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**UNDERWATER SHOCK ANALYSIS OF NONLINEAR
STRUCTURES, A REFERENCE MANUAL FOR
THE USA-STAGS CODE (VERSION 3)**

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9 December 1980

Final Report for Period 1 March 1978—9 December 1980

CONTRACT No. DNA 001-78-C-0029

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DNA 5545F	2. GOVT ACCESSION NO. AD-A208	3. REPORT'S CATALOG NUMBER 919
4. TITLE (and Subtitle) UNDERWATER SHOCK ANALYSIS OF NONLINEAR STRUCTURES, A REFERENCE MANUAL FOR THE USA-STAGS CODE (VERSION 3)	5. TYPE OF REPORT & PERIOD COVERED Final Report for Period 1 Mar 78--9 Dec 80	
7. AUTHOR(s) J. A. DeRuntz F. A. Brogan	6. PERFORMING ORG. REPORT NUMBER LMSC- D779760	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Lockheed Missiles & Space Company, Inc. 3251 Hanover Street Palo Alto, California 94304	8. CONTRACT OR GRANT NUMBER(s) DNA 001-78-C-0029	
11. CONTROLLING OFFICE NAME AND ADDRESS Director Defense Nuclear Agency Washington, D.C. 20305	10. PROGRAM ELEMENT, PROJECT, TASK AND WORK UNIT NUMBERS Subtask Q68QAXSF501-01	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	12. REPORT DATE 9 December 1980	
	13. NUMBER OF PAGES 212	
	15. SECURITY CLASS. (of this report) UNCLASSIFIED	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES This work sponsored by the Defense Nuclear Agency under RDT&E RMSS Code X344078469 Q68QAXSF50101 H2590D.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Fluid Structure Interaction Free Surface Underwater Shock Bulk Cavitation Doubly Asymptotic Approximation Structural Geometric and Discrete Analysis Computer Code Material Nonlinearity Staggered Solution Procedure		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report is a reference manual for the third version of the USA-STACS Code that calculates the nonlinear transient response of a totally or partially submerged structure to a spherical shock wave of arbitrary pressure profile and source location. USA-STAGS is the result of interfacing USA (Underwater Shock Analysis) and STAGS (Stress Analysis of General Shells). The fluid is assumed to be an infinite acoustic medium whose response to motions of the structure is described by either of the Doubly Asymptotic Approximations, DAA ₁ or DAA ₂ .		

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SUMMARY

This report is a reference manual for the third version of the USA-STAGS Code that calculates the nonlinear transient response of a totally or partially submerged structure to a spherical shock wave of arbitrary pressure profile and source location. USA-STAGS is the result of interfacing USA (Underwater Shock Analysis) and STAGS (Stress Analysis of General Shells). The fluid is assumed to be an infinite acoustic medium whose response to motions of the structure is described by either of the Doubly Asymptotic Approximations, DAA_1 or DAA_2 .

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PREFACE

The authors express their appreciation to B. O. Almroth and Dr. T. L. Geers for sowing the seeds which eventually led to the realization of the USA-STAGS Code and to Dr. C. A. Felippa who has provided both time and software to this effort.

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SECTION I

INTRODUCTION

This report is a reference manual for the third version of the USA-STAGS Code that calculates the nonlinear transient response of a totally or partially submerged structure to a spherical shock wave of arbitrary pressure profile and source location. This constitutes a revision of [1], the original manual that describes the interfacing of USA (Underwater Shock Analysis) [2], and STAGS (STress Analysis of General Shells) [3].

The USA Code computes the transient response of a totally or partially submerged, shock-wave-excited elastic structure using a linear (or linearized) stiffness matrix that has been constructed by a finite-element or finite-difference structural analyzer of choice. STAGS is a general-purpose nonlinear finite-element, structural code that is very efficient for the analysis of inelastic collapse of stiffened shell structures. USA-STAGS employs the staggered solution strategy upon which USA itself is constructed. In this procedure the structural response equations and the fluid response equations are solved separately, step-by-step, through extrapolation of terms which couple the two systems thus preserving the modularity of each code. This technique has been shown to be unconditionally stable with respect to time step size in the linear response problem [4].

The fluid equations treated by USA-STAGS apply to an infinite or semi-infinite acoustic medium and either the Doubly Asymptotic Approximation (DAA₁) or the Improved Doubly Asymptotic Approximation (DAA₂) [5, 6] is used to determine the fluid pressure on the "wet" surface of the structure.

The following additions, changes and enhancements have been incorporated in the USA-STAGS Code since [1] was issued:

- 1) STAGS C-1 has become the standard version for underwater shock analysis.
- 2) An imaging formulation that allows the analysis of problems involving partially submerged structures and structures totally submerged near the free surface has been implemented.
- 3) A technique has been developed to include the effects of bulk cavitation in the incident wave excitation that provides a complete description of fluid particle velocity consistent with the occurrence of surface cutoff.
- 4) Surface-of-revolution fluid elements can now treat both beam-like and bar-like response.
- 5) The Improved Doubly Asymptotic Approximation (DAA₂) is now operational.

- 6) The fluid equation system is processed in an out-of-core mode to allow substantial increases in the allowable number of fluid elements.
- 7) A capability to do linear analysis has been built into the USA-STAGS Code.
- 8) An improvement has been added to the integration time step control to allow STAGS to change the step size if required for convergence.
- 9) A hydrostatic prestress analysis of the structure can be made to provide non-zero initial values for nonlinear underwater shock analysis.
- 10) A capability to conduct a collapse analysis of the structure upon completion of the transient analysis has been added.
- 11) USA-STAGS is now operational on the VAX 11/780 virtual memory system machine.

1.1 STAGGERED SOLUTION PROCEDURE

USA-STAGS is constructed around the staggered solution procedure which avoids the simultaneous solution of the structural response equations and the fluid response equations. Such a simultaneous solution would be costly from two viewpoints. First, a special-purpose version of STAGS would have been required. Second, the computation time would have been substantially increased over that required for the transient analysis of a dry structure due to the widespread coupling induced by the fluid.

On the other hand, the 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 some computations, the fluid equations used in USA have been modified in such a way that unconditional stability has been achieved for the linear elastic structural response problem [4].

At this time an investigation of time step stability of the coupled USA-STAGS system has not been performed. Stability will depend not only upon the specific types of nonlinearity inherent in the STAGS equations but also upon which of the family of STAGS integration algorithms is used in any particular case. It is likely, however, that unconditional stability will exist for some range of mildly nonlinear behavior.

1.2 DOUBLY ASYMPTOTIC APPROXIMATIONS

The DAA₁ is embodied in a linear first order matrix ordinary differential equation that defines the fluid pressure due to the scattered wave at the fluid-structure boundary. The principal advantage of the DAA₁ then is that it models the infinite acoustic medium surrounding the structure as a membrane covering the wet surface of the struc-

ture. 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.

The principal disadvantage of the DAA_1 is that it constitutes an approximation to the "exact" boundary-element representation of the surrounding medium [7,8]. The DAA_1 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 [6,7,9].

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 because it is a second order matrix differential equation. 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 [2]. Analytical studies of spherical shell response [6] also show such marked improvement.

Although the DAA_1 and DAA_2 have been shown to be suitable for engineering analysis of underwater shock problems, the physics of such problems still include features of great complexity not currently treated. For example, local fluid cavitation at the fluid-structure interface may substantially alter structural response for incident shock waves of short duration. Effective means of including hull cavitation phenomena in the numerical solution of underwater shock problems are still being sought.

1.3 USA FEATURES

A number of special features are incorporated in the USA 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 for both submerged and partially submerged structures 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, the effects of bulk cavitation on the free field pressure history are approximately treated.

1.4 STAGS FEATURES

STAGS is primarily intended for the nonlinear analysis of shell structures; therefore, great emphasis has been placed on computational efficiency. The capabilities of STAGS include the following processors: 1) linear stress analysis; 2) geometrically nonlinear elastic stress analysis; 3) inelastic stress analysis, geometrically linear or nonlinear; 4) bifurcation buckling analysis with linear or geometrically nonlinear prestress (elastic); 5) small vibration analysis with prestress based on linear or geometrically nonlinear analysis (elastic); and 6) transient response analysis, linear or geometrically nonlinear, elastic or inelastic. In a STAGS analysis, the structure can be defined as composed of a number of shell branches. Linear springs (axial or torsional) and nonlinear general beam elements also can be included. If the beams are defined as stiffeners attached to the shell along a line on its surface, appropriate displacement constraints will be enforced automatically. Loading is either mechanical (forces or forced displacements) or thermal. Any boundary conditions or other displacement constraints are permitted as long as they are linear. Displacement-dependent hydrostatic loads may be used. For transient problems, velocity-dependent damping may be included in specified regions. General damping proportional to mass or linear stiffness may also be selected.

A number of quadrilateral and triangular finite-elements are available as options for discretization of the shell branches. The discretization procedures available include a flat element in which lateral displacements are bicubic and in-plane displacements at least quadratic. At each corner node, there are six or seven degrees of freedom: three displacement components, three rotation components, and optionally the shear strain. In addition, displacements along the element boundaries may be included as degrees of freedom at midpoint nodes, thus the maximum number of degrees of freedom per element is 32. Refined quadrilateral elements constructed from sub-triangles may also be used. These quadrilaterals need not be flat.

Bifurcation buckling and small vibration analyses lead to linear eigenvalue problems. In STAGS, these are solved through the generation of invariant subspaces by simultaneous power iteration [11]. Nonlinear static analysis results in nonlinear algebraic equations. For solution of such equations, the STAGS user has the options of using either the modified or the regular Newton method [12]. For transient analysis numerical integration the following options are available: 1) the central difference scheme; 2) trapezoidal rule; 3) Gear's two- and three-order methods; or 4) Park's method. A discussion of these methods is available in Ref. [13].

1.5 SPECIAL NON-FEATURES

Some features of modest complexity have yet to be incorporated into the USA-STAGS 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 elements that produce such matrices. Fourth, a means to handle the matrices produced by acoustic elements based on a pressure formulation [14,15] is desirable, in that such elements permit highly efficient modeling of internal fluid volumes.

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

FLUID-STRUCTURE INTERACTION PROBLEM FORMULATION AND SOLUTION PROCEDURE

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

2.1 STRUCTURAL RESPONSE EQUATION

The discretized differential equation system for the dynamic response of a nonlinear structure can be expressed in the form

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

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

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

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

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, $\underline{f}_D$ is the dry-structure applied force vector, $\underline{A}_f$ is the diagonal area matrix associated with elements in the fluid mesh, and $\underline{G}$ is the transformation matrix that relates the structural and fluid nodal surface forces. More will be said about $\underline{G}$ in the next subsection.

2.2 DAA₁ EQUATION

The Doubly Asymptotic Approximation may be written [5,6]

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

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 $\underline{M}_f$ 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 [16].

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 $p_S = \rho c u_S$, 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 $A_f p_S = M_f \dot{u}_S$, which is the correct limit for long acoustic wavelengths.

For excitation by an incident acoustic wave, 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

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

These equations may be solved simultaneously at each time step by the transfer of $- \underline{G} \underline{A}_f p_S$ and $\rho c \underline{M}_f \underline{G}^T \ddot{\underline{x}}$ 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, at least in the linear case.

The simplest implementation of the staggered solution procedure recommended in [4] 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 $\underline{G}^T \underline{\ddot{x}}$, 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

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

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

$$\underline{H} = \underline{D}_s - (\underline{D}_s + \underline{D}_{f1} - \frac{1}{\rho} \underline{A}_f \underline{R}^{-1}) \underline{\Gamma} \quad (2.10)$$

where $\underline{R}$ is the diagonal matrix formed by the distances R_i . Equations (2.9) are the equations solved by the USA-STAGS 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

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

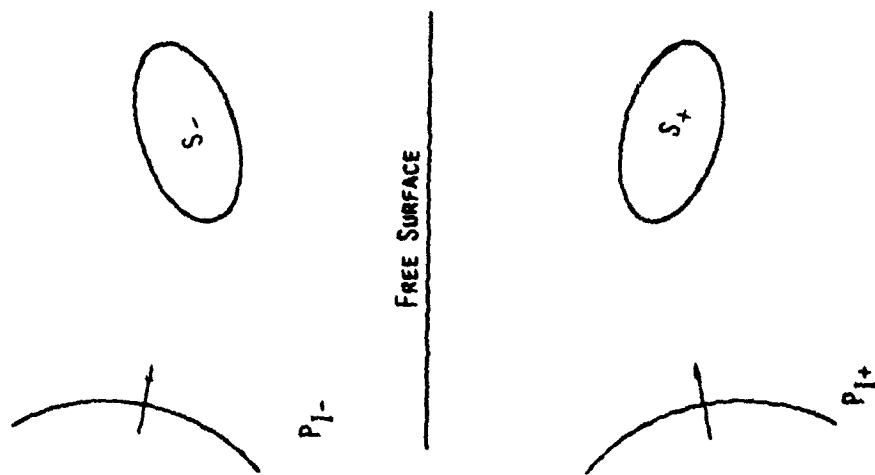


Figure 2-1 Image Technique for Free Surface

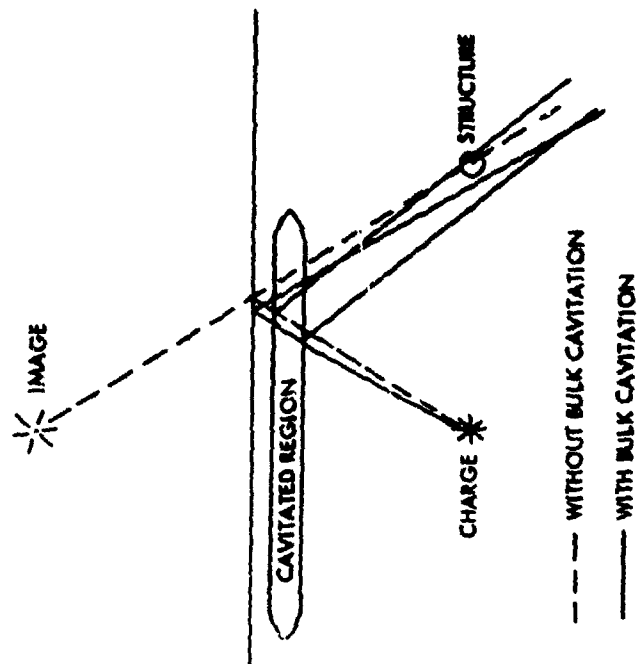


Figure 2-2 Free Field Ray Diagram

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 [17] 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

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

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

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)]

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

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 [18]. 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 cavitated 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 [19]. 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

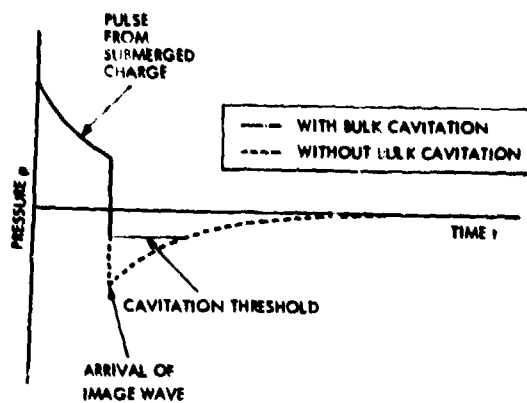


Figure 2-3 Free-Field Pressure as a Result of Free-Surface Reflection

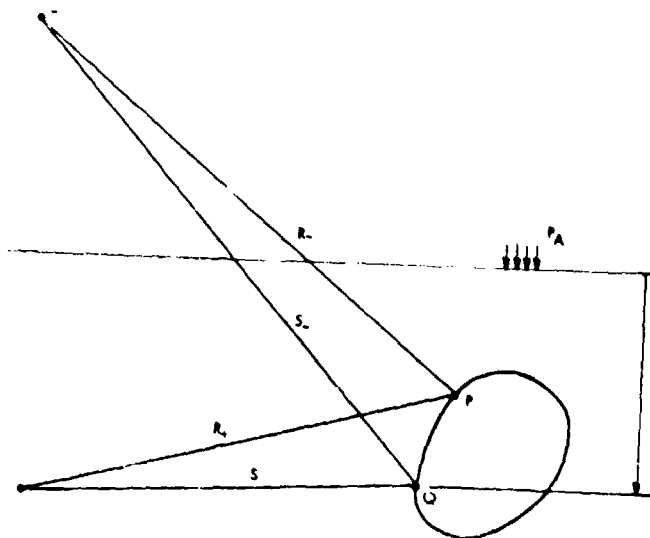


Figure 2-4 Geometry of Primary and Image Waves

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 standoff 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 [20].

