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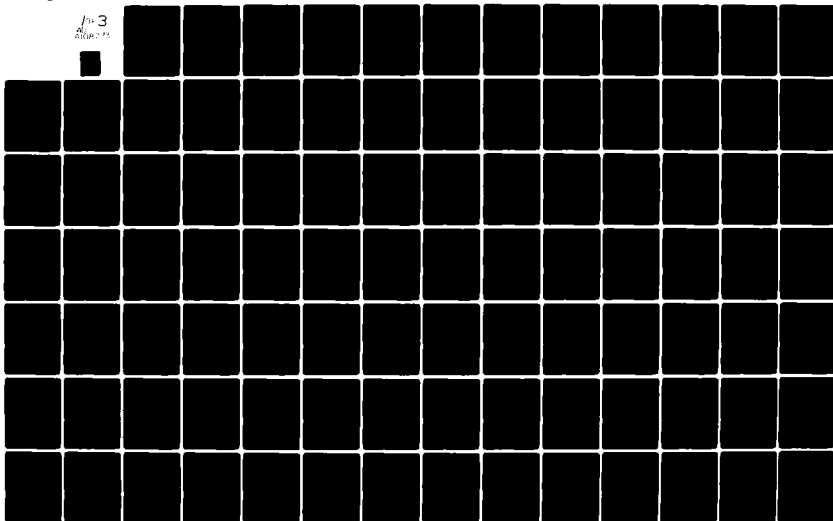
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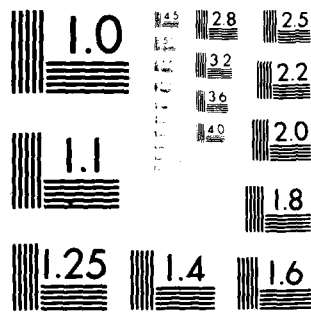
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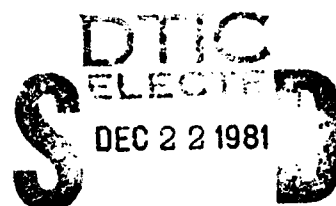
A Reference Manual

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20. ABSTRACT (Continued)

-difference) computational model is used for the structure, while the computational model for the fluid is based upon either of the Doubly Asymptotic Approximations.

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PREFACE

The authors express their appreciation to Dr. K. C. Park for his consultation and to Dr. C. L. Yen for providing the modal results for the infinite-cylinder problem and constructing the finite-element structural models used in the examples.

1. ☒ **Classification**
 2. ☐ **Reliability Codes**
 3. ☐ **Mobile and/or**
 4. ☐ **Special**

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SECTION I

INTRODUCTION

This report documents the third version of a computer program, the Underwater Shock Analysis (USA) Code, that calculates the transient response of a totally or partially submerged structure to a spherical shock wave of arbitrary pressure-profile and source location. The structure is considered to be linear-elastic and the surrounding fluid is treated as an infinite or semi-infinite acoustic medium. The computational model for the structure is constructed through the use of an auxiliary discrete-element (finite-element, finite-difference) code of choice [1,2], while that for the fluid is constructed through the use of the Doubly Asymptotic Approximation (DAA₁) or the Improved Doubly Asymptotic Approximation (DAA₂) [3,4].

As implied above, this manual constitutes a revision of [5], the original manual for the USA Code. In addition to various maintenance upgrades introduced into the code since it was first developed, the following extensions have been incorporated: 1) Fluid surface elements for wet-surface segments of revolution that permit a circumferential expansion of structural surface motions into an arbitrary number of Fourier components; this allows the inclusion of both beam-like and bar-like motions of the structure as a special case; 2) An imaging formulation that extends DAA analysis to problems involving partially submerged structures and structures totally submerged near the fluid's free surface; 3) A model for the effects of bulk cavitation on incident-wave excitation that provides a complete description of fluid-particle velocity consistent with the occurrence of surface cutoff; 4) The introduction of the DAA₂; and 5) Out-of-core processing of the fluid equation system.

1.1 DOUBLY SYMPTOTIC APPROXIMATION

The principal advantage of the DAA₁ and DAA₂ is that they model the acoustic medium surrounding the structure as a membrane covering the wet surface of the structure. Hence fluid motion is described merely in terms of wet-surface response variables, which are then linked by compatibility relations to the structural response variables. Furthermore, this description is a simple matrix ordinary differential equation with desirable computational properties.

The principal disadvantage of the DAA₁ is that it constitutes an approximation to the "exact" boundary-element representation of the surrounding medium [6,7]. The DAA₁ does approach exactness for both high-frequency (early-time) and low frequency (late-time) structural motions, however, and effects a smooth transition between the two asymptotes. In addition, it has exhibited satisfactory accuracy in a variety of check calculations [4,6,8]. Hence, in view of its desirable computational properties, the DAA₁ is considered suitable for engineering analysis.

The DAA_2 is an improved approximation that is based upon the DAA_1 ; however, it can describe the intermediate frequency range better than the DAA_1 . Computationally it has been used to study the response of the infinite cylindrical shell under a plane wave step loading in which significant improvements in accuracy have been noted. Analytical studies of spherical shell response [4] also show such marked improvement.

1.2 STAGGERED SOLUTION PROCEDURE

The governing matrix equation for structural response is a second-order differential equation in time, while that for fluid response is a first-order ordinary differential equation. Simultaneous solution of these equations by direct step-by-step numerical integration, however, is unacceptably expensive. Hence the USA code utilizes a staggered solution procedure [9] for step-by-step solution of the equations in time.

Now a staggered solution procedure involves a response extrapolation at each time step, which usually leads to numerical instability for time increments exceeding a critical value. Because this critical value may be unacceptably small for many computations, the governing equations for fluid response have been modified in such a way that unconditional stability is achieved. Thus, through avoidance of both direct simultaneous solution and conditional stability constraints, highly efficient computation is possible for the greatest variety of cases.

As an illustration of the capabilities of USA, a transient response calculation has been performed for a 2490 degree-of-freedom (DOF) structural model with a stiffness-matrix average half-bandwidth of 85 DOF. The central-processing-unit (CPU) time on a Univac 1108 required for the 280 time-step calculation (with a single change in time increment during the calculation) was 28 minutes. The corresponding time on a CDC 6600, on which the code also operates, would be about 10 minutes.

1.3 INPUT/OUTPUT

The USA Code requires three types of input data in order to perform its function. First, structural mesh-geometry, mass-matrix and stiffness-matrix data must be provided by the structural analysis code used by the analyst. Second, fluid mesh-geometry and boundary-element data must be furnished. Finally, location of the fluid's free surface, charge standoff, incident pressure-profile, and time integration specifications must be provided.

The code, in its turn, outputs structural displacement and velocity histories, and fluid pressure histories for the wet surface. Response data post-processors furnish pseudo-velocity shock spectra, and response-history and shock-spectrum plots. In addition, post-processors embedded in the structural analysis code may be used to obtain, for example, stress and strain response histories, as well as stress/strain-history and stress/strain-computer plots. As

currently configured, the USA Code can routinely handle problems with as many as 3000 Structural and 400 fluid DOF within a core allocation of 65000 decimal words.

1.4 SPECIAL FEATURES

A number of special features are incorporated in the code. First, a capability has been provided to handle a fluid mesh on the wet surface that is not coincident with the surface mesh for the structural model. This permits, for example, the use of a refined structural mesh in a region of high stress gradients, even though a relatively coarse mesh is retained for the fluid.

Second, options for variable-increment time integration and computation restart are furnished. The former allows the use of small time increments during periods where the response is expected to be varying rapidly in time, and the use of large time increments for periods characterized by a slowly varying response. The latter permits the division of a response computation into segments, so that the analyst may examine the results at selected points along the way. Such examination is facilitated by the use of the "printer-plot" routine that augments the usual printout data with response plots "drawn" by the printer.

Third, the code incorporates fluid boundary elements for both general and body-of-revolution wet-surface geometries [10]. This feature is especially useful for compartment-by-compartment analysis of a submarine. Such an analysis utilizes a general-structure discrete-element model of a particular compartment of interest, with the remainder of the submarine modeled as a bar/beam. Hence a detailed analysis of an entire submarine may be performed with several discrete-element models of moderate size, avoiding the use of a single gigantic model.

Fourth, the analyst can use either the DAA_1 or DAA_2 through input of a single scalar parameter to take advantage of the enhanced accuracy demonstrated by the latter in computations for idealized geometries.

Fifth, out-of-core processing for both the structural and fluid equation systems frees the user from concern over core limitations on the number of structural and fluid elements in his model.

Sixth, free-field shock wave input to the structure is associated with a spherical wave and can be input for use with linear interpolation or cubic spline fitting routines. Pressure histories for exponentially decaying incident waves can be automatically generated. Fluid pressure and particle velocity histories corresponding to the input shock are displayed for the user with the "printer-plot" software mentioned above.

Seventh, routines embedded in USA can be used to facilitate coupling with any linear structural analyzer provided that the stiffness matrix is made available row by row (or,

column by column). These routines assemble the matrix in the partitioned skylined format required by USA. In addition, the stiffness matrix can be displayed for check purposes.

1.5 SPECIAL NON-FEATURES

Some features of modest complexity have yet to be incorporated into the USA Code. First, an option for automatic time-step integration would free the analyst from having to select integration time increments in accordance with his expectations regarding response behavior. Second, the ability to handle very large problems would be useful in those cases where structural segmentation is not possible. Third, a capability to treat banded structural mass and damping matrices would be helpful, in order to accommodate structural analyzers that produce such matrices. Fourth, a means to handle the matrices produced by acoustic elements based on a pressure formulation [11,12] is desirable, in that such elements permit highly efficient modeling of internal fluid volumes. Finally, a capability to treat localized nonlinear structural behavior, such as that exhibited by nonlinear equipment mounts, would permit highly efficient treatment of such behavior; for widespread nonlinear effects, however, recourse must be made to a fully nonlinear code, such as USA-STAGS [13].

An important feature of greater complexity has yet to be introduced into the code. This is a treatment of hull cavitation, which may substantially affect structural response for incident shock waves of short duration. The introduction of this feature requires the accurate treatment of highly nonlinear phenomena, and presents a challenging task for future work.

SECTION II

THEORY

This section describes the theoretical foundation of the USA Code. It is constructed as an overview, with coverage of details left to referenced papers and reports.

2.1 STRUCTURAL RESPONSE EQUATION

The matrix ordinary differential equation for the dynamic response of a linear-elastic structure is [1]

$$\underline{\underline{M}}_S \ddot{\underline{x}} + \underline{\underline{C}}_S \dot{\underline{x}} + \underline{\underline{K}}_S \underline{x} = \underline{f} \quad (2.1)$$

where $\underline{x}$ is the structural displacement vector, $\underline{\underline{M}}_S$, $\underline{\underline{C}}_S$ and $\underline{\underline{K}}_S$ are the structural mass, damping and stiffness matrices, respectively, $\underline{f}$ is the external force vector, and a dot denotes a temporal derivative. Generally, $\underline{\underline{M}}_S$, $\underline{\underline{C}}_S$ and $\underline{\underline{K}}_S$ are highly banded, symmetric matrices of large order; at present, the USA Code considers $\underline{\underline{M}}_S$ to be diagonal and $\underline{\underline{C}}_S$ to be zero.

For excitation of a submerged structure by an acoustic wave, $\underline{f}$ is given by

$$\underline{f} = -\underline{\underline{G}} \underline{\underline{A}}_f (\underline{p}_I + \underline{p}_S) \quad (2.2)$$

where $\underline{p}_I$ and $\underline{p}_S$ are nodal pressure vectors for the wet-surface fluid mesh pertaining to the (known) incident wave and the (unknown) scattered wave, respectively, $\underline{\underline{A}}_f$ is the diagonal area matrix associated with elements in the fluid mesh, and $\underline{\underline{G}}$ is the transformation matrix that relates the structural and fluid nodal surface forces. More will be said about $\underline{\underline{G}}$ in the next subsection.

2.2 DAA₁ EQUATION

The Doubly Asymptotic Approximation may be written [3,4]

$$\underline{\underline{M}}_f \dot{\underline{p}}_S + \rho c \underline{\underline{A}}_f \underline{p}_S = \rho c \underline{\underline{M}}_f \underline{\dot{u}}_S \quad (2.3)$$

where $\underline{u}_S$ is the vector of scattered-wave fluid-particle velocities normal to the structure's wet surface, ρ and c are the density and sound velocity of the fluid, respectively, and $\underline{\underline{M}}_f$ is the symmetric fluid mass matrix for the wet-surface fluid mesh. This matrix is produced by a boundary-element treatment of Laplace's equation for the irrotational flow generated in an infinite, inviscid, incompressible fluid

by motions of the structure's wet surface; it is fully populated with non-zero matrix elements. When transformed into structural coordinates, the fluid mass matrix yields the added mass matrix, which, when combined with the structural mass matrix, yields the virtual mass matrix for motions of a structure submerged in an incompressible fluid [14].

As mentioned in Section I, the approximate relation (2.3) is called "doubly asymptotic" because it approaches exactness in both the high-frequency (early-time) and low-frequency (late-time) limits. For high-frequency motions, $|\dot{p}_S| \gg |p_S|$, so that (2.3) approaches the relation $p_S = \rho c \underline{u}_S$, which is the correct limit for short acoustic wavelengths. For low-frequency motions, $|\dot{p}_S| \ll |p_S|$, so that (2.3) approaches the incompressible-flow relation $\underline{A}_f p_S = \underline{M}_f \dot{\underline{u}}_S$, which is the correct limit for long acoustic wavelengths.

For excitation by an incident acoustic wave, $\underline{u}_S$ is related to structural response by the kinematic compatibility relation

$$\underline{G}^T \dot{\underline{x}} = \underline{u}_I + \underline{u}_S \quad (2.4)$$

where the superscript "T" denotes matrix transposition. Equation (2.4) expresses the constraint that normal fluid-particle velocity match normal structural velocity on the wet surface of the structure. The fact that the transformation matrix relating those velocities is $\underline{G}^T$ follows from the invariance of virtual work with respect to either of the wet surface coordinate systems. Generally, $\underline{G}$ is a rectangular matrix whose height greatly exceeds its width, inasmuch as the number of structural DOF usually exceeds considerably the number of fluid DOF.

2.3 INTERACTION EQUATIONS

The introduction of (2.2) into (2.1) and (2.4) into (2.3) yields the interaction equations

$$\begin{aligned} \underline{M}_S \ddot{\underline{x}} + \underline{C}_S \dot{\underline{x}} + \underline{K}_S \underline{x} &= - \underline{G} \underline{A}_f (p_I + p_S) \\ \underline{M}_f \dot{\underline{p}}_S + \rho c \underline{A}_f p_S &= \rho c \underline{M}_f (\underline{G}^T \dot{\underline{x}} - \dot{\underline{u}}_I) \end{aligned} \quad (2.5)$$

These equations may be solved simultaneously at each time step by the transfer of $- \underline{G} \underline{A}_f p_S$ and $\rho c \underline{M}_f \underline{G}^T \dot{\underline{x}}$ to the left sides of their respective equations. Such a procedure is exceedingly expensive, however, because of the large connectivity of the coefficient matrix involved. As mentioned in Section I, efficient computation is possible through the application of a staggered solution procedure that is unconditionally stable with respect to the choice of time increment.

The simplest implementation of the staggered solution procedure recommended in [9] may be effected as follows. $\underline{M}_S$ is taken to be diagonal and, to allow for the possibility that $\underline{M}_S$ may have zero entries for rotational DOF, $\underline{G}$ is constructed such that only the transla-

tional DOF for the structure couple with the fluid DOF [see (2.4)]; then the first of (2.5) may be partitioned to obtain $\underline{\ddot{x}}^T$, which may then be introduced into the second of (2.5). Premultiplication of the resulting equation by $\frac{1}{\rho c} \underline{A}_f \underline{M}_f^{-1}$ then yields

$$\begin{aligned} \frac{1}{\rho c} \underline{A}_f \dot{\underline{p}}_S + (\underline{D}_{f1} + \underline{D}_S) \underline{p}_S = & -\underline{A}_f \underline{G}^T \underline{M}_S^{-1} (\underline{C}_S \dot{\underline{x}} + \underline{K}_S \underline{x}) \\ & -(\underline{D}_S \underline{p}_I + \underline{A}_f \dot{\underline{u}}_I) \end{aligned} \quad (2.6)$$

where $\underline{D}_{f1} = \underline{A}_f \underline{M}_f^{-1} \underline{A}_f$ and $\underline{D}_S = \underline{A}_f \underline{G}^T \underline{M}_S^{-1} \underline{G} \underline{A}_f$ are symmetric, and where $\underline{M}_S^{-1}$ is a diagonal matrix with each nonzero element given as the reciprocal of the corresponding nonzero element of $\underline{M}_S$ and each zero element mirroring the corresponding zero element of $\underline{M}_S$. The first of (2.5) and (2.6) are herein termed "the augmented interaction equations".

2.4 SPHERICAL INCIDENT WAVE

Each element of the vectors $\underline{p}_I$ and $\dot{\underline{u}}_I$ for a spherical incident wave are given by

$$\begin{aligned} p_{Ii}(t) &= \frac{S}{R_i} p_I \left(t - \frac{R_i - S}{c} \right) \\ \dot{u}_{Ii}(t) &= \left[\frac{1}{\rho c} \dot{p}_{Ii}(t) + \frac{1}{\rho R_i} p_{Ii}(t) \right] \gamma_i \end{aligned} \quad (2.7)$$

where S is the "charge standoff", i.e., the distance between the origin of the incident spherical wave and the nearest point on the structure's wet surface, R_i is the distance from the origin of the incident spherical wave to the i th fluid node on the wet surface, γ_i is the cosine of the angle between the vector corresponding to R_i and the wet-surface normal at the i th fluid node, and $p_I(t)$ is the incident-wave pressure-profile defined at $R_i = S$. For a shock wave, $p_I(t)$ is discontinuous at $t = 0$ and the $\dot{u}_{Ii}(t)$ contain singularities.

In order to remove shock-wave singularities from $\dot{\underline{u}}_I$ in (2.6), a modified pressure vector is defined as

$$\underline{p}_M = \underline{\Gamma} \underline{p}_I + \underline{p}_S \quad (2.8)$$

where $\underline{\Gamma}$ is a diagonal matrix with direction-cosine elements γ_i . The introduction of (2.8) into (2.6) and the first of (2.5), followed by utilization of the second of (2.7) then yields the modified, augmented, interaction equations

$$\begin{aligned} \underline{M}_S \ddot{\underline{x}} + \underline{C}_S \dot{\underline{x}} + \underline{K}_S \underline{x} &= -\underline{G} \underline{A}_f [\underline{p}_M + (\underline{I} - \underline{\Gamma}) \underline{p}_I] \\ \frac{1}{\rho c} \underline{A}_f \dot{\underline{p}}_M + (\underline{D}_{f1} + \underline{D}_S) \underline{p}_M &= -\underline{A}_f \underline{G}^T \underline{M}_S^{-1} (\underline{C}_S \dot{\underline{x}} + \underline{K}_S \underline{x}) - \underline{H} \underline{p}_I \end{aligned} \quad (2.9)$$

in which $\underline{I}$ is the identity matrix, and

$$\underline{H} = \underline{D}_s - (\underline{D}_s + \underline{D}_{fl} - \frac{1}{\rho} \underline{A}_f \underline{R}^{-1}) \underline{\Gamma} \quad (2.10)$$

where $\underline{R}$ is the diagonal matrix formed by the distances R_i . Equations (2.9) (with $\underline{C}_s = 0$) are the equations solved by the USA Code to determine the structural responses $\underline{x}$ and $\dot{\underline{x}}$, and the wet-surface pressures $\underline{p} = (\underline{I} - \underline{\Gamma}) \underline{p}_I + \underline{p}_M$.

2.5 FREE SURFACE EFFECTS

When a structure is partially submerged, or when a totally submerged structure lies near the free surface of a semi-infinite fluid, imaging techniques may be utilized to ensure that the total pressure vanishes at the free surface. (This implies that the effects of gravity are negligible in this class of problems, which they generally are.) In this case, the interactive system consists of an infinite fluid domain, the structure S_+ , and its image S_- (see Figure 2-1). The incident wave now consists of a (positive) primary wave plus a (negative) image wave, the latter emanating from the image of the primary wave's origin. Zero pressure at the free surface is therefore maintained if the motions of S_- are constrained to be opposite to those of S_+ .

The kinetic energy T_s , the Rayleigh dissipation function D_s , the potential energy V_s , and the work potential Π_s , for the structural system $S_+ + S_-$ are given by

$$\begin{aligned} T_s &= \frac{1}{2} (\dot{\underline{x}}_+^T \underline{M}_s \dot{\underline{x}}_+ + \dot{\underline{x}}_-^T \underline{M}_s \dot{\underline{x}}_-) \\ D_s &= \frac{1}{2} (\dot{\underline{x}}_+^T \underline{C}_s \dot{\underline{x}}_+ + \dot{\underline{x}}_-^T \underline{C}_s \dot{\underline{x}}_-) \\ V_s &= \frac{1}{2} (\underline{x}_+^T \underline{K}_s \underline{x}_+ + \underline{x}_-^T \underline{K}_s \underline{x}_-) \\ \Pi_s &= -\underline{x}_+^T \underline{f}_+ - \underline{x}_-^T \underline{f}_- \end{aligned} \quad (2.11)$$

The appropriate constraints are $\underline{x}_- = -\underline{x}_+$ and $\underline{f}_- = -\underline{f}_+$, so that (2.11) become

$$\begin{aligned} T_s &= \dot{\underline{x}}_+^T \underline{M}_s \dot{\underline{x}}_+ \\ D_s &= \dot{\underline{x}}_+^T \underline{C}_s \dot{\underline{x}}_+ \\ V_s &= \underline{x}_+^T \underline{K}_s \underline{x}_+ \\ \Pi_s &= -2 \underline{x}_+^T \underline{f}_+ \end{aligned} \quad (2.12)$$

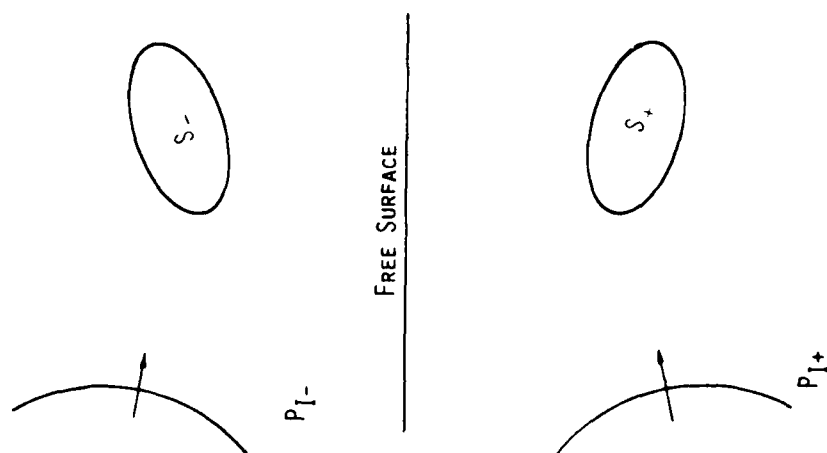


Figure 2-1 Image Technique for Free Surface

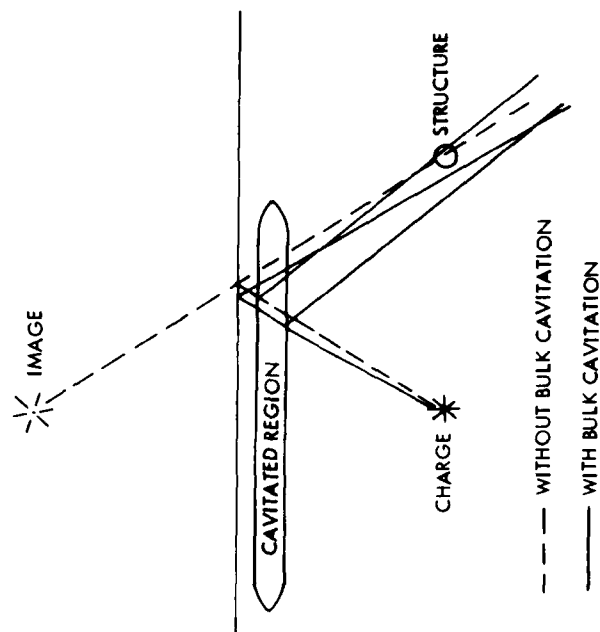


Figure 2-2 Free Field Ray Diagram

The DAA kinetic energy T_f and work potential Π_f for the fluid system may be written as

$$\begin{aligned} T_f &= \frac{1}{2} \underline{u}_S^T \underline{M}_f \underline{u}_S \\ \Pi_f &= -\underline{u}_S^{*T} \underline{A}_f \underline{p}_S - \frac{1}{\rho c} \underline{u}_S^{*T} \underline{M}_f \dot{\underline{p}}_S \end{aligned} \quad (2.13)$$

where

$$\underline{M}_f = \begin{bmatrix} \underline{M} & \underline{M}' \\ \underline{M}' & \underline{M} \end{bmatrix}, \quad \underline{A}_f = \begin{bmatrix} \underline{A} & \underline{0} \\ \underline{0} & \underline{A} \end{bmatrix} \quad (2.14)$$

and an asterisk denotes temporal integration. The submatrix $\underline{M}$ accounts for added mass coupling between wet-surface elements on S_+ and, similarly, between elements on S_- ; $\underline{M}'$ accounts for added mass coupling between elements on S_+ and elements on S_- . The constraints for the fluid system are

$$\underline{u}_S = \begin{bmatrix} \underline{I} \\ -\underline{I} \end{bmatrix} \underline{u}_{S+}, \quad \underline{p}_S = \begin{bmatrix} \underline{I} \\ -\underline{I} \end{bmatrix} \underline{p}_{S+} \quad (2.15)$$

so that (2.13) becomes

$$\begin{aligned} T_f &= \underline{u}_{S+}^T (\underline{M} - \underline{M}') \underline{u}_{S+} \\ \Pi_f &= -2 \underline{u}_{S+}^{*T} [\underline{A} \underline{p}_{S+} + \frac{1}{\rho c} (\underline{M} - \underline{M}') \dot{\underline{p}}_{S+}] \end{aligned} \quad (2.16)$$

The application of Lagrange's equation [15] to (2.12) and (2.16) now yields

$$\begin{aligned} \underline{M}_S \ddot{\underline{x}}_+ + \underline{C}_S \dot{\underline{x}}_+ + \underline{K}_S \underline{x}_+ &= \underline{f}_+ \\ \frac{1}{\rho c} (\underline{M} - \underline{M}') \dot{\underline{p}}_{S+} + \underline{A} \underline{p}_{S+} &= (\underline{M} - \underline{M}') \dot{\underline{u}}_{S+} \end{aligned} \quad (2.17)$$

Also, (2.2) and (2.4) must be modified to include the effects of both the incident primary and image waves. This gives

$$\begin{aligned} \underline{f}_+ &= -\underline{G} \underline{A} (\underline{p}_{I+}^+ + \underline{p}_{I+}^- + \underline{p}_{S+}) \\ \underline{G}^T \dot{\underline{x}}_+ &= \underline{u}_{I+}^+ + \underline{u}_{I+}^- + \underline{u}_{S+} \end{aligned} \quad (2.18)$$

where, e.g., $\underline{p}_{I+}^-$ denotes incident-wave pressure on S_+ associated with the image wave. The introduction of (2.18) into (2.17) then yields the doubly asymptotic interaction equations for problems involving a free surface

$$\underline{\tilde{M}}_S \ddot{\underline{x}}_+ + \underline{\tilde{C}}_S \dot{\underline{x}}_+ + \underline{\tilde{K}}_S \underline{x}_+ = \underline{G} \underline{A} (\underline{P}_{I+}^+ + \underline{P}_{I+}^- + \underline{P}_{S+}) \quad (2.19)$$

$$(\underline{\tilde{M}} - \underline{\tilde{M}}) \dot{\underline{P}}_{S+} + \rho c \underline{A} \underline{P}_{S+} = \rho c (\underline{\tilde{M}} - \underline{\tilde{M}}') (\underline{G}^T \ddot{\underline{x}}_+ - \underline{u}_{I+}^+ - \underline{u}_{I+}^-)$$

A comparison of (2.19) with (2.5) reveals that the effects of the free surface are embodied in the image-wave pressure and fluid-particle-velocity vectors, and in the modified added-mass matrix.

Finally, augmentation of (2.19) to secure unconditional stability, followed by introduction of the modified pressure [cf. (2.8)]

$$\underline{P}_M = \underline{\tilde{\Gamma}}_+^+ \underline{P}_{I+}^+ + \underline{\tilde{\Gamma}}_+^- \underline{P}_{I+}^- + \underline{P}_{S+} \quad (2.20)$$

to remove shock-wave singularities, proceeds as described in Subsections 2.3 and 2.4. The modified, augmented interaction equations corresponding to (2.9) for the infinite fluid medium are then readily obtained.

It is important to mention at this point that the DAA formulation just described does not account for high-frequency scattered waves from S_- that impinge upon S_+ . For most floating structures, such waves are not generated, as the wet surfaces of S_+ and S_- usually intersect to form a convex surface; they are generated, however, for a totally submerged structure lying near the free surface. Even so, it has been shown that, as far as structural response is concerned, the effects of the scattered wave are generally negligible [16]. In other words, the response is basically driven by the incident primary and image waves.

2.6 BULK CAVITATION

In the absence of bulk cavitation, the imaging method serves as a useful device to model the reflection of free-field waves from the fluid's free surface. The occurrence of bulk cavitation near the surface, however, changes that simple acoustic reflection problem into a complex reflection-refraction problem, as indicated in Figure 2-2. If refraction distortions produced by a relatively thin cavitating region are not too severe, however, bulk cavitation effects will still appear to the structure as emanating from an image source.

Experimental records of free-field pressure histories for compact charges exhibit the behavior shown in Figure 2-3 [17]. The dashed line denotes the history produced by a negative-image model, while the horizontal line indicates that the effect of bulk cavitation is to "cut off" the pressure at a cavitation threshold. The approximate treatment introduced here involves pre-examination of the image-based free-field pressure at the

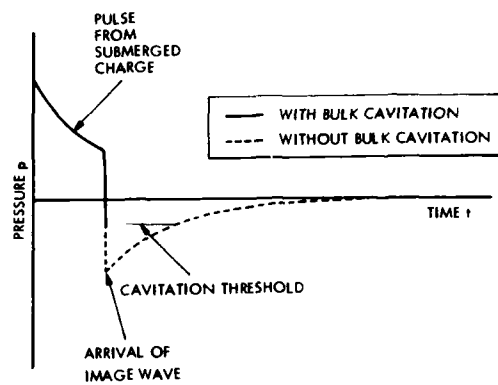


Figure 2-3 Free-Field Pressure as a Result of Free-Surface Reflection

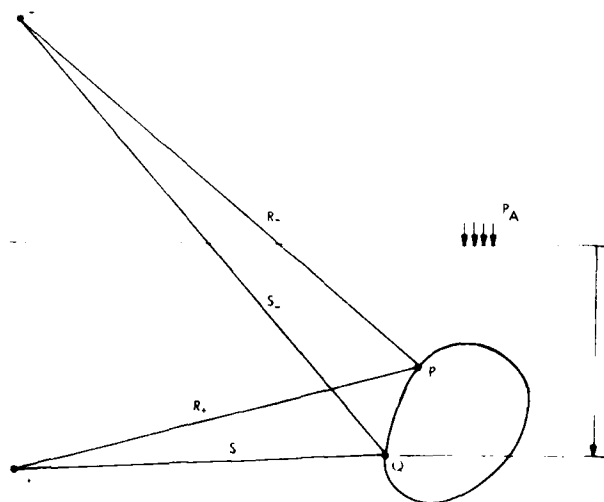


Figure 2-4 Geometry of Primary and Image Waves

standoff point, i.e., the point on the submerged structure closest to the charge. Whenever that pressure becomes negative to the extent that its magnitude exceeds the absolute ambient pressure at that depth, a positive contribution is incorporated into the negative-image source so that the free-field pressure at the standoff point never dips below the cavitation threshold. When the structure's overall dimensions are small relative to the distance from the structure to the cavitating region, the effects of the positive contribution will not vary appreciably in the vicinity of the structure.

The preceding discussion leads to the following development. The two-source model of Figure 2-4 yields as the free-field pressure at any point $\underline{P}$

$$p_{\underline{P}}(t) = \frac{S}{R_+} p_+(t - \frac{R_+ - S}{c}) + \frac{S}{R_-} p_-(t - \frac{R_- - S}{c}) \quad (2.21)$$

where $p_+(t) = p_-(t) = 0$ for $t < 0$. At the standoff point, (2.21) becomes

$$p_Q(t) = p_+(t) + \frac{S}{S_-} p_-(t - \frac{S_- - S}{c}) \quad (2.22)$$

Now $p_-(t) = -p_+(t)$ as long as the resulting $p_Q(t)$ exceeds the cavitation threshold so that "cutoff" does not occur; otherwise, $p_Q(t)$ remains at the threshold value $-(p_A + \gamma Z)$ where p_A is atmospheric pressure and γ is the fluid's weight density. Hence, during the "cutoff period",

$$p_-(t) = -\frac{S}{S_-} [p_+(t + \frac{S_- - S}{c}) + p_A + \gamma Z] \quad (2.23)$$

The model just described fits a prescribed free-field pressure history at the stand-off point in such a way that surface cutoff effects appear to the structure as emanating from an image source. Because the model is complete, it also provides the free-field fluid-particle-velocity information required for DAA calculations. The usefulness of the model has been demonstrated from the results of free-field tests specifically designed to produce both pressure and fluid-particle-velocity data [18].

2.7 USA-DAA₂ IMPLEMENTATION

The Improved Doubly Asymptotic Approximation [DAA₂] can be written as [4]

$$\begin{aligned} M_f \ddot{\underline{P}}_S + \rho c A_f \dot{\underline{P}}_S + \rho c \Omega_f A_f \underline{P}_S = \\ \rho c [M_f (G^T \ddot{\underline{x}} - \ddot{\underline{u}}_I) \Omega_f M_f (G^T \ddot{\underline{x}} - \dot{\underline{u}}_I)] \end{aligned} \quad (2.24)$$

where

$$\underline{\Omega}_f = \eta \rho c \underline{A}_f \underline{M}_f^{-1} \quad (2.25)$$

All vector and matrix quantities in the above are related to the same finite element wet-surface fluid mesh as that used for the lowest order DAA (DAA_1) described in Section 2.2.

Note that DAA_2 is a second-order equation, whereas DAA_1 is a first-order equation. In addition, DAA_2 includes a new scalar parameter η that appears in (2.25). It can be established from physical considerations [4], that η must be bounded as

$$0 \leq \eta \leq 1 \quad (2.26)$$

A precise choice of η is apparently not predicated by any fundamental principle. Hence it must be regarded at this time as a factor which may be adjusted to achieve optimum accuracy for a particular problem. In [4], it is observed that $\eta = 1$ leads to the best accuracy for a spherical shell.

In order to implement DAA_2 (2.24) is first integrated once in time and multiplied through by $\underline{A}_f \underline{M}_f^{-1}$. Equation (2.25) is then substituted into the result and a new variable, the scattered pressure integral $\underline{q}_S$, is defined by

$$\underline{q}_S = \underline{p}_S^* \quad (2.27)$$

where an asterisk denotes temporal integration. The result is

$$\begin{aligned} \underline{A}_f \ddot{\underline{q}}_S + \rho c \underline{D}_{f1} \dot{\underline{q}}_S + \eta \rho^2 c^2 \underline{D}_{f2} \underline{q}_S = \\ \rho c \underline{A}_f (\underline{G}^T \ddot{\underline{x}} - \dot{\underline{u}}_I) + \eta \rho^2 c^2 \underline{D}_{f1} (\underline{G}^T \dot{\underline{x}} - \underline{u}_I) \end{aligned} \quad (2.28)$$

where

$$\underline{D}_{f2} = \underline{A}_f \underline{M}_f^{-1} \underline{A}_f \underline{M}_f^{-1} \underline{A}_f \quad (2.29)$$

It is noted that (2.28) is symmetric and that $\underline{D}_{f1}$ has already been defined following (2.6).

To avoid shock-wave singularities in $\underline{\dot{u}}_I$, the relation for a spherical shock is used as

$$\rho c \underline{\dot{u}}_I = \underline{\Gamma} (\underline{\dot{p}}_I + c \underline{R}^{-1} \underline{p}_I) \quad (2.30)$$

while the modified pressure-integral vector is defined as

$$\underline{q}_M = \underline{q}_S + \underline{\Gamma}^* \underline{p}_I \quad (2.31)$$

Substitution of (2.30), (2.31) into (2.28) then gives

$$\begin{aligned} \underline{A}_f \underline{\ddot{q}}_M + \rho c \underline{D}_{f1} \underline{\dot{q}}_M + \eta \rho^2 c^2 \underline{D}_{f2} \underline{q}_M = \\ \rho c \underline{A}_f \underline{G}^T \underline{\ddot{x}} + \eta \rho^2 c^2 \underline{D}_{f1} \underline{G}^T \underline{\dot{x}} + c [(1-\eta) \rho \underline{D}_{f1} - \underline{A}_f \underline{R}^{-1}] \underline{\Gamma} \underline{p}_I \\ + \eta \rho^2 c^2 (\underline{D}_{f2} - \frac{1}{\rho} \underline{D}_{f1} \underline{R}^{-1}) \underline{\Gamma}^* \underline{p}_I \end{aligned} \quad (2.32)$$

where the identity

$$\underline{R}^{-1} \underline{\Gamma} = \underline{\Gamma} \underline{R}^{-1} \quad (2.33)$$

has been used in (2.32), as both matrices are diagonal. Associated with (2.32) is the structural equation of motion

$$\underline{M}_s \underline{\ddot{x}} + \underline{C}_s \underline{\dot{x}} + \underline{K}_s \underline{x} = -\underline{G} \underline{A}_f [\underline{\dot{q}}_M + (\underline{I} - \underline{\Gamma}) \underline{p}_I] \quad (2.34)$$

Equations (2.32) and (2.34) define the DAA₂-modified interaction equations that are solved according to the staggered solution strategy; hence an examination of stability must be conducted. It has been shown that the step-by-step integration of (2.32) and (2.34) is conditionally stable; however, no systematic study of stability has yet been undertaken. In view of the fact that unconditional stability was achieved for USA-DAA₁ by augmentation, and that (2.24) is essentially the DAA₁ with a correction term, augmentation of (2.32) was carried out in the same manner as that used for DAA₁.

Accordingly, (2.34) is first solved for $\ddot{\underline{x}}$ and substituted into (2.32) to give

$$\begin{aligned}
 \underline{A}_f \ddot{\underline{q}}_M + \rho c (\underline{D}_{f1} + \underline{D}_s) \dot{\underline{q}}_M + \eta \rho^2 c^2 \underline{D}_{f2} \underline{q}_M = \\
 - \rho c \underline{A}_f \underline{G}^T \underline{M}_s^{-1} (\underline{C}_s \dot{\underline{x}} + \underline{K}_s \underline{x}) + \eta \rho^2 c^2 \underline{D}_{f1} \underline{G}^T \dot{\underline{x}} \\
 - \rho c \{ \underline{D}_s - [\underline{D}_s + (1-\eta) \underline{D}_{f1} - \frac{1}{\rho} \underline{A}_f \underline{R}^{-1}] \underline{\Gamma} \} \underline{P}_I \\
 + \eta \rho^2 c^2 (\underline{D}_{f2} - \frac{1}{\rho} \underline{D}_{f1} \underline{R}^{-1}) \underline{\Gamma} \underline{P}_I^*
 \end{aligned} \tag{2.35}$$

where $\underline{D}_s$ has already been defined following (2.6).

Equations (2.34) and (2.35) are the DAA₂-modified, augmented interaction equations that have been implemented in the USA Code.

SECTION III

ORGANIZATION

The USA Code has been written in standard FORTRAN IV for use on both Univac and CDC computers. Machine dependency has been isolated in one utility program described below. Program modularity has been strictly enforced, with communication between computational modules controlled by means of a data management system.

The basic structure of the code is shown in Fig. 3-1. The structural preprocessor is a separate code selected by the user to provide the computational model for the structure. The skyline utility merely reformats $\underline{M}_s$ and $\underline{K}_s$ as provided by the structural preprocessor for processing by the USA Code (recall that $\underline{C}_s$ is taken as zero). The fluid mass preprocessor forms $\underline{A}_f$, $\underline{M}_f$, $\underline{D}_{f1}$, $\underline{D}_{f2}$ and $\underline{G}$ using a virtual memory simulator for out-of-core processing, while the matrix augmentation preprocessor forms $\underline{D}_s$ and $\underline{A}_f \underline{G}^T \underline{M}_s^{-1}$ [see (2.9)]. The main processor is the time integrator, which forms $\underline{\Gamma}$ and $\underline{H}$ and then solves (2.9) in step-by-step fashion using the staggered solution procedure. The response postprocessor provides tabular and graphic output for the computed kinematic responses as well as pseudo-velocity shock spectra. Finally, the data manager controls the flow of data between processors. More detailed descriptions of the various program components follow, while information required for utilization of the code is contained in Appendices A through D.

3.1 THE DATA MANAGER DMGASP

DMGASP is a self-contained utility module that functions as a manager of auxiliary storage and as the focal point for all block input/output activities [19]. Constituting the lowest level of the NOSTRA Data Management System [20], it carries out the direct transfer of data blocks between core and peripheral storage. (The terminology "direct transfer" is used here to denote unformatted and unbuffered data transmission.) The basic auxiliary storage management operations embodied in DMGASP are

- Activate storage device
- Position device
- Read data block from device
- Write data block on device
- Deactivate device

In the USA Code, DMGASP is operated as a stand-alone I/O package that receives directives directly from the master processors. Assembly language versions of DMGASP currently exist for UNIVAC 1100 EXEC-8, CDC SCOPE 3.4 (NOS/BE), and CDC NOS operating systems; hence the USA Code may be used only on these systems at this time.

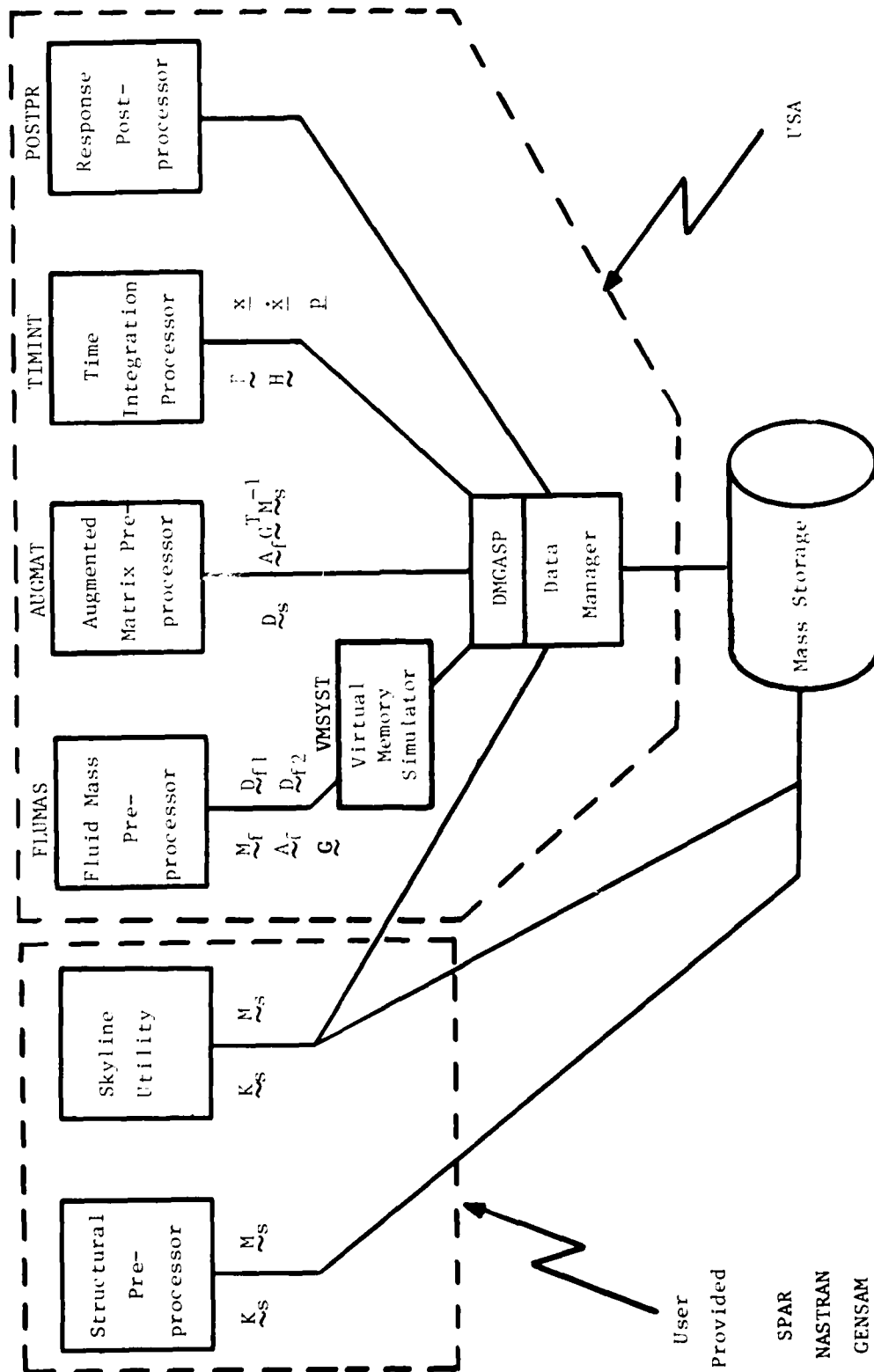


Figure 3-1. Organization of USA Code

3.2 THE VIRTUAL MEMORY SIMULATOR VMSYST

VMSYST is a virtual storage simulator for computers that are not built around a virtual memory system [21]. All data in the virtual system is partitioned into pages, which are blocks of consecutive data words of a fixed page size. Pages residing in core in the page buffer are called active pages. Inactive pages are resident in auxiliary storage only. In this utility the page and page buffer sizes can be conveniently adjusted to suit the application. Input and output to auxiliary storage is handled by DMGASP; otherwise VMSYST is written in transportable FORTRAN.

The primary advantage of a virtual memory system is the efficient processing of many small records such as columns or rows of large full matrices that can be treated as vectors. In essence VMSYST keeps track of whether a desired block of data is resident in core in the page buffer, or, has been moved to an external storage device by DMGASP. If it is not currently resident in the page buffer, VMSYST retrieves it and makes it available to the application program. This double movement of data is the major price paid for the benefits of the virtual system.

In USA, VMSYST is used for the out-of-core generation of the fluid mass matrix described in Section 3.5.

3.3 THE STRUCTURAL PREPROCESSOR

This is a user-provided code that assembles the structural mass and stiffness matrices and generates information that relates the internal and external descriptions of the structural DOF. Input typically includes

- Mesh geometry
 - Coordinate systems
 - Node locations
- Element definitions
 - Type
 - Connectivity
- Material properties
 - Mass density
 - Moduli
- Constraints
 - Symmetry conditions
 - Element external constraints
 - Element internal constraints

Fluid internal to the submerged structure must be included in the structural model. At this time, USA treats only diagonal mass matrices associated with a lumped mass representation of the structure, and only single precision matrices can be processed.

3.4 THE SKYLINE UTILITY

This preprocessor converts the structural mass and stiffness matrices generated by the structural preprocessor into the internal "skyline" format required by the USA time integration processor [22,23]. As there are a variety of ways to store large, sparse, symmetric matrices, virtually any structural preprocessor that is to be used with the USA Code will require a utility package to change the storage format. At this time, conversion utilities have been written for SPAR [24], NASTRAN [25] and GENSAM [26]. User instructions for constructing the skyline utility for other structural codes are given in Appendix E. As is noted there, USA now contains a set of utilities to facilitate this process.

Figure 3.1 shows 2 paths to mass storage from the skyline utility. The SPAR converter uses DMGASP for both input and output, whereas the NASTRAN converter uses unformatted buffered FORTRAN commands for input and DMGASP for output.

Constraints are also handled differently in these two utilities. NASTRAN provides a reduced stiffness matrix which already incorporates any prescribed constraints. SPAR does not; however, USA has the ability to apply constraints due to symmetry or attachment to ground during the time integration. Structural DOF that must be set to zero are flagged by the skyline utility [23].

3.5 THE FLUID MASS PREPROCESSOR FLUMAS

This code constructs the fluid mass matrix for a structure submerged in an infinite, inviscid, incompressible fluid by the boundary element technique [14]. In addition, FLUMAS can form the mass matrix for a body in the vicinity of a fluid free surface through the use of imaging techniques. Out-of-core processing is facilitated by use of the virtual memory system VMSYST so that core size is not a limitation on the number of fluid DOF. The code also generates fluid mesh data and a set of transformation coefficients relating the structural and fluid DOF. The computation of these coefficients is based upon the use of centroidal nodes for the fluid elements and the assumption of a bilinear variation of displacement over the surface of each structural element. This assures that the description of the fluid pressure forces in the two mesh systems is statically equivalent without inducing moments at the structural nodes. Finally, the code generates the symmetric matrices D_{f1} and D_{f2} that appear in the computational form of the DAA_1 and DAA_2 equations which involve the inverse of the fluid mass matrix.

FLUMAS contains a refined formulation for the fluid mass matrix that includes the primary effects of element curvature. In addition, it has the capability to treat structures containing both general geometry and arbitrary axis, multi-branch, multi-harmonic surface-of-revolution components, as described in [10]. The code can also efficiently construct the fluid mass matrix for a body with one or two planes of symmetry by using a mesh which covers 1/2 or 1/4 of the surface. Symmetric or anti-symmetric fluid motions can then be imposed on the portions of the surface not covered by the mesh. Two-dimensional "plane-strain" behavior of long cylinders can also be simulated. The code contains an automatic mesh generator for cylindrical surfaces and an improved error exit control that facilitates fluid mesh debugging. Finally, a useful diagnostic tool in the code is the capability to solve the fluid-boundary-mode problem $\underline{M}_f \underline{u} = \lambda \underline{A}_f \underline{u}$ [14].

Typical input data for this processor includes

- Mesh geometry
 - Fluid Wet-Surface Mesh
 - Structure Wet-Surface Mesh
- Element definitions
 - General curved surface
 - Surface of revolution
- Material property
 - Mass density
 - DAA₂ parameter
- Constraints
 - Location of free surface
 - Half model
 - Quarter model
 - Long cylinder
 - Node reassignment in fluid-structure transformation

A detailed description of the required input data is given in Appendix A.

3.6 THE AUGMENTED MATRIX PREPROCESSOR AUGMAT

This processor accepts data from the structural and fluid analyzers to construct the specific matrices required for solution of the augmented Eqs. (2.9) or (2.34)/(2.35). The output of this code includes not only the required matrices in skyline form, but also a distillation of the output from both the structural and fluid processors. This has been done so that only one permanent file need be referenced as input to the time integrator; this results in improved data handling and core usage. In contrast to earlier versions of USA, AUGMAT does not form the fluid matrices $\underline{D}_{f1}$ and $\underline{D}_{f2}$ but rather puts

them in the skyline format required by SKYPUL. $\underline{D}_{f1}$ and $\underline{D}_{f2}$ are now formed only in FLUMAS. The structural stiffness matrix can also be displayed in AUGMAT for checkout purposes. Input to this code involves the following information

- Mass matrices
 - Fluid
 - Structure
- Structural DOF correspondence table
 - External and internal node descriptions
 - Factorization order
 - DOF reduction due to constraints
- Fluid mesh geometry
 - Global coordinates of fluid nodes
 - Direction cosines for nodal surface normals
 - Areas of fluid elements
- Fluid/structure DOF transformation coefficients
- Fluid material properties
 - DAA₂ parameter
- Constraints
 - Half model
 - Quarter model

Although this constitutes a substantial amount of information, almost all of it is retrieved from permanent data files. A detailed discussion of the required input data is contained in Appendix B.

3.7 THE TIME INTEGRATION PROCESSOR TIMINT

This main processor constitutes an implementation of the unconditionally stable staggered solution technique developed in [9] for DAA₁. The primary output is a set of permanent data files that contain nodal values for structural displacement, structural velocity and wet-surface pressure at every time step. In addition, parallel files are created that retain restart information at time intervals dictated by the user. The code has a variable time step capability and can treat a spherical incident wave of arbitrary pressure profile and source location. Exponentially decaying waves can also be treated by providing magnitude and decay information. In addition, incident wave pressure and particle velocity are tabulated and displayed with a "printer-plot" package. If the body is in the vicinity of a free surface, unloading due to reflection of the incident

wave from the surface is included and the effects of bulk cavitation on the free field pressure history are approximately treated. Finally, selected response histories can be listed and then displayed for immediate examination using the "printer-plot" graphics package embedded both in TIMINT and in POSTPR (see Sect. 3.8).

The computational strategy for the staggered solution procedure is embodied in the following eight steps, assuming the solution is known at time t :

- (1) Estimate the unknown structural restoring force $\underline{K}_s \underline{x}$ at $t + \Delta t$ from the extrapolation of current and past values
- (2) Transform this extrapolation into fluid node values and form the right-hand side of the fluid equation, which also involves the known incident pressure at $t + \Delta t$
- (3) Solve the fluid equation and obtain a preliminary estimate of the total pressure vector at $t + \Delta t$
- (4) Transform fluid pressures into structural nodal forces
- (5) Solve the structural equation for the displacement and velocity vectors at $t + \Delta t$
- (6) Transform the computed structural restoring forces at $t + \Delta t$ into fluid node values and reform the right hand side of the fluid equation
- (7) Re-solve the fluid equation and obtain refined values for the total pressures at $t + \Delta t$
- (8) Save system responses

Steps 1, 3, and 5 constitute the basic staggered solution technique, while Steps 2 and 4 are required because of the difference between the fluid and structural surface meshes. The iteration on the fluid solution reflected in Steps 6 and 7 has been added to enhance accuracy. Inasmuch as the computation time is overwhelmed by the structural solution requirements, this requires only a small increase in total run time. The use of a three-point extrapolation method in Step 1 also improves accuracy, as discussed in [9].

Implicit integration algorithms have been used for both the fluid and structural equations. The former is treated with the 3-step Park method [27] while the latter is treated with the "JO" implementation of the trapezoidal rule [28].

Typical input to this processor includes

- Incident wave characteristics

Location of source
Location of standoff
Pressure profile
Linear interpolation
Cubic spline fit
Exponentially decaying wave

- Time step information
 - Start and finish times
 - Time increment values
- Restart data
- Display directives
 - Displacements
 - Velocities
 - Pressures

Detailed user information concerning TIMINT is given in Appendix C.

3.8 THE RESPONSE POSTPROCESSOR POSTPR

This utility is responsible for the listing and "printer-plot" as well as "vector-plot" graphic display of selected system responses and pseudo-velocity shock spectra. Output files containing the structural displacement field at user-specified instants in time may also be created from the response history files to provide "snapshots" of the deformed structure. Some of the same capabilities are also embedded in the TIMINT processor for immediate selective scanning of the output. POSTPR, however, is used for more detailed examination of the results at a later time. As a complete display of all structural and fluid DOF histories for even a moderate size problem could run into thousands of pages of output, care must be exercised in the selection of data to be displayed. Usage of this code is discussed in Appendix D.

