00
0.24000E+01	-.15507E+00	-.25518E+00
0.30000E+01	-.22175E+00	-.15476E+00
0.36000E+01	-.28844E+00	-.54339E-01
0.42000E+01	-.35512E+00	0.46080E-01
0.48000E+01	-.42180E+00	0.14650E+00
0.54000E+01	-.48848E+00	0.24692E+00

0.62500E+01	-.58295E+00	0.38918E+00
0.72500E+01	-.69409E+00	0.55655E+00
0.82500E+01	-.80522E+00	0.72392E+00
0.92500E+01	-.91636E+00	0.89128E+00
0.10000E+02	-.10136E+01	0.10377E+01

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.6000E+00	* 0.2886E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.25[illegible]+05	* 0.2531E+05
0.1200E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.1800E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.2400E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+C5	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.3000E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.3600E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.4200E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.4800E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.5400E+01	* 0.2886E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.6250E+01	* 0.2886E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.7250E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.8250E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.9250E+01	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05
0.1000E+02	* 0.2888E+05	* 0.2586E+05	* 0.2355E+05	* -.1112E+05	* -.9174E+04	* -.7681E+04	* 0.2532E+05	* 0.2531E+05	* 0.2531E+05

TIME=0.128169E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE	RADIAL BENDING STRESS ***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	-.33029E+00	0.19874E+00	** 0.75674E+05	0.75674E+05	0.75674E+05
0.28000E+02	-.44965E+00	0.30739E+00	** 0.66837E+05	0.66837E+05	0.66837E+05
0.29000E+02	-.56901E+00	0.41604E+00	** 0.60926E+05	0.60926E+05	0.60926E+05
0.30000E+02	-.68837E+00	0.52469E+00	** 0.57210E+05	0.57210E+05	0.57210E+05
0.30750E+02	-.77788E+00	0.60618E+00	** 0.54365E+05	0.54365E+05	0.54365E+05
0.31750E+02	-.89724E+00	0.71483E+00	** 0.45632E+05	0.45632E+05	0.45632E+05
0.32750E+02	-.10166E+01	0.82348E+00	** 0.36973E+05	0.36973E+05	0.36973E+05
0.33750E+02	-.11360E+01	0.93213E+00	** 0.28418E+05	0.28418E+05	0.28418E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	-.55520E+00	0.39634E+00
0.60000E+00	-.56873E+00	0.40938E+00
0.12000E+01	-.58582E+00	0.42585E+00
0.18000E+01	-.60291E+00	0.44232E+00
0.24000E+01	-.62000E+00	0.45880E+00
0.30000E+01	-.63709E+00	0.47527E+00
0.36000E+01	-.65418E+00	0.49175E+00
0.42000E+01	-.67127E+00	0.50822E+00

0.48000E+01	-.68837E+00	0.52469E+00
0.54000E+01	-.70546E+00	0.54117E+00
0.62500E+01	-.72967E+00	0.56450E+00
0.72500E+01	-.75815E+00	0.59196E+00
0.82500E+01	-.78664E+00	0.61942E+00
0.92500E+01	-.81512E+00	0.64687E+00
0.10000E+02	-.84005E+00	0.67090E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X			STRESS-Y			SHEAR-XY		
	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.6000E+00	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.1200E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.1800E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.2400E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.3000E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.3600E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.4200E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.4800E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.5400E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.6250E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.7250E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.8250E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.9250E+01	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04
0.1000E+02	* 0.3675E+04	* 0.3409E+04	* 0.3196E+04	* 0.6093E+05	* 0.5721E+05	* 0.5436E+05	* -.3207E+04	* -.3207E+04	* -.3206E+04

TIME=0.157157E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS		RADIAL BENDING STRESS		
	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.14056E+00	0.22743E-01	** -.28102E+05	-.28102E+05	-.28102E+05
0.28000E+02	0.20670E+00	-.33820E-01	** -.23873E+05	-.23873E+05	-.23873E+05
0.29000E+02	0.27284E+00	-.90382E-01	** -.22000E+05	-.22000E+05	-.22000E+05
0.30000E+02	0.33898E+00	-.14694E+00	** -.20823E+05	-.20823E+05	-.20823E+05
0.30750E+02	0.38859E+00	-.18937E+00	** -.19918E+05	-.19918E+05	-.19918E+05
0.31750E+02	0.45473E+00	-.24593E+00	** -.17146E+05	-.17146E+05	-.17146E+05
0.32750E+02	0.52087E+00	-.30249E+00	** -.14365E+05	-.14365E+05	-.14365E+05
0.33750E+02	0.58701E+00	-.35905E+00	** -.11513E+05	-.11513E+05	-.11513E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.68892E-01	0.32166E+00
0.60000E+00	0.96334E-01	0.27405E+00
0.12000E+01	0.13100E+00	0.21391E+00
0.18000E+01	0.16566E+00	0.15377E+00
0.24000E+01	0.20033E+00	0.93624E-01
0.30000E+01	0.23499E+00	0.33482E-01

0.36000E+01	0.26966E+00	-.26660E-01
0.42000E+01	0.30432E+00	-.86802E-01
0.48000E+01	0.33898E+00	-.14694E+00
0.54000E+01	0.37365E+00	-.20709E+00
0.62500E+01	0.42276E+00	-.29229E+00
0.72500E+01	0.48053E+00	-.39252E+00
0.82500E+01	0.53830E+00	-.49276E+00
0.92500E+01	0.59608E+00	-.59300E+00
0.10000E+02	0.64663E+00	-.68070E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	STRESS-X *R=0.3000E+02	STRESS-X *R=0.3075E+02	STRESS-Y *R=0.2900E+02	STRESS-Y *R=0.3000E+02	STRESS-Y *R=0.3075E+02	SHEAR-XY *R=0.2900E+02	SHEAR-XY *R=0.3000E+02	SHEAR-XY *R=0.3075E+02
0.0	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.6000E+00	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.1200E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.1800E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.2400E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.3000E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.3600E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.4200E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.4800E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.5400E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.6250E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.7250E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.8250E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.9250E+01	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05
0.1000E+02	* -.2595E+05	* -.2422E+05	* -.2290E+05	* -.2200E+05	* -.2082E+05	* -.1992E+05	* -.1873E+05	* -.1872E+05	* -.1872E+05

TIME=0.186145E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	DISPLACEMENTS OUT-OF-PLANE	RADIAL BENDING STRESS ***LED-EDG	RADIAL BENDING STRESS CHD-PNT	RADIAL BENDING STRESS TRL-EDG
0.27000E+02	0.25773E+00	-.19632E+00	** -.44022E+05	-.44022E+05	-.44022E+05
0.28000E+02	0.35375E+00	-.29426E+00	** -.38984E+05	-.38984E+05	-.38984E+05
0.29000E+02	0.44976E+00	-.39020E+00	** -.35179E+05	-.35179E+05	-.35179E+05
0.30000E+02	0.54578E+00	-.48613E+00	** -.32784E+05	-.32784E+05	-.32784E+05
0.30750E+02	0.61779E+00	-.55808E+00	** -.30957E+05	-.30957E+05	-.30957E+05
0.31750E+02	0.71381E+00	-.65402E+00	** -.25332E+05	-.25332E+05	-.25332E+05
0.32750E+02	0.80983E+00	-.74996E+00	** -.19781E+05	-.19781E+05	-.19781E+05
0.33750E+02	0.90585E+00	-.84589E+00	** -.14419E+05	-.14419E+05	-.14419E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.44682E+00	-.45210E+00
0.60000E+00	0.45687E+00	-.45556E+00
0.12000E+01	0.46957E+00	-.45992E+00
0.18000E+01	0.48228E+00	-.46429E+00

0.24000E+01	0.49498E+00	-.46866E+00
0.30000E+01	0.50768E+00	-.47303E+00
0.36000E+01	0.52038E+00	-.47740E+00
0.42000E+01	0.53308E+00	-.48176E+00
0.48000E+01	0.54578E+00	-.48613E+00
0.54000E+01	0.55848E+00	-.49050E+00
0.62500E+01	0.57648E+00	-.49669E+00
0.72500E+01	0.59764E+00	-.50397E+00
0.82500E+01	0.61881E+00	-.51125E+00
0.92500E+01	0.63998E+00	-.51853E+00
0.10000E+02	0.65850E+00	-.52490E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X			STRESS-Y			SHEAR-XY		
	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.6000E+00	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.1200E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.1800E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.2400E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.3000E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.3600E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.4200E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.4800E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.5400E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.6250E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.7250E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.8250E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.9250E+01	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04
0.1000E+02	* 0.2887E+05	* 0.2686E+05	* 0.2535E+05	* -.3518E+05	* -.3278E+05	* -.3096E+05	* 0.6183E+04	* 0.6181E+04	* 0.6180E+04

TIME=0.215133E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS		RADIAL BENDING STRESS		
	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.61188E-01	-.68930E-01	** 0.11510E+05	0.11510E+05	0.11510E+05
0.28000E+02	0.75653E-01	-.82111E-01	** 0.96758E+04	0.96758E+04	0.96758E+04
0.29000E+02	0.90118E-01	-.95290E-01	** 0.89649E+04	0.89649E+04	0.89649E+04
0.30000E+02	0.10458E+00	-.10847E+00	** 0.85199E+04	0.85199E+04	0.85199E+04
0.30750E+02	0.11543E+00	-.11835E+00	** 0.81767E+04	0.81767E+04	0.81767E+04
0.31750E+02	0.12990E+00	-.13153E+00	** 0.71316E+04	0.71316E+04	0.71316E+04
0.32750E+02	0.14436E+00	-.14471E+00	** 0.60978E+04	0.60978E+04	0.60978E+04
0.33750E+02	0.15883E+00	-.15789E+00	** 0.50258E+04	0.50258E+04	0.50258E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.15319E+00	-.25159E+00
0.60000E+00	0.14825E+00	-.23705E+00

0.12000E+01	0.14201E+00	-.21868E+00
0.18000E+01	0.13577E+00	-.20031E+00
0.24000E+01	0.12954E+00	-.18194E+00
0.30000E+01	0.12330E+00	-.16357E+00
0.36000E+01	0.11706E+00	-.14521E+00
0.42000E+01	0.11082E+00	-.12684E+00
0.48000E+01	0.10458E+00	-.10847E+00
0.54000E+01	0.98344E-01	-.90102E-01
0.62500E+01	0.89507E-01	-.64080E-01
0.72500E+01	0.79110E-01	-.33467E-01
0.82500E+01	0.68712E-01	-.28534E-02
0.92500E+01	0.58315E-01	0.27760E-01
0.10000E+02	0.49217E-01	0.54546E-01

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.6000E+00	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.1200E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.1800E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.2400E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.3000E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.3600E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.4200E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.4800E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.5400E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.6250E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.7250E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.8250E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.9250E+01	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04
0.1000E+02	0.3703E+05	0.3462E+05	0.3280E+05	0.8965E+04	0.8520E+04	0.8177E+04	0.8785E+04	0.8783E+04	0.8781E+04

TIME=0.244121E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	-.11515E+00	0.10322E+00	** 0.49779E+04	0.49779E+04	9.49779E+04
0.28000E+02	-.16981E+00	0.16170E+00	** 0.48937E+04	0.48937E+04	0.48937E+04
0.29000E+02	-.22446E+00	0.22018E+00	** 0.42977E+04	0.42977E+04	0.42977E+04
0.30000E+02	-.27912E+00	0.27665E+00	** 0.39187E+04	0.39187E+04	0.39187E+04
0.30750E+02	-.32011E+00	0.32251E+00	** 0.36370E+04	0.36370E+04	0.36370E+04
0.31750E+02	-.37476E+00	0.38098E+00	** 0.27497E+04	0.27497E+04	0.27497E+04
0.32750E+02	-.42942E+00	0.43946E+00	** 0.18780E+04	0.18780E+04	0.18780E+04
0.33750E+02	-.48408E+00	0.49793E+00	** 0.10948E+04	0.10948E+04	0.10948E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X IN-PLANE OUT-OF-PLANE

0.0	-.24081E+00	0.32853E+00
0.60000E+00	-.24470E+00	0.32346E+00
0.12000E+01	-.24962E+00	0.31706E+00
0.18000E+01	-.25453E+00	0.31066E+00
0.24000E+01	-.25945E+00	0.30425E+00
0.30000E+01	-.26437E+00	0.29785E+00
0.36000E+01	-.26928E+00	0.29145E+00
0.42000E+01	-.27420E+00	0.28505E+00
0.48000E+01	-.27912E+00	0.27865E+00
0.54000E+01	-.28403E+00	0.27225E+00
0.62500E+01	-.29100E+00	0.26318E+00
0.72500E+01	-.29920E+00	0.25251E+00
0.82500E+01	-.30739E+00	0.24185E+00
0.92500E+01	-.31559E+00	0.23118E+00
0.10000E+02	-.32276E+00	0.22184E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.6000E+00	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.1200E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.1800E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.2400E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.3000E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.3600E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.4200E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.4800E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.5400E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.6250E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.7250E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.8250E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.9250E+01	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04
0.1000E+02	* -.3742E+05	* -.3501E+05	* -.3318E+05	* 0.4298E+04	* 0.3919E+04	* 0.3637E+04	* -.7571E+04	* -.7569E+04	* -.7567E+04

TIME=0.273109E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE	RADIAL BENDING STRESS ***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	-.31290E+00	0.19413E+00	** 0.35796E+05	0.35796E+05	0.35796E+05
0.28000E+02	-.39396E+00	0.25945E+00	** 0.31391E+05	0.31391E+05	0.31391E+05
0.29000E+02	-.47503E+00	0.32478E+00	** 0.28284E+05	0.28284E+05	0.28284E+05
0.30000E+02	-.55610E+00	0.39011E+00	** 0.26330E+05	0.26330E+05	0.26330E+05
0.30750E+02	-.61690E+00	0.43910E+00	** 0.24831E+05	0.24831E+05	0.24831E+05
0.31750E+02	-.69796E+00	0.50443E+00	** 0.20235E+05	0.20235E+05	0.20235E+05
0.32750E+02	-.77903E+00	0.56976E+00	** 0.15674E+05	0.15674E+05	0.15674E+05
0.33750E+02	-.86010E+00	0.63509E+00	** 0.11228E+05	0.11228E+05	0.11228E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	-.47957E+00	0.33444E+00
0.60000E+00	-.48735E+00	0.34009E+00
0.12000E+01	-.49717E+00	0.34724E+00
0.18000E+01	-.50699E+00	0.35438E+00
0.24000E+01	-.51681E+00	0.36153E+00
0.30000E+01	-.52663E+00	0.36867E+00
0.36000E+01	-.53645E+00	0.37582E+00
0.42000E+01	-.54628E+00	0.38296E+00
0.48000E+01	-.55610E+00	0.39011E+00
0.54000E+01	-.56592E+00	0.39725E+00
0.62500E+01	-.57983E+00	0.40730E+00
0.72500E+01	-.59620E+00	0.41928E+00
0.82500E+01	-.61257E+00	0.43119E+00
0.92500E+01	-.62894E+00	0.44310E+00
0.10000E+02	-.64326E+00	0.45352E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.6000E+00	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.1200E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.1800E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.2400E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.3000E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.3600E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.4200E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.4800E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.5400E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.6250E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.7250E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.8250E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.9250E+01	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04
0.1000E+02	* -.3226E+05	* -.3000E+05	* -.2828E+05	* 0.2828E+05	* 0.2633E+05	* 0.2483E+05	* -.3331E+04	* -.3330E+04	* -.3330E+04