2.7 USA-DAA₂ IMPLEMENTATION

The Improved Doubly Asymptotic Approximation [DAA₂] can be written as [6]

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

where

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

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 (DAA₁) described in Section 2.2.

Note that DAA₂ is a second-order equation, whereas DAA₁ is a first-order equation. In addition, DAA₂ 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 [6], it is observed that $\eta = 1$ leads to the best accuracy for a spherical shell.

In order to implement DAA₂ (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

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

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

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

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 $\ddot{x}$ 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 OF USA-STAGS CODE

Organization of the USA-STAGS system is shown in Figure 3-1. STAGS operates on two levels within this structure; first as a preprocessor, and second as a driven utility during the time integration phase of the analysis. In the preprocessing mode STAGS generates two types of information. The first is data that are required later by the STAGS time integrator, and the second is data that are needed for fluid preprocessing. Both sets of information are placed in mass storage where the latter data are retrieved by the fluid mass matrix processor FLUMAS and then by the processor AUGMAT. AUGMAT produces the final form of the fluid matrix equations to be integrated. Data transfer within USA is carried out with the data manager DMGASP, while out-of-core processing in FLUMAS is accomplished by the virtual memory simulator VMSYST. Out-of-core processing of the fluid equation system during time integration is carried out by the SKYPUL processor which is not shown in 3-1.

The time integration processor is TIMINT which drives both the USA integrator for the fluid and the STAGS integrator for the structure. TIMINT places the structural displacements and velocities and the total fluid pressures into mass storage at each time step. User selected response data are then displayed in tabular and graphic form at the conclusion of the run. The processor POSTPR has the same display capability as TIMINT, but is used for more detailed examination of the results at a later time.

In the following these separate functional components are discussed individually. Detailed information for utilization of the code is contained in the Appendices.

3.1 STAGS PREPROCESSING

Execution of a purely structural analysis, linear or nonlinear, is carried out by two independent programs STAGS1 and STAGS2. The STAGS1 program is basically a preprocessor which reads input data defining a structural model with loads and boundary conditions and prepares an output file, TAPE2, for use by STAGS2. STAGS2 performs the actual analysis and reads no input. The STAGS1 preprocessor program has been slightly modified for use with the USA Code. Input data for STAGS1, as described in the STAGS Users Manual [3], remains unchanged except for one logical record, B-1. An additional data word, IFLUA, is added to this record. A value of -1 for this item signifies the USA-STAGS combination will be executed. The user must also ensure that the local coordinate systems associated with each wet surface of the structure must be consistent

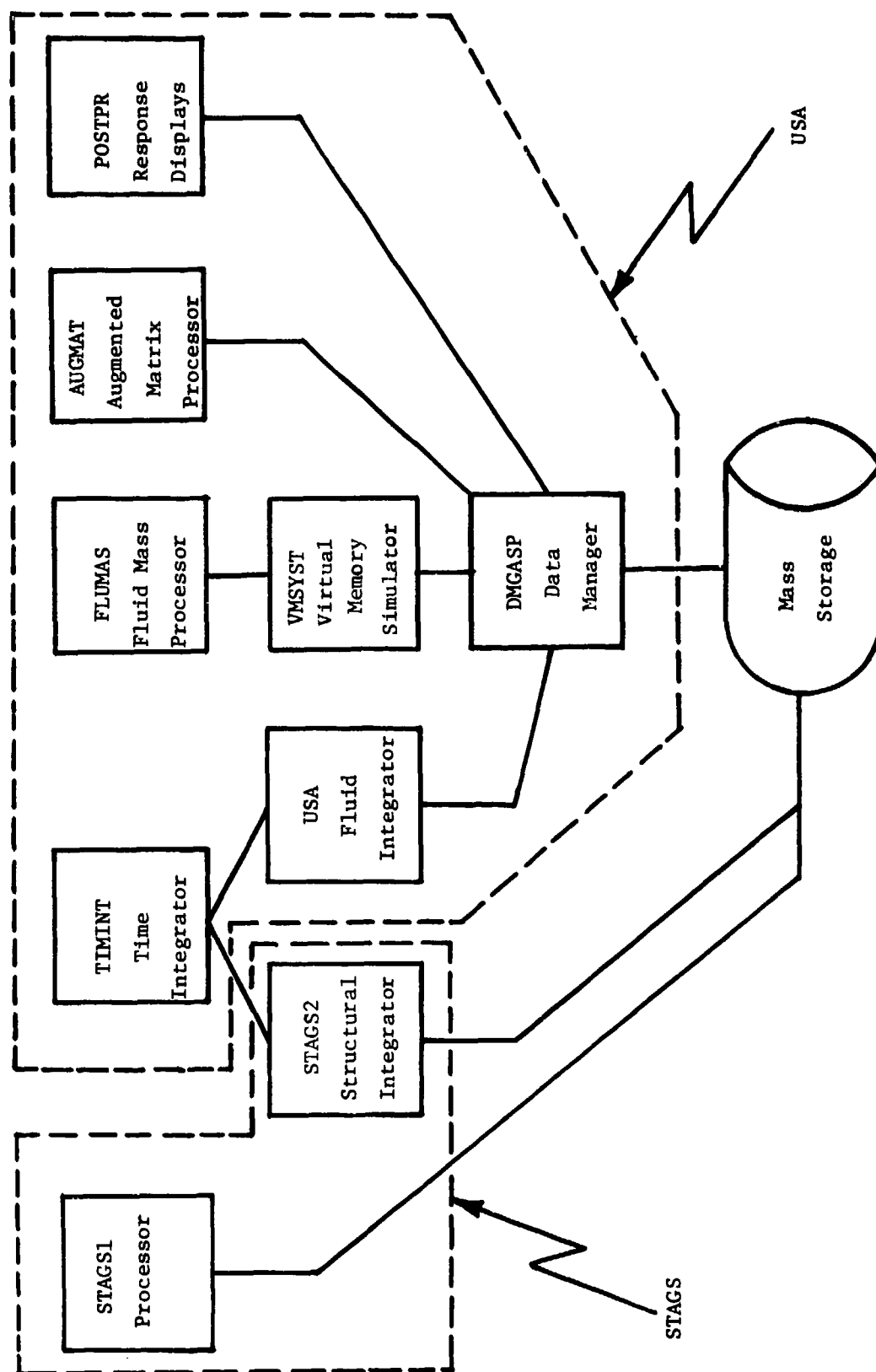


Figure 3-1 Organization of the USA-STAGS Code

with normal displacements that are positive into the fluid. The STAGS1 processor then outputs two additional files, TAPE18 and TAPE19. TAPE18 contains a list of global coordinates of the structural nodes. TAPE19 contains diagonal mass components for each structural degree of freedom and also a vector which identifies the degree of freedom numbers with displacement components at the nodes. Both files are sequential and may be saved on tapes (by system copy utility routines) or as permanent disc files; however, for immediate access by USA processors, disc files are preferable. These data are retrieved by the fluid processors FLUMAS and AUGMAT whose functions are described below. The STAGS1 preprocessor also prepares a sequential "model definition file" on TAPE21. This file may be used as input with the STAGS plot program (STAPL) to obtain plots of the structural model.

3.2 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 [16]. 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 $M_f \underline{u} = \lambda A_f \underline{u}$ [16].

Typical input data for this processor includes

- o Mesh geometry
 - Fluid wet-surface mesh
 - Structure wet-surface mesh
- o Element definitions
 - General curved surface
 - Surface of revolution
- o Material property
 - Mass density
 - Speed of sound
 - DAA₂ parameter
- o 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 C.

3.3 THE AUGMENTED MATRIX PREPROCESSOR AUGMAT

This processor uses data from both STAGS1 and FLUMAS 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 condensation of the output from both STAGS1 and FLUMAS. 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-STAGS, AUGMAT does not form the fluid matrices D_{f1} and D_{f2} but rather puts them in the skyline format required by SKYPUL [21,22]. D_{f1} and D_{f2} are now formed only in FLUMAS. Input to this code involves the following information

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

3.4 THE TIME INTEGRATION PROCESSOR TIMINT

This main processor constitutes an implementation of the unconditionally stable staggered solution technique developed in [4] 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 Sec. 3.5).

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 vector 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, 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 [4]. The 3-step implicit Park [23] integration method is used for the fluid solution, while the integration algorithms embedded in STAGS have been described earlier.

Typical input to this processor includes

- o Incident wave characteristics
 - Location of source
 - Location of standoff
 - Pressure profile
 - Linear interpolation
 - Cubic spline fit
 - Exponentially decaying wave

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

Detailed user information concerning TIMINT is given in Appendix E.

3.5 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 F.

3.6 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 [24]. Constituting the lowest level of the NOSTRA Data Management System [25], 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

- o Activate storage device
- o Position device
- o Read data block from device
- o Write data block on device
- o 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.

The UNIVAC version of DMGASP has been operational since 1974 and embodies a wide spectrum of extensively tested functions, including magnetic tape handling. On the other hand, the CDC SCOPE version has been operational since mid-1977 and has been tested only on a subset of functions dealing with mass storage I/O. The CDC NOS is a variant of the CDC SCOPE version and has been used since late 1977.

Finally, a FORTRAN 77 version of DMGASP was produced in 1980 for the VAX 11/780.

3. THE VIRTUAL MEMORY SIMULATOR VMSYST

VMSYST is a virtual storage simulator for computers that are not built around a virtual memory system [26]. 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 or 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-STAGS, VMSYST is used for the out-of-core generation of the fluid mass matrix described in Section 3.2.

3.8 THE SKYPUL PROCESSOR

SKYPUL (SKYmatrix Processing Utility Library) is a system of computer codes designed to process large-order sparse symmetric matrices stored in the so-called skyline, profile, envelope or variable-band arrangement [22]. Although the fluid equation system produced by the family of doubly asymptotic approximations is full, SKYPUL can process this system in a multi-block out-of-core mode so that there is no essential restriction on the number of fluid degrees of freedom that can be used.

The main virtues of SKYPUL are the generality of the representation and the simplicity of storage resource management. The latter advantage is reflected in the clean implementation of the basic skymatrix processing operations such as factorization and equation solving. The resulting codes are relatively easier to understand and maintain than those based on more sophisticated sparse matrix storage schemes.

A distinguishing feature of SKYPUL is that all of the constituent programs comply with the organizational, internal documentation, and array self-description standards set forth in the General Description Manual of the Engineering Analysis System (EASY) [21].

SECTION IV

EXAMPLE PROBLEMS

This section is eventually intended to contain a collection of sample problems for USA-STAGS that covers the general range of application to linear and non-linear analysis of structures with simple geometric shapes, i.e., cylinders and spheres. At this time only one sample problem is included, that of the infinite circular cylindrical shell excited by a transverse, plane, step wave. The case considered here is for linear elastic behavior only and, although this does not fully demonstrate the computational power of USA-STAGS, it does lend itself to direct comparison of the same problem treated by USA in its stand alone configuration [2].

4.1 SUBMERGED INFINITE CYLINDRICAL SHELL

For this problem, a 72-node, 36-element 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 appropriate input to STAGS1. 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 preprocessor FLUMAS that adds fictitious elements in the axial direction.

The transverse, plane step-wave is 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 cylinder are 1 and 0.01, respectively.

Computational results are shown in detail in Appendices B through F and it is noted that there is little discernable difference between the USA-STAGS and USA-SPAR analyses (See [2]).

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APPENDIX A

CONTROL CARDS FOR CDC FILE MANIPULATION AND PROGRAM EXECUTION

FILE DESCRIPTION		
NAME	FUNCTION	(PROGRAM)
FLUMAS	FLUID MASS PROCESSOR	(FLUMAS)
AUGMAT	AUGMENTED MATRIX PROCESSOR	(AUGMAT)
POSTPR	RESPONSE DISPLAY PROGRAM	(POSTPR)
STAGS1	STAGS PREPROCESSOR	(STAGS1)
STAGS2	STAGS EXECUTION PROGRAM	(STAGS2)
STAPL	STAGS FLCT PROCESSOR	(STAPL)
USAS	USA-STAGS PROGRAM	(USAS)
FLUSYM	FLUID MASS SOURCE	(FLUMAS)
AUGSYM	AUGMENTED MATRIX SOURCE	(AUGMAT)
POSTSYM	RESPONSE DISPLAY SOURCE	(POSTPR)
ICMSYM	DATA MANAGER SOURCE	(FLUMAS/AUGMAT/USAS/POSTPR)
ICMLIB	DATA MANAGER LIBRARY	(FLUMAS/AUGMAT/USAS/POSTPR)
VIRSYM	VIRTUAL MEMORY SOURCE	(FLUMAS)
VIRLIB	VIRTUAL MEMORY LIBRARY	(FLUMAS)
INTSYM	FLUID INTEGRATION SOURCE	(USAS)
INTLIB	FLUID INTEGRATION LIBRARY	(USAS)
SKUSYM	SKYLINE PROCESSOR SOURCE	(USAS)
SKULIB	SKYLINE PROCESSOR LIBRARY	(USAS)
MCDSYM	INTSYM MODIFICATION SOURCE	(USAS)
MCDLIB	INTLIB MODIFICATION LIBRARY	(USAS)
USASYM	USAS OVERLAY SOURCE	(USAS)
USAREL	USAS OVERLAY RELOCATABLE	(USAS)
SCV1	STAGS1 OVERLAY SOURCE	(STAGS1)
RCV1	STAGS1 OVERLAY RELOCATABLE	(STAGS1)
SCV2	STAGS2 OVERLAY SOURCE	(STAGS2)
RCV2	STAGS2 OVERLAY RELOCATABLE	(STAGS2)
SYM1	STAGS1 SOURCE	(STAGS1)
LIB1	STAGS1 LIBRARY	(STAGS1)
SYM2	STAGS2 SOURCE	(USAS/STAGS2)
LIB2	STAGS2 LIBRARY	(USAS/STAGS2)
SYMU	STAGS UTILITY SOURCE	(STAGS1/STAGS2/STAPL/USAS)
LIBU	STAGS UTILITY LIBRARY	(STAGS1/STAGS2/STAPL/USAS)
STAPL	STAPL SOURCE	(STAPL)
RELPL	STAPL RELOCATABLE	(STAPL)
USTSYM	USA-STAGS INTERFACE SOURCE	(USAS)
USTLIB	USA-STAGS INTERFACE LIBRARY	(USAS)

* * * * *

RELOCATABLE/LIBRARY FILE GENERATION

* * * * *
CONTROL CARD
* * * * *

UPDATE(P=IOMSYM,I=22,F)
FTN(L=C,I=CCMPLE,B=ICPKEL,S=CPCTEXT/PPTEXT)
LIBGEN(F=IOMREL,P=ICMLIB)

UPDATE(P=FLUSYM,I=ZZ,F)
FTN(L=0,I=COMPILE,B=FLUMAS)

UPDATE(P=VIRSYM,I=ZZ,F)
FTN(L=0,I=COMPILE,B=VIRREL)
LIBGEN(F=VIRREL,P=VIRLIB)

UPDATE(P=AUGSYM,I=ZZ,F)
FTN(L=0,I=COMPILE,B=AUGMAT)

UPDATE(P=INTSYM,I=ZZ,F)
FTN(I=COMPILE,L=0,B=INTREL)
LIBGEN(F=INTREL,P=INTLIB)

UPDATE(P=SKLSYM,I=ZZ,F)
FTN(I=COMPILE,L=0,B=SKUREL)
LIBGEN(F=SKUREL,P=SKULIB)

UPDATE(P=MODSYM,I=ZZ,F)
FTN(I=COMPILE,L=0,B=MODREL)
LIBGEN(F=MODREL,P=MODLIB)

UPDATE(P=POSSYM,I=ZZ,F)
FTN(L=0,I=COMPILE,B=POSTPR)

UPDATE(P=USASYM,I=ZZ,F)
FTN(L=0,I=COMPILE,B=USAREL,PL=400000)

UPDATE(P=SOV1,I=ZZ,F)
FTN(L=0,I=COMPILE,B=RCV1,PL=100000)

UPDATE(P=SOV2,I=ZZ,F)
FTN(L=0,I=COMPILE,B=RCV2,PL=400000)

UPDATE(P=SYM1,I=ZZ,F) NO INPUT RECORD FOR UPDATE
FTN(L=0,I=COMPILE,CPT=2,B=REL1)
LIBGEN(F=REL1,P=LIB1)

UPDATE(P=SYM2,I=ZZ,F)
FTN(L=0,I=COMPILE,CPT=2,B=REL2)
LIBGEN(F=REL2,P=LIB2)

UPDATE(P=SYMU,I=ZZ,F)
FTN(L=0,I=COMPILE,CPT=2,B=RELU,S=CPCTEXT)
LIBGEN(F=RELU,P=LIBU)

UPDATE(P=USTSYM,I=ZZ,F)
FTN(I=COMPILE,L=0,B=USTREL)
LIBGEN(F=USTREL,P=USTLIB)

ABSOLUTE PROGRAM GENERATION

CONTROL CARD

DEFINE,STAGS1.