SECTION IV

EXAMPLE PROBLEMS

This section presents results generated by the USA Code for three idealized underwater and free surface shock problems. The structure studied in the first problem is a hollow circular beam of finite length, while that involved in the second and third problems is an infinite, circular cylindrical shell. In all cases, the structure is excited by a transverse, plane step-wave of unit incident pressure and material properties are used that correspond to a steel shell immersed in water. The input data are normalized so that the density and speed of sound for the fluid both equal unity; hence, the density, Young's modulus, and Poisson's ratio for the structural material are taken as 7.85, 98.125, and 0.3, respectively. The radius and wall thickness of the beam and the cylinder are 1 and 0.01, respectively, while the length of the beam is 9. In order to assess the accuracy of the computational results, selected response histories are compared with those obtained by other methods.

4.1 CIRCULAR BEAM

The response variable of primary interest in this problem is the late-time asymptotic translational velocity V_∞ of the structure. An analytical expression for this quantity may be obtained from (2.5) by taking $\dot{\underline{x}} = \underline{\gamma}_{ps} v(t)$, where $\underline{\gamma}_{ps}$ is the vector of direction cosines relating the translational motions of the structural nodes and the direction of propagation of the plane incident wave. (The elements of $\underline{\gamma}_{ps}$ that pertain to the rotational DOF are, of course, zero.) The introduction of this relation into the first of 2.5, followed by premultiplication of the resulting equation by $\underline{\gamma}_{ps}^T$, then yields

$$m_s \dot{v} = - \underline{\gamma}_s^T \underline{C} \underline{A}_f (\underline{p}_I + \underline{p}_S) \quad (4.1)$$

where $m_s = \underline{\gamma}_{ps}^T \underline{M} \underline{\gamma}_{ps}$; this follows from the fact that $\underline{C}_s \underline{\gamma}_{ps} = \underline{K}_s \underline{\gamma}_{ps} = \underline{0}$.

After the wave front of the plane step-wave has enveloped the structure, i.e., for $t > t_e$,

$$\begin{aligned} \underline{p}_I &= \rho c U_I \underline{1} \\ \underline{p}_I^* &= \rho c U_I (t \underline{1} - \underline{t}_A) \\ \underline{u}_I &= U_I \underline{\gamma}_p \end{aligned} \quad (4.2)$$

where U_I is the fluid particle velocity characterizing the step-wave, $\underline{1}$ is the unity vector, the asterisk denotes the temporal integral of the quantity beneath it, $\underline{t}_A$ is the vector of incident-wave arrival times for the fluid surface elements, and $\underline{\gamma}_p$ is the vector of direction cosines relating the normals of the fluid elements to propagation vector of

the plane incident wave. In addition, $|\dot{p}_S| \ll |p_S|$ for late-time motions (see Section 2.2), so that the second of (2.5) becomes

$$p_S = A_f^{-1} M_f (G^T Y_{PS} \dot{v} - \dot{u}_I), t \gg t_e \quad (4.3)$$

The introduction of this relation into (4.1) then yields

$$(m_s + m_a) \dot{v} = - Y_{PS}^T G A_f p_I + Y_{PS}^T G M_f \dot{u}_I, t \gg t_e \quad (4.4)$$

where the added mass $m_a = Y_{PS}^T G M_f G^T Y_{PS}$. But, from (4.4), $G^T Y_{PS} = Y_P$, so that m_a is also given as $m_a = Y_P^T M_f Y_P$.

With $G^T Y_{PS} = Y_P$, the first of (4.2) yields $Y_{PS}^T G A_f p_I = \rho c U_{I-P}^T A_f l = 0$, inasmuch as the wet surface of the structure is closed. Hence, the right side of (4.4) vanishes for $t > t_e$, which gives the expected result $\dot{v} = 0$. This prompts the use of integrated forms of (4.1) and (4.3) (with quiescent initial conditions), which yields, instead of (4.4),

$$(m_s + m_a) v = - Y_{P-f}^T A_f p_I + Y_{P-f}^T M_f u_I, t \gg t_e \quad (4.5)$$

The introduction of the second and third of (4.2) into this equation then provides the desired expression for late-time asymptotic translational velocity

$$V_\infty = \frac{m_d + m_a}{m_s + m_a} U_I \quad (4.6)$$

where the structure's displaced mass m_d may be shown to be expressible as $m_d = \rho c \int_{t_A}^{t_I} A_f(t) dt$. Note that (4.6) is a general result, applicable to any wet-surface geometry.

Two different uniform mesh geometries were used to study the circular beam. Ten- and twenty-node models were constructed with beam elements provided by the structural analyzer SPAR [29]. The corresponding fluid models contained 11 and 21 elements of equal size, with 12 and 24 circumferential integration points (see [10]). In each case there was a fluid element on each end to account for axial motion while all the rest were evenly distributed along the length. For the beam considered, $m_s = 4.439$ and $m_d = 28.274$; with m_a determined as $m_a = Y_P^T M_f Y_P$, mesh geometry has a small effect on the value calculated for V_∞ . It was found that $m_a = 24.509$ for the coarse mesh and $m_a = 24.332$ for the fine mesh, which yield $V_\infty = 1.823$ and $V_\infty = 1.828$, respectively.

In the response calculations, a constant time step of 0.1 (20 steps per envelopment period) was used for both models; the results are shown in Figures 4-1 and 4-2. Velocities at the ends of the beam are higher than those at the center because the three-dimensional flow field at the ends offers less resistance to the plane wave excitation than the two-dimensional flow field at the center. It is noted that the responses of both

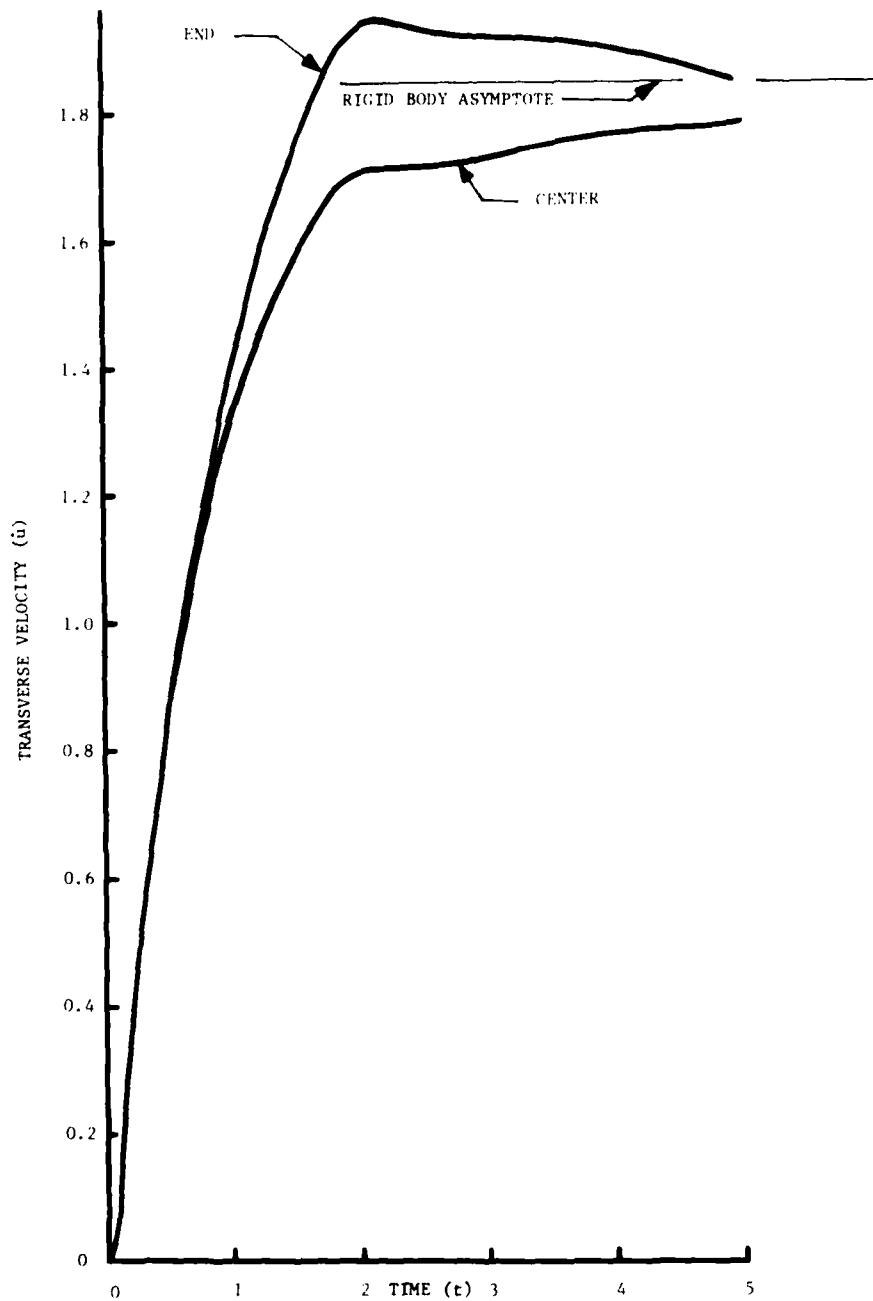


Figure 4-1 Transverse Velocity of Finite Beam, Coarse Mesh

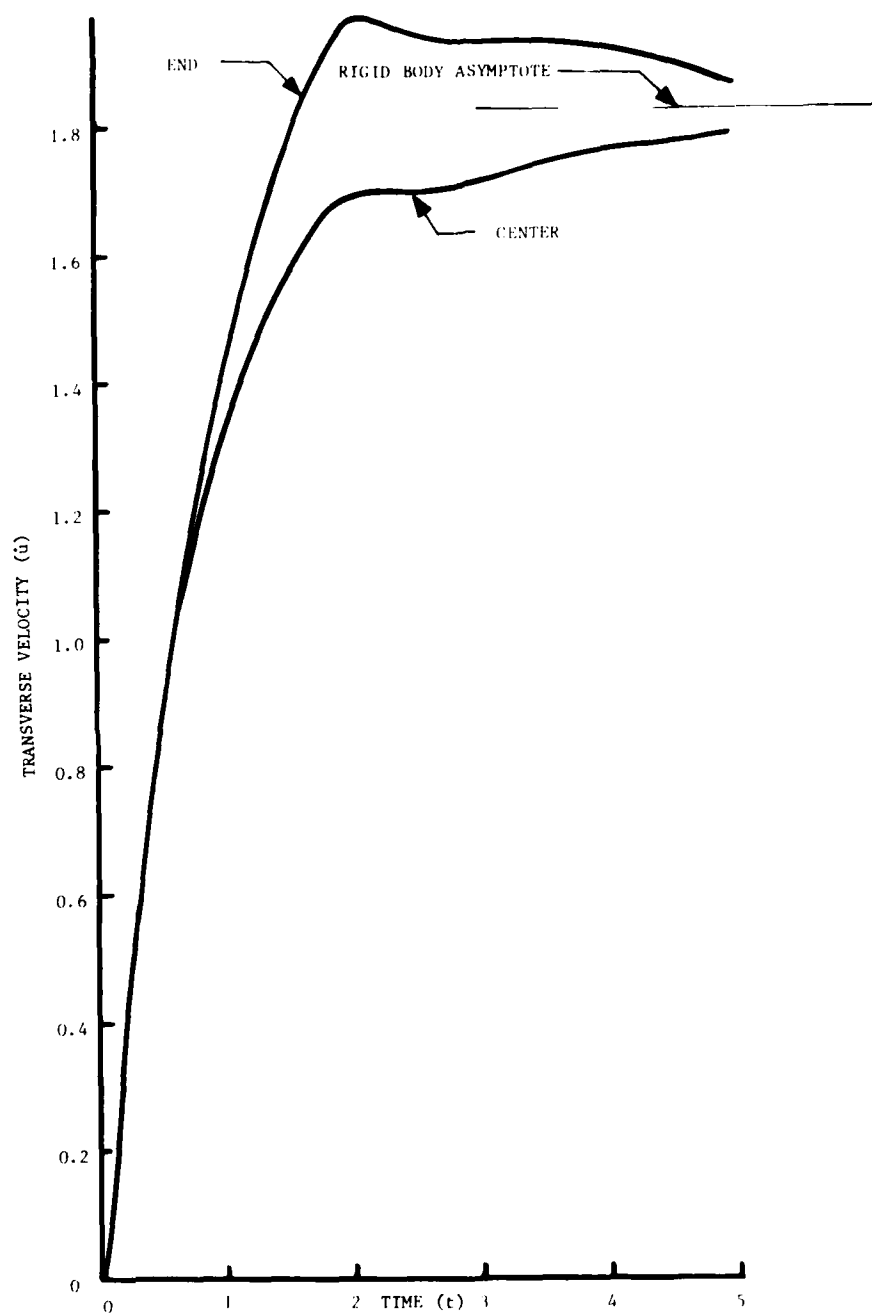


Figure 4-2 Transverse Velocity of Finite Beam, Halved Mesh

models are similar although those for the finer mesh appear to tend to the rigid body asymptotic velocity more precisely.

The USA(3) Code can also treat the bar response of the circular beam and to illustrate this capability the axial displacement response of the end under the side-on loading is shown in Figure 4-3 for the coarse mesh problem only. The expected static displacement is easily determined from the physical characteristics of the problem to be 2.293 and it is noted that the computational result is settling down to that value. However, the time required for this to happen is much greater than the time for the beam to achieve the expected transverse velocity shown in Figure 4-1. This is because the axial frequency of the beam is low due to the entrained fluid. The natural frequency of this system can easily be found by Rayleigh's method as follows.

Under a harmonic excitation $u = Bx \sin \omega t$ the maximum potential energy $U_{\max}$ and the maximum kinetic energy $T_{\max}$ can be shown to be

$$\begin{aligned} U_{\max} &= \frac{1}{2} B^2 A E \ell \\ T_{\max} &= \frac{1}{24} B^2 A \rho \ell^3 \omega^2 + \frac{1}{8} B^2 m_f \ell^2 \omega^2 \end{aligned} \quad (4.7)$$

where u is the axial displacement measured from one end, x is the axial coordinate, ω is the circular frequency, t is time, A is the cross-sectional area, E is Young's modulus, ℓ is the bar/beam length and m_f is the fluid added mass for the axial breathing mode of the bar/beam. Equating $U_{\max}$ to $T_{\max}$ then gives a value for the period P_{wet} as

$$P_{\text{wet}} = P_{\text{dry}} \sqrt{1 + 3 m_f / m_s}$$

where

$$\begin{aligned} P_{\text{dry}} &= \pi \ell \sqrt{\rho / 3E} \\ m_s &= \rho A \ell \end{aligned} \quad (4.8)$$

For the problem at hand $P_{\text{dry}} = 4.617$, $m_f = 4.913$, and $m_s = 4.493$ which gives $P_{\text{wet}} = 9.597$, about twice as long as the dry period. It is noted from the peak-to-peak times shown in Figure 4-3 that the computational result is in excellent agreement.

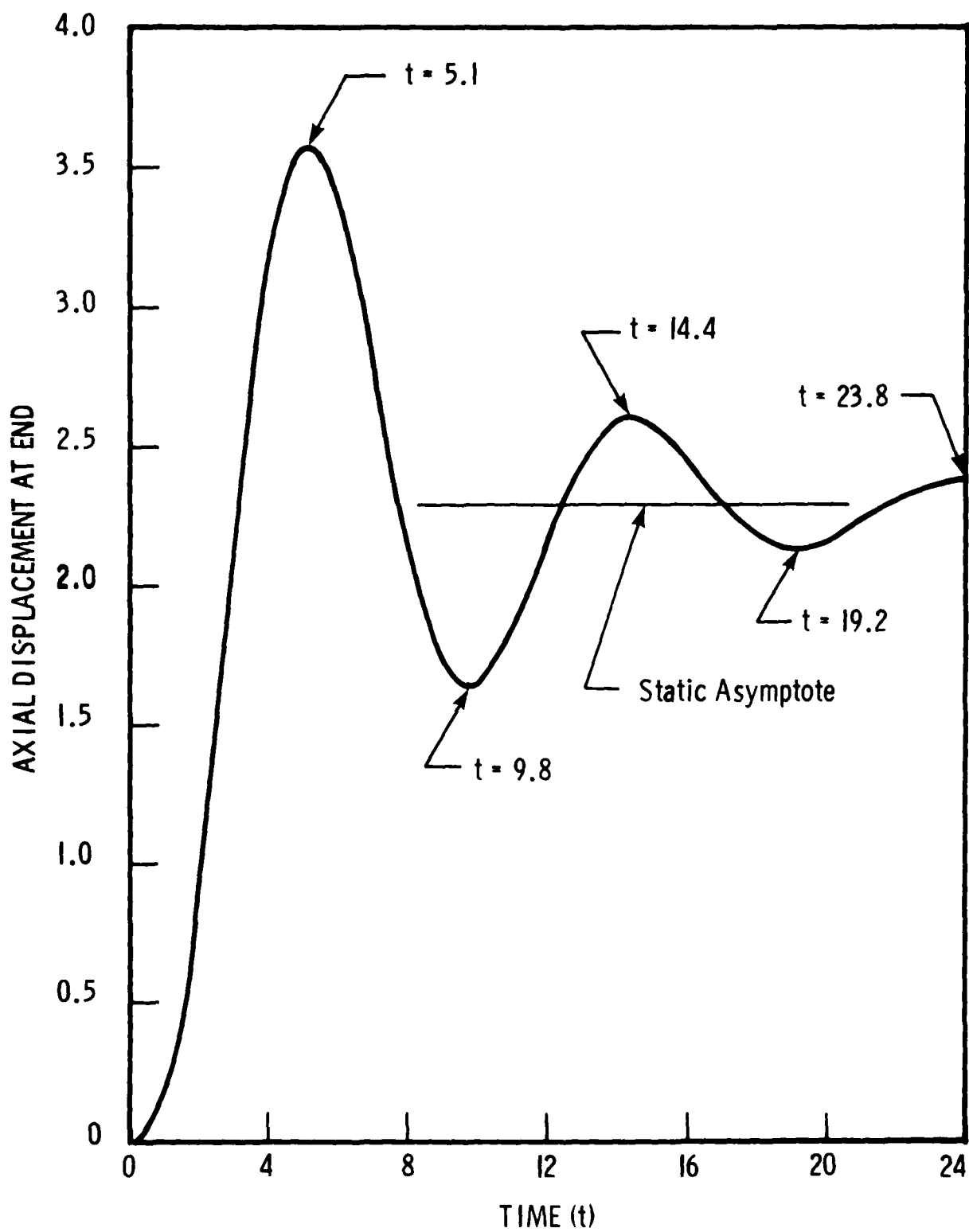


Figure 4-3 Axial Displacement at End of Finite Beam, Coarse Mesh

4.2 SUBMERGED INFINITE CYLINDRICAL SHELL

For this problem, a 72-node, 36-element SPAR model with a uniform circumferential mesh was constructed. The length of the cylindrical shell equalled the circumferential dimension of the square plate elements used for the model; hence the shell was one element long. Kinematic constraints of zero axial displacement and no end rotation were enforced through the skyline utility, as described in Section 3.3. The fluid model consists of 36 equally-spaced elements around the circumference; the two-dimensional nature of the infinite shell geometry was simulated by exercising an option in the fluid pre-processor FLUMAS that adds fictitious elements in the axial direction.

Two-dimensional $n=0, 1$, and 2 modal response results were generated by circumferential Fourier decomposition of USA-generated responses. For comparison DAA analytical solutions were generated by the method described in [8] and [30]. The primary response variables of interest were radial displacement for $n=0$, radial and tangential velocity for $n=1$, and radial and tangential displacement for $n=2$. A time step of 0.025 was used up to $t=1$; for t between 1 and 2 this was increased to 0.05, and for t greater than 2 a time step of 0.1 was used.

The USA and corresponding analytical results are shown, harmonic by harmonic, in Figures 4-4 through 4-8. In all cases the maximum errors made by USA fall into the range of 1 to 2%.

4.3 SEMI-SUBMERGED INFINITE CYLINDRICAL SHELL

Analytical solutions for the problem of a shock-wave-excited, infinite, circular cylindrical shell whose axis lies in the plane of the free surface of a semi-infinite acoustic medium may readily be obtained. The appropriate geometry for an imaging representation of this problem is shown in Figure 4-9. An earlier treatment is described in [31], where the stiffness of the shell is neglected and an approximate expression is obtained for the asymptotic value for vertical rigid-body translational velocity. In this subsection it is shown that both exact and approximate solutions for the infinite-fluid case may be used directly to obtain solutions for the case of a semi-infinite fluid, as follows.

The shell and fluid variables are first expanded in circumferential harmonics as

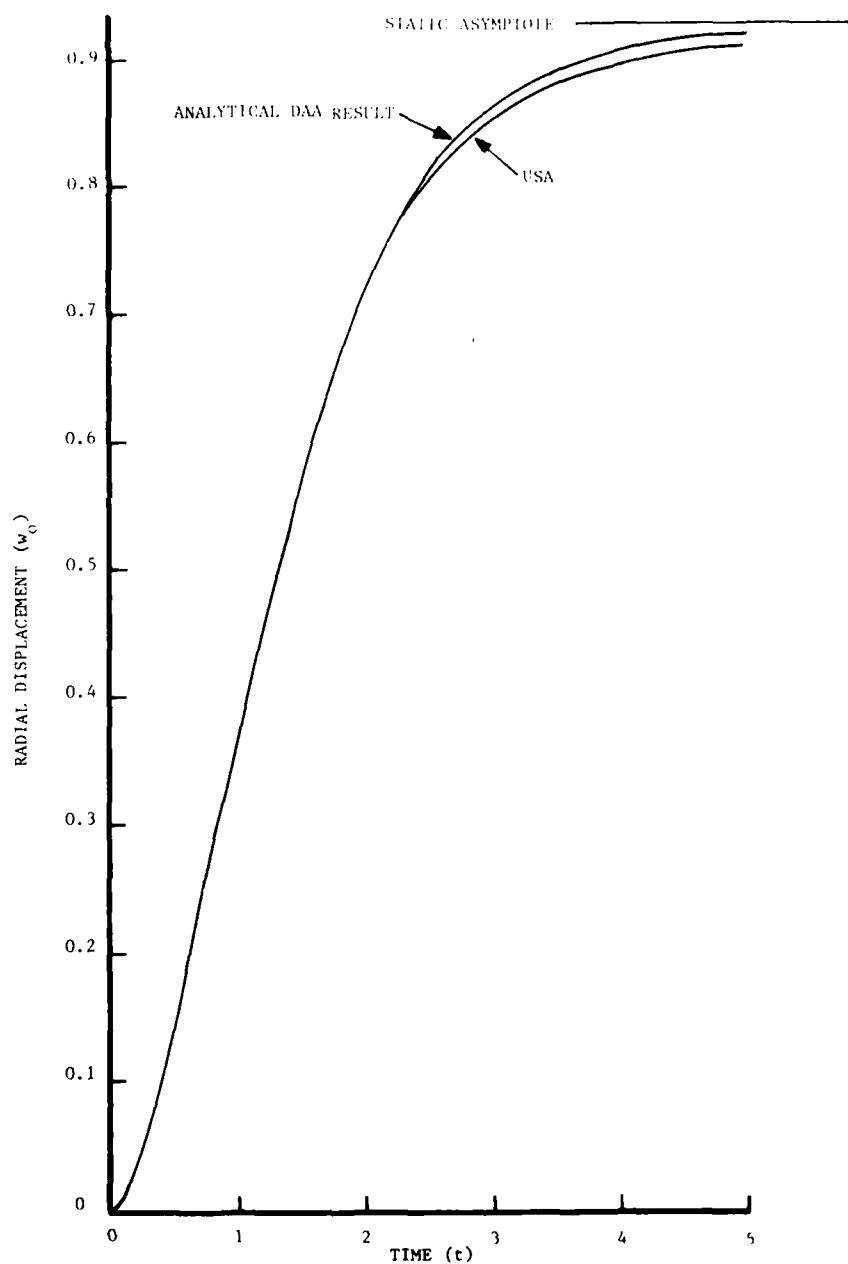


Figure 4-4 $n=0$ Radial Displacement of Infinite Cylinder in Infinite Fluid

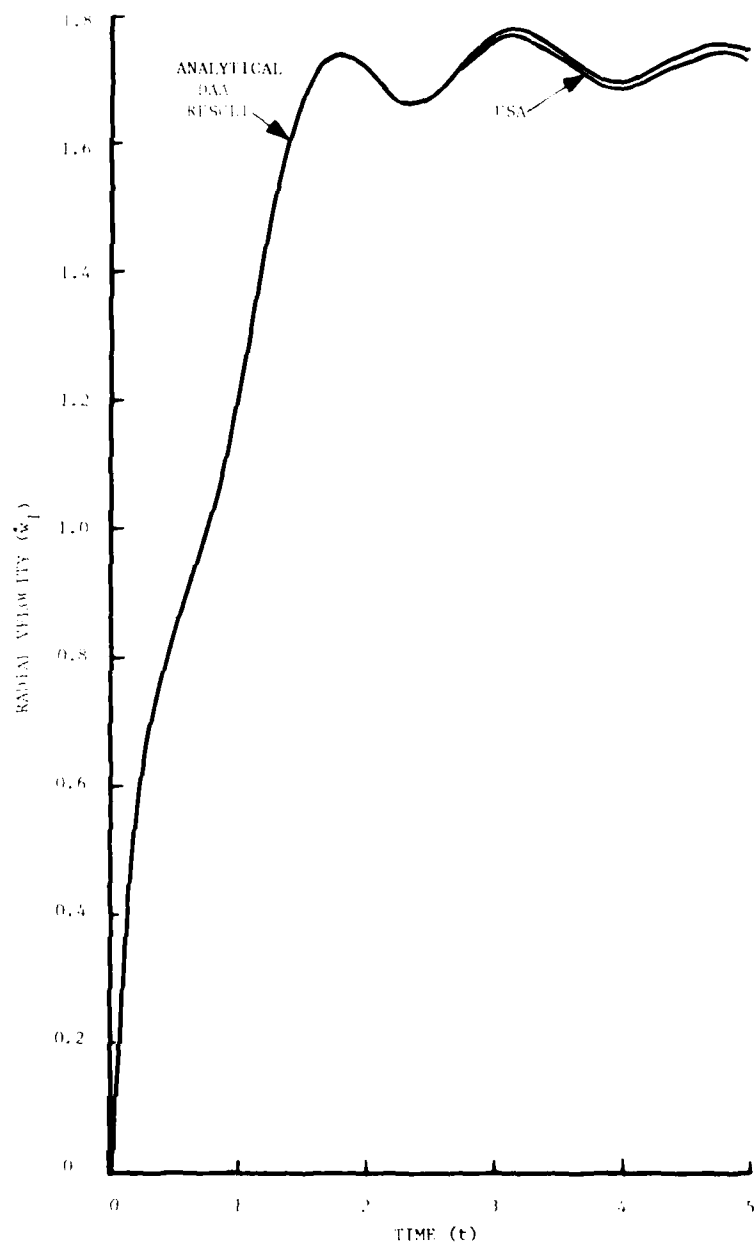


Figure 4-5 $n=1$ Radial Velocity of Infinite Cylinder in Infinite Fluid

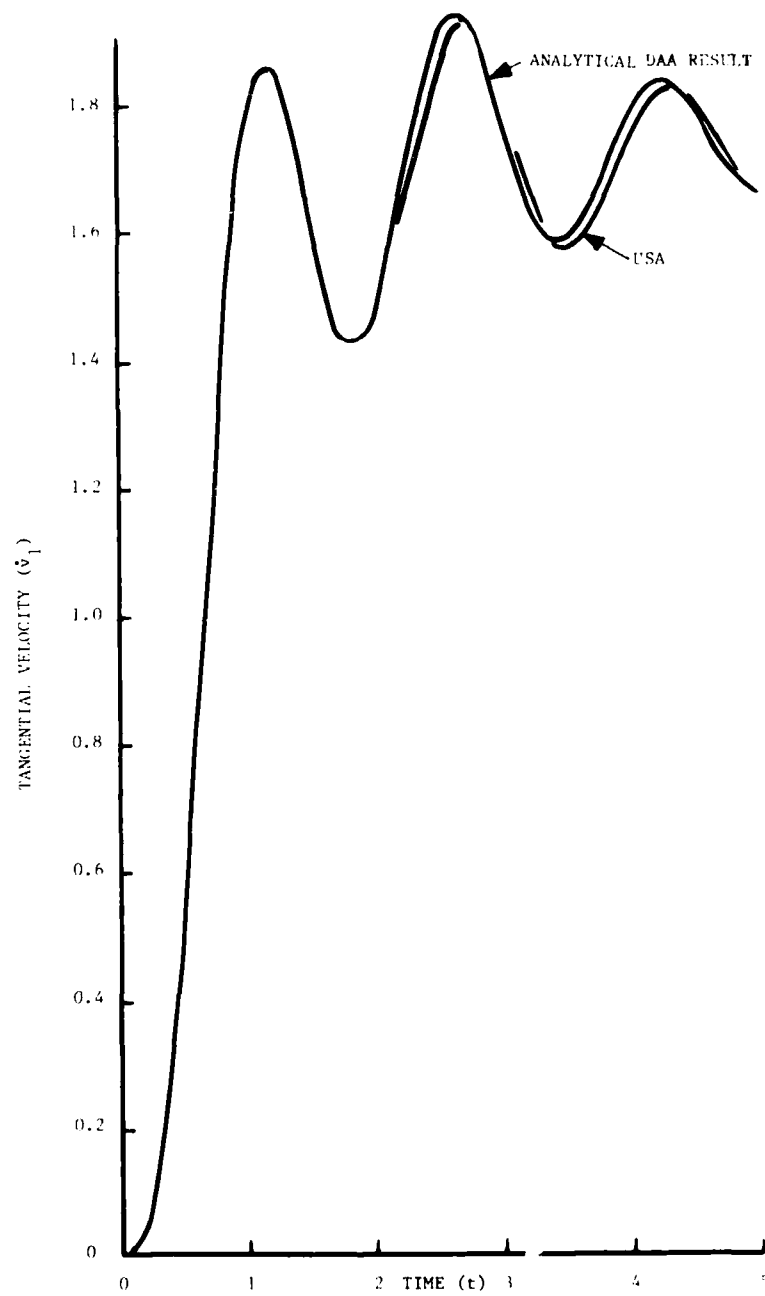


Figure 4-6 $n=1$ Tangential Velocity of Infinite Cylinder in Infinite Fluid

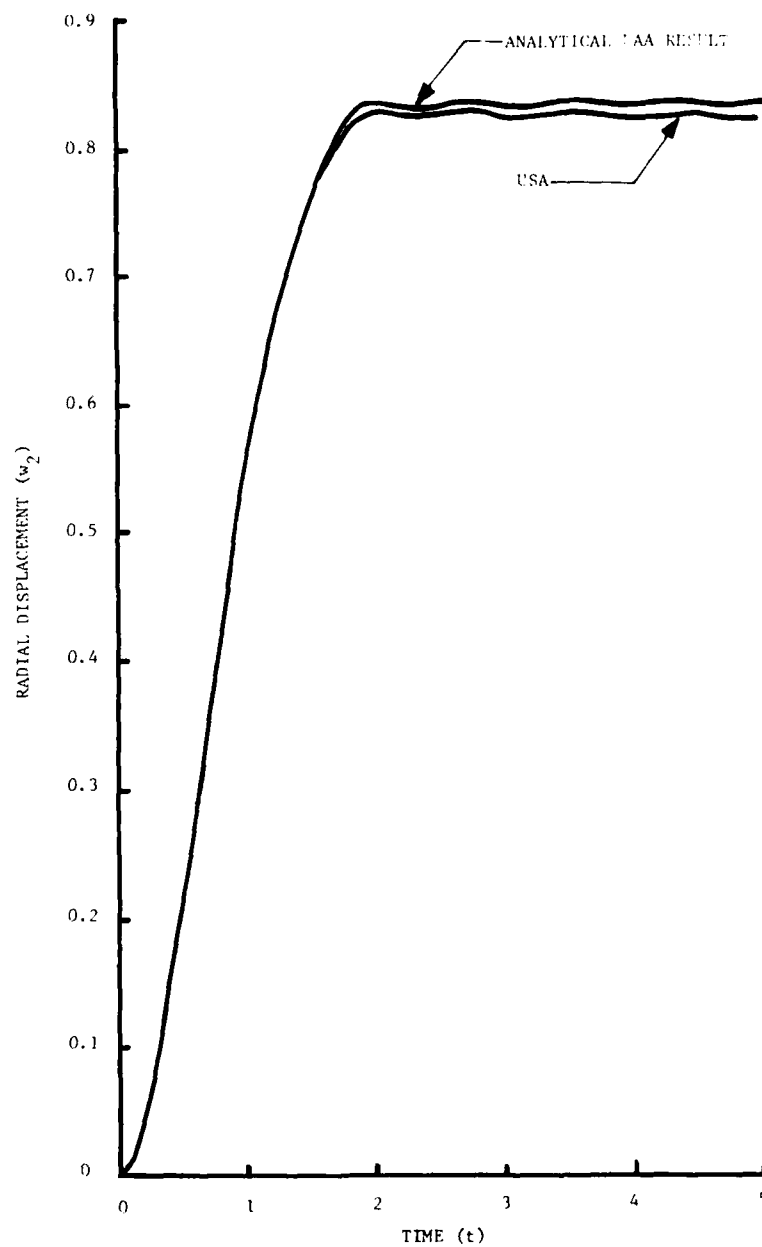


Figure 4-7 $n=2$ Radial Displacement of Infinite Cylinder
in Infinite Fluid

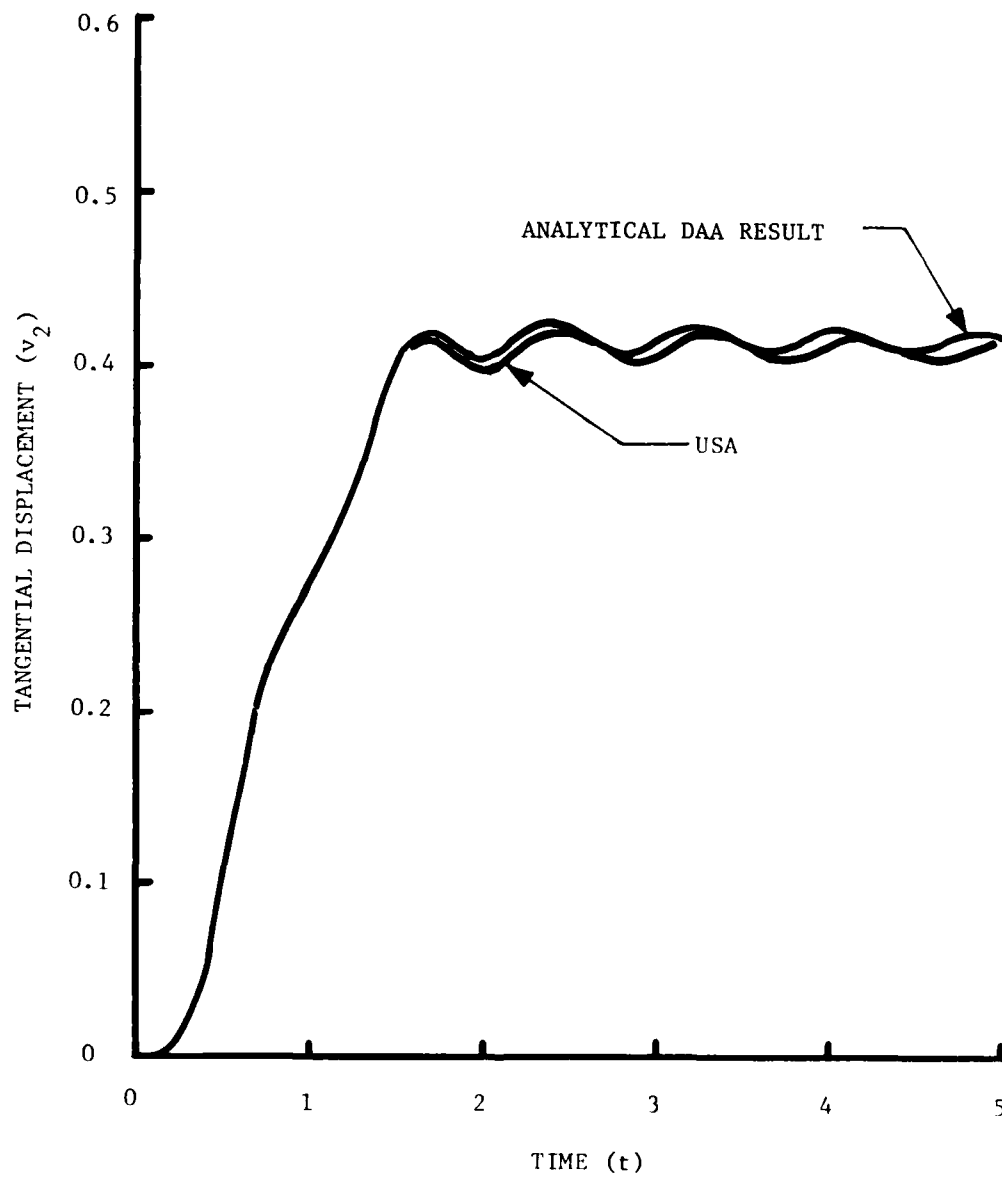


Figure 4-8 $n=2$ Tangential Displacement of Infinite Cylinder in Infinite Fluid

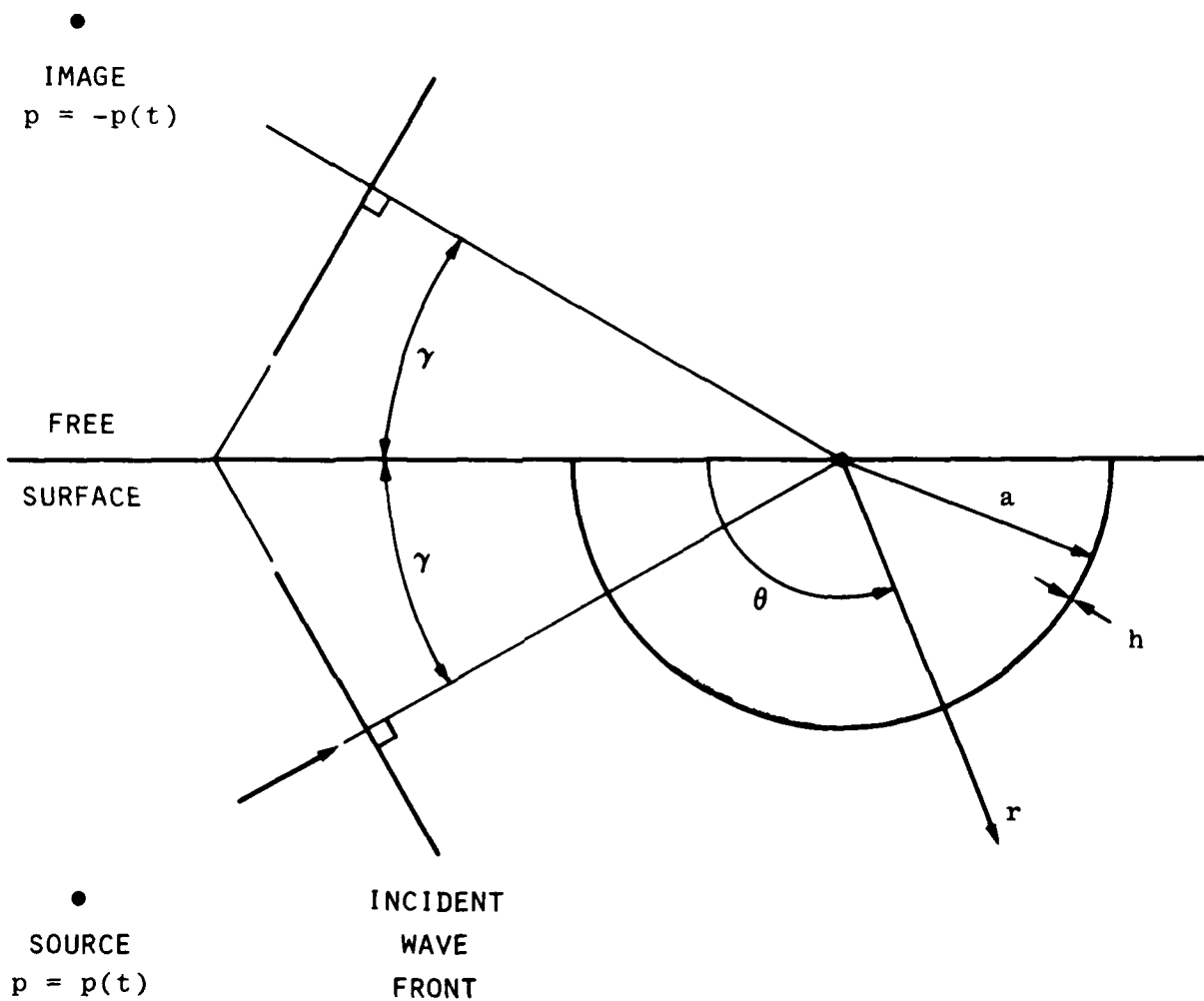


Figure 4-9 Geometry of Free Surface Problem for Plane Wave Impinging Upon Infinite Cylinder

$$\begin{pmatrix} w(\theta, t) \\ v(\theta, t) \\ p(r, \theta, t) \\ p_I(r, \theta, t) \\ u_I(r, \theta, t) \end{pmatrix} = \sum_{n=0}^{\infty} \begin{pmatrix} w_n^c(t) \cos n\theta & w_n^s(t) \sin n\theta \\ v_n^s(t) \sin n\theta & v_n^c(t) \cos n\theta \\ p_n^c(t) \cos n\theta & p_n^s(t) \sin n\theta \\ p_{In}^c(r, t) \cos n\theta & p_{In}^s(r, t) \sin n\theta \\ u_{In}^c(r, t) \cos n\theta & u_{In}^s(r, t) \sin n\theta \end{pmatrix} \quad (4.9)$$

where w and v are the radial and circumferential shell displacements, respectively, p is the total fluid pressure and p_I and u_I are the pressure and radial fluid-particle velocity of the incident wave. Because this is a linear problem, the solution consists of the superposition of two infinite-fluid solutions, the time-dependent part of which will be denoted by a superscript I . The result is

$$\begin{pmatrix} w(\theta, t) \\ v(\theta, t) \\ p(r, \theta, t) \end{pmatrix} = \sum_{n=0}^{\infty} (-1)^n \begin{pmatrix} w_n^I(t) \cos n(\theta - \gamma) \\ v_n^I(t) \sin n(\theta - \gamma) \\ p_n^I(r, t) \cos n(\theta - \gamma) \end{pmatrix} - \sum_{n=0}^{\infty} (-1)^n \begin{pmatrix} w_n^I(t) \cos n(\theta + \gamma) \\ v_n^I(t) \sin n(\theta + \gamma) \\ p_n^I(r, t) \cos n(\theta + \gamma) \end{pmatrix} \quad (4.10)$$

The multipliers $(-1)^n$ are required if the results of [3,4,30,32,33] are used to provide the infinite-fluid solutions for step-wave excitation. This is because of the convention adopted there that the incident wave first contacts the cylinder at $\theta = \pi$. It should be noted that (4.10) holds for any plane-wave input if the infinite-fluid solution can be found and no cavitation occurs in the fluid.

The trigonometric terms in (4.10) can easily be simplified to give

$$\begin{pmatrix} w(\theta, t) \\ v(\theta, t) \\ p(r, \theta, t) \end{pmatrix} = 2 \sum_{n=1}^{\infty} (-1)^n \sin n\gamma \begin{pmatrix} w_n^I(t) \sin n\theta \\ -v_n^I(t) \cos n\theta \\ p_n^I(r, t) \sin n\theta \end{pmatrix} \quad (4.11)$$

Note from (4.10) that the solution for $n=0$ is identically zero. Also note that if the time-dependent part of the free surface solution is denoted by a superscript F , then

$$\begin{pmatrix} w_n^F(t) \\ v_n^F(t) \\ p_n^F(r, t) \end{pmatrix} = (-1)^n 2 \sin n\gamma \begin{pmatrix} w_n^I(t) \\ -v_n^I(t) \\ p_n^I(r, t) \end{pmatrix} \quad (4.12)$$

This extremely simple result applies to exact solutions produced by the residual potential method [3,30,32], approximate solutions produced by the DAA [3,4], and the approximate post-envelopment solutions given in [33].

For a USA-Code treatment of this problem, a 40-node, 19-element SPAR half-model was constructed consisting of one 5° plate element, seventeen 10° plate-elements and a second 5° plate-element. The angle γ was taken as 45°. In other respects, this analysis paralleled that of the totally submerged cylindrical shell described in Subsection 4.2.

Velocity responses for $n=1$ are shown in Figures 4-10 and 4-11, while displacement results for $n=2$ are shown in Figures 4-12 and 4-13. The level of USA-Code error for $n=1$ is about 1%; it is of interest to note that the approximate asymptotic velocity provided by the analysis of [31] is $V_\infty = 2.623$, which is about 10% high.

The $n=2$ post-envelopment solution during the final phase of shell envelopment is quite sensitive to temporal and spatial discretization details. This sensitivity is reflected in the level of USA-Code error exhibited in Figures 4-12 and 4-13, and is associated with the pressure discontinuity at the front of the step-wave. The error here is somewhat greater than that in Figures 4-7 and 4-8, as both the incident wave and its negative image are now involved.

4.4 DAA₂ STUDIES

As an initial test of USA-DAA₂, the infinite-cylinder case has also been run and physical response variables have been Fourier-decomposed to produce modal responses. For comparison, corresponding exact solutions have been obtained analytically by the residual potential (RP) method [30]. Comparisons are shown in Figures 4-14 through 4-18.

The difference between the family of doubly asymptotic solutions and the exact solution shown in Figure 4-14 is intrinsic to the infinite cylinder and occurs because of the infinite value of the $n=0$ fluid mass coefficient. Hence the interaction consists only of the high frequency asymptote of the DAA family. For a finite cylinder, the fluid mass for the breathing mode is always finite, so that the low-frequency contribution of the DAA family does participate.

Velocity responses for $n=1$ are shown in Figures 4-15 and 4-16, where it is noted that $\eta=0$ (DAA_1) and $\eta = 1$ provide rather wide bounds on the exact solution in the intermediate time range, while a value of $\eta = 1/2$ is remarkably close to the exact solution. In Figures 4-17 and 4-18, the displacement responses do not show such wide differences between $\eta = 1/2$ and $\eta = 1$; however, they both demonstrate a striking superiority over the DAA_1 result. It would appear from this limited evidence that $\eta = 1/2$ is probably optimum for the infinite cylinder case.

In closing, it should be emphasized that a study of the stability of (2.34) and (2.35) has yet to be undertaken. However, the results obtained thus far are very encouraging in this regard. No indication of instability whatsoever was encountered in generating the infinite cylinder results in which the time step was doubled twice during the run, as was done in the DAA_1 runs.