TIME=0.302097E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE***	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.14668E+00	-.13697E+00 **	-.12667E+05	-.12667E+05	-.12667E+05
0.28000E+02	0.16321E+00	-.14404E+00 **	-.11402E+05	-.11402E+05	-.11402E+05
0.29000E+02	0.17954E+00	-.15112E+00 **	-.10084E+05	-.10084E+05	-.10084E+05
0.30000E+02	0.19587E+00	-.15819E+00 **	-.92564E+04	-.92564E+04	-.92564E+04
0.30750E+02	0.20812E+00	-.16349E+00 **	-.86191E+04	-.86191E+04	-.86191E+04
0.31750E+02	0.22445E+00	-.17057E+00 **	-.66709E+04	-.66709E+04	-.66709E+04
0.32750E+02	0.24078E+00	-.17764E+00 **	-.47477E+04	-.47477E+04	-.47477E+04
0.33750E+02	0.25712E+00	-.18471E+00 **	-.29183E+04	-.29183E+04	-.29183E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.28705E+00	-.34584E+00
0.60000E+00	0.27779E+00	-.32678E+00
0.12000E+01	0.26609E+00	-.30269E+00
0.18000E+01	0.25438E+00	-.27861E+00
0.24000E+01	0.24268E+00	-.25452E+00
0.30000E+01	0.23098E+00	-.23044E+00
0.36000E+01	0.21928E+00	-.20636E+00
0.42000E+01	0.20758E+00	-.18227E+00
0.48000E+01	0.19587E+00	-.15819E+00
0.54000E+01	0.18417E+00	-.13411E+00
0.62500E+01	0.16759E+00	-.99987E-01
0.72500E+01	0.14809E+00	-.59847E-01
0.82500E+01	0.12859E+00	-.19707E-01
0.92500E+01	0.10908E+00	0.20432E-01
0.10000E+02	0.92016E-01	0.55554E-01

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.6000E+00	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.1200E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.1800E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.2400E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.3000E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.3600E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.4200E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.4800E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.5400E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.6250E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.7250E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.8250E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.9250E+01	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05
0.1000E+02	* 0.2863E+05	* 0.2663E+05	* 0.2511E+05	* -.1008E+05	* -.9256E+04	* -.8619E+04	* 0.1055E+05	* 0.1055E+05	* 0.1055E+05

TIME=0.331085E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE***	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.18395E+00	-.67796E-01 **	-.25494E+05	-.25494E+05	-.25494E+05
0.28000E+02	0.27732E+00	-.15719E+00 **	-.22653E+05	-.22653E+05	-.22653E+05
0.29000E+02	0.37069E+00	-.24658E+00 **	-.20855E+05	-.20855E+05	-.20855E+05
0.30000E+02	0.46406E+00	-.33598E+00 **	-.19722E+05	-.19722E+05	-.19722E+05
0.30750E+02	0.53408E+00	-.40302E+00 **	-.18858E+05	-.18858E+05	-.18858E+05
0.31750E+02	0.62745E+00	-.49242E+00 **	-.16195E+05	-.16195E+05	-.16195E+05
0.32750E+02	0.72082E+00	-.58181E+00 **	-.13526E+05	-.13526E+05	-.13526E+05
0.33750E+02	0.81418E+00	-.67120E+00 **	-.10845E+05	-.10845E+05	-.10845E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.28131E+00	-.12225E+00
0.60000E+00	0.29988E+00	-.14397E+00
0.12000E+01	0.32333E+00	-.17140E+00
0.18000E+01	0.34679E+00	-.19883E+00
0.24000E+01	0.37024E+00	-.22626E+00
0.30000E+01	0.39369E+00	-.25369E+00
0.36000E+01	0.41715E+00	-.28112E+00
0.42000E+01	0.44060E+00	-.30855E+00
0.48000E+01	0.46406E+00	-.33598E+00
0.54000E+01	0.48751E+00	-.36341E+00
0.62500E+01	0.52074E+00	-.40227E+00
0.72500E+01	0.55983E+00	-.44798E+00
0.82500E+01	0.59892E+00	-.49370E+00
0.92500E+01	0.63801E+00	-.53942E+00
0.10000E+02	0.67221E+00	-.57942E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.6000E+00	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.1200E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.1800E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.2400E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.3000E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.3600E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.4200E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.4800E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.5400E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.6250E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.7250E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.8250E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.9250E+01	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04
0.1000E+02	* 0.1081E+05	* 0.1028E+05	* 0.9889E+04	* -.2085E+05	* -.1972E+05	* -.1886E+05	* -.2628E+04	* -.2628E+04	* -.2627E+04

TIME=0.360073E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE***	LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.86047E-02	0.41158E-01 **	-.76767E+04	-.76767E+04	-.76767E+04
0.28000E+02	0.46539E-01	0.22826E-03 **	-.68244E+04	-.68244E+04	-.68244E+04
0.29000E+02	0.84472E-01	-.40701E-01 **	-.65411E+04	-.65411E+04	-.65411E+04
0.30000E+02	0.12241E+00	-.81631E-01 **	-.63613E+04	-.63613E+04	-.63613E+04
0.30750E+02	0.15086E+00	-.11233E+00 **	-.62273E+04	-.62273E+04	-.62273E+04
0.31750E+02	0.18879E+00	-.15326E+00 **	-.58061E+04	-.58061E+04	-.58061E+04
0.32750E+02	0.22672E+00	-.19419E+00 **	-.53680E+04	-.53680E+04	-.53680E+04

0.33750E+02	0.26466E+00	-.23512E+00	**	-.48636E+04	-.48636E+04	-.48636E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	-.74963E-02	0.10820E+00
0.60000E+00	0.57024E-02	0.88914E-01
0.12000E+01	0.22374E-01	0.64551E-01
0.18000E+01	0.39046E-01	0.40188E-01
0.24000E+01	0.55718E-01	0.15824E-01
0.30000E+01	0.72390E-01	-.85398E-02
0.36000E+01	0.89062E-01	-.32904E-01
0.42000E+01	0.10573E+00	-.57267E-01
0.48000E+01	0.12241E+00	-.81631E-01
0.54000E+01	0.13908E+00	-.10599E+00
0.62500E+01	0.16270E+00	-.14051E+00
0.72500E+01	0.19046E+00	-.18112E+00
0.82500E+01	0.21827E+00	-.22172E+00
0.92500E+01	0.24606E+00	-.26233E+00
0.10000E+02	0.27037E+00	-.29786E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X			STRESS-Y			SHEAR-XY		
	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.6000E+00	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.1200E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.1800E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.2400E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.3000E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.3600E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.4200E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.4800E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.5400E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.6250E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.7250E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.8250E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.9250E+01	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04
0.1000E+02	* -.1239E+05	* -.1139E+05	* -.1063E+05	* -.6541E+04	* -.6361E+04	* -.6227E+04	* -.5993E+04	* -.5992E+04	* -.5992E+04

TIME=0.389062E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE	***	RADIAL BENDING STRESS LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	-.77466E-01	0.19669E-02	**	0.12717E+05	0.12717E+05	0.12717E+05
0.28000E+02	-.14329E+00	0.70949E-01	**	0.11222E+05	0.11222E+05	0.11222E+05
0.29000E+02	-.20910E+00	0.13993E+00	**	0.10436E+05	0.10436E+05	0.10436E+05
0.30000E+02	-.27492E+00	0.20891E+00	**	0.99378E+04	0.99378E+04	0.99378E+04
0.30750E+02	-.32429E+00	0.26065E+00	**	0.95630E+04	0.95630E+04	0.95630E+04

0.31750E+02	-.39011E+00	0.32963E+00 **	0.83948E+04	0.83948E+04	0.83948E+04
0.32750E+02	-.45593E+00	0.39861E+00 **	0.72201E+04	0.72201E+04	0.72201E+04
0.33750E+02	-.52175E+00	0.46760E+00 **	0.60232E+04	0.60232E+04	0.60232E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	-.90709E-01	-.32766E-01
0.60000E+00	-.10943E+00	-.82104E-02
0.12000E+01	-.13307E+00	0.22807E-01
0.18000E+01	-.15671E+00	0.53824E-01
0.24000E+01	-.18035E+00	0.84842E-01
0.30000E+01	-.20400E+00	0.11586E+00
0.36000E+01	-.22764E+00	0.14688E+00
0.42000E+01	-.25128E+00	0.17790E+00
0.48000E+01	-.27492E+00	0.20891E+00
0.54000E+01	-.29857E+00	0.23993E+00
0.62500E+01	-.33206E+00	0.28387E+00
0.72500E+01	-.37147E+00	0.33557E+00
0.82500E+01	-.41087E+00	0.38727E+00
0.92500E+01	-.45028E+00	0.43896E+00
0.10000E+02	-.48475E+00	0.48420E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.6000E+00	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.1200E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.1800E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.2400E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.3000E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.3600E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.4200E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.4800E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.5400E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.6250E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.7250E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.8250E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.9250E+01	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04
0.1000E+02	-.6990E+03	-.8066E+03	-.8947E+03	0.1044E+05	0.9938E+04	0.9563E+04	0.6318E+04	0.6317E+04	0.6316E+04

TIME=0.418050E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	OUT-OF-PLANE	***	RADIAL BENDING STRESS LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	-.21656E+00	0.11188E+00	**	0.31933E+05	0.31933E+05	0.31933E+05
0.28000E+02	-.28852E+00	0.17479E+00	**	0.27952E+05	0.27952E+05	0.27952E+05
0.29000E+02	-.36047E+00	0.23770E+00	**	0.25380E+05	0.25380E+05	0.25380E+05

0.30000E+02	-.43242E+00	0.30060E+00	** 0.23763E+05	0.23763E+05	0.23763E+05
0.30750E+02	-.48639E+00	0.34779E+00	** 0.22524E+05	0.22524E+05	0.22524E+05
0.31750E+02	-.55834E+00	0.41069E+00	** 0.18721E+05	0.18721E+05	0.18721E+05
0.32750E+02	-.63030E+00	0.47360E+00	** 0.14942E+05	0.14942E+05	0.14942E+05
0.33750E+02	-.70225E+00	0.53651E+00	** 0.11221E+05	0.11221E+05	0.11221E+05

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	-.31166E+00	0.15261E+00
0.60000E+00	-.32393E+00	0.16765E+00
0.12000E+01	-.33943E+00	0.18664E+00
0.18000E+01	-.35493E+00	0.20564E+00
0.24000E+01	-.37042E+00	0.22463E+00
0.30000E+01	-.38592E+00	0.24362E+00
0.36000E+01	-.40142E+00	0.26262E+00
0.42000E+01	-.41692E+00	0.28161E+00
0.48000E+01	-.43242E+00	0.30060E+00
0.54000E+01	-.44792E+00	0.31960E+00
0.62500E+01	-.46988E+00	0.34651E+00
0.72500E+01	-.49571E+00	0.37816E+00
0.82500E+01	-.52155E+00	0.40982E+00
0.92500E+01	-.54738E+00	0.44148E+00
0.10000E+02	-.56998E+00	0.46917E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

	STRESS-X			STRESS-Y			SHEAR-XY		
X	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.6000E+00	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.1200E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.1800E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.2400E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.3000E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.3600E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.4200E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.4800E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.5400E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.6250E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.7250E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.8250E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.9250E+01	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04
0.1000E+02	* -.1101E+05	* -.1025E+05	* -.9671E+04	* 0.2538E+05	* 0.2376E+05	* 0.2252E+05	* 0.1821E+04	* 0.1820E+04	* 0.1820E+04

TIME=0.447038E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

	DISPLACEMENTS		RADIAL BENDING STRESS		
R	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.75809E-01	-.24173E-01	** -.17831E+05	-.17831E+05	-.17831E+05

0.28000E+02	0.10653E+00	-.51367E-01 **	-.15568E+05	-.15568E+05	-.15568E+05
0.29000E+02	0.13725E+00	-.78560E-01 **	-.14251E+05	-.14251E+05	-.14251E+05
0.30000E+02	0.16797E+00	-.10575E+00 **	-.13424E+05	-.13424E+05	-.13424E+05
0.30750E+02	0.19101E+00	-.12615E+00 **	-.12789E+05	-.12789E+05	-.12789E+05
0.31750E+02	0.22173E+00	-.15334E+00 **	-.10843E+05	-.10843E+05	-.10843E+05
0.32750E+02	0.25245E+00	-.18053E+00 **	-.89059E+04	-.89059E+04	-.89059E+04
0.33750E+02	0.28317E+00	-.20773E+00 **	-.69689E+04	-.69689E+04	-.69689E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.96182E-01	0.49810E-02
0.60000E+00	0.10348E+00	-.62705E-02
0.12000E+01	0.11269E+00	-.20482E-01
0.18000E+01	0.12190E+00	-.34694E-01
0.24000E+01	0.13111E+00	-.48906E-01
0.30000E+01	0.14033E+00	-.63117E-01
0.36000E+01	0.14954E+00	-.77329E-01
0.42000E+01	0.15875E+00	-.91541E-01
0.48000E+01	0.16797E+00	-.10575E+00
0.54000E+01	0.17718E+00	-.11997E+00
0.62500E+01	0.19023E+00	-.14010E+00
0.72500E+01	0.20559E+00	-.16379E+00
0.82500E+01	0.22094E+00	-.18747E+00
0.92500E+01	0.23630E+00	-.21116E+00
0.10000E+02	0.24974E+00	-.23188E+00

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STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	STRESS-Y *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	SHEAR-XY *R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.6000E+00	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.1200E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.1800E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.2400E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.3000E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.3600E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.4200E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.4800E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.5400E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.6250E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.7250E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.8250E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.9250E+01	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04
0.1000E+02	* -.7152E+04	* -.6668E+04	* -.6299E+04	* -.1425E+05	* -.1342E+05	* -.1279E+05	* -.3179E+04	* -.3178E+04	* -.3177E+04

TIME=0.476026E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

DISPLACEMENTS   RADIAL BENDING STRESS

R	IN-PLANE	OUT-OF-PLANE	***LED-EDG	CHD-PNT	TRL-EDG
0.27000E+02	0.15848E+00	-.71601E-01	** -.16790E+05	-.16790E+05	-.16790E+05
0.28000E+02	0.22881E+00	-.13765E+00	** -.14946E+05	-.14946E+05	-.14946E+05
0.29000E+02	0.29913E+00	-.20370E+00	** -.13693E+05	-.13693E+05	-.13693E+05
0.30000E+02	0.36946E+00	-.26974E+00	** -.12903E+05	-.12903E+05	-.12903E+05
0.30750E+02	0.42220E+00	-.31928E+00	** -.12300E+05	-.12300E+05	-.12300E+05
0.31750E+02	0.49253E+00	-.38532E+00	** -.10442E+05	-.10442E+05	-.10442E+05
0.32750E+02	0.56285E+00	-.45137E+00	** -.85810E+04	-.85810E+04	-.85810E+04
0.33750E+02	0.63318E+00	-.51742E+00	** -.67286E+04	-.67286E+04	-.67286E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.24672E+00	-.14044E+00
0.60000E+00	0.25919E+00	-.15358E+00
0.12000E+01	0.27494E+00	-.17017E+00
0.18000E+01	0.29070E+00	-.18677E+00
0.24000E+01	0.30645E+00	-.20336E+00
0.30000E+01	0.32220E+00	-.21996E+00
0.36000E+01	0.33795E+00	-.23655E+00
0.42000E+01	0.35370E+00	-.25315E+00
0.48000E+01	0.36946E+00	-.26974E+00
0.54000E+01	0.38521E+00	-.28634E+00
0.62500E+01	0.40752E+00	-.30985E+00
0.72500E+01	0.43378E+00	-.33751E+00
0.82500E+01	0.46003E+00	-.36516E+00
0.92500E+01	0.48628E+00	-.39282E+00
0.10000E+02	0.50926E+00	-.41702E+00

STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X			STRESS-Y			SHEAR-XY		
	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02	*R=0.2900E+02	*R=0.3000E+02	*R=0.3075E+02
0.0	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.6000E+00	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.1200E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.1800E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.2400E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.3000E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.3600E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.4200E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.4800E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.5400E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.6250E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.7250E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.8250E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.9250E+01	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03
0.1000E+02	* 0.1691E+05	* 0.1590E+05	* 0.1514E+05	* -.1369E+05	* -.1290E+05	* -.1230E+05	* -.4395E+03	* -.4396E+03	* -.4397E+03

TIME=0.505014E-01 SEC

DISPLACEMENTS AND BENDING STRESSES VS. RADIAL STATION

R	DISPLACEMENTS IN-PLANE	DISPLACEMENTS OUT-OF-PLANE		RADIAL BENDING STRESS LED-EDG	RADIAL BENDING STRESS CHD-PNT	RADIAL BENDING STRESS TRL-EDG
0.27000E+02	0.42755E-01	-.34927E-01	**	-.40075E+04	-.40075E+04	-.40075E+04
0.28000E+02	0.60821E-01	-.53295E-01	**	-.36811E+04	-.36811E+04	-.36811E+04
0.29000E+02	0.78887E-01	-.71664E-01	**	-.33163E+04	-.33163E+04	-.33163E+04
0.30000E+02	0.96953E-01	-.90032E-01	**	-.30860E+04	-.30860E+04	-.30860E+04
0.30750E+02	0.11050E+00	-.10381E+00	**	-.29116E+04	-.29116E+04	-.29116E+04
0.31750E+02	0.12857E+00	-.12218E+00	**	-.23709E+04	-.23709E+04	-.23709E+04
0.32750E+02	0.14663E+00	-.14055E+00	**	-.18364E+04	-.18364E+04	-.18364E+04
0.33750E+02	0.16470E+00	-.15891E+00	**	-.13271E+04	-.13271E+04	-.13271E+04

DISPLACEMENTS VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	IN-PLANE	OUT-OF-PLANE
0.0	0.85907E-01	-.10400E+00
0.60000E+00	0.87029E-01	-.10258E+00
0.12000E+01	0.88447E-01	-.10079E+00
0.18000E+01	0.89864E-01	-.98997E-01
0.24000E+01	0.91282E-01	-.97204E-01
0.30000E+01	0.92700E-01	-.95411E-01
0.36000E+01	0.94117E-01	-.93618E-01
0.42000E+01	0.95535E-01	-.91825E-01
0.48000E+01	0.96953E-01	-.90032E-01
0.54000E+01	0.98370E-01	-.88239E-01
0.62500E+01	0.10038E+00	-.85699E-01
0.72500E+01	0.10274E+00	-.82710E-01
0.82500E+01	0.10510E+00	-.79722E-01
0.92500E+01	0.10747E+00	-.76733E-01
0.10000E+02	0.10953E+00	-.74118E-01

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STRESSES VS. CHORDWISE LOCATION
AT IMPACT RADIUS

X	STRESS-X *R=0.2900E+02	STRESS-X *R=0.3000E+02	STRESS-X *R=0.3075E+02	STRESS-Y *R=0.2900E+02	STRESS-Y *R=0.3000E+02	STRESS-Y *R=0.3075E+02	SHEAR-XY *R=0.2900E+02	SHEAR-XY *R=0.3000E+02	SHEAR-XY *R=0.3075E+02
0.0	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.6000E+00	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.1200E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.1800E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.2400E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.3000E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.3600E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.4200E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.4800E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.5400E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.6250E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.7250E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.8250E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.9250E+01	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04
0.1000E+02	* 0.9763E+04	* 0.9137E+04	* 0.8662E+04	* -.3316E+04	* -.3086E+04	* -.2912E+04	* 0.2334E+04	* 0.2333E+04	* 0.2333E+04

APPENDIX H

COMPILED LISTING OF SOURCE PROGRAM AND SUBROUTINES

(PAGES 252-287)

```
             C     INITIALIZE THE PROBLEM
0001          2002 FORMAT(1H ,7HENTERED)
0002               COMMON/XMID/ XCEN1(25),XCEN2(25)
0003               COMMON/BLADE/ X0(25),Y0(25),THETA(24),XM(25)
0004               COMMON/AR/ XNODE(25,25),YNODE(25),MAX(25),PRESS(25,25),
                  1AANODE(25,25),PPL(25,25),PVL(25,25),PRSS(25,25)
0005               COMMON/MODE/ BET(10),VKI(10),WI(10),GI(10),FI(10),FDI(10),GDI(10),
                  1AA(10),B5(10),PI(10),QI(10),Q(10),QD(10),QDI(10),WO(10),PH2(3,625
                  110),PP(625,2),DEF(2,625),VEL(2,625),STRSS(3,625),SH2(3,625,10)
0006               COMMON/LK/VDT(6,1000),ISLIDE(6,1000),GAMMA(6),VR(6,1000),
                  1ALPHA(6),ISPLIT(6),GAMMA1(1000),GAMMA2(1000),
                  1SPP(1000),P0(1000),LAMD11(1000),LAMD21(1000),FIMP2D(1000
                  1),FIMP3D(1000),DIST(1000),SPP1(1000)
0007               COMMON/VARBLI/NA(1000),RM1(1000),RM2(1000),ITSLD(1000),GMAL1(1000)
                  1,VRL1(1000),ALPL1(1000),ISPLT(1000),VDTL1(1000),WM1(1000)
0008               COMMON/L/I)(6),RM(6),XI(6),YI(6),IHIT(6),RL(6),X(6),Y(6),WM(6)
0009               COMMON/PRNT/NJ3(25),DEFBI(1000,25),DEFBO(1000,25),CODI(1000,25),
                  1CODO(1000,25),SIGMB1(1000,25,3),SIGMB2(1000,25,3),SIGMA1(1000,3,
                  125),SIGMA2(1000,3,25),TIMEP(1000)
0010               DIMENSION HIMODE(10),VMI(10),XO(25),YO(25),INDEX(25),
                  1X1(6),Y1(6),DELTL(6),CL(6),ADVNCE(6),BKBIK(6
                  1),IBACK(6),XNEAR(6),DFB(6),DELTA(6),DMAX(6),
                  1SDFB(6),PIFORC(25,25),POFORC(25,25),DR(10),CLO(6)
0011               REAL LAMD11,LAMD21
0012               READ(5,*)V,RIMP,TSTOP,ALPHAO,XOCL,YOCL,NR,NN,NM,NVA,IPDEL,DEN,ISYM
0013               IF(ISYM.EQ.1)GO TO 2001
0014               READ(5,*) (RL(M),M=1,3),(CL(M),M=1,3),(WM(L),L=1,3)
0015               RM(1)=(RL(1)-2*RL(2)+2*RL(3))*2
0016               RM(2)=(RL(2)-2*RL(3))*2
0017               RM(3)=2*RL(3)
0018               DELTL(3)=0.
0019               DELTL(2)=(CL(3)-CL(2))/2
0020               DELTL(1)=(CL(3)-CL(1))/2
0021               DO 2003 L=4,6
0022               ML=L-3
0023               RL(L)=RL(ML)
0024               RM(L)=RM(ML)
0025               CL(L)=CL(ML)
0026               DELTL(L)=DELTL(ML)
0027               WM(L)=WM(ML)
0028          2003 CONTINUE
0029               GO TO 2004
0030          2001 READ(5,*)(RL(M),M=1,NVA),(RM(L),L=1,NVA)
0031               READ(5,*)(CL(M),M=1,NVA),(DELTL(M),M=1,NVA),(WM(L),L=1,NVA)
0032          2004 READ(5,*)(MAX(I3),I3=1,NR)
0033               READ(5,*)(NJ3(I3),I3=1,NR)
0034               READ(5,*)(VMI(I6),I6=1,NM)
0035               READ(5,*)(DR(I6),I6=1,NM)
```

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```
      READ(5,*)(WO(I6),I6=1,NM)
      DO 6005 L=1,NVA
 6005 CLO(L)=CL(L)
      WRITE(6,2002)
      DO 199 I6=1,NM
      READ(5,*)((PH2(J6,K6,I6),K6=1,NN),J6=1,2)
  199 CONTINUE
      DO 299 I6=1,NM
      READ(5,*)((SH2(J6,K6,I6),K6=1,NN),J6=1,3)
  299 CONTINUE
      DO 399 I3=1,NR
      LIM=MAX(I3)
      READ(5,*)YNODE(I3),(XNODE(I3,J3),J3=1,LIM)
  399 CONTINUE
C     ZERO OUT THE MODAL COEFFICIENTS
      DO 801 I6=1,NM
      Q(I6)=0.
  801 QD(I6)=0.
C     SEARCH FOR THE HIGHEST NATURAL FREQUENCY
      DO 46 J6=1,NM
      DO 46 I6=1,NM
      HIMODE(I6)=WO(I6)
      IF(I6.EQ.1) GO TO 46
      IF(HIMODE(I6).GE.HIMODE(I6-1)) GO TO 46
      H6=HIMODE(I6)
      HIMODE(I6)=HIMODE(I6-1)
      HIMODE(I6-1)=H6
   46 CONTINUE
C     CALCULATE THE PRESSURE AREA FOR EACH NODE
      DO 7 I3=1,NR
      LIM=MAX(I3)
      DO 8 J3=1,LIM
      XL=XNODE(I3,J3-1)
      IF(J3-1.LT.1)XL=XNODE(I3,J3)
      XR=XNODE(I3,J3+1)
      IF(J3+1.GT.LIM)XR=XNODE(I3,J3)
      RA=YNODE(I3+1)
      IF(I3+1.GT.NR)RA=YNODE(I3)
      RB=YNODE(I3-1)
      IF(I3-1.LT.1)RB=YNODE(I3)
      AANODE(I3,J3)=(XR-XL)*(RA-RB)/4.
    8 CONTINUE
    7 CONTINUE
C     CALCULATE THE PARAMETERS FOR MODAL ANALYSIS
      DO 400 I6=1,NM
      BET(I6)=DR(I6)*WO(I6)
      VKI(I6)=VMI(I6)*WO(I6)**2
  400 WI(I6)=SQRT(ABS(WO(I6)**2-BET(I6)**2))
```

```
C     FIND WHICH RADIUS OF THE BLADE IS THE IMPACT RADIUS
      DO 110 I3=1,NR
      YIMP=YNODE(I3)
      IF(YIMP.EQ.RIMP)I7=I3
  110 CONTINUE
      NSTAT=MAX(I7)
      NSTAF=NSTAT-1
      READ(5,*)(XO(JC),JC=1,NSTAT),(YO(JC),JC=1,NSTAT)
      DO 180 J5=1,NSTAT
  180 XM(J5)=XNODE(I7,J5)
C     LOCATE THE MID POINTS OF THE BLADE SEGMENTS
      XCEN1(1)=XM(1)
      NST=NSTAF-1
      DO 413 JC=1,NST
      IF(JC.EQ.1)GO TO 414
      XCEN1(JC)=XCEN2(JC-1)
  414 XCEN2(JC)=(XM(JC+2)+XM(JC+1))/2.
      IF(JC.EQ.(NSTAF-1))XCEN2(JC)=XM(JC+2)
  413 CONTINUE
C     ESTABLISH THE INITIAL COORDINATES OF THE BLADE
      DO 101 JC=1,NSTAT
      X0(JC)=XO(JC)
  101 Y0(JC)=YO(JC)
      I=0
      ITPRNT=1
      TIME=0.
      IFV=0
      IFSLD=0
      IIFLG=0
C     **************  PRINT INITIAL CONDITIONS  ***********************
      DIMENSION ICNTL(6),ICNTM(10),ICNTN(625),ICNTR(25)
      DO 2005 J=1,NVA
 2005 ICNTL(J)=J
      DO 2006 J=1,NM
 2006 ICNTM(J)=J
      DO 2007 J=1,NN
 2007 ICNTN(J)=J
      DO 2008 J=1,NR
 2008 ICNTR(J)=J
      WRITE(6,2010)V,RIMP,TSTOP,ALPHA0,XOCL,YOCL,NR,NN,NM,NVA,IPDEL,
     1DEN,ISYM
 2010 FORMAT(1H1,57HV,RIMP,TSTOP,ALPHA0,XOCL,YOCL,NR,NN,NM,NVA,IPDEL,DEN
     1,ISYM,/1H ,6(E12.6,1H,),5(I3,1H,),E12.6,1H,,I3)
      WRITE(6,2011)(ICNTL(J),J=1,NVA)
 2011 FORMAT(1H0,2HRL,1X,6(I2,1H,))
      WRITE(6,2012)(RL(J),J=1,NVA)
 2012 FORMAT(1H ,6(E12.6,1H,))
      WRITE(6,2013)(ICNTL(J),J=1,NVA)
```

```
 2013 FORMAT(1H0,2HRM,1X,6(I2,1H,))
      WRITE(6,2012)(RM(J),J=1,NVA)
      WRITE(6,2014)(ICNTL(J),J=1,NVA)
 2014 FORMAT(1H0,2HCL,1X,6(I2,1H,))
      WRITE(6,2012)(CL(J),J=1,NVA)
      WRITE(6,2015)(ICNTL(J),J=1,NVA)
 2015 FORMAT(1H0,5HDELTL,1X,6(I2,1H,))
      WRITE(6,2012)(DELTL(J),J=1,NVA)
      WRITE(6,2016)(ICNTL(J),J=1,NVA)
 2016 FORMAT(1H0,2HWM,1X,6(I2,1H,))
      WRITE(6,2012)(WM(J),J=1,NVA)
      WRITE(6,2017)(ICNTR(J),J=1,NR)
 2017 FORMAT(1H0,3HMAX,1X,25(I2,1H,))
      WRITE(6,2018)(MAX(J),J=1,NR)
 2018 FORMAT(1H ,25(I3,1H,))
      WRITE(6,2019)(ICNTR(J),J=1,NR)
 2019 FORMAT(1H0,3HNJ3,1X,25(I2,1H,))
      WRITE(6,2018)(NJ3(J),J=1,NR)
      WRITE(6,2020)(ICNTM(J),J=1,NM)
 2020 FORMAT(1H0,3HVMI,1X,10(I2,1H,))
      WRITE(6,2021)(VMI(J),J=1,NM)
 2021 FORMAT(1H ,10(E11.5,1H,))
      WRITE(6,2022)(ICNTM(J),J=1,NM)
 2022 FORMAT(1H0,2HDR,1X,10(I2,1H,))
      WRITE(6,2021)(DR(J),J=1,NM)
      WRITE(6,2023)(ICNTM(J),J=1,NM)
 2023 FORMAT(1H0,2HWO,1X,10(I2,1H,))
      WRITE(6,2021)(WO(J),J=1,NM)
      DO 2024 I6=1,NM
      DO 2024 J6=1,2
      WRITE(6,2025)J6,I6,J6,NN,I6
 2025 FORMAT(1H0,4HPH2(,I2,3H,1,,I2,11H) THRU PH2(,I2,1H,,I3,1H,,I2,1H))
      WRITE(6,2026) (PH2(J6,K6,I6),K6=1,NN)
 2026 FORMAT(1H0,63(/1H ,10(E11.5,1H,)))
 2024 CONTINUE
      DO 2027 I6=1,NM
      DO 2027 J6=1,3
      WRITE(6,2028)J6,I6,J6,NN,I6
 2028 FORMAT(1H0,4HSH2(,I2,3H,1,,I2,11H) THRU SH2(,I2,1H,,I3,1H,,I2,1H))
      WRITE(6,2029) (SH2(J6,K6,I6),K6=1,NN)
 2029 FORMAT(1H0,63(/1H ,10(E11.5,1H,)))
 2027 CONTINUE
      WRITE(6,1049)
 1049 FORMAT(1H1,53X,26HPLANFORM GEOMETRY OF BLADE)
      DO 1100 I3=1,NR
      LIM=MAX(I3)
      WRITE(6,1050)YNODE(I3)
 1050 FORMAT(/1H0,130(1H*),/1H ,60X,2HY=,F9.4)
```