LCSET(PRESET=ZERO,LIB=LIB1/LIB0)

LOAD(RCV1)

NOGC(STAGS1)

DEFINE,USAS.

LCSET(PRESET=ZERO,LIB=LIB1/LIB2/LIB0/POCLIB/INTLIB/ICPLIB/SKCLIB)

LOAD(USAREL)

NOGC(USAS)

DEFINE,STAGS2.

LCSET(PRESET=ZERO,LIB=LIB2/LIB0)

LOAD(RCV2)

NOGC(STAGS2)

* * * * *

STAGS1 EXECUTION

(PREPARATORY TO FLUID PASS AND
AUGMENTED MATRIX PREPROCESSING)

* * * * *

CONTROL CARD

* * * * *

ATTACH,STAGS1.

DEFINE(TAPE18=GLOCCR,ID=USER)

DEFINE(TAPE19=STRPAS,ID=USER)

DEFINE(TAPE21=PCD1. (OPTIONAL) DATA FOR STAPL PLOT OF MODEL

STAGS1. READ STAGS1 INPUT.

* * * * *

FLUMAS EXECUTION

LIBRARY(IOMLIB,VIRLIB)

FLUMAS. READ FLUMAS INPUT WITH GRNAM = USER+GLOCCR

* * * * *

AUGMAT EXECUTION

LIBRARY(IOMLIB)

AUGMAT. READ AUGMAT INPUT WITH STRNAM = USER+STRPAS

* * * * *

STAGS1-USAS EXECUTION (INITIAL RUN)

ATTACH,STAGS1,USAS.

DEFINE(TAPE22=RUN1.

SAVE DATA FOR RESTART OR STAPL PLCTS.

RFL(120000)

REDUCE(-)

STAGS1. READ STAGS1 INPUT.

RFL(200000)

REDUCE(-)

USAS. READ USAS INPLT

STAGS1-USAS EXECUTION (RESTART)

CONTROL CARD

RFL(120000)
REDUCE(-)
STAGS1,,X. READ STAGS1 INPUT, SUPPRESS STAGS1 OUTPUT.
ATTACH,RUN1.
DEFINE,TAPE22=RUN2.
COPYMF,RUN1,TAPE22.
RFL(200000)
REDUCE(-)
USAS. READ USAS INPUT.

POSTPR EXECUTION

LIBRARY(IOMLIB,INTLIB)
POSTPR. READ POSTPR INPUT.

STAGS1-STAGS2 EXECUTION

ATTACH,STAGS1,STAGS2.
RFL(120000) STAGS1 FIELD LENGTH SHOULD BE LESS THAN STAGS2 FIELD LENGTH
REDUCE(-)
STAGS1. READ STAGS1 INPUT.
RFL(160000)
REDUCE(-)
STAGS2. COMPLETE PROBLEM SOLUTION.

APPENDIX B
SAMPLE PROBLEM FOR STAGS1 PREPROCESSING

This appendix contains a sample input deck and subsequent output for the infinite cylindrical shell problem presented in Section 4. See STAGS user manual [3] for detailed instructions for deck setup.

STAGS-C1 JUN88 VAX 11/780

+++ OPEN. 10 = FOR010 , Acc= DIRECT , Stat= SCRATCH

CARD NUMBER INPUT DATA CARDS. PAGE 1
***** DATA *****

STAGS1 DATA FOR FULL CYLINDER

6 0 0 0 1 -1 \$ B-1

1 0 0 1 \$ B-2

1 0 1 \$ B-3

1.

0.

0 1000 0 2 \$ D-1

0. 1000. .05 .1

0 1

2 37 \$ F-1

1 4 1 2 \$ G-1 CLOSED SHELL CONDITION

1 0 \$ I-1

98.125 .3 0. 7.85 \$ I-2

1 1 1 \$ K-1

1 .01

5 4

0. .1750 0. 360. 1.

0. 0. 0.

0. 90. 0.

1 0 0. 0. 1 \$ M-5

410

4 6 4 3 \$ P-1 BOUNDARY CONDITIONS

0

0

STAGS-C1 / PHASE 1

CASE TITLE - STAGS1 DATA FOR FULL CYLINDER

COMPUTATIONAL STRATEGY

GRAV= 0.100000E+01
- - - TRANSIENT RESPONSE ANALYSIS - - -

COMBINED STRUCTURAL-FLUID ANALYSIS

LOAD FACTOR A 0.000000E+00 STARTING LOAD FACTOR STEP LOAD MAXIMUM LOAD
0.000000E+00 0.000000E+00 0.000000E+00

IXSTF IXFAC
0 0

ISTART ISEC ICUT INEWT ISTRAT
0 1000 0 2 0

ERROR TOLERANCE = 0.100000E-02 UNDERRELAXATION = 0.000000E+00

TIME INCREMENT ----- 5.00000E-02

START AND STOP TIMES ----- 0.00000E+00 1.00000E+03

MAX. EXPECTED DISPLACEMENT - 1.00000E-01

ALPHA 0.00000E+00

BETA ----- 0.00000E+00

STARTING TIME FOR AUTOMATIC TIME STEP INCREASE 0.000000E+00

IMPLICIT ORDINARY DIFFERENTIAL EQUATION SOLVER
TRAPEZOIDAL FORMULA

MODEL COMPOSITION

ITEM	QUANTITY
SHELL UNITS	1
ELEMENT UNITS	0
TOTAL UNITS	1

SHELL UNIT SUMMARY

UNIT	ROWS	COLS
1	2	37

NUMBER OF INTERSECTIONS INVOLVING SHELL UNIT BOUNDARIES (NINTS) = 1

NINTS = 1 MUNIT = 1 MBOUND = 4 NUNIT = 1 NBOUND = 2

BLANK COMMON BUFFER DIMENSION (NSPACE)

DECIMAL	HEX
16000	3E80

VIRTUAL MEMORY SPECIFICATIONS

NO. OF PAGES 7 PAGE SIZE 1279

FM DATA SPACE = 5696, BLOCK SIZE = 5003

RESOURCE DATA TABLES

TABLE	NO. OF ENTRIES
MATERIAL	1
BEAM SECTION	0
WALL CONSTRUCTION	1
USER PARAMETERS	2

MATERIAL PROPERTY TABLE

ITAM	E1	U12	G	RHO	A1	E2	A2
1	0.98125E+02	0.30000E+00	0.37740E+02	0.78500E+01	0.00000E+00	0.98125E+02	0.00000E+00
NO. OF TABULATED MATERIALS (NTAM) = 1							

SHELL WALL PROPERTY TABLE

ITAW = 1,	GENERAL LAYERED SHELL,	NLAY = 1,	NLIP = 0
ILAY	MATL	TL	ZETL
1	1	0.10000E-01	0.00000E+00
NO. OF TABULATED WALLS (NTAW) = 1			
		L50	0

UNIT 1 (SHELL) - DESCRIPTION

SURFACE GEOMETRY

CYLINDER.

X1 = 0.0000E+00
 X2 = 0.1750E+00
 Y1 = 0.0000E+00
 Y2 = 0.3600E+03
 PROP(5) = 0.1000E+01
 PROP(6) = 0.0000E+00
 PROP(7) = 0.0000E+00
 PROP(8) = 0.0000E+00

GLOBAL ORIENTATION

IGLOBE = 4 - GLOBAL ORIENTATION VIA TRANSLATION OF UNIT ORIGIN PLUS EULERIAN ANGLES

XG = 0.0000E+00, YG = 0.0000E+00, ZG = 0.0000E+00

ROTATION OF UNIT ABOUT

X-AXIS Y-AXIS Z-AXIS
 0.0000000E+00 0.9000000E+02 0.0000000E+00

WALL CONSTRUCTION

TABULATED ENTRY ORIENTATION
 1 0.0000E+00 0.0000E+00 DEG.

DISCRETIZATION

GRIDPOINTS

ROWS COLS
 2 37

X-SPACING
 UNIFORM

Y-SPACING
UNIFORM

SHELL ELEMENTS

QUAF - 410

BOUNDARY LINE	ROW	COL	COORDINATES SURFACE			COORDINATES GLOBAL CARTESIAN		
			X	Y	Z	XG	YG	ZG
1	1	1	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
1	1	2	0.0000	10.0000	0.0000	0.9848	0.1736	0.0000
1	1	3	0.0000	20.0000	0.0000	0.9397	0.3420	0.0000
1	1	4	0.0000	30.0000	0.0000	0.8660	0.5000	0.0000
1	1	5	0.0000	40.0000	0.0000	0.7660	0.6428	0.0000
1	1	6	0.0000	50.0000	0.0000	0.6428	0.7660	0.0000
1	1	7	0.0000	60.0000	0.0000	0.5000	0.8660	0.0000
1	1	8	0.0000	70.0000	0.0000	0.3420	0.9397	0.0000
1	1	9	0.0000	80.0000	0.0000	0.1736	0.9848	0.0000
1	1	10	0.0000	90.0000	0.0000	0.0000	1.0000	0.0000
1	1	11	0.0000	100.0000	0.0000	-0.1736	0.9848	0.0000
1	1	12	0.0000	110.0000	0.0000	-0.3420	0.9397	0.0000
1	1	13	0.0000	120.0000	0.0000	-0.5000	0.8660	0.0000
1	1	14	0.0000	130.0000	0.0000	-0.6428	0.7660	0.0000
1	1	15	0.0000	140.0000	0.0000	-0.7660	0.6428	0.0000
1	1	16	0.0000	150.0000	0.0000	-0.8660	0.5000	0.0000
1	1	17	0.0000	160.0000	0.0000	-0.9397	0.3420	0.0000
1	1	18	0.0000	170.0000	0.0000	-0.9848	0.1736	0.0000
1	1	19	0.0000	180.0000	0.0000	-1.0000	0.0000	0.0000
1	1	20	0.0000	190.0000	0.0000	-0.9848	-0.1736	0.0000
1	1	21	0.0000	200.0000	0.0000	-0.9397	-0.3420	0.0000
1	1	22	0.0000	210.0000	0.0000	-0.8660	-0.5000	0.0000
1	1	23	0.0000	220.0000	0.0000	-0.7660	-0.6428	0.0000
1	1	24	0.0000	230.0000	0.0000	-0.6428	-0.7660	0.0000
1	1	25	0.0000	240.0000	0.0000	-0.5000	-0.8660	0.0000
1	1	26	0.0000	250.0000	0.0000	-0.3420	-0.9397	0.0000
1	1	27	0.0000	260.0000	0.0000	-0.1736	-0.9848	0.0000
1	1	28	0.0000	270.0000	0.0000	0.0000	-1.0000	0.0000
1	1	29	0.0000	280.0000	0.0000	0.1736	-0.9848	0.0000
1	1	30	0.0000	290.0000	0.0000	0.3420	-0.9397	0.0000
1	1	31	0.0000	300.0000	0.0000	0.5000	-0.8660	0.0000
1	1	32	0.0000	310.0000	0.0000	0.6428	-0.7660	0.0000
1	1	33	0.0000	320.0000	0.0000	0.7660	-0.6428	0.0000
1	1	34	0.0000	330.0000	0.0000	0.8660	-0.5000	0.0000
1	1	35	0.0000	340.0000	0.0000	0.9397	-0.3420	0.0000
1	1	36	0.0000	350.0000	0.0000	0.9848	-0.1736	0.0000

1	1	37	0.0000	360.0000	1.0000	0.0000	0.0000
---	---	----	--------	----------	--------	--------	--------

BOUNDARY LINE	MESH ROW COL	SURFACE X	Y	GLOBAL CARTESIAN		ZG
				XG	YG	
2	1 37	0.0000	360.0000	1.0000	0.0000	0.0000
2	2 37	0.1750	360.0000	1.0000	0.0000	-0.1750

BOUNDARY LINE	MESH ROW COL	SURFACE X	Y	GLOBAL CARTESIAN		ZG
				XG	YG	
3	2 1	0.1750	0.0000	1.0000	0.0000	-0.1750
3	2 2	0.1750	10.0000	0.9848	0.1736	-0.1750
3	2 3	0.1750	20.0000	0.9397	0.3420	-0.1750
3	2 4	0.1750	30.0000	0.8660	0.5000	-0.1750
3	2 5	0.1750	40.0000	0.7660	0.6428	-0.1750
3	2 6	0.1750	50.0000	0.6428	0.7660	-0.1750
3	2 7	0.1750	60.0000	0.5000	0.8660	-0.1750
3	2 8	0.1750	70.0000	0.3420	0.9397	-0.1750
3	2 9	0.1750	80.0000	0.1736	0.9848	-0.1750
3	2 10	0.1750	90.0000	0.0000	1.0000	-0.1750
3	2 11	0.1750	100.0000	-0.1736	0.9848	-0.1750
3	2 12	0.1750	110.0000	-0.3420	0.9397	-0.1750
3	2 13	0.1750	120.0000	-0.5000	0.8660	-0.1750
3	2 14	0.1750	130.0000	-0.6428	0.7660	-0.1750
3	2 15	0.1750	140.0000	-0.7660	0.6428	-0.1750
3	2 16	0.1750	150.0000	-0.8660	0.5000	-0.1750
3	2 17	0.1750	160.0000	-0.9397	0.3420	-0.1750
3	2 18	0.1750	170.0000	-0.9848	0.1736	-0.1750
3	2 19	0.1750	180.0000	-1.0000	0.0000	-0.1750
3	2 20	0.1750	190.0000	-0.9848	-0.1736	-0.1750
3	2 21	0.1750	200.0000	-0.9397	-0.3420	-0.1750
3	2 22	0.1750	210.0000	-0.8660	-0.5000	-0.1750
3	2 23	0.1750	220.0000	-0.7660	-0.6428	-0.1750
3	2 24	0.1750	230.0000	-0.6428	-0.7660	-0.1750
3	2 25	0.1750	240.0000	-0.5000	-0.8660	-0.1750
3	2 26	0.1750	250.0000	-0.3420	-0.9397	-0.1750
3	2 27	0.1750	260.0000	-0.1736	-0.9848	-0.1750
3	2 28	0.1750	270.0000	0.0000	-1.0000	-0.1750
3	2 29	0.1750	280.0000	0.1736	-0.9848	-0.1750
3	2 30	0.1750	290.0000	0.3420	-0.9397	-0.1750
3	2 31	0.1750	300.0000	0.5000	-0.8660	-0.1750
3	2 32	0.1750	310.0000	0.6428	-0.7660	-0.1750
3	2 33	0.1750	320.0000	0.7660	-0.6428	-0.1750
3	2 34	0.1750	330.0000	0.8660	-0.5000	-0.1750
3	2 35	0.1750	340.0000	0.9397	-0.3420	-0.1750
3	2 36	0.1750	350.0000	0.9848	-0.1736	-0.1750
3	2 37	0.1750	360.0000	1.0000	0.0000	-0.1750