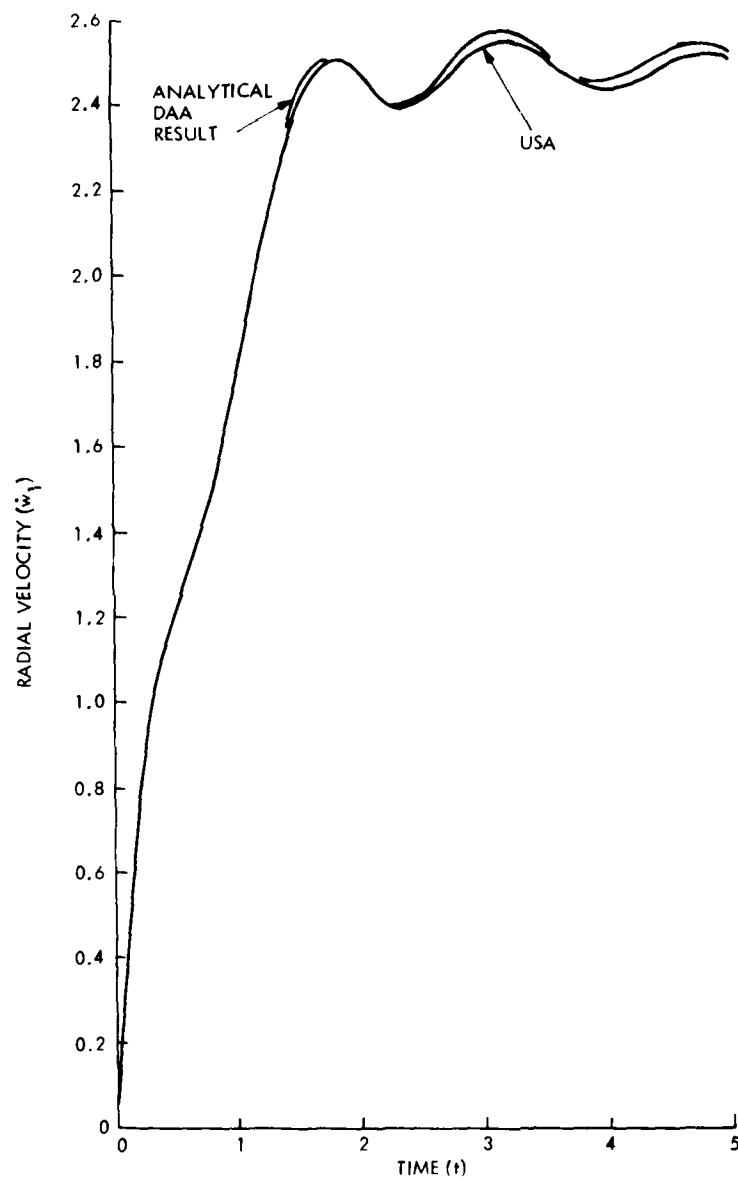


Figure 4-10 $n=1$ Radial Velocity of Infinite Cylinder at Surface of Semi-Infinite Fluid

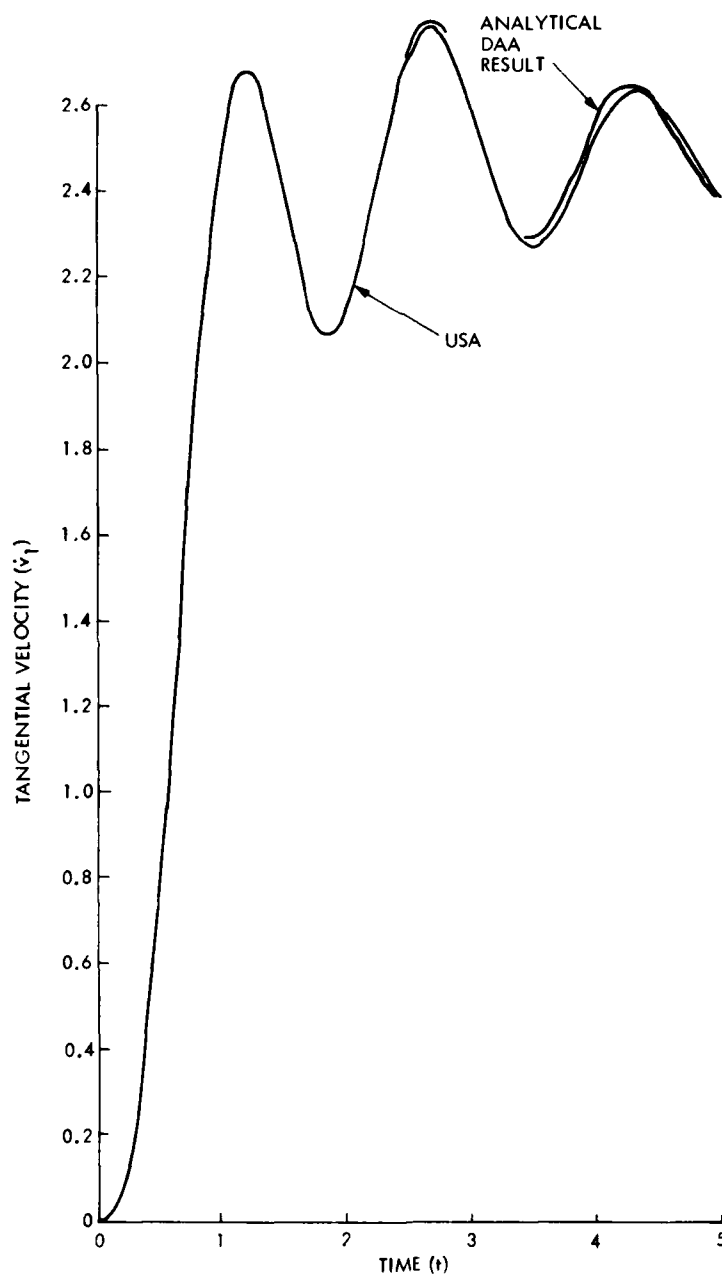


Figure 4-11 $n=1$ Tangential Velocity of Infinite Cylinder at Surface of Semi-Infinite Fluid

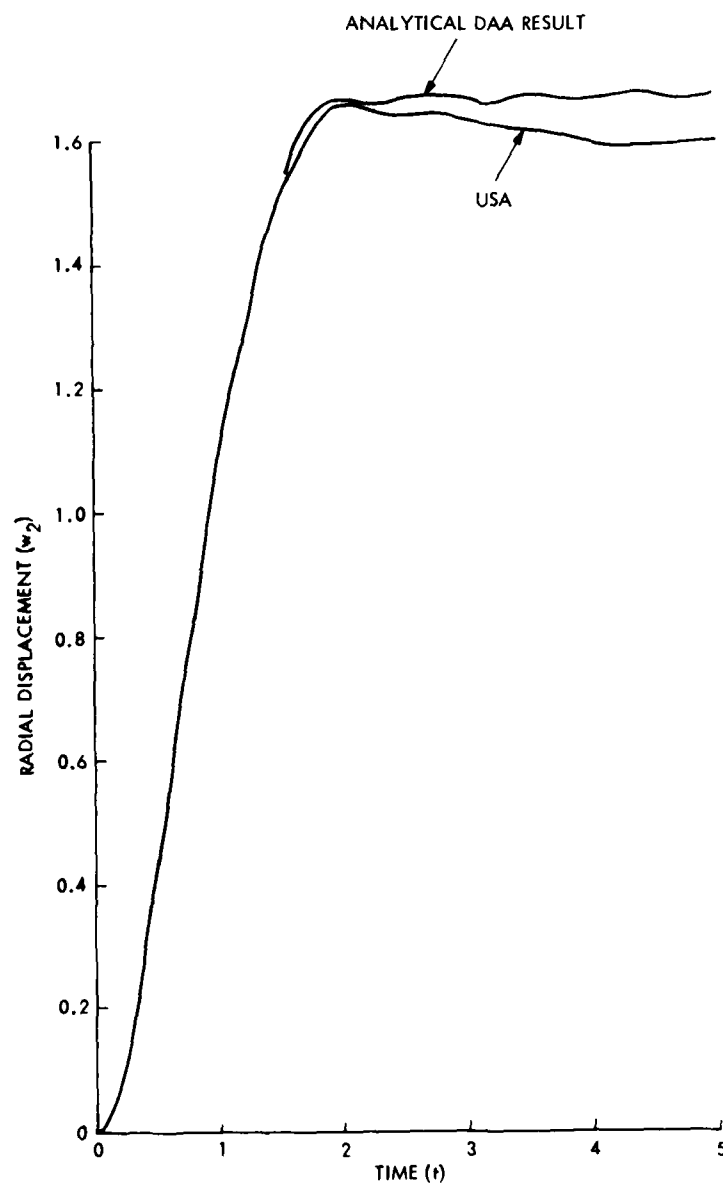


Figure 4-12 $n=2$ Radial Displacement of Infinite Cylinder at Surface of Semi-Infinite Fluid

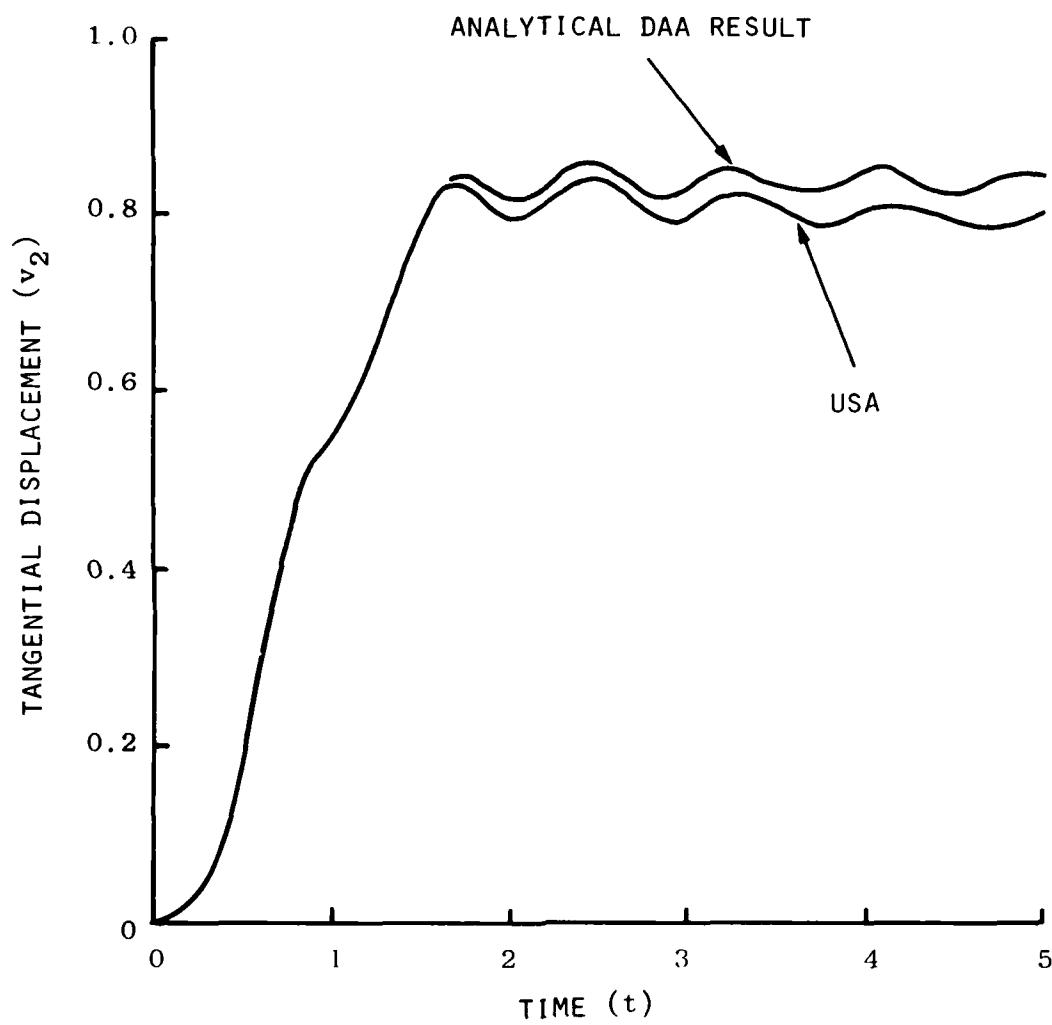


Figure 4-13 $n=2$ Tangential Displacement of Infinite Cylinder at Surface of Semi-Infinite Fluid

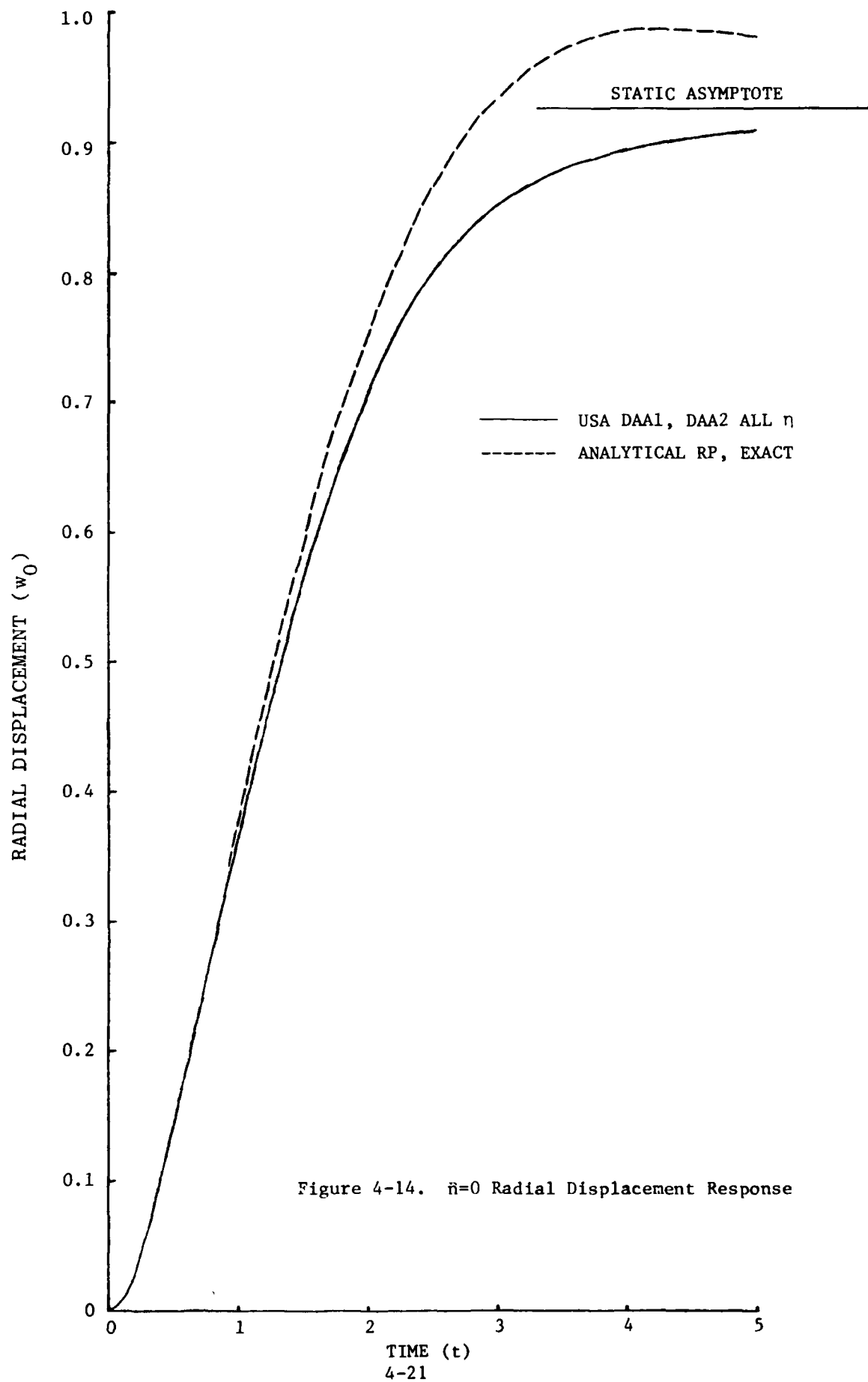


Figure 4-14. $\bar{n}=0$ Radial Displacement Response

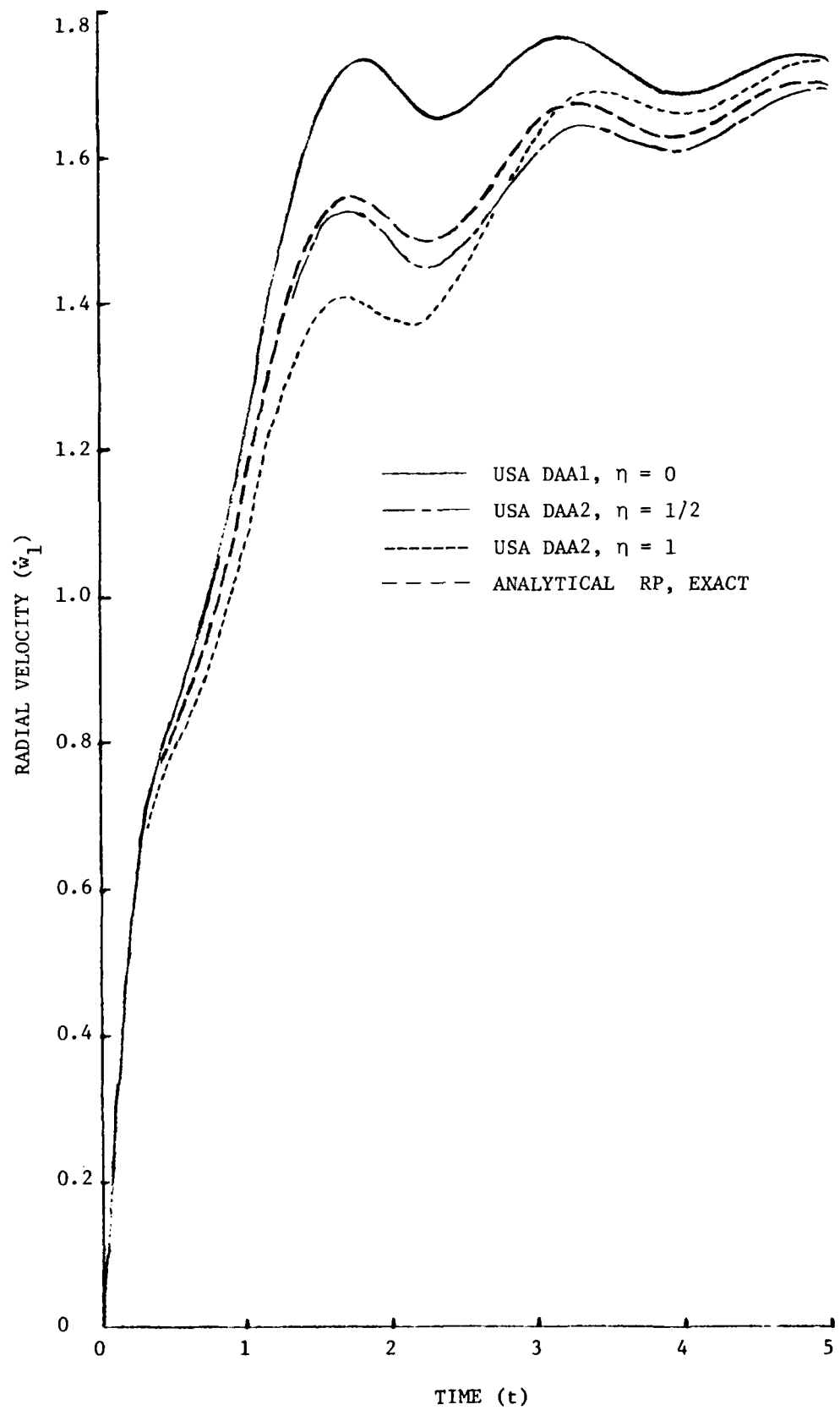


Figure 4-15. n=1 Radial Velocity Response

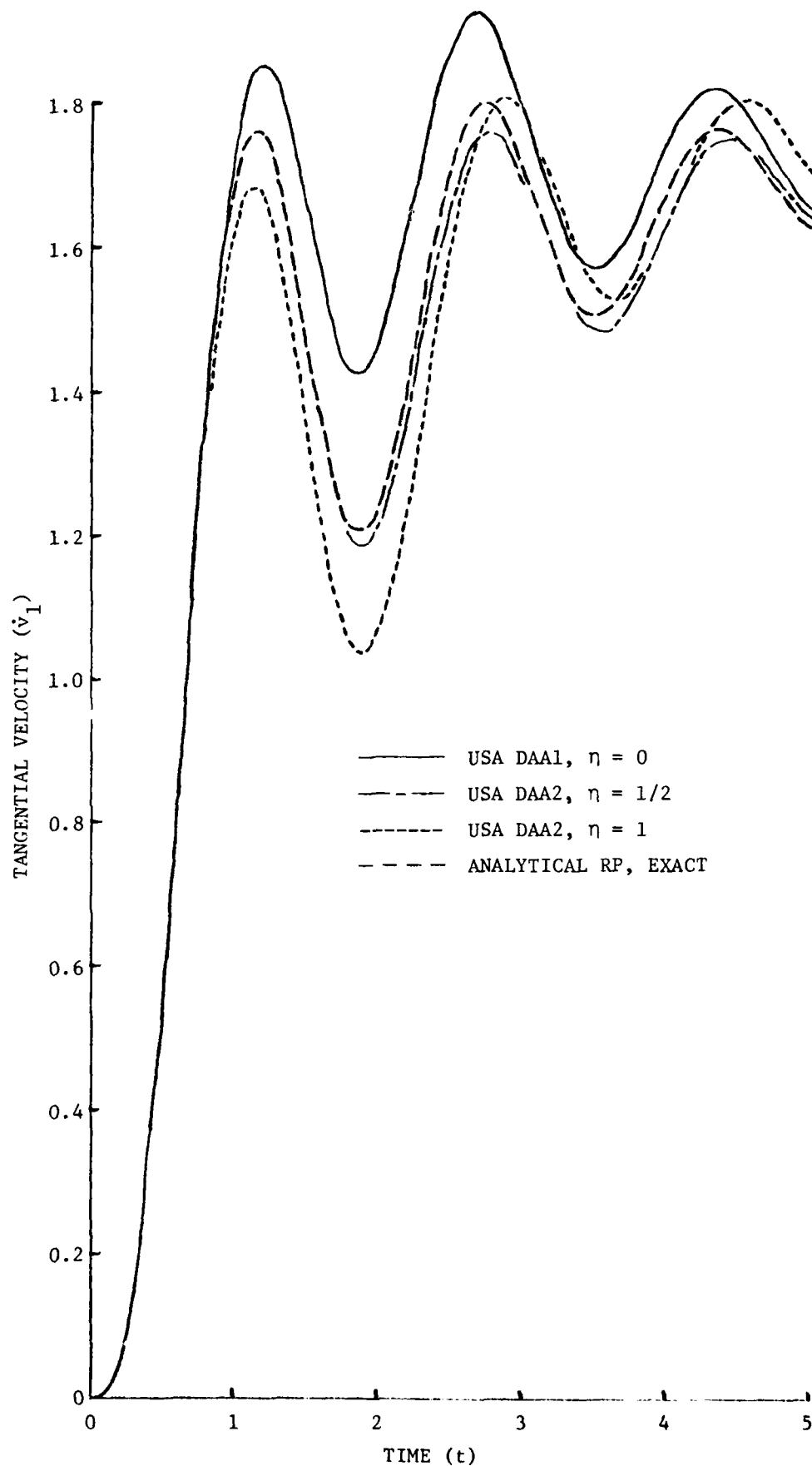


Figure 4-16. $n=1$ Tangential Velocity Response

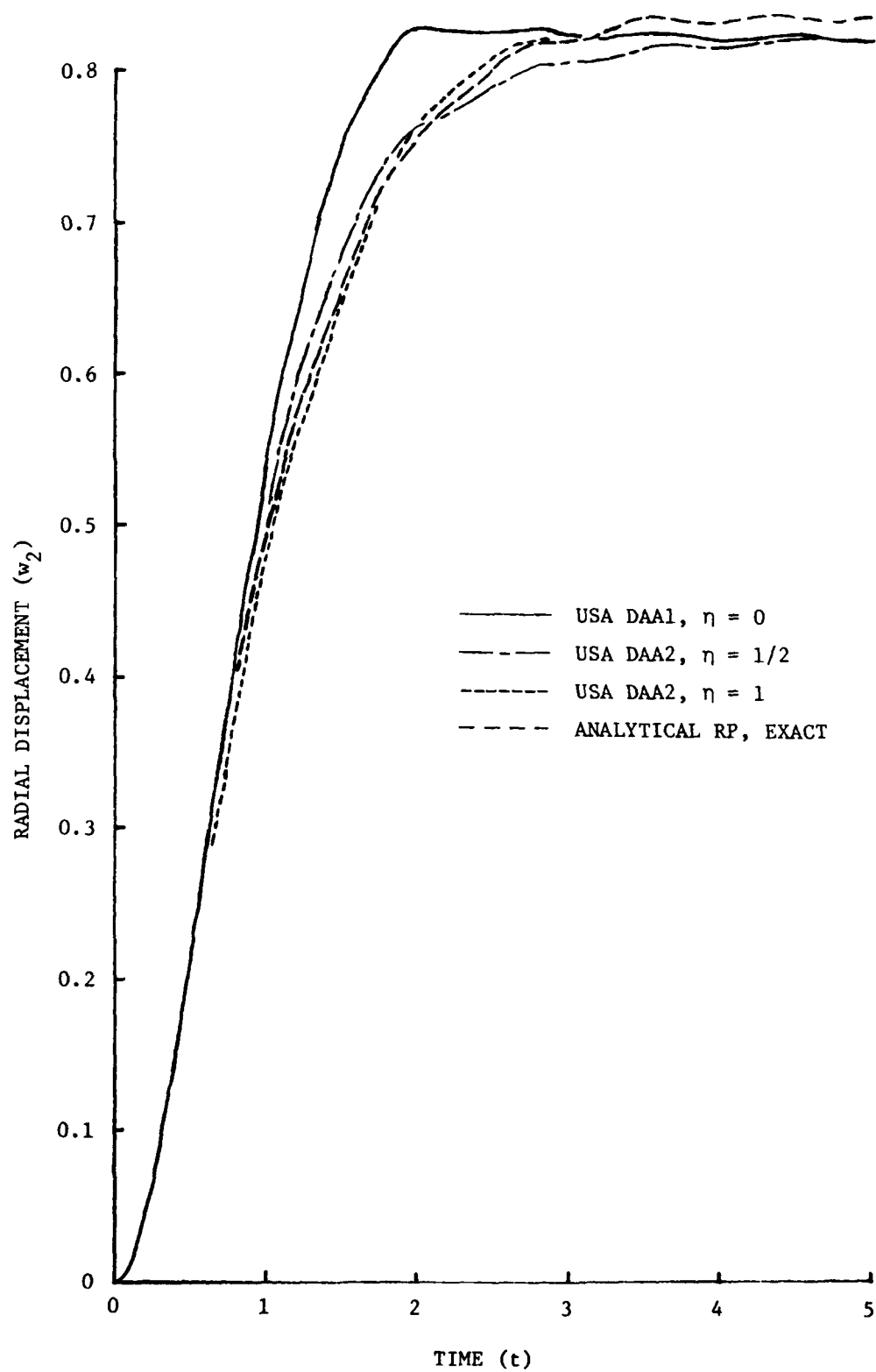


Figure 4-17. $n=2$ Radial Displacement Response

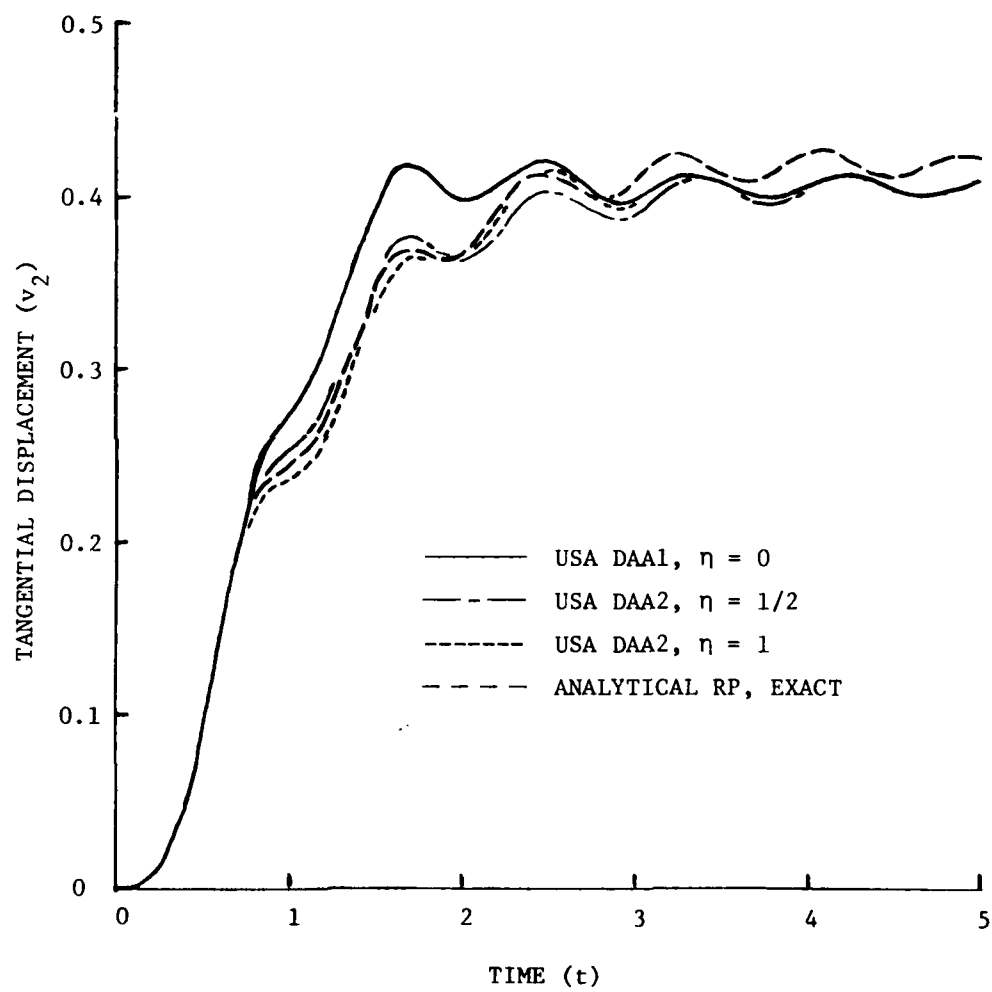


Figure 4-18. $n=2$ Tangential Displacement Response

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APPENDIX A
USER INFORMATION FOR THE FLUID PREPROCESSOR FLUMAS

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

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F L U M A S

THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE
CONSTRUCTS THE FLUID MASS MATRIX FOR A STRUCTURE SUBMERGED IN AN
INFINITE, INVISCID, INCOMPRESSIBLE FLUID BY THE BOUNDARY ELEMENT
TECHNIQUE. IT ALSO GENERATES FLUID MESH DATA AND A SET OF
TRANSFORMATION COEFFICIENTS THAT RELATE THE STRUCTURAL AND FLUID
DEGREES OF FREEDOM ON THE WET SURFACE. THE CODE HAS THE CAPABILITY
TO TREAT STRUCTURES CONTAINING BOTH SURFACE-OF-REVOLUTION (SOR)
AND GENERAL-GEOMETRY (GEN) COMPONENTS. THE CODE CAN CONSTRUCT THE
FLUID MASS MATRIX FOR BOTH QUARTER AND HALF MODELS WITH
ARBITRARILY ASSIGNED SYMMETRY OR ANTISYMMETRY CONDITIONS. AND CAN
SIMULATE THE TWO-DIMENSIONAL PLANE STRAIN BEHAVIOR OF LONG
CYLINDERS. THE PRESENCE OF A FREE SURFACE IN THE VICINITY OF THE
SUBMERGED STRUCTURE CAN ALSO BE ACCOUNTED FOR. A VERY USEFUL
DIAGNOSTIC TOOL CONTAINED WITHIN THE CODE IS THE ABILITY TO SOLVE
THE FLUID BOUNDARY MODE EIGENVALUE PROBLEM

THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNTZ, JR.
OF LOCKHEED MISSILES AND SPACE RESEARCH LABS IN PALO ALTO
CALIFORNIA. PLEASE CONSULT WITH AUTHOR BEFORE MAKING CHANGES
AND ALSO REPORT ANY MALFUNCTIONS OR PROBLEMS. WRITE IN CARE OF
LOCKHEED PALO ALTO RESEARCH LABORATORY, BLDG 205, DEPT 52-33,
3251 HANOVER ST., PALO ALTO, CA 94304 OR CALL 415-493-4411
EXTS. 45069 OR 45133. SEPTEMBER, 1980

M A X I M U M V A L U E S

MAXIMUM NUMBER OF STRUCTURAL GRID POINTS	1000
MAXIMUM NUMBER OF GENERAL SURFACE ELEMENTS	400
MAXIMUM NUMBER OF SURFACE OF REVOLUTION SEGMENTS	200
MAXIMUM NUMBER OF SURFACE OF REVOLUTION BRANCHES	6

W A R N I N G F R O M T H E P R O G R A M M E R G E N E R A L

THIS CODE CONTAINS THE SPECIAL INGREDIENT DWGASP NOT FOUND IN
OTHER BRANCHES. DWGASP IS A DATA MANAGEMENT UTILITY MODULE THAT
WILL ACTIVATE AND DEACTIVATE ALL AUXILIARY STORAGE DATA FILES
REFERENCED BY THE CODE. HENCE THE NAMES OF SUCH FILES SHOULD NOT
APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH MIGHT NORMALLY
ACTIVATE AND DEACTIVATE THE FILES. THE USER IS ALSO CAUTIONED THAT

PREVIOUSLY CREATED FILES MUST ALREADY BE RESIDENT IN THE SYSTEM BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN ROLLED-OUT TO TAPE DMGASP WILL ATTEMPT TO HAVE THE FILE ROLLED-IN EVERY 15 SECONDS FOR UP TO 6 MINUTES ON THE UNIVAC 1100-EXEC 8 OPERATING SYSTEM. IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT IS THEREFORE GOOD POLICY TO SIMPLY ACTIVATE AND DEACTIVATE THE FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN EXISTING FILE, THE UNIVAC VERSION OF DMGASP WILL MODIFY THE NAME OF THE FILE GENERATED BY THIS RUN TO AVOID ANY CONFLICT. FILE NAME DUPLICATION WILL CAUSE NO PROBLEM ON THE CDC SCOPE OPERATING SYSTEM AS SCOPE WILL SIMPLY CATALOG A NEW CYCLE OF THE SAME FILE. ON THE OTHER HAND THE CDC NOS SYSTEM IS SIMILAR TO UNIVAC IN THIS REGARD AND THE RUN WILL ABORT SINCE THE NAME-CHANGING FEATURE OF DMGASP HAS NOT BEEN IMPLEMENTED FOR NOS. QUALIFIER*FILENAME IS THE REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC PERMANENT FILE NAMES. ON CDC SCOPE, THE QUALIFIER IS INTERPRETED AS THE USER'S ID, WHICH IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC NOS, THE QUALIFIER IS INTERPRETED AS THE USER'S CATALOG NUMBER, WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER*FILENAME(CYCLE) ON CDC SCOPE

PROGRAM SIZE

ALL ARRAYS REFERENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-05 VERSION, HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH REQUEST IN THE CONTROL CARD DECK

DEFINITION OF INPUT PARAMETERS

INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO STANDARD FORTRAN USAGE:

A	-	ALPHANUMERIC
E	-	FLOATING POINT
F	-	FIXED POINT
I	-	INTEGER
L	-	LOGICAL

VARIABLE	TYPE	DESCRIPTION
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NSTRC	I	NUMBER OF STRUCTURAL NODES OR GRID POINTS
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117 WHOSE GLOBAL COORDINATES ARE TO BE READ AS
 118 INPUT DATA FROM CARDS. AT THE VERY LEAST
 119 THE SUM OF NSTRF AND NSTRF (SEE BELOW)
 120 MUST INCLUDE ALL THE WET NODES, I.E., THOSE
 121 LYING ON THE FLUID-STRUCTURE CONTACT
 122 BOUNDARY. IF THE ULTIMATE PURPOSE OF THIS
 123 RUN IS TO CONDUCT AN UNDERWATER SHOCK
 124 ANALYSIS WITH THE USA CODE FOR THE
 125 STRUCTURE IN QUESTION THEN IT IS ADVISABLE
 126 TO INCLUDE IN THE INPUT TO THIS PROCESSOR
 127 ALL OF THE INTERNAL OR DRY STRUCTURAL NODE
 128 POINTS AS WELL IN ORDER TO FACILITATE POST
 129 PROCESSING OF THE TRANSIENT RESPONSE
 130 ANALYSIS FOR THE DRY STRUCTURE. THIS
 131 NUMBER MAY ALSO INCLUDE ADDITIONAL NODE
 132 POINTS THAT ARE NOT PART OF THE STRUCTURAL
 133 MODEL BUT WHICH ARE NECESSARY TO DEFINE
 134 THE FLUID MESH. HOWEVER SUCH ADDITIONAL
 135 NODES SHOULD APPEAR LAST AS THEY ARE NOT
 136 REQUIRED BY ANY OTHER USA PROCESSOR AND
 137 ARE THEREFORE ULTIMATELY DELETED
 138

139 NSTRF 1 NUMBER OF STRUCTURAL NODE OR GRID POINTS
 140 WHOSE GLOBAL COORDINATES ARE TO BE READ
 141 FROM A PERMANENT FILE (SEE GDSNAM).
 142 ADDITIONAL NODE POINTS THAT ARE NOT PART
 143 OF THE STRUCTURAL MODEL ARE NOT PERMITTED
 144 IN THIS DATA SET IF ACTUAL STRUCTURAL NODE
 145 POINT DATA IS ALSO INPUT FROM CARDS. THIS
 146 IS DUE TO THE FACT THAT THE FILE DATA IS
 147 READ FIRST THEN THE DATA FROM CARDS AND
 148 ANY ADDITIONAL NON-STRUCTURAL NODE POINTS
 149 MUST APPEAR LAST IN THE GRID POINT LIST.
 150 THIS FILE MUST ALWAYS BE REFERENCED WHEN
 151 INTERFACING WITH STAGS
 152

153 NGEN 1 NUMBER OF GENERAL FLUID DEGREES OF FREEDOM
 154 WHOSE ASSOCIATED ELEMENTS CANNOT BE FORMED
 155 BY AN AUTOMATIC MESH GENERATION PROCEDURE
 156

157 NBRA 1 NUMBER OF DISTINCT SURFACE OF REVOLUTION
 158 AXES OR BRANCHES
 159

160 NCYL 1 NUMBER OF GENERAL FLUID CONTROL POINTS
 161 WHICH LIE ON A RIGHT CIRCULAR CYLINDRICAL
 162 SURFACE WHOSE ASSOCIATED RECTANGULAR
 163 ELEMENTS COVER THE ENTIRE LATERAL SURFACE.
 164 SUCH ELEMENTS CAN BE FORMED BY AN
 165 AUTOMATIC MESH GENERATION SCHEME WHICH IS
 166 EXTENDED IN THE CODE. STRUCTURAL GRID
 167 POINT COORDINATES NEED NOT BE INPUT IN
 168 THIS CASE UNLESS DICTATED BY OTHER
 169 CIRCUMSTANCES
 170

171 MHAS 1 STARTING CIRCUMFERENTIAL HARMONIC FOR
 172 SURFACE OF REVOLUTION ELEMENTS
 173

174 NHAF 1 FINAL CIRCUMFERENTIAL HARMONIC FOR

233 DAA1 RUNS IT IS ADVISEABLE TO ENTER A
234 NONZERO VALUE AND THE PRECISE VALUE CAN BE
235 CHANGED LATER IN THE AUGMAT PROCESSOR IF
236 NECESSARY. IF A ZERO VALUE IS ENTERED THEN
237 TWO MATRICES REQUIRED FOR DAA2 EXECUTION
238 ARE NOT EVEN CONSTRUCTED
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PRTGMT L TRUE IF FLUID MESH GEOMETRY DATA IS TO BE LISTED, OTHERWISE FALSE

PRTRN L TRUE IF FLUID-STRUCTURE TRANSFORMATION DATA IS TO BE LISTED, OTHERWISE FALSE

PRTMF L TRUE IF FLUID MASS MATRIX IS TO BE LISTED, OTHERWISE FALSE IN WHICH CASE ONLY THE DIAGONAL TERMS ARE PRINTED. THIS PARAMETER ALSO GOVERNS THE PRINTING OF THE MATRIX THAT APPEARS IN THE DAA EQUATIONS

CALCAM L TRUE IF THE FLUID MASS MATRIX IS TO BE COMPUTED, OTHERWISE FALSE AND THE RUN WILL TERMINATE AFTER THE FLUID MESH GEOMETRY DATA HAS BEEN PROCESSED. USE A VALUE OF TRUE ONLY AFTER DEBUGGING OF THE GEOMETRY DATA HAS BEEN COMPLETED

PRTCOE L TRUE IF THE B AND C MATRICES ARE TO BE PRINTED FOR SOME DIAGNOSTIC REASON, OTHERWISE FALSE UNDER NORMAL OPERATING CONDITIONS. THESE MATRICES ARE FULL AND GENERALLY NONSYMMETRIC. THE PRODUCT B-CINVT IS THE PRINCIPAL COMPUTATION THAT IS REQUIRED TO FORM THE FLUID MASS MATRIX (SEE PERUNTZ AND GERS, ADDED MASS COMPUTATION BY THE BOUNDARY INTEGRAL METHOD, INT J NUM METH, VOL 12, 1978, PP 531-550)

EIGMAF L TRUE IF EIGENVALUES AND EIGENVECTORS OF THE FLUID BOUNDARY MODE PROBLEM ARE DESIRED, OTHERWISE FALSE. THE PRESENCE OF NEGATIVE EIGENVALUES IS AN INDICATION THAT THE FLUID MESH IS IN ERROR, HENCE THIS CAN BE AN IMPORTANT DEBUGGING TOOL

TWODIM L TRUE IF A TWO DIMENSIONAL PLANE STRAIN FLUID MASS MATRIX IS REQUIRED, OTHERWISE FALSE. THE Z DIRECTION MUST BE PERPENDICULAR TO THE PLANE OF THE FLUID MODEL. IF THIS IS NOT SO A TEMPORARY OR PERMANENT COORDINATE ROTATION CAN BE APPLIED FOR COMPUTATION OF THE MATRIX (SEE ROTQUA OR ROTGLO)

HAFMOD L TRUE IF THE FLUID MESH INPUT GEOMETRY CORRESPONDS TO A HALF MODEL, OTHERWISE FALSE. THE VARIABLES DEPTH, CXFS, CYFS, AND CZFS ARE USED TO DEFINE THE LOCATION

291 AND ORIENTATION OF THE SYMMETRY PLANE.
 292 THIS OPTION CANNOT BE USED SIMULTANEOUSLY
 293 WITH PRESUR = .TRUE.
 294

295 QUAMOD L TRUE IF THE FLUID MESH INPUT GEOMETRY
 296 CORRESPONDS TO A QUARTER MODEL. OTHERWISE
 297 FALSE. THE X2 AND Y2 PLANES ARE CONSIDERED
 298 TO BE THE PLANES OF SYMMETRY OF THE MODEL
 299 BY DEFAULT. IF NECESSARY, A COORDINATE
 300 ROTATION CAN BE APPLIED TO SATISFY THIS
 301 REQUIREMENT (SEE ROTQUA BELOW). IF NCYL IS
 302 NOT EQUAL TO ZERO SUCH A ROTATION MUST BE
 303 USED IN CONJUNCTION WITH THE QUARTER
 304 MODEL. THIS ROTATION WILL NOT AFFECT THE
 305 ORIENTATION OF THE FLUID MESH REFERENCE
 306 AXES IN SUBSEQUENT USA PROCESSING
 307

308 PCHCDS L TRUE IF THE DIAGONAL GENERALIZED AREA
 309 MATRIX IS TO BE PUNCHED OUT ON CARDS FOR
 310 INPUT TO NASTRAN. OTHERWISE FALSE
 311

312 NASTAM L TRUE IF THE FLUID MASS MATRIX OR ITS
 313 MANIPULATED FORM WHICH APPEARS IN THE DAA
 314 EQUATION IS TO BE PUT IN THE PERMANENT
 315 FILE DESIGNATED BY FLUNAM IN A FORMAT
 316 WHICH CAN BE READ BY NASTRAN. OTHERWISE
 317 FALSE
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319 STOMAS L TRUE IF THE FLUID MASS MATRIX ITSELF IS TO
 320 BE PUT IN PERMANENT STORAGE. OTHERWISE
 321 FALSE. IN CONTRAST TO EARLIER VERSIONS OF
 322 THIS CODE THIS PARAMETER CAN BE SET TO
 323 FALSE FOR NORMAL OPERATION OF THE USA CODE
 324

325 STOINV L TRUE IF THE MANIPULATED FORM OF THE FLUID
 326 MASS MATRIX WHICH APPEARS IN THE DAA
 327 EQUATION IS TO BE PUT IN PERMANENT
 328 STORAGE. OTHERWISE FALSE. THIS MATRIX
 329 CONSISTS OF THE INVERTED FLUID MASS MATRIX
 330 THAT HAS BEEN PRE- AND POST-MULTIPLIED BY
 331 THE DIAGONAL FLUID ELEMENT AREA MATRIX AND
 332 THEN MULTIPLIED BY BOTH THE MASS DENSITY
 333 AND THE SPEED OF SOUND OF THE FLUID. IN
 334 CONTRAST WITH EARLIER VERSIONS OF THIS
 335 CODE THIS PARAMETER MUST BE SET TO TRUE
 336 FOR NORMAL OPERATION OF THE USA CODE
 337

338 FRWTF L TRUE IF THE PERMANENT FILE CONTAINING THE
 339 FLUID MASS MATRIX OR ITS MANIPULATED FORM
 340 IS TO BE CREATED BY BUFFERED, UNFORMATTED
 341 FORTRAN WRITE STATEMENTS. OTHERWISE FALSE
 342 AND DMGASP WILL CREATE THE FILE
 343

344 FRWTGE L TRUE IF THE PERMANENT FILE CONTAINING THE
 345 FLUID MESH GEOMETRY IS TO BE CREATED BY
 346 BUFFERED, UNFORMATTED FORTRAN WRITE
 347 STATEMENTS. OTHERWISE FALSE AND DMGASP
 348 WILL CREATE THE FILE

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FRWTGR L TRUE IF THE PERMANENT FILE CONTAINS
STRUCTURAL GRID POINT COORDINATES HAS
BEEN CREATED BY BUFFERED, UNFORMATTED
FORTRAN WRITE STATEMENTS, OTHERWISE FALSE
IN WHICH CASE IT IS ASSUMED THAT DWGASP
WAS USED TO CREATE THE FILE. CONSULT A
LISTING OF THE SUBROUTINE READST FOR THE
FILE STRUCTURE THAT IS EXPECTED WHICH
DIFFERS FOR THE TWO POSSIBLE CASES. THIS
FILE MUST EXIST FOR INTERFACING WITH STAGS

FRESUR L TRUE IF FREE SURFACE EFFECTS ARE TO BE
INCLUDED IN THE FLUID MASS MATRIX,
OTHERWISE FALSE. THE VARIABLES DEPTH,
CYFS, CYFS, AND CZFS ARE USED TO DEFINE
THE LOCATION AND ORIENTATION OF THE FREE
SURFACE. THIS OPTION CANNOT BE USED
SIMULTANEOUSLY WITH HAFMOD = .TRUE.

RENUMB L TRUE IF SOME RENUMBERING OF THE STRUCTURAL
NODE NUMBERS MUST BE CARRIED OUT AFTER THE
FLUID-STRUCTURE TRANSFORMATION DATA HAS
BEEN GENERATED, OTHERWISE FALSE. THIS
OPTION IS IMPORTANT IF THE USE OF A
PARTICULAR STRUCTURAL NODE NUMBER IS
CONVENIENT TO DEFINE THE FLUID MESH OUT.
INSTEAD, A NEARBY STRUCTURAL NODE SHOULD
BE USED FOR FORCE APPLICATION DURING THE
UNDERWATER SHOCK ANALYSIS TIME INTEGRATION
RUN. THIS CASE IS PARTICULARLY IMPORTANT
IF THE TWO POINTS IN QUESTION ARE JOINED
BY A RIGID LINK AND THE STRUCTURAL POINT
ORIGINALLY USED TO DEFINE THE FLUID MESH
IS ELIMINATED FROM THE STIFFNESS MATRIX BY
A CONSTRAINT EQUATION. WITHOUT THE USE OF
THIS OPTION THE APPROPRIATE FORCE WOULD
NOT BE APPLIED TO THE EQUATIONS OF MOTION

STOGMT L TRUE IF THE FLUID MESH GEOMETRY AND
FLUID-STRUCTURE TRANSFORMATION DATA IS TO
PUT IN PERMANENT STORAGE, OTHERWISE FALSE

ROTGE0 L TRUE IF THE FLUID MESH GEOMETRY IS TO BE
REFERENCED TO A SET OF GLOBAL COORDINATE
AXES WHICH IS DIFFERENT FROM THAT OF THE
BASIC INPUT DATA FOR ALL SUB-ROUTINE DATA
PROCESSING (SEE GEANG). OTHERWISE FALSE

ROTQUA L TRUE IF THE FLUID MESH GEOMETRY IS TO BE
REFERENCED TO A SET OF GLOBAL COORDINATE
AXES WHICH IS DIFFERENT FROM THAT OF THE
BASIC INPUT DATA ONLY FOR COMPUTATION OF
THE FLUID MASS MATRIX (SEE QUANG).
OTHERWISE FALSE. THIS OPTION IS TO BE USED
IF A QUARTER MODEL IS REQUIRED AND THE
INPUT DATA REFERENCE AXES DO NOT COINCIDE
WITH THE DEFAULT SYMMETRY AXES. THIS

407 FEATURE CAN ALSO BE USED IN CONJUNCTION
408 WITH THE TWO DIMENSIONAL PLANE STRAIN
409 MODEL AS WELL (SEE IMODIN)
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FLUNAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH WILL CONTAIN THE FLUID MASS MATRIX
GEONAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH WILL CONTAIN THE FLUID MESH GEOMETRY AND FLUID-STRUCTURE TRANSFORMATION DATA
GRONAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH CONTAINS THE GLOBAL COORDINATES OF THE STRUCTURAL GRID POINTS
DAANAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH WILL CONTAIN THE MANIPULATED DAA FOR OF THE FLUID MASS MATRIX
NVEC	I	NUMBER OF FLUID BOUNDARY MODE EIGENVECTORS DESIRED. THESE ARE ORDERED STARTING WITH THE LOWEST ORDER MODES FIRST. IF ALL THE MODES ARE DESIRED THE USER CAN JUST SET NVEC TO 1000 AND THE CODE WILL AUTOMATICALLY REDUCE THIS NUMBER TO THE ORDER OF THE FLUID MASS MATRIX. THIS IS CONVENIENT WHEN THE MODEL CONTAINS SIX ELEMENTS FOR SEVERAL HARMONICS AND/OR BRANCHES AND THE USER DOES NOT WANT TO SEND TIME COUNTING UP THE TOTAL. THIS IS RECOMMENDED ONLY FOR SMALL OR INTERMEDIATE SIZE PROBLEMS. FOR LARGE PROBLEMS PRINTING OF ONLY THE FIRST 10 EIGENVECTORS IS RECOMMENDED. AS IT IS ONLY THE FIRST FEW ARE GENERALLY USEFUL TO VERIFY SYMMETRIES OR OTHER FEATURES OF THE MODEL. THE FIRST ONE IS ALWAYS A BREATHING TYPE MODE UNLESS THE FLUID MODEL CONSISTS SOLELY OF BEAM TYPE FOR ELEMENTS
NUMZ	I	NUMBER OF FICTITIOUS ELEMENTS TO BE ADDED IN AXIAL DIRECTION WHICH INCREASE THE HALF LENGTH OF THE SURFACE FOR THE SIMULATION OF A TWO DIMENSIONAL PLANE STRAIN FLUID MASS MATRIX. THESE ELEMENTS DO NOT INTRODUCE NEW DIAPHRAGMS OF FREEDOM
ZLEN	E,F	LENGTH OF FICTITIOUS AXIAL ELEMENTS USED IN THE SIMULATION OF A TWO DIMENSIONAL PLANE STRAIN FLUID MASS MATRIX
CO	E,F	USED FOR FLUID MESH MODELS WITH PLANES OF SYMMETRY. CO TAKES ON THE VALUE OF EITHER PLUS OR MINUS ONE TO DENOTE SYMMETRIC OR ANTISYMMETRIC FLOW CONDITIONS IN EACH FLUID REGION INCLUDING THOSE THAT ARE NOT EXPLICITLY CONTAINED IN THE MODEL. FOR A QUARTER MODEL 4 VALUES ARE REQUIRED. ONE

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DEPTH	E, F	FOR EACH QUADRANT, ONLY 2 VALUES ARE NECESSARY FOR A HALF MODEL
CXFS, CYFS, CZFS	E, F	MAGNITUDE OF PERPENDICULAR DISTANCE FROM THE ORIGIN OF COORDINATES TO THE PLANE OF A FREE SURFACE OR THE PLANE OF SYMMETRY FOR A HALF MODEL
PATM	E, F	DIRECTION COSINES OF A UNIT VECTOR NORMAL TO THE PLANE OF A FREE SURFACE OR THE PLANE OF SYMMETRY FOR A HALF MODEL AND POINTING OUT OF THE FLUID REGION
GRAVAC	E, F	EXPLICITLY CONTAINED IN THE MODEL. THEY MUST BE RELATIVE TO THE GLOBAL CARTESIAN COORDINATES OF THE FLUID MESH. IF ANY COORDINATE ROTATIONS ARE APPLIED TO THE FLUID MESH GEOMETRY (SEE ROTGEO AND ROTQUA) THESE QUANTITIES WILL ALSO BE TRANSFORMED
GEDANG	E, F	ACCELERATION DUE TO GRAVITY
QUAANG	E, F	EUCLIDIAN ANGLES OF ROTATION USED TO DESCRIBE A TEMPORARY COORDINATE TRANSFORMATION FOR THE FLUID MESH GEOMETRY (SEE GEORANG ABOVE FOR PRECISE DEFINITION). IF A QUARTER MODEL IS REQUIRED AND THE MESH HAS BEEN GENERATED AUTOMATICALLY FOR A CYLINDRICAL SURFACE BOUNDED BY 0 AND 180 DEGREES THEN THE APPROPRIATE ANGLES TO USE HERE WOULD BE 90, 90, AND 0
NSHIFT	1	A PARAMETER THAT IS ADDED TO THE VALUE OF NLAST (SEE BELOW) IN THE NUMBERING OF

FLUID ELEMENTS AUTOMATICALLY GENERATED FOR
 CYLINDRICAL SURFACES. THIS OPTION IS
 USEFUL IF A FLUID MESH HAS BEEN
 CONSTRUCTED WITH BOTH GEN ELEMENTS AND
 CYLINDRICAL SURFACE ELEMENTS AND THEY GEN
 ELEMENTS ARE REMOVED OR ADDED LATER IN A
 REMODELING EFFORT. SINCE GEN ELEMENTS
 APPEAR FIRST IN THE ELEMENT LIST THE USE
 OF THIS PARAMETER ELIMINATES ANY NEED TO
 CHANGE THE NUMBERING SCHEME ON DATA CARDS
 FOR CYLINDRICAL SURFACE ELEMENTS. NSHIFT
 MAY BE POSITIVE, NEGATIVE, OR ZERO

NSEQ 1 STRUCTURAL GRID POINT NUMBER
 NS I INDICATOR TO DENOTE TYPE OF COORDINATE
 SYSTEM GRID POINT DATA IS REFERRED TO.
 ALLOWABLE VALUES ARE:
 0 - GLOBAL CARTESIAN
 1 - POLAR CYLINDRICAL. AXIS IN GLOBAL X
 DIRECTION
 2 - POLAR CYLINDRICAL. AXIS IN GLOBAL Y
 DIRECTION
 3 - POLAR CYLINDRICAL. AXIS IN GLOBAL Z
 DIRECTION

XC,YC,ZC E,F CARTESIAN COORDINATES OF STRUCTURAL GRID
 POINT IF NS = 0. IF NS = 1, 2, OR 3 THESE
 ARE THE RADIAL, CIRCUMFERENTIAL, AND AXIAL
 COORDINATES RESPECTIVELY IN A POLAR
 CYLINDRICAL SYSTEM. THE CIRCUMFERENTIAL
 ANGLE MUST BE EXPRESSED IN DEGREES AND BE
 MEASURED FROM THE Y, Z, OR X AXIS
 RESPECTIVELY ACCORDING TO WHETHER NS IS
 EQUAL TO 1, 2, OR 3. IF THE POINT IN
 QUESTION IS INTERIOR TO THE NET SURFACE OR
 IS NOT USED IN THE DEFINITION OF THE FLUID
 MESH THE COORDINATES THEMSELVES ARE NOT
 REQUIRED

NEL I GENERAL FLUID ELEMENT INDEX WHICH RUNS
 FROM 1 TO NGEN IN SEQUENTIAL ORDER

NC I NUMBER OF CORNER POINTS OF GENERAL FLUID
 ELEMENT, CURRENTLY RESTRICTED TO THE
 VALUES 3 OR 4. SEE FLUID ELEMENT LIBRARY.
 THE CORNER POINTS WILL USUALLY PARTICIPATE
 IN THE FLUID-STRUCTURE TRANSFORMATION

NN I NUMBER OF ADDITIONAL STRUCTURAL POINTS
 ASSOCIATED WITH A PARTICULAR GENERAL FLUID
 ELEMENT, CURRENTLY HAVING PERMISSIBLE
 VALUES OF 0, 1, 2, 3, AND 5. IF KTRN = 0
 (SEE BELOW AND FLUID ELEMENT LIBRARY), IF
 KTRN IS NOT EQUAL TO ZERO THEN IT MAY HAVE
 ANY VALUE UP TO 12 FOR RECTANGLES AND 13
 FOR TRIANGLES. THESE ADDITIONAL POINTS

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ALWAYS PARTICIPATE IN THE FLUID-STRUCTURE TRANSFORMATION. IT IS EXTREMELY IMPORTANT TO THE UNDERWATER SHOCK ANALYSIS THAT ALL WETTED STRUCTURAL NODES LOCATED WITHIN AND ON THE BORDERS OF THE FLUID ELEMENT BE INCLUDED IN NN EVEN IF THE CASE KTRN NOT EQUAL TO ZERO MUST BE INVOKED

KURV I
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FLUID ELEMENT CURVATURE FLAG. ACCEPTABLE VALUES ARE:
0 - FLAT ELEMENT
1 - CURVED ELEMENT. CODE WILL DETERMINE AVERAGE CURVATURE OF ELEMENT FROM NEIGHBOR POINT LOCATIONS. DO NOT USE THIS OPTION IF NN = 0
2 - CURVED ELEMENT. USER MUST INPUT PRINCIPLE RADIUS OF CURVATURE. IF EITHER RADIUS IS SET TO 10000 OR GREATER THEN ITS ASSOCIATED CURVATURE WILL BE SET TO ZERO

KTRN I
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SHOULD HAVE THE VALUE OF ZERO UNDER NORMAL CIRCUMSTANCES WHEN THE FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS ARE COMPUTED BY THE CODE. IF KTRN IS NONZERO THEN THESE COEFFICIENTS ARE DETERMINED BY HAND FOR THE ELEMENT IN QUESTION AND MUST BE READ AS INPUT DATA. THIS MUST BE DONE IF THE ELEMENT DOES NOT FIT ANY OF THE STANDARD PATTERNS IN THE FLUID ELEMENT LIBRARY. A DISCUSSION OF HOW TO DO THIS IN AN APPROXIMATE FASHION IS GIVEN BELOW (SEE TRAN)

NODE I
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NODE POINT NUMBERS OF FLUID ELEMENT CORNER POINTS TAKEN IN COUNTER CLOCKWISE DIRECTION. IN GENERAL THE SIDE DEFINED BY THE FIRST TWO CORNER POINTS SHOULD BE ROUGHLY ORIENTED IN THE DIRECTION OF ONE OF THE PRINCIPAL AXES OF THE ELEMENT SO AS TO KEEP THE PRODUCT OF INERTIA OF THE ELEMENT SMALL RELATIVE TO ITS PRINCIPAL MOMENTS OF INERTIA. IF THIS RULE IS NOT FOLLOWED IT IS POSSIBLE THAT THE FLUID - STRUCTURE TRANSFORMATION ARRAY FOR THE ELEMENT WILL BE ILL CONDITIONED. ASSIGN A NEGATIVE VALUE TO ANY NODE NUMBER THAT IS NOT PART OF THE STRUCTURAL FINITE ELEMENT MODEL SO THEY WILL NOT PARTICIPATE IN THE FLUID - STRUCTURE TRANSFORMATION. AT PRESENT SUCH POINTS CAN ONLY BE USED IN CONJUNCTION WITH 6 - NODE QUADRILATERALS. SEE FLUID ELEMENT LIBRARY

ITEM I
I
NODE POINT NUMBERS OF FLUID ELEMENT NEIGHBOR POINTS AGAIN TAKEN IN COUNTER CLOCKWISE ORDER STARTING FROM FIRST CORNER