```
      LIMP=LIM-10
      IF(LIMP.LE.0)LIN1=LIM
      IF(LIMP.GT.0)LIN1=10
      KN=1
      LIMP=LIM-LIN1
      IF(LIMP.LE.0)GO TO 1001
      KN=2
      LIMP1=LIMP-10
      IF(LIMP1.LE.0)LIN2=LIMP
      IF(LIMP1.GT.0)LIN2=10
      LIMP=LIMP-LIN2
      IF(LIMP.LE.0)GO TO 1001
      KN=3
      LIN3=LIMP
 1001 DO 1002 NLIN=1,KN
      IF(NLIN.EQ.1)GO TO 1003
      IF(NLIN.EQ.2)GO TO 1004
      IF(NLIN.EQ.3)GO TO 1005
 1003 KN1=LIN1
      DO 1006 IXX=1,LIN1
 1006 INDEX(IXX)=IXX
      WRITE(6,1051)(INDEX(IXX),IXX=1,LIN1)
 1051 FORMAT(/1H ,3X,10(1HX,I2,8X))
      WRITE(6,1052)(XNODE(I3,J3),J3=1,LIN1)
 1052 FORMAT(/1H ,10(F9.4,2X))
      GO TO 1002
 1004 KN1=LIN2+10
      DO 1007 IXX=11,KN1
 1007 INDEX(IXX)=IXX
      WRITE(6,1051)(INDEX(IXX),IXX=11,KN1)
      WRITE(6,1052)(XNODE(I3,J3),J3=11,KN1)
      GO TO 1002
 1005 KN1=LIN3+20
      DO 1008 IXX=21,KN1
 1008 INDEX(IXX)=IXX
      WRITE(6,1053)(INDEX(IXX),IXX=21,KN1)
 1053 FORMAT(/1H ,3X,5(1HX,I2,8X))
      WRITE(6,1052)(XNODE(I3,J3),J3=21,KN1)
 1002 CONTINUE
 1100 CONTINUE
      WRITE(6,1054)
 1054 FORMAT(//1H0,51X,29HINITIAL BLADE CAMBER GEOMETRY,/1H ,57X,
     117HAT IMPACT STATION,//1H ,39X,4HNODE,4X,19HIN-PLANE COORDINATE,
     14X,23HOUT OF PLANE COORDINATE)
      DO 1009 JC=1,NSTAT
      WRITE(6,1055)JC,XO(JC),YO(JC)
 1055 FORMAT(1H ,40X,I2,9X,F10.5,16X,F10.5)
 1009 CONTINUE
```

```
0216            WRITE(6,1056)
0217       1056 FORMAT(//1H0,58X,16HMISSILE GEOMETRY,/1H0,44X,7HSECTION,2X,        00002410
               19HTHICKNESS,2X,5HWIDTH,4X,6HLENGTH,3X,6HOFFSET,/)                00002420
0218            DO 1010 L=1,NVA                                                   00002430
0219            WRITE(6,1057)L,RM(L),WM(L),CL(L),DELTL(L)                         00002440
0220       1057 FORMAT(1H ,47X,I1,4X,4(3X,F6.3))                                  00002450
0221       1010 CONTINUE                                                          00002460
0222            WRITE(6,1058)                                                     00002470
0223       1058 FORMAT(//1H0,60X,10HMODAL DATA,/1H0,31X,4HMODE,2X,                00002480
               113HFREQ(RAD/SEC),4X,10HMODAL MASS,6X,15HMODAL STIFFNESS,3X,      00002490
               113HDAMPING RATIO)                                                 00002500
0224            DO 1011 I6=1,NM                                                   00002510
0225            WRITE(6,1059)I6,WO(I6),VMI(I6),VKI(I6),DR(I6)                     00002520
0226       1059 FORMAT(1H ,32X,I2,3X,E12.6,3(5X,E12.6))                           00002530
0227       1011 CONTINUE                                                          00002540
0228            WRITE(6,1060)V,ALPHA0,DEN,X0CL,Y0CL,RIMP                          00002550
0229       1060 FORMAT(//1H0,77X,9HCHORDWISE,/1H ,23X,6HIMPACT,10X,6HIMPACT,9X,   00002560
               17HMISSILE,12X,18HIMPACT COORDINATES,12X,6HIMPACT,/1H ,22X,       00002570
               16HVELOCITY,9X,5HANGLE,10X,7HDENSITY,9X,8HIN-PLANE,6X,            00002580
               112HOUT-OF-PLANE,7X,6HRADIUS,/1H0,16X,6(4X,E12.6))                00002590
          C     ****************************************************************00002600
          C     ESTABLISH THE INCREMENTAL ENTRY POINT OF THE PROGRAM             00002605
0230        800 I=I+1                                                             00002610
          C     FIND THE ANGLE OF THE BLADE CHORD AND THE ANGLE OF THE BIRD WITH R00002620
          C     TO THE X-AXIS                                                     00002630
0231            THETA0=ACOS((X0(NSTAT)-X0(1))/(SQRT((X0(NSTAT)-X0(1))**2+(Y0(NSTA 00002640
               1T)-Y0(1))**2)))                                                  00002650
0232            IF((Y0(5)-Y0(1)).LT.0.)THETA0=-THETA0                             00002660
0233            IF(I.GT.1)GO TO 121                                               00002670
0234            BETA=THETA0-ALPHA0                                                00002680
          C     FIND THE BLADE SEGMENT ANGLES                                     00002690
0235        121 DO 21 JC=1,NSTAF                                                  00002700
0236            THETA(JC)=ACOS((X0(JC+1)-X0(JC))/(SQRT((X0(JC+1)-X0(JC))**2+(Y0(JC00002710
               1+1)-Y0(JC))**2)))                                                00002720
0237            IF((Y0(JC+1)-Y0(JC)).LT.0.)THETA(JC)=-THETA(JC)                   00002730
0238         21 CONTINUE                                                          00002740
          C     FIND THE FORWARD AND AFT POINTS OF THE BIRD SECTIONS              00002750
0239            DO 20 L=1,NVA                                                     00002760
0240            IF(I.GT.1)GO TO 19                                                00002770
0241            X(L)=X0CL+RL(L)*SIN(BETA)-DELTL(L)*COS(BETA)                      00002780
0242            Y(L)=Y0CL-RL(L)*COS(BETA)-DELTL(L)*SIN(BETA)                      00002790
0243            X1(L)=X(L)-CL(L)*COS(BETA)                                        00002800
0244            Y1(L)=Y(L)-CL(L)*SIN(BETA)                                        00002810
0245            GO TO 20                                                          00002820
0246         19 IF(II(L).GT.1) GO TO 20                                           00002830
0247            IF(II(L).EQ.0) VDT(L,I-1)=0.                                      00002840
0248            ADVNCE(L)=V*DT-VDT(L,I-1)                                         00002850
0249            X(L)=X(L)+ADVNCE(L)*COS(BETA)                                     00002860
                                                                                  00002870
```

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0250            Y(L)=Y(L)+ADVNCE(L)*SIN(BETA)
0251            X1(L)=X1(L)+V*DT*COS(BETA)
0252            Y1(L)=Y1(L)+V*DT*SIN(BETA)
0253            ACL=CL(L)
0254            CL(L)=CL(L)-VDT(L,I-1)
0255            IF((CL(L)/ACL).LE..01)II(L)=2
0256            IF(ABS(CL(L)/CLO(L)).LT..01)II(L)=2
0257       20   CONTINUE
          C     FIND THE INITIAL CONTACT POINTS OF THE BIRD
0258            IT=0
0259            DO 30 L=1,NVA
0260            IF(I.EQ.1)GO TO 11
0261            IF(II(L).GT.1)GO TO 30
0262       11   BKB1K(L)=0.
0263            IBACK(L)=0
0264            DO 3100 JC=1,NSTAF
0265            ISLIDE(L,I)=0
0266            UAK1=(Y0(JC+1)-Y1(L))*COS(BETA)-(X0(JC+1)-X1(L))*SIN(BETA)
0267            A1K1=(X0(JC)-X1(L))*SIN(BETA)-(Y0(JC)-Y1(L))*COS(BETA)
0268            IF(THETA(JC).GE.0..AND.UAK1.GE.0..AND.A1K1.GE.0.) GO TO 31
0269            IF(THETA(JC).LT.0..AND.UAK1.LE.0..AND.A1K1.LE.0.) GO TO 31
0270            IHIT(L)=0
0271            GO TO 3100
0272       31   BKB1K(L)=(X(L)-X0(JC+1))*(Y(L)-Y0(JC))-(X(L)-X0(JC))*(Y(L)-Y0(JC+1
               1))
0273            IHIT(L)=JC
0274            IF(THETA(JC).GE.0..AND.BKB1K(L).GE.0.)IBACK(L)=1
0275            IF(THETA(JC).LT.0..AND.BKB1K(L).LE.0.)IBACK(L)=1
          C     CHECK WHETHER THE IMPACT ANGLE IS SHALLOW ENOUGH TO CONSTITUTE
          C     SLIDING ALONG THE BLADE
0276            IF(ABS(THETA(JC)-BETA).GE.1.7E-3) GO TO 32
0277            IF(ABS(3.141592654-ABS(THETA(JC)-BETA)).GE.1.7E-3)GO TO 32
          C                                   SLIDING
0278            ISLIDE(L,I)=1
          C     CHECK WHETHER THE BLADE ANGLE IS CLOSE TO 90 DEGREES
0279            PPII=3.141592654
0280            IF(ABS(PPII/2.-ABS(THETA(JC))).GE.1.7E-3) GO TO 33
          C     THE BLADE ANGLE IS CLOSE TO 90 DEGREES
0281            YI(L)=Y(L)
0282            XI(L)=(Y(L)-Y0(JC))*COTAN(THETA(JC))+X0(JC)
0283            XNEAR(L)=XM(JC)
0284            GO TO 34
          C     THE BLADE ANGLE IS NOT 90 DEGREES
0285       33   XI(L)=X(L)
0286            YI(L)=(X(L)-X0(JC))*TAN(THETA(JC))+Y0(JC)
0287            XNEAR(L)=XM(JC)
0288       34   DFB(L)=0.
0289            DELTA(L)=((XI(L)-X0(JC))**2+(YI(L)-Y0(JC))**2)**.5
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                C     CHECK WHETHER THE SLIDE IS GOING FROM MODE N TO N+1 AND WHETHER TH00003360
                C     FORWARD POINT OF THE BIRD SECTION IS BEYOND THE END NODE OF THE BL00003370
                C     SEGMENT
 0290                 IF((THETA(JC).LT.0..AND.YI(L).LE.Y0(JC+1)).OR.(THETA(JC).GE.0..AND00003380
                     1.YI(L).GE.Y0(JC+1))) GO TO 35                                    00003390
 0291                 IF((THETA(JC).LT.0..AND.YI(L).GE.Y0(JC)).OR.(THETA(JC).GE.0.AND.  00003400
                     1YI(L).LE.Y0(JC)))GO TO 36                                        00003410
 0292                 GAMMA(L)=XNEAR(L)+DELTA(L)                                        00003420
 0293                 GO TO 40                                                          00003430
 0294            35   XI(L)=X0(JC+1)                                                    00003440
 0295                 YI(L)=Y0(JC+1)                                                    00003450
 0296                 XNEAR(L)=XM(JC+1)                                                 00003460
 0297                 IHIT(L)=JC+1                                                      00003470
 0298                 ISLIDE(L,K)=0                                                     00003480
 0299                 DELTA(L)=0.                                                       00003490
 0300                 GO TO 38                                                          00003500
 0301            36   XI(L)=X0(JC)                                                      00003510
 0302                 YI(L)=Y0(JC)                                                      00003520
 0303                 XNEAR(L)=XM(JC-1)                                                 00003530
 0304                 IHIT(L)=JC-1                                                      00003540
 0305                 ISLIDE(L,K)=0                                                     00003550
 0306                 DELTA(L)=((X0(JC)-X0(JC-1))**2+(Y0(JC)-Y0(JC-1))**2)**.5          00003560
 0307            38   DFB(L)=((X(L)-XI(L))**2+(Y(L)-YI(L))**2)**.5                      00003570
 0308                 IF(DFB(L).LT.1.0E-5)GO TO 340                                     00003580
 0309                 DALPHA=ACOS((X(L)-XI(L))/DFB(L))                                  00003590
 0310                 DFB(L)=ABS(DFB(L)*COS(BETA-DALPHA))                               00003600
 0311                 GAMMA(L)=XNEAR(L)+DELTA(L)                                        00003610
 0312                 GO TO 40                                                          00003620
 0313           340   DFB(L)=0.                                                         00003630
 0314                 GAMMA(L)=XNEAR(L)+DELTA(L)                                        00003640
 0315                 GO TO 40                                                          00003650
                C                       IMPACT ANGLE IS NOT SHALLOW                     00003660
 0316            32   XI(L)=(((Y(L)-Y0(JC))*COS(BETA)-X(L)*SIN(BETA))*COS(THETA(JC))    00003670
                     1+X0(JC)*SIN(THETA(JC))*COS(BETA))/SIN(THETA(JC)-BETA)            00003680
                C     CHECK WHETHER THE BLADE SEGMENT ANGLE IS CLOSE TO 90 DEGREES     00003690
 0317                 PPII=3.141592654                                                  00003700
 0318                 IF(ABS(PPII/2.-ABS(THETA(JC))).LT.1.7E-3)GO TO 37                 00003710
                C     BLADE SEGMENT ANGLE IS NOT 90 DEGREES                             00003720
 0319                 YI(L)=(XI(L)-X0(JC))*TAN(THETA(JC))+Y0(JC)                        00003730
 0320                 GO TO 39                                                          00003740
                C     BLADE SEGMENT ANGLE IS CLOSE TO 90 DEGREES-USE TAN(BETA)          00003750
 0321            37   YI(L)=(XI(L)-X(L))*TAN(BETA)+Y(L)                                 00003760
                C     FIND XNEAR,DELTA AND DFB                                          00003770
 0322            39   XNEAR(L)=XM(JC)                                                   00003780
 0323                 DELTA(L)=((X0(JC)-XI(L))**2+(Y0(JC)-YI(L))**2)**.5                00003790
 0324                 GAMMA(L)=XNEAR(L)+DELTA(L)                                        00003800
 0325                 DFB(L)=((XI(L)-X(L))**2+(YI(L)-Y(L))**2)**.5                      00003810
                C     IF THIS BIRD SECTION'S FORWARD POINT IS IN BACK OF THE BLADE FIND 00003830
```

```
C      OUT IF IT IS THE GREATEST DISTANCE BEHIND THE BLADE
  40   IF(IBACK(L).EQ.0)GO TO 30
       IT=IT+1
       DMAX(IT)=DFB(L)
       IF(IT.EQ.1)GO TO 30
       IF(DMAX(IT).GE.DMAX(IT-1))GO TO 30
       DJ7=DMAX(IT)
       DMAX(IT)=DMAX(IT-1)
       DMAX(IT-1)=DM7
       GO TO 30
 3100  CONTINUE
  30   CONTINUE
       PPII=3.141592654
C      RESET THE POSITION OF THE BIRD SO THAT THE BIRD SECTION CLOSEST TO
C      THE BLADE WILL HIT FIRST
       DO 41 L=1,NVA
       IF(I.EQ.1) GO TO 12
       IF(II(L).GT.1) GO TO 41
  12   IF(IHIT(L).EQ.0)GO TO 41
C      IF ALL OF THE FORWARD POINTS ARE IN FRONT OF THE BLADE THE BIRD WI
C      HAVE TO BE MOVED TOWARD THE BLADE
       IF(IT.EQ.0)GO TO 42
C      FOWRARD POINTS BEHING THE BLADE-MOVE THE BIRD BACK
       X(L)=X(L)-DMAX(IT)*COS(BETA)
       Y(L)=Y(L)-DMAX(IT)*SIN(BETA)
       DFB(L)=((XI(L)-X(L))**2+(YI(L)-Y(L))**2)**.5
       GO TO 41
C      ALL FORWARD POINTS ARE IN FRONT OF THE BLADE
  42   SDFB(L)=DFB(L)
       IF(L.EQ.1) GO TO 41
       IF(SDFB(L).LE.SDFB(L-1)) GO TO 41
       DJ7=SDFB(L)
       SDFB(L)=SDFB(L-1)
       SDFB(L-1)=DJ7
  41   CONTINUE
C      IF ALL FORWARD POINTS ARE IN FRONT OF THE BLADE MOVE THE BIRD TOWA
C      THE BLADE
       IF(IT.GT.0)GO TO 43
       DO 44 L=1,NVA
       IF(I.EQ.1) GO TO 13
       IF(II(L).GT.1)GO TO 44
  13   X(L)=X(L)+SDFB(NVA)*COS(BETA)
       Y(L)=Y(L)+SDFB(NVA)*SIN(BETA)
  44   DFB(L)=((XI(L)-X(L))**2+(YI(L)-Y(L))**2)**.5
C      TEST FOR WHICH BIRD SECTIONS WILL IMPACT ON THE BLADE AND SET II(L
C      IF IMPACT WILL OCCUR DURING THIS TIME STEP
  43   DO 45 L=1,NVA
       IF(IHIT(L).EQ.0) GO TO 45
```