BOUNDARY LINE	MESH ROW COL	SURFACE X	Y	GLOBAL CARTESIAN XG	YG	ZG
4	1 1	0.0000	0.0000	1.0000	0.0000	0.0000
4	2 1	0.1750	0.0000	1.0000	0.0000	-0.1750

BOUNDARY CONDITIONS

BOUNDARY CONDITION AT LINE 1 IS SYMMETRIC
 BOUNDARY CONDITION AT LINE 2 IS JUNCTURE
 BOUNDARY CONDITION AT LINE 3 IS SYMMETRIC
 BOUNDARY CONDITION AT LINE 4 IS UNRESTRAINED

SHELL UNIT WALL PROPERTIES (UNIT 1)

T	X	Y	TYPE	NLAY	MLIP	ISL	ISS	ISD	ZE
E	0.3567E-01	0.2038E+01	GENERAL LAYERED	1	0	0	0	0	0.00000

LAYER	MATL	THICKNESS	ZETL	LSO
1	1	0.1000E-01	0.0000E+00	0

CONSTITUTIVE MATRIX, CIJ

(EX)	(NX)	(NY)	(NX)	(NY)	(MXY)
0.107830E+01	0.323489E+00	0.107830E+01	0.000000E+00	0.000000E+00	0.000000E+00
			0.000000E+00	0.000000E+00	0.000000E+00
			0.377404E+00	0.000000E+00	0.000000E+00
			0.898581E-05	0.269574E-05	0.000000E+00
				0.898581E-05	0.000000E+00
					0.314503E-05

UNIT 1 PRE-PROCESSING SUMMARY

ELEMENTS	GEOMETRIC RELS	CONSTITUTIVE RELS	WEIGHT INCREMENT	NEW GROSS WEIGHT
SHLL		LINEAR	ELASTIC	0.8621E-01

UNIT 1 LOAD SUMMARY

LOAD SYSTEMS	INITIAL CONDITIONS	ATTACHED MASSES	PRESTRESS
NSYS 0	NICS 0	NAMAS 0	NPRST 0

OUTPUT CONTROL PARAMETERS

DISPL	STRS	RESUL	STRAINS	STRESSES	PLAS	STR	REACTIONS
IPRD 0		IPRR 0	IPRE 0	IPRS 0		IPRP 0	IPRF 0

IPRSDP 0
IPRSTR 0

P-11

COMPUTATIONAL DOF ASSIGNMENTS

UNIT	ROW	COL	U	V	W	RU	RV	RW	MID1	MID2	MID3
1	1	1	0	1	2	3	0	0			
1	2	1	0	4	5	6	0	0			
1	1	2	0	7	8	9	0	0			
1	2	2	0	10	11	12	0	0			
1	1	3	0	13	14	15	0	0			
1	2	3	0	16	17	18	0	0			
1	1	4	0	19	20	21	0	0			
1	2	4	0	22	23	24	0	0			
1	1	5	0	25	26	27	0	0			
1	2	5	0	28	29	30	0	0			
1	1	6	0	31	32	33	0	0			
1	2	6	0	34	35	36	0	0			
1	1	7	0	37	38	39	0	0			
1	2	7	0	40	41	42	0	0			
1	1	8	0	43	44	45	0	0			
1	2	8	0	46	47	48	0	0			
1	1	9	0	49	50	51	0	0			
1	2	9	0	52	53	54	0	0			
1	1	10	0	55	56	57	0	0			
1	2	10	0	58	59	60	0	0			

1	2	36	0	214	215	216	0	0
1	1	37	0	1	2	3	0	0
1	2	37	0	4	5	6	0	0

PREPROCESSING SUMMARY

NO. OF UNITS	NO. OF D.O.F. (TOTAL)	NO. OF D.O.F. (ACTIVE)
1	518	216

U S A - S T A G S PRE-PROCESSING . . .

+++ OPEN, 3 = FOR003 , Acc= SEQUENT, Stat= NEW
 +++ Form = UNFORMATTED
 +++ OPEN, 4 = FOR004 , Acc= SEQUENT, Stat= NEW
 +++ Form = UNFORMATTED

STRUCTURAL NODE LIST, 72 NODES

NODE	XG	YG	ZG
1	0.100000E+01	0.000000E+00	-0.437114E-07
2	0.984808E+00	0.173648E+00	-0.430473E-07
3	0.939693E+00	0.342020E+00	-0.410753E-07
4	0.866025E+00	0.500000E+00	-0.378552E-07
5	0.766044E+00	0.642788E+00	-0.334849E-07
6	0.642788E+00	0.766044E+00	-0.280971E-07
7	0.500000E+00	0.866025E+00	-0.218557E-07
8	0.342020E+00	0.939693E+00	-0.149502E-07
9	0.173648E+00	0.984808E+00	-0.759041E-08
10	-0.437114E-07	0.100000E+01	0.191069E-14
11	-0.173648E+00	0.984808E+00	0.759040E-08
12	-0.342020E+00	0.939693E+00	0.149502E-07
13	-0.500000E+00	0.866025E+00	0.218557E-07
14	-0.642788E+00	0.766044E+00	0.280971E-07
15	-0.766044E+00	0.642788E+00	0.334849E-07
16	-0.866025E+00	0.500000E+00	0.378552E-07
17	-0.939693E+00	0.342020E+00	0.410753E-07
18	-0.984808E+00	0.173648E+00	0.430473E-07
19	-0.100000E+01	-0.874228E-07	0.437114E-07
20	-0.984808E+00	-0.173648E+00	0.430473E-07
21	-0.939693E+00	-0.342020E+00	0.410753E-07
22	-0.866025E+00	-0.500000E+00	0.378552E-07
23	-0.766044E+00	-0.642788E+00	0.334849E-07
24	-0.642788E+00	-0.766044E+00	0.280971E-07
25	-0.500000E+00	-0.866025E+00	0.218557E-07
26	-0.342020E+00	-0.939693E+00	0.149502E-07
27	-0.173648E+00	-0.984808E+00	0.759040E-08
28	0.119249E-07	-0.100000E+01	-0.521253E-15
29	0.173648E+00	-0.984808E+00	-0.759040E-08
30	0.342020E+00	-0.939693E+00	-0.149502E-07
31	0.500000E+00	-0.866025E+00	-0.218557E-07

32	0.64270E+00	-0.766044E+00	-0.280971E-07
33	0.766044E+00	-0.642788E+00	-0.334849E-07
34	0.866025E+00	-0.500000E+00	-0.378552E-07
35	0.939693E+00	-0.342020E+00	-0.410753E-07
36	0.984808E+00	-0.173648E+00	-0.430473E-07
37	0.100000E+01	0.000000E+00	-0.175000E+00
38	0.984808E+00	0.173648E+00	-0.175000E+00
39	0.939693E+00	0.342020E+00	-0.175000E+00
40	0.866025E+00	0.500000E+00	-0.175000E+00
41	0.766044E+00	0.642788E+00	-0.175000E+00
42	0.642788E+00	0.766044E+00	-0.175000E+00
43	0.500000E+00	0.866025E+00	-0.175000E+00
44	0.342020E+00	0.939693E+00	-0.175000E+00
45	0.173648E+00	0.984808E+00	-0.175000E+00
46	-0.513609E-07	0.100000E+01	-0.175000E+00
47	-0.173648E+00	0.984808E+00	-0.175000E+00
48	-0.342020E+00	0.939693E+00	-0.175000E+00
49	-0.500000E+00	0.866025E+00	-0.175000E+00
50	-0.642788E+00	0.766044E+00	-0.175000E+00
51	-0.766044E+00	0.642788E+00	-0.175000E+00
52	-0.866025E+00	0.500000E+00	-0.175000E+00
53	-0.939693E+00	0.342020E+00	-0.175000E+00
54	-0.984808E+00	0.173648E+00	-0.175000E+00
55	-0.100000E+01	-0.874228E-07	-0.175000E+00
56	-0.984808E+00	-0.173648E+00	-0.175000E+00
57	-0.939693E+00	-0.342020E+00	-0.175000E+00
58	-0.866025E+00	-0.500000E+00	-0.175000E+00
59	-0.766044E+00	-0.642788E+00	-0.175000E+00
60	-0.642788E+00	-0.766044E+00	-0.175000E+00
61	-0.500000E+00	-0.866025E+00	-0.175000E+00
62	-0.342020E+00	-0.939693E+00	-0.175000E+00
63	-0.173648E+00	-0.984808E+00	-0.175000E+00
64	0.427539E-08	-0.100000E+01	-0.175000E+00
65	0.173648E+00	-0.984808E+00	-0.175000E+00
66	0.342020E+00	-0.939693E+00	-0.175000E+00
67	0.500000E+00	-0.866025E+00	-0.175000E+00
68	0.642788E+00	-0.766044E+00	-0.175000E+00
69	0.766044E+00	-0.642788E+00	-0.175000E+00
70	0.866025E+00	-0.500000E+00	-0.175000E+00
71	0.939693E+00	-0.342020E+00	-0.175000E+00
72	0.984808E+00	-0.173648E+00	-0.175000E+00

NDOF = 432 DIAGONAL MASS MATRIX (GLOBAL)

0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578407E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06
0.119730E-02	0.119730E-02	0.119730E-02	0.582905E-06	0.578406E-06	0.285337E-06

575	576	581	582	583	584	585	586	591	592
593	594	595	596	601	602	603	604	605	606
611	612	613	614	615	616	621	622	623	624
625	626	631	632	633	634	635	636	641	642
643	644	645	646	651	652	653	654	655	656
661	662	663	664	665	666	671	672	673	674
675	676	681	682	683	684	685	686	691	692
693	694	695	696	701	702	703	704	705	706
711	712	713	714	715	716	721	722	723	724
725	726								

ELEMENT	TYPE	NODES	1	(COUNTERCLOCKWISE ORDER)
1	410	1	37	38 2
2	410	2	38	39 3
3	410	3	39	40 4
4	410	4	40	41 5
5	410	5	41	42 6
6	410	6	42	43 7
7	410	7	43	44 8
8	410	8	44	45 9
9	410	9	45	46 10
10	410	10	46	47 11
11	410	11	47	48 12
12	410	12	48	49 13
13	410	13	49	50 14
14	410	14	50	51 15
15	410	15	51	52 16
16	410	16	52	53 17
17	410	17	53	54 18
18	410	18	54	55 19
19	410	19	55	56 20
20	410	20	56	57 21
21	410	21	57	58 22
22	410	22	58	59 23
23	410	23	59	60 24
24	410	24	60	61 25
25	410	25	61	62 26
26	410	26	62	63 27
27	410	27	63	64 28
28	410	28	64	65 29
29	410	29	65	66 30
30	410	30	66	67 31
31	410	31	67	68 32
32	410	32	68	69 33
33	410	33	69	70 34
34	410	34	70	71 35

35	410	35	71	72	36
36	410	36	72	37	1

NODAL COORDINATES SAVED ON UNIT 3 -- USC
 MASS/DOF VECTORS SAVED ON UNIT 4 -- USD

+++ CLOSE, 3
 +++ CLOSE, 4

FLOATING POINT OPERATION COUNT	
NEQ	NFLOPS NONZEROS
216	26748 3240

AVERAGE SEMI-BANDWIDTH = 15

ESTIMATED FACTORIZATION TIME 0.040223 SECONDS.

STAGE1 MASS STORAGE STATISTICS

FILE NAME	FILE LENGTH	FILE FUNCTION
1	2436	CONFIGURATION
2	585	DOF ASSIGNMENT
3	713	LOADS
4	585	MASSSES
5	32	RESOURCES
FMDATA	20012	VARIATION DATA
FMDATA	1944	GLOBAL VECTORS

CALCULATION OF ELEMENT INTERPOLATION AND CONSTITUTIVE MATRICES COMPLETE.

+++++
 + AUXILIARY STORAGE TABLE +
 +
 + ALDI Ext-filnam Unit EC Opt PRU Cdlloc Next Limit Read Written +
 + 8 FOR010 10 1 T 64 333 478 100000 50226 56448 +
 +
 + 1 Active devices (0 full) +
 + 0 To ops, 22 Writes, 19 Reads 106674 Words XFD +
 +
 +++++

+++ CLOSE, 10

\$\$ ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
5.171094E+01	41	106674	30528

APPENDIX C
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.