639 POINT. ANY INTERIOR POINTS MUST APPEAR
640 LAST. SEE FLUID ELEMENT LIBRARY
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RAD1	E,F	PROVIDES A MEANS OF SHIFTING THE FLUID CONTROL POINT OUT OF THE PLANE OF THE STRUCTURAL NODE POINTS TO ALLOW FOR A FINITE PLATE OR SHELL THICKNESS. GENERALLY USED TO DEFINE SEPARATE FLUID ELEMENTS ON OPPOSITE SIDES OF A SURFACE. A POSITIVE VALUE INDICATES AN ECCENTRICITY IN THE DIRECTION OF THE OUTWARD UNIT NORMAL VECTOR. THIS OPTION MAY BE USED ONLY WITH KURV EQUAL TO 2 AT THIS TIME. WHEN DEFINING TWO FLUID ELEMENTS ON OPPOSITE SIDES OF A SURFACE THE FIRST AND SECOND NODE NUMBERS INPUT FOR ONE ELEMENT (SEE NOTE) SHOULD BE THE SECOND AND FIRST NODE NUMBERS RESPECTIVELY FOR THE OTHER ELEMENT. IN THIS WAY THE LOCAL COORDINATE SYSTEM FOR EACH ELEMENT IS REFERRED TO THE SAME BASELINE THUS PRESERVING A DESIRED SYMMETRY IN THE CALCULATIONS
RAD2	E,F	RADIUS OF CURVATURE OF FLUID ELEMENT IN DIRECTION PERPENDICULAR TO SIDE JOINING FIRST CORNER POINT AND SECOND CORNER POINT
ECCEN	E,F	RADIUS OF CURVATURE OF FLUID ELEMENT IN DIRECTION FROM FIRST CORNER POINT TO SECOND CORNER POINT
TRAN	E,F	HAND DETERMINED COEFFICIENTS OF THE FLUID-STRUCTURE TRANSFORMATION ARRAY THAT MUST BE READ AS INPUT DATA. THE MOST CONVENIENT WAY OF GENERATING THESE COEFFICIENTS IS TO FIRST BREAK THE ELEMENT INTO SUB-ELEMENTS SUCH AS TRIANGLES OR RECTANGLES SUCH THAT EVERY STRUCTURAL NODE IS A CORNER POINT FOR ONE OR MORE SUB-ELEMENTS. THE WEIGHTING COEFFICIENTS FOR TRIANGLES AND RECTANGLES ARE ONE-THIRD AND ONE-FOURTH RESPECTIVELY AND REPRESENT THE PERCENTAGE OF FLUID PRESSURE FORCE ON THE SUB-ELEMENT THAT IS TRANSMITTED TO ANY PARTICULAR CORNER POINT. THE FLUID-STRUCTURE TRANSFORMATION COEFFICIENT FOR ANY PARTICULAR STRUCTURAL NODE IS THEN EXPRESSED AS A SUM OVER THE SUB-ELEMENTS THAT COUPLE WITH THE NODE IN QUESTION. THE CONTRIBUTION TO THIS SUM FROM EACH SUB-ELEMENT IS JUST THE WEIGHTING COEFFICIENT OF THE SUB-ELEMENT TIMES THE AREA OF THE SUB-ELEMENT DIVIDED BY THE TOTAL AREA OF THE ELEMENT. NOTE THAT THE SUM OF THE FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS FOR ANY FLUID ELEMENT MUST TOTAL UNITY. IF THE FLUID ELEMENT HAS A NON-STRUCTURAL POINT AS A CORNER FOLLOW

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THE ABOVE PROCESS ANYWAY AND THEN ADD THE
RESULTING COEFFICIENT FOR THE POINT IN
QUESTION TO THAT FOR ITS NEAREST
STRUCTURAL NODE. IF NECESSARY THE
CONTRIBUTION COULD EVEN BE DIVIDED BETWEEN
TWO OR MORE NODE POINTS. ONCE COMPUTED,
THE ORDER OF INPUT TO THE CODE MUST AGREE
WITH THE ORDER TAKEN FIRST BY THE CORNER
POINT NODE NUMBERS (SEE NODE) AND THEN BY
THE NEIGHBOR POINT NODE NUMBERS (SEE ITEM)
CONSECUTIVELY

NTCY I

NUMBER OF STRUCTURAL NODE POINTS THAT
COUPLE WITH A CURVED RECTANGULAR FLUID
ELEMENT WHICH IS TO BE AUTOMATICALLY
FORMED FOR AN AXIAL SEGMENT OF A RIGHT
CIRCULAR CYLINDRICAL SURFACE. AVAILABLE
OPTIONS ARE:

- 2 - STRUCTURAL NODES WILL BE ON MIDPOINT
OF CURVED SIDES
- 4 - STRUCTURAL NODES WILL BE AT CORNERS
- 6 - FLUID ELEMENT WILL OVERLAP TWO (2)
STRUCTURAL ELEMENTS. VARIABLE KFUN
BELOW ALSO REQUIRED IN THIS CASE
- 9 - FLUID ELEMENT WILL OVERLAP FOUR (4)
STRUCTURAL ELEMENTS. TWO IN THE
AXIAL DIRECTION AND TWO IN THE
CIRCUMFERENTIAL DIRECTION

KFUN I

DESCRIBES MANNER IN WHICH A SIX NODE
RECTANGULAR FLUID ELEMENT OVERLAYS TWO
RECTANGULAR STRUCTURAL ELEMENTS.
PERMISSIBLE VALUES ARE:

- 1 - CONFIGURATION CONSISTS OF TWO
STRUCTURAL ELEMENTS IN AXIAL
DIRECTION
- 2 - CONFIGURATION CONSISTS OF TWO
STRUCTURAL ELEMENTS IN
CIRCUMFERENTIAL DIRECTION

KROT I

IF KROT = 0 THE Z DIRECTION WILL BE TAKEN
AS THE AXIS FOR AUTOMATICALLY GENERATED
ELEMENTS OVER A CYLINDRICAL SURFACE. IF
KROT IS NOT EQUAL TO ZERO A ROTATION OF
AXIS WILL BE PERFORMED (SEE CYLANG)

KARC I

A VALUE OF ZERO USED UNDER NORMAL
CONDITIONS INDICATES THAT THE AREA
ASSOCIATED WITH AUTOMATICALLY GENERATED
CYLINDRICAL SURFACE ELEMENTS IS TO BE
CALCULATED USING THE CHORD WHICH AGREES
WITH WHAT MOST STRUCTURAL FINITE ELEMENT
CODES ASSUME. A VALUE OTHER THAN ZERO WILL
SPECIFY THAT THE ARC LENGTH IS TO BE USED
INSTEAD. THE DIFFERENCE BETWEEN THESE TWO
CASES IS GENERALLY VERY SMALL FOR ANY

755 REASONABLE CIRCUMFERENTIAL SPACING OF THE
756 ELEMENTS. THE LATTER CAN GENERATE A
757 SLIGHTLY MORE ACCURATE FLUID MASS MATRIX
758 HOWEVER THE FORMER CAN GIVE A SLIGHTLY
759 BETTER STRUCTURAL RESPONSE CALCULATION
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NCRC	I	NUMBER OF CIRCUMFERENTIAL GENERAL ELEMENTS TO BE FORMED AUTOMATICALLY FOR AN AXIAL SEGMENT OF A RIGHT* CIRCULAR CYLINDRICAL SURFACE
NLAST	I	NUMBER OF LAST FLUID ELEMENT IN SURFACE MESH WHICH PRECEDES THE INPUT FOR THIS AXIAL SEGMENT. NLAST CAN HAVE THE VALUE OF ZERO IF REQUIRED
NSTART	I	NUMBER OF STRUCTURAL GRID OR NODE POINT AT BOTTOM LEFT HAND CORNER OF THE FIRST OF THIS SET OF CIRCUMFERENTIAL GENERAL FLUID ELEMENTS. IF NTCY = 2 THIS IS THE NODE AT THE MIDPOINT OF THE LEFT HAND SIDE
NDAX1	I	INCREMENT TO BE APPLIED TO NSTART IN DESIGNATING THE NUMBER OF THE CORRESPONDING STRUCTURAL NODE AT THE FIRST ROW OF CIRCUMFERENTIAL STRUCTURAL NODES TO THE RIGHT OF NSTART IN THE AXIAL DIRECTION
NDCR	I	INCREMENT TO BE APPLIED TO NSTART IN DESIGNATING THE NUMBER OF THE CORRESPONDING STRUCTURAL NODE AT THE FIRST ROW OF AXIAL STRUCTURAL NODES ABOVE NSTART IN THE CIRCUMFERENTIAL DIRECTION. FOR THE CASE NTCY = 6 WITH KFUN = 2, OR NTCY = 9 IT IS ASSUMED THAT NDCR IS THE SAME FOR EACH CIRCUMFERENTIAL INCREMENT
NDAX2	I	INCREMENT TO BE APPLIED TO NSTART + NDAX1 IN DESIGNATING THE NUMBER OF THE CORRESPONDING STRUCTURAL NODE AT THE SECOND ROW OF CIRCUMFERENTIAL STRUCTURAL NODES TO THE RIGHT OF NSTART IN THE AXIAL DIRECTION. THIS CASE IS CHARACTERIZED BY NTCY = 6 WITH KFUN = 1, OR NTCY = 9. OTHERWISE NDAX2 CAN BE SET TO ZERO
RAD	E,F	RADIUS OF CIRCULAR CYLINDRICAL SURFACE
AXL1	E,F	AXIAL COORDINATE OF THE FIRST ROW OF STRUCTURAL NODES IN THE CIRCUMFERENTIAL DIRECTION THAT COUPLE WITH A PARTICULAR SET OF CYLINDRICAL SURFACE GENERAL ELEMENTS. THIS ROW WILL FORM THE LEFT AXIAL BOUNDARY OF THE SET OF FLUID ELEMENTS
AXL2	E,F	AXIAL COORDINATE OF THE SECOND ROW OF STRUCTURAL NODES IN THE CIRCUMFERENTIAL

813 DIRECTION THAT COUPLE WITH A PARTICULAR
814 SET OF CYLINDRICAL SURFACE GENERAL
815 ELEMENTS. THIS ROW WILL FORM THE RIGHT
816 AXIAL BOUNDARY OF THE SET OF FLUID
817 ELEMENTS IF NTCY = 2. NTCY = 4, OR
818 NTCY = 6 WITH KFUN = 2. IF NTCY = 6 WITH
819 KFUN = 1, OR NTCY = 9 THIS ROW WILL LIE
820 WITHIN THE INTERIOR OF THE FLUID ELEMENT
821 AND THE STRUCTURAL NODES AT THIS LOCATION
822 WILL BE CONSIDERED AS NEIGHBOR POINTS IN
823 THE FLUID STRUCTURE TRANSFORMATION ARRAY
824

825 THETS E,F
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ANGLE IN DEGREES THAT SPECIFIES THE
STARTING BOUNDARY FOR A SET OF GENERAL
ELEMENTS AROUND THE PARTIAL CIRCUMFERENCE
OF A RIGHT CIRCULAR CYLINDRICAL SURFACE.
THE X AXIS IS DEFINED AS ZERO AND THETS
CAN BE NEGATIVE IF DESIRED. THIS OPTION IS
IMPORTANT AS A DISCONTINUITY OF 360
DEGREES IN THE ANGULAR FUNCTION AT THE X
AXIS IS NOT PERMITTED

ANGLE IN DEGREES THAT SPECIFIES THE
FINISHING BOUNDARY FOR A SET OF GENERAL
ELEMENTS AROUND THE PARTIAL CIRCUMFERENCE
OF A RIGHT CIRCULAR CYLINDRICAL SURFACE. *
THE X AXIS IS DEFINED AS ZERO AND THET
MUST BE POSITIVE. HOWEVER IT CAN BE EITHER
LARGER OR SMALLER THAN THE MAGNITUDE OF
THETS

AXIAL COORDINATE OF THE THIRD ROW OF
STRUCTURAL NODES IN THE CIRCUMFERENTIAL
DIRECTION THAT COUPLE WITH A PARTICULAR
SET OF CYLINDRICAL SURFACE GENERAL
ELEMENTS. IF AXL3 IS NON-ZERO THEN IT MUST
BE ALGEBRAICALLY GREATER THAN AXL2 AND
THIS ROW WILL THEN FORM THE RIGHT AXIAL
BOUNDARY OF THE SET OF FLUID ELEMENTS.
THIS CASE IS CHARACTERIZED BY NTCY = 6
WITH KFUN = 1, OR NTCY = 9

EUCLIDIAN ANGLES OF ROTATION USED TO ORIENT
THE AXIS OF CYLINDRICAL SURFACE GENERAL
ELEMENTS (SEE GEORG FOR GENERAL
DEFINITION). IN THE FOLLOWING SPECIAL
CASES OF IMPORTANCE THE DESIRED AXIS IS
SHOWN IN THE LEFT HAND COLUMN WHILE THE
APPROPRIATE ANGLES ARE GIVEN TO THE RIGHT:

X - 90, 180, 90 OR 0, +/-90, 0
Y - 0, 90, 90 OR +/-90, 0, 0
Z - NO INPUT, SET KROT = 0

THIS OPTION IS NECESSARY WHEN USING STAGS
AS THE STRUCTURAL PROCESSOR IN ITS DEFAULT
MODE IN WHICH CASE IT USES THE X DIRECTION
AS THE CYLINDER AXIS

871	N1	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT
872			DEFINES THE BEGINNING OF A SURFACE OF
873			REVOLUTION BRANCH OR SEGMENT
874			
875	N2	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT
876			DEFINES THE END OF A SURFACE OF REVOLUTION
877			BRANCH OR SEGMENT
878			
879	R1	E, F	RADIUS TO WET SURFACE FROM AXIS OF SURFACE
880			OF REVOLUTION ELEMENT AT STRUCTURAL GRID
881			POINT DEFINING THE START OF A SURFACE BRANCH
882			OR SEGMENT
883			
884	R2	E, F	RADIUS TO WET SURFACE FROM AXIS OF SURFACE
885			OF REVOLUTION ELEMENT AT STRUCTURAL GRID
886			POINT DEFINING THE END OF A SURFACE BRANCH OR
887			SEGMENT
888			
889	NSET	I	NUMBER OF DATA CARDS REQUIRED TO DEFINE
890			SURFACE OF REVOLUTION FLUID ELEMENTS ALONG
891			THE LENGTH OF A PARTICULAR SURFACE BRANCH OR
892			AXIS. IF NSET = 1 IT IS ASSUMED THAT THE
893			PHYSICAL CONFIGURATION OF THE SURFACE BRANCH
894			IS AS DESCRIBED BELOW UNDER ISEG
895			
896			
897	N3	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT
898			DEFINES THE AXIS OF THE SURFACE OF
899			REVOLUTION BRANCH IN CONJUNCTION WITH N1
900			IF N2 = N1. THIS CASE CORRESPONDS TO A
901			DISC
902			
903	ISEG	I	NUMBER OF SURFACE OF REVOLUTION ELEMENTS
904			THAT CAN BE DEFINED BETWEEN TWO AXIAL
905			STATIONS SUCH THAT THE RADIUS OF THE
906			SURFACE VARIES LINEARLY ALONG THE LENGTH
907			AND THAT EVERY PAIR OF INTERMEDIATE
908			ADJACENT STRUCTURAL NODE NUMBERS DIFFER BY
909			A COMMON INCREMENTAL VALUE. THIS NEED NOT
910			IMPLY EQUAL AXIAL SPACING OF THE SURFACE
911			ELEMENTS AS THE STRUCTURAL NODES MAY NOT
912			NECESSARILY BE EQUALLY SPACED ALONG THE
913			AXIS
914			
915	NUMCHG	I	NUMBER OF STRUCTURAL GRID POINTS THAT MUST
916			BE RE-ENUMERATED IN THE FLUID-STRUCTURE
917			TRANSFORMATION DATA
918			
919	NODOLD	I	STRUCTURAL GRID POINT NUMBER THAT IS TO BE
920			CHANGED TO NODNEW IN THE FLUID-STRUCTURE
921			TRANSFORMATION DATA
922			
923	NODNEW	I	NEW STRUCTURAL GRID POINT NUMBER ASSIGNED
924			TO FLUID-STRUCTURE TRANSFORMATION DATA IN
925			PLACE OF NODOLD. THIS GRID POINT MUST
926			ALREADY BE PART OF THE STRUCTURAL NODE
927			GLOBAL COORDINATE DATA INPUT FROM CARDS
928			AND/OR PERMANENT FILE

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*****
* INPUT DATA CARD DECK
*****

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ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
CHARACTERS MAY BE USED FOR CDC OPERATION

NOTE THAT THERE IS A DESCRIPTIVE ENTRY IN THE FIRST FIELD OF SOME
INPUT CARDS AND THAT THE DATA FOR THAT CARD ACTUALLY BEGINS IN THE
SECOND FIELD. THIS OCCURS IN SUBROUTINES READST, GENELM, CYLGE0
AND SORINP IN WHICH THE DESCRIPTOR IS GRID, GEN, CYL, AND SOR
RESPECTIVELY. THIS PRACTICE IS A RESULT OF CHOOSING THE 'GRID'
CARDS TO BE IDENTICAL TO THE INPUT TO NASTRAN FOR CONVENIENCE IN
INTERFACING WITH THAT CODE. THE 'GEN', 'CYL' AND 'SOR' CARDS HAVE
NOTHING TO DO WITH NASTRAN AND THE USAGE OF SUCH LABELS HERE IS
FOR IDENTIFICATION ONLY

GENERAL PROBLEM DEFINITION (SUBROUTINE AMINPT):

```

72 COLUMN ALPHANUMERIC TITLE
NSTRC NSTRF NGEN NBRA NCYL

```

IF NBRA NOT = 0 INCLUDE THE FOLLOWING THREE CARDS

```

NHAS NIAF NHAI NFUN ITRG
NSEG(1), I=1,NBRA
NCIR(1), I=1,NBRA

```

```

RHO CEE DAA2
PRIGMT PRITRN PRITMF CALCAM PRICOE
EIGMAF TWODIM HAFMOD QUAMOD
PCHCDS NASTAM STOMAS STDINV
FRWTFI FRWTGE FRWTGR FRESUR
RENUMB STOGMT ROTGEO ROTQUA
FLUNAM GEONAM GRONAM DAANAM

```

IF EIGMAF = .TRUE, INCLUDE THE FOLLOWING CARD

```

NVEC

```

IF TWODIM = .TRUE, INCLUDE THE FOLLOWING TWO CARDS

```

NUMZ
ZLEN

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IF QUAMOD = .TRUE, INCLUDE THE FOLLOWING CARD

```

CO(1), I=1,4

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IF HAFMOD = .TRUE, INCLUDE THE FOLLOWING TWO CARDS

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987      CQ(I), I=1,2
988      DEPTH CXFS      CYFS      CZFS
989
990      IF PRESUR = .TRUE. INCLUDE THE FOLLOWING TWO CARDS
991
992      DEPTH CXFS      CYFS      CZFS
993      PATM  GRAVAC
994
995      IF ROTJEO = .TRUE. INCLUDE THE FOLLOWING CARD
996
997      GEOANG(I), I=1,3
998
999      IF ROTJJA = .TRUE. INCLUDE THE FOLLOWING CARD
1000
1001      QUAANG(I), I=1,3
1002
1003      IF NCYL NOT = 0 READ THE FOLLOWING CARD
1004
1005      NSHIFT
1006
1007      STRUCTURAL NODE COORDINATES (SUBROUTINE READST):
1008      -----
1009
1010      IF NSTRC NOT = 0 INCLUDE THE FOLLOWING CARDS
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1012      GRID  NSEQ  NS      XC      YC      ZC      )
1013      .      .      .      .      .      .      )
1014      .      .      .      .      .      .      )
1015      .      .      .      .      .      .      )
1016      .      .      .      .      .      .      )
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CYLANGI), I=1,3
SURFACE-OF-REVOLUTION ELEMENT DEFINITION (SUBROUTINE SORINP):

IF NBRA NOT = 0 READ THE FOLLOWING CARDS FOR EACH SOR BRANCH

SOP	N1	N2	R1	R2	NSET

IF N1 = N2 READ THE FOLLOWING CARD

N3

IF NSET = 1 OMIT THE FOLLOWING CARD

N1	N2	R1	R2	ISEG	TOTAL = NSET
.	.	.	.	.	.
.	.	.	.	.	.

STRUCTURAL NODE RENUMBERING (SUBROUTINE AMGEOM):

IF RENUMB = .TRUE. READ THE FOLLOWING CARDS

NUMCHG	NODOLD	NODNEW	TOTAL = NUMCHG
.	.	.	.
.	.	.	.

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FLUID ELEMENT LIBRARY

THE CORNER POINTS OF EACH OF THE ELEMENT TYPES SHOWN BELOW ARE ASSUMED TO LIE IN THE SAME PLANE AND THE DIRECTION OF THE UNIT NORMAL VECTOR IS TAKEN TO BE POSITIVE AS CURING UP FROM THE PAGE AND OUT INTO THE FLUID REGION. THE VIEWER IS THUS PLACED IN THE SAME RELATIVE POSITION AS A SCUBA DIVER GAZING AT THE SIDE OF A SUNKEN TREASURE SHIP. THE NODE ORDER FOR INPUT MUST ALWAYS BE IN THE COUNTERCLOCKWISE DIRECTION AS SHOWN BECAUSE THE RIGHT HAND RULE IS USED IN THE CODE TO DETERMINE THE POSITIVE OUTWARD DIRECTION. NOTE THAT CORNER POINTS ARE TAKEN FIRST, THEN ANY OTHER POINTS WHICH MAY BE INVOLVED IN THE FLUID-STRUCTURE TRANSFORMATION FOLLOW. YOU MAY PLAY CONNECT-THE-DOTS WITH YOUR PENCIL TO MAKE THE FIGURES MORE LEGIBLE IF YOU WISH

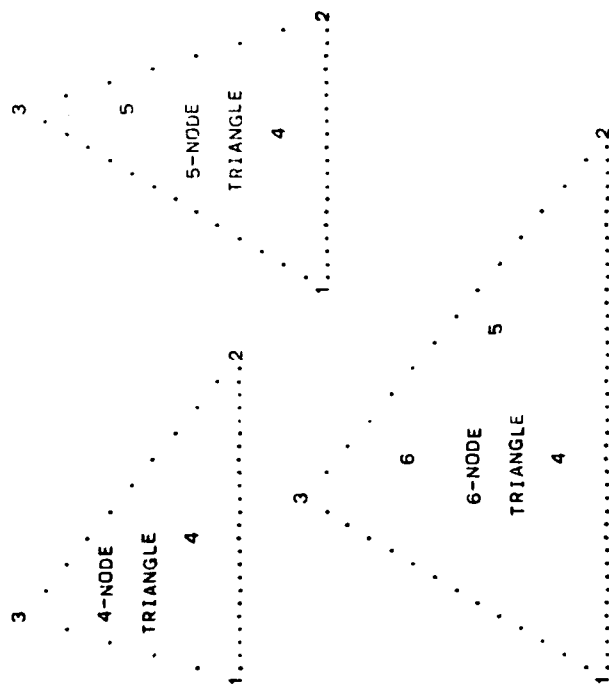
BASIC FLUID ELEMENT CONFIGURATIONS:

3	3
4	4
GENERAL	GENERAL
TRIANGLE	QUADRILATERAL
1.....2	1.....2

BASIC FLUID ELEMENT CONFIGURATIONS WITH ADDITIONAL TRANSFORMATION POINTS:

4...3	6-NODE	GENERAL	3
6-NODE	6	QUADRILATERAL	2
1.....2	1.....5	1.....2	
GENERAL	4	5	
QUADRILATERAL	7	9-NODE	3
1.....2	8.....9	6	
GENERAL	GENERAL	QUADRILATERAL	2
1.....5	1.....2		

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The following discussion is provided as an aid to user understanding of the sample output that is included here.

The first item needing explanation is the block subdivision table. During construction of the mass matrix the code must determine whether a particular fluid DOF pertains to a GEN (includes both GEN and CYL elements) or SOR element. In the latter case, it must also store the branch or axis of the element, its harmonic, and also whether that DOF corresponds to a cosine or sine function. DOF with similar characteristics are naturally kept together in the same block. When the mass matrix is automatically processed in an out of core mode GEN elements are also partitioned into blocks for computational convenience.

The parameters appearing in the block subdivision table are:

- ISUB - block number
- ITYP - GEN or SOR
- IBEG - first row of block
- IROW - number of rows in block
- IBRA - SOR branch or axis
- IHAR - harmonic number
- IFUN - COS or SIN

Next, the terms appearing under "Fluid Mesh Geometric Arrays" are defined as:

- NCOR - number of corner points for a particular fluid element
- X,Y,Z - global cartesian coordinates of the fluid element centroidal control point
- NX,NY,NZ - components of the outward unit normal vector for the fluid element
- NTRA - number of structural node points that are coupled to a particular fluid element for the purpose of force application
- AOO,A20,A11,A02 - area and moments and product of inertia of fluid element. Used internally for construction of the fluid mass matrix and of the fluid-structure transformation coefficients for general elements. For SOR elements, these values are for the sub-elements.
- BII,CII - diagonal terms of B and C matrices used for the construction of fluid mass matrix (see [14])

When SOR elements are included in the fluid mesh the following new terms will appear in the output:

NSOR - number of SOR element
 NFLU - DOF in fluid mass matrix
 RAD - radius of fluid element control point from axis of revolution
 NCIR - number of integration points or sub-elements used in circumferential direction

Local Fluid-Structure Transformation Coefficients appear next. This is a summary that indicates which structural nodes couple with a particular fluid control point and the weighting factor for each. The weighting factors must always sum to unity for any fluid control point.

The generalized areas that follow are simply A00 for GEN elements. For SOR elements with IHAR = 0 they are A00*NCIR; for all other SOR elements they become .5*A00*NCIR.

The eigenvalues and eigenvectors that follow the listing of the added mass matrix correspond to the "Fluid Boundary Mode" problem [14]. For the infinite cylindrical shell problem presented here, the exact eigenvalues should behave as $1/n$ with corresponding modes $\cos n\theta$ and $\sin n\theta$. The first eigenvalue listed, $0.11831+04$, is an approximation to ∞ for $n=0$ and it can be seen that the subsequent eigenvalues are relatively well behaved.

If a table labeled "SUMMARY OF I-O ACTIVITY" appears in the output, this indicates that automatic out-of-core processing has taken place. In such a case the "Fluid Boundary Mode" problem is not solved and its diagnostic characteristics are unavailable to the user. If there are any serious errors in the fluid mesh geometry that have remained undetected through the generation of the mass matrix these may show up in the construction of the matrix $\tilde{D}_{f1}$ [see Eq. (2.6)], i.e., the occurrence of factorization errors for the elements in question.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Run	For	Initial	Strain	Concentration
1	0	0	0	36
1	1	1	5	1
1	1	1	1	1

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

CYL-GEOM^r

CYL * DASH

55
500
175

5

2	0	0	0	0	0
35	0	0	1	1	2
1.	-.0875	.0875	-.5	355.	

EXQI

@ADD.P CYLFLUDAT

FLUMAS RUN FOR INFINITE CYLINDER SIMULATION

MAXIMUM FLUID NODES = 69
 SCRATCH ALLOCATION = 10000
 FLUID MASS DENSITY = .10000000+01
 FLUID SOUND SPEED = .10000000+01
 DAA2 SCALAR FACTOR = .50000000+00

USER OPTIONS FOR THIS RUN:

PRTRMT	PRTRTN	PRTAMF	CALCAM	PRTCOE
T	T	T	T	F
EIGMAP	MODIM	HAFMOD	QUAMOD	
T	T	F	F	
POCUS	HASTAM	STOMAS	STOINV	
F	F	F	F	
FRNTEL	FRWIGE	FRWIGR	FRESUR	
F	F	F	F	
RENURB	STOCHT	ROIGED	RDIOQA	
F	T	F	F	

FLUID MASS MATRIX BLOCK SUBDIVISION PARAMETERS:

ISUB	ITYP	IBEG	IROW	IBRA	IHAR	IFUN
1	GFN	1	30			

FLUID MESH GEOMETRIC ARRAYS:

N	NCOR	X	Z	NX	NY	NZ
1	4	.10000000+01	.00000000	.10000000+01	.00000000	.00000000
2	4	.9840775+00	.00000000	.9840775+00	.1736418+00	.00000000
3	4	.9399262+00	.00000000	.9399262+00	.3420201+00	.00000000
4	4	.8660254+00	.00000000	.8660254+00	.5000001+00	.00000000
5	4	.7660444+00	.00000000	.7660444+00	.6427876+00	.00000000
6	4	.6427876+00	.00000000	.6427876+00	.7660444+00	.00000000
7	4	.4999999+00	.00000000	.4999999+00	.8660254+00	.00000000
8	4	.3420201+00	.00000000	.3420201+00	.9399262+00	.00000000

9	4	173-0815+00	.98480776+00	.00000000	.17354815+00	.98480776+00	.00000000
10	4	-28810229-07	.10000000+01	.00000000	-.28810229-07	.10000000+01	.00000000
11	4	-173-0822+00	.98480774+00	.00000000	-173-0822+00	.98480774+00	.00000000
12	4	-34202018+00	.93969261+00	.00000000	-34202018+00	.93969261+00	.00000000
13	4	-50000002+00	.86502339+00	.00000000	-50000002+00	.86502339+00	.00000000
14	4	-64278765+00	.76604411+00	.00000000	-64278765+00	.76604411+00	.00000000
15	4	-76604448+00	.64278765+00	.00000000	-76604448+00	.64278765+00	.00000000
16	4	-86602543+00	.49999999+00	.00000000	-86602543+00	.49999999+00	.00000000
17	4	-939-265+00	.34202008+00	.00000000	-939-265+00	.34202008+00	.00000000
18	4	-984-0777+00	.17364312+00	.00000000	-984-0777+00	.17364312+00	.00000000
19	4	-100-0000+01	.57620648-07	.00000000	-100-0000+01	.57620648-07	.00000000
20	4	-984-0774+00	.17364312+00	.00000000	-984-0774+00	.17364312+00	.00000000
21	4	-939-265+00	.34202008+00	.00000000	-939-265+00	.34202008+00	.00000000
22	4	-86602543+00	.49999999+00	.00000000	-86602543+00	.49999999+00	.00000000
23	4	-76604448+00	.64278765+00	.00000000	-76604448+00	.64278765+00	.00000000
24	4	-64278765+00	.76604411+00	.00000000	-64278765+00	.76604411+00	.00000000
25	4	-499-265+00	.34202008+00	.00000000	-499-265+00	.34202008+00	.00000000
26	4	-34202007+00	.17364312+00	.00000000	-34202007+00	.17364312+00	.00000000
27	4	-173-0822+00	.98480774+00	.00000000	-173-0822+00	.98480774+00	.00000000
28	4	.71529525-07	.10000000+01	.00000000	.71529525-07	.10000000+01	.00000000
29	4	.173-0827+00	.98480774+00	.00000000	.173-0827+00	.98480774+00	.00000000
30	4	.34202026+00	.93969261+00	.00000000	.34202026+00	.93969261+00	.00000000
31	4	.50000007+00	.86602543+00	.00000000	.50000007+00	.86602543+00	.00000000
32	4	.64278769+00	.76604411+00	.00000000	.64278769+00	.76604411+00	.00000000
33	4	.76604453+00	.64278765+00	.00000000	.76604453+00	.64278765+00	.00000000
34	4	.86602546+00	.49999999+00	.00000000	.86602546+00	.49999999+00	.00000000
35	4	.939-266+00	.34202003+00	.00000000	.939-266+00	.34202003+00	.00000000
36	4	.984-0777+00	.17364312+00	.00000000	.984-0777+00	.17364312+00	.00000000

N	NTRA	A00	A10	A11	A02	B11	C11
1	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
2	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
3	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
4	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
5	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
6	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
7	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
8	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
9	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
10	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
11	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
12	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
13	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
14	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
15	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
16	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
17	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
18	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
19	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
20	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
21	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
22	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
23	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
24	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
25	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
26	2	.30504511-01	.77238-03-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01

27	2	.3054511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
28	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
29	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
30	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
31	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
32	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
33	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
34	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
35	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01
36	2	.30504511-01	.7723869-04	-.30109243-12	.77850044-04	.61574592+00	.64371217+01

LOCAL FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS:

NFLU	NSTR	
1	1	
2	2	.50000+00
3	3	.50000+00
4	4	.50000+00
5	5	.50000+00
6	6	.50000+00
7	7	.50000+00
8	8	.50000+00
9	9	.50000+00
10	10	.50000+00
11	11	.50000+00
12	12	.50000+00
13	13	.50000+00
14	14	.50000+00
15	15	.50000+00
16	16	.50000+00
17	17	.50000+00
18	18	.50000+00
19	19	.50000+00
20	20	.50000+00
21	21	.50000+00
22	22	.50000+00
23	23	.50000+00
24	24	.50000+00
25	25	.50000+00
26	26	.50000+00
27	27	.50000+00
28	28	.50000+00
29	29	.50000+00
30	30	.50000+00
31	31	.50000+00
32	32	.50000+00
33	33	.50000+00
34	34	.50000+00
35	35	.50000+00
36	36	.50000+00
37	37	.50000+00
38	38	.50000+00
39	39	.50000+00
40	40	.50000+00
41	41	.50000+00
42	42	.50000+00
43	43	.50000+00
44	44	.50000+00

```

23 .50000+00 .50000+00
45
24 .50000+00 .50000+00
46
47
48
25 .50000+00 .50000+00
49
50
26 .50000+00 .50000+00
51
52
27 .50000+00 .50000+00
53
54
28 .50000+00 .50000+00
55
56
29 .50000+00 .50000+00
57
58
30 .50000+00 .50000+00
59
60
31 .50000+00 .50000+00
61
62
32 .50000+00 .50000+00
63
64
33 .50000+00 .50000+00
65
66
34 .50000+00 .50000+00
67
68
35 .50000+00 .50000+00
69
70
36 .50000+00 .50000+00
71
72
.50000+00 .50000+00

```

```

*** G ASG,UPR CYL*G*OM., F/ 4/TRK/ 1024
*** @ USE 2,CYL*G*OM.

```

```

*****
+ A U T I L I T Y S T O R A G E T A B L E
*****
+
+ LD1 EDN(Q*DEF) IFN FC OP SEC COLOC NEXT LIMIT READ WRITEN +
+ 2 CYL*GEUM 2 46 UPR28 36 36 65536 0 766 +
+
+ 0 TP-OPS, 1 ACTIVE DEVICES ( 0 FULL)
+ 13 WRITES, 3 READS, 766 WORDS XFD
+
*****

```

```

*** @ FREE CYL*G*OM.

```

GENERALIZED FLUID AREAS:

1	2	3	4	5	6	7	8	9	10
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
11	12	13	14	15	16	17	18	19	20
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
21	22	23	24	25	26	27	28	29	30
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
31	32	33	34	35	36				
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01				

ADDED MASS MATRIX IN FLUID COORDINATES:

[illegible]

A-31

3	10070+01	10022+01	10075+01	10028+01	10031+01	10036+01
4	10019+01	10020+01	10022+01	10025+01	10026+01	10028+01
5	10018+01	10019+01	10020+01	10021+01	10022+01	10023+01
6	10016+01	10017+01	10018+01	10019+01	10020+01	10021+01
7	10015+01	10016+01	10017+01	10018+01	10019+01	10020+01
8	10014+01	10015+01	10016+01	10017+01	10018+01	10019+01
9	10013+01	10014+01	10015+01	10016+01	10017+01	10018+01
10	10012+01	10013+01	10014+01	10015+01	10016+01	10017+01
11	10011+01	10012+01	10013+01	10014+01	10015+01	10016+01
12	10010+01	10011+01	10012+01	10013+01	10014+01	10015+01
13	10009+01	10010+01	10011+01	10012+01	10013+01	10014+01
14	10008+01	10009+01	10010+01	10011+01	10012+01	10013+01
15	10007+01	10008+01	10009+01	10010+01	10011+01	10012+01
16	10006+01	10007+01	10008+01	10009+01	10010+01	10011+01
17	10005+01	10006+01	10007+01	10008+01	10009+01	10010+01
18	10004+01	10005+01	10006+01	10007+01	10008+01	10009+01
19	10003+01	10004+01	10005+01	10006+01	10007+01	10008+01
20	10002+01	10003+01	10004+01	10005+01	10006+01	10007+01
21	10001+01	10002+01	10003+01	10004+01	10005+01	10006+01
22	10000+01	10001+01	10002+01	10003+01	10004+01	10005+01
23	9999+01	10000+01	10001+01	10002+01	10003+01	10004+01
24	9998+01	9999+01	10000+01	10001+01	10002+01	10003+01
25	9997+01	9998+01	9999+01	10000+01	10001+01	10002+01
26	9996+01	9997+01	9998+01	9999+01	10000+01	10001+01
27	9995+01	9996+01	9997+01	9998+01	9999+01	10000+01
28	9994+01	9995+01	9996+01	9997+01	9998+01	9999+01
29	9993+01	9994+01	9995+01	9996+01	9997+01	9998+01
30	9992+01	9993+01	9994+01	9995+01	9996+01	9997+01
31	9991+01	9992+01	9993+01	9994+01	9995+01	9996+01
32	9990+01	9991+01	9992+01	9993+01	9994+01	9995+01
33	9989+01	9990+01	9991+01	9992+01	9993+01	9994+01
34	9988+01	9989+01	9990+01	9991+01	9992+01	9993+01
35	9987+01	9988+01	9989+01	9990+01	9991+01	9992+01
36	9986+01	9987+01	9988+01	9989+01	9990+01	9991+01

7	95426+00	-9,331+00	-96590+00	-6550+00	-12714+01	13559+01	-20158+00	-11093+01	-70446+0	-99923+01
8	95126+00	-89794+00	-11149+01	-68602+00	-12599+01	12527+01	-48252+00	-50707+00	12797+01	-10952+01
9	95426+00	-69102+00	-12300+01	-68003+00	-68003+00	83395+00	-10548+01	4144+00	12557+01	-15091+01
10	95426+00	-3158+00	-13077+01	-13332+01	-24396+00	19159+00	-13341+01	11426+01	64499+00	-50468+00
11	95426+00	-11229+00	-13457+01	-13244+01	-2182100	-50193+00	-12564+01	1316+01	-26366+00	95115+00
12	95426+00	-77536+01	-11559+01	-11559+01	-6557+00	-16611+01	-84190+00	69072+00	-1050+00	12489+01
13	95426+00	-12992+01	-12992+01	-12992+01	-12992+01	-13588+01	-20170+00	4556+01	-13490+01	11157+01
14	95426+00	-51209+00	-12160+01	-13778+01	-12456+01	-12527+01	49253+00	-84046+00	-10199+01	11533+00
15	95426+00	-77337+00	-10399+01	-25393+01	-13459+01	-191330+00	10448+01	-13130+01	-105810	-10559+00
16	95426+00	-5117+00	-94248+00	-68000+00	-12719+01	-19166100	13341+01	11223+01	10495+01	-10539+01
17	95426+00	-11004+01	-76043+00	-19401+00	-10345+01	50193+00	12531+01	-50717+00	12797+01	-10539+01
18	95426+00	-12046+01	-55528+00	-1131+01	-6435+00	10611+01	84193+00	41333+00	10495+01	-10539+01
19	95426+00	-12046+01	-33326+01	-1332+01	-2337+00	13359+01	10167+00	11335+01	64411+01	12153+01
20	95426+00	-11301+01	-10111+00	-13244+01	-22442+00	12527+01	49253+00	13306+01	-46837+00	12505+01
21	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
22	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
23	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
24	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
25	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
26	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
27	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
28	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
29	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
30	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
31	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
32	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
33	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
34	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
35	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
36	95426+00	-11377+01	3525+00	-11559+01	-6647+00	83399+00	-10548+01	90130+00	-1050+00	-1050+00
1	60956+00	-22233+00	12308+01	-12280+01	-43215+00	45536+00	-12703+01	-30101+00	13124+01	-42718+00
2	53330+00	12637+01	10947+01	-94613+00	-10456+01	12304+01	22761+00	13147+01	21405+00	-11186+01
3	12944+01	-10163+01	-13598+00	-58076+00	-11592+01	60503+00	13457+01	30477+00	-13125+01	83967+00
4	11244+01	-21033+00	12308+01	13335+01	-21244+00	-13281+01	24087+00	-13147+01	-13125+01	83967+00
5	13136+00	-12636+01	-10947+01	-3308+00	15331+01	-46715+00	-12609+01	-30567+00	13125+01	-11507+01
6	90297+00	-11117+01	13603+00	-11121+01	-6132+00	11659+01	-68003+00	13146+01	13125+01	-10491+00
7	13470+01	-2200+00	12307+01	-10389+01	-3186+00	67212+00	10295+01	13146+01	13125+01	13223+01
8	86158+00	12637+01	10947+01	36046+00	-12615+01	-86285+00	10382+01	-13146+01	-13140+00	35728+01
9	31650+00	10417+01	13598+00	13155+01	18924+01	-11718+01	-66900+00	-30383+00	13125+01	-13348+01
10	12085+01	-22136+00	-12307+01	55987+00	12744+01	45562+00	-12705+01	13146+01	-13125+01	42763+00
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12	33183+00	-16417+01	13593+00	-12182+01	-63105+00	62158+00	13446+01	-13146+01	-13125+01	-13294+00
13	74616+00	-22197+00	12307+01	12912+00	-12566+01	-13279+01	24100+00	13146+01	13125+01	83967+00
14	12410+01	12637+01	10948+01	13065+01	-21572+00	-46731+00	-12658+01	13148+01	13125+01	11507+01
15	97766+00	10418+01	13598+00	76443+00	11786+01	11655+01	-66661+00	30375+00	-13125+01	40500+00
16	83461+01	-22203+00	-12307+01	-78347+00	10210+01	-87216+00	10294+01	-13147+01	-13125+01	-13223+01
17	10467+01	-11039+01	-10949+01	13004+01	-47912+00	-86271+00	10380+01	-30404+00	13125+01	-13223+01
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21	12085+01	12637+01	10948+01	94003+00	10457+01	12301+01	22773+00	-13148+01	13125+01	11605+01
22	11524+00	-22209+00	-12307+01	-13433+01	-22205+00	-13278+01	24093+00	13150+01	13125+01	83967+00
23	15124+00	-12639+01	-10949+01	-33810+00	-13321+01	-46750+00	-12658+01	30421+00	-13125+01	-11498+01
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36	-68526+00	-83363+00	-10108+01	-30139+00	-13150+01	-96221+00

+++ @ FREE UNIT01.

+++ @ ASG,UTR CYL*DRAG.. F/ 4/TRK/ 1024

+++ @ USE ..CYL*DRAG..

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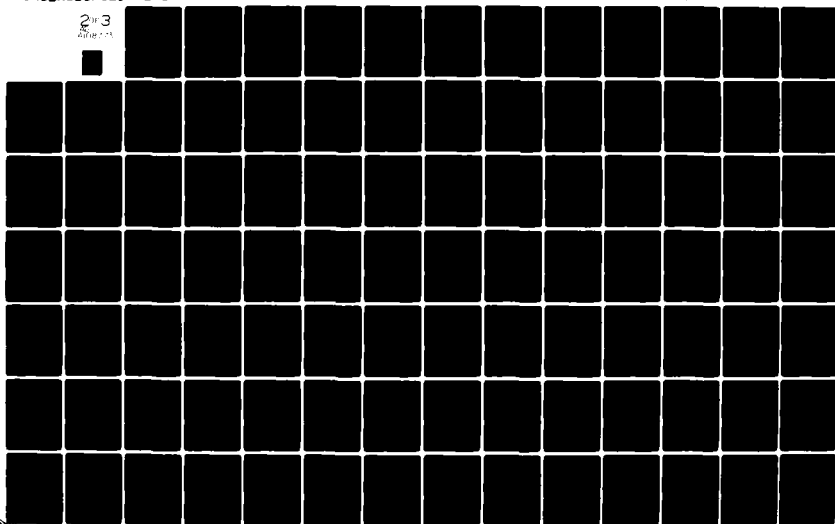
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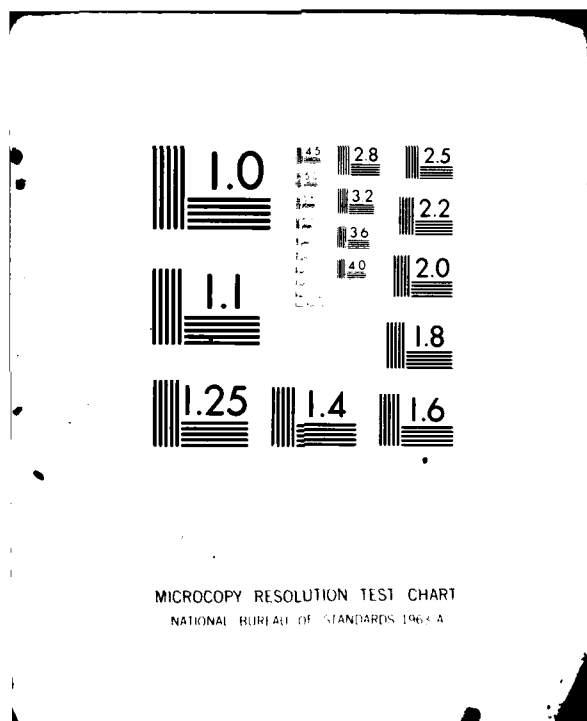
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AD-A108 773

LOCKHEED MISSILES AND SPACE CO INC PALO ALTO CA F/G 20/11
THE UNDERWATER SHOCK ANALYSIS CODE (USA-VERSION 3): A REFERENCE--ETC(U)
SEP 80 J A DERUNTZ, T L DEERS, C A FELIPPA DNA001-78-C-0029
UNCLASSIFIED LMSC-D777843 DNA-5615F NL

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AD-A108 773





30	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
31	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
32	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
33	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
34	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
35	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
36	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
37	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
38	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
39	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
40	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
41	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
42	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
43	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
44	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
45	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
46	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
47	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
48	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
49	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
50	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
51	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
52	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
53	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
54	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
55	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
56	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
57	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
58	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
59	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
60	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
61	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
62	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
63	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
64	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
65	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
66	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
67	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
68	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
69	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
70	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
71	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
72	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
73	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
74	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
75	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
76	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
77	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
78	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
79	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
80	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
81	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
82	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
83	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
84	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
85	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
86	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
87	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
88	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
89	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
90	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
91	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
92	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
93	-1.0410+00	-9.7826-02	-6.3482-02	-2.5384-02	-1.0727-02					
94	-2.7099+00	-1.0110+00	-9.7821-02	-6.3489-02	-2.3331-02					
95	-1.0410+00	-2.7099+00	-1.0410+00	-9.7822-02	-3.5863-02					
96	-9.7821-02	-1.0110+00	-2.7099+00	-6.3484-02	-6.3485-02					
97	-6.3489-02	-9.7822-02	-1.0410+00	-9.7822-02	-1.0410+00					
98	-3.5863-02	-6.3484-02	-9.7825-02	-1.0410+00	-2.7099+00					
99	-2.5384-02	-3.5863-02	-6.3490-02	-1.0410+00	-2.7099+00					
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8	81700-05	-70718-05	-33842-05	87246-05	-74011-05	62611-05	-54703-05	40308-05	18180-05	12290-03
9	-78870-05	10142-05	-58448-05	-26067-05	-16032-04	-16656-04	68682-05	-27775-05	18180-05	12290-03
10	93470-05	-91181-05	10062-04	-56366-05	-87428-05	16247-04	-97863-05	27897-05	18180-05	12290-03
11	-16029-04	17442-04	-14725-04	12728-04	-14431-05	-84976-05	91763-05	-97245-05	18180-05	12290-03
12	10632-04	-20220-04	11524-01	-41338-05	-37110-05	90655-05	-84363-05	16191-05	18180-05	12290-03
13	84571-05	94936-05	-98957-05	24915-05	57029-05	-38343-05	-14156-05	-87022-05	18180-05	12290-03
14	-12474-03	60609-05	62412-05	-97570-05	24515-05	-40867-05	12653-04	-55047-05	18180-05	12290-03
15	10773-03	-17230-03	75259-05	62731-05	-96133-05	11483-04	14670-04	10061-04	18180-05	12290-03
16	16271-03	10789-03	-12600-03	68953-05	93516-05	-20294-04	17459-04	-91073-05	18180-05	12290-03
17	47983-03	10768-03	12608-03	-12469-03	83958-05	10621-04	-16651-04	98738-05	18180-05	12290-03
18	-92503-02	43119-03	16266-03	10910-03	-12795-03	12510-03	54387-05	-10350-01	18180-05	12290-03
19	11455-05	-92357-02	48359-03	16160-03	11109-03	-12980-03	11067-04	40079-05	18180-05	12290-03
20	-88767+00	11455+00	-92520-02	48407-03	15883-03	11027-03	-12523-03	12605-04	18180-05	12290-03
21	15635+01	-87680+00	11455+00	-92523-02	48118-03	16649-03	10470-03	-12469-03	18180-05	12290-03
22	-89598+00	11455+00	-88767+00	11454+00	-92456-02	47532-03	16977-03	10885-03	18180-05	12290-03
23	11455+00	-88767+00	15635+01	-88766+00	11455+00	-92503-02	47494-03	16523-03	18180-05	12290-03
24	-92547-02	11454+00	-88766+00	15635+01	-88766+00	11455+00	-92430-02	47473-03	18180-05	12290-03
25	49973-03	-92468-02	11455+00	-88768+00	15635+01	-88768+00	15635+01	92133-02	18180-05	12290-03
26	15812-03	47339-03	11455+00	-92463-02	-87674-03	15635+01	-88766+00	-92133-02	18180-05	12290-03
27	10803-03	17204-03	47252-03	-92457-02	11454+00	-88766+00	15635+01	-88767+00	18180-05	12290-03
28	-12193-03	10165-03	16776-03	-11455+00	-88766+00	15635+01	-88766+00	-92133-02	18180-05	12290-03
29	36560-05	-11173-03	97915-03	48008-03	-92531-02	-88766+00	15635+01	-88767+00	18180-05	12290-03
30	86083-05	-25854-05	-11526-03	16215-03	48581-03	-92457-02	11454+00	-88767+00	18180-05	12290-03
31	-90379-05	-82500-05	70473-05	-12244-03	10144-03	16462-03	-48585-03	-92430-02	18180-05	12290-03

32	.205-01-05	-9.151-05	.92448-04	.70895-05	-12159-03	.10752-03	.15846-03	.48533-03	-.92497-02	.11454+00
33	.28377-05	.23864-05	-13199-04	.49141-05	.13388-04	-12370-03	.10794-03	.16422-03	.47554-03	-.92470-02
34	-.55063-06	-.71973-06	.88774-05	-13164-04	.82459-05	.58177-05	-.12229-03	.10344-03	.17038-03	.48103-03
35	-.92623-06	.51054-05	-12330-04	.17500-04	-11594-04	.34090-05	.17730-04	-.12829-03	.10779-03	.10001-03
36	-.37281-05	-.51437-06	.10553-04	-14716-04	.91716-05	-.24974-05	-.55043-05	.14390-04	-.12560-03	.10784-03
31										
1	.10448-03	.10667-03	.48983-03	-.92508-02	.11455-00	-.38768+00				
2	-.11846-03	.10491-03	.15774-04	.48639-03	-.92548-02	.11455+00				
3	.20789-05	-.11000-03	.10609-03	.16301-03	.48133-03	-.92545-02				
4	.91395-05	.11102-04	-.12389-04	.10517-03	.16320-03	.48638-03				
5	-.11746-04	.10206-04	.14987-04	-.12367-03	.16596-03	.15760-03				
6	.13714-04	.10410-04	.27984-04	.10201-04	-11143-03	.10597-03				
7	-.21047-04	.11816-04	-.11761-04	.91068-05	.26331-05	-.11849-03				
8	.23218-04	-.11018-04	.14005-04	-.19893-04	.11677-04	.63560-05				
9	-.12351-04	.11304-04	-.10947-04	.16054-04	-.14910-04	.67054-05				
10	-.91311-06	.21325-05	.02922-05	-.10300-04	.50349-05	-.79481-05				
11	.62098-05	-.50306-05	-.16243-05	.70002-05	.14773-05	-.12219-05				
12	-.16594-05	.81082-05	-.96993-04	.15665-05	-.23154-05	.55714-05				
13	-.16437-05	-.41044-05	.14497-04	-.85513-05	.27009-06	.36022-05				
14	-.66473-05	.10506-05	-.86130-05	.10792-04	-.14730-05	-.59337-05				
15	.10450-04	.30306-05	.14269-05	-.10655-05	.60373-05	-.40396-05				
16	-.26451-05	.70853-05	-.79912-05	.71808-05	-.78370-05	.10576-04				
17	-.35237-05	-.50322-05	.13735-04	-.11755-04	.73947-05	-.88799-05				
18	.36332-05	-.11304-05	-.72617-05	.10413-04	-.47828-05	.15437-05				
19	-.75293-06	.30403-05	.20186-05	-.67192-05	.52286-05	-.23441-05				
20	.63108-05	-.51087-05	.43804-05	-.16951-05	-.23236-05	.66698-05				
21	-.13010-04	.91019-05	-.28013-05	.24307-05	.32580-05	-.63592-05				
22	.70412-05	-.11015-04	.90747-05	-.43502-05	.63653-05	-.15757-05				
23	.11166-04	.91055-05	-.15743-04	.10217-04	-.10546-04	.76305-05				
24	-.12314-03	.71134-05	.44899-05	-.11420-04	.13023-04	-.10341-04				
25	.10116-03	-.12206-03	.15169-04	.20740-05	-.93451-05	.64285-05				
26	.16737-03	.10035-03	-.12969-03	.14275-04	-.34639-05	-.99975-07				
27	.47003-03	.10182-03	.10884-03	-.12451-03	.18633-04	-.50775-05				
28	-.92454-02	.44256-03	.16349-03	.10404-03	-.12882-03	.14939-04				
29	.11453+00	-.90474-02	.47870-03	.16821-03	.10555-03	-.12387-03				
30	-.88765+00	.11354+00	-.92446-02	.47564-03	.10783-03	.10411-03				
31	.15635+01	-.83765+00	.11454+00	-.92460-02	.47502-03	.16837-03				
32	-.88766+00	.11035+01	-.88766+00	.11454+00	-.92461-02	.47994-03				
33	.11455+00	-.87666+00	.15635+01	-.68767+00	.11454+00	-.92541-02				
34	-.92551-02	.11455+00	-.88767+00	.15635+01	-.88716+00	.11455+00				
35	.48319-03	-.92511-02	.11454+00	-.88766+00	.15635+01	-.88768+00				
36	.16410-03	.48561-03	-.92566-02	.11455+00	-.83768+00	.15635+01				

 + AUXILIARY STORAGE TABLE
 +
 + LDI EDN(Q+ETH) IFN 36 UP SEC COLOC NEXT LIMIT READ WRITTEN +
 + 3 CYL*DAAM 3 36 UP28 94 65536 0 2582 +
 +
 + 0 TP-OPS. 1 ACTIVE DEVICES (0 FULL)
 + 16 WRITES, 1 READS, 5950 WORDS XFD +

*** @ FREE CYL*DAAM:.

APPENDIX B
USER INFORMATION FOR THE AUGMENTED MATRIX PREPROCESSOR AUGMAT

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

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PROGRAM SIZE

ALL ARRAYS REFERENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS VERSION. HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH REQUEST IN THE CONTROL CARD DECK

DEFINITION OF INPUT PARAMETERS

INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO STANDARD FORTRAN USAGE:

A	-	ALPHANUMERIC
E	-	FLOATING POINT
F	-	FIXED POINT
I	-	INTEGER
L	-	LOGICAL

VARIABLE	TYPE	DESCRIPTION
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STRNAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH CONTAINS THE STRUCTURAL MASS AND STIFFNESS MATRICES AS WELL AS BOOKKEEPING INFORMATION RELATING THE INTERNAL AND EXTERNAL DEGREES OF FREEDOM. WHEN INTERFACING WITH THE NON-HEAR STRUCTURAL ANALYZER STAGS THE STIFFNESS MATRIX IS NOT PRESENT
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FLUNAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH CONTAINS THE MANIPULATED DAA FORM OF THE FLUID MASS MATRIX
--------	---	--

GENNAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH CONTAINS THE FLUID MESH GEOMETRY AND FLUID-STRUCTURE TRANSFORMATION DATA
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PRENAM	A	NAME OF PERMANENT MASS STORAGE FILE CREATED BY THIS PROCESSOR WHICH CONTAINS ALL THE INFORMATION REQUIRED TO CONDUCT THE UNDERWATER SHOCK ANALYSIS OF THE STRUCTURE IN QUESTION EXCEPT FOR THE EXCITATION AND INTEGRATION DATA
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FRWTS	L	TRUE IF THE PERMANENT FILE CONTAINING THE STRUCTURAL MASS AND STIFFNESS MATRICES
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WAS CREATED BY BUFFERED FORTRAN WRITE
 STATEMENTS. OTHERWISE FALSE

L
 TRUE IF TRANSLATIONAL CONSTRAINTS MUST BE
 APPLIED TO STRUCTURAL NODES DUE TO
 SYMMETRY CONDITIONS IF HALF OR QUARTER
 MODELS ARE BEING USED. OTHERWISE FALSE.
 CONSTRAINTS ON ROTATIONAL STRUCTURAL
 FREEDOMS DO NOT ENTER THE AUGMENTED
 MATRICES. CONSTRAINTS MUST BE APPLIED ONLY
 IF NRICOS = 0 (SEE BELOW)

L
 TRUE IF AUGMENTED FORM OF MATRICES
 APPEARING IN THE FLUID EQUATIONS ARE TO BE
 PRINTED IN FULL. OTHERWISE FALSE IN WHICH
 CASE ONLY THE MATRIX MASTER RECORD AND THE
 DIAGONAL TERMS ARE PRINTED. THE FIRST
 MATRIX SHOWN IS THE INVERSE FORM OF THE
 STRUCTURAL MASS AND IT IS THE ONLY SPARSE
 MATRIX IN THE FLUID EQUATIONS. HENCE A MAP
 OF ITS CONNECTIVITY IS ALWAYS SHOWN. THE
 NEXT MATRIX IS A COMBINATION OF BOTH THE
 FLUID AND STRUCTURE INVERSE MASS MATRICES.
 FOR DAA2 RUNS TWO ADDITIONAL MATRICES
 APPEAR THAT INVOLVE ONLY THE FLUID MASS
 INVERSE. THE FIRST COMES DIRECTLY FROM THE
 DAA1 EQUATION WHILE THE SECOND IS ITS
 ITERATED FORM THAT APPEARS IN THE DAA2
 EQUATION. IT IS RECOMMENDED THAT A VALUE
 OF FALSE BE USED UNDER NORMAL CONDITIONS

L
 TRUE IF FLUID MESH GEOMETRY DATA IS TO BE
 LISTED. OTHERWISE FALSE

L
 TRUE IF FLUID-STRUCTURE TRANSFORMATION
 DATA IS TO BE LISTED. OTHERWISE FALSE

L
 TRUE IF SKYLINE STRUCTURAL STIFFNESS
 MATRIX IS TO BE DISPLAYED. OTHERWISE
 FALSE. WHEN INTERFACING WITH STAGS THIS
 VARIABLE MUST ALWAYS BE TAKEN AS FALSE
 SINCE THE GLOBAL STIFFNESS OPERATOR DOES
 NOT EXIST IN THE SAME FORM AS THAT FOR USA
 IN THE STAND ALONE CONFIGURATION

DAA2 E.F
 A PARAMETER BOUNDED BY ZERO AND UNITY THAT
 GOVERNS THE USE OF THE IMPROVED DOUBLY
 ASYMPTOTIC APPROXIMATION. A VALUE OF ZERO
 REDUCES THE FLUID SOLUTION TO THE STANDARD
 DOUBLY ASYMPTOTIC APPROXIMATION. HOWEVER A
 PRECISE CHOICE FOR THIS PARAMETER IS NOT
 GIVEN BY ANY FUNDAMENTAL PRINCIPLE. IT HAS
 BEEN OBSERVED THAT A VALUE OF 1.0 LEADS TO
 THE BEST ACCURACY FOR A SPHERICAL SHELL
 WHILE A VALUE OF 0.5 SEEMS TO BE BEST FOR
 THE INFINITE CYLINDRICAL SHELL. IT CAN BE
 SHOWN THAT THIS SCALAR PARAMETER DOES HAVE
 A RELATIONSHIP WITH THE DIAGONAL LOCAL

175 CURVATURE MATRIX FOR THE FLUID ELEMENTS.
 176 IF A VALUE OF ZERO WAS USED IN THE FLUID
 177 MASS RUN AND A DAA2 RUN IS DESIRED THEN
 178 THE FLUID MASS PROCESSOR MUST BE RUN
 179 WITH A NONZERO VALUE BEFORE FURTHER
 180 COMPUTATION CAN TAKE PLACE
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NSTR	I	NUMBER OF NODE POINTS IN STRUCTURAL MODEL
NSFR	I	NUMBER OF STRUCTURAL DEGREES OF FREEDOM. WHEN INTERFACING WITH STAGS THIS WILL BE SIX (6) TIMES THE VALUE OF NSTR
NFRE	I	THE LARGEST DEGREE OF FREEDOM INDEX AT ANY STRUCTURAL NODE WHICH IS REFERENCED IN THE ANALYSIS. FREEDOMS 1, 2, AND 3 ARE ASSUMED TO BE TRANSLATIONAL WHILE 4, 5, AND 6 ARE RESERVED FOR ROTATIONS. ALWAYS USE SIX (6) WHEN INTERFACING WITH STAGS
NFTR	I	THE LARGEST TRANSLATIONAL DEGREE OF FREEDOM INDEX AT ANY NODE WHICH IS REFERENCED IN THE ANALYSIS. ALWAYS USE THREE (3) WHEN INTERFACING WITH STAGS
MXWD	I	NUMBER OF WORDS PER BLOCK TO BE USED FOR PARTITIONED SKYLINE FLUID MATRICES. GENERALLY USE SOME MULTIPLE OF 448 TO ACCOMMODATE EITHER THE 28 WORD SECTOR ON UNIVAC OR THE 64 WORD PRU ON CDC SO THAT FILE SIZE IS MINIMIZED
NUMBLK	I	NUMBER OF BLOCKS OR MATRIX VALUE RECORDS INTO WHICH THE SKYLINE STRUCTURAL STIFFNESS MATRIX HAS BEEN PARTITIONED
NWDBLK	I	MAXIMUM BLOCK SIZE FOR SKYLINE STRUCTURAL STIFFNESS MATRIX
NSETLC	I	NUMBER OF DATA SETS NEEDED TO DEFINE THE TYPE OF STRUCTURAL COORDINATE SYSTEM WITH WHICH ANY PARTICULAR GENERAL FLUID ELEMENT MUST INTERFACE. THIS DATA IS NOT REQUIRED FOR SURFACE OF REVOLUTION FLUID ELEMENTS BUT INCLUDES ANY FLUID ELEMENTS THAT WERE GENERATED AUTOMATICALLY IN FLUMAS FOR A CYLINDRICAL SURFACE
NDICOS	I	DESIGNATES THE TYPE OF COORDINATE SYSTEM USED IN THE STRUCTURAL SOLUTION. ACCEPTABLE VALUES ARE: 0 - GLOBAL COORDINATES 1 - LOCAL COORDINATES WITH THE FIRST DEGREE OF FREEDOM NORMAL TO THE FLUID-STRUCTURE CONTACT BOUNDARY 2 - LOCAL COORDINATES WITH THE SECOND DEGREE OF FREEDOM NORMAL TO THE

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FLUID-STRUCTURE CONTACT BOUNDARY
3 - LOCAL COORDINATES WITH THE THIRD
DEGREE OF FREEDOM NORMAL TO THE
FLUID-STRUCTURE CONTACT BOUNDARY

AT THIS TIME OPTIONS 1, 2, OR 3 MAY BE
USED ONLY FOR RIGHT CIRCULAR CYLINDERS OR
SPHERES. MORE LATITUDE IN THESE CHOICES IS
ULTIMATELY PLANNED. FOR USAGE WITH STAGS A
VALUE OF 0 MUST ALWAYS BE USED AS STAGS
CARRIES OUT ITS OWN GLOBAL TO LOCAL
TRANSFORMATION. GLOBAL COORDINATES ARE
AUTOMATICALLY SET IN THIS PROCESSOR FOR
ALL SURFACE OF REVOLUTION FLUID ELEMENTS

JSTART I FIRST OF ONE OR MORE FLUID ELEMENTS HAVING
THE SAME VALUE OF NDICOS

JSTOP I LAST OF ONE OR MORE FLUID ELEMENTS HAVING
THE SAME VALUE OF NDICOS

JINC I INCREMENT TO BE APPLIED IN ASSIGNING THE
VALUE OF NDICOS TO FLUID ELEMENTS IN THE
RANGE FROM JSTART TO JSTOP

NUMCON I NUMBER OF DATA SETS REQUIRED TO DEFINE THE
CONSTRAINTS TO BE APPLIED TO TRANSLATIONAL
STRUCTURAL DEGREES OF FREEDOM DUE TO
SYMMETRY CONDITIONS. THESE CONSTRAINTS
NEED BE APPLIED ONLY TO STRUCTURAL NODES
ON THE WET SURFACE

ICON I WILL HAVE THE VALUE 1, 2, OR 3 DEPENDING
UPON WHETHER THE TRANSLATIONAL CONSTRAINT
IS TO BE APPLIED IN THE X, Y, OR Z GLOBAL
COORDINATE DIRECTION. ONLY ONE CONSTRAINT
IS ALLOWABLE AT A STRUCTURAL NODE AT THIS
TIME HOWEVER THIS LIMITATION IS NOT
PARTICULARLY RESTRICTIVE. CONSTRAINTS TO
THE AUGMENTED MATRICES ARE REQUIRED ONLY
IF A FLUID ELEMENT ASSOCIATED WITH A
PARTICULAR STRUCTURAL NODE IS ORIENTED
SUCH THAT THE UNIT OUTWARD NORMAL VECTOR
OF THE FLUID ELEMENT HAS A COMPONENT
PERPENDICULAR TO THE SYMMETRY PLANE. FOR
EXAMPLE, A QUARTER CYLINDER MODEL WOULD
REQUIRE A CIRCUMFERENTIAL CONSTRAINT BUT
NOT AN AXIAL ONE

NSTART I FIRST OF ONE OR MORE STRUCTURAL NODES
HAVING THE SAME VALUE OF ICON

NSTOP I LAST OF ONE OR MORE STRUCTURAL NODES
HAVING THE SAME VALUE OF ICON

NINC I INCREMENT TO BE APPLIED IN ASSIGNING THE
VALUE OF ICON TO STRUCTURAL NODES IN THE
RANGE FROM NSTART TO NSTOP

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291      PRTPNT          I      A VALUE OF ONE (1) WILL PRODUCE A DISPLAY
292                        OF THE DIAGONAL LOCATION POINTERS OF THE
293                        SKYLINE STRUCTURAL STIFFNESS MATRIX.
294                        OTHERWISE SET TO ZERO UNDER NORMAL
295                        CONDITIONS
296
297
298      PRTRVAL         I      A VALUE OF ONE (1) WILL PRODUCE A DISPLAY
299                        OF THE SKYLINE STIFFNESS MATRIX.
300                        OTHERWISE SET TO ZERO AND ONLY THE
301                        DIAGONAL TERMS WILL BE PRINTED BY DEFAULT.
302                        USE A NON-ZERO VALUE ONLY FOR DIAGNOSTIC
303                        REASONS OR FOR VERY SMALL PROBLEMS AS THE
304                        AMOUNT OF OUTPUT CAN BE ENORMOUS
305
306
307      MAPVAL          I      A VALUE OF ONE (1) WILL PRODUCE A MAP-TYPE
308                        DISPLAY OF MATRIX VALUES TO SHOW THE
309                        CONNECTIVITY ALONE, OTHERWISE SET TO ZERO
310                        UNDER NORMAL CONDITIONS
311
312
313      MVR1            I      INDEX OF FIRST MATRIX VALUE RECORD TO BE
314                        DISPLAYED. UNDER NORMAL CONDITIONS USE A
315                        VALUE OF ZERO AND THE CODE WILL START THE
316                        DISPLAY AT THE BEGINNING OF THE MATRIX.
317                        USE A NON-ZERO VALUE ONLY WHEN A SPECIFIC
318                        SET OF BLOCKS IS TO BE PRINTED FOR SOME
319                        DIAGNOSTIC REASON
320
321
322      MVR2            I      INDEX OF LAST MATRIX VALUE RECORD TO BE
323                        DISPLAYED. UNDER NORMAL CONDITIONS USE A
324                        VALUE OF ZERO AND THE CODE WILL DISPLAY TO
325                        THE END OF THE MATRIX. USE A NON-ZERO
326                        VALUE ONLY WHEN A SPECIFIC SET OF BLOCKS
327                        IS TO BE PRINTED FOR SOME DIAGNOSTIC
328                        REASON
329
330
331      INPUT          DATA CARD DECK
332
333
334      ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
335      IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
336      ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
337      FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
338      EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
339      CHARACTERS MAY BE USED FOR CDC OPERATION
340
341      GENERAL PROBLEM DEFINITION (MAIN PROGRAM PREPROC):
342      -----
343
344      72 COLUMN ALPHANUMERIC TITLE
345      STRNAM FLUNAM GEONAM PRENAM
346      FRMTST SYMCON PRFAUG
347      PRGTMT PRTRN PRSTF
348      DAAZ NSFR NFRE NFTR

```

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349 M4WD
350
351 IF PRSTF = .TRUE. INCLUDE THE FOLLOWING CARD
352
353 NUMBLK NWDBLK
354
355 IF THE FLUID MODEL CONSISTS OF ONLY SURFACE OF REVOLUTION ELEMENTS
356 SKIP THE FOLLOWING SET OF CARDS
357
358 NSETLC
359 NDICOS JSTART JSTOP JINC ) TOTAL = NSETLC
360 . . . . . )
361 . . . . . )
362
363 SET SYMMETRY CONSTRAINTS (SUBROUTINE CONSTR):
364 -----
365
366 IF SYMCON = .TRUE. INCLUDE THE FOLLOWING CARDS
367
368 NUMCON
369 ICON NSTART NSTOP NINC ) TOTAL = NUMCON
370 . . . . . )
371 . . . . . )
372
373 DISPLAY SKYLINE STRUCTURAL STIFFNESS MATRIX (SUBROUTINE STFMAT):
374 -----
375
376 IF PRSTF = .TRUE. INCLUDE THE FOLLOWING CARDS
377
378 PRTPNT PRTPAL MAPVAL
379 MVR1 MVR2

```

The following discussion is provided as an aid to user understanding of the sample output that is included here.

After a summary of the fluid mesh geometry arrays (see Appendix A) the first item needing explanation is that entitled "Fluid Element Wetted Freedom Indicator". This is simply a listing of the input variable NDICOS (see user manual) for each fluid element.

The section "Structural Grid Point Numbers Associated With Internal Sequence Numbers" contains a correspondence table that relates the internal sequence numbers assigned by the fluid mass processor with the external structural node number assigned by the user.

The next item entitled "Grid Point and Freedom Number for Each Row of Stiffness Matrix" identifies an integer vector that is constructed by the user in the Skyline Utility (see Figure 3-1, also Appendix E). For each structural equation the entry in the vector consists of ten times the structural node number plus the local degree of freedom number.

The last item requiring explanation is the "Freedom/Equation Correspondence Table". This is an integer matrix of 6 rows and as many columns as there are structural node points. Any particular row corresponds to a local degree of freedom number while a column corresponds to the internal sequence number for a particular external node number. The matrix entry for any particular set of row and column is the structural equation number for that pair.

Depending upon user input the structural stiffness matrix (identifier "STIF") may then be displayed as well as the appropriate fluid matrices. The matrix called TMIT corresponds to $\underline{D}_s$ [see Eq. (2.6)], while DFDS denotes the sum of $\underline{D}_s$ and $\underline{D}_{f1}$ [see Eq. (2.6)]. In DAA₂ runs $\underline{D}_{f1}$ is labeled DAA1 while $\underline{D}_{f2}$ is labeled DAA2.

1	AUGMAT RUN FOR INFINITE CYLINDER SIMULATION:				CYL*PREP
2	CYL*KSKY	F	CYL*DAIM	CYL*GEOM	
3		F			
4		T			
5					
6	0.				
7	72	432	6	3	
8	448				
9	6	2688			
10	1	1	26	1	
11	0	0	0		
12	0				

EXQT

@ADD,P CYLAUGDAT

AUGMAT RUN FOR INFINITE CYLINDER SIMULATION

+++ @ ASG,AX CYL*GEOM.
+++ @ USE 14,CYL*GEOM.

USER OPTIONS FOR THIS RUN:

FRWST SYMCON PRTAUG
F F
PRTCMT PRTRN PRSTF
T T

THIS IS A DAA1 RUN

FLUID MASS DENSITY = .10000000+01
FLUID SOUND SPEED = .10000000+01

2735 WORDS OF STORAGE REQUIRED FOR THIS RUN

+++ @ ASG,UPR CYL*PREP., F/ 4/TRK/ 1024
+++ @ USE 16,CYL*PREP.

+++++
+ AUXILIARY STORAGE TABLE
+
+LDI EDN(Q*EFN) IFN EC OP SEC CDLOC NEXT LIMIT READ WRITTEN +
+ 12 CYL*GEOM 14 36 AX 28 36 64 65536 766 0 +
+ 14 CYL*PREP 16 36 UPR28 9 0 65536 0 0 +
+
+ 0 TP-OPS. 2 ACTIVE DEVICES (0 FULL) 766 WORDS (FD +
+ 0 WRITES, 13 READS.
+++++

+++ @ FREE CYL*GEOM.

FLUID MESH GEOMETRIC ARRAYS:

N	NTRA	X	Y	Z	NX	NY	NZ	A00
1	2	.10000000+01	.00000000	.00000000	.10000000+01	.00000000	.00000000	.30504511-01
2	2	.98480775+00	.17364818+00	.00000000	.98480775+00	.17364818+00	.00000000	.30504511-01
3	2	.93969262+00	.34202015+00	.00000000	.93969262+00	.34202015+00	.00000000	.30504511-01

4	2	.86602540+00	.50000001+00	.00000000	.86602540+00	.50000001+00	.00000000	.30504511-01
5	2	.76604443+00	.64278762+00	.00000000	.76604443+00	.64278762+00	.00000000	.30504511-01
6	2	.64278760+00	.76604443+00	.00000000	.64278760+00	.76604443+00	.00000000	.30504511-01
7	2	.49999999+00	.86602541+00	.00000000	.49999999+00	.86602541+00	.00000000	.30504511-01
8	2	.3427012+00	.93969263+00	.00000000	.3427012+00	.93969263+00	.00000000	.30504511-01
9	2	.1731815+00	.98480776+00	.00000000	.17364815+00	.98480776+00	.00000000	.30504511-01
10	2	-.28810223-07	.10000000+01	.00000000	-.28810229-07	.10000000+01	.00000000	.30504511-01
11	2	-.1731822+00	.98480774+00	.00000000	-.17364822+00	.98480774+00	.00000000	.30504511-01
12	2	.3427018+00	.93969261+00	.00000000	-.34202018+00	.93969261+00	.00000000	.30504511-01
13	2	-.5002002+00	.86602539+00	.00000000	-.50000002+00	.86602539+00	.00000000	.30504511-01
14	2	-.64278765+00	.76604441+00	.00000000	-.64278765+00	.76604441+00	.00000000	.30504511-01
15	2	-.76604448+00	.64278758+00	.00000000	-.76604448+00	.64278758+00	.00000000	.30504511-01
16	2	-.86602543+00	.49999999+00	.00000000	-.86602543+00	.49999999+00	.00000000	.30504511-01
17	2	-.93969265+00	.34202008+00	.00000000	-.93969265+00	.34202008+00	.00000000	.30504511-01
18	2	-.98480777+00	.17364812+00	.00000000	-.98480777+00	.17364812+00	.00000000	.30504511-01
19	2	-.10000000+01	-.57620458-07	.00000000	-.10000000+01	-.57620458-07	.00000000	.30504511-01
20	2	-.98480774+00	-.17364823+00	.00000000	-.98480774+00	-.17364823+00	.00000000	.30504511-01
21	2	-.93969253+00	-.34202022+00	.00000000	-.93969259+00	-.34202022+00	.00000000	.30504511-01
22	2	-.86602537+00	.50000006+00	.00000000	-.86602537+00	.50000006+00	.00000000	.30504511-01
23	2	-.76604440+00	-.64278766+00	.00000000	-.76604440+00	-.64278766+00	.00000000	.30504511-01
24	2	-.64278754+00	-.76604450+00	.00000000	-.64278754+00	-.76604450+00	.00000000	.30504511-01
25	2	-.49999995+00	-.86602543+00	.00000000	-.49999995+00	-.86602543+00	.00000000	.30504511-01
26	2	-.34202007+00	-.93969265+00	.00000000	-.34202007+00	-.93969265+00	.00000000	.30504511-01
27	2	-.17364807+00	-.98480777+00	.00000000	-.17364807+00	-.98480777+00	.00000000	.30504511-01
28	2	.71529525-07	-.10000000+01	.00000000	.71529525-07	-.10000000+01	.00000000	.30504511-01
29	2	.17364827+00	-.98480774+00	.00000000	.17364827+00	-.98480774+00	.00000000	.30504511-01
30	2	.34202026+00	-.93969258+00	.00000000	.34202026+00	-.93969258+00	.00000000	.30504511-01
31	2	.50000007+00	-.86602536+00	.00000000	.50000007+00	-.86602536+00	.00000000	.30504511-01
32	2	.64278769+00	-.76604437+00	.00000000	.64278769+00	-.76604437+00	.00000000	.30504511-01
33	2	.76604453+00	-.64278751+00	.00000000	.76604453+00	-.64278751+00	.00000000	.30504511-01
34	2	.86602546+00	-.49999991+00	.00000000	.86602546+00	-.49999991+00	.00000000	.30504511-01
35	2	.93969266+00	-.34202003+00	.00000000	.93969266+00	-.34202003+00	.00000000	.30504511-01
36	2	.98480777+00	-.17364809+00	.00000000	.98480777+00	-.17364809+00	.00000000	.30504511-01

LOCAL FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS:

NFLU	NSTR	
1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8	8	
9	9	
10	10	
11	11	
12	12	
13	13	
14	14	
15	15	
16	16	
17	17	
18	18	
19	19	
20	20	
21	21	
22	22	
23	23	
24	24	
25	25	
26	26	
27	27	
28	28	
29	29	
30	30	
31	31	
32	32	
33	33	
34	34	
35	35	
36	36	

11	21	22
	.50000+00	.50000+00
12	23	24
	.50000+00	.50000+00
13	25	25
	.50000+00	.50000+00
14	27	28
	.50000+00	.50000+00
15	29	30
	.50000+00	.50000+00
16	31	32
	.50000+00	.50000+00
17	33	34
	.50000+00	.50000+00
18	35	36
	.50000+00	.50000+00
19	37	38
	.50000+00	.50000+00
20	39	40
	.50000+00	.50000+00
21	41	42
	.50000+00	.50000+00
22	43	44
	.50000+00	.50000+00
23	45	46
	.50000+00	.50000+00
24	47	48
	.50000+00	.50000+00
25	49	50
	.50000+00	.50000+00
26	51	52
	.50000+00	.50000+00
27	53	54
	.50000+00	.50000+00
28	55	56
	.50000+00	.50000+00
29	57	58
	.50000+00	.50000+00
30	59	60
	.50000+00	.50000+00
31	61	62
	.50000+00	.50000+00
32	63	64
	.50000+00	.50000+00
33	65	66
	.50000+00	.50000+00
34	67	68
	.50000+00	.50000+00
35	69	70
	.50000+00	.50000+00
36	71	72
	.50000+00	.50000+00

FLUID ELEMENT WETTED FREEDOM INDICATOR:

1	2	3	4	5	6	7	8	9	10
1	1	1	1	1	1	1	1	1	1

11	12	13	14	15	16	17	18	19	20
1	1	1	1	1	1	1	1	1	1
21	22	23	24	25	26	27	28	29	30
1	1	1	1	1	1	1	1	1	1
31	32	33	34	35	36				
1	1	1	1	1	1				
1	2	3	4	5	6	7	8	9	10
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
11	12	13	14	15	16	17	18	19	20
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
21	22	23	24	25	26	27	28	29	30
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
31	32	33	34	35	36				
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01
1	2	3	4	5	6	7	8	9	10
.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01	.30505-01

+++ * ASG,AX CYL*MSKY.
+++ * USE 22,CYL*MSKY.

DIAGONAL STRUCTURAL MASS MATRIX:

1	2	3	4	5	6	7	8	9	10
.11973-02	.11973-02	.11973-02	.11973-02	.11973-02	.11973-02	.11973-02	.11973-02	.11973-02	.11973-02
11	12	13	14	15	16	17	18	19	20
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
21	22	23	24	25	26	27	28	29	30
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
31	32	33	34	35	36	37	38	39	40
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
41	42	43	44	45	46	47	48	49	50
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
51	52	53	54	55	56	57	58	59	60
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
61	62	63	64	65	66	67	68	69	70
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
71	72	73	74	75	76	77	78	79	80
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
81	82	83	84	85	86	87	88	89	90
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
91	92	93	94	95	96	97	98	99	100
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
101	102	103	104	105	106	107	108	109	110
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
111	112	113	114	115	116	117	118	119	120
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
121	122	123	124	125	126	127	128	129	130
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
131	132	133	134	135	136	137	138	139	140
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
141	142	143	144	145	146	147	148	149	150
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
151	152	153	154	155	156	157	158	159	160
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000

161	162	163	164	165	166	167	168	169	170
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
171	172	173	174	175	176	177	178	179	180
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
181	182	183	184	185	186	187	188	189	190
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
191	192	193	194	195	196	197	198	199	200
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
201	202	203	204	205	206	207	208	209	210
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
211	212	213	214	215	216	217	218	219	220
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
221	222	223	224	225	226	227	228	229	230
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
231	232	233	234	235	236	237	238	239	240
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
241	242	243	244	245	246	247	248	249	250
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
251	252	253	254	255	256	257	258	259	260
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
261	262	263	264	265	266	267	268	269	270
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
271	272	273	274	275	276	277	278	279	280
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
281	282	283	284	285	286	287	288	289	290
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
291	292	293	294	295	296	297	298	299	300
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
301	302	303	304	305	306	307	308	309	310
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
311	312	313	314	315	316	317	318	319	320
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
321	322	323	324	325	326	327	328	329	330
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
331	332	333	334	335	336	337	338	339	340
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
341	342	343	344	345	346	347	348	349	350
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
351	352	353	354	355	356	357	358	359	360
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
361	362	363	364	365	366	367	368	369	370
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
371	372	373	374	375	376	377	378	379	380
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
381	382	383	384	385	386	387	388	389	390
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
391	392	393	394	395	396	397	398	399	400
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
401	402	403	404	405	406	407	408	409	410
.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02
411	412	413	414	415	416	417	418	419	420
.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000	.00000	.00000
421	422	423	424	425	426	427	428	429	430
.11973-02	.11973-02	.11973-02	.00000	.00000	.00000	.11973-02	.11973-02	.11973-02	.00000
431	432								
.00000	.00000								

STRUCTURAL GRID POINT NUMBERS ASSOCIATED WITH INTERNAL SEQUENCE NUMBERS:

1	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
11	11	12	13	14	15	16	17	18	19	20
11	11	12	13	14	15	16	17	18	19	20
21	21	22	23	24	25	26	27	28	29	30
21	21	22	23	24	25	26	27	28	29	30
31	31	32	33	34	35	36	37	38	39	40
31	31	32	33	34	35	36	37	38	39	40
41	41	42	43	44	45	46	47	48	49	50
41	41	42	43	44	45	46	47	48	49	50
51	51	52	53	54	55	56	57	58	59	60
51	51	52	53	54	55	56	57	58	59	60
61	61	62	63	64	65	66	67	68	69	70
61	61	62	63	64	65	66	67	68	69	70
71	71	72								
71	71	72								

OLD PLAN AND FREEDOM NUMBER FOR EACH ROW OF STIFFNESS MATRIX:

1	1	2	3	4	5	6	7	8	9	10
1	1	12	13	14	15	16	21	22	23	24
11	11	12	13	14	15	16	17	18	19	20
25	25	26	31	32	33	34	35	36	41	42
21	21	22	23	24	25	26	27	28	29	30
43	43	44	45	46	51	52	53	54	55	56
31	31	32	33	34	35	36	37	38	39	40
61	61	62	63	64	65	66	71	72	73	74
41	41	42	43	44	45	46	47	48	49	50
75	75	76	81	82	83	84	85	86	91	92
51	51	52	53	54	55	56	57	58	59	60
93	93	94	95	96	101	102	103	104	105	106
61	61	62	63	64	65	66	67	68	69	70
111	111	112	113	114	115	116	121	122	123	124
71	71	72	73	74	75	76	77	78	79	80
125	125	126	131	132	133	134	135	136	141	142
81	81	82	83	84	85	86	87	88	89	90
143	143	144	145	146	151	152	153	154	155	156
91	91	92	93	94	95	96	97	98	99	100
161	161	162	163	164	165	166	171	172	173	174

101	102	103	104	105	106	107	103	103	110
175	176	181	182	183	184	185	186	191	192
111	112	113	114	115	116	117	116	119	120
193	194	195	196	201	202	203	204	205	206
121	122	123	124	125	126	127	126	129	130
211	212	213	214	215	216	221	222	223	224
131	132	133	134	135	136	137	138	139	140
225	226	231	232	233	234	235	236	241	242
141	142	143	144	145	146	147	146	149	150
243	244	245	246	251	252	253	254	255	256
151	152	153	154	155	156	157	159	159	160
261	262	263	264	265	266	271	272	273	274
161	162	163	164	165	166	167	168	169	170
275	276	281	282	283	284	285	286	291	292
171	172	173	174	175	176	177	178	179	180
293	294	295	296	301	302	303	304	305	306
181	182	183	184	185	186	187	188	189	190
311	312	313	314	315	316	321	322	323	324
191	192	193	194	195	196	197	198	199	200
325	326	331	332	333	334	335	336	341	342
201	202	203	204	205	206	207	208	209	210
343	344	345	346	351	352	353	354	355	356
211	212	213	214	215	216	217	218	219	220
361	362	363	364	365	366	371	372	373	374
221	222	223	224	225	226	227	228	229	230
375	376	381	382	383	384	385	386	391	392
231	232	233	234	235	236	237	238	239	240
393	394	395	396	401	402	403	404	405	406
241	242	243	244	245	246	247	248	249	250
411	412	413	414	415	416	421	422	423	424
251	252	253	254	255	256	257	258	259	260
425	426	431	432	433	434	435	436	441	442
261	262	263	264	265	266	267	268	269	270
443	444	445	446	451	452	453	454	455	456
271	272	273	274	275	276	277	278	279	280
461	462	463	464	465	466	471	472	473	474
281	282	283	284	285	286	287	288	289	290
475	476	481	482	483	484	485	486	491	492
291	292	293	294	295	296	297	298	299	300

493	494	495	496	501	502	503	504	505	506
301	302	303	304	305	306	307	308	309	310
511	512	513	514	515	516	521	522	523	524
311	312	313	314	315	316	317	318	319	320
525	526	531	532	533	534	535	536	541	542
321	322	323	324	325	326	327	328	329	330
543	544	545	546	551	552	553	554	555	556
331	332	333	334	335	336	337	338	339	340
561	562	563	564	565	566	571	572	573	574
341	342	343	344	345	346	347	348	349	350
575	576	581	582	583	584	585	586	591	592
351	352	353	354	355	356	357	358	359	360
593	594	595	596	601	602	603	604	605	606
361	362	363	364	365	366	367	368	369	370
611	612	613	614	615	616	621	622	623	624
371	372	373	374	375	376	377	378	379	380
625	626	631	632	633	634	635	636	641	642
381	382	383	384	385	386	387	388	389	390
643	644	645	646	651	652	653	654	655	656
391	392	393	394	395	396	397	398	399	400
661	662	663	664	665	666	671	672	673	674
401	402	403	404	405	406	407	408	409	410
675	676	681	682	683	684	685	686	691	692
411	412	413	414	415	416	417	418	419	420
693	694	695	696	701	702	703	704	705	706
421	422	423	424	425	426	427	428	429	430
711	712	713	714	715	716	721	722	723	724
431	432								
725	726								

FREEDOM/EQUATION CORRESPONDENCE TABLE:

1	1	2	3	4	5	6	7	8	9	10
2	1	7	13	19	25	31	37	43	49	55
3	2	8	14	20	26	32	38	44	50	56
4	3	9	15	21	27	33	39	45	51	57
5	4	10	16	22	28	34	40	46	52	58
6	5	11	17	23	29	35	41	47	53	59
	6	12	18	24	30	36	42	48	54	60
11	11	12	13	14	15	16	17	18	19	20
61	61	67	73	79	85	91	97	103	109	115
62	62	68	74	80	86	92	98	104	110	116

3	63	69	75	81	87	93	99	105	111	117
4	64	70	76	82	88	94	100	106	112	118
5	65	71	77	83	89	95	101	107	113	119
6	66	72	78	84	90	96	102	108	114	120
1	21	22	23	24	25	26	27	28	29	30
2	121	127	133	139	145	151	157	163	169	175
3	122	128	134	140	146	152	158	164	170	176
4	123	129	135	141	147	153	159	165	171	177
5	124	130	136	142	148	154	160	166	172	178
6	125	131	137	143	149	155	161	167	173	179
	126	132	138	144	150	156	162	168	174	180
1	31	32	33	34	35	36	37	38	39	40
2	181	187	193	199	205	211	217	223	229	235
3	182	188	194	200	206	212	218	224	230	236
4	183	189	195	201	207	213	219	225	231	237
5	184	190	196	202	208	214	220	226	232	238
6	185	191	197	203	209	215	221	227	233	239
	186	192	198	204	210	216	222	228	234	240
1	41	42	43	44	45	46	47	48	49	50
2	241	247	253	259	265	271	277	283	289	295
3	242	248	254	260	266	272	278	284	290	296
4	243	249	255	261	267	273	279	285	291	297
5	244	250	256	262	268	274	280	286	292	298
6	245	251	257	263	269	275	281	287	293	299
	246	252	258	264	270	276	282	288	294	300
1	51	52	53	54	55	56	57	58	59	60
2	301	307	313	319	325	331	337	343	349	355
3	302	308	314	320	326	332	338	344	350	356
4	303	309	315	321	327	333	339	345	351	357
5	304	310	316	322	328	334	340	346	352	358
6	305	311	317	323	329	335	341	347	353	359
	306	312	318	324	330	336	342	348	354	360
1	61	62	63	64	65	66	67	68	69	70
2	361	367	373	379	385	391	397	403	409	415
3	362	368	374	380	386	392	398	404	410	416
4	363	369	375	381	387	393	399	405	411	417
5	364	370	376	382	388	394	400	406	412	418
6	365	371	377	383	389	395	401	407	413	419
	366	372	378	384	390	396	402	408	414	420
1	71	72								
2	421	427								
3	422	428								
4	423	429								
5	424	430								
6	425	431								
	426	432								

+++ * ASG.T UNIT20.
 +++ * USE 20,UNIT20.
 F4/ 4/TRK/ 256

MASTER RECORD OF MATRIX STIF

MATRIX HEADER : L11 ROWS COLS SIZE-4
 000444 432 432 0
 KTX ATTRIBUTES: SINGLE SYMM REAL SKYLIN MULTPL

MAXMVR MVR12 MRU MULROW NMVR
 6 2688 432 6 6

MVR	BLOCK EXTENT TABLE		RECORD ACCESS DIRECTORY	
	F-COL	L-ROW	LDI DLOC(I)	DLOC(O)
1	1	132	20	37 00000045
2	121	258	20	133 00000205
3	241	376	20	225 00000345
4	321	420	20	325 00000505
5	1	326	20	421 00000645
6	1	432	20	517 00001005
				2688

CHECK MDT

MATRIX DESCRIPTOR TABLE (MDT)

MTRX BULKCOM ADDRESSES DEVICE DESCRIPTOR AREA
 PKT NAME HDR EXT-DEV-NAME TYPX OPTX LIMIT REEL
 1 STIF 1 5 10 0 0 0

MISCELLANEOUS INPUT AREA
 VAL1 VAL2 VAL34 VAL56
 000444 0 0.000 0.000

MATRIX HEADER
 MTR ROWS COLS
 000444 432 432

VALUE RECORD 1 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 133 2298 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	1	292	432	432	0	1	132	132	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

DIAG	COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7	COL 8	COL 9	COL 10
	1.36189-02	8.86689-01	8.89374-01	2.30450-07	3.01072-05	3.04495-05	1.36189-02	8.86689-01	8.89374-01	2.30450-07
DIAG	COL 11	COL 12	COL 13	COL 14	COL 15	COL 16	COL 17	COL 18	COL 19	COL 20
	3.01072-05	3.04495-05	1.36189-02	8.86689-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86689-01
DIAG	COL 21	COL 22	COL 23	COL 24	COL 25	COL 26	COL 27	COL 28	COL 29	COL 30
	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86689-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05

DIAG	COL 31	COL 32	COL 33	COL 34	COL 35	COL 36	COL 37	COL 38	COL 39	COL 40
	1.36189-02	3.36691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07
DIAG	COL 41	COL 42	COL 43	COL 44	COL 45	COL 46	COL 47	COL 48	COL 49	COL 50
	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01
DIAG	COL 51	COL 52	COL 53	COL 54	COL 55	COL 56	COL 57	COL 58	COL 59	COL 60
	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	6.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05
DIAG	COL 61	COL 62	COL 63	COL 64	COL 65	COL 66	COL 67	COL 68	COL 69	COL 70
	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07
DIAG	COL 71	COL 72	COL 73	COL 74	COL 75	COL 76	COL 77	COL 78	COL 79	COL 80
	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01
DIAG	COL 81	COL 82	COL 83	COL 84	COL 85	COL 86	COL 87	COL 88	COL 89	COL 90
	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05
DIAG	COL 91	COL 92	COL 93	COL 94	COL 95	COL 96	COL 97	COL 98	COL 99	COL 100
	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07
DIAG	COL 101	COL 102	COL 103	COL 104	COL 105	COL 106	COL 107	COL 108	COL 109	COL 110
	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01
DIAG	COL 111	COL 112	COL 113	COL 114	COL 115	COL 116	COL 117	COL 118	COL 119	COL 120
	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05
DIAG	COL 121	COL 122	COL 123	COL 124	COL 125	COL 126	COL 127	COL 128	COL 129	COL 130
	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07
DIAG	COL 131	COL 132								
	3.01072-05	3.04495-05								

 VALUE RECORD 2 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 127 2313 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	2	2	402	432	0	121	258	120	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

DIAG	COL 133	COL 134	COL 135	COL 136	COL 137	COL 138	COL 139	COL 140	COL 141	COL 142
	1.36189-02	8.86691-01	8.89373-01	2.30448-07	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89373-01	2.30448-07
	COL 143	COL 144	COL 145	COL 146	COL 147	COL 148	COL 149	COL 150	COL 151	COL 152

DIAG	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
	COL 153	COL 154	COL 155	COL 156	COL 157	COL 158	COL 159	COL 160	COL 161	COL 162
DIAG	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
	COL 163	COL 164	COL 165	COL 166	COL 167	COL 168	COL 169	COL 170	COL 171	COL 172
DIAG	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
	COL 173	COL 174	COL 175	COL 176	COL 177	COL 178	COL 179	COL 180	COL 181	COL 182
DIAG	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
	COL 183	COL 184	COL 185	COL 186	COL 187	COL 188	COL 189	COL 190	COL 191	COL 192
DIAG	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
	COL 193	COL 194	COL 195	COL 196	COL 197	COL 198	COL 199	COL 200	COL 201	COL 202
DIAG	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
	COL 203	COL 204	COL 205	COL 206	COL 207	COL 208	COL 209	COL 210	COL 211	COL 212
DIAG	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
	COL 213	COL 214	COL 215	COL 216	COL 217	COL 218	COL 219	COL 220	COL 221	COL 222
DIAG	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
	COL 223	COL 224	COL 225	COL 226	COL 227	COL 228	COL 229	COL 230	COL 231	COL 232
DIAG	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
	COL 233	COL 234	COL 235	COL 236	COL 237	COL 238	COL 239	COL 240	COL 241	COL 242
DIAG	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
	COL 243	COL 244	COL 245	COL 246	COL 247	COL 248	COL 249	COL 250	COL 251	COL 252
DIAG	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
	COL 253	COL 254	COL 255	COL 256	COL 257	COL 258				
DIAG	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05				

B-22

 VALUE RECORD 3 OF MATRIX STIF EASY HDR: C0044 432 432

MVR PREFIX: SPAR 26 121 2220 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	3	292	432	432	0	241	378	120	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

COL 259	COL 260	COL 261	COL 262	COL 263	COL 264	COL 265	COL 266	COL 267	COL 268
DIAG 1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07

DIAG	COL 269	COL 270	COL 271	COL 272	COL 273	COL 274	COL 275	COL 276	COL 277	COL 278
	3.01072-05	3.04495-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
DIAG	COL 279	COL 280	COL 281	COL 282	COL 283	COL 284	COL 285	COL 286	COL 287	COL 288
	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
DIAG	COL 289	COL 290	COL 291	COL 292	COL 293	COL 294	COL 295	COL 296	COL 297	COL 298
	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
DIAG	COL 299	COL 300	COL 301	COL 302	COL 303	COL 304	COL 305	COL 306	COL 307	COL 308
	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
DIAG	COL 309	COL 310	COL 311	COL 312	COL 313	COL 314	COL 315	COL 316	COL 317	COL 318
	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
DIAG	COL 319	COL 320	COL 321	COL 322	COL 323	COL 324	COL 325	COL 326	COL 327	COL 328
	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
DIAG	COL 329	COL 330	COL 331	COL 332	COL 333	COL 334	COL 335	COL 336	COL 337	COL 338
	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
DIAG	COL 339	COL 340	COL 341	COL 342	COL 343	COL 344	COL 345	COL 346	COL 347	COL 348
	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05
DIAG	COL 349	COL 350	COL 351	COL 352	COL 353	COL 354	COL 355	COL 356	COL 357	COL 358
	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07
DIAG	COL 359	COL 360	COL 361	COL 362	COL 363	COL 364	COL 365	COL 366	COL 367	COL 368
	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01
DIAG	COL 369	COL 370	COL 371	COL 372	COL 373	COL 374	COL 375	COL 376	COL 377	COL 378
	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05

 VALUE RECORD 4 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 43 795 2688

MVR HEADER:

WORD STIF	1	WORD 2	4	WORD 3	292	WORD 4	432	WORD 5	432	WORD 6	420	WORD 7	361	WORD 8	420	WORD 9	42	WORD 10	0
WORD 11	0	WORD 12	0	WORD 13	0	WORD 14	0	WORD 15	0	WORD 16	0	WORD 17	0	WORD 18	0	WORD 19	0	WORD 20	0
WORD 21	0	WORD 22	0	WORD 23	0	WORD 24	0	WORD 25	0	WORD 26	0	WORD 27	0	WORD 28	0	WORD 29	0	WORD 30	0

MATRIX VALUES:

DIAG	COL 379	COL 380	COL 381	COL 382	COL 383	COL 384	COL 385	COL 386	COL 387	COL 388
	1.36189-02	8.86691-01	8.89372-01	2.30448-07	3.01072-05	3.04496-05	1.36189-02	8.86691-01	8.89372-01	2.30448-07

DIAG COL 389 COL 390 COL 391 COL 392 COL 393 COL 394 COL 395 COL 396 COL 397 COL 398
 3.01072-05 3.04495-05 1.36189-02 8.86691-01 8.89372-01 2.30448-07 3.01072-05 3.04496-05 1.36189-02 8.86691-01

DIAG COL 399 COL 400 COL 401 COL 402 COL 403 COL 404 COL 405 COL 406 COL 407 COL 408
 8.89372-01 2.30448-07 3.01072-05 3.04496-05 1.36189-02 5.86691-01 8.89372-01 2.30448-07 3.01072-05 3.04496-05

DIAG COL 409 COL 410 COL 411 COL 412 COL 413 COL 414 COL 415 COL 416 COL 417 COL 418
 1.36189-02 8.86691-01 8.89372-01 2.30448-07 3.01072-05 3.04496-05 1.36189-02 8.86691-01 8.89372-01 2.30448-07

DIAG COL 419 COL 420
 3.01072-05 3.04496-05

 VALUE RECORD 5 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 7 2541 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	5	292	432	432	0	1	426	6	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

DIAG COL 421 COL 422 COL 423 COL 424 COL 425 COL 426
 1.36189-02 8.86691-01 8.89374-01 2.30450-07 3.01072-05 3.04495-05

 VALUE RECORD 6 OF MATRIX STIF EASY HDR: 000444 432 432

MVR PREFIX: SPAR 26 7 2577 2688

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
STIF	0	292	432	432	0	1	432	0	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

COL 427 COL 428 COL 429 COL 430 COL 431 COL 432

DIAG 1.36189-02 8.36689-01 8.89374-01 2.33450-07 3.01072-05 3.04495-05

+++ @ FREE UNIT20
 +++ @ FREE CYL*SKY.
 +++ @ ASG,T UNIT20.
 +++ @ USE 20,UNIT20. F4/ 4/TRK/ 256

DAA FORM OF STRUCTURAL MASS INVERSE MATRIX:

+++ @ ASG,T UNIT18., F4/ 4/TRK/ 256
 +++ @ USE 18,UNIT18.

MASTER RECORD OF MATRIX TMIT

MATRIX HEADER : MTI ROWS COLS SIZE-4
 000444 36 36 0
 MTX ATTRIBUTES: SINGLE SYMM REAL SKYLIN MULTBL

MAXMVR MVRSTZ MVR MULROW NMVR
 1 448 448 1

MVR BLOCK EXTENT TABLE RECORD ACCESS DIRECTORY
 * F-COL L-COL ROWS LDI DLOC(1) DLOC(0) SIZE
 1 1 36 36 14 65 00000101 148

VALUE RECORD 1 OF MATRIX TMIT EASY HDR: 000444 36 36

MVR PREFIX: AUGM 20 37 36 443

MVR HEADER:

WORD	1	WORD	2	WORD	3	WORD	4	WORD	5	WORD	6	WORD	7	WORD	8	WORD	9	WORD	10
TMIT	1		292				26												
WORD 11	0	WORD 12	0	WORD 13	0	WORD 14	0	WORD 15	0	WORD 16	0	WORD 17	0	WORD 18	0	WORD 19	0	WORD 20	0
WORD 21	0	WORD 22	0	WORD 23	0	WORD 24	0	WORD 25	0	WORD 26	0								

MATRIX VALUES:

DIAG 3.86591-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01 3.88593-01

DIAG 3.88593-01

DIAG	3.88593-01	3.68593-01	3.80593-01	3.98593-01	3.88593-01	3.88593-01	3.88593-01
	COL 31	COL 32	COL 33	COL 34	COL 35	COL 36	
DIAG	3.88593-01	3.88593-01	3.88593-01	3.88593-01	3.88593-01	3.83591-01	

MATRIX VALUES:

A scatter plot showing a positive linear relationship between two variables. The x-axis is labeled with values from 1 to 36, and the y-axis is labeled with values from 1 to 36. Each data point is marked with a '+' symbol, forming a straight line that starts at (1, 1) and ends at (36, 36).

[illegible]

DIAG 6.59491-01 6.59493-01 6.59492-01 6.59492-01 6.59492-01 6.59491-01 6.59493-01 6.59492-01

COL 21 COL 22 COL 23
DIAG 6.59492-01 6.59493-01 6.59491-01

VALUE RECORD 2 OF MATRIX DFDS EASY HDR: 000444 36 36

MVR PREFIX: AUGM 26 11 285 148

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
DFDS	2	292	36	36	0	1	33	10	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

COL 24 COL 25 COL 26 COL 27 COL 28 COL 29 COL 30 COL 31 COL 32 COL 33
DIAG 6.59492-01 6.59493-01 6.59491-01 6.59491-01 6.59491-01 6.59491-01 6.59491-01 6.59491-01 6.59491-01 6.59492-01

VALUE RECORD 3 OF MATRIX DFDS EASY HDR: 000444 36 36

MVR PREFIX: AUGM 26 4 105 148

MVR HEADER:

WORD 1	WORD 2	WORD 3	WORD 4	WORD 5	WORD 6	WORD 7	WORD 8	WORD 9	WORD 10
DFDS	3	292	26	36	0	1	36	3	0
WORD 11	WORD 12	WORD 13	WORD 14	WORD 15	WORD 16	WORD 17	WORD 18	WORD 19	WORD 20
0	0	0	0	0	0	0	0	0	0
WORD 21	WORD 22	WORD 23	WORD 24	WORD 25	WORD 26				
0	0	0	0	0	0				

MATRIX VALUES:

COL 34 COL 35 COL 36
DIAG 6.59491-01 6.59491-01 6.59491-01

+ AUXILIARY STORAGE TABLE +

1	FILE LIBRARY DATA	0	242
2	FLUID GEOMETRY AND TRANSFORMATION DATA	9	540
3	GENERALIZED FLUID AREAS	29	36
4	FREEDOM EQUATION CORRESPONDENCE TABLE	31	432
5	DIAGONAL STRUCTURAL MASS INV	47	432
6	SKYPUL RMR AND MVR FOR DAA STRUCTURAL MASS INV	63	
7	SKYPUL RMR AND MVR FOR DAA VIRTUAL MASS INV	81	

APPENDIX C
USER INFORMATION FOR THE TIME INTEGRATION PROCESSOR TIMINT

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE CONDUCTS A STEP-BY-STEP DIRECT NUMERICAL TIME INTEGRATION OF THE GOVERNING EQUATIONS OF SUBMERGED STRUCTURES EXPOSED TO SPHERICAL SHOCK WAVES OF ARBITRARY PRESSURE PROFILE AND SOURCE LOCATION. THE FLUID EQUATIONS UTILIZE THE WELL-KNOWN DOUBLY ASYMPTOTIC APPROXIMATION (DAA) WHILE THE STRUCTURE ITSELF MAY BE TREATED BY A VARIETY OF LINEAR OR NONLINEAR PROGRAM MODULES THAT CARRY OUT THE SPATIAL ANALYSIS AT EACH TIME STEP. THE CODE USES THE STAGGERED SOLUTION PROCEDURE WHEREIN THE STRUCTURAL RESPONSE EQUATIONS AND THE FLUID RESPONSE EQUATIONS ARE SOLVED SEPARATELY AT EACH TIME STEP THROUGH EXTRAPOLATION OF THE TERMS WHICH COUPLE THE TWO SYSTEMS.

THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNTZ, JR.
OF LOCKHEED MISSILES AND SPACE CO. RESEARCH LABS IN PALO ALTO
CALIFORNIA. PLEASE CONSULT WITH AUTHOR BEFORE MAKING CHANGES
AND ALSO REPORT ANY MALFUNCTIONS OR PROBLEMS. WRITE IN CARE OF
LOCKHEED PALO ALTO RESEARCH LABORATORY, BLDG 205, DEPT 52-33
33251 HANDEYER ST., PALO ALTO, CALIF., 94304 OR CALL 415-493-4111
EXTS. 45069 OR 45133.
SEPTEMBER, 1980

MAXIMUM VALUES

MAXIMUM NUMBER OF INPUT PRESSURE DATA POINTS:

INFINITE FLUID		4 C 2
FREE SURFACE PROBLEM		2 0 1

MAXIMUM NUMBER OF CUBIC SPLINE TIME POINTS:

INFINITE FLUID		102
----------------	-------	-----

FREE SURFACE		51
ROBLEM		51

MAXIMUM NUMBER OF DIFFERENT TIME STEP SIZES	...	10
...	...	...