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0363              IF(I.EQ.1)II(L)=0                                                 00004320
0364              IF(II(L).GT.1)GO TO 45                                            00004330
0365              IF(DFB(L).LT..01)II(L)=1                                          00004340
0366        45    CONTINUE                                                          00004350
           C      SET THE TIME STEP TO ONE TENTH THE HIGHEST NATURAL PERIOD DURING T00004360
           C      TIME THAT THE BIRD IS IMPACTING                                   00004370
0367              CONST=2.*PPII/(10.*HIMODE(NM))                                    00004380
           C      IF THE BIRD HAS COMPLETELY IMPACTED SET THE TIME STEP TO ONE TENTH00004390
           C      LOWEST NATURAL PERIOD                                             00004400
0368              IF(IFV.GT.0)CONST=2.*PPII/(10.*HIMODE(1))                         00004410
0369              DT=CONST                                                          00004420
           C      CALCULATE THE RELATIVE IMPACT VELOCITY AND ANGLE-CHANGE DT IF VREL00004430
           C      IS GREATER THAN THE LENGTH OF THE IMPACTING BIRD SECTION          00004440
0370              DO 47 L=1,NVA                                                     00004450
0371              JK=IHIT(L)                                                        00004460
0372              IF(IHIT(L).EQ.0)GO TO 47                                          00004470
0373              IF(II(L).GT.1)GO TO 47                                            00004480
0374              IF(I.EQ.1)GO TO 48                                                00004490
0375              J9=I8-1                                                           00004500
0376              DO 203 JB=1,NSTAF                                                 00004510
0377              J9=J9+1                                                           00004520
0378              IF(JB.EQ.IHIT(L))JT=J9                                            00004530
0379       203    CONTINUE                                                          00004540
0380              IF(ABS(PPII/2.-ABS(THETA(IHIT(L)))).GE.PPII/12.)GO TO 49          00004550
0381              OMEGA=(VEL(1,JT+1)-VEL(1,JT))/(Y0(JK+1)-Y0(JK))                   00004560
0382              GO TO 50                                                          00004570
0383        49    OMEGA=(VEL(2,JT+1)-VEL(2,JT))/(X0(JK+1)-X0(JK))                   00004580
0384        50    XID=VEL(1,JT)-(YI(L)-Y0(IHIT(L)))*OMEGA                           00004590
0385              YID=VEL(2,JT)+(XI(L)-X0(IHIT(L)))*OMEGA                           00004600
0386              GO TO 51                                                          00004610
0387        48    XID=0.                                                            00004620
0388              YID=0.                                                            00004630
0389        51    VI=XID*COS(BETA)+YID*SIN(BETA)                                    00004640
0390              VB=XID*COS(THETA(IHIT(L)))+YID*SIN(THETA(IHIT(L)))                00004650
0391              VX1=(V-VI)*COS(BETA)-VB*COS(THETA(IHIT(L)))                       00004660
0392              VY1=(V-VI)*SIN(BETA)-VB*SIN(THETA(IHIT(L)))                       00004670
0393              VR(L,I)=(VX1**2+VY1**2)**.5                                       00004680
0394              ALPHA(L)=ACOS((VX1*COS(THETA(IHIT(L)))+VY1*SIN(THETA(IHIT(L))))/  00004690
                 1VR(L,I))                                                          00004700
0395              ISPLIT(L)=1                                                       00004710
0396              IF(ALPHA(L).LE.PPII/2.)GO TO 56                                   00004720
0397              ALPHA(L)=PPII-ALPHA(L)                                            00004730
0398              ISPLIT(L)=-1                                                      00004740
0399        56    IF(II(L).EQ.0)GO TO 52                                            00004750
           C      CHECK WHETHER VREL*DT IS GREATER THAN THE LENGTH OF IMPACTING BIRD00004760
           C      SECTION AND SHORTEN DT IF IT IS                                   00004770
0400              DT1=CL(L)/VR(L,I)                                                 00004780
0401              IF(DT1.LT.DT)DT=DT1                                               00004790
```

```
0402             GO TO 47
           C     CHECK WHETHER VREL*DT IS GREATER THAN DFB FOR BIRD SECTIONS NOT IN
           C     CONTACT W&TH THE BLADE YET
0403        52   DT1=DFB(L)/VR(L,I)
0404             IF(DT1.GE.DT)GO TO 47
0405             IF(DT1.LT.DT/2.)GO TO 53
0406             DT=DT1
0407             GO TO 47
           C     IF THIS BIRD SECTION WILL TAKE LESS THAN ONE HALF THIS TIME STEP T
           C     IMPACT THEN IMPACT IT DURING THIS TIME STEP
0408        53   II(L)=1
0409        47   CONTINUE
           C     FOR EACH BIRD SECTION CALCULATE THE LENGTH OF THE SECTION THAT WIL
           C     IMPACT DURING THIS TIME STEP
0410             DO 54 L=1,NVA
0411             IF(IHIT(L).EQ.0)GO TO 55
0412             IF(II(L).GT.1)GO TO 55
0413             IF(II(L).EQ.0)GO TO 55
0414             VDT(L,I)=VR(L,I)*DT-DFB(L)
0415             GO TO 54
0416        55   VDT(L,I)=0.
0417        54   CONTINUE
           C                        NODAL LOADS
           C     ZERO OUT THE PRESSURES AND IN-PLANE AND OUT OF-PLANE FORCES ON ALL
0418             DO 61 I3=1,NR
0419             LIM=MAX(I3)
0420             DO 61 J3=1,LIM
0421             PRESS(I3,J3)=0.
0422             PIFORC(I3,J3)=0.
0423             FRSS(I3,J3)=0.
0424             PPL(I3,J3)=0
0425             PVL(I3,J3)=0
0426        61   POFORC(I3,J3)=0.
           C     CALCULATE THE INITIAL IMPACT FORCE FOR BIRD SECTIONS HITTING THE
           C     BLADE DURINGTHISTIME STEP
0427             IF(IFSLD.EQ.1.OR.IIFLG.EQ.1)GO TO 57
0428             CALL PINIT(L1,NVA,BETA,JC1,XNERL1,DLTAL1,I8,NSTAF,PPII,E,F,
                1G,AL,R1,S,DEN,I,V,I7,DT,RIMP,NSTAT)
0429        57   IF(IFSLD.EQ.1.OR.IIFLG.EQ.1)GO TO 58
0430             IF(NA(I).EQ.0.AND.ITSLD(I).EQ.7)GO TO 60
0431             IF(NA(I).EQ.0.AND.ITSLD(I).LT.7)GO TO 59
0432             IF(ALPL1(I).LT.1.7E-3)GO TO 59
0433             KFIN=I
0434             GO TO 58
0435        59   IFSLD=1
0436             KFIN=I-1
0437             GO TO 58
0438        60   IIFLG=1
```

```
 0439              KFIN=I-1
            C      CALCULATE THE NODE PRESSURES FOR EACH BIRD SECTION THAT HAS IMPACT
            C      IN A PREVIOUS TIME STEP
 0440         58   DO 64 K=1,KFIN
            C      THIS BIRD SECTION HAS IMPACTED THE BLADE AND SQUASHED
            C       -IF THE BIRD SECTION CAME ON THE BLADE DURING THIS TIME STEP
            C        -FIND THE X-COORDINATE OF THE CENTER OF THE CLOSED LOOP (SPP1)
            C        -AND SET THE VALUE OF DIST-PRESSURES ARE NOT CALCULATED FOR
            C       -THE FIRST TIME STEP OF IMPACT
 0441         65   IF(K.LT.I)GO TO 72
 0442              SPP1(K)=SPP(K)+(LAMD11(K)-LAMD21(K))/2.
 0443              IF((GMAL1(K)-SPP(K)).LT.0.)SPP1(K)=SPP(K)+(LAMD21(K)-
                  1LAMD11(K))/2.
 0444              DIST(K)=(LAMD11(K)+LAMD21(K))/2.
 0445              GO TO 64
 0446         72   A=RIMP+(WM1(K)-RM1(K))/2.
 0447              B=RIMP-(WM1(K)-RM1(K))/2.
 0448              IF((A-B).GT.0.)GO TO 7200
 0449              A=RIMP
 0450              B=RIMP
 0451       7200   DIST(K)=DIST(K)+VRL1(K)*DT/2.
            C      CALCULATE THE PRESSURE DISTRIBUTION DUE TO THIS BIRD SECTION
 0452              CALL PRESUR(NR,A,B,DIST(K),ISPLT(K),SPP(K),SPP1(K),VDTL1(
                  1K),GAMMA1(K),GAMMA2(K),P0(K),RM1(K),ALPL1(K),VRL1(K),DEN,
                  1NSTAT,IIFLG)
 0453         64   CONTINUE
            C      CALCULATE THE IN-PLANE AND OUT OF PLANE FORCES ON EACH NODE
 0454         62   I5=0
 0455              FV=0.
 0456              DO 73 I3=1,NR
 0457              LIM=MAX(I3)
 0458              DO 74 J3=1,LIM
            C       -FIND WHICH BLADE SEGMENT ANGLE SHOULD BE USED WITH THIS NODE AND
            C       -CALCULATE THE IN-PLANE AND OUT OF-PLANE FORCES ON THIS NODE USIN
            C       -THE CORRECT ANGLE
 0459              SECT=XM(NSTAT)-XM(1)
 0460              CAMLIM=XNODE(I3,1)
 0461              DO 75 JC=1,NSTAF
 0462              WIDTH=(XM(JC+1)-XM(JC))*(XNODE(I3,LIM)-XNODE(I3,1))/SECT
 0463              CAMLIM=CAMLIM+WIDTH
 0464              IF(XNODE(I3,J3).GT.CAMLIM.OR.XNODE(I3,J3).LT.(CAMLIM-WIDTH))GO
                  1TO 75
 0465              ANGLE=THETA(JC)
 0466              IF(J3.NE.1.AND.J3.NE.LIM)ANGLE=(THETA(JC)+THETA(JC+1))/2.
 0467              PIFORC(I3,J3)=PRSS(I3,J3)*AANODE(I3,J3)*SIN(ANGLE)
 0468              POFORC(I3,J3)=-PRSS(I3,J3)*AANODE(I3,J3)*COS(ANGLE)
 0469         75   CONTINUE
 0470              I5=I5+1
```

```
0471              PP(I5,1)=PIFORC(I3,J3)
0472              PP(I5,2)=POFORC(I3,J3)                                           00005760
0473              IF(I3.EQ.I7.AND.J3.EQ.1)I8=I5                                    00005770
0474              FV=FV+PP(I5,1)+PP(I5,2)                                          00005780
0475          74  CONTINUE                                                         00005790
0476          73  CONTINUE                                                         00005800
              C                -CALCULATE THE MODAL RESPONSE DURING THIS TIME STEP 00005810
              C                -USING THE RESULTS OF THE PREVIOUS TIME STEP AS     00005820
              C                -INITIAL CONDITIONS                                 00005830
0477              CALL MODAL(NM,NSTAT,NN,I8,FV,DT)                                 00005840
              C                -CALCULATE THE NEW COORDINATES OF THE NODES DESCRIBING 00005850
              C                -THE BLADE SHAPE AT THE IMPACTED RADIAL STATION     00005860
0478              I9=I8                                                            00005870
0479              DO 445 JB=1,NSTAT                                                00005880
0480              X0(JB)=X0(JB)+DEF(1,I9)                                          00005890
0481              Y0(JB)=Y0(JB)+DEF(2,I9)                                          00005900
0482              I9=I9+1                                                          00005910
0483         445  CONTINUE                                                         00005920
              C    -CALCULATE THE TOTAL ELAPSED TIME                               00005930
0484              TIME=TIME+DT                                                     00005940
0485              III=0                                                            00005950
0486              DO 1200 L=1,NVA                                                  00005960
0487              IF(II(L).GT.1.OR.IHIT(L).EQ.0)III=III+1                          00005970
0488        1200  CONTINUE                                                         00005980
0489              IF(IFV.EQ.1)GO TO 202                                            00005990
0490              IF(III.EQ.6)GO TO 202                                            00006000
0491              CALL PRINTP(I,TIME,NR)                                           00006010
0492         202  IF(I.EQ.1)GO TO 200                                              00006020
0493              IF(TIME.GE.TSTOP)GO TO 200                                       00006030
0494              IF(I.EQ.ITPRNT)GO TO 200                                         00006040
0495              GO TO 201                                                        00006050
0496         200  CALL PRINTV(I,TIME,IPDEL,ITPRNT,NR,IJPRNT,I7)                    00006060
0497              IF(III.LT.6)GO TO 201                                            00006070
0498              CALL PRINTP(I,TIME,NR)                                           00006080
              C    -CHECK WHETHER THE ENTIRE LENGTH OF THE BIRD HAS IMPACTED       00006090
0499         201  IF(FV.EQ.0.) GO TO 77                                            00006100
0500              IF(TIME.LT.TSTOP  J TO 800                                       00006110
0501              WRITE(6,600)TIM'                                                 00006120
0502         600  FORMAT(1H1,29X-     E DURATION OF PROBLEM TOO SHORT FOR MISSILE TO 00006140
                 1IMPACT BLADE C.     .ELY',/1H0,53X,'ELAPSED TIME=',1X,E11.5,1X'SEC' 00006150
                 1)                                                                 
0503              GO TO 998                                                        00006160
0504          77  IF(IFV.EQ.1) GO TO 78                                            00006170
0505              IF(I.EQ.1)GO TO 78                                               00006180
0506              IFV=1                                                            00006190
0507              TELAPS=TIME-DT                                                   00006200
0508              WRITE(6,601)TELAPS                                               00006210
0509         601  FORMAT(1H0,35X,47HTIME ELAPSED FOR MISSILE TO FULLY IMPACT BLADE=,00006230
```

```
                       11X,E11.5,1X,3HSEC)
0510            78  IF(TIME.LT.TSTOP)GO TO 800
0511           998  CALL PRINTR(I7,NSTAT,NR,IJPRNT)
0512           999  STOP
0513                END
```