F L U M A S

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

THIS PROGRAM WAS DEVELOPED AND CODED BY JOHN A. DERUNITZ, 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,
3251 HANOVER ST., PALO ALTO, CALIF.. 94304 OR CALL 415-493-4411
EXTS. 45069 OR 45133. SEPTEMBER, 1980

MAXIMUM VALUES

MAXIMUM NUMBER OF STRUCTURAL GRID POINTS	1 0 0 0
MAXIMUM NUMBER OF GENERAL SURFACE ELEMENTS	4 0 0
MAXIMUM NUMBER OF SURFACE OF REVOLUTION SEGMENTS	2 0 0
MAXIMUM NUMBER OF SURFACE OF REVOLUTION BRANCHES	6

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. 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
-----	----	-----

NSTRC	I	NUMBER OF STRUCTURAL NODE OR GRID POINTS
-------	---	--

WHOSE GLOBAL COORDINATES ARE TO BE READ AS
 INPUT DATA FROM CARDS. AT THE VERY LEAST
 THE SUM OF NSTRC AND NSTRF (SEE BELOW)
 MUST INCLUDE ALL THE WET NODES, I.E., THOSE
 LYING ON THE FLUID-STRUCTURE CONTACT
 BOUNDARY. IF THE ULTIMATE PURPOSE OF THIS
 RUN IS TO CONDUCT AN UNDERWATER SHOCK
 ANALYSIS WITH THE USA CODE FOR THE
 STRUCTURE IN QUESTION THEN IT IS ADVISABLE
 TO INCLUDE IN THE INPUT TO THIS PROCESSOR
 ALL OF THE INTERNAL OR DRY STRUCTURAL NODE
 POINTS AS WELL IN ORDER TO FACILITATE POST
 PROCESSING OF THE TRANSIENT RESPONSE
 ANALYSIS FOR THE DRY STRUCTURE. THIS
 NUMBER MAY ALSO INCLUDE ADDITIONAL NODE
 POINTS THAT ARE NOT PART OF THE STRUCTURAL
 MODEL BUT WHICH ARE NECESSARY TO DEFINE
 THE FLUID MESH. HOWEVER SUCH ADDITIONAL
 NODES SHOULD APPEAR LAST AS THEY ARE NOT
 REQUIRED BY ANY OTHER USA PROCESSOR AND
 ARE THEREFORE ULTIMATELY DELETED

NUMBER OF STRUCTURAL NODE OR GRID POINTS
 WHOSE GLOBAL COORDINATES ARE TO BE READ
 FROM A PERMANENT FILE (SEE GRDNAM).
 ADDITIONAL NODE POINTS THAT ARE NOT PART
 OF THE STRUCTURAL MODEL ARE NOT PERMITTED
 IN THIS DATA SET IF ACTUAL STRUCTURAL NODE
 POINT DATA IS ALSO INPUT FROM CARDS. THIS
 IS DUE TO THE FACT THAT THE FILE DATA IS
 READ FIRST THEN THE DATA FROM CARDS AND
 AN ADDITIONAL NON-STRUCTURAL NODE POINTS
 MUST APPEAR LAST IN THE GRID POINT LIST.
 THIS FILE MUST ALWAYS BE REFERENCED WHEN
 INTERFACING WITH STAGS

NUMBER OF GENERAL FLUID DEGREES OF FREEDOM
 WHOSE ASSOCIATED ELEMENTS CANNOT BE FORMED
 BY AN AUTOMATIC MESH GENERATION PROCEDURE

NUMBER OF DISTINCT SURFACE OF REVOLUTION
 AXES OR BRANCHES

NUMBER OF GENERAL FLUID CONTROL POINTS
 WHICH LIE ON A RIGHT CIRCULAR CYLINDRICAL
 SURFACE WHOSE ASSOCIATED RECTANGULAR
 ELEMENTS COVER THE ENTIRE LATERAL SURFACE.
 SUCH ELEMENTS CAN BE FORMED BY AN
 AUTOMATIC MESH GENERATION SCHEME WHICH IS
 EMBEDDED IN THE CODE. STRUCTURAL GRID
 POINT COORDINATES NEED NOT BE INPUT IN
 THIS CASE UNLESS DICTATED BY OTHER
 CIRCUMSTANCES

STARTING CIRCUMFERENTIAL HARMONIC FOR
 SURFACE OF REVOLUTION ELEMENTS

FINAL CIRCUMFERENTIAL HARMONIC FOR

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NSTRF I

NGEN I

NBRA I

NCYL I

NHAS I

NHAF I

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NHAI	I				
SURFACE OF REVOLUTION ELEMENTS					
INCREMENT TO BE APPLIED IN ASSIGNING CIRCUMFERENTIAL HARMONICS IN THE RANGE FROM NHAS TO NHAF					
NFUN	I				
NUMBER OF TRIGONOMETRIC FUNCTIONS THAT WILL BE USED IN ASSIGNING SURFACE OF REVOLUTION FLUID DEGREES OF FREEDOM. PERMISSIBLE VALUES ARE:					
1 - EITHER SINE OR COSINE WILL BE USED ACCORDING TO VALUE OF ITRG DESCRIBED BELOW					
2 - BOTH SINE AND COSINE FUNCTIONS WILL BE USED					
ITRG	I				
IF NFUN = 1 ITRG DESIGNATES THE PARTICULAR TRIGONOMETRIC FUNCTION TO BE USED FOR SURFACE OF REVOLUTION FLUID DEGREES OF FREEDOM. ALLOWABLE VALUES ARE:					
1 - COSINE FUNCTION IS USED					
2 - SINE FUNCTION IS USED					
NSEG	I				
NUMBER OF SURFACE OF REVOLUTION SEGMENTS ALONG ANY PARTICULAR AXIS OR BRANCH					
NCIR	I				
NUMBER OF SUB-ELEMENTS AROUND THE CIRCUMFERENCE OF A SURFACE OF REVOLUTION BRANCH. UNDER NORMAL CONDITIONS USE A VALUE OF ZERO AND THE CODE WILL CHOOSE AN APPROPRIATE VALUE BASED UPON THE ASPECT RATIO OF THE SUB-ELEMENT. A MINIMUM OF TWELVE (12) IS ALLOWED AND NCIR IS ALWAYS A MULTIPLE OF FOUR (4). USE A NON-ZERO VALUE ONLY UNDER SPECIAL CIRCUMSTANCES AND ADHERE TO THESE GUIDELINES					
RHO	E,F				
FLUID MASS DENSITY					
CEE	E,F				
FLUID SPEED OF SOUND					
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 CURVATURE MATRIX FOR THE FLUID ELEMENTS. IF DAA2 RUNS ARE CONTEMPLATED AS WELL AS					

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
239			
240		L	TRUE IF FLUID MESH GEOMETRY DATA IS TO BE
241			LISTED. OTHERWISE FALSE
242			
243		L	TRUE IF FLUID-STRUCTURE TRANSFORMATION
244			DATA IS TO BE LISTED. OTHERWISE FALSE
245			
246		L	TRUE IF FLUID MASS MATRIX IS TO BE LISTED.
247			OTHERWISE FALSE IN WHICH CASE ONLY THE
248			DIAGONAL TERMS ARE PRINTED. THIS PARAMETER
249			ALSO GOVERNS THE PRINTING OF THE MATRIX
250			THAT APPEARS IN THE DAA EQUATIONS
251			
252		L	TRUE IF THE FLUID MASS MATRIX IS TO BE
253			COMPUTED. OTHERWISE FALSE AND THE RUN WILL
254			TERMINATE AFTER THE FLUID MESH GEOMETRY
255			DATA HAS BEEN PROCESSED. USE A VALUE OF
256			TRUE ONLY AFTER DEBUGGING OF THE GEOMETRY
257			DATA HAS BEEN COMPLETED
258			
259		L	TRUE IF THE B AND C MATRICES ARE TO BE
260			PRINTED FOR SOME DIAGNOSTIC REASON.
261			OTHERWISE FALSE UNDER NORMAL OPERATING
262			CONDITIONS. THESE MATRICES ARE FULL AND
263			GENERALLY NONSYMMETRIC. THE PRODUCT B*CNV
264			IS THE PRINCIPAL COMPUTATION THAT IS
265			REQUIRED TO FORM THE FLUID MASS MATRIX
266			(SEE DERUNTZ AND GEERS, ADDED MASS
267			COMPUTATION BY THE BOUNDARY INTEGRAL
268			METHOD. INT J NUM METH. VOL 12. 1978. PP
269			531-550)
270			
271		L	TRUE IF EIGENVALUES AND EIGENVECTORS OF
272			THE FLUID BOUNDARY MODE PROBLEM ARE
273			DESIRED. OTHERWISE FALSE. THE PRESENCE OF
274			NEGATIVE EIGENVALUES IS AN INDICATION THAT
275			THE FLUID MESH IS IN ERROR. HENCE THIS CAN
276			BE AN IMPORTANT DEBUGGING TOOL
277			
278		L	TRUE IF A TWO DIMENSIONAL PLANE STRAIN
279			FLUID MASS MATRIX IS REQUIRED. OTHERWISE
280			FALSE. THE Z DIRECTION MUST BE
281			PERPENDICULAR TO THE PLANE OF THE FLUID
282			MODEL. IF THIS IS NOT SO A TEMPORARY OR
283			PERMANENT COORDINATE ROTATION CAN BE
284			APPLIED FOR COMPUTATION OF THE MATRIX (SEE
285			ROTQUA OR ROTGEO)
286			
287		L	TRUE IF THE FLUID MESH INPUT GEOMETRY
288			CORRESPONDS TO A HALF MODEL. OTHERWISE
289			FALSE. THE VARIABLES DEPTH, CXFS, CYFS,
290			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 XZ AND YZ 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
318			
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	FRWTFI	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 CONTAINING STRUCTURAL GRID POINT COORDINATES HAS BEEN CREATED BY BUFFERED, UNFORMATTED FORTRAN WRITE STATEMENTS. OTHERWISE FALSE IN WHICH CASE IT IS ASSUMED THAT DMGASP 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, CXFS, 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 BUT, 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
ROTGEO	L	TRUE IF THE FLUID MESH GEOMETRY IS TO BE REFERRED TO A SET OF GLOBAL COORDINATE AXES WHICH IS DIFFERENT FROM THAT OF THE BASIC INPUT DATA FOR ALL SUBSEQUENT USA PROCESSING (SEE GEOANG). OTHERWISE FALSE
ROTOUA	L	TRUE IF THE FLUID MESH GEOMETRY IS TO BE REFERRED 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 QUAANG). 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 TWODIM)
410			
411	FLUNAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH
412			WILL CONTAIN THE FLUID MASS MATRIX
413			
414	GEONAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH
415			WILL CONTAIN THE FLUID MESH GEOMETRY AND
416			FLUID-STRUCTURE TRANSFORMATION DATA
417			
418	GRDNAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH
419			CONTAINS THE GLOBAL COORDINATES OF THE
420			STRUCTURAL GRID POINTS
421			
422	DAANAM	A	NAME OF PERMANENT MASS STORAGE FILE WHICH
423			WILL CONTAIN THE MANIPULATED DAA FORM OF
424			THE FLUID MASS MATRIX
425			
426	NVEC	I	NUMBER OF FLUID BOUNDARY MODE EIGENVECTORS
427			DESIRED. THESE ARE ORDERED STARTING WITH
428			THE LOWEST ORDER MODES FIRST. IF ALL THE
429			Modes ARE DESIRED THE USER CAN JUST SET
430			NVEC TO 1000 AND THE CODE WILL
431			AUTOMATICALLY REDUCE THIS NUMBER TO THE
432			ORDER OF THE FLUID MASS MATRIX. THIS IS
433			CONVENIENT WHEN THE MODEL CONTAINS SOR
434			ELEMENTS FOR SEVERAL HARMONICS AND/OR
435			BRANCHES AND THE USER DOES NOT WANT TO
436			SPEED TIME COUNTING UP THE TOTAL. THIS IS
437			RECOMMENDED ONLY FOR SMALL OR INTERMEDIATE
438			SIZE PROBLEMS. FOR LARGE PROBLEMS PRINTING
439			OF ONLY THE FIRST 10 EIGENVECTORS IS
440			RECOMMENDED. AS IT IS ONLY THE FIRST FEW
441			ARE GENERALLY USEFUL TO VERIFY SYMMETRIES
442			OR OTHER FEATURES OF THE MODEL. THE FIRST
443			ONE IS ALWAYS A BREATHING TYPE MODE UNLESS
444			THE FLUID MODEL CONSISTS SOLELY OF BEAM
445			TYPE SOR ELEMENTS
446			
447	NUMZ	I	NUMBER OF FICTITIOUS ELEMENTS TO BE ADDED
448			IN AXIAL DIRECTION WHICH INCREASE THE
449			HALF LENGTH OF THE SURFACE FOR THE
450			SIMULATION OF A TWO DIMENSIONAL PLANE
451			STRAIN FLUID MASS MATRIX. THESE ELEMENTS
452			DO NOT INTRODUCE NEW DEGREES OF FREEDOM
453			
454	ZLEN	E,F	LENGTH OF FICTITIOUS AXIAL ELEMENTS USED
455			IN THE SIMULATION OF A TWO DIMENSIONAL
456			PLANE STRAIN FLUID MASS MATRIX
457			
458	CO	E,F	USED FOR FLUID MESH MODELS WITH PLANES OF
459			SYMMETRY. CO TAKES ON THE VALUE OF EITHER
460			PLUS OR MINUS ONE TO DENOTE SYMMETRIC OR
461			ANTISYMMETRIC FLOW CONDITIONS IN EACH
462			FLUID REGION INCLUDING THOSE THAT ARE NOT
463			EXPLICITLY CONTAINED IN THE MODEL. FOR A
464			QUARTER MODEL 4 VALUES ARE REQUIRED. ONE

465			FOR EACH QUADRANT. ONLY 2 VALUES ARE
466			NECESSARY FOR A HALF MODEL
467			
468			MAGNITUDE OF PERPENDICULAR DISTANCE FROM
469			THE ORIGIN OF COORDINATES TO THE PLANE OF
470			A FREE SURFACE OR THE PLANE OF SYMMETRY
471			FOR A HALF MODEL
472			
473			DIRECTION COSINES OF A UNIT VECTOR NORMAL
474			TO THE PLANE OF A FREE SURFACE OR THE
475			PLANE OF SYMMETRY FOR A HALF MODEL AND
476			POINTING OUT OF THE FLUID REGION
477			EXPLICITLY CONTAINED IN THE MODEL. THEY
478			MUST BE RELATIVE TO THE GLOBAL CARTESIAN
479			COORDINATES OF THE FLUID MESH. IF ANY
480			COORDINATE ROTATIONS ARE APPLIED TO THE
481			FLUID MESH GEOMETRY (SLE ROTGEO AND
482			ROTQUA) THESE QUANTITIES WILL ALSO BE
483			TRANSFORMED
484			
485			AMBIENT ATMOSPHERIC PRESSURE THAT IS USED
486			ULTIMATELY TO TEST FOR BULK CAVITATION IN
487			THE UNDERWATER SHOCK ANALYSIS
488			
489			ACCELERATION DUE TO GRAVITY
490			
491			EULERIAN ANGLES OF ROTATION USED TO
492			DESCRIBE A PERMANENT COORDINATE
493			TRANSFORMATION FOR THE FLUID MESH
494			GEOMETRY. THREE VALUES EXPRESSED IN
495			DEGREES ARE REQUIRED. THE FIRST IS THE
496			ROTATION ABOUT THE ORIGINAL X AXIS. THE
497			SECOND IS THE ROTATION ABOUT THE LINE
498			COINCIDENT WITH THE CURRENT ORIENTATION
499			OF THE ORIGINAL Y AXIS AFTER THE FIRST
500			ROTATION, AND FINALLY THE THIRD IS THE
501			ROTATION ABOUT THE LINE COINCIDENT WITH
502			THE CURRENT ORIENTATION OF THE ORIGINAL Z
503			AXIS AFTER THE FIRST TWO ROTATIONS.
504			ALTHOUGH THIS METHOD MAY BE SOMEWHAT
505			CUMBERSOME FOR ARBITRARY SPATIAL
506			ORIENTATIONS ALMOST ALL CASES OF PRACTICAL
507			INTEREST WILL DEAL ONLY WITH VALUES OF 0,
508			90, AND/OR 180 DEGREES
509			
510			EULERIAN ANGLES OF ROTATION USED TO
511			DESCRIBE A TEMPORARY COORDINATE
512			TRANSFORMATION FOR THE FLUID MESH
513			GEOMETRY (SEE GEORG ABOVE FOR PRECISE
514			DEFINITION). IF A QUARTER MODEL IS
515			REQUIRED AND THE MESH HAS BEEN GENERATED
516			AUTOMATICALLY FOR A CYLINDRICAL SURFACE
517			BOUNDED BY 0 AND 180 DEGREES THEN THE
518			APPROPRIATE ANGLES TO USE HERE WOULD BE
519			90, 90, AND 0
520			
521			A PARAMETER THAT IS ADDED TO THE VALUE OF
522			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 THEN 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

STRUCTURAL GRID POINT NUMBER

NSEQ I

INDICATOR TO DENOTE TYPE OF COORDINATE SYSTEM GRID POINT DATA IS REFERRED TO. ALLOWABLE VALUES ARE:

NS I

- 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

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 WET SURFACE OR IS NOT USED IN THE DEFINITION OF THE FLUID MESH THE COORDINATES THEMSELVES ARE NOT REQUIRED

XC,YC,ZC E,F

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

NEL 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

NC 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

NN I

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

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

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 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