MAXIMUM NUMBER OF PREVIOUS RESPONSE FILES	9
.....	9

MAXIMUM: NUMBER OF TRANSIENT RESPONSE DISPLAYS		100
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RUN TIME INFORMATION

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THE FOLLOWING INFORMATION IS PROVIDED FOR THE ESTIMATION OF CPU TIME IN SECONDS TO WHICH MUST BE ADDED INPUT/OUTPUT CHARGES. CORE-BLOCK TIME, EXECUTIVE REQUESTS, FILE CHARGES, ETC. THE RULE TO FOLLOW IS TO ESTIMATE CPU TIME AND THEN INCREASE THIS TO ARRIVE AT AN APPROXIMATE SYSTEM CHARGE ESTIMATE. FOR SMALL PROBLEMS THE SYSTEM CHARGES CAN EASILY DOMINATE AND A LARGE FACTOR WOULD HAVE TO BE APPLIED TO THE RUN TIME COMPUTED BELOW. FOR FAIRLY LARGE PROBLEMS (2500 DOF) THIS FACTOR DROPS DOWN TO ABOUT TWO (2) FOR UNIVAC OPERATION

THE ESTIMATES FOR STRUCTURAL FACTORIZATION AND ADVANCEMENT TIMES GIVEN BELOW DO NOT APPLY TO THE USA-STAGS SYSTEM. PLEASE CONSULT A STAGS MANUAL

DEFINITION OF VARIABLES REQUIRED FOR RUN TIME COMPUTATION:

NSFR	NUMBER OF TIME STEPS
NTINC	NUMBER OF DIFFERENT TIME STEP INCREMENTS
NDISP	NUMBER OF DEGREES OF FREEDOM FOR WHICH TRANSIENT RESPONSE HISTORIES ARE TO BE DISPLAYED AT CONCLUSION OF RUN
NSFR	NUMBER OF DEGREES OF FREEDOM OF STRUCTURAL SYSTEM
NFLU	NUMBER OF DEGREES OF FREEDOM OF FLUID SYSTEM
BAVE	AVERAGE HALF BAND WIDTH OF STRUCTURAL STIFFNESS MATRIX
BRMS	ROOT MEAN SQUARE HALF BAND WIDTH OF STRUCTURAL STIFFNESS MATRIX, USE AVERAGE HALF BAND WIDTH IF THIS QUANTITY IS NOT READILY AVAILABLE
TCPU	TOTAL CENTRAL PROCESSING UNIT TIME REQUIRED FOR LISTED ITEMS BELOW
	$TCPU = TPRE + NTINC \cdot (TFS + TFF) + NSTEP \cdot (TAS + TAF) + TDISP$
TPRE	CPU TIME SPENT ON PRE-PROCESSING BEFORE TIME INTEGRATION COMMENCES
	$TPRE = 1000 \cdot CS \cdot (NSFR + NFLU)$
TFS	TIME REQUIRED TO FACTOR STRUCTURAL EQUATION SYSTEM
	$TFS = CS \cdot NSFR \cdot BRMS \cdot 2/2$
TAS	TIME REQUIRED FOR ADVANCEMENT OF ONE TIME STEP FOR STRUCTURAL SYSTEM
	$TAS = 3 \cdot CS \cdot NSFR \cdot BAVE$
TFF	TIME REQUIRED TO FACTOR FLUID EQUATION SYSTEM
	$TFF = CS \cdot NFLU \cdot 3/6$

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TAF      TIME REQUIRED FOR ADVANCEMENT OF ONE TIME STEP FOR
          FLUID SYSTEM
          TAF = CS*NFLU**2

          CPU TIME SPENT ON DISPLAY OF RESPONSE HISTORIES
          TDISP = 500.*CS*NSTEP*NDISP

          UNIT OPERATION CONSTANT IN SECONDS, CONSISTING OF A
          FLOATING ADDITION, A FLOATING MULTIPLY, AND INDEXING
          CS
          VALUES OF CONSTANT CS
          - - - - -
          OPERATING SYSTEM
          PRECISION UNIVAC UNIVAC CDC
                   1108 1110 6600
          SINGLE 5.5X10-6 3.2X10-6 1.5X10-6
          DOUBLE 9.0X10-6 4.5X10-6 - - -
          AT THIS TIME THE CODE OPERATES ONLY IN SINGLE
          PRECISION

          IN ADDITION TO BILLABLE CHARGES DUE TO EXECUTION OF THIS CODE
          THERE WILL PROBABLY BE A DAILY CHARGE FOR PERMANENT FILE STORAGE.
          RESPONSE AND RESTART FILES CREATED BY THIS CODE CAN BE EXTREMELY
          LENGTHY HENCE SUCH OUTPUT FROM LARGE RUNS SHOULD BE TRANSFERRED TO
          TAPE AT THE EARLIEST OPPORTUNITY TO MINIMIZE THESE CHARGES

          *****
          WARNING FROM THE PROGRAMMER GENERAL
          *****
```

THIS CODE CONTAINS THE SPECIAL INGREDIENT DMGASP NOT FOUND IN OTHER BRANDS. DMGASP IS A DATA MANAGEMENT UTILITY MODULE THAT WILL ACTIVATE AND DEACTIVATE ALL AUXILIARY STORAGE DATA FILES REFERENCED BY THE CODE. HENCE THE NAMES OF SUCH FILES SHOULD NOT APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH MIGHT NORMALLY ACTIVATE AND DEACTIVATE THE FILES. THE USER IS ALSO CAUTIONED THAT PREVIOUSLY CREATED FILES MUST ALREADY BE RESIDENT IN THE SYSTEM BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN ROLLED-OUT TO TAPE DMGASP WILL ATTEMPT TO HAVE THE FILE ROLLED-IN EVERY 15 SECONDS FOR UP TO 6 MINUTES ON THE UNIVAC 1100-EXEC 8 OPERATING SYSTEM. IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT IS THEREFORE GOOD POLICY TO SIMPLY ACTIVATE AND DEACTIVATE THE FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN EXISTING FILE, THE UNIVAC VERSION OF DMGASP WILL MODIFY THE NAME OF THE FILE GENERATED BY THIS RUN TO AVOID ANY CONFLICT. FILE NAME DUPLICATION WILL CAUSE NO PROBLEM ON THE CDC SCOPE OPERATING SYSTEM AS SCOPE WILL SIMPLY CATALOG A NEW CYCLE OF THE SAME FILE.

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175 ON THE OTHER HAND THE CDC NOS SYSTEM IS SIMILAR TO UNIVAC IN THIS
176 REGARD AND THE RUN WILL ABORT SINCE THE NAME-CHANGING FEATURE OF
177 DMGASP HAS NOT BEEN IMPLEMENTED FOR NOS. QUALIFIER*FILENAME IS THE
178 REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC PERMANENT FILE NAMES.
179 ON CDC SCOPE, THE QUALIFIER IS INTERPRETED AS THE USERS ID, WHICH
180 IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC
181 NOS, THE QUALIFIER IS INTERPRETED AS THE USERS CATALOG NUMBER,
182 WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER
183 CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER*FILENAME(CYCLE)
184 ON CDC SCOPE
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P R O G R A M S I Z E

ALL ARRAYS REFERENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS VERSION, HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH REQUEST IN THE CONTROL CARD DECK

D E F I N I T I O N O F I N P U T P A R A M E T E R S

INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO STANDARD FORTRAN USAGE:

VARIABLE	TYPE	DESCRIPTION
PRUNAM	A	NAME OF PRE-PROCESSED MASS STORAGE FILE CONTAINING ALL FLUID AND STRUCTURE DATA THAT DOES NOT DEPEND UPON THE SHOCK INPUT AND TIME INTEGRATION PARAMETERS
POSNAM	A	NAME OF MASS STORAGE FILE AVAILABLE FOR POST-PROCESSING WHICH CONTAINS SYSTEM RESPONSES
STRNEW	A	LEAVE BLANK FOR NORMAL USAGE. OTHERWISE THIS IS THE NAME OF A DIFFERENT STRUCTURAL STIFFNESS MATRIX FILE THAT IS TO BE USED IN THE TIME INTEGRATION RUN RATHER THAN

THE ONE USED IN THE AUGMAT PROCESSOR. THE ONLY CONDITIONS UNDER WHICH THIS ABNORMAL CASE CAN BE USED ARE WHEN THE STRUCTURE AND ITS MASS ARE THE SAME AS BEFORE. BUT ITS ELASTIC CONSTANTS ARE DIFFERENT AS OFTEN OCCURS IN PARAMETER STUDIES. IN SUCH CASES AUGMAT NEED NOT BE RERUN

RESNAM A NAME OF MASS STORAGE FILE THAT CONTAINS INFORMATION FOR RESTARTING THE TRANSIENT RESPONSE ANALYSIS

WRTNAM A NAME OF MASS STORAGE FILE UPON WHICH RESTART DATA IS TO BE WRITTEN. IF LEFT BLANK THEN RESTART DATA WILL BE WRITTEN ON THE FILE DENOTED BY RESNAM

XC, YC, ZC E.F. CARTESIAN COORDINATES OF THE LOCATION OF SPHERICAL CHARGE IN FLUID MESH SYSTEM

SX, SY, SZ E.F. CARTESIAN COORDINATES OF THE CHARGE STANDOFF POINT IN THE FLUID MESH SYSTEM. THIS IS THE POINT ON THE STRUCTURE THAT IS CLOSEST TO THE CHARGE. THE INTEGRATION PROCESS STARTS AT TIME EQUAL TO ZERO WITH THE SPHERICAL WAVE JUST TOUCHING THE STRUCTURE AT THIS POINT ASSOCIATED WITH THE MINIMUM DISTANCE TO THE CHARGE

EXPWAV L TRUE IF THE INCIDENT PRESSURE PULSE IS EXPRESSED IN THE FORM OF AN EXPONENTIALLY DECAYING FUNCTION. OTHERWISE FALSE

SPLINE L TRUE IF THE INCIDENT PRESSURE PULSE IS DESCRIBED BY A CUBIC SPLINE FUNCTION. CARE SHOULD ALWAYS BE TAKEN WITH THE CHOICE OF INPUT DATA POINTS SINCE THIS ALGORITHM WILL PRODUCE A CONTINUOUS FUNCTION THAT CAN OSCILLATE WILDLY AROUND AREAS OF RAPID CHANGE. IN SUCH CASES IT IS IMPORTANT TO CLUSTER DATA POINTS IN THESE AREAS

JPHIST I NUMBER OF INCIDENT PRESSURE HISTORY DATA POINTS. SEE ABOVE FOR MAXIMUM NUMBER ALLOWED BY CORE ALLOCATION

DTHIST E.F. TIME INTERVAL ASSOCIATED WITH ANY TWO SUCCESSIVE INCIDENT PRESSURE HISTORY DATA POINTS

PNORM E.F. CONSTANT MULTIPLICATIVE FACTOR TO BE APPLIED TO THE INPUT PRESSURE HISTORY DATA POINTS

PHIST E.F. INCIDENT PRESSURE HISTORY DATA POINTS. THE VALUES USED IN THE TIME INTEGRATION PROCESS ARE THE PRODUCT OF PHIST AND PNORM TO ALLOW FOR THE POSSIBILITY THAT THE

INPUT DATA MAY HAVE BEEN EXPERIMENTALLY
 OBTAINED AT A POINT WHICH IS NOT EQUAL TO
 SC ABOVE. PNDWM MUST THEREFORE REFLECT THE
 1/R SCALING DIFFERENCE BETWEEN SC AND THE
 LOCATION OF THE PRESSURE SENSOR DURING THE
 PULSE CHARACTERIZATION EXPERIMENT. IF THE
 INCIDENT PRESSURE GOES TO ZERO AT SOME
 POINT AND REMAINS THERE THEN DATA NEED
 ONLY BE PROVIDED FOR THAT TIME SPAN AND
 THE CODE WILL AUTOMATICALLY ENSURE THAT
 THE INCIDENT PRESSURE REMAINS ZERO
 THEREAFTER. WHEN RESTARTING THE TRANSIENT
 ANALYSIS THE REQUIRED INCIDENT PRESSURE
 DATA IS IDENTICAL TO THAT USED IN THE
 INITIAL RUN. IF SPLINE IS FALSE THEN THE
 PRESSURE HISTORY DATA MUST BE EQUALLY
 SPACED IN TIME WITH THE INCREMENT DTHIST.
 IF SPLINE IS TRUE THE PRESSURE HISTORY
 DATA CAN BE UNEQUALLY SPACED ACCORDING TO
 DATA PROVIDED IN TIMES (SEE BELOW). WHEN
 USING THE SPLINE CAPABILITY THE LAST
 PRESSURE DATA POINT MUST BE ZERO SO THAT
 THE CODE CAN AUTOMATICALLY GENERATE ZERO
 PRESSURES BEYOND THAT POINT. OTHERWISE AN
 OUT-OF-RANGE ERROR EXIT WILL BE TAKEN

PZERO E.F PEAK VALUE OF PRESSURE FOR EXPONENTIALLY
 DECAYING INCIDENT PULSE

DECAY E.F DECAY TIME FOR EXPONENTIALLY DECAYING
 INCIDENT PRESSURE PULSE. THIS IS THE TIME
 IT TAKES FOR THE PRESSURE TO DROP TO 1/E
 (ABOUT .36788) OF ITS PEAK VALUE

TIMES E.F TIME VALUES ASSOCIATED WITH UNEQUALLY
 SPACED INCIDENT PRESSURE HISTORY VALUES

NTINT I NUMBER OF TIME STEP SIZES TO BE USED IN
 THE INTEGRATION PROCESS. SEE ABOVE FOR
 MAXIMUM NUMBER ALLOWED BY CORE ALLOCATION

STRTIM E.F THE STARTING TIME AT WHICH ANY PARTICULAR
 STEP SIZE IS TO BE USED UNTIL IT IS EITHER
 SUPERCEDED BY ANOTHER STEP SIZE OR THE
 ENTIRE TRANSIENT ANALYSIS HAS BEEN
 COMPLETED

DELTIM E.F TIME STEP SIZE ASSOCIATED WITH STRTIM
 ABOVE

FINTIM E.F TIME AT WHICH THE PRESENT ANALYSIS IS TO
 BE TERMINATED

NSAVER I FREQUENCY OF SAVING SYSTEM RESPONSES ON
 PERMANENT FILE POSNAM. NSAVER EXPRESSED IN
 NUMBER OF TIME STEPS

NRESET I FREQUENCY OF SAVING RESTART INFORMATION

ON PERMANENT FILE RESNAM OR WRNAM. NRESET
IS EXPRESSED IN NUMBER OF TIME STEPS

LOCBEG I LOCATION IN POSNAM FILE WHERE RESPONSES
FROM CURRENT RUN ARE TO BE PLACED. THIS
LOCATION IS MEASURED EITHER IN SECTORS
(28 WORDS) ON UNIVAC SYSTEMS OR PHYSICAL
RECORD UNITS (PRU OF 64 WORDS) ON CDC
HARDWARE. A ZERO VALUE IS THE DESIGNATION
OF THE BEGINNING OF THE FILE FOR EITHER
SYSTEM IN THIS CODE. IF LOCBEG = 0, A NEW
PERMANENT FILE IS ASSIGNED FOR THE RUN
WITH THE NAME DENOTED BY POSNAM. OTHERWISE
POSNAM IS TAKEN TO BE AN EXISTING FILE.
UNDER RESTART CONDITIONS THE APPROPRIATE
VALUE OF LOCBEG IS ASCERTAINED FROM
OUTPUT GENERATED DURING PRECEDING RUNS

LOCRES I LOCATION IN PERMANENT FILE RESNAM WHERE
RESTART DATA IS TO BE FOUND. SEE LOCBEG
FOR DEFINITION OF LOCATION. SET EQUAL TO
ZERO IF CURRENT RUN IS NOT A RESTART.
OTHERWISE APPROPRIATE VALUE OF LOCRES IS
ASCERTAINED FROM OUTPUT GENERATED DURING
PRECEDING RUNS

LOCWRT I LOCATION IN PERMANENT FILE RESNAM OR
WRNAM WHERE NEW RESTART DATA GENERATED IN
THE CURRENT RUN IS TO BE WRITTEN. SEE
LOCBEG FOR DEFINITION OF LOCATION. IF
WRNAM HAS BEEN LEFT BLANK (SEE ABOVE) THE
RESTART DATA IS WRITTEN ON THE SAME FILE
AS THAT CONTAINING THE DATA USED TO
RESTART THE CURRENT RUN. IN SUCH A CASE IT
IS IMPORTANT THAT LOCWRT BE CAREFULLY
CHOSEN SO THAT PREVIOUS DATA IS NOT
INADVERTENTLY OVERWRITTEN. AN APPROPRIATE
VALUE CAN BE FOUND FROM OUTPUT GENERATED
FROM PRECEDING RUNS. IF LOCWRT = ZERO, A
NEW PERMANENT FILE IS ASSIGNED FOR THE RUN
WITH THE NAME DENOTED BY WRNAM. OTHERWISE
WRNAM IS TAKEN TO BE AN EXISTING FILE

FORWRT L TRUE IF PERMANENT FILE DENOTED BY POSNAM
IS TO BE CREATED USING UNFORMATTED FORTRAN
WRITE. OTHERWISE FILE WILL BE CREATED BY
DIRECT TRANSFER USING THE DATA MANAGEMENT
SYSTEM DMGASP

DISPLA L TRUE IF SELECTED TRANSIENT RESPONSE
HISTORIES ARE TO BE DISPLAYED. OTHERWISE
FALSE

NPREVT I NUMBER OF TIME STEPS PREVIOUSLY COMPUTED
WITH RESPONSES SAVED IN PERMANENT FILE
DENOTED BY POSNAM. NPREVT WILL BE NONZERO
ONLY FOR RESTART RUNS BUT IT CAN BE ZERO
UNDER RESTART CONDITIONS IF POSNAM DENOTES

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A NEW RESPONSE FILE. THE USE OF NPREV
 ENSURES THAT ANY TRANSIENT RESPONSE
 DISPLAY MADE IN CONJUNCTION WITH THE TIME
 INTEGRATION RUN WILL INCLUDE THE ENTIRE
 HISTORY AVAILABLE FROM THAT FILE AND NOT
 JUST THE PORTION COMPUTED DURING THE
 CURRENT RUN. IF POSNAM CONTAINS THE
 COMPLETE TRANSIENT SOLUTION BACK TO TIME
 ZERO THEN NPREV MUST BE THE NUMBER OF
 TIME STEPS PLUS ONE TO ACCOUNT FOR THE
 FACT THAT THE INITIAL CONDITIONS APPEAR IN
 THE FIRST RECORD. IF THIS RUN IS THE VERY
 FIRST OF A PARTICULAR SHOCK ANALYSIS THEN
 NPREV WILL BE ZERO

NPREF I
 NUMBER OF RESPONSE FILES FROM PREVIOUS
 RUNS THAT MAKE UP THE DESIRED TRANSIENT
 ANALYSIS DISPLAY. DO NOT ADD IN THE
 CURRENT RUN AS THIS IS DONE BY THE CODE.
 NPREF PRESENTLY CANNOT EXCEED NINE (9)

NTIMES I
 THE NUMBER OF RESPONSE RECORDS THAT ARE
 STORED IN ANY PARTICULAR RESPONSE FILE.
 THESE MUST BE ORDERED CHRONOLOGICALLY FOR
 INPUT. NTIMES WILL GENERALLY BE THE NUMBER
 OF TIME STEPS MADE DURING THE TIME THE
 FILE WAS CREATED EXCEPT IF THE FILE GOES
 BACK TO TIME EQUAL TO ZERO. IN THIS CASE
 NTIMES IS EQUAL TO THE NUMBER OF TIME
 STEPS PLUS ONE TO ACCOUNT FOR THE FIRST
 RECORD THAT CONTAINS THE INITIAL
 CONDITIONS

XVPNAM A
 NAMES OF PREVIOUS RESPONSE FILES THAT MAKE
 UP A CONTINUOUS SET OF TRANSIENT DATA,
 ORDERED CHRONOLOGICALLY. DO NOT INCLUDE
 POSNAM IN THIS LIST

LISTRE L
 TRUE IF TRANSIENT RESPONSE HISTORIES ARE
 TO BE LISTED IN TABULAR FORM, OTHERWISE
 FALSE

PRTPLOT L
 TRUE IF PRINTER PLOTS ARE TO BE GENERATED
 FOR TRANSIENT RESPONSE HISTORIES.
 OTHERWISE FALSE

NWETHS I
 NUMBER OF STRUCTURAL HISTORIES (EITHER
 DISPLACEMENTS OR VELOCITIES) TO BE
 DISPLAYED FOR WHICH THE APPROPRIATE
 STRUCTURAL FREEDOMS CAN BE IDENTIFIED
 INTERNALLY THROUGH THE FREEDOM/EQUATION
 CORRESPONDENCE TABLE. ALL STRUCTURAL NODES
 WHICH PARTICIPATE IN THE FLUID-STRUCTURE
 TRANSFORMATION WILL FALL INTO THIS
 CATEGORY AS WELL AS ANY OTHERS WHOSE GRID
 POINT COORDINATES WERE ENTERED AS DATA FOR

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522

THE FLUID MASS PROCESSOR

NDRYHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER DISPLACEMENTS OR VELOCITIES) TO BE DISPLAYED FOR WHICH THE APPROPRIATE STRUCTURAL FREEDOMS CANNOT BE IDENTIFIED INTERNALLY THROUGH THE FREEDOM/EQUATION CORRESPONDENCE TABLE. DRY STRUCTURE NODE POINTS CAN FALL INTO THIS CATEGORY IF THE USER DID NOT INCLUDE THEM IN THE DATA STREAM FOR THE FLUID MASS PROCESSOR. IN THIS CASE ONE MUST IDENTIFY THE INTERNAL SEQUENCE NUMBER APPROPRIATE TO THE DESIRED DEGREE OF FREEDOM BY A MYSTICAL PROCESS WHICH INVOLVES THE INTIMATE KNOWLEDGE OF THE ELIMINATION ORDER AND ANY REDUCTION OF THE NUMBER OF ACTIVE FREEDOMS DUE TO THE APPLICATION OF CONSTRAINTS. MORAL OF THE STORY - RUN ALL STRUCTURAL GRID POINTS THROUGH THE FLUID MASS PROCESSOR EVEN IF THEY NEVER GET WET
NUMSET	I	NUMBER OF DATA SETS USED TO DEFINE RESPONSE DISPLAYS FOR SEVERAL DEGREES OF FREEDOM THAT DIFFER BY A CONSTANT INCREMENT. THIS FEATURE CAN BE USED TO SIMPLIFY INPUT DATA TO SHOW A NUMBER OF TRANSIENT RESULTS AT DIFFERENT PLACES ALONG A GENERATOR OF A CYLINDER OR, AROUND THE CIRCUMFERENCE AT ANY AXIAL STATION
NODOUT	I	EXTERNAL IDENTIFICATION NUMBER OF STRUCTURAL NODE FOR WHICH A TIME HISTORY DISPLAY IS DESIRED
NFROUT	I	STRUCTURAL DEGREE OF FREEDOM NUMBER FOR WHICH A TIME HISTORY DISPLAY IS DESIRED
NEQHST	I	INTERNAL SEQUENCE NUMBER DETERMINED BY HAND FOR STRUCTURAL DEGREES OF FREEDOM WHICH ARE TO BE DISPLAYED AND ARE NOT INCLUDED IN THE FREEDOM/EQUATION CORRESPONDENCE TABLE FOR REASONS KNOWN ONLY TO THE USER
NODFIR	I	FIRST OF SEVERAL EQUALLY INCREMENTED NODE NUMBERS AT WHICH OUTPUT IS DESIRED
NODLAS	I	LAST OF SEVERAL EQUALLY INCREMENTED NODE NUMBERS AT WHICH OUTPUT IS DESIRED
NODINC	I	INCREMENT TO BE APPLIED IN ASSIGNING NODE NUMBERS FOR OUTPUT
NPREHS	I	NUMBER OF FLUID PRESSURE HISTORIES TO BE DISPLAYED
NEQHPR	I	FLUID CONTROL POINT NUMBER FOR WHICH A

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523 TIME HISTORY DISPLAY IS DESIRED FOR THE
524 TOTAL PRESSURE
525
526 SCALE          L
527
528     TRUE IF MULTIPLICATIVE CONSTANT FACTORS
529     ARE TO BE APPLIED TO THE DISPLAYED VALUES
530     OF THE STRUCTURAL DISPLACEMENTS AND
531     VELOCITIES. TOTAL FLUID PRESSURES AND/OR
532     TIME. OTHERWISE FALSE. SUCH FACTORS ARE
533     NOT APPLIED TO THE PERMANENT FILES
534     CONTAINING THE RESPONSE HISTORIES
535
536 RESFAC          E.F
537
538     MULTIPLICATIVE LENGTH CONVERSION FACTOR TO
539     BE APPLIED TO THE DISPLAYED VALUES OF THE
540     STRUCTURAL DISPLACEMENT AND VELOCITY
541     HISTORIES
542
543 PREFAC          E.F
544
545     MULTIPLICATIVE PRESSURE CONVERSION FACTOR
546     TO BE APPLIED TO THE DISPLAYED VALUES OF
547     THE TOTAL PRESSURE HISTORIES
548
549 TIMFAC          E.F
550
551     MULTIPLICATIVE TIME CONVERSION FACTOR TO
552     BE APPLIED TO THE DISPLAYED VALUES OF THE
553     TIME AXIS FOR ALL THE TRANSIENT RESPONSE
554     HISTORIES
555
556 *****
557
558 INPUT DATA CARD DECK
559
560 *****
561
562 ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
563 IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
564 ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
565 FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
566 EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
567 CHARACTERS MAY BE USED FOR CDC OPERATION
568
569 GENERAL PROBLEM DEFINITION (SUBROUTINE INPDAT):
570 -----
571
572 72 COLUMN ALPHANUMERIC TITLE
573 PRENAM          POSNAM          STRNEW
574 RESNAM          WRTNAM
575 XC              YC              ZC
576 SX              SY              SZ
577 EXPWAV          SPLINE
578 JPHIST
579 PNORM
580
581 IF SPLINE = .FALSE. READ THE FOLLOWING CARD
582
583 DTHIST
584
585 IF EXPWAV = .FALSE. READ THE FOLLOWING CARDS
586
587 PHIST(1), I=1,JPHIST
588
589
590

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581 IF EXPWAY = .TRUE. READ THE FOLLOWING CARD
582
583 PZERO DECAY
584
585 CUBIC SPLINE INCIDENT PRESSURE HISTORY DATA (SUBROUTINE CSPRES):
586 -----
587
588 IF SPLINE = .TRUE. READ THE FOLLOWING CARDS
589
590 TIMES(I), I=1,JPHEST
591 PHIST(I), I=1,JPHEST
592
593 GENERAL PROBLEM DEFINITION (SUBROUTINE INPDAT):
594 -----
595
596 NTINT
597 STRTIM DELTIM ) TOTAL = NTINT
598 . )
599 . )
600
601 FINTM
602 NSAVR NRESET
603 LOGBEG LOGRES LOCWRT
604 FORWRT
605
606 POST PROCESSING (SUBROUTINE POSTRE):
607 -----
608
609 DISPLA
610
611 IF DISPLA = .FALSE. THIS TERMINATES THE INPUT DATA DECK
612
613 NPREV NPREF
614
615 IF NPREF NOT = 0 READ THE FOLLOWING CARDS
616
617 NTIMES(I), I=1,NPREF
618 XVPNAM(I), I=1,NPREF
619
620 POST PROCESSING (SUBROUTINE RESDSP):
621 -----
622
623 LISTRE PRTPLT
624
625 POST PROCESSING (SUBROUTINE STROSP):
626 -----
627
628 NWETHS NDRYHS NUMSET )
629 NODOUT NFROUT ) TOTAL = NWETHS
630 . )
631 . )
632 NODOUT NFROUT NEQHS )
633 . ) TOTAL = NDRYHS
634 . )
635 . )
636
637 IF NUMSET = 0 OMIT THE FOLLOWING CARD
638
639 NFROUT NODFIR NODLAS NODINC )
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639      NWETHS  NDRYHS  NUMSET      )      )
640      NODOUT  NFRQUT      )      )      TOTAL = NWETHS
641      .      .      )      )
642      .      .      )      )
643      NODOUT  NFRQUT  NEQHST      )      )
644      .      .      )      )      TOTAL = NDRYHS
645      .      .      )      )
646      .      .      )      )
647      IF NUMSET = 0 OMIT THE FOLLOWING CARD
648      )
649      NFRQUT  NODFIR  NODLAS  NODINC      )
650      )
651      POST PROCESSING (SUBROUTINE RESDSP):
652      -----
653      NPREHS  NUMSET      )      )
654      NEQHPR      )      )      TOTAL = NPREHS
655      .      )      )
656      .      )      )
657      .      )      )
658      IF NUMSET = 0 OMIT THE FOLLOWING CARD
659      )
660      NODFIR  NODLAS  NODINC      )
661      )
662      POST PROCESSING (SUBROUTINE FILBUF):
663      -----
664      )
665      )
666      SCALEF
667      )
668      IF SCALEF = .TRUE. READ THE FOLLOWING CARD
669      )
670      RESFAC  PREFAC  TIMFAC

```

THIS SET FOR
VELOCITIES

The following discussion is provided as an aid to user understanding of the sample output that is included here.

First, the amount of storage required for the run given in the output refers solely to the blank common that is set in the main program, UNWASH. An error exit is taken if insufficient storage is available and the user must see that more is provided either by a recompilation on UNIVAC 1100-OS or by a field length request on CDC.

Sector address information for the response and restart files that is listed at various places in the output is extremely important for subsequent restart runs.

The next item needing discussion is the transient response tabular listings. The desired responses are displayed in matrix form so that each row contains the entire history of a particular degree of freedom except for the first row which is time. Each column therefore contains the instantaneous values of the complete set of response variables desired at a particular time. Each row is identified by the structural or fluid node and its degree of freedom. The letters D, V, and P stand for displacement, velocity and pressure, respectively.

Although printer plots of the transient response results can be displayed as part of the run such output has been deferred to the post-processing phase in Appendix D for this sample problem.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34

.....

[illegible]

QADD,P CYLINTDAT

TIMINT RUN FOR INFINITE CYLINDER SIMULATION

+++ @ ASG,AX CYL*PREP.
+++ @ USE 16,CYL*PREP.

THIS IS A DAA1 RUN

CHARGE LOCATION DATA:

XC = .10000000+05
YC = .00000000
ZC = .00000000
SC = .99990000+04

PRESSURE HISTORY DATA: DTHIST = .50000000+02

1
.10000+01
2
.10000+01

TIME STEP DATA:

N	TS	DT
1	.00000	.25000-01
2	.10000+01	.50000-01
3	.20000+01	.10000+00
4	.50000+01	

INCIDENT PRESSURE AND PARTICLE VELOCITY:

	1	2	3	4	5	6	7	8	9	10
T	.00000	.41667+00	.83333+00	.12500+01	.16667+01	.20833+01	.25000+01	.29167+01	.33333+01	.37500+01
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10000+01	.10000+01	.10001+01	.10001+01	.10002+01	.10002+01	.10002+01	.10003+01	.10003+01	.10004+01

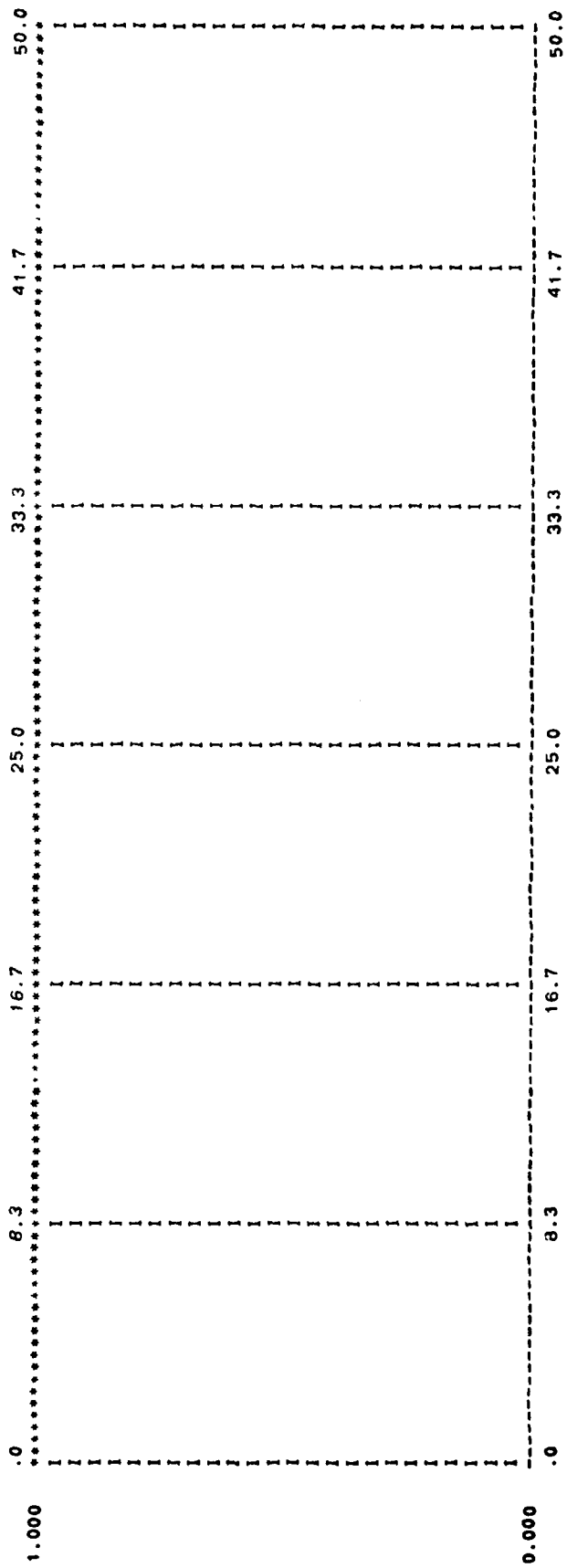
	11	12	13	14	15	16	17	18	19	20
T	.41667+01	.45833+01	.50000+01	.54167+01	.58333+01	.62500+01	.66667+01	.70833+01	.75000+01	.79167+01
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10004+01	.10005+01	.10005+01	.10005+01	.10006+01	.10006+01	.10007+01	.10007+01	.10007+01	.10008+01

	21	22	23	24	25	26	27	28	29	30
T	.83333+01	.87500+01	.91667+01	.95833+01	.10000+02	.10417+02	.10833+02	.11250+02	.11667+02	.12083+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10008+01	.10009+01	.10009+01	.10010+01	.10010+01	.10010+01	.10011+01	.10011+01	.10012+01	.10012+01

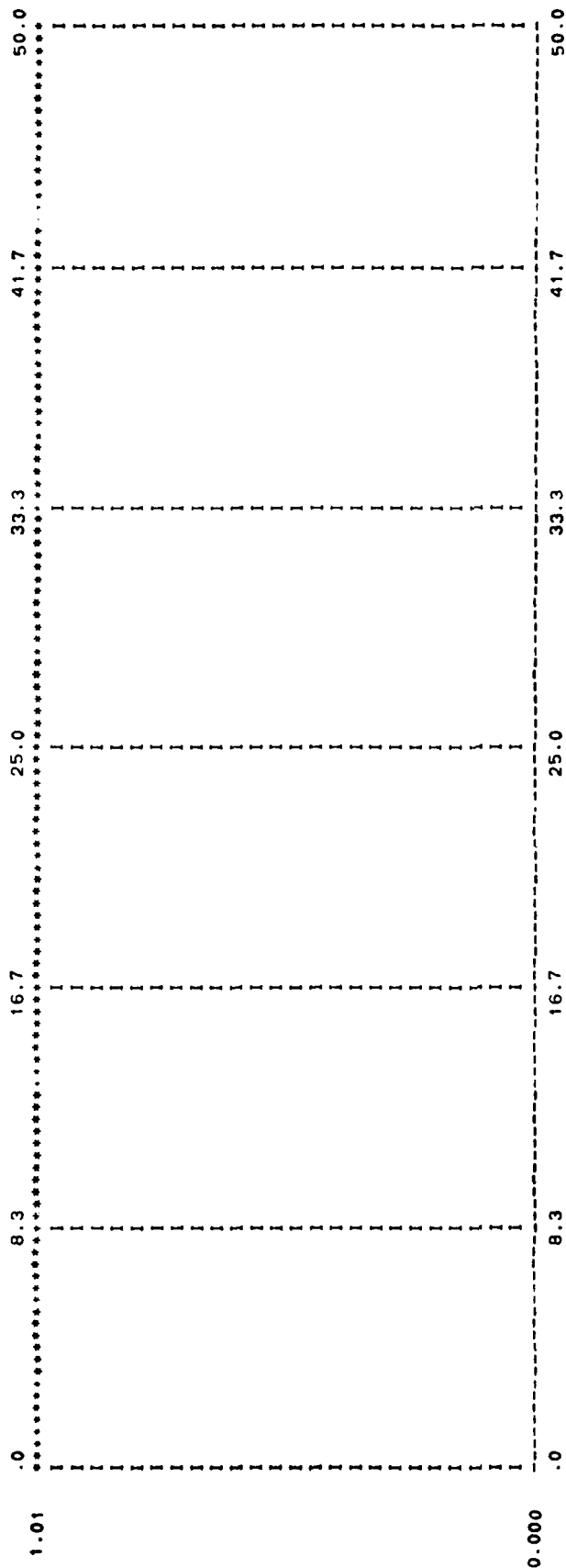
	31	32	33	34	35	36	37	38	39	40
T	.12500+02	.12917+02	.13333+02	.13750+02	.14167+02	.14583+02	.15000+02	.15417+02	.15833+02	.16250+02
P	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
V	.10013+01	.10013+01	.10013+01	.10014+01	.10014+01	.10015+01	.10015+01	.10015+01	.10016+01	.10016+01

T	41	42	43	44	45	46	47	48	49	50
P	.16667+02	.17093+02	.17500+02	.17917+02	.18333+02	.18750+02	.19167+02	.19583+02	.20000+02	.20417+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	51	52	53	54	55	56	57	58	59	60
P	.20833+02	.21250+02	.21667+02	.22083+02	.22500+02	.22917+02	.23333+02	.23750+02	.24167+02	.24583+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	61	62	63	64	65	66	67	68	69	70
P	.25000+02	.25417+02	.25833+02	.26250+02	.26667+02	.27083+02	.27500+02	.27917+02	.28333+02	.28750+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	71	72	73	74	75	76	77	78	79	80
P	.29167+02	.29583+02	.30000+02	.30417+02	.30833+02	.31250+02	.31667+02	.32083+02	.32500+02	.32917+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	81	82	83	84	85	86	87	88	89	90
P	.33333+02	.33750+02	.34167+02	.34583+02	.35000+02	.35417+02	.35833+02	.36250+02	.36667+02	.37083+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	91	92	93	94	95	96	97	98	99	100
P	.37500+02	.37917+02	.38333+02	.38750+02	.39167+02	.39583+02	.40000+02	.40417+02	.40833+02	.41250+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	101	102	103	104	105	106	107	108	109	110
P	.41667+02	.42083+02	.42500+02	.42917+02	.43333+02	.43750+02	.44167+02	.44583+02	.45000+02	.45417+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	111	112	113	114	115	116	117	118	119	120
P	.45833+02	.46250+02	.46667+02	.47083+02	.47500+02	.47917+02	.48333+02	.48750+02	.49167+02	.49583+02
V	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01	.10000+01
T	121									
P	.50000+02									
V	.10000+01									

INCIDENT PRESSURE PULSE:



INCIDENT PARTICLE VELOCITY:



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+++ @ ASG,T      UNIT20.,      F4/  4/TRK/  256
+++ @ USE        20,UNIT20.

+++ @ ASG,UP     CYL*POST.,    F/   4/TRK/  1024
+++ @ USE        12,CYL*POST.

+++ @ ASG,UP     CYL*REST.,    F/   4/TRK/  1024
+++ @ USE        14,CYL*REST.

+++ @ ASG,AX     CYL*KSKY.
+++ @ USE        22,CYL*KSKY.
  
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12536 WORDS OF STORAGE REQUIRED FOR THIS RUN

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+++ @ ASG,T      UNIT19.,      F4/  4/TRK/  256
+++ @ USE        19,UNIT19.

+++ @ ASG,T      UNIT13.,      F4/  4/TRK/  256
+++ @ USE        13,UNIT13.

+++ @ ASG,T      UNIT18.,      F4/  4/TRK/  256
+++ @ USE        18,UNIT18.

+++ @ FREE      UNIT13.
  
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RESTART DATA FOR T = .750000 WRITTEN AT LOCATION 0 ON PERMANENT FILE CYL*REST

POST PROCESSING RESPONSE FILE LOCATION IS 1054

+++ @ ASG.T UNIT13.
+++ @ USE 13,UNIT13.
+++ @ FREE UNIT13.

RESTART DATA FOR T = 2.000000 WRITTEN AT LOCATION 121 ON PERMANENT FILE CYL*REST

POST PROCESSING RESPONSE FILE LOCATION IS 2074

+++ @ ASG.T UNIT13.
+++ @ USE 13,UNIT13.
+++ @ FREE UNIT13.

RESTART DATA FOR T = 5.000000 WRITTEN AT LOCATION 242 ON PERMANENT FILE CYL*REST

POST PROCESSING RESPONSE FILE LOCATION IS 3094

SECTOR ADDRESS OF RESPONSE FILE CYL*POST AT EXIT IS 3094

SECTOR ADDRESS OF RESTART FILE CYL*REST AT EXIT IS 363

+++++
+ A U X I L I A R Y S T O R A G E T A B L E
+
+
+ LDI EDN(Q*EFN) IFN EC OP SEC CDLOC NEXT LIMIT READ WRITTEN +
+ 10 CYL*POST 12 36 UP 28 3094 3094 65536 0 82173 +
+ 12 CYL*REST 14 36 UP 28 363 363 65536 0 9939 +
+ 14 CYL*PREP 16 36 AX 28 63 192 65536 246582 0 +
+ 16 UNIT18 18 36 T 28 96 576 16384 2733696 48384 +
+ 17 UNIT19 19 36 T 28 16 48 16384 405888 4032 +
+ 18 UNIT20 20 36 T 28 48 48 16384 120528 117936 +
+ 20 CYL*MSKY 22 36 AX 28 613 640 16384 1500367 0 +
+
+ 7 ACTIVE DEVICES (0 FULL)
+ 0 TP-OPS. 588 WRITES, 3329 READS, 5272117 WORDS XFD +
+++++

+++ @ FREE CYL*POST.

+++ @ FREE CYL*REST.

+++ @ ASG.AX CYL*POST.

+++ @ USE 12,CYL*POST.

+++ ● FREE CYL*POST.

TRANSIENT RESPONSE HISTORIES:

	1	2	3	4	5	6	7	8	9	10
19/1 T	-0.0000	.25000-01	.50000-01	.75000-01	.10000+00	.12500+00	.15000+00	.17500+00	.20000+00	.22500+00
19/1 D	.00000	-.12761-05	-.77204-05	-.23805-04	-.51117-04	-.87200-04	-.12606-03	-.15307-03	-.17700-03	-.19999-03
19/2 D	.00000	.29228-08	.29601-07	.15183-06	.53000-06	.14410-05	.32943-05	.66550-05	.12400-04	.22567-04
19/1 V	.00000	-.20877-00	-.73000+00	-.10601+01	-.12158+01	-.14613+01	-.15886+01	-.16791+01	-.17400+01	-.17960+01
19/1 V	.00000	-.10209-03	-.41417-03	-.87189-03	-.13312-02	-.15705-02	-.15354-02	-.11207-02	-.31900-03	.91760-03
19/2 V	.00000	.23382-06	.19020-05	.78680-05	.22134-04	.50505-04	.97550-04	.17138-03	.29100-03	.51760-03
37/1 V	.00000	-.50333-04	-.20308-03	-.42464-03	-.63168-03	-.72185-03	-.72185-03	-.51061-03	-.10400-03	.50251-03
10/0 P	.00000	.16367+01	.12214+01	.89728+00	.67175+00	.53000+00	.43038+00	.37550+00	.33700+00	.31373+00
10/0 P	.00000	.64336-03	.13301-02	.15851-02	.12747-02	.52002-03	.16906-02	.16906-02	-.29500-02	-.42580-02
19/0 P	.00000	.31716-03	.64800-03	.76221-03	.59007-03	.21714-03	-.29775-03	-.87822-03	-.14900-02	-.21342-02
	11	12	13	14	15	16	17	18	19	20
19/1 T	.25000+00	.27500+00	.30000+00	.32500+00	.35000+00	.37500+00	.40000+00	.42500+00	.45000+00	.47500+00
19/1 D	-.12015-03	-.35159-04	.11411-03	.33543-03	.64977-03	.10815-02	.16707-02	.24753-02	.35638-02	.50395-02
19/2 D	.41028-04	.81028-04	.16714-03	.35596-03	.75415-03	.15402-02	.30189-02	.55728-02	.97037-02	.15050-01
19/1 V	-.18132+01	-.18612+01	-.18823+01	-.18983+01	-.19104+01	-.19105+01	-.19264+01	-.19317+01	-.19300+01	-.19306+01
19/1 V	.25091-02	.46899-02	.72702-02	.10487-01	.14581-01	.19904-01	.27183-01	.37025-01	.50200-01	.67682-01
19/2 V	.10072-02	.21448-02	.47402-02	.10354-01	.21001-01	.41800-01	.75960-01	.12835-01	.20210+00	.29761+00
37/1 V	.13032-02	.22781-02	.34103-02	.46867-02	.60099-02	.75948-02	.91686-02	.10740-01	.12400-01	.14008-01
10/0 P	.30092+00	.29575+00	.29504+00	.29901+00	.30489+00	.31208+00	.32169+00	.33134+00	.34100+00	.35102+00
10/0 P	.54041-02	-.64911-02	-.73517-02	-.78323-02	-.75970-02	-.60506-02	-.26067-02	.30941-02	.11900-01	.24376-01
19/0 P	-.27400-02	-.32973-02	-.38418-02	-.43843-02	-.48609-02	-.53416-02	-.57534-02	-.61409-02	-.65100-02	-.68896-02
	21	22	23	24	25	26	27	28	29	30
19/1 T	.50000+00	.52500+00	.55000+00	.57500+00	.60000+00	.62500+00	.65000+00	.67500+00	.70000+00	.72500+00
19/1 D	.70053-02	.95736-02	.12845-01	.16899-01	.21081-01	.27510-01	.34078-01	.41400-01	.48600-01	.55840-01
19/2 D	.24003-01	.36592-01	.51413-01	.69104-01	.89092-01	.11112-00	.13341+00	.16071+00	.19000+00	.21562+00
19/1 V	-.19426+01	-.19451+01	-.19472+01	-.19493+01	-.19516+01	-.19540+01	-.19570+01	-.19596+01	-.19600+01	-.19600+01
19/1 V	.80085-01	.11588+00	.14500+00	.17841+00	.21222+00	.24610+00	.27932+00	.31170+00	.34300+00	.37543+00
19/2 V	.41049+00	.53259+00	.65316+00	.76205+00	.85097+00	.92350+00	.98502+00	.10390+01	.10900+01	.11596+01
37/1 V	.15050-01	.17375-01	.18947-01	.20447-01	.21850-01	.23100-01	.24430-01	.25600-01	.26900-01	.28458-01
10/0 P	.36076+00	.37048+00	.38003+00	.38915+00	.39768+00	.40500+00	.41298+00	.42007+00	.42700+00	.43481+00
10/0 P	.40160-01	.53176-01	.80392-01	.10212+00	.12097+00	.14417+00	.16208+00	.17797+00	.19100+00	.20401+00
19/0 P	-.72084-02	-.76077-02	-.79120-02	-.81959-02	-.84432-02	-.86077-02	-.86684-02	-.85010-02	-.79600-02	-.68364-02
	31	32	33	34	35	36	37	38	39	40
19/1 T	.75000+00	.77500+00	.80000+00	.82500+00	.85000+00	.87500+00	.90000+00	.92500+00	.95000+00	.97500+00
19/1 D	.64435-01	.79052-01	.90521-01	.10288+00	.11618+00	.13018+00	.14584+00	.16225+00	.17900+00	.19636+00
19/2 D	.24045+00	.27694+00	.31002+00	.34455+00	.38038+00	.41717+00	.45484+00	.49557+00	.53600+00	.57912+00
19/1 V	-.19078+01	-.19706+01	-.19738+01	-.19755+01	-.19816+01	-.19877+01	-.19896+01	-.19930+01	-.19900+01	-.20010+01
19/1 V	.40791+00	.44139+00	.47600+00	.51273+00	.55131+00	.59216+00	.63505+00	.67130+00	.70800+00	.74760+00
19/2 V	.12265+01	.12927+01	.13533+01	.14083+01	.14587+01	.15000+01	.15611+01	.16060+01	.16700+01	.17239+01
37/1 V	.30000-01	.33505-01	.38002-01	.45062-01	.55064-01	.70015-01	.89069-01	.11500+00	.14700+00	.18575+00
10/0 P	.40029+00	.44623+00	.45100+00	.45616+00	.46047+00	.46400+00	.46807+00	.47324+00	.47700+00	.48084+00
10/0 P	.21016+00	.22489+00	.23217+00	.23709+00	.23071+00	.23946+00	.23600+00	.29211+00	.41700+00	.47750+00
19/0 P	-.47568-02	-.12409-02	.43500-02	.12819-01	.25010-01	.41711-01	.63651-01	.91016-01	.12300+00	.16047+00
	41	42	43	44	45	46	47	48	49	50
19/1 T	.10000+01	.10500+01	.11000+01	.11500+01	.12000+01	.12500+01	.13000+01	.13500+01	.14000+01	.14500+01
19/1 D	.21251+00	.23950+00	.25837+00	.26882+00	.27205+00	.27000+00	.26424+00	.25570+00	.24500+00	.23483+00
19/2 D	.62279+00	.71326+00	.80753+00	.90522+00	.10053+00	.11070+01	.12067+01	.13071+01	.14000+01	.14893+01
19/1 V	-.20504+01	-.20147+01	-.20207+01	-.20326+01	-.20425+01	-.20500+01	-.20600+01	-.20774+01	-.20800+01	-.20996+01
19/1 V	.61802+00	.46164+00	.29310+00	.12472+00	.44838-02	-.84307-01	-.14117+00	-.19012+00	-.21300+00	-.22175+00
19/2 V	.17698+01	.18489+01	.19321+01	.19894+01	.20377+01	.20377+01	.20038+01	.19321+01	.18250+01	.17048+01
37/1 V	.22013+00	.32554+00	.41618+00	.48448+00	.54156+00	.59302+00	.64562+00	.69669+00	.74360+00	.78612+00

1/0 P	.48386+00	.48892+00	.49411+00	.49974+00	.50513+00	.50734+00	.50947+00	.51217+00	.51488+00
10/0 P	.68076+00	.63793+00	.74001+00	.65775+00	.59438+00	.58675+00	.59154+00	.59775+00	.63700+00
19/0 P	.20016+00	.27914+00	.34633+00	.39722+00	.43531+00	.46672+00	.52513+00	.54816+00	.56591+00
51	52	53	54	55	56	57	58	59	60
19/1 D	.15000+01	.15500+01	.16000+01	.16500+01	.17000+01	.17500+01	.18000+01	.18500+01	.19000+01
19/2 D	.22176+00	.21278+00	.20180+00	.19080+00	.17939+00	.16794+00	.15552+00	.14334+00	.13111+00
19/2 D	.15720+01	.16510+01	.17245+01	.18002+01	.18844+01	.19633+01	.20383+01	.21121+01	.21855+01
19/1 V	.21114+01	.21224+01	.21311+01	.21356+01	.21380+01	.21380+01	.20998+01	.20640+01	.20133+01
19/1 V	.22115+00	.21807+00	.21300+00	.22410+00	.23553+00	.23918+00	.24297+00	.24419+00	.24511+00
19/2 V	.16057+01	.15536+01	.15433+01	.15609+01	.15180+01	.14955+01	.14539+01	.14334+01	.13712+01
37/1 V	.82749+00	.87000+01	.91218+00	.95361+00	.99100+00	.10318+01	.10831+01	.11324+01	.11813+01
1/0 P	.51666+00	.51997+00	.52615+00	.53687+00	.55115+00	.56025+00	.61700+00	.71715+00	.76375+00
10/0 P	.65332+00	.68427+00	.70236+00	.71160+00	.72145+00	.73145+00	.73516+00	.74111+00	.74441+00
19/0 P	.58043+00	.53456+00	.60719+00	.61607+00	.62713+00	.62689+00	.63066+00	.62511+00	.60347+00
61	62	63	64	65	66	67	68	69	70
19/1 D	.20000+01	.21000+01	.22000+01	.23000+01	.24000+01	.25000+01	.26000+01	.27000+01	.28000+01
19/2 D	.10647+00	.82492+01	.60850+01	.42618+01	.28508+01	.17198+01	.80888+02	.78444+03	.95511+02
19/2 D	.23116+01	.24797+01	.26323+01	.27945+01	.29604+01	.31719+01	.33655+01	.35543+01	.37311+01
19/1 V	.19267+01	.18709+01	.18540+01	.18438+01	.18318+01	.18168+01	.18301+01	.18305+01	.18211+01
19/1 V	.24700+00	.23265+00	.22077+00	.216327+00	.21293+00	.20952+00	.20692+01	.20545+01	.20478+01
19/2 V	.14815+01	.14807+01	.15712+01	.17552+01	.18858+01	.19438+01	.19274+01	.18424+01	.18254+01
37/1 V	.13097+01	.13850+01	.14114+01	.14201+01	.14352+01	.14512+01	.14610+01	.15040+01	.15131+01
1/0 P	.81041+00	.85088+00	.86019+00	.86848+00	.88190+00	.89330+00	.88663+00	.88208+00	.88411+00
10/0 P	.74527+00	.75485+00	.77817+00	.81195+00	.84735+00	.87611+00	.88625+00	.88301+00	.89160+00
19/0 P	.63450+00	.71372+00	.74721+00	.76256+00	.77747+00	.78600+00	.81236+00	.85450+00	.95972+00
71	72	73	74	75	76	77	78	79	80
19/1 D	.30000+01	.31000+01	.32000+01	.33000+01	.34000+01	.35000+01	.36000+01	.37000+01	.38000+01
19/2 D	.24365+01	.30727+01	.36181+01	.40069+01	.42295+01	.43845+01	.46221+01	.49653+01	.53335+01
19/2 D	.41108+01	.42912+01	.44510+01	.46209+01	.47778+01	.49325+01	.50988+01	.52534+01	.54210+01
19/1 V	.18430+01	.18360+01	.18273+01	.18283+01	.18205+01	.18005+01	.17793+01	.17500+01	.17153+01
19/1 V	.66204+01	.61029+01	.48101+01	.29604+01	.14520+01	.16472+01	.30645+01	.38011+01	.36011+01
19/2 V	.18663+01	.17411+01	.16331+01	.15859+01	.15105+01	.15419+01	.16004+01	.16738+01	.16911+01
37/1 V	.16135+01	.16406+01	.16234+01	.16234+01	.16184+01	.16418+01	.16430+01	.16303+01	.16317+01
1/0 P	.87501+00	.87853+00	.88735+00	.89344+00	.90413+00	.92215+00	.94519+00	.97410+00	.10093+01
10/0 P	.90115+00	.91015+00	.92282+00	.94051+00	.95144+00	.95912+00	.95036+00	.94270+00	.94293+00
19/0 P	.90819+00	.98506+00	.96470+00	.95099+00	.95587+00	.96102+00	.95605+00	.94192+00	.93455+00
81	82	83	84	85	86	87	88	89	90
19/1 D	.40000+01	.41000+01	.42000+01	.43000+01	.44000+01	.45000+01	.46000+01	.47000+01	.48000+01
19/2 D	.59786+01	.62463+01	.64470+01	.66308+01	.67994+01	.69569+01	.71193+01	.72872+01	.74611+01
19/2 D	.57570+01	.59298+01	.61120+01	.62982+01	.64818+01	.66614+01	.68367+01	.70090+01	.71817+01
19/1 V	.17133+01	.17285+01	.17390+01	.17463+01	.17590+01	.17730+01	.17803+01	.17864+01	.17917+01
19/1 V	.24578+01	.20967+01	.19337+01	.18469+01	.17414+01	.16472+01	.30684+01	.37292+01	.27810+01
19/2 V	.16764+01	.17793+01	.18651+01	.18570+01	.18151+01	.17764+01	.17300+01	.17160+01	.17214+01
37/1 V	.16511+01	.16480+01	.16534+01	.16776+01	.17045+01	.17331+01	.17520+01	.17520+01	.17482+01
1/0 P	.10584+01	.98897+00	.97153+00	.96378+00	.96787+00	.97525+00	.97058+00	.95391+00	.95754+00
10/0 P	.95460+00	.96925+00	.97453+00	.97760+00	.98186+00	.97909+00	.97014+00	.96371+00	.96911+00
19/0 P	.94457+00	.94341+00	.94601+00	.95977+00	.97137+00	.98434+00	.99828+00	.10151+01	.10212+01
91	92	93	94	95	96	97	98	99	100
19/1 D	.50000+01	.51000+01	.52000+01	.53000+01	.54000+01	.55000+01	.56000+01	.57000+01	.58000+01
19/2 D	.82043+01	.82043+01	.82043+01	.82043+01	.82043+01	.82043+01	.82043+01	.82043+01	.82043+01
19/2 D	.75198+01	.75198+01	.75198+01	.75198+01	.75198+01	.75198+01	.75198+01	.75198+01	.75198+01
19/1 V	.17403+01	.17403+01	.17403+01	.17403+01	.17403+01	.17403+01	.17403+01	.17403+01	.17403+01
19/1 V	.10764+01	.10764+01	.10764+01	.10764+01	.10764+01	.10764+01	.10764+01	.10764+01	.10764+01

19/2 V	.16578+01
37/1 V	.17345+01
1/0 P	.96885+00
10/0 P	.98829+00
19/0 P	.99335+00

APPENDIX D
USER INFORMATION FOR THE POSTPROCESSOR POSTPR

This appendix includes a copy of the users manual, and a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4.

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..... P O S T P R

THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SMOG ANALYSIS CODE IS RESPONSIBLE FOR THE INITIATION AND PRINT-OUT GRAPHIC DISPLAY OF SELECTED TRANSIENT RESPONSES AND FREQUENCY SPECTRA UPON COMPLETION OF AN UNDERWATER SMOG ANALYSIS OF A SUBMERGED STRUCTURE. IT CAN ALSO CREATE A DOCUMENT FILE CONTAINING A SERIES OF SNAPSHOTS OF THE CURRENT PICTURE AT USER SPECIFIED TIMES.