```
C     ******************************************************************
C     *********************  SUBROUTINES  ******************************
C     ******************************************************************
      SUBROUTINE P3D(A,ALPHA,PO,GAMDA1,GAMDA2,TLOAD)
      DIMENSION ALOAD(2),XR(2),YR(2)
      R=(GAMDA1+GAMDA2)/2.
      DIFF=(GAMDA1-GAMDA2)/2.
      DELY=R/25.
      DO 10 N=1,2
      ALOAD(N)=0.
      SIGN=-1.
      IF(N.EQ.2)SIGN=1.
      DO 11 IR=1,25
      YR(1)=IR*DELY
      YR(2)=YR(1)-DELY
      XR(1)=SIGN*((R**2-YR(1)**2)**.5)
      XR(2)=SIGN*((R**2-YR(2)**2)**.5)
      DELX=ABS(XR(1)/25.)
      VTLOAD=0.
      DO 12 IX=1,2
      DO 13 IY=1,2
      IF(IX.EQ.2.AND.IY.EQ.1)GO TO 13
      R1=((XR(IX)+DIFF)**2+YR(IY)**2)**.5
      IF(R1.LT.1.E-5)GO TO 20
      COSPSI=(XR(IX)+DIFF)/R1
      GO TO 21
   20 COSPSI=1.
   21 GAMMA2=(4./3.)*A*A*((SIN(ALPHA)/(1.-COSPSI*COS(ALPHA))**2)*((1.-
     1(COSPSI*COS(ALPHA))**2)**.5)*SIN(ALPHA))
      IF((R1*R1/GAMMA2).LE.20.)GO TO 30
      P=0.
      GO TO 31
   30 P=PO*(2.-EXP(-R1*R1/GAMMA2))*EXP(-R1*R1/GAMMA2)
   31 VTLOAD=VTLOAD+P
   13 CONTINUE
   12 CONTINUE
      VLOAD=0.
      DO 14 IQ=1,25
      DO 14 II=1,2
      DO 15 IY=1,2
      JQ=IQ
      IF(II.EQ.2)JQ=IQ-1
      MULT=1
      IF(II.EQ.IY)MULT=2
      X=XR(1)-SIGN*JQ*DELX
      R1=((X+DIFF)**2+YR(IY)**2)**.5
      IF(R1.LT.1.E-5)GO TO 22
      COSPSI=(X+DIFF)/R1
```

```
0045              GO TO 23
0046        22    COSPSI=1.
0047        23    GAMMA2=(4./3.)*A*A*((SIN(ALPHA)/(1.-COSPSI*COS(ALPHA))**2)*
                 1((1.-(COSPSI*COS(ALPHA))**2)**.5)*SIN(ALPHA))
0048              IF((R1*R1/GAMMA2).LE.20.)GO TO 40
0049              P=0.
0050              GO TO 15
0051        40    P=PO*(2.-EXP(-R1*R1/GAMMA2))*EXP(-R1*R1/GAMMA2)
0052        15    VLOAD=VLOAD+MULT*P
0053        14    CONTINUE
0054              ALOAD(N)=ALOAD(N)+(VTLOAD+VLOAD)*DELX*DELY/6.
0055        11    CONTINUE
0056        10    CONTINUE
0057              TLOAD=0.
0058              DO 16 N=1,2
0059        16    TLOAD=TLOAD+ALOAD(N)
0060              RETURN
0061              END
```

```
            C     *****************************************************************
0001              SUBROUTINE LAMBDA(GAMDA1,DEL,G1,G2,F,I,ALPHA,BESTL,ISPLT,SP,X1,X2)
0002              K=0
0003              IF(ABS(2.*GAMDA1/G2).GT.20.)GO TO 10
0004              IF(ABS(2.*DEL/G2).GT.20.)GO TO 10
0005              E111=EXP(-GAMDA1/G1)
0006              E121=EXP(-DEL/G1)
0007              E122=EXP(-DEL/G2)
0008              E211=EXP(-2.*GAMDA1/G1)
0009              E221=EXP(-2.*DEL/G1)
0010              E222=EXP(-2.*DEL/G2)
0011              GAMDA2=GAMDA1
0012        1     K=K+1
0013              IF(K.EQ.1)GO TO 2
0014              GAMDA2=BESTL
0015              IF(ABS(2.*GAMDA2/G2).GT.20.)GO TO 10
0016        2     E112=EXP(GAMDA2/G2)
0017              E212=EXP(2.*GAMDA2/G2)
0018              A1=(G1/4.)*E211*((2.*(GAMDA1-F)+G1)*(E221-1.)+2.*DEL* E221)
                 1+2.*G1*E111*((GAMDA1-F+G1)*(1.-E121)-DEL*E121)
0019              A2=(G2/4.)*((2.*(GAMDA2+F)+G2)*(E222-1.)+2.*DEL*E222)+2.*G2*E112*
                 1((GAMDA2+F+G2)*(1.-E122)-DEL*E122)-E212*A1
0020              A3=2.*E112*((GAMDA2+F)*(E122-1.)+DEL*E122)-((GAMDA2+F)*(E222-1.)
                 1+DEL*E222)
0021              BESTL=GAMDA2-A2/A3
0022              TEST=ABS(1.-BESTL/GAMDA2)
0023              IF(K.EQ.200)GO TO 3
0024              IF(TEST.LE.1.0E-3)GO TO 4
0025              GO TO 1
0026        3     TESP=100.*TEST
0027              WRITE(6,5)TESP,I,ALPHA
0028        5     FORMAT(1H0,67HWARNING: CONVERGENCE TEST FOR LAMDA2 NOT SATISFIED--
                 1PERCENT ERROR= ,F8.3,/1H0,44X,11HTIME STEP= ,I5,4X,14HIMPACT ANGLE
                 1= ,F7.4,1X,3HRAD)
0029              GO TO 4
0030       10     IF(ISPLT.EQ.1)BESTL=0.0
0031              IF(ISPLT.EQ.-1)BESTL=0.0
0032        4     RETURN
0033              END
```

```
              C      *****************************************************************00007340
      0001           SUBROUTINE CAMBER(XNODE,YNODE,A,B,ISPLIT,RM,ALPHA,SPP,VDT,COSFEE, 00007350
                    1VR,DEN,NSTAT,PRESSC)                                               00007360
      0002           IF(YNODE.GT.A.OR.YNODE.LT.B)GO TO 511                              00007370
              C               -CALCULATE THE SQUASHED BIRD THICKNESS                    00007380
              C               -FOR A 2D JET                                             00007390
      0003           IF(ISPLIT.EQ.-1)GO TO 512                                          00007400
      0004           THICK=RM*(1.+COS(ALPHA))/2.                                        00007410
      0005           IF((XNODE-SPP).LT.0.)THICK=RM*(1.-COS(ALPHA))/2.                   00007420
      0006           GO TO 513                                                          00007430
      0007       512 THICK=RM*(1.-COS(ALPHA))/2.                                        00007440
      0008           IF((XNODE-SPP).LT.0.)THICK=RM*(1.+COS(ALPHA))/2.                   00007450
      0009           GO TO 513                                                          00007460
              C               -CALCULATE THE SQUASHED BIRD THICKNESS                    00007470
              C               -FOR A 3D JET                                             00007480
      0010       511 H3D=VDT*(RM**2)/(4.*((DIST+VDT)**2-DIST**2))                       00007490
      0011           THICK=H3D*(1.+COS(ALPHA)-2.*COS(ALPHA)*(ACOS(COSFEE))/3.141592654)00007500
              C               -FIND WHICH BLADE CURVATURE REGION                        00007510
              C               -THIS NODE FALLS WITHIN                                   00007520
      0012       513 CALL REGION(XNODE,NSTAT,JC1)                                       00007530
              C               -FIND THE VALUE OF ONE OVER THE RADIUS OF CURVATURE       00007540
      0013           CALL INCURV(JC1,P1)                                                00007550
      0014           VEL=VR                                                             00007560
      0015           IF(YNODE.GT.A.OR.YNODE.LT.B)VEL=VR*COSFEE                          00007570
      0016           PRESSC=P1*THICK*DEN*(VEL**2)                                       00007580
      0017           FRESSC=0.                                                          00007590
      0018           RETURN                                                             00007600
      0019           END                                                                00007610
```