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

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KURV I

KTRN I

NODE I

ITEM I

639 POINT. ANY INTERIOR POINTS MUST APPEAR
640 LAST. SEE FLUID ELEMENT LIBRARY

641

642 RAD1 E.F. RADIUS OF CURVATURE OF FLUID ELEMENT IN
643 DIRECTION FROM FIRST CORNER POINT TO
644 SECOND CORNER POINT

645

646 RAD2 E.F. RADIUS OF CURVATURE OF FLUID ELEMENT IN
647 DIRECTION PERPENDICULAR TO SIDE JOINING
648 FIRST CORNER POINT AND SECOND CORNER POINT

649

650 ECCEN E.F. PROVIDES A MEANS OF SHIFTING THE FLUID
651 CONTROL POINT OUT OF THE PLANE OF THE
652 STRUCTURAL NODE POINTS TO ALLOW FOR A
653 FINITE PLATE OR SHELL THICKNESS. GENERALLY
654 USED TO DEFINE SEPARATE FLUID ELEMENTS ON
655 OPPOSITE SIDES OF A SURFACE. A POSITIVE
656 VALUE INDICATES AN ECCENTRICITY IN THE
657 DIRECTION OF THE OUTWARD UNIT NORMAL
658 VECTOR. THIS OPTION MAY BE USED ONLY WITH
659 KURV EQUAL TO 2 AT THIS TIME. WHEN
660 DEFINING TWO FLUID ELEMENTS ON OPPOSITE
661 SIDES OF A SURFACE THE FIRST AND SECOND
662 NODE NUMBERS INPUT FOR ONE ELEMENT (SEE
663 NODE) SHOULD BE THE SECOND AND FIRST NODE
664 NUMBERS RESPECTIVELY FOR THE OTHER
665 ELEMENT. IN THIS WAY THE LOCAL COORDINATE
666 SYSTEM FOR EACH ELEMENT IS REFERRED TO THE
667 SAME BASELINE THUS PRESERVING A DESIRED
668 SYMMETRY IN THE CALCULATIONS

669

670 TRAN E.F. HAND DETERMINED COEFFICIENTS OF THE
671 FLUID-STRUCTURE TRANSFORMATION ARRAY THAT
672 MUST BE READ AS INPUT DATA. THE MOST
673 CONVENIENT WAY OF GENERATING THESE
674 COEFFICIENTS IS TO FIRST BREAK THE ELEMENT
675 INTO SUB-ELEMENTS SUCH AS TRIANGLES OR
676 RECTANGLES SUCH THAT EVERY STRUCTURAL NODE
677 IS A CORNER POINT FOR ONE OR MORE SUB-
678 ELEMENTS. THE WEIGHTING COEFFICIENTS FOR
679 TRIANGLES AND RECTANGLES ARE ONE-THIRD AND
680 ONE-FOURTH RESPECTIVELY AND REPRESENT THE
681 PERCENTAGE OF FLUID PRESSURE FORCE ON THE
682 SUB-ELEMENT THAT IS TRANSMITTED TO ANY
683 PARTICULAR CORNER POINT. THE FLUID-
684 STRUCTURE TRANSFORMATION COEFFICIENT FOR
685 ANY PARTICULAR STRUCTURAL NODE IS THEN
686 EXPRESSED AS A SUM OVER THE SUB-ELEMENTS
687 THAT COUPLE WITH THE NODE IN QUESTION. THE
688 CONTRIBUTION TO THIS SUM FROM EACH SUB-
689 ELEMENT IS JUST THE WEIGHTING COEFFICIENT
690 OF THE SUB-ELEMENT TIMES THE AREA OF THE
691 SUB-ELEMENT DIVIDED BY THE TOTAL AREA OF
692 THE ELEMENT. NOTE THAT THE SUM OF THE
693 FLUID-STRUCTURE TRANSFORMATION
694 COEFFICIENTS FOR ANY FLUID ELEMENT MUST
695 TOTAL UNITY. IF THE FLUID ELEMENT HAS A
696 NON-STRUCTURAL POINT AS A CORNER FOLLOW

697 THE ABOVE PROCESS ANYWAY AND THEN ADD THE
698 RESULTING COEFFICIENT FOR THE POINT IN
699 QUESTION TO THAT FOR ITS NEAREST
700 STRUCTURAL NODE. IF NECESSARY THE
701 CONTRIBUTION COULD EVEN BE DIVIDED BETWEEN
702 TWO OR MORE NODE POINTS. ONCE COMPUTED,
703 THE ORDER OF INPUT TO THE CODE MUST AGREE
704 WITH THE ORDER TAKEN FIRST BY THE CORNER
705 POINT NODE NUMBERS (SEE NODE) AND THEN BY
706 THE NEIGHBOR POINT NODE NUMBERS (SEE ITEM)
707 CONSECUTIVELY
708
709 NTCV I
710
711 NUMBER OF STRUCTURAL NODE POINTS THAT
712 COUPLE WITH A CURVED RECTANGULAR FLUID
713 ELEMENT WHICH IS TO BE AUTOMATICALLY
714 FORMED FOR AN AXIAL SEGMENT OF A RIGHT
715 CIRCULAR CYLINDRICAL SURFACE. AVAILABLE
716 OPTIONS ARE:
717
718 2 - STRUCTURAL NODES WILL BE ON MIDPOINT
719 OF CURVED SIDES
720 4 - STRUCTURAL NODES WILL BE AT CORNERS
721 6 - FLUID ELEMENT WILL OVERLAP TWO (2)
722 STRUCTURAL ELEMENTS. VARIABLE KFUN
723 BELOW ALSO REQUIRED IN THIS CASE
724 9 - FLUID ELEMENT WILL OVERLAP FOUR (4)
725 STRUCTURAL ELEMENTS, TWO IN THE
726 AXIAL DIRECTION AND TWO IN THE
727 CIRCUMFERENTIAL DIRECTION
728
729 KFUN I
730
731 DESCRIBES MANNER IN WHICH A SIX NODE
732 RECTANGULAR FLUID ELEMENT OVERLAYS TWO
733 RECTANGULAR STRUCTURAL ELEMENTS.
734 PERMISSIBLE VALUES ARE:
735
736 1 - CONFIGURATION CONSISTS OF TWO
737 STRUCTURAL ELEMENTS IN AXIAL
738 DIRECTION
739 2 - CONFIGURATION CONSISTS OF TWO
740 STRUCTURAL ELEMENTS IN
741 CIRCUMFERENTIAL DIRECTION
742
743 KROT I
744
745 IF KROT = 0 THE Z DIRECTION WILL BE TAKEN
746 AS THE AXIS FOR AUTOMATICALLY GENERATED
747 ELEMENTS OVER A CYLINDRICAL SURFACE. IF
748 KROT IS NOT EQUAL TO ZERO A ROTATION OF
749 AXES WILL BE PERFORMED (SEE CYLANG)
750
751 KARC I
752
753 A VALUE OF ZERO USED UNDER NORMAL
754 CONDITIONS INDICATES THAT THE AREA
755 ASSOCIATED WITH AUTOMATICALLY GENERATED
756 CYLINDRICAL SURFACE ELEMENTS IS TO BE
757 CALCULATED USING THE CHORD WHICH AGREES
758 WITH WHAT MOST STRUCTURAL FINITE ELEMENT
759 CODES ASSUME. A VALUE OTHER THAN ZERO WILL
760 SPECIFY THAT THE ARC LENGTH IS TO BE USED
761 INSTEAD. THE DIFFERENCE BETWEEN THESE TWO
762 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
760			
761		I	NUMBER OF CIRCUMFERENTIAL GENERAL ELEMENTS
762	NCRC		TO BE FORMED AUTOMATICALLY FOR AN AXIAL
763			SEGMENT OF A RIGHT CIRCULAR CYLINDRICAL
764			SURFACE
765			
766		I	NUMBER OF LAST FLUID ELEMENT IN SURFACE
767	NLAST		MESH WHICH PRECEEDS THE INPUT FOR THIS
768			AXIAL SEGMENT. NLAST CAN HAVE THE VALUE OF
769			ZERO IF REQUIRED
770			
771		I	NUMBER OF STRUCTURAL GRID OR NODE POINT AT
772	NSTART		BOTTOM LEFT HAND CORNER OF THE FIRST OF
773			THIS SET OF CIRCUMFERENTIAL GENERAL FLUID
774			ELEMENTS. IF NTCY = 2 THIS IS THE NODE AT
775			THE MIDPOINT OF THE LEFT HAND SIDE
776			
777		I	INCREMENT TO BE APPLIED TO NSTART IN
778	NMAX1		DESIGNATING THE NUMBER OF THE
779			CORRESPONDING STRUCTURAL NODE AT THE FIRST
780			ROW OF CIRCUMFERENTIAL STRUCTURAL NODES TO
781			THE RIGHT OF NSTART IN THE AXIAL DIRECTION
782			
783		I	INCREMENT TO BE APPLIED TO NSTART IN
784	NDCR		DESIGNATING THE NUMBER OF THE
785			CORRESPONDING STRUCTURAL NODE AT THE FIRST
786			ROW OF AXIAL STRUCTURAL NODES ABOVE NSTART
787			IN THE CIRCUMFERENTIAL DIRECTION. FOR THE
788			CASE NTCY = 6 WITH KFUN = 2, OR NTCY = 9
789			IT IS ASSUMED THAT NDCR IS THE SAME FOR
790			EACH CIRCUMFERENTIAL INCREMENT
791			
792		I	INCREMENT TO BE APPLIED TO NSTART + NMAX1
793	NMAX2		IN DESIGNATING THE NUMBER OF THE
794			CORRESPONDING STRUCTURAL NODE AT THE
795			SECOND ROW OF CIRCUMFERENTIAL STRUCTURAL
796			NODES TO THE RIGHT OF NSTART IN THE AXIAL
797			DIRECTION. THIS CASE IS CHARACTERIZED BY
798			NTCY = 6 WITH KFUN = 1, OR NTCY = 9.
799			OTHERWISE NMAX2 CAN BE SET TO ZERO
800			
801	RAU	E.F	RADIUS OF CIRCULAR CYLINDRICAL SURFACE
802			
803	AXL1	E.F	AXIAL COORDINATE OF THE FIRST ROW OF
804			STRUCTURAL NODES IN THE CIRCUMFERENTIAL
805			DIRECTION THAT COUPLE WITH A PARTICULAR
806			SET OF CYLINDRICAL SURFACE GENERAL
807			ELEMENTS. THIS ROW WILL FORM THE LEFT
808			AXIAL BOUNDARY OF THE SET OF FLUID
809			ELEMENTS
810			
811	AXL2	E.F	AXIAL COORDINATE OF THE SECOND ROW OF
812			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

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THETS E.F

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THETF E.F

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AXL3 E.F

CYLANG E.F

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 THETF
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

EULERIAN 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 DEFINES THE BEGINNING OF A SURFACE OF REVOLUTION BRANCH OR SEGMENT
872			
873	N2	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT DEFINES THE END OF A SURFACE OF REVOLUTION BRANCH OR SEGMENT
874			
875	R1	E,F	RADIUS TO WET SURFACE FROM AXIS OF SURFACE OF REVOLUTION ELEMENT AT STRUCTURAL GRID POINT DEFINING THE START OF A SUR BRANCH OR SEGMENT
876			
877	R2	E,F	RADIUS TO WET SURFACE FROM AXIS OF SURFACE OF REVOLUTION ELEMENT AT STRUCTURAL GRID POINT DEFINING THE END OF A SUR BRANCH OR SEGMENT
878			
879	NSET	I	NUMBER OF DATA CARDS REQUIRED TO DEFINE SURFACE OF REVOLUTION FLUID ELEMENTS ALONG THE LENGTH OF A PARTICULAR SUR BRANCH OR AXIS. IF NSET = 1 IT IS ASSUMED THAT THE PHYSICAL CONFIGURATION OF THE SUR BRANCH IS AS DESCRIBED BELOW UNDER ISEG
880			
881	N3	I	GRID POINT NUMBER OF STRUCTURAL NODE THAT DEFINES THE AXIS OF THE SURFACE OF REVOLUTION BRANCH IN CONJUNCTION WITH N1 IF N2 = N1. THIS CASE CORRESPONDS TO A DISC
882			
883	ISEG	I	NUMBER OF SURFACE OF REVOLUTION ELEMENTS THAT CAN BE DEFINED BETWEEN TWO AXIAL STATIONS SUCH THAT THE RADIUS OF THE SURFACE VARIES LINEARLY ALONG THE LENGTH AND THAT EVERY PAIR OF INTERMEDIATE ADJACENT STRUCTURAL NODE NUMBERS DIFFER BY A COMMON INCREMENTAL VALUE. THIS NEED NOT IMPLY EQUAL AXIAL SPACING OF THE SUR ELEMENTS AS THE STRUCTURAL NODES MAY NOT NECESSARILY BE EQUALLY SPACED ALONG THE AXIS
884			
885	NUMCHG	I	NUMBER OF STRUCTURAL GRID POINTS THAT MUST BE RENUMBERED IN THE FLUID-STRUCTURE TRANSFORMATION DATA
886			
887	NODOLD	I	STRUCTURAL GRID POINT NUMBER THAT IS TO BE CHANGED TO NODNEW IN THE FLUID-STRUCTURE TRANSFORMATION DATA
888			
889	NODNEW	I	NEW STRUCTURAL GRID POINT NUMBER ASSIGNED TO FLUID-STRUCTURE TRANSFORMATION DATA IN PLACE OF NODOLD. THIS GRID POINT MUST ALREADY BE PART OF THE STRUCTURAL NODE GLOBAL COORDINATE DATA INPUT FROM CARDS AND/OR PERMANENT FILE
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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, GENELW, 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 AMJNPT):

72 COLUMN ALPHANUMERIC TITLE
 NSTRC NSTRF NGEN NBRA NCYL

IF NBRA NOT = 0 INCLUDE THE FOLLOWING THREE CARDS

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

RHO	CEE	DAA2			
PRTGMT	PRTIRN	PRTAMF	CALCAM	PRTCOE	
EIGMAF	TWODIM	HAFMOD	QUAMOD		
PCHCDS	NASTAM	STOMAS	STOINV		
FRWIFL	FRWTGE	FRWTGR	FRESUR		
RENUMB	STOGMT	ROTGEO	ROTQUA		
FLUNAM		GEONAM		GRDNAM	DAANAM

IF EIGMAF = .TRUE. INCLUDE THE FOLLOWING CARD

NVEC

IF TWODIM = .TRUE. INCLUDE THE FOLLOWING TWO CARDS

NUMZ
 ZLEN

IF QUAMOD = .TRUE. INCLUDE THE FOLLOWING CARD

CO(I), I=1,4

IF HAFMOD = .TRUE. INCLUDE THE FOLLOWING TWO CARDS


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1045 CYLANG(1). I=1.3
1046 SURFACE-OF-REVOLUTION ELEMENT DEFINITION (SUBROUTINE SORINP):
1047 -----
1048
1049 IF NBRA NOT = 0 READ THE FOLLOWING CARDS FOR EACH SOR BRANCH
1050
1051 SOR  N1  N2  R1  R2  NSET
1052
1053 IF N1 = N2 READ THE FOLLOWING CARD
1054
1055 N3
1056
1057 IF NSET = 1 OMIT THE FOLLOWING CARD
1058
1059 N1  N2  R1  R2  ISEG  )
1060 .  .  .  .  .  )
1061 .  .  .  .  .  )
1062 .  .  .  .  .  )
1063 TOTAL = NSET
1064
1065 STRUCTURAL NODE RENUMBERING (SUBROUTINE AMGEOM):
1066 -----
1067
1068 IF RENUMB = .TRUE. READ THE FOLLOWING CARDS
1069
1070 NUMCHG
1071 NODOLD  NODNEW  )
1072 .  .  .  )
1073 .  .  .  )
1074 .  .  .  )
1075 .  .  .  )
1076 .  .  .  )
1077 .  .  .  )
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1101 .  .  .  )
1102 .  .  .  )

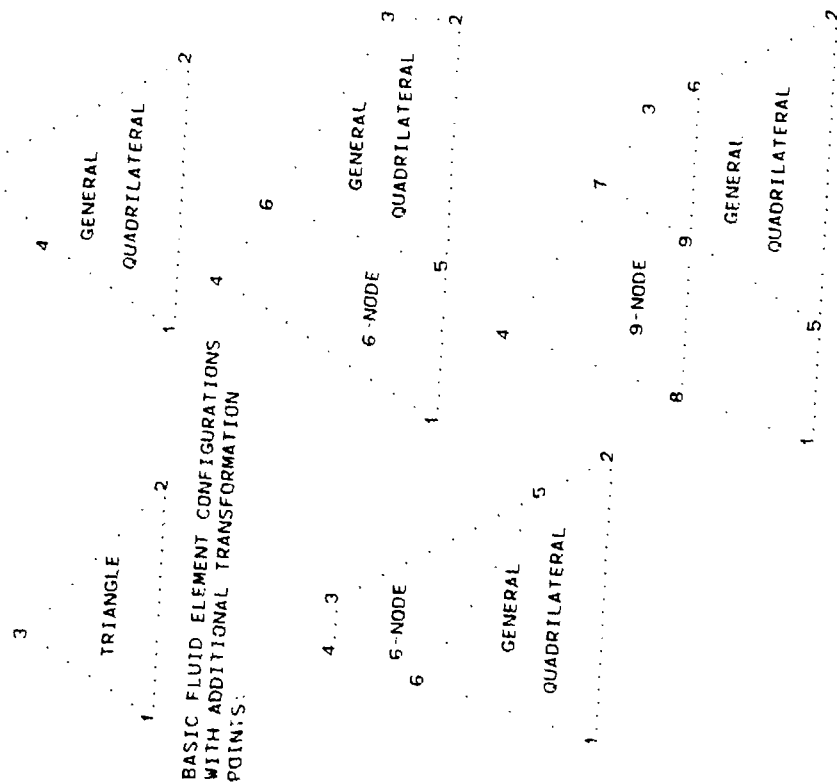
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FLUID ELEMENT LIBRARY

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 COMING 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:



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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
- IHAP - 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
- A00,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 [16])

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 [16]. 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 D_{f1} [see Eq. (2.6)], i.e., the occurrence of factorization errors for the elements in question.