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THIS PROGRAM WAS DEVELOPED AND CODED BY J. A. DEGEN, JR., OF LOCKHEED MISSILES AND SPACE RESEARCH LABORATORY, PALO ALTO, CALIFORNIA. PLEASE CONSULT WITH THE RESEARCHER MAKING CHANGES AND ADD REPORT ANY VARIATIONS OF THE CODE TO THE RESEARCHER. LOCKHEED ALSO AUTO RESEARCH LABORATORY, 3250 DEWEY DRIVE, GAITHERSBURG, MARYLAND 20878. CALL 410-333-4411 EXT. 4009 OR 45133. SEPTEMBER, 1990

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..... W A R N I N G F R O M T H E P R O G R A M M E R G E N E R A L

THIS CODE CONTAINS THE SELECTED INCIDENT SMOGAS NOT FOUND IN OTHER BRANDS. SMOGAS IS A DATA MANAGEMENT UTILITY MODULE THAT WILL ACTIVATE AND DEACTIVATE ALL EXISTING SMOGAS DATA FILES REFERENCED BY THE CODE. THE NAMES OF SUCH FILES SHOULD NOT APPEAR ON ANY CONTROL CARDS IN THE RUN STREAM WHICH NOT NORMALLY ACTIVATED AND DEACTIVATED FILES. THE USER IS ALSO CAUTIONED THAT PREVIOUSLY CREATED FILES WILL BE DELETED IN THE SYSTEM BEFORE THE RUN IS INITIATED. IF A FILE HAS BEEN RELOADED-OUT TO TAPE SMOGAS WILL ATTEMPT TO HAVE THE FILE LOADED EVERY 15 SECONDS FOR UP TO 5 MINUTES ON THE UNIVAC 1100-EXC-8 OPERATING SYSTEM. IF AN EXISTING DATA FILE HAS NOT BEEN REFERENCED FOR SOME TIME IT IS THEREFORE GOOD POLICY TO START ACTIVATE AND DEACTIVATE THE FILE BEFORE EXECUTION OF THIS CODE. IF THE USER ATTEMPTS TO CREATE A NEW DATA FILE WITH A NAME WHICH IS ALREADY ASSIGNED TO AN EXISTING FILE, THE UNIVAC VERSION OF SMOGAS WILL MODIFY THE NAME OF THE FILE GENERATED BY THIS RUN TO AVOID ANY EXISTING FILE NAME. DUPLICATION WILL CAUSE A PROBLEM ON THE CDC SCOPE OPERATING SYSTEM AS SCOPE WILL STILL ATTACH A NEW CYCLE OF THE SAME FILE. ON THE OTHER HAND, THE CDC SCOPE SYSTEM IS SIMILAR TO UNIVAC IN THIS REGARD AND THE RUN WILL ABOUT SINCE THE NAME CHANGING FEATURE OF SMOGAS HAS NOT BEEN IMPLEMENTED FOR CDC. CALIBRATION IS THE REQUIRED INPUT DATA FORMAT FOR ALL UNIVAC-EXC-8 FILE NAMES. ON CDC SCOPE, THE QUALIFIER IS INTERPRETED AS THE USER ID, WHICH IN MOST INSTALLATIONS CAN BE SELECTED ARBITRARILY. ON CDC NOS, THE QUALIFIER IS INTERPRETED AS THE USER'S CATALOG NUMBER, WHICH IS USUALLY PRESCRIBED BY THE INSTALLATION. A CYCLE NUMBER CAN ALSO BE APPENDED TO GIVE THE FORM QUALIFIER-FILE-NAME (CYCLE) ON CDC SCOPE

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PROGRAM SIZE

ALL ARRAYS REFERENCED IN THIS CODE THAT ARE PROBLEM DEPENDENT
RESIDE IN BLANK COMMON. THE SIZE OF BLANK COMMON IS DETERMINED BY
A PARAMETER STATEMENT IN THE MAIN PROGRAM FOR THE UNIVAC 1100-OS
VERSION. HENCE A RECOMPILATION IS NECESSARY TO INCREASE OR
DECREASE CORE ALLOCATION. IN THE CDC 6600 VERSION RECOMPILATION IS
UNNECESSARY AS THE LENGTH OF BLANK COMMON IS SET BY A FIELD LENGTH
REQUEST IN THE CONTROL CARD DECK

DEFINITION OF INPUT PARAMETERS

INPUT VARIABLE NAMES GIVEN BELOW ARE GENERALLY THOSE WHICH ARE
ALSO USED IN THE CODING AND THE VARIABLE TYPES CORRESPOND TO
STANDARD FORTRAN USAGE:

-----
VARIABLE TYPE. DESCRIPTION
-----
NFILES I NUMBER OF RESPONSE FILES THAT MAKE UP THE
DESIGNED TRANSIENT ANALYSIS DISPLAY. NFILES
PRESENTLY CAN NOT EXCEED TEN (10)

NTIMES I THE NUMBER OF RESPONSE RECORDS THAT ARE
STORED IN ANY PARTICULAR RESPONSE FILE.
THESE MUST BE ORDERED CHRONOLOGICALLY FOR
INPUT. NTIMES WILL GENERALLY BE THE NUMBER
OF TIME STEPS MADE DURING THE TIME THE
FILE WAS CREATED EXCEPT IF THE FILE GOES
BACK TO TIME EQUAL TO ZERO. IN THIS CASE
NTIMES IS EQUAL TO THE NUMBER OF TIME
STEPS PLUS ONE TO ACCOUNT FOR THE FIRST
RECORD THAT CONTAINS THE INITIAL
CONDITIONS

PRENAM A NAME OF PRE-PROCESSED MASS STORAGE FILE
CONTAINING ALL FLUID AND STRUCTURE DATA

XVPNAM A NAMES OF RESPONSE FILES THAT MAKE UP A
CONTINUOUS SET OF TRANSIENT DATA. ORDERED
CHRONOLOGICALLY

FORWRT L TRUE IF PERMANENT FILES DENOTED BY XVPNAM

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DISPLA	L	WERE CREATED USING UNFORMATTED FORTRAN WRITE. OTHERWISE FILES WERE CREATED BY DIRECT TRANSFER USING THE DATA MANAGEMENT SYSTEM DMGASP
		TRUE IF SELECTED TRANSIENT RESPONSE HISTORIES ARE TO BE DISPLAYED. OTHERWISE FALSE. THIS VARIABLE MUST BE TRUE EVEN IF PSEUDO-VELOCITY SHOCK SPECTRA ARE THE ONLY ONLY OUTPUT DESIRED SINCE STRUCTURAL VELOCITY HISTORIES MUST BE USED FOR THIS COMPUTATION
DEFORM	L	TRUE IF A PERMANENT FILE IS TO BE CREATED THAT CONTAINS A CHRONOLOGICAL SUCCESSION OF RECORDS EACH OF WHICH CONSISTS OF THE COMPLETE DISPLACEMENT FIELD AT SPECIFIC TIMES WITHOUT ANY EXTRANEIOUS TIME OR BOOKKEEPING DATA. SUCH A FILE CAN BE IMAGINED AS A SERIES OF SNAPSHOTS OF THE DEFORMED STRUCTURE THROUGHOUT THE SHOCK ANALYSIS. THIS CAPABILITY CANNOT BE USED IF FORWRT IS TRUE
LISTRE	L	TRUE IF TRANSIENT RESPONSE HISTORIES ARE TO BE LISTED IN TABULAR FORM. OTHERWISE FALSE
PRTPLT	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED FOR TRANSIENT RESPONSE HISTORIES. OTHERWISE FALSE
VECPLT	L	TRUE IF PLOTS ARE TO BE GENERATED FOR TRANSIENT RESPONSE HISTORIES. OTHERWISE FALSE. A PLOT PACKAGE IS NOT PROVIDED WITH THE USA CODE AND IT IS THE USERS RESPONSIBILITY TO COMPLETE THIS FEATURE IN A CALL FROM SUBROUTINE RESSHK IF DESIRED. THE EXISTING CALL USES 'DISPLA' SOFTWARE
NWETHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER DISPLACEMENTS OR VELOCITIES) TO BE DISPLAYED FOR WHICH THE APPROPRIATE STRUCTURAL FREEDOMS CAN BE IDENTIFIED INTERNALLY THROUGH THE FREEDOM/EQUATION CORRESPONDENCE TABLE. ALL STRUCTURAL NODES WHICH PARTICIPATE IN THE FLUID-STRUCTURE TRANSFORMATION WILL FALL INTO THIS CATEGORY AS WELL AS ANY OTHERS WHOSE GRID POINT COORDINATES WERE ENTERED AS DATA FOR THE FLUID MASS PROCESSOR
NDRYHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER DISPLACEMENTS OR VELOCITIES) TO BE DISPLAYED FOR WHICH THE APPROPRIATE STRUCTURAL FREEDOMS CANNOT BE IDENTIFIED INTERNALLY THROUGH THE FREEDOM/EQUATION CORRESPONDENCE TABLE. DRY STRUCTURE NODE

POINTS CAN FALL INTO THIS CATEGORY IF THE USER DID NOT INCLUDE THEM IN THE DATA STREAM FOR THE FLUID MASS PROCESSOR. IN THIS CASE ONE MUST IDENTIFY THE INTERNAL SEQUENCE NUMBER APPROPRIATE TO THE DESIRED DEGREE OF FREEDOM BY A MYSTICAL PROCESS WHICH INVOLVES THE INTIMATE KNOWLEDGE OF THE ELIMINATION ORDER AND ANY REDUCTION OF THE NUMBER OF ACTIVE FREEDOMS DUE TO THE APPLICATION OF CONSTRAINTS. MORAL OF THE STORY - RUN ALL STRUCTURAL GRID POINTS THROUGH THE FLUID MASS PROCESSOR EVEN IF THEY NEVER GET WET

NUMSET I NUMBER OF DATA SETS USED TO DEFINE RESPONSE DISPLAYS FOR SEVERAL DEGREES OF FREEDOM THAT DIFFER BY A CONSTANT INCREMENT. THIS FEATURE CAN BE USED TO SIMPLIFY INPUT DATA TO SHOW A NUMBER OF TRANSIENT RESULTS AT DIFFERENT PLACES ALONG A GENERATOR OF A CYLINDER OR, AROUND THE CIRCUMFERENCE AT ANY AXIAL STATION

NODOUT I EXTERNAL IDENTIFICATION NUMBER OF STRUCTURAL NODE FOR WHICH A TIME HISTORY DISPLAY IS DESIRED

NFROUT I STRUCTURAL DEGREE OF FREEDOM NUMBER FOR WHICH A TIME HISTORY DISPLAY IS DESIRED

NEQHST I INTERNAL SEQUENCE NUMBER DETERMINED BY HAND FOR STRUCTURAL DEGREES OF FREEDOM WHICH ARE TO BE DISPLAYED AND ARE NOT INCLUDED IN THE FREEDOM/EQUATION CORRESPONDENCE TABLE FOR REASONS KNOWN ONLY TO THE USER

NODFIR I FIRST OF SEVERAL EQUALLY INCREMENTED NODE NUMBERS AT WHICH OUTPUT IS DESIRED

NODLAS I LAST OF SEVERAL EQUALLY INCREMENTED NODE NUMBERS AT WHICH OUTPUT IS DESIRED

NODINC I INCREMENT TO BE APPLIED IN ASSIGNING NODE NUMBERS FOR OUTPUT

NPRESS I NUMBER OF FLUID PRESSURE HISTORIES TO BE DISPLAYED

NEQHPR I FLUID CONTROL POINT NUMBER FOR WHICH A TIME HISTORY DISPLAY IS DESIRED FOR THE TOTAL PRESSURE

SCALEF L TRUE IF MULTIPLICATIVE CONSTANT FACTORS ARE TO BE APPLIED TO THE DISPLAYED VALUES OF THE STRUCTURAL DISPLACEMENTS AND VELOCITIES, TOTAL FLUID PRESSURES AND/OR TIME, OTHERWISE FALSE. SUCH FACTORS ARE

233			NOT APPLIED TO THE PERMANENT FILES
234			CONTAINING THE RESPONSE HISTORIES
235			
236	RESFAC	E,F	MULTIPLICATIVE LENGTH CONVERSION FACTOR TO
237			BE APPLIED TO THE DISPLAYED VALUES OF THE
238			STRUCTURAL DISPLACEMENT AND VELOCITY
239			HISTORIES
240			
241	PREFAC	E,F	MULTIPLICATIVE PRESSURE CONVERSION FACTOR
242			TO BE APPLIED TO THE DISPLAYED VALUES OF
243			THE TOTAL PRESSURE HISTORIES
244			
245	TIMFAC	E,F	MULTIPLICATIVE TIME CONVERSION FACTOR TO
246			BE APPLIED TO THE DISPLAYED VALUES OF THE
247			TIME AXIS FOR ALL THE TRANSIENT RESPONSE
248			HISTORIES
249			
250	SHSPEC	L	TRUE IF PSEUDO-VELOCITY SHOCK SPECTRA ARE
251			ALSO DESIRED FOR STRUCTURAL FREEDOMS WHOSE
252			VELOCITY RESPONSE IS TO BE DISPLAYED,
253			OTHERWISE FALSE
254			
255	SHLIST	L	TRUE IF PSEUDO-VELOCITY SHOCK SPECTRA ARE
256			TO BE LISTED IN TABULAR FORM, OTHERWISE
257			FALSE
258			
259	SHRPL	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED
260			FOR PSEUDO-VELOCITY SHOCK SPECTRA,
261			OTHERWISE FALSE
262			
263	SHVCPL	L	TRUE IF VECTOR PLOTS ARE TO BE GENERATED
264			FOR PSEUDO-VELOCITY SHOCK SPECTRA,
265			OTHERWISE FALSE (SEE VELPLT)
266			
267	FREQLOW	E,F	LOWER LIMIT OF FREQUENCY RANGE TO BE
268			SCANNED FOR PSEUDO-VELOCITY SHOCK SPECTRA
269			
270	FREQUP	E,F	UPPER LIMIT OF FREQUENCY RANGE TO BE
271			SCANNED FOR PSEUDO-VELOCITY SHOCK SPECTRA
272			
273	DFREQ	E,F	FREQUENCY INCREMENT TO BE USED IN
274			GENERATING PSEUDO-VELOCITY SHOCK SPECTRA
275			
276	SNPNAM	A	NAME OF PERMANENT FILE TO BE CREATED
277			CONTAINING STRUCTURAL SNAPSHOT DATA
278			
279	NSNAP	I	NUMBER OF TIMES FOR WHICH THE DISPLACEMENT
280			FIELD IS TO BE WRITTEN IN THE PERMANENT
281			FILE DENOTED BY SNPNAM
282			
283	PRTDIS	L	TRUE IF STRUCTURAL DISPLACEMENT FIELD IS
284			TO BE PRINTED FOR EACH SNAPSHOT, OTHERWISE
285			FALSE
286			
287	TIME	E,F	TIME AT WHICH SNAPSHOT IS DESIRED, MUST BE
288			ORDERED CHRONOLOGICALLY
289			
290			

```

291      INPUT      DATA      CARD      DECK
292
293      * * * * *
294
295      * * * * *
296
297      ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
298      IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
299      ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
300      FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
301      EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
302      CHARACTERS MAY BE USED FOR CDC OPERATION
303
304      TASK DEFINITION (MAIN PROGRAM POSTPR):
305      -----
306
307      72 COLUMN ALPHANUMERIC TITLE, ONLY THE FIRST 48 WILL APPEAR ON PLOTS
308      NFILES
309      NTIMES(I), I=1,NFILES
310      PRENAM
311      XVPNAM(I), I=1,NFILES
312      FORWRT DISPLA DEFORM
313
314      TRANSIENT RESPONSE DISPLAY (SUBROUTINE RESSHK):
315      -----
316
317      IF DISPLA = .FALSE. SKIP ALL INPUT FROM HERE TO SUBROUTINE SNAPPY
318
319      LISTRE PRITPLT VECPLT
320
321      TRANSIENT RESPONSE DISPLAY (SUBROUTINE STRDSP):
322      -----
323
324      NWETHS NDRYHS NUMSET )
325      NODOUT NFROUT ) TOTAL = NWETHS
326      . . . )
327      NODOUT NFROUT NEQHST )
328      . . . ) TOTAL = NDRYHS
329      . . . )
330      . . . )
331      IF NUMSET = 0 OMIT THE FOLLOWING CARD
332      NFROUT NODFIR NODLAS NODINC )
333      NWETHS NDRYHS NUMSET )
334      NODOUT NFROUT ) TOTAL = NWETHS
335      . . . )
336      NODOUT NFROUT NEQHST )
337      . . . ) TOTAL = NDRYHS
338      . . . )
339      . . . )
340      IF NUMSET = 0 OMIT THE FOLLOWING CARD
341      NFROUT NODFIR NODLAS NODINC )
342      NWETHS NDRYHS NUMSET )
343      NODOUT NFROUT ) TOTAL = NWETHS
344      . . . )
345      NODOUT NFROUT NEQHST )
346      . . . ) TOTAL = NDRYHS
347      . . . )
348      . . . )

```

```

349 NPREHS NUMSET
350 NEQHPR      ) TOTAL = NPREHS
351      .
352      .
353      .
354
355 IF NUM-ET = 0 OMIT THE FOLLOWING CARD
356
357 NODFIR NODLAS NODINC
358
359 TRANSIENT RESPONSE DISPLAY (SUBROUTINE FILBUF):
360 -----
361
362 SCALEF
363
364 IF SCALEF = .TRUE. READ THE FOLLOWING CARD
365
366 RESFAC PREFAC TIMFAC
367
368 PSEUDO-VELOCITY SHOCK SPECTRA (SUBROUTINE RESSHK):
369 -----
370
371 SHSPEC
372
373 IF SHSPEC = .TRUE. READ THE FOLLOWING CARDS
374
375 SHLIST SHRPPL SHVCPL
376 FREQW FREQW DFREQ
377
378 SNAPSHOT FILE CREATION (SUBROUTINE SNAPPY):
379 -----
380
381 IF DEFORM = .FALSE. THIS TERMINATES THE INPUT DATA DECK
382
383 SNPNAM
384 NSNAP
385 PRDIS
386 TIME
387      .
388      ) TOTAL = NSNAP

```

The following discussion is provided as an aid to user understanding of the sample output that is included here.

The input deck shown on the next page requests vector plots for both the transient response histories and pseudo-velocity shock spectra. This is appropriate if the DISSPLA plot package is available at the user installation. Otherwise appropriate modifications must either be made to use a different plot package or the input deck should be modified. In any case the printer plot package is resident in USA.

The format used for listing the pseudo-velocity shock spectra is similar to that used for the display of the transient response histories shown in Appendix C except that the first row is now frequency rather than time.

INFINITE CYLINDER, PLANE STEP WAVE

1	1		
2	91		
3	CYL*PREP		
4	CYL*POST		
5	F	T	F
6	F	T	T
7	F	0	
8	2	1	
9	19	1	
10	19	2	
11	4	0	
12	1	1	
13	19	1	
14	19	2	
15	37	1	
16	3		
17	1		
18	10		
19	19		
20	F		
21	T		
22	T	T	
23	0.	3.	.025

EXOT

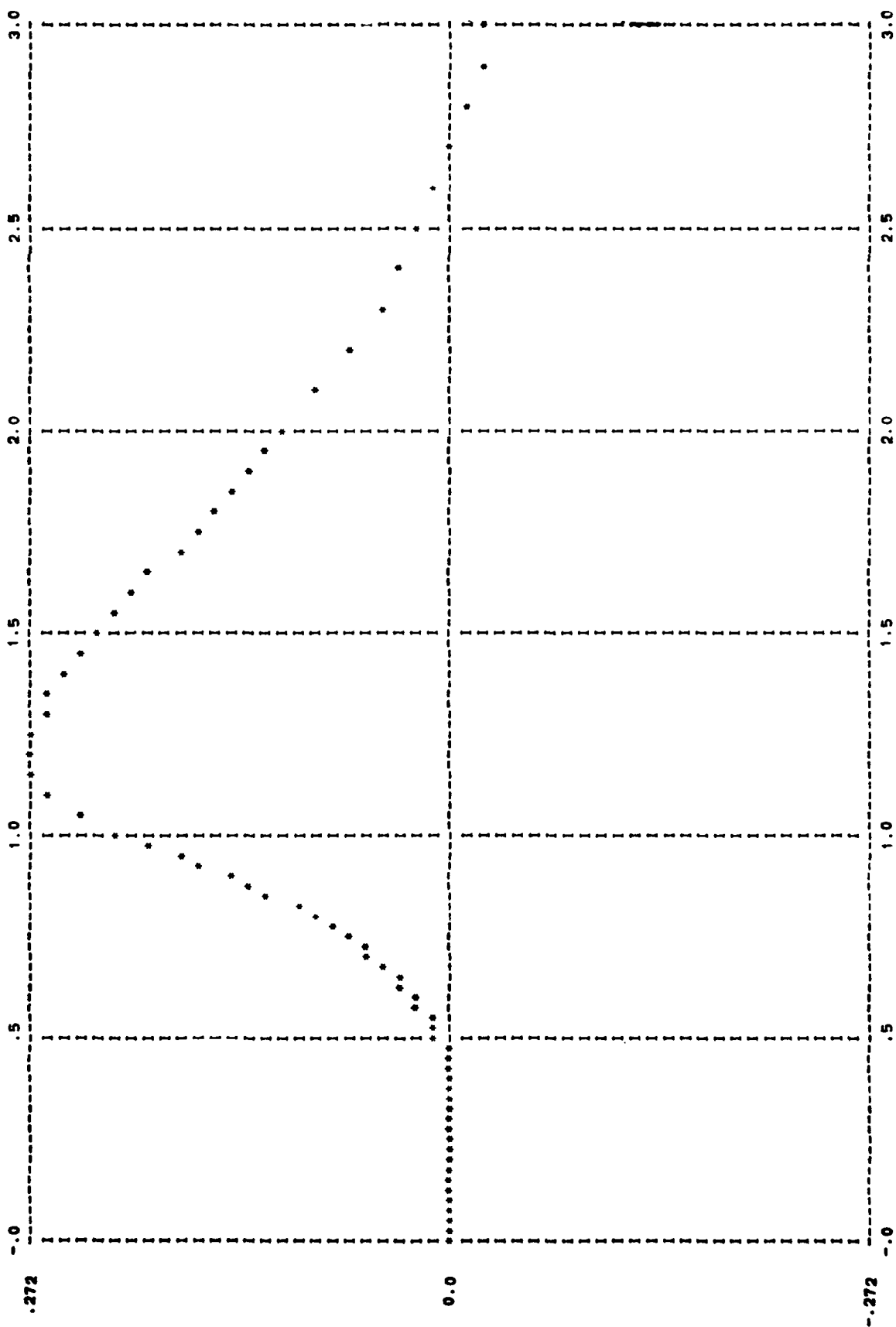
D-10

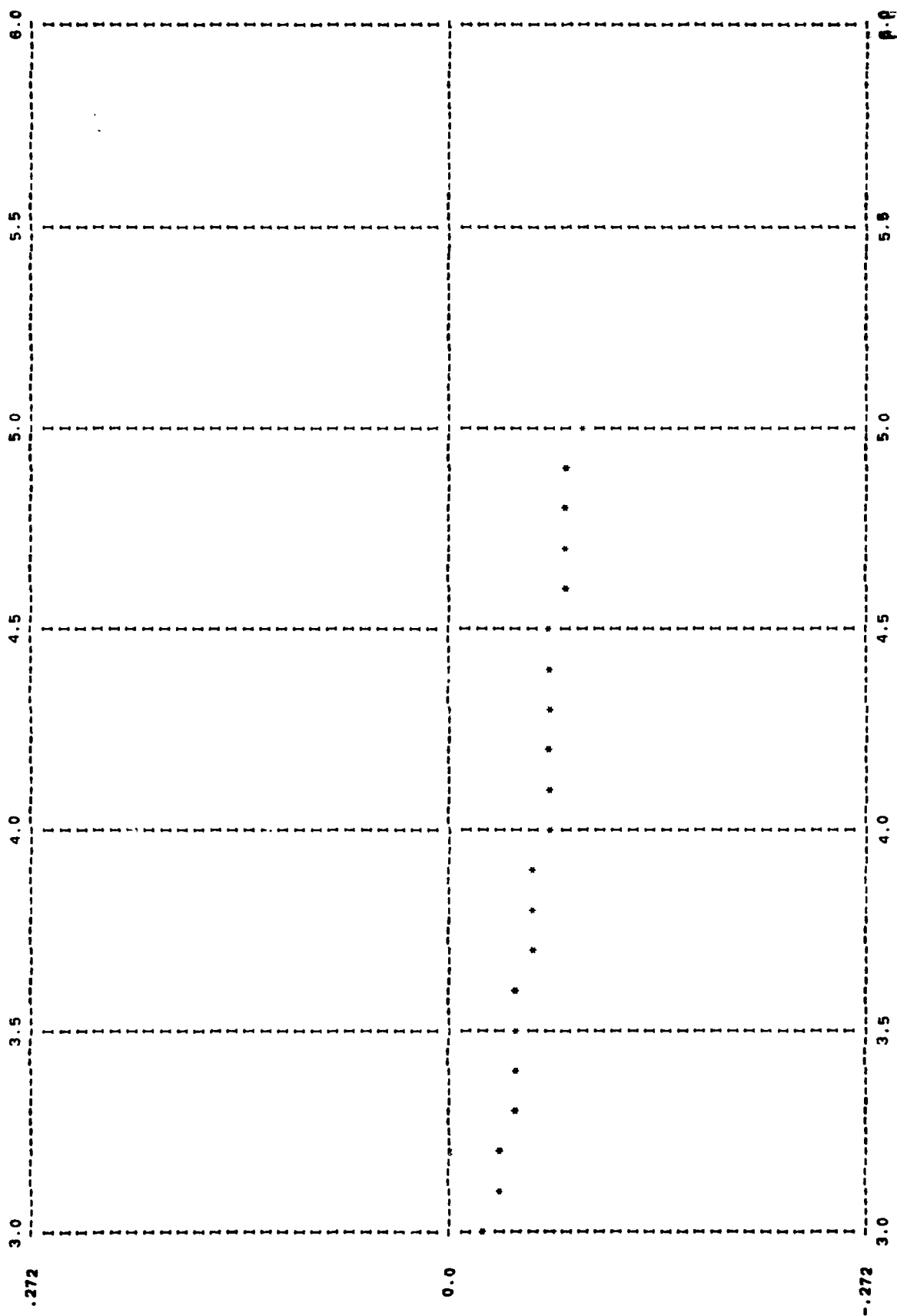
PHADD.P CYLPOSDAT

INFINITE CYLINDER, PLANE STEP WAVE

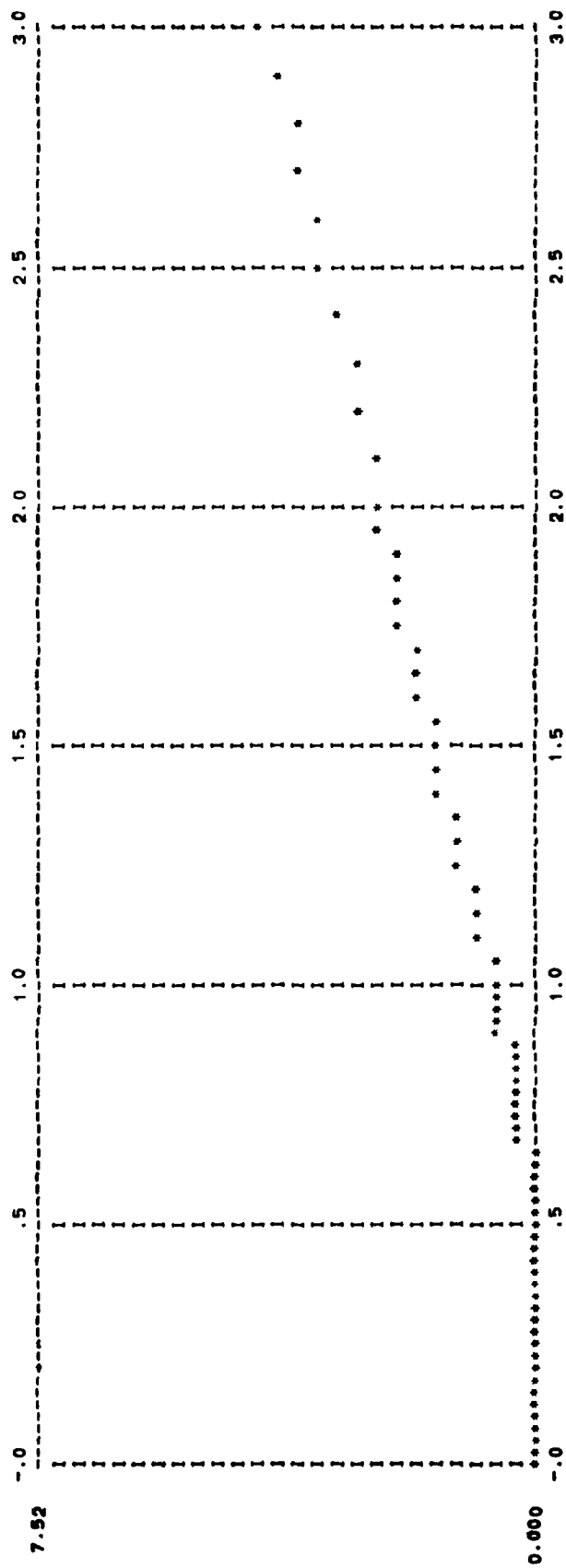
+++	•	ASG, AX	CYL*PREP.
+++	•	USE	16, CYL*PREP.
+++	•	FREE	CYL*PREP.
+++	•	ASG, AX	CYL*POST.
+++	•	USE	12, CYL*POST.
+++	•	FREE	CYL*POST.

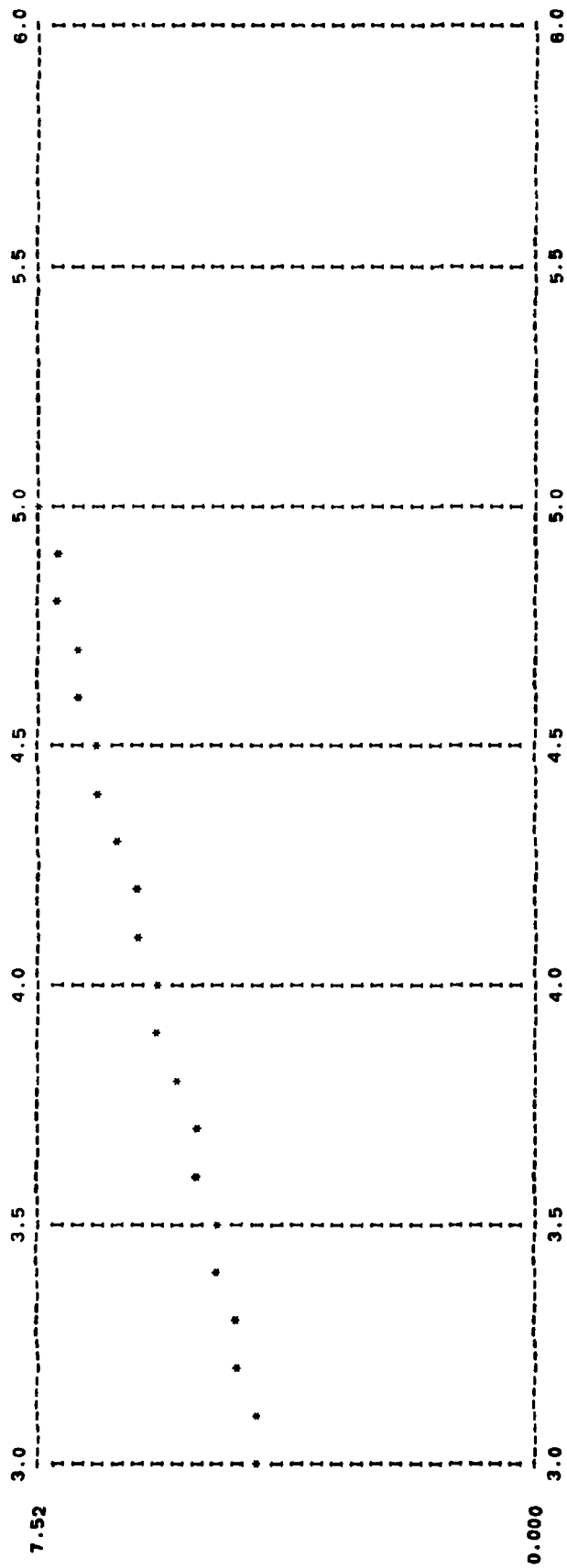
DISPLACEMENT RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 1:



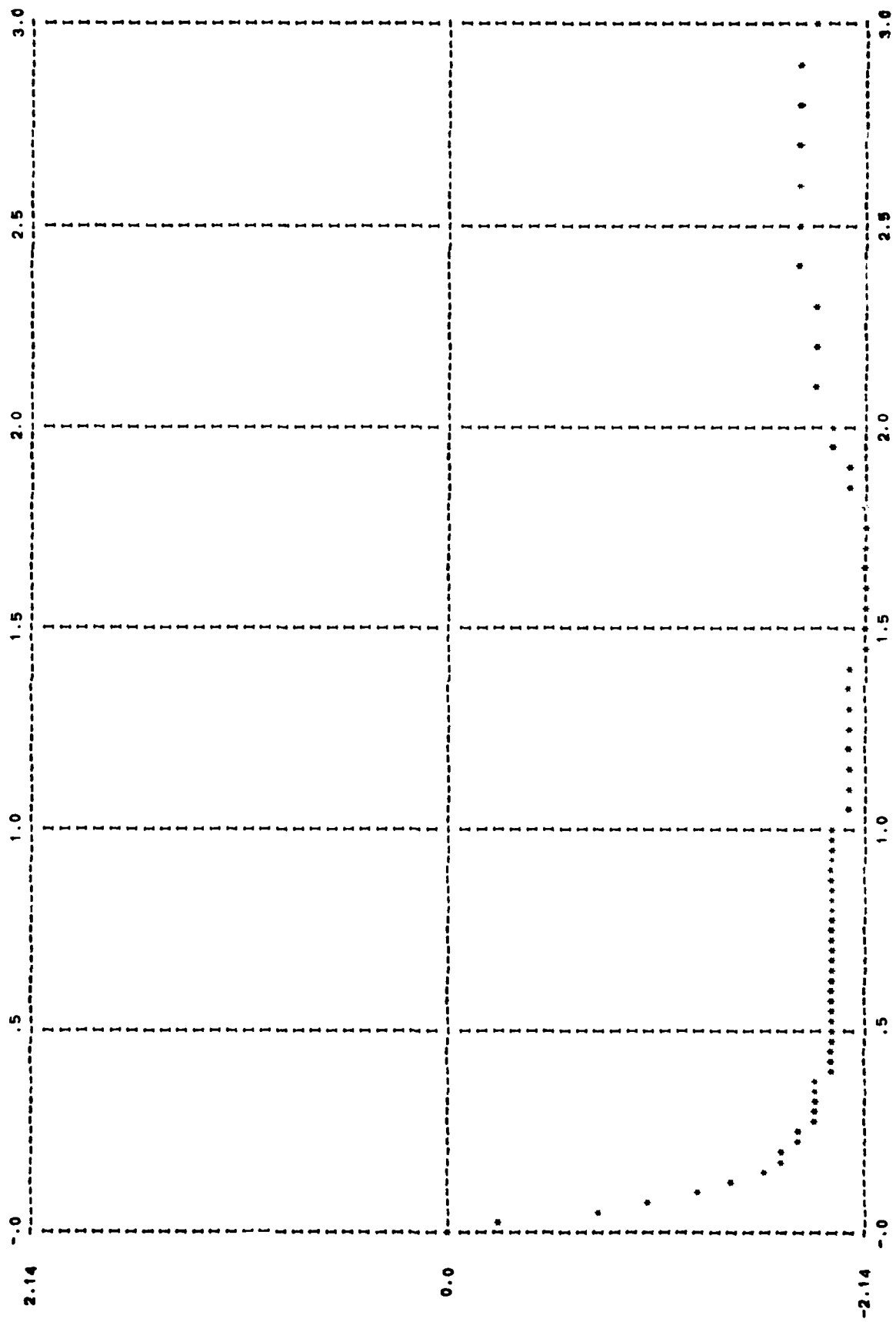


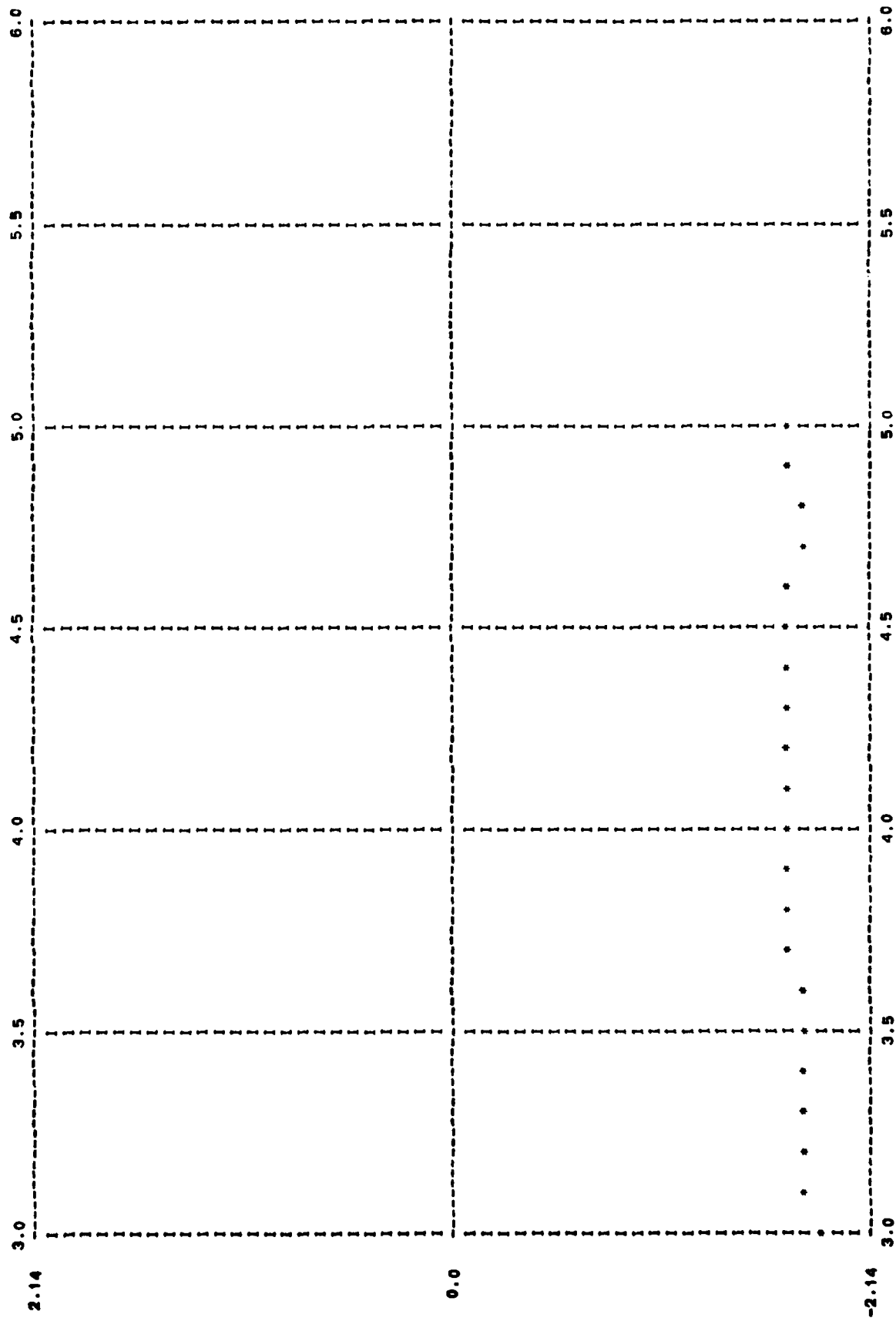
DISPLACEMENT RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 2:



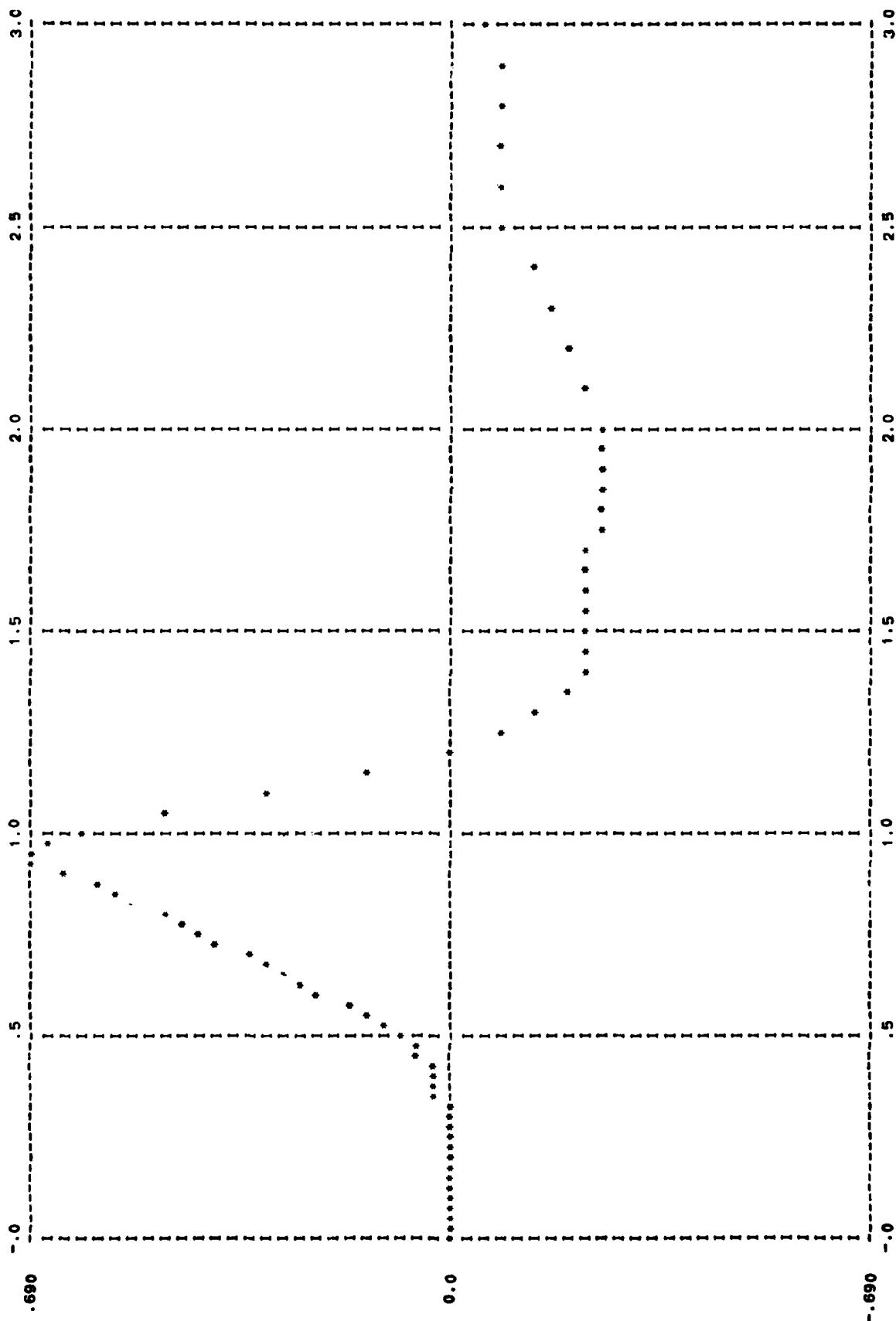


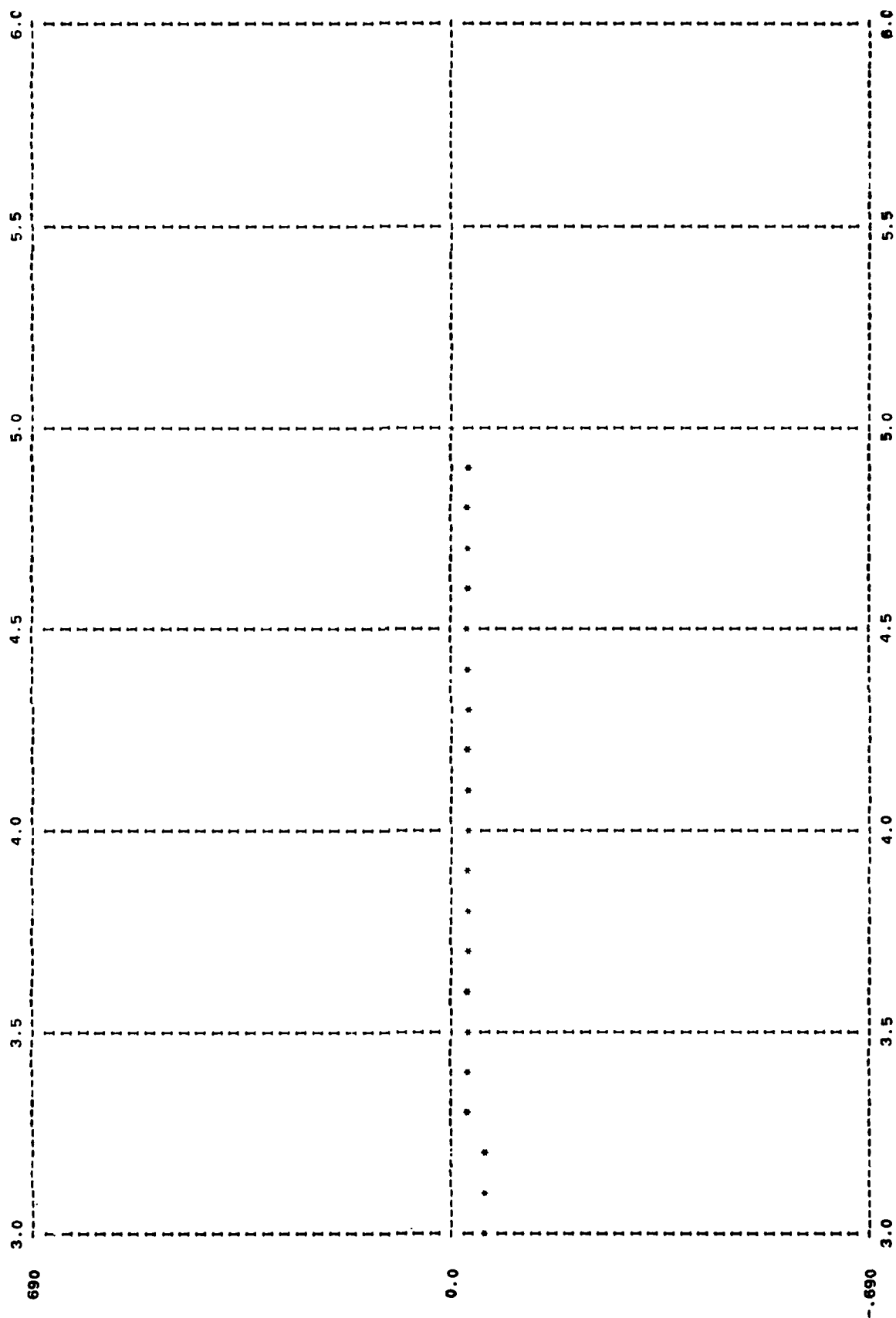
VELOCITY RESPONSE OF STRUCTURAL NODE 1, FREEDOM NUMBER 1:



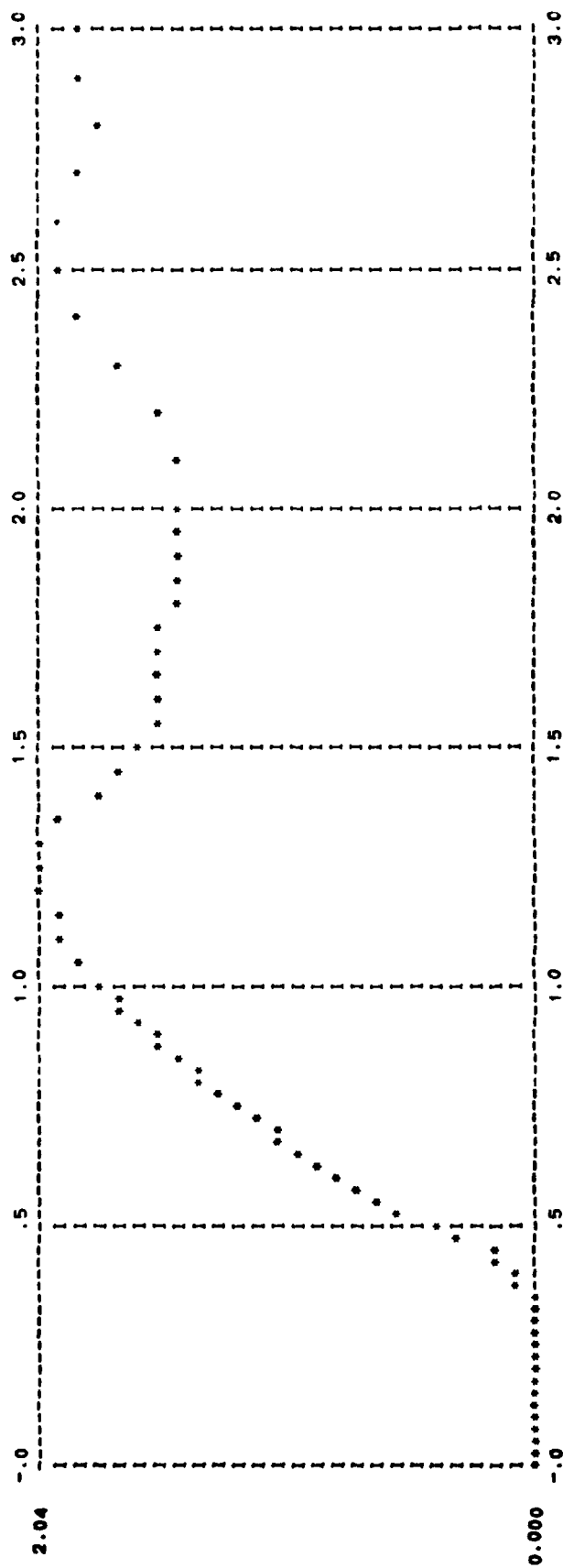


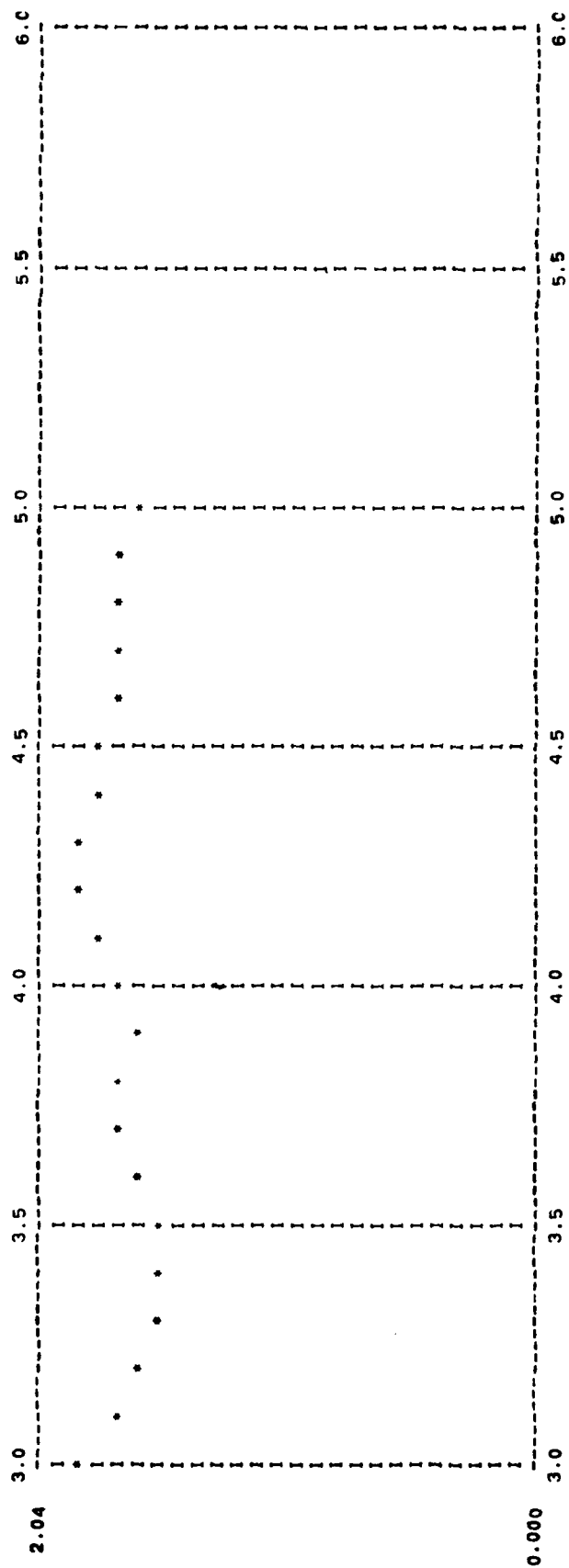
VELOCITY RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 1:



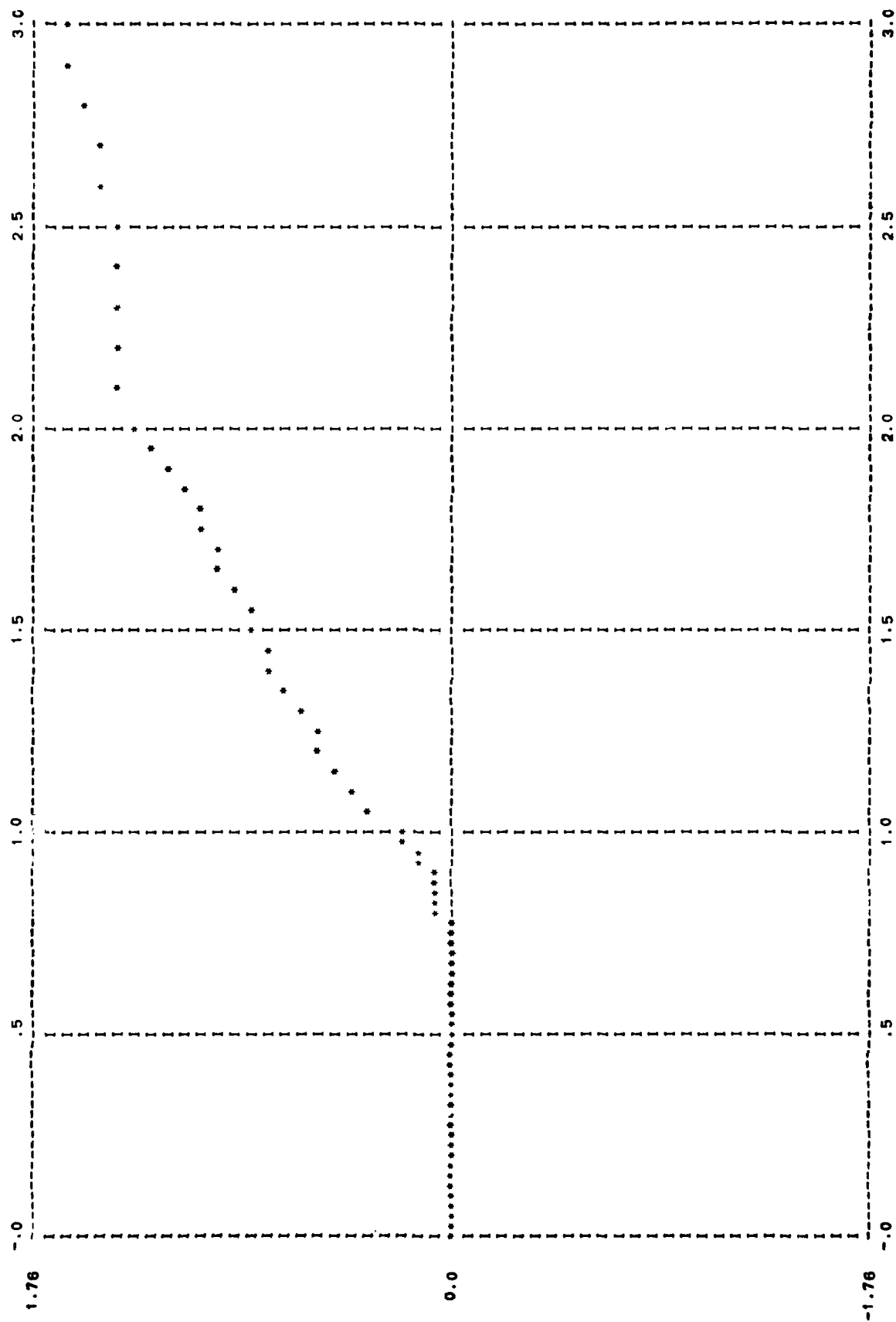


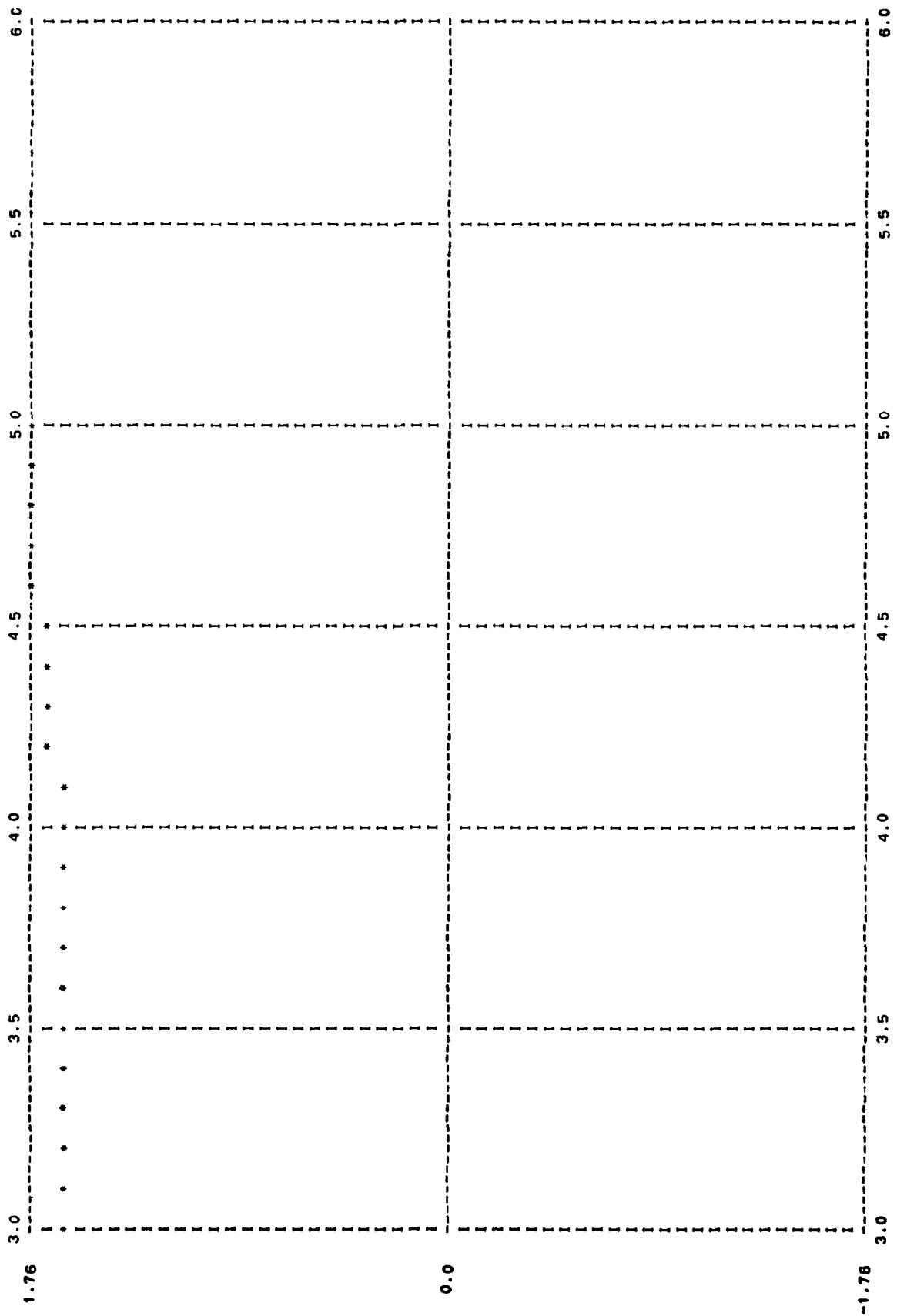
VELOCITY RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 2:



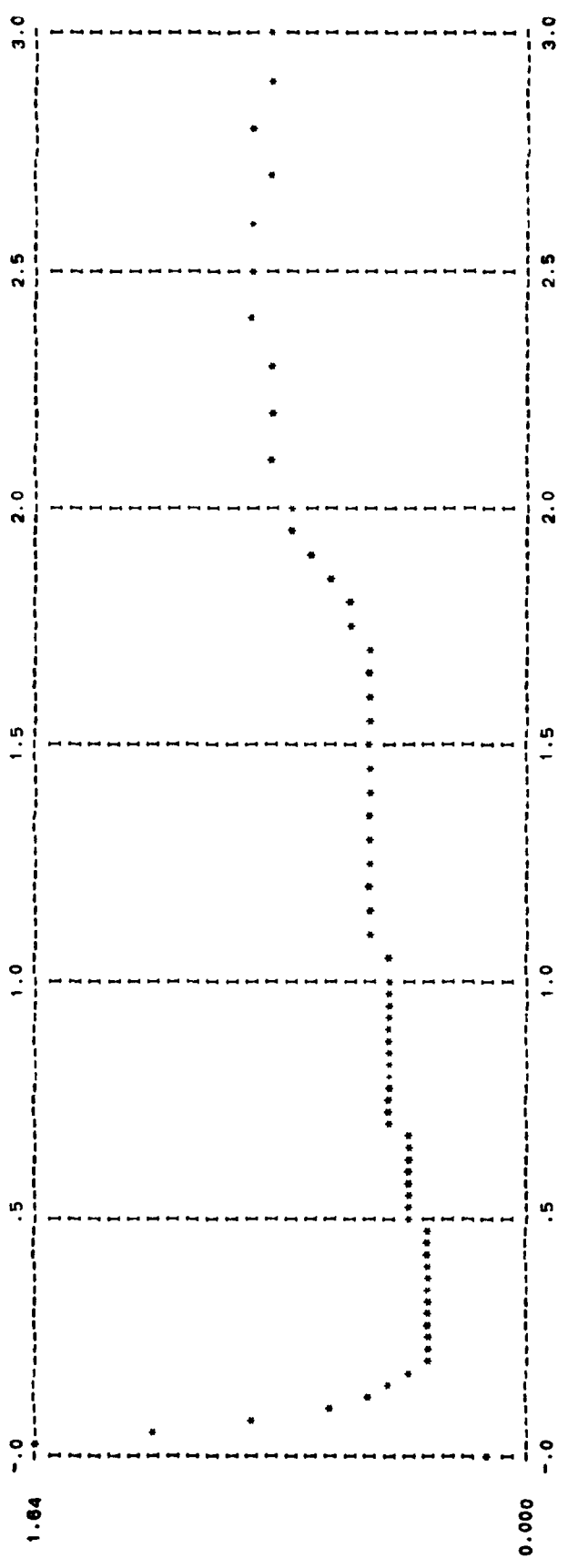


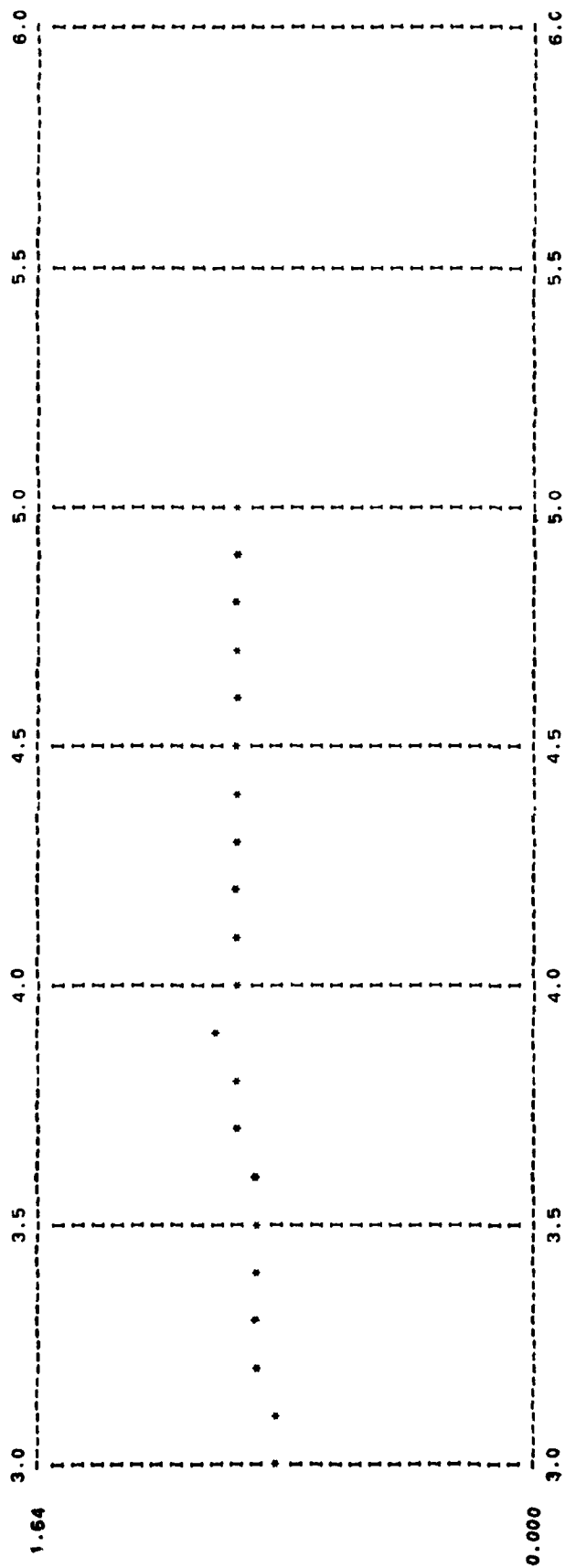
VELOCITY RESPONSE OF STRUCTURAL NODE 37, FREEDOM NUMBER 1:



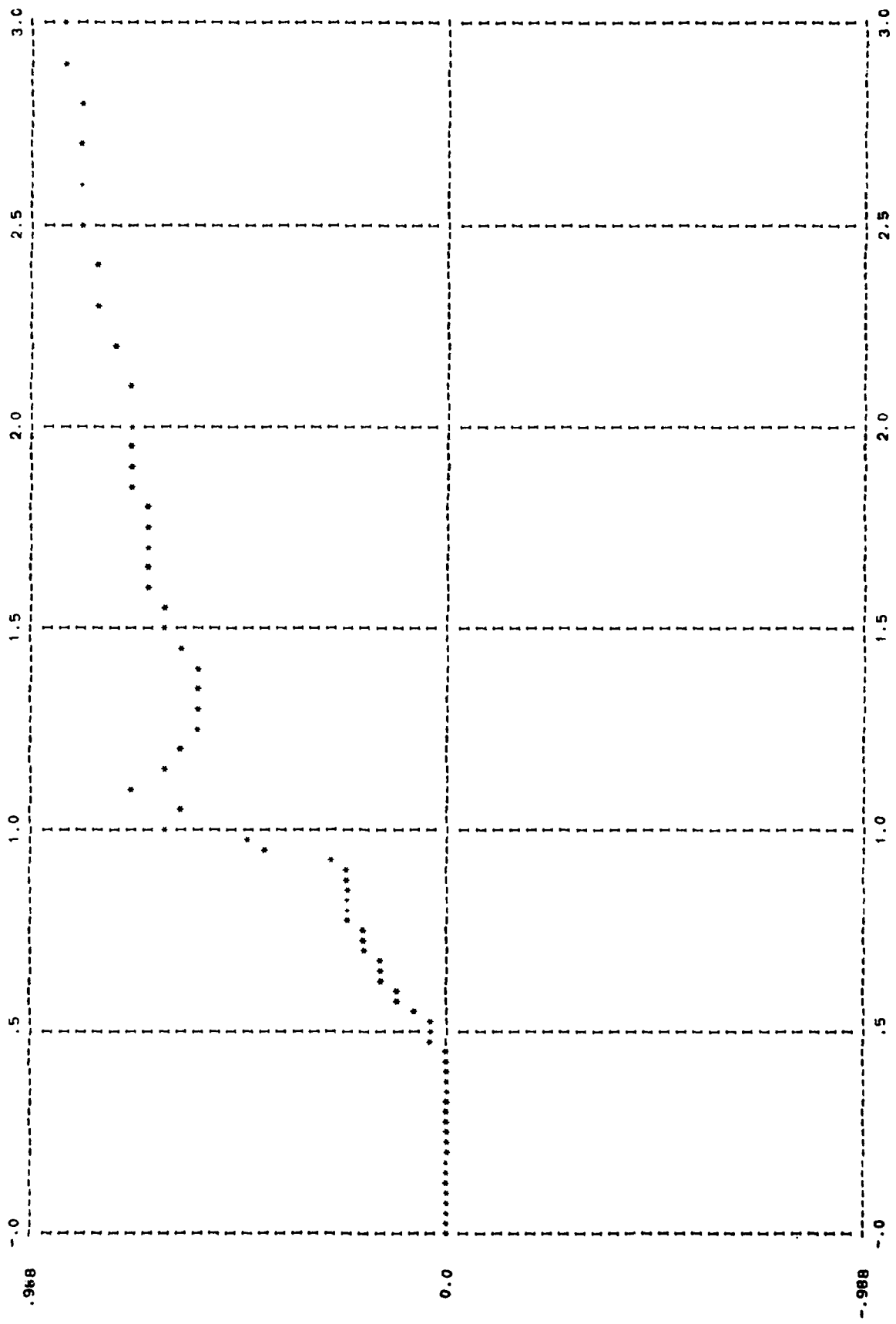


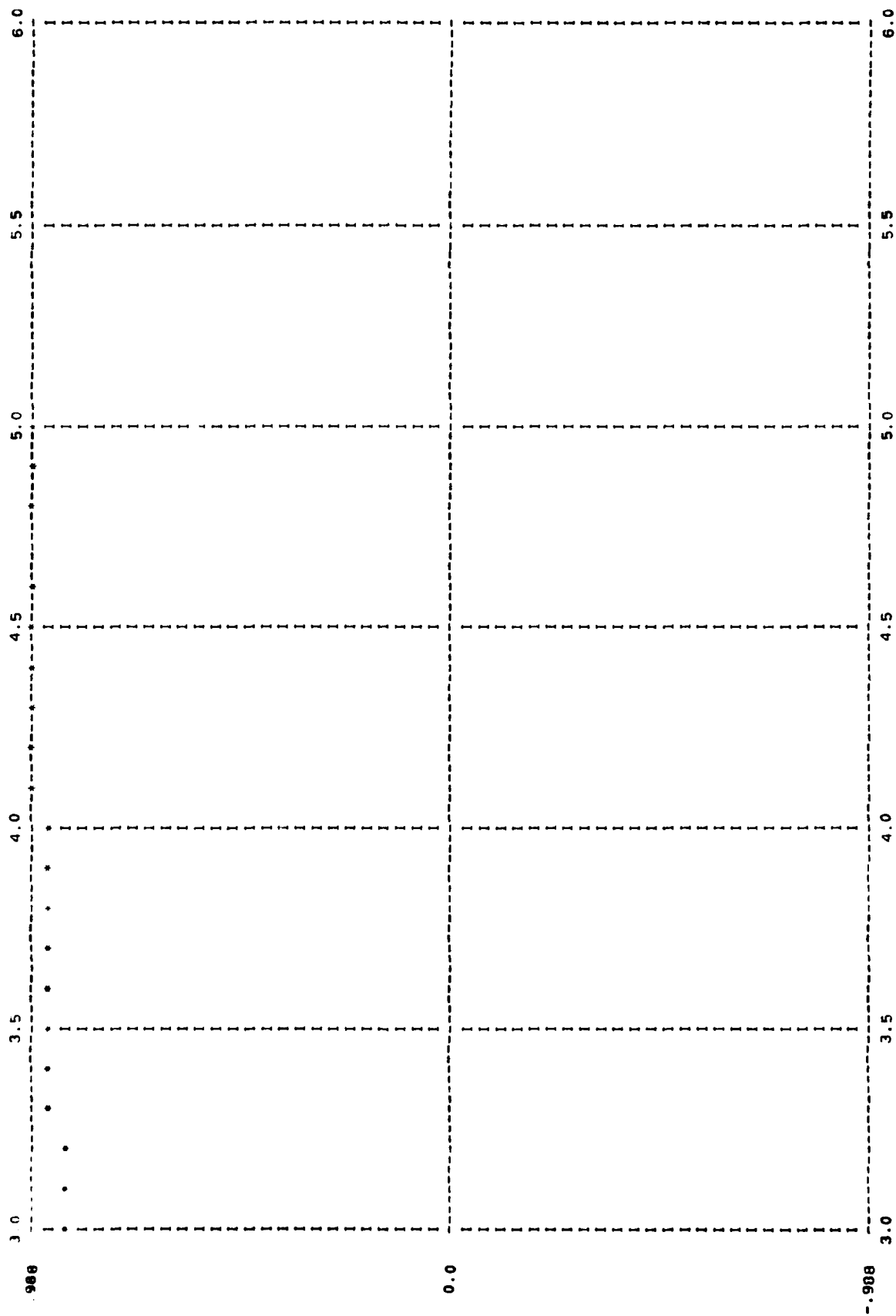
PRESSURE RESPONSE OF FLUID NODE 1:



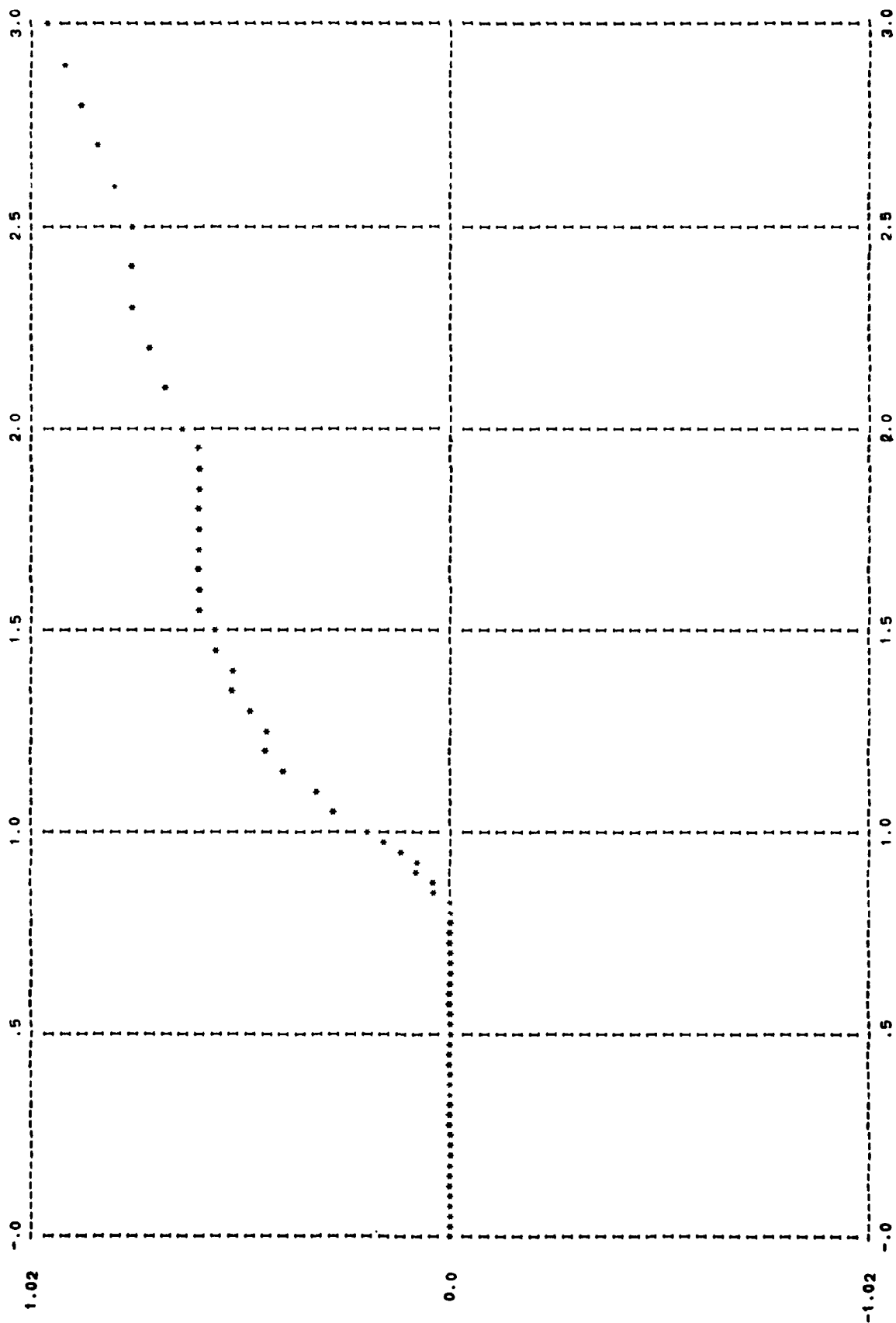


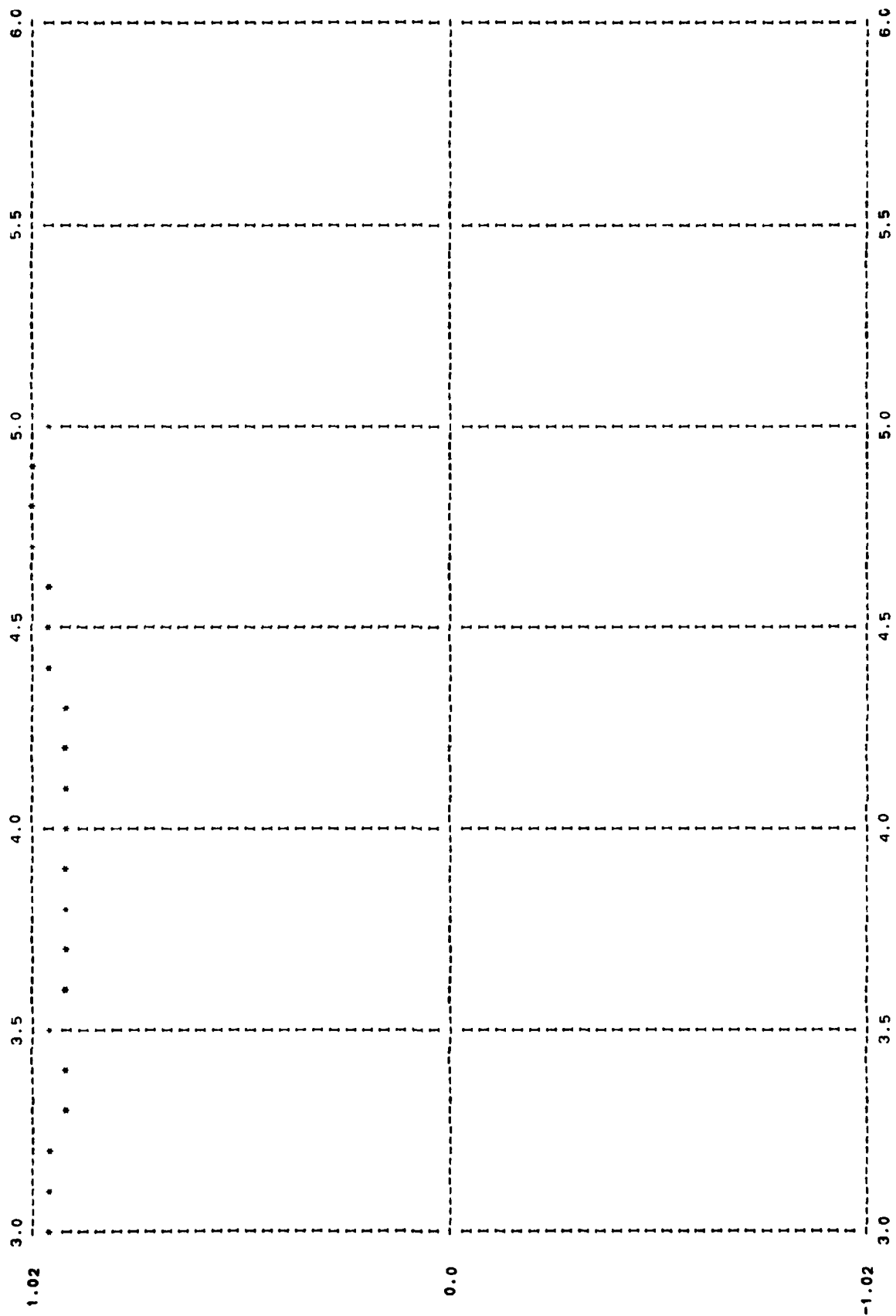
PRESSURE RESPONSE OF FLUID NODE 10:





PRESSURE RESPONSE OF FLUID NODE 19:





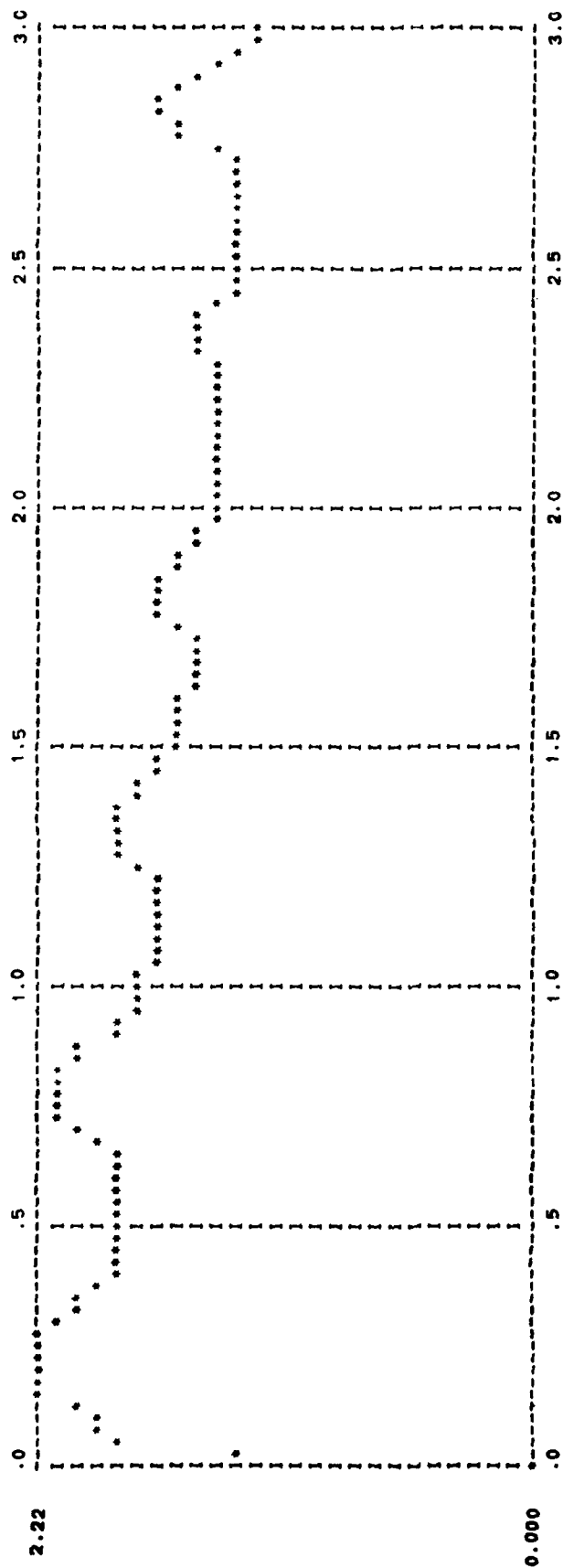
+++ ● ASG, T	UNIT13.	F4/	4/TRK/	256
+++ ● USE	13,UNIT13.			
+++ ● FREE	UNIT13.			

PSEUDO-VELOCITY SHOCK SPECTRA:

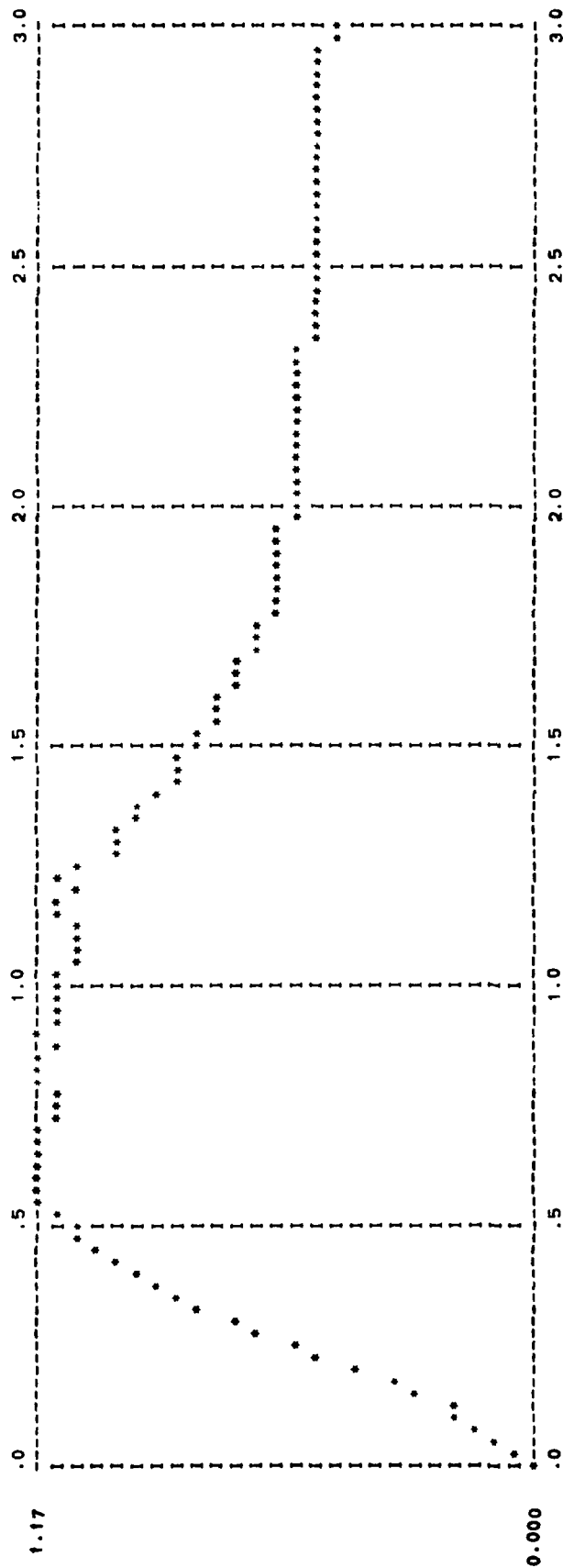
	1	2	3	4	5	6	7	8	9	10
F	.0000	.2500+01	.5000-01	.7500-01	.1000+00	.1250+00	.1500+00	.1750+00	.2000+00	.2250+00
1/1 S	.0000	.13015+01	.18316+01	.19198+01	.19773+01	.20304+01	.21882+01	.22248+01	.22500+01	.22500+00
19/1 S	.0000	.42658-01	.84865-01	.12617+00	.16615+00	.20410+00	.26240+00	.32706+00	.40027+00	.49633+00
19/2 S	.0000	.10902+01	.16848+01	.16955+01	.1734+01	.16815+01	.16146+01	.16532+01	.16911+01	.17245+01
37/1 S	.0000	.84337+00	.14352+01	.16059+01	.15199+01	.14705+01	.14021+01	.13259+01	.12500+01	.11990+01
	11	12	13	14	15	16	17	18	19	20
F	.2500+00	.2750+00	.3000+00	.3250+00	.3500+00	.3750+00	.4000+00	.4250+00	.4500+00	.4750+00
1/1 S	.22071+01	.21883+01	.21420+01	.20845+01	.20173+01	.19116+01	.19002+01	.19024+01	.18914+01	.18898+01
19/1 S	.57862+00	.65191+00	.72122+00	.79267+00	.85681+00	.91000+00	.95544+00	.99291+00	.10371+01	.10730+01
19/2 S	.17543+01	.17777+01	.17901+01	.17895+01	.17751+01	.17513+01	.18013+01	.18867+01	.19241+01	.19865+01
37/1 S	.11496+01	.10969+01	.10400+01	.98433+00	.92003+00	.87425+00	.82628+00	.78711+00	.75423+00	.72545+00
	21	22	23	24	25	26	27	28	29	30
F	.5000+00	.5250+00	.5500+00	.5750+00	.6000+00	.6250+00	.6500+00	.6750+00	.7000+00	.7250+00
1/1 S	.18332+01	.18768+01	.18706+01	.18641+01	.18567+01	.18492+01	.18436+01	.19718+01	.20817+01	.21068+01
19/1 S	.10295+01	.11291+01	.11561+01	.11660+01	.11586+01	.11733+01	.11577+01	.11606+01	.11516+01	.11482+01
19/2 S	.21105+01	.22591+01	.24510+01	.26565+01	.27356+01	.27032+01	.26835+01	.25414+01	.23074+01	.20715+01
37/1 S	.62180+00	.67596+00	.65314+00	.63457+00	.61495+00	.59819+00	.58138+00	.56777+00	.55231+00	.53985+00
	31	32	33	34	35	36	37	38	39	40
F	.7500+00	.7750+00	.8000+00	.8250+00	.8500+00	.8750+00	.9000+00	.9250+00	.9500+00	.9750+00
1/1 S	.21707+01	.21364+01	.21000+01	.20917+01	.20736+01	.20154+01	.19027+01	.18825+01	.18212+01	.17731+01
19/1 S	.11428+01	.11445+01	.11511+01	.11557+01	.11490+01	.11470+01	.11503+01	.11422+01	.11288+01	.11251+01
19/2 S	.18423+01	.16583+01	.14814+01	.13497+01	.12125+01	.11917+01	.11157+01	.10798+01	.10610+01	.10419+01
37/1 S	.52795+00	.51479+00	.50382+00	.49443+00	.48114+00	.47218+00	.46473+00	.45749+00	.44910+00	.44107+00
	41	42	43	44	45	46	47	48	49	50
F	.1000+01	.10250+01	.10500+01	.10750+01	.11000+01	.11250+01	.11500+01	.11750+01	.12000+01	.12250+01
1/1 S	.17447+01	.17373+01	.17243+01	.17153+01	.17056+01	.17017+01	.16946+01	.16852+01	.16747+01	.16790+01
19/1 S	.11187+01	.11056+01	.10863+01	.10720+01	.10643+01	.10477+01	.11127+01	.11075+01	.10804+01	.11174+01
19/2 S	.10261+01	.10088+01	.99145+00	.97698+00	.96035+00	.94515+00	.93271+00	.91858+00	.90332+00	.89303+00
37/1 S	.43190+00	.42650+00	.44754+00	.48116+00	.49509+00	.53519+00	.53316+00	.53293+00	.54153+00	.50230+00
	51	52	53	54	55	56	57	58	59	60
F	.12500+01	.12750+01	.13000+01	.13250+01	.13500+01	.13750+01	.14000+01	.14250+01	.14500+01	.14750+01
1/1 S	.17500+01	.18406+01	.18521+01	.18368+01	.18503+01	.18274+01	.17654+01	.17383+01	.16913+01	.16926+01
19/1 S	.10546+01	.10057+01	.10025+01	.97725+00	.95254+00	.92215+00	.87959+00	.84299+00	.85412+00	.83571+00
19/2 S	.88119+00	.86834+00	.85652+00	.84719+00	.83702+00	.82605+00	.81431+00	.80588+00	.79771+00	.78901+00
37/1 S	.50708+00	.46756+00	.43882+00	.40787+00	.37787+00	.36244+00	.35399+00	.34408+00	.34013+00	.33639+00
	61	62	63	64	65	66	67	68	69	70
F	.15000+01	.15250+01	.15500+01	.15750+01	.16000+01	.16250+01	.16500+01	.16750+01	.17000+01	.17250+01
1/1 S	.16800+01	.16203+01	.15911+01	.15666+01	.15421+01	.15515+01	.15500+01	.15424+01	.15344+01	.15243+01
19/1 S	.79080+00	.77590+00	.76081+00	.74530+00	.72638+00	.71376+00	.68306+00	.68306+00	.66815+00	.65361+00
19/2 S	.77964+00	.87876+00	.10787+01	.13339+01	.14075+01	.16416+01	.16843+01	.16262+01	.16910+01	.14572+01
37/1 S	.33197+00	.32719+00	.32205+00	.31657+00	.31079+00	.30472+00	.29839+00	.29507+00	.29187+00	.28844+00
	71	72	73	74	75	76	77	78	79	80
F	.17500+01	.17750+01	.18000+01	.18250+01	.18500+01	.18750+01	.19000+01	.19250+01	.19500+01	.19750+01
1/1 S	.15778+01	.16672+01	.16693+01	.16503+01	.16666+01	.16165+01	.15745+01	.15571+01	.14852+01	.14622+01
19/1 S	.63950+00	.63087+00	.62415+00	.61775+00	.61168+00	.60516+00	.60060+00	.59561+00	.59006+00	.58663+00
19/2 S	.13974+01	.13190+01	.12949+01	.11719+01	.10145+01	.97330+00	.89774+00	.79380+00	.67150+00	.63815+00
37/1 S	.28479+00	.28095+00	.27694+00	.27277+00	.26849+00	.26409+00	.25962+00	.25509+00	.25053+00	.24595+00

F	B1	B2	B1	B4	B5	B6	B7	B8	B1	90
	.20000+01	.20250+01	.20500+01	.20750+01	.21000+01	.21250+01	.21500+01	.21750+01	.22000+01	.22250+01
1/1 S	.14537+01	.14445+01	.14315+01	.14240+01	.14209+01	.14143+01	.14152+01	.14116+01	.14075+01	.14029+01
19/1 S	.58262+00	.57888+00	.57537+00	.57207+00	.56993+00	.56570+00	.56293+00	.55999+00	.55701+00	.55394+00
19/2 S	.62380+00	.61664+00	.61148+00	.60612+00	.60057+00	.59433+00	.58892+00	.58285+00	.57661+00	.57023+00
37/1 S	.24137+00	.23682+00	.23230+00	.22782+00	.22411+00	.21906+00	.21478+00	.21517+00	.20914+00	.21451+00
F	91	92	93	94	95	96	97	98	91	100
	.22500+01	.22750+01	.23000+01	.23250+01	.23500+01	.23750+01	.24000+01	.24250+01	.24500+01	.24750+01
1/1 S	.13978+01	.13966+01	.14620+01	.15059+01	.15438+01	.15316+01	.15189+01	.14572+01	.13311+01	.13303+01
19/1 S	.55075+00	.54737+00	.54376+00	.53988+00	.53667+00	.53109+00	.52611+00	.52069+00	.51979+00	.52214+00
19/2 S	.56370+00	.55705+00	.55026+00	.54336+00	.53636+00	.52939+00	.52498+00	.52048+00	.61156+00	.67642+00
37/1 S	.21655+00	.22468+00	.25009+00	.26629+00	.27193+00	.26632+00	.26577+00	.31908+00	.30522+00	.29338+00
F	101	102	103	104	105	106	107	108	101	110
	.25000+01	.25250+01	.25500+01	.25750+01	.26000+01	.26250+01	.26500+01	.26750+01	.27000+01	.27250+01
1/1 S	.13208+01	.13305+01	.13171+01	.13148+01	.13136+01	.13012+01	.13059+01	.13022+01	.12983+01	.12953+01
19/1 S	.52430+00	.52623+00	.52789+00	.52924+00	.53025+00	.53089+00	.53110+00	.53088+00	.53017+00	.52897+00
19/2 S	.62761+00	.55835+00	.62454+00	.58268+00	.59824+00	.62315+00	.63313+00	.62501+00	.59934+00	.61225+00
37/1 S	.34231+00	.33014+00	.31353+00	.30259+00	.29097+00	.29788+00	.30175+00	.29532+00	.28237+00	.26980+00
F	111	112	113	114	115	116	117	118	111	120
	.27500+01	.27750+01	.28000+01	.28250+01	.28500+01	.28750+01	.29000+01	.29250+01	.29500+01	.29750+01
1/1 S	.14651+01	.15588+01	.16298+01	.16688+01	.16988+01	.16993+01	.15531+01	.14404+01	.13005+01	.12349+01
19/1 S	.52724+00	.52496+00	.52212+00	.51870+00	.51470+00	.51012+00	.50494+00	.49919+00	.49286+00	.48598+00
19/2 S	.62636+00	.67434+00	.78758+00	.90087+00	.88337+00	.94127+00	.93049+00	.96681+00	.93651+00	.94185+00
37/1 S	.25894+00	.26098+00	.25977+00	.27717+00	.27369+00	.25941+00	.24289+00	.25190+00	.23999+00	.25006+00
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	.30000+01									
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37/1 S	.25185+00									

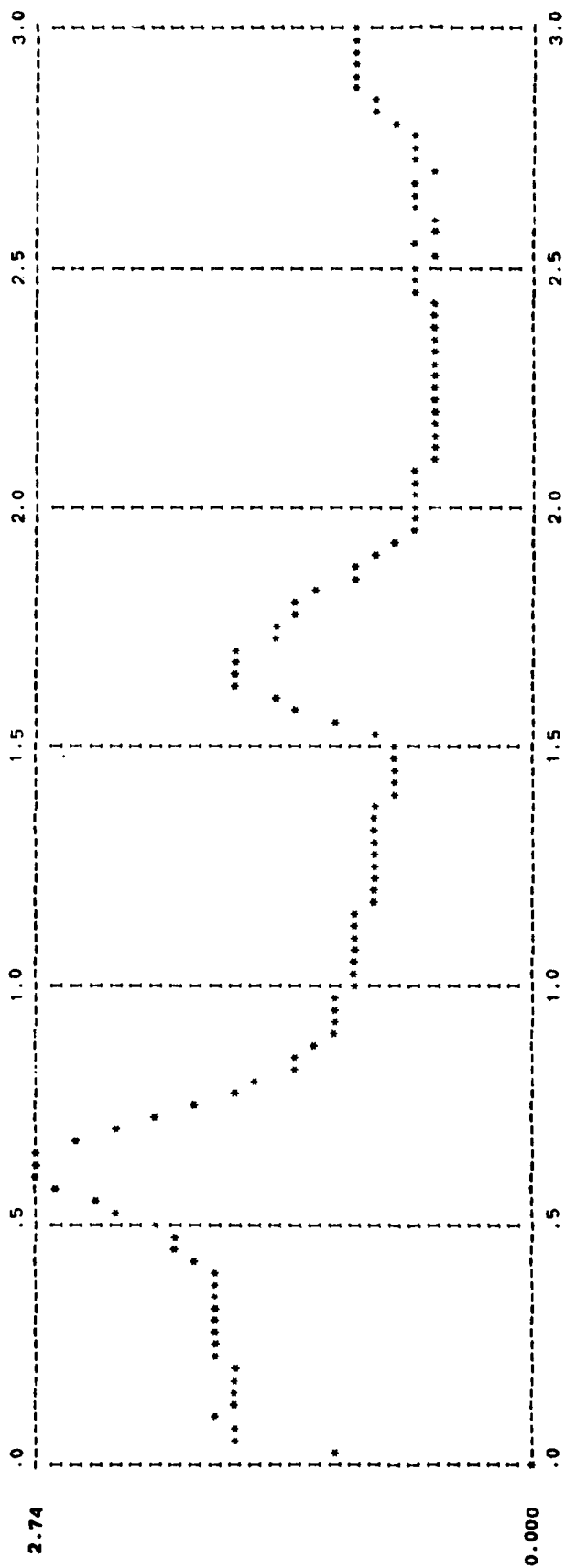
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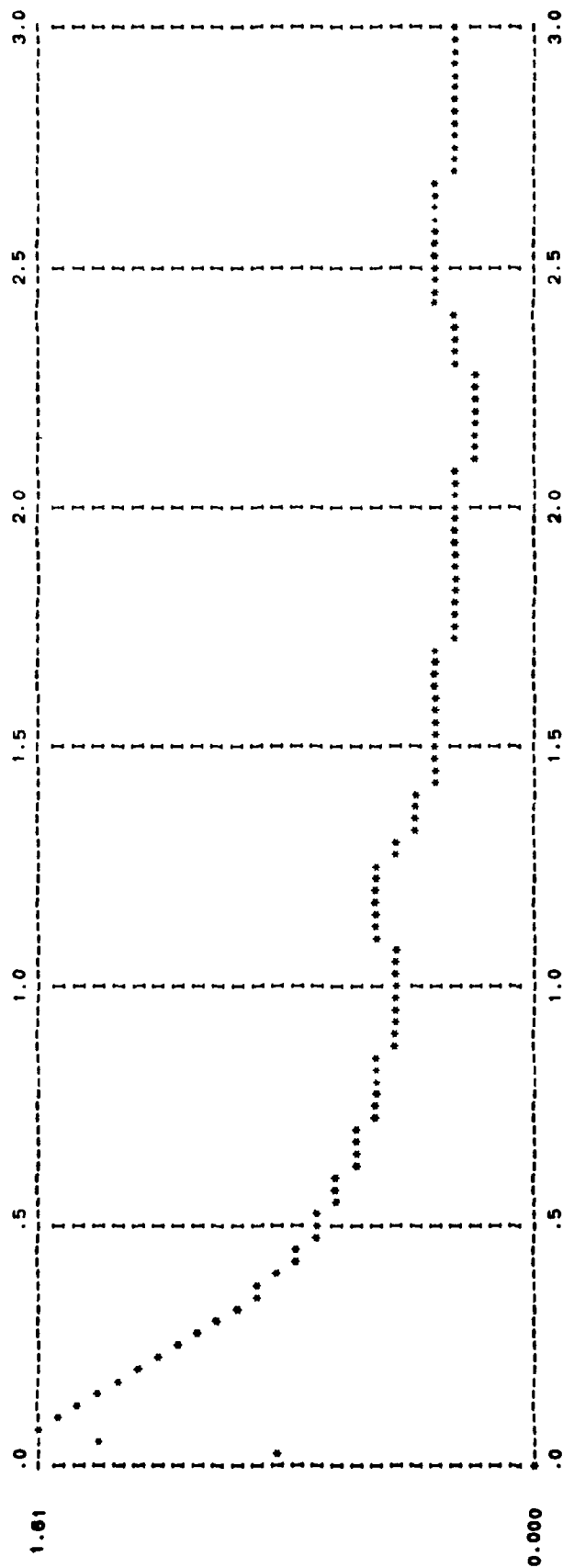
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APPENDIX E
USER INSTRUCTIONS FOR INTERFACING WITH USA

To use the Underwater Shock Analysis (USA) Code in its linear stand-alone mode, the user must first construct a permanent data file that contains the structural mass and stiffness matrices and some assorted bookkeeping information. The purpose of this appendix is to describe the structure of the file and to specify how it is to be created. At this time utility routines that carry out this task have been written for SPAR, NASTRAN and GENSAM. An abbreviated form of this file is also required when USA is coupled with a non-linear structural analyzer and such an interface also exists for STAGS.

USA contains the data management utility module DMGASP that carries out all data transfer activities between core and peripheral storage. This is done by unformatted and unbuffered data transmissions and it is imperative that DMGASP be used to create the structural interface file. Otherwise the user must supply or have access to a similar means of direct transfer. Section 3 of [19] contains a comprehensive discussion of the half-dozen or so DMGASP commands that are required to activate, position, write upon, read from, and free a peripheral storage device. Subsidiary commands also exist for error handling and listing of selected information pertaining to auxiliary storage.

The current configuration of USA uses a diagonal mass matrix associated with a lumped mass representation of the structure, assumes that there is no velocity dependent structural damping, and further, only, single precision matrices may be processed. In addition, if the stiffness matrix has been reordered or reduced in any way for input to USA the mass matrix must also be reordered or condensed so that its degrees of freedom (DOF) are the same and appear in the same order as in the stiffness matrix. Finally, the stiffness matrix must be placed in a multi-block* skyline format as discussed in the SKYPUL manual [23]. This description consists of a Matrix Master Record (MMR) followed by a series of Matrix Value Records (MVR) which contain the numerical values of the matrix. These are the only constructs the user need be concerned with; all others required are already embedded in USA. During construction of the MMR a logical device index (LDI) must be set in the record which USA will access later. For UNIVAC operation, this should be set equal to twenty (20), while for CDC operation this should be set as two (2).

The USA code now includes four routines in the AUGMAT processor that can be used to facilitate assembly of the MMR and the MVR for any symmetric matrix. The routine BLKSKY is used to sequentially call SETPAR which determines the skyline profile, SETMMR which

* For small problems a single block is permissible.

constructs the matrix master record and finally SETMVR which produces the matrix value records. However, the user must ensure that the matrix can be provided row by row (or column by column) with any and all zeroes filled in. Please contact the developer for further details.

The file structure required is shown in Table E-1 where NDOF stands for the number of structural DOF which USA must process. NMMR is the number of words in the matrix master record, and NWBL is the number of words in each matrix value record (which is expected to be the same for each record). NWBL should also be an integer multiple of 448 for most efficient use of storage.

The Grid Point/DOF vector consists of an integer value for each global DOF from 1 through NDOF that is constructed as ten times the external node number plus the local DOF number that apply to that particular structural equation.

For example, if the 87th DOF to appear in the mass and stiffness matrices corresponds to the second degree of freedom at a node identified externally as 4637 then the 87th entry in the Grid Point/DOF vector would be 46372. Local translational degrees of freedom should be numbered 1-3, rotational degrees of freedom should be numbered from 4-6 and any others should be numbered with 7-9. If more than 9 degrees of freedom are carried at any node it is a simple matter to change the factor of ten to one hundred in a few places in USA to accommodate this.

It should be noted that records 1-4 are always accessed by the USA pre-processor AUGMAT before the time integration phase of the analysis commences.* This portion of the file is required for both USA in the linear stand-alone mode, and for USA when it is interfaced with a nonlinear structural analyzer. In this latter case, the fifth and succeeding records do not exist.

There is a minor difference in the way that the fifth and succeeding records are constructed in the SPAR and NASTRAN utilities. In the SPAR interface one pass is made through the stiffness matrix to first determine its connectivity and set up the book-keeping to construct the MMR. The MMR is then written and a second pass is made through the matrix to write the MVR's immediately following the MMR. In the NASTRAN interface only one pass is made through the stiffness matrix. Hence, the MMR is not constructed until all the MVR's have been written. To follow the order required by Table E-1 space is left in the file for the MMR to be written in its proper order on the file after the entire set of MVR's have been written. Because of this there will generally be a buffer area of irrelevant data (garbage) between the MMR and the first MVR on a NASTRAN file in contrast to a SPAR file.

* The fifth and succeeding records can be accessed in AUGMAT if the user wishes to check the stiffness matrix.

Table E-1

Record	Number of Words	Data
1	1	NDOF
2	NDOF	Diagonal Mass Matrix
3	1	NDOF
4	NDOF	Grid Point/DOF Vector
5	1	NMMR
6	NMMR	Matrix Master Record for Stiffness Matrix
7	NWBL	First Matrix Value Record for Stiffness Matrix
.	.	.
.	NWBL	Second Matrix Value Record for Stiffness Matrix
.	.	.
.	:	.
.	.	.
.	NWBL	Last Matrix Value Record for Stiffness Matrix

The amount of space currently allowed for the MMR on a NASTRAN skyline file is 10 PRU's (640 words) on CDC and 10 sectors (280 words) on UNIVAC. These values translate into a current limit of 283 and 80 skyline blocks for the two systems, respectively. If more capability is desired the statement MMRPRU = 10 at the beginning of subroutine KDD of the NASTRAN skyline utility can be increased to suit the user's needs.

The SKYPUL processor has the ability to apply constraints due to symmetry or attachment to ground during the time integration. Structural DOF that are to remain zero must have their associated diagonal location pointers (LDP) flagged with a negative sign during construction of the MVR and it is highly recommended that this capability be included in every USA structural interface utility.

AD-A108 773

LOCKHEED MISSILES AND SPACE CO INC PALO ALTO CA
THE UNDERWATER SHOCK ANALYSIS CODE (USA-VERSION
SEP 80 J A DERUNTZ, Y L BEERS, C A FELIPPA
LMSC-D777843 DNA-5615F

F/6 20/11
31: A REFERENCE--ETC(U)
DNA001-78-C-0029
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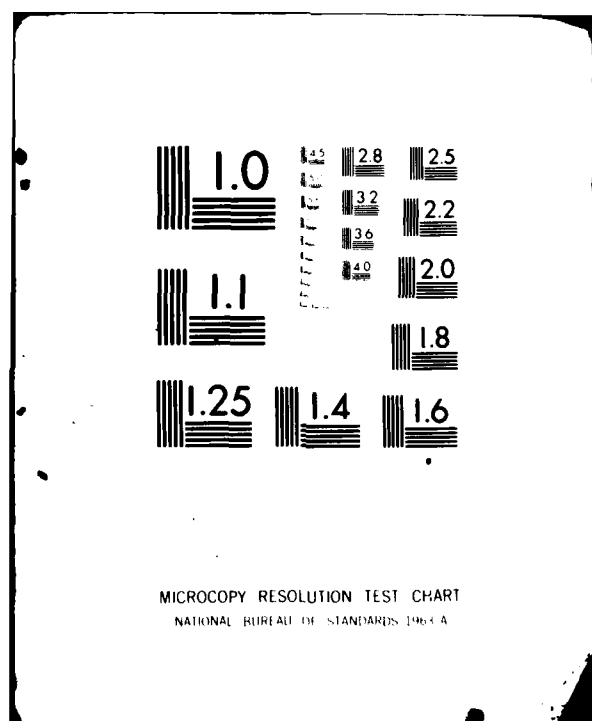


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