```
C     ******************************************************************
      SUBROUTINE REGION(XNODE,NSTAT,JC1)
      COMMON/XMID/ XCEN1(25),XCEN2(25)
      NST=NSTAT-2
      DO 514 KJ=1,NST
      IF(XNODE.LT.XCEN1(KJ).OR.XNODE.GE.XCEN2(KJ))GO TO 514
      JC1=KJ
  514 CONTINUE
      RETURN
      END
```

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                C       *****************************************************************00007720
0001                    SUBROUTINE INCURV(JC1,P1)                                         00007730
0002                    COMMON/BLADE/X0(25),Y0(25),THETA(24),XM(25)                       00007740
0003                    XMID1=X0(JC1)+COS(THETA(JC1))*(((X0(JC1+1)-X0(JC1))**2+(Y0(JC1+1)-00007750
                       1Y0(JC1))**2)**.5)/2.
0004                    YMID1=Y0(JC1)+SIN(THETA(JC1))*(((X0(JC1+1)-X0(JC1))**2+(Y0(JC1+1)-00007760
                       1Y0(JC1))**2)**.5)/2.                                              00007770
0005                    XMID2=X0(JC1+1)+COS(THETA(JC1+1))*(((X0(JC1+2)-X0(JC1+1))**2+     00007780
                       1(Y0(JC1+2)-Y0(JC1+1))**2)**.5)/2.                                 00007790
0006                    YMID2=Y0(JC1+1)+SIN(THETA(JC1+1))*(((X0(JC1+2)-X0(JC1+1))**2+     00007800
                       1(Y0(JC1+2)-Y0(JC1+1))**2)**.5)/2.                                 00007810
0007                    DELPHI=THETA(JC1+1)-THETA(JC1)                                    00007820
0008                    IF(DELPHI.LT.1.7E-5)GO TO 501                                     00007830
0009                    CHORD=SQRT((XMID1-XMID2)**2+(YMID1-YMID2)**2)                     00007840
0010                    RCURV=CHORD/(2.*SIN(DELPHI/2.))                                   00007850
0011                    P1=1./RCURV                                                       00007860
0012                    GO TO 500                                                         00007870
0013            501     P1=0.                                                             00007880
0014            500     RETURN                                                            00007890
0015                    END                                                               00007900
                                                                                          00007910
```

```
                C     ******************************************************************
0001                  SUBROUTINE FRESUR(NR,A,B,DIST,ISPLIT,SPP,SPP1,VDT,GAMMA1,GAMMA2,P0
                     1,RM,ALPHA,VR,DEN,NSTAT,IIFLG)
0002                  COMMON/AR/ XNODE(25,25),YNODE(25)    ,MAX(25),PRESS(25,25),
                     1AANODE(25,25),PPL(25,25),PVL(25,25),FRSS(25,25)
0003                  DO 501 I3=1,NR
0004                  LIM=MAX(I3)
0005                  DO 502 J3=1,LIM
0006                  IF(YNODE(I3).GE.A.OR.YNODE(I3).LE.B)GO TO 503
0007                  IF(ISPLIT.EQ.-1)GO TO 504
                C                                  2D JET
                C                      FLOW FROM NODE N TO N+1--ISPLIT=1
0008                  DOT=XNODE(I3,J3)-SPP1
0009                  IF(DOT.LT.0.)DOT=-DOT
0010                  IF(DOT.GT.(DIST+VDT))GO TO 502
0011                  IF(DOT.LT.DIST.AND.IIFLG.EQ.1)GO TO 502
0012                  XDOT=XNODE(I3,J3)-SPP
0013             507  IF(XDOT.LT.0.)GO TO 5000
0014                  IF((XDOT/GAMMA1).GT.75.)GO TO 600
0015                  FEXP=EXP(-XDOT/GAMMA1)
0016                  GO TO 601
0017            5000  IF(ABS(XDOT/GAMMA2).GT.75.)GO TO 600
0018                  FEXP=EXP(XDOT/GAMMA2)
0019                  GO TO 601
0020             600  FEXP=0.
0021             601  PPL(I3,J3)=P0*FEXP*(2.-FEXP)
0022                  IF(PRESS(I3,J3).LT.PPL(I3,J3))PRESS(I3,J3)=PPL(I3,J3)
0023                  GO TO 506
                C                      FLOW FROM NODE N+1 TO N--ISPLIT=-1
0024             504  DOT=SPP1-XNODE(I3,J3)
0025                  IF(DOT.LT.0.)DOT=-DOT
0026                  IF(DOT.GT.(DIST+VDT))GO TO 502
0027                  IF(DOT.LT.DIST.AND.IIFLG.EQ.1)GO TO 502
0028                  XDOT=SPP-XNODE(I3,J3)
0029                  GO TO 507
                C                                  3D JET
                C                      FLOW FROM NODE N TO N+1--ISPLIT=1
0030             503  SIGN=1.
0031                  IF(ISPLIT.EQ.-1)SIGN=-1.
0032                  IF(YNODE(I3).LE.B)GO TO 509
0033                  DOT=((XNODE(I3,J3)-SPP1)**2+(YNODE(I3)-A)**2)**.5
0034                  IF(DOT.GT.(DIST+VDT))GO TO 502
0035                  IF(DOT.LT.DIST.AND.IIFLG.EQ.1)GO TO 502
0036                  XDOT=XNODE(I3,J3)-SPP
0037                  RDOT=((XNODE(I3,J3)-SPP)**2+(YNODE(I3)-A)**2)**.5
0038             510  IF(RDOT.LT.1.E-3)GO TO 700
0039                  COSFEE=(XNODE(I3,J3)-SPP)*SIGN/RDOT
0040                  GO TO 701
```

```
0041      700  COSFEE=1.
0042      701  Y2=((RM*SIN(ALPHA)/(1.-COSFEE*COS(ALPHA)))**2)*SIN(ALPHA)*
              1((1.-(COSFEE*COS(ALPHA))**2)**.5)/3.
0043           IF(ABS((RDOT**2)/Y2).GT.75.)GO TO 600
0044           FEXP=EXP(-(RDOT**2)/Y2)
0045           PPL(I3,J3)=P0*FEXP*(2.-FEXP)
0046           IF(PRESS(I3,J3).LT.PPL(I3,J3))PRESS(I3,J3)=PPL(I3,J3)
0047           GO TO 506
0048      509  DOT=((XNODE(I3,J3)-SPP1)**2+(YNODE(I3)-B)**2)**.5
0049           IF(DOT.GT.(DIST+VDT))GO TO 502
0050           IF(DOT.LT.DIST.AND.IIFLG.EQ.1)GO TO 502
0051           RDOT=((XNODE(I3,J3)-SPP)**2+(YNODE(I3)-B)**2)**.5
0052           XDOT=XNODE(I3,J3)-SPP
0053           GO TO 510
          C                      ADD ON THE PRESSURE EFFECTS DUE TO
          C                                BLADE CAMBER
0054      506  CALL CAMBER(XNODE(I3,J3),YNODE(I3),A,B,ISPLIT,RM,ALPHA,SPP,VDT,
              1COSFEE,VR,DEN,NSTAT,PRESSC)
0055           IF(PVL(I3,J3).LT.PRESSC)PVL(I3,J3)=PRESSC
0056           PRESS(I3,J3)=PRESS(I3,J3)+PVL(I3,J3)
0057           IF(DOT.LT.DIST)GO TO 502
0058           PRSS(I3,J3)=PRESS(I3,J3)
0059      502  CONTINUE
0060      501  CONTINUE
0061           RETURN
0062           END
```

```
           C      *****************************************************************
0001              SUBROUTINE MODAL(NM,NSTAT,NN,I8,FV,T)
0002              COMMON/MODE/BET(10),VKI(10),WI(10),GI(10),FI(10),FDI(10),GDI(10),
                 1AA(10),BB(10),PI(10),QI(10),Q(10),QD(10),QDI(10),WO(10),PH2(3,625,
                 110),PP(625,2),DEF(2,625),VEL(2,625),STRSS(3,625),SH2(3,625,10)
           C                         IF FV=0 THIS IS FREE VIBRATION
           C                         CALCULATE THE PARAMETERS
0003              DO 420 I6=1,NM
0004              C3=EXP(-BET(I6)*T)
0005              GI(I6)=C3*SIN(WI(I6)*T)/WI(I6)
0006              FI(I6)=C3*COS(WI(I6)*T)+BET(I6)*GI(I6)
0007              FDI(I6)=-GI(I6)*WO(I6)**2
0008              GDI(I6)=C3*(COS(WI(I6)*T)-(BET(I6)/WI(I6))*SIN(WI(I6)*T))
0009              AA(I6)=(1.-FI(I6))/VKI(I6)
0010        420   BB(I6)=-FDI(I6)/VKI(I6)
           C                         ZERO OUT THE DEFLECTIONS
           C                              STRESSES AND VELOCITIES
0011        150   DO 430 JB=1,NN
0012              DEF(1,JB)=0.
0013              DEF(2,JB)=0.
0014              STRSS(1,JB)=0.
0015              STRSS(2,JB)=0.
0016              STRSS(3,JB)=0.
0017              VEL(1,JB)=0.
0018        430   VEL(2,JB)=0.
0019              DO 440 I6=1,NM
0020              PI(I6)=0.
           C                              CALCULATE THE GENERALIZED FORCE
           C                                      FOR EACH MODE
0021              DO 450 K6=1,NN
0022        450   PI(I6)=PI(I6)+PH2(1,K6,I6)*PP(K6,1)+PH2(2,K6,I6)*PP(K6,2)
           C                              CALCULATE THE MODAL COEFFICIENTS
           C                                   AND THEIR TIME DERIVATIVES
0023              QI(I6)=FI(I6)*Q(I6)+GI(I6)*QD(I6)+AA(I6)*PI(I6)
0024              QDI(I6)=FDI(I6)*Q(I6)+GDI(I6)*QD(I6)+BB(I6)*PI(I6)
0025              Q(I6)=QI(I6)
0026              QD(I6)=QDI(I6)
0027              DO 460 JB=1,NN
0028              DEF(1,JB)=DEF(1,JB)+PH2(1,JB,I6)*QI(I6)
0029              DEF(2,JB)=DEF(2,JB)+PH2(2,JB,I6)*QI(I6)
0030              STRSS(1,JB)=STRSS(1,JB)+SH2(1,JB,I6)*QI(I6)
0031              STRSS(2,JB)=STRSS(2,JB)+SH2(2,JB,I6)*QI(I6)
0032              STRSS(3,JB)=STRSS(3,JB)+SH2(3,JB,I6)*QI(I6)
0033              VEL(1,JB)=VEL(1,JB)+PH2(1,JB,I6)*QDI(I6)
0034              VEL(2,JB)=VEL(2,JB)+PH2(2,JB,I6)*QDI(I6)
0035        460   CONTINUE
0036        440   CONTINUE
0037              RETURN
```

```
0038            END                                          00009140
```

```
               C     ***************    PRESSURE PRINTOUT    ****************************
0001                 SUBROUTINE PRINTP(I,TIME,NR)
0002                 COMMON/AR/XNODE(25,25),YNODE(25),MAX(25),PRESS(25,25),
                    1AANODE(25,25),PPL(25,25),PVL(25,25),PRSS(25,25)
0003                 DIMENSION MAXL(5)
               C
               C               FIND OUT WHICH RADIAL STATIONS
               C               BORDER THE PRESSURE DISTRIBUTION
               C               -II3 IS THE LOWER RADIAL STATION
               C               -IK3 IS THE UPPER RADIAL STATION
0004                 II3=0
0005                 IK3=0
0006                 DO 10 I4=1,NR
0007                 K3=NR+1-I4
0008                 LIM1=MAX(I4)
0009                 LIM2=MAX(K3)
0010                 DO 15 J3=1,LIM1
0011                 IF(II3.GT.0)GO TO 15
0012                 IF(PRESS(I4,J3).EQ.0.)GO TO 15
0013                 II3=I4
0014           15    CONTINUE
0015                 DO 20 L3=1,LIM2
0016                 IF(IK3.GT.0)GO TO 20
0017                 IF(PRESS(K3,L3).EQ.0.)GO TO 20
0018                 IK3=K3
0019           20    CONTINUE
0020           10    CONTINUE
               C               PRINT THE TIME STEP AND THE TIME
0021                 IF(I.EQ.1)GO TO 500
0022                 WRITE(6,100)I,TIME
0023          100    FORMAT(1H1,47X,10HTIME STEP=,I4,2X,5HTIME=,E12.6,1X,3HSEC)
               C               IF NO NODAL LOADS PRINT NO PRESSURES
               C               AND RETURN TO MAIN PROGRAM
0024                 IF(II3.GT.0)GO TO 30
0025                 WRITE(6,101)
0026          101    FORMAT(1H0,52X,27HALL NODE PRESSURES ARE ZERO)
0027                 GO TO 500
               C               FIND OUT HOW MANY RADIAL STATIONS
               C               WILL HAVE TO BE PRINTED
0028           30    ITY=IK3-II3+1
0029                 DO 35 KK=1,5
0030                 IF((ITY-5).LE.0)GO TO 31
0031                 MAXL(KK)=5
0032                 ITOTL=KK
0033                 ITY=ITY-5
0034                 GO TO 35
0035           31    MAXL(KK)=ITY
0036                 ITOTL=KK
0037                 GO TO 40
```

```
0038          35   CONTINUE
              C               ITOTL CONTAINS THE THE TOTAL NUMBER
              C               OF GROUPS OF FIVE RADIAL STATIONS
              C               THAT WILL BE PRINTED ACROSS A PAGE
              C               FOR EACH GROUP PRINTED ACROSS A PAGE
              C               MAXL CONTAINS THE NUMBER OF RADIAL
              C               STATIONS THAT WILL BE PRINTED ACROSS
0039          40   IS=II3
0040               DO 50 IL=1,ITOTL
0041               IE=IS+MAXL(IL)-1
              C                    PRINT THE HEADINGS
0042               WRITE(6,102)(YNODE(IY),IY=IS,IE)
0043         102   FORMAT(//1H0,8X,2HY=,E11.5,4(13X,2HY=,E11.5))
0044               WRITE(6,202)
0045         202   FORMAT(//)
0046               ICF=MAXL(IL)
0047               DO 60 IC=1,ICF
0048               IF(IC.EQ.1)GO TO 61
0049               IF(IC.EQ.2)GO TO 62
0050               IF(IC.EQ.3)GO TO 63
0051               IF(IC.EQ.4)GO TO 64
0052               WRITE(6,1035)
0053        1035   FORMAT(1H+,108X,1HX,11X,1HP)
0054               GO TO 60
0055          61   WRITE(6,1031)
0056        1031   FORMAT(1H+,4X,1HX,11X,1HP)
0057               GO TO 60
0058          62   WRITE(6,1032)
0059        1032   FORMAT(1H+,30X,1HX,11X,1HP)
0060               GO TO 60
0061          63   WRITE(6,1033)
0062        1033   FORMAT(1H+,56X,1HX,11X,1HP)
0063               GO TO 60
0064          64   WRITE(6,1034)
0065        1034   FORMAT(1H+,82X,1HX,11X,1HP)
0066          60   CONTINUE
0067               DO 70 J3=1,25
0068               WRITE(6,103)
0069         103   FORMAT(/)
0070               IPF=MAXL(IL)
0071               DO 80 IP=1,IPF
0072               I3=IS+IP-1
0073               LIM=MAX(I3)
0074               IF(J3.GT.LIM)GO TO 80
0075               IF(IP.EQ.1)GO TO 81
0076               IF(IP.EQ.2)GO TO 82
0077               IF(IP.EQ.3)GO TO 83
0078               IF(IP.EQ.4)GO TO 84
```

```
            WRITE(6,1045)XNODE(I3,J3),PRESS(I3,J3)
      1045  FORMAT(1H+,105X,2(2X,E10.4))
            GO TO 80
      81    WRITE(6,1041)XNODE(I3,J3),PRESS(I3,J3)
      1041  FORMAT(1H+,1X,2(2X,E10.4))
            GO TO 80
      82    WRITE(6,1042)XNODE(I3,J3),PRESS(I3,J3)
      1042  FORMAT(1H+,27X,2(2X,E10.4))
            GO TO 80
      83    WRITE(6,1043)XNODE(I3,J3),PRESS(I3,J3)
      1043  FORMAT(1H+,53X,2(2X,E10.4))
            GO TO 80
      84    WRITE(6,1044)XNODE(I3,J3),PRESS(I3,J3)
      1044  FORMAT(1H+,79X,2(2X,E10.4))
      80    CONTINUE
      70    CONTINUE
            IS=IE+1
      50    CONTINUE
      500   RETURN
            END
```


C-7

```
             C      ***************************************************************00010310
      0001          SUBROUTINE PRINTV(I,TIME,IPDEL,ITPRNT,NR,IJPRNT,I7)            00010320
      0002          COMMON/MODE/DUMMY(20150),DEF(2,625),VEL(2,625),STRSS(3,625),   00010330
                   1SH2(3,625,10)                                                  00010340
      0003          COMMON/PRNT/NJ3(25),DEFBI(1000,25),DEFBO(1000,25),CODI(1000,25), 00010350
                   1CODO(1000,25),SIGMB1(1000,25,3),SIGMB2(1000,25,3),SIGMA1(1000,3, 00010360
                   125),SIGMA2(1000,3,25),TIMEP(1000)                              00010370
      0004          COMMON/AR/XNODE(25,25),YNODE(25),MAX(25),PRESS(25,25),         00010380
                   1AANODE(25,25),PPL(25,25),PVL(25,25),PRSS(25,25)                00010390
      0005          ITPRNT=ITPRNT+IPDEL                                            00010400
      0006          IJPRNT=(ITPRNT-1)/IPDEL                                        00010410
      0007          TIMEP(IJPRNT)=TIME                                             00010420
      0008          J5=0                                                           00010430
      0009          DO 10 I3=1,NR                                                  00010440
      0010          LIM=MAX(I3)                                                    00010450
      0011          NXPRNT=NJ3(I3)                                                 00010460
      0012          DO 20 J3=1,LIM                                                 00010470
      0013          J5=J5+1                                                        00010480
      0014          IF(J3.NE.NXPRNT)GO TO 21                                       00010490
      0015          DEFBI(IJPRNT,I3)=DEF(1,J5)                                     00010500
      0016          DEFBO(IJPRNT,I3)=DEF(2,J5)                                     00010510
      0017     21   IF(I3.NE.I7)GO TO 20                                           00010520
      0018          CODI(IJPRNT,J3)=DEF(1,J5)                                      00010530
      0019          CODO(IJPRNT,J3)=DEF(2,J5)                                      00010540
      0020     20   CONTINUE                                                       00010550
      0021     10   CONTINUE                                                       00010560
      0022          I5=0                                                           00010570
      0023          I4=0                                                           00010575
      0024          DO 30 I3=1,NR                                                  00010580
      0025          LIM=MAX(I3)                                                    00010590
      0026          NSPRNT=NJ3(I3)                                                 00010600
      0027          IC=0                                                           00010610
      0028          IFLG=0                                                         00010630
      0029          DO 40 J3=1,LIM                                                 00010640
      0030          I5=I5+1                                                        00010650
      0031          IF((J3.NE.1).AND.(J3.NE.LIM).AND.(J3.NE.NSPRNT))GO TO 41       00010660
      0032          IC=IC+1                                                        00010670
      0033          IF(IC.EQ.1) SIGMB1(IJPRNT,I3,1)=STRSS(2,I5)                    00010680
      0034          IF(IC.EQ.2) SIGMB1(IJPRNT,I3,2)=STRSS(2,I5)                    00010690
      0035          IF(IC.EQ.3) SIGMB1(IJPRNT,I3,3)=STRSS(2,I5)                    00010700
      0036     41   IF((I3.NE.I7-1).AND.(I3.NE.I7).AND.(I3.NE.I7+1))GO TO 40       00010710
      0037          IF(IFLG.EQ.1)GO TO 42                                          00010720
      0038          I4=I4+1                                                        00010730
      0039     42   SIGMA1(IJPRNT,I4,J3)=STRSS(1,I5)                               00010740
      0040          SIGMA2(IJPRNT,I4,J3)=STRSS(2,I5)                               00010750
      0041          SIGMB2(IJPRNT,J3,I4)=STRSS(3,I5)                               00010760
      0042          IFLG=1                                                         00010770
      0043     40   CONTINUE                                                       00010780
```

```
      30 CONTINUE
         RETURN
         END
```

```
              C     ******************************************************************
0001                SUBROUTINE PRINTR(I7,NSTAT,NR,IJPRNT)
0002                COMMON/AR/XNODE(25,25),YNODE(25),MAX(25),PRESS(25,25),
                   1AANODE(25,25),PPL(25,25),PVL(25,25),PRSS(25,25)
0003                COMMON/PRNT/NJ3(25),DEFBI(1000,25),DEFBO(1000,25),CODI(1000,25),
                   1CODO(1000,25),SIGMB1(1000,25,3),SIGMB2(1000,25,3),SIGMA1(1000,3,
                   125),SIGMA2(1000,3,25),TIMEP(1000)
0004                DIMENSION R(3),STRS1(3,25),STRS2(3,25),X(25),STRS3(3,25)
0005                DO 10 IT=1,IJPRNT
0006                WRITE(6,100)TIMEP(IT)
0007          100   FORMAT(//1H0,56X,5HTIME=,E12.6,1X,3HSEC,//1H ,39X,53HDISPLACEMENTS
                   1 AND BENDING STRESSES VS. RADIAL STATION,//1H ,26X,13HDISPLACEMENT
                   1S,18X,21HRADIAL BENDING STRESS,/1H ,9X,1HR,9X,8HIN-PLANE,7X,
                   112HOUT-OF-PLANE,3H***,7HLED-EDG,8X,7HCHD-PNT,8X,7HTRL-EDG)
0008                DO 11 I3=1,NR
0009                WRITE(6,101)YNODE(I3),DEFBI(IT,I3),DEFBO(IT,I3),(SIGMB1(IT,I3,IV),
                   1IV=1,3)
0010          101   FORMAT(1H ,3(4X,E11.5),1X,2H**,1X,E11.5,2(4X,E11.5))
0011          11    CONTINUE
0012                DO 30 K=1,3
0013                IF(K.EQ.2)GO TO 32
0014                I8=I7+1
0015                IF(K.EQ.1)I8=I7-1
0016                IF(I8.LT.1)GO TO 31
0017                IF(I8.GT.NR)GO TO 31
0018                R(K)=YNODE(I8)
0019                LIM1=MAX(I8)
0020                LIM2=LIM1-1
0021                DO 40 J3=1,NSTAT
0022                IF(XNODE(I7,J3).LT.XNODE(I8,1).OR.XNODE(I7,J3).GT.XNODE(I8,LIM1))
                   1GO TO 41
0023                DO 50 J4=1,LIM2
0024                IF(XNODE(I7,J3).LT.XNODE(I8,J4).OR.XNODE(I7,J3).GT.XNODE(I8,J4+1))
                   1GO TO 50
0025                STRS1(K,J3)=(SIGMA1(IT,K,J4+1)-SIGMA1(IT,K,J4))*(XNODE(I7,J3)-
                   1XNODE(I8,J4))/(XNODE(I8,J4+1)-XNODE(I8,J4))+SIGMA1(IT,K,J4)
0026                STRS2(K,J3)=(SIGMA2(IT,K,J4+1)-SIGMA2(IT,K,J4))*(XNODE(I7,J3)-
                   1XNODE(I8,J4))/(XNODE(I8,J4+1)-XNODE(I8,J4))+SIGMA2(IT,K,J4)
0027                STRS3(K,J3)=(SIGMB2(IT,J4+1,K)-SIGMB2(IT,J4,K))*(XNODE(I7,J3)-
                   1XNODE(I8,J4))/(XNODE(I8,J4+1)-XNODE(I8,J4))+SIGMB2(IT,J4,K)
0028          50    CONTINUE
0029                GO TO 40
0030          41    STRS1(K,J3)=0.
0031                STRS2(K,J3)=0.
0032                STRS3(K,J3)=0.
0033          40    CONTINUE
0034                GO TO 30
0035          31    R(K)=0.
```

```
0036          DO 45 J3=1,NSTAT
0037          STRS1(K,J3)=0.
0038          STRS2(K,J3)=0.
0039     45   STRS3(K,J3)=0.
0040          GO TO 30
0041     32   R(K)=YNODE(I7)
0042          DO 33 J3=1,NSTAT
0043          STRS1(2,J3)=SIGMA1(IT,2,J3)
0044          STRS2(2,J3)=SIGMA2(IT,2,J3)
0045          STRS3(2,J3)=SIGMB2(IT,J3,2)
0046     33   X(J3)=XNODE(I7,J3)-XNODE(I7,1)
0047     30   CONTINUE
0048          WRITE(6,104)
0049    104   FORMAT(//1H0,47X,36HDISPLACEMENTS VS. CHORDWISE LOCATION,
             1/1H ,57X,16HAT IMPACT RADIUS,//1H ,50X,1HX,9X,8HIN-PLANE,
             16X,12HOUT-OF-PLANE)
0050          DO 60 J3=1,NSTAT
0051          WRITE(6,103)X(J3),CODI(IT,J3),CODO(IT,J3)
0052    103   FORMAT(1H ,41X,3(4X,E11.5))
0053     60   CONTINUE
0054          WRITE(6,102)(R(JK),JK=1,3),(R(JL),JL=1,3),(R(JM),JM=1,3)
0055    102   FORMAT(//1H0,50X,31HSTRESSES VS. CHORDWISE LOCATION,
             1/1H ,57X,16HAT IMPACT RADIUS,//1H ,27X,8HSTRESS-X,32X,8HSTRESS-Y,
             132X,8HSHEAR-XY,/1H ,4X,1HX,6X,3(3H*R=,E10.4),2(1X,3(3H*R=,E10.4)))
0056          DO 61 J3=1,NSTAT
0057          WRITE(6,105)X(J3),(STRS1(KL,J3),KL=1,3),(STRS2(KL,J3),KL=1,3),
             1(STRS3(KL,J3),KL=1,3)
0058    105   FORMAT(1H ,E10.4,3(1X,3(1H*,1X,E10.4,1X)))
0059     61   CONTINUE
0060     10   CONTINUE
0061          RETURN
0062          END
```