The following input and output for the infinite circular cylindrical shell problem contain some minor differences due to the fact that the input is appropriate to the standard CDC or UNIVAC USA-STAGS version 3 whereas the output is from the VAX virtual memory machine. The basic reason for this is that the VAX version does not explicitly process the fluid equation system in a multi-block, out-of-core mode in contrast to the CDC and UNIVAC versions. In addition, permanent file naming conventions differ slightly; however it is anticipated that these differences should not prove to be a difficulty for the user.

** CYLFLUDAT **

FILE: USA*DATA

TIME: 23:03:45

DATE 12/580

PAGE

11

FLUMAS RUN FOR INFINITE CYLINDER SIMULATION

	0	72	0	0	36	
1	1.	1.	1.	1.	1.	
2	T	T	T	T	T	
3	T	T	T	T	T	
4	T	T	T	T	T	
5	F	F	F	F	F	
6	F	F	F	F	F	
7	F	F	F	F	F	
8	F	T	F	F	F	
9						CYL*GEOM
10	36					STG*CYLCOR
11	500					
12	175					
13	0					
14	CYL	2	0	0	0	
15		36	0	1	36	
16		1.	-.0875	.0875	-5.	355.

CYL*DAAM

FLUIDS RUN FOR INFINITE CYLINDER SIMULATION

MAXIMUM FLUID NODES = 156

SCRATCH ALLOCATION = 50000

FLUID MASS MATRIX BLOCK SUBDIVISION PARAMETERS:

ISUB ITP IBEG IROW IBRA IHAR IFUN

1 GEN 1 36

FLUID MASS DENSITY = 0.10000000E+01

FLUID SOUND SPEED = 0.10000000E+01

USER OPTIONS FOR THIS RUN:

PRTHMT T PRTRN T PRTHF T CALCAM T PRTCOE F

EICHAF T TUDIM T HAFHOD F QUAMOD F

PCWCHS F NASTAM F STORAS T STOINV T

FRUTFL F FRUTGE F FRUTGR T FRESUR F

REMURB F STOGHT T ROTGEO F ROTDUA F

*** OPEN. 1 - DIRTY:CYL.USC . Acc= SEQUENT, Stat= OLD
*** Form = UNFORMATTED

AUXILIARY STORAGE TABLE

LDI Ext-File Unit EC Opt PRU Cdlac Next Limit Read Writen +
1 DIRTY:CYL.US 1 1 AX 64 0 10000 100000 0 +
C +
+
+ 1 Active devices (0 full) +

0 To ocs. 0 Writs. 3 Reads 0 Words XFD

+++ CLOSE. 1

GLOBAL COORDINATES OF STRUCTURAL NODE POINTS:

N	GRID	X	Y	Z
1	1	0.10000000E+01	0.00000000E+00	-0.43711392E-07
2	2	0.98480773E+00	0.17364818E+00	-0.43047315E-07
3	3	0.93969262E+00	0.34202012E+00	-0.41875271E-07
4	4	0.86602539E+00	0.50000000E+00	-0.37855177E-07
5	5	0.76604444E+00	0.64278758E+00	-0.33484870E-07
6	6	0.64278758E+00	0.76604444E+00	-0.28097139E-07
7	7	0.49999997E+00	0.86602539E+00	-0.21855694E-07
8	8	0.34202012E+00	0.93969262E+00	-0.14950176E-07
9	9	0.17364818E+00	0.98480773E+00	-0.75904056E-08
10	10	-0.43711392E-07	0.10000000E+01	0.19106857E-14
11	11	-0.17364818E+00	0.98480773E+00	0.75904033E-08
12	12	-0.34202012E+00	0.93969262E+00	0.14950176E-07
13	13	-0.50000000E+00	0.86602539E+00	0.21855698E-07
14	14	-0.64278758E+00	0.76604444E+00	0.28097142E-07
15	15	-0.76604444E+00	0.64278758E+00	0.33484870E-07
16	16	-0.86602539E+00	0.50000000E+00	0.37855177E-07
17	17	-0.93969262E+00	0.34202012E+00	0.41875271E-07
18	18	-0.98480773E+00	0.17364818E+00	0.43047315E-07
19	19	-0.10000000E+01	-0.87422784E-07	0.43711392E-07
20	20	-0.98480773E+00	-0.17364818E+00	0.43047315E-07
21	21	-0.93969262E+00	-0.34202012E+00	0.41875271E-07
22	22	-0.86602539E+00	-0.49999997E+00	0.37855177E-07
23	23	-0.76604444E+00	-0.64278758E+00	0.33484870E-07
24	24	-0.64278758E+00	-0.76604444E+00	0.28097137E-07
25	25	-0.49999997E+00	-0.86602539E+00	0.21855692E-07
26	26	-0.34202012E+00	-0.93969262E+00	0.14950173E-07
27	27	-0.17364818E+00	-0.98480773E+00	0.75904012E-08
28	28	0.11924080E-07	-0.10000000E+01	-0.52125312E-15
29	29	0.17364818E+00	-0.98480773E+00	-0.75904021E-08
30	30	0.34202012E+00	-0.93969262E+00	-0.14950174E-07
31	31	0.49999997E+00	-0.86602539E+00	-0.21855692E-07
32	32	0.64278758E+00	-0.76604444E+00	-0.28097137E-07
33	33	0.76604444E+00	-0.64278758E+00	-0.33484870E-07
34	34	0.86602539E+00	-0.50000000E+00	-0.37855173E-07
35	35	0.93969262E+00	-0.34202012E+00	-0.41875271E-07
36	36	0.98480773E+00	-0.17364818E+00	-0.43047315E-07
37	37	0.10000000E+01	0.00000000E+00	-0.17500004E+00
38	38	0.98480773E+00	0.17364818E+00	-0.17500004E+00
39	39	0.93969262E+00	0.34202012E+00	-0.17500004E+00
40	40	0.86602539E+00	0.50000000E+00	-0.17500004E+00
41	41	0.76604444E+00	0.64278758E+00	-0.17500004E+00
42	42	0.64278758E+00	0.76604444E+00	-0.17500004E+00

N	NCOR	X	Y	Z	NX	NY	NZ
43	4	0.10000000E+01	0.00000000E+00	0.00000000E+00	0.10000000E+01	0.00000000E+00	0.00000000E+00
44	4	0.98480773E+00	0.17364818E+00	0.00000000E+00	0.98480773E+00	0.17364818E+00	0.00000000E+00
45	4	0.93969262E+00	0.34202012E+00	0.00000000E+00	0.93969262E+00	0.34202012E+00	0.00000000E+00
46	4	0.86602539E+00	0.50000000E+00	0.00000000E+00	0.86602539E+00	0.50000000E+00	0.00000000E+00
47	4	0.76604444E+00	0.64278758E+00	0.00000000E+00	0.76604444E+00	0.64278758E+00	0.00000000E+00
48	4	0.64278758E+00	0.76604444E+00	0.00000000E+00	0.64278758E+00	0.76604444E+00	0.00000000E+00
49	4	0.49999997E+00	0.86602545E+00	0.00000000E+00	0.49999997E+00	0.86602545E+00	0.00000000E+00
50	4	0.34202015E+00	0.93969262E+00	0.00000000E+00	0.34202015E+00	0.93969262E+00	0.00000000E+00
51	4	0.17364818E+00	0.98480773E+00	0.00000000E+00	0.17364818E+00	0.98480773E+00	0.00000000E+00
52	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
53	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
54	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
55	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
56	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
57	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
58	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
59	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
60	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
61	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
62	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
63	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
64	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
65	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
66	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
67	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
68	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
69	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
70	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
71	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00
72	4	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00

FLUID MESH GEOMETRIC ARRAYS:

17	4	-0.93969262E+00	0.34202021E+00	0.00000000E+00	-0.93969262E+00	0.34202021E+00	0.00000000E+00
18	4	-0.98480773E+00	0.17364830E+00	0.00000000E+00	-0.98480773E+00	0.17364830E+00	0.00000000E+00
19	4	-0.10000000E+01	0.15087426E-06	0.00000000E+00	-0.10000000E+01	0.15087426E-06	0.00000000E+00
20	4	-0.98480779E+00	-0.17364300E+00	0.00000000E+00	-0.98480779E+00	-0.17364300E+00	0.00000000E+00
21	4	-0.93969262E+00	-0.34202015E+00	0.00000000E+00	-0.93969262E+00	-0.34202015E+00	0.00000000E+00
22	4	-0.86602539E+00	-0.49999997E+00	0.00000000E+00	-0.86602539E+00	-0.49999997E+00	0.00000000E+00
23	4	-0.76604450E+00	-0.64278758E+00	0.00000000E+00	-0.76604450E+00	-0.64278758E+00	0.00000000E+00
24	4	-0.64278787E+00	-0.76604426E+00	0.00000000E+00	-0.64278787E+00	-0.76604426E+00	0.00000000E+00
25	4	-0.49999991E+00	-0.86602545E+00	0.00000000E+00	-0.49999991E+00	-0.86602545E+00	0.00000000E+00
26	4	-0.34202006E+00	-0.93969262E+00	0.00000000E+00	-0.34202006E+00	-0.93969262E+00	0.00000000E+00
27	4	-0.17364813E+00	-0.98480779E+00	0.00000000E+00	-0.17364813E+00	-0.98480779E+00	0.00000000E+00
28	4	0.11924880E-07	-0.10000000E+01	0.00000000E+00	0.11924880E-07	-0.10000000E+01	0.00000000E+00
29	4	0.17364815E+00	-0.98480773E+00	0.00000000E+00	0.17364815E+00	-0.98480773E+00	0.00000000E+00
30	4	0.34202009E+00	-0.93969262E+00	0.00000000E+00	0.34202009E+00	-0.93969262E+00	0.00000000E+00
31	4	0.49999991E+00	-0.86602545E+00	0.00000000E+00	0.49999991E+00	-0.86602545E+00	0.00000000E+00
32	4	0.64278752E+00	-0.76604450E+00	0.00000000E+00	0.64278752E+00	-0.76604450E+00	0.00000000E+00
33	4	0.76604432E+00	-0.64278775E+00	0.00000000E+00	0.76604432E+00	-0.64278775E+00	0.00000000E+00
34	4	0.86602533E+00	-0.50000018E+00	0.00000000E+00	0.86602533E+00	-0.50000018E+00	0.00000000E+00
35	4	0.93969256E+00	-0.34202036E+00	0.00000000E+00	0.93969256E+00	-0.34202036E+00	0.00000000E+00
36	4	0.98480773E+00	-0.17364835E+00	0.00000000E+00	0.98480773E+00	-0.17364835E+00	0.00000000E+00

CII

BII

A02

A11

A20

A00

NTRA

N

1	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
2	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
3	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
4	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
5	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
6	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
7	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
8	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
9	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
10	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
11	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
12	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
13	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
14	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
15	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
16	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
17	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
18	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
19	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
20	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
21	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
22	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
23	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
24	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
25	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
26	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
27	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01

28	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
29	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
30	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
31	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
32	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
33	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
34	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
35	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01
36	2	0.30504508E-01	0.77238677E-04	-0.13500312E-12	0.77850054E-04	0.61574590E+00	0.64371219E+01

LOCAL FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS:

NFLU	NSTR
1	1 37
2	0.50000E+00 0.50000E+00
3	0.50000E+00 0.50000E+00
4	0.50000E+00 0.50000E+00
5	0.50000E+00 0.50000E+00
6	0.50000E+00 0.50000E+00
7	0.50000E+00 0.50000E+00
8	0.50000E+00 0.50000E+00
9	0.50000E+00 0.50000E+00
10	0.50000E+00 0.50000E+00
11	0.50000E+00 0.50000E+00
12	0.50000E+00 0.50000E+00
13	0.50000E+00 0.50000E+00
14	0.50000E+00 0.50000E+00
15	0.50000E+00 0.50000E+00
16	0.50000E+00 0.50000E+00
17	0.50000E+00 0.50000E+00
18	0.50000E+00 0.50000E+00
19	0.50000E+00 0.50000E+00

20 0.50000E+00 0.50000E+00 56
 21 0.50000E+00 0.50000E+00 57
 22 0.50000E+00 0.50000E+00 58
 23 0.50000E+00 0.50000E+00 59
 24 0.50000E+00 0.50000E+00 60
 25 0.50000E+00 0.50000E+00 61
 26 0.50000E+00 0.50000E+00 62
 27 0.50000E+00 0.50000E+00 63
 28 0.50000E+00 0.50000E+00 64
 29 0.50000E+00 0.50000E+00 65
 30 0.50000E+00 0.50000E+00 66
 31 0.50000E+00 0.50000E+00 67
 32 0.50000E+00 0.50000E+00 68
 33 0.50000E+00 0.50000E+00 69
 34 0.50000E+00 0.50000E+00 70
 35 0.50000E+00 0.50000E+00 71
 36 0.50000E+00 0.50000E+00 72
 0.50000E+00 0.50000E+00
 2 = DIRTY:CYL.GEO

+++ OPEN, 2 = DIRTY:CYL.GEO, Acc= DIRECT, Stat= NEW

++++++
 + AUXILIARY STORAGE TABLE +
 ++++++
 + LDI Ext-film Unit EC Opt PRU Cdlloc Next Limit Read Written +
 + 2 DIRTY:CYL.GE 2 1 UPR 64 19 100000 0 763 +
 + 0 +
 + +
 + 1 Active devices (0 full) +
 + 0 Tp ops, 13 Whites, 0 Reads 763 Words XFD +
 ++++++