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                C     ***************************************************************
0001                  SUBROUTINE PINIT(L1,NVA,BETA,JC1,XNERL1,DLTAL1,I8,NSTAF,PPII,E,F,
                     1G,AL,R1,S,DEN,I,V,I7,DT,RIMP,NSTAT)
0002                  COMMON/VARBLI/NA(1000),RM1(1000),RM2(1000),ITSLD(1000),GMAL1(1000)
                     1,VRL1(1000),ALPL1(1000),ISPLT(1000),VDTL1(1000),WM1(1000)
0003                  COMMON/L/II(6),RM(6),XI(6),YI(6),IHIT(6),RL(6),X(6),Y(6),WM(6)
0004                  COMMON/LK/VDT(6,1000),ISLIDE(6,1000),GAMMA(6),VR(6,1000),
                     1ALPHA(6),ISPLIT(6),GAMMA1(1000),GAMMA2(1000),SPP(1000),P0(1000),
                     1LAMD11(1000),LAMD21(1000),FIMP2D(1000),FIMP3D(1000),DIST(1000),
                     1SPP1(1000)
0005                  COMMON/BLADE/X0(25),Y0(25),THETA(24),XM(25)
0006                  COMMON/AR/XNODE(25,25),YNODE(25),MAX(25),PRESS(25,25),
                     1AANODE(25,25),PPL(25,25),PVL(25,25),PRSS(25,25)
0007                  COMMON/MODE/DUMMY(21400),VEL(2,625),STRSS(3,625),SH2(3,625,10)
0008                  REAL LAMD11,LAMD21
0009                  NA(I)=0
0010                  L1=0
0011                  RM1(I)=0.
0012                  RM2(I)=0.
0013                  ITSLD(I)=7
0014                  DO 10 L=1,NVA
0015                  IF(L.GT.ITSLD(I))GO TO 20
0016                  IF(II(L).NE.1)GO TO 10
0017                  IF(ISLIDE(L,I).EQ.1)GO TO 20
0018                  RM1(I)=RM1(I)+RM(L)
0019                  NA(I)=NA(I)+1
0020                  IF(NA(I).GT.1)GO TO 11
0021                  L1=L
0022                  WM1(I)=WM(L)
0023                  GO TO 10
0024            11    IF(WM(L).GT.WM1(I))WM1(I)=WM(L)
0025                  GO TO 10
0026            20    IF(ITSLD(I).EQ.7)ITSLD(I)=L
0027                  RM2(I)=RM2(I)+RM(L)
0028            10    CONTINUE
0029                  IF(NA(I).EQ.0)GO TO 100
0030                  A=RIMP+(WM1(I)-RM1(I))/2.
0031                  B=RIMP-(WM1(I)-RM1(I))/2.
0032                  IF((A-B).GT.0.)GO TO 7200
0033                  A=RIMP
0034                  B=RIMP
0035            7200  DL=A-B
0036                  RL1=(RM1(I)-RM(L1))/2.
0037                  RLL=RL1
0038                  XIT1=XI(L1)
0039                  YIT1=YI(L1)
0040                  JC1=IHIT(L1)
0041            32    Z=RL1/SIN(THETA(JC1)-BETA)
```

```
0042          D=((X0(JC1+1)-XIT1)**2+(Y0(JC1+1)-YIT1)**2)**.5
0043          IF(Z.LE.D)GO TO 31
0044          JC1=JC1+1
0045          XIT1=X0(JC1)
0046          YIT1=Y0(JC1)
0047          RL1=RL1-D*SIN(THETA(JC1-1)-BETA)
0048          GO TO 32
0049     31   XI1=XIT1+Z*COS(THETA(JC1))
0050          YI1=YIT1+Z*SIN(THETA(JC1))
0051          XNERL1=XM(JC1)
0052          DLTAL1=((X0(JC1)-XI1)**2+(Y0(JC1)-YI1)**2)**.5
0053          GMAL1(I)=XNERL1+DLTAL1
0054          DO 33 KL=1,NVA
0055          RK1=RL(L1)-RL(KL)-RM(KL)/2.
0056          RK2=RL(L1)-RL(KL)+RM(KL)/2.
0057          IF((RK1.LE.RLL).AND.(RK2.GT.RLL))KIM=KL
0058     33   CONTINUE
0059          RV=RL(L1)-RL(KIM)-RLL
0060          XKM=X(KIM)+RV*SIN(BETA)
0061          YKM=Y(KIM)-RV*COS(BETA)
0062          DFBL1=((XKM-XI1)**2+(YKM-YI1)**2)**.5
0063          IF(I.EQ.1)GO TO 35
0064          J9=I8-1
0065          DO 36 JB=1,NSTAF
0066          J9=J9+1
0067          IF(JB.EQ.JC1)JT=J9
0068     36   CONTINUE
0069          IF(ABS(PPII/2.-ABS(THETA(JC1))).GE.PPII/12.)GO TO 37
0070          OMEGA=(VEL(1,JT+1)-VEL(1,JT))/(Y0(JC1+1)-Y0(JC1))
0071          GO TO 38
0072     37   OMEGA=(VEL(2,JT+1)-VEL(2,JT))/(X0(JC1+1)-X0(JC1))
0073     38   XID=VEL(1,JT)-(YI1-Y0(JC1))*OMEGA
0074          YID=VEL(2,JT)+(XI1-X0(JC1))*OMEGA
0075          GO TO 39
0076     35   XID=0.
0077          YID=0.
0078     39   VI=XID*COS(BETA)+YID*SIN(BETA)
0079          VB=XID*COS(THETA(JC1))+YID*SIN(THETA(JC1))
0080          VX1=(V-VI)*COS(BETA)-VB*COS(THETA(JC1))
0081          VY1=(V-VI)*SIN(BETA)-VB*SIN(THETA(JC1))
0082          VRL1(I)=(VX1**2+VY1**2)**.5
0083          ALPL1(I)=ACOS((VX1*COS(THETA(JC1))+VY1*SIN(THETA(JC1)))/
             1VRL1(I))
0084          ISPLT(I)=1
0085          IF(ALPL1(I).LE.PPII/2.)GO TO 40
0086          ALPL1(I)=PPII-ALPL1(I)
0087          ISPLT(I)=-1
0088     40   VDTL1(I)=VRL1(I)*DT
```

```
0089            IF(ALPL1(I).LT.1.7E-3)GO TO 100
      C         CALCULATE THE PARAMETERS ASSOCIATED WITH THE FLUID JET MODEL
0090            E1J=RM1(I)*COTAN(ALPL1(I))/2.
0091            F=14.*RM1(I)*(1.-2.*ALPL1(I)/PPII)*SIN(ALPL1(I))/9.
0092            G1J=RM1(I)*(COTAN(ALPL1(I))+28.*(1.-2.*ALPL1(I)/PPII)*SIN(ALPL1(
               1I))/9.)/2.
0093            IF(ABS(PPII/2.-ABS(ALPL1(I))).GE.1.E-3)GO TO 200
0094            E1J=0.
0095            F=0.
0096            G1J=0.
0097      200   FACTOR=(PPII/2.-ALPL1(I))
0098            IF(FACTOR.GE.1.7E-3)GO TO 59
0099            RATIO=1.
0100            GO TO 60
0101      59    RATIO=FACTOR/SIN(FACTOR)
0102      60    AL=(28.*RM1(I)*RATIO/(9.*PPII))*SIN(ALPL1(I))*(1.+SIN(ALPL1(I))
               1)
0103            A2F=DL*RM1(I)*(1.+COS(ALPL1(I)))/2.
0104            A3F=PPII*(RM1(I)**2)*(1.-ALPL1(I)/PPII+SIN(2.*ALPL1(I))/
               1(2.*PPII))/4.
0105            E3J=4.*COTAN(ALPL1(I))/(3.*PPII*(1.+SQRT(SIN(ALPL1(I)))))*RM1(I)
0106            F3J=(2.3*(1.-2.*ALPL1(I)/PPII)*(1.-(1.-2.*ALPL1(I)/PPII)**27)
               1+.1*SIN(2.*ALPL1(I)))*RM1(I)/2.
0107            G3J=E3J+F3J
0108            E=(E3J*A3F+E1J*A2F)/(A3F+A2F)
0109            G=(G3J*A3F+G1J*A2F)/(A3F+A2F)
0110            R1=AL*COTAN(ALPL1(I)/2.)
0111            S=AL+(RM1(I)/2.)*((COTAN(ALPL1(I)))**2)
0112            PHI=S/R1
0113            GAMMA1(I)=4.*RM1(I)*(1.-ALPL1(I)/PPII)*SIN(ALPL1(I))/3.
0114            GAMMA2(I)=4.*RM1(I)*ALPL1(I)*SIN(ALPL1(I))/(3.*PPII)
0115            LAMD11(I)=AL-R1*SIN(ALPL1(I)-PHI)+F
0116            IF(PHI.GT.ALPL1(I))LAMD11(I)=AL+S-R1*ALPL1(I)+F
0117            IF(THETA(JC1).LE.PPII/2..AND.ALPL1(I).LE.PPII/2.)SPP(I)=
               1GMAL1(I)-G
0118            IF(THETA(JC1).LE.PPII/2..AND.ALPL1(I).GT.PPII/2.)SPP(I)=
               1GMAL1(I)+G
0119            IF(THETA(JC1).GT.PPII/2..AND.ALPL1(I).LE.PPII/2.)SPP(I)=
               1GMAL1(I)-G
0120            IF(THETA(JC1).GT.PPII/2..AND.ALPL1(I).GT.PPII/2.)SPP(I)=
               1GMAL1(I)+G
0121            IF(ISPLT(I).EQ.1.AND.GMAL1(I)-E.LT.XM(1)) GO TO 58
0122            IF(ISPLT(I).EQ.-1.AND.GMAL1(I)+E.GT.XM(NSTAT))GO TO 58
0123            CALL LAMBDA(LAMD11(I),VDTL1(I),GAMMA1(I),GAMMA2(I),F,I,ALPL1
               1(I),BESTL,ISPLT(I),SPP(I),XM(1),XM(NSTAT))
0124            LAMD21(I)=BESTL
      C         CALCULATE THE VALUE OF THE IMPACT FORCE FOR THE 2D AND 3D JET
0125            IF(ABS(LAMD11(I)/GAMMA1(I)).LE.20.)GO TO 581
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      EX1=0.
      GO TO 582
  581 EX1=EXP(-LAMD11(I)/GAMMA1(I))
  582 IF(ABS(LAMD21(I)/GAMMA2(I)).LE.20.)GO TO 583
      EX2=0.
      GO TO 584
  583 EX2=EXP(-LAMD21(I)/GAMMA2(I))
  584 P0(I)=.5*DEN*VRL1(I)**2
      FIMP2D(I)=(P0(I)/2.)*(GAMMA1(I)*(3.+EX1*(EX1-4.))+GAMMA2(I
     1)*(3.+EX2*(EX2-4.)))*(A-B)
      CALL P3D(RM1(I),ALPL1(I),P0(I),LAMD11(I),LAMD21(I),TLOAD)
      FIMP3D(I)=TLOAD
      GO TO 167
   58 FIMP2D(I)=0.
      FIMP3D(I)=0.
C     SUM UP THE TOTAL IMPACT FORCE
  167 FIMP=FIMP2D(I)+FIMP3D(I)
C     FIND OUT BETWEEN WHICH 2 NODES THE IMPACT OCCURS-IF THE IMPACT FOR
C     IS ZERO-USE THE VALUE OF GAMMA IF IT(L) IS NOT GREATER THAN 1
C               -USE THE MID-POINT OF THE BLADE IF II(L) IS 2
      IF(FIMP.EQ.0.)GO TO 163
      IF((SPP(I)-GMAL1(I)).LE.0.)SFIMP=GMAL1(I)-E
      IF((SPP(I)-GMAL1(I)).GT.0.)SFIMP=GMAL1(I)+E
      GO TO 164
  163 SFIMP=GMAL1(I)
C     DISTRIBUTE THE FORCE BETWEEN THE TWO CLOSEST NODES AS PRESSURE
  164 MAXM1=MAX(I7)-1
      DO 166 J3=1,MAXM1
      XMA=SFIMP-XNODE(I7,J3)
      XMB=XNODE(I7,J3+1)-SFIMP
      IF(XMA.LT.0..OR.XMB.LT.0.)GO TO 166
      PRSS(I7,J3)=PRSS(I7,J3)+XMB*FIMP/(AANODE(I7,J3)*(XMA+XMB))
      PRSS(I7,J3+1)=PRSS(I7,J3+1)+XMA*FIMP/(AANODE(I7,J3+1)*(XMA+XMB))
      GO TO 100
  166 CONTINUE
  100 RETURN
      END
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