+++ CLOSE, 2

1	2	3	4	5	6	7	8	9	10
0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01
11	12	13	14	15	16	17	18	19	20
0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01
21	22	23	24	25	26	27	28	29	30
0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01
31	32	33	34	35	36				
0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01	0.30505E-01				

[illegible]

[illegible]


```

29 0.10043E+01 0.10036E+01 0.10031E+01 0.10028E+01 0.10025E+01 0.10022E+01
30 0.10055E+01 0.10043E+01 0.10036E+01 0.10031E+01 0.10028E+01 0.10025E+01
31 0.10083E+01 0.10055E+01 0.10043E+01 0.10036E+01 0.10031E+01 0.10028E+01
32 0.10055E+01 0.10083E+01 0.10055E+01 0.10043E+01 0.10036E+01 0.10031E+01
33 0.10043E+01 0.10055E+01 0.10083E+01 0.10055E+01 0.10043E+01 0.10036E+01
34 0.10076E+01 0.10043E+01 0.10055E+01 0.10083E+01 0.10055E+01 0.10043E+01
35 0.10031E+01 0.10036E+01 0.10043E+01 0.10055E+01 0.10083E+01 0.10055E+01
36 0.10028E+01 0.10031E+01 0.10036E+01 0.10043E+01 0.10055E+01 0.10083E+01
+++ OPEN, 3 = DIRTY:CYL.FLU , Acc= DIRECT , Stat= NEW

```

```

+++++
+ A U X I L I A R Y   S T O R A G E   T A B L E
+++++
+
+ LDI Ext-filnam Unit EC Opt PRU Cdlac Next Limit Read Written +
+ 3 DIRTY:CYL.FL 3 1 UPR 64 21 21 100000 0 1296 +
+ U
+
+
+ 1 Active devices ( 0 full)
+ 0 To ops, 14 Writes, 0 Reads 2059 Words XFD
+++++

```

```

+++ CLOSE, 3
+++ OPEN, 4 = FOR004 , Acc= DIRECT , Stat= SCRATCH

```

EIGENVALUES:

	1	2	3	4	5	6	7	8	9	10
0.11031E+04	0.99737E+00	0.99736E+00	0.99735E+00	0.49753E+00	0.49753E+00	0.33039E+00	0.33037E+00	0.24644E+00	0.24643E+00	0.19591E+00
0.19590E+00	0.16224E+00	0.16223E+00	0.13030E+00	0.13827E+00	0.12052E+00	0.12051E+00	0.10690E+00	0.10688E+00	0.10688E+00	0.96230E-01
0.96223E-01	0.87805E-01	0.87793E-01	0.81142E-01	0.81134E-01	0.75892E-01	0.75868E-01	0.71864E-01	0.71843E-01	0.71843E-01	0.68892E-01
0.68893E-01	0.66801E-01	0.66785E-01	0.65605E-01	0.65589F-01	0.65225E-01					

EIGENVECTORS:

	1	2	3	4	5	6	7	8	9	10
-0.95426E+00	-0.67723E+00	0.11642E+01	0.10280E+01	0.62627E+00	0.29220E+00	0.13150E+01	-0.10819E+01	0.77303E+00	0.84137E+00	
-0.95426E+00	-0.46437E+00	0.12648E+01	0.66617E+00	0.99724E+00	0.91256E+00	0.98618E+00	-0.31021E+00	0.13025E+01	-0.26721E+00	
-0.95426E+00	-0.23719E+00	0.13274E+01	0.22684E+00	0.12482E+01	0.12871E+01	0.39429E+00	0.60653E+00	0.12237E+01	-0.11853E+01	
-0.95426E+00	-0.28747E-02	0.12495E+01	-0.24186E+00	0.13434E+01	0.13173E+01	-0.30374E+00	0.12395E+01	0.57173E+00	-0.12563E+01	
-0.95426E+00	0.23151E+00	0.13306E+01	-0.69125E+00	0.12861E+01	0.99469E+00	-0.92029E+00	0.12926E+01	-0.34747E+00	-0.42988E+00	
-0.95426E+00	0.45687E+00	0.12713E+01	-0.10386E+01	0.10686E+01	0.40545E+00	-0.12904E+01	0.74076E+00	-0.11044E+01	0.70372E+00	
-0.95426E+00	0.67230E+00	0.11732E+01	-0.12708E+01	0.72207E+00	-0.29261E+00	0.13150E+01	-0.15759E+00	-0.13450E+01	0.13347E+01	
-0.95426E+00	0.86526E+00	0.10396E+01	-0.13495E+01	0.20866E+00	-0.91193E+00	-0.98679E+00	-0.98239E+00	-0.95556E+00	0.10118E+01	
-0.95426E+00	0.10320E+01	0.87440E+00	-0.12655E+01	-0.17968E+00	-0.12871E+01	-0.39433E+00	-0.13473E+01	-0.11920E+00	-0.33744E-01	
-0.95426E+00	0.11673E+01	0.68263E+00	-0.10289E+01	-0.62630E+00	-0.13173E+01	0.30380E+00	-0.10820E+01	0.77308E+00	-0.10552E+01	
-0.95426E+00	0.12672E+01	0.47005E+00	-0.66821E+00	-0.99747E+00	-0.99473E+00	0.92039E+00	-0.31019E+00	0.13032E+01	-0.13228E+01	
-0.95426E+00	0.13285E+01	0.24324E+00	-0.22690E+00	-0.12483E+01	-0.40547E+00	0.12905E+01	0.60677E+00	0.12238E+01	-0.64535E+00	

13	-0.95426E+00	0.13495E+01	0.90521E-02	0.24181E+00	-0.13494E+01	0.29250E+00	0.13148E+01	0.12396E+01	0.57185E+00	0.49313E+00
14	-0.95426E+00	0.13295E+01	-0.22534E+00	0.68144E+00	-0.12858E+01	0.91223E+00	0.98701E+00	0.12926E+01	-0.34733E+00	0.12791E+01
15	-0.95426E+00	0.12691E+01	-0.45304E+00	0.10387E+01	-0.10685E+01	0.12871E+01	0.39432E+00	0.74058E+00	-0.11049E+01	0.11515E+01
16	-0.95426E+00	0.11701E+01	-0.66686E+00	0.12708E+01	-0.72206E+00	0.13175E+01	-0.30376E+00	0.15778E+00	-0.13448E+01	0.20111E+00
17	-0.95426E+00	0.10356E+01	-0.86049E+00	0.13495E+01	-0.28865E+00	0.99454E+00	-0.92069E+00	0.98251E+00	-0.95587E+00	0.89267E+00
18	-0.95426E+00	0.86966E+00	-0.10280E+01	0.12655E+01	0.17970E+00	0.40534E+00	0.12907E+01	-0.13473E+01	-0.11935E+00	0.13491E+01
19	-0.95426E+00	0.67722E+00	-0.11641E+01	0.10290E+01	0.62640E+00	-0.29233E+00	-0.13148E+01	-0.10819E+01	0.77336E+00	-0.84168E+00
20	-0.95426E+00	0.46425E+00	-0.12650E+01	0.66815E+00	0.99741E+00	-0.91203E+00	-0.98685E+00	-0.31015E+00	0.13034E+01	0.26745E+00
21	-0.95426E+00	0.23718E+00	-0.13275E+01	0.22679E+00	0.12481E+01	-0.12872E+01	0.39432E+00	0.60668E+00	0.12337E+01	0.11853E+01
22	-0.95426E+00	0.28867E-02	-0.13495E+01	0.24186E+00	0.13483E+01	-0.13174E+01	0.30387E+00	0.12396E+01	0.57158E+00	0.12563E+01
23	-0.95426E+00	0.23151E+00	-0.13306E+01	0.63143E+00	0.12859E+01	-0.99479E+00	0.92060E+00	0.12924E+01	-0.34807E+00	0.42984E+00
24	-0.95426E+00	0.45887E+00	-0.12712E+01	0.10387E+01	0.10685E+01	-0.40541E+00	0.12907E+01	0.74068E+00	-0.11045E+01	0.70379E+00
25	-0.95426E+00	0.67220E+00	-0.11732E+01	0.12707E+01	0.72205E+00	0.29249E+00	0.13149E+01	-0.15770E+00	-0.13444E+01	-0.13345E+01
26	-0.95426E+00	0.86526E+00	-0.10396E+01	0.13495E+01	0.28859E+00	0.91205E+00	-0.98682E+00	-0.98222E+00	-0.95513E+00	-0.10119E+01
27	-0.95426E+00	0.11632E+01	-0.87440E+00	0.12655E+01	-0.17970E+00	0.12871E+01	0.39424E+00	-0.13473E+01	-0.11910E+00	0.33725E+01
28	-0.95426E+00	0.11673E+01	-0.68258E+00	0.10289E+01	-0.62630E+00	0.13174E+01	-0.30387E+00	0.10819E+01	0.77285E+00	0.10553E+01
29	-0.95426E+00	0.12672E+01	-0.47005E+00	0.56611E+00	-0.99737E+00	0.99480E+00	-0.92071E+00	-0.31031E+00	0.13031E+01	0.13227E+01
30	-0.95426E+00	0.13285E+01	-0.24325E+00	0.22680E+00	-0.12482E+01	0.40550E+00	-0.12908E+01	0.60661E+00	0.12234E+01	0.64530E+00
31	-0.95426E+00	0.13495E+01	-0.90647E-02	0.24184E+00	-0.13494E+01	-0.29247E+00	0.13150E+01	0.12395E+01	0.57125E+00	-0.49299E+00
32	-0.95426E+00	0.13295E+01	0.22543E+00	0.68134E+00	-0.12860E+01	-0.91197E+00	-0.98676E+00	0.12926E+01	-0.34802E+00	-0.12790E+01
33	-0.95426E+00	0.12691E+01	0.45305E+00	0.10387E+01	-0.10685E+01	-0.12872E+01	-0.39425E+00	0.74065E+00	-0.11046E+01	-0.11515E+01
34	-0.95426E+00	0.11701E+01	0.66692E+00	0.12707E+01	-0.72206E+00	-0.13175E+01	0.30409E+00	0.15782E+00	-0.13443E+01	-0.20119E+00
35	-0.95426E+00	0.10356E+01	0.86051E+00	0.13495E+01	-0.28859E+00	-0.99483E+00	0.92081E+00	-0.98219E+00	-0.95495E+00	0.89282E+00
36	-0.95426E+00	0.86966E+00	0.10280E+01	0.12655E+01	0.17969E+00	-0.40556E+00	0.12908E+01	-0.13472E+01	-0.11873E+00	0.13490E+01

1	-0.10708E+01	0.76846E+00	0.11043E+01	-0.11760E+01	-0.66746E+00	0.93333E+00	-0.91007E+00	-0.97751E-01	0.13462E+01	-0.95054E+00
2	-0.13173E+01	0.13455E+01	-0.11947E+00	0.22209E+00	-0.13284E+01	0.11235E+01	0.82055E+00	-0.13482E+01	-0.92658E-01	0.11121E+01
3	-0.62404E+00	0.57553E+00	-0.12239E+01	0.13259E+01	-0.24733E+00	0.54662E+00	0.10992E+01	0.10096E+00	-0.13478E+01	0.56182E+00
4	0.51582E+00	0.76929E+00	-0.11044E+01	0.68551E+00	0.11621E+01	-0.13125E+01	-0.40609E+00	0.13472E+01	0.93532E-01	0.13065E+01
5	0.12866E+01	-0.13444E+01	0.11943E+00	0.85631E+00	0.10413E+01	0.91381E-01	0.13394E+01	-0.10158E+00	0.13472E+01	-0.10701E+00
6	0.11386E+01	-0.57562E+00	0.12240E+01	-0.12721E+01	-0.44942E+00	0.13438E+01	-0.59806E-01	0.13466E+01	-0.93246E-01	0.13427E+01
7	0.17765E+00	0.76800E+00	0.11049E+01	-0.13859E-01	-0.13478E+01	0.37471E+00	0.13178E+01	0.10256E+00	-0.13466E+01	-0.35986E+00
8	-0.91104E+00	0.13447E+01	-0.11968E+00	0.12631E+01	-0.47339E+00	0.12122E+01	0.51839E+00	0.13447E+01	0.92667E-01	-0.12162E+01
9	-0.13483E+01	0.57633E+00	-0.12242E+01	0.87708E+00	0.10250E+01	-0.79672E+00	0.11383E+01	-0.10137E+00	0.13468E+01	0.78086E+00
10	-0.82272E+00	-0.76805E+00	0.11048E+01	-0.66268E+00	0.11736E+01	0.93594E+00	-0.91331E+00	0.13453E+01	-0.92959E-01	0.34609E+00
11	0.29132E+00	0.13451E+01	0.11957E+00	-0.13310E+01	-0.22180E+00	0.11212E+01	0.82064E+00	0.10201E+00	-0.13464E+01	-0.11107E+01
12	0.11968E+01	-0.57657E+00	0.12244E-01	-0.24794E+00	-0.13258E+01	-0.54610E+00	0.11987E+01	0.13448E+01	0.92941E-01	0.55956E+00
13	0.12470E+01	0.76871E+00	0.11046E+01	0.11616E+01	-0.68500E+00	-0.13104E+01	-0.40430E+00	0.10275E+00	0.13462E+01	0.13056E+01
14	0.40585E+00	0.13460E+01	-0.11986E+00	0.10428E+01	0.85673E+00	0.91311E-01	-0.13386E+01	-0.13450E+01	-0.93340E-01	0.10760E+00
15	-0.72403E+00	0.57585E+00	-0.12240E+01	-0.44905E+00	0.12727E+01	0.13405E+01	-0.61528E-01	0.10425E+00	-0.13453E+01	-0.13463E+01
16	-0.13375E+01	-0.76921E+00	-0.11044E+01	-0.13494E+01	-0.13218E+01	0.37572E+00	0.13181E+01	0.13438E+01	0.92662E-01	0.36175E+00
17	-0.99402E+00	0.13458E+01	0.11965E+00	0.47426E+00	-0.12636E+01	-0.12110E+01	0.51808E+00	0.10270E+00	0.13457E+01	0.12191E+01
18	0.58367E-01	-0.57605E+00	0.12240E+01	0.10251E+01	-0.87673E+00	0.79553E+00	-0.11374E+01	-0.13440E+01	-0.92941E-01	0.78343E+00
19	0.10696E+01	0.76988E+00	0.11041E+01	0.11755E+01	0.66369E+00	0.93493E+00	-0.91291E+00	0.10154E+00	-0.13457E+01	-0.94680E+00
20	0.13172E+01	0.13451E+01	-0.11953E+00	-0.22121E+00	0.13317E+01	0.11192E+01	0.81960E+00	0.13468E+01	0.93282E-01	0.11105E+01
21	0.62372E+00	0.57569E+00	-0.12237E+01	-0.13269E+01	0.24659E+00	-0.54558E+00	0.11974E+01	-0.10174E+00	0.13457E+01	0.56153E+00
22	-0.51561E+00	-0.76936E+00	-0.11042E+01	-0.68638E+00	-0.11636E+01	-0.13088E+01	-0.40359E+00	-0.13470E+01	-0.93321E-01	-0.13049E+01
23	-0.12865E+01	-0.13452E+01	0.11936E+00	0.85726E+00	-0.10417E+01	0.90581E-01	-0.13378E+01	0.1024E+00	-0.13460E+01	-0.10862E+00
24	-0.11388E+01	-0.57527E+00	0.12236E+01	0.12732E+01	0.45031E+00	0.13413E+00	-0.59625E-01	0.13461E+01	0.93307E-01	0.13433E+01
25	-0.17695E+00	0.76931E+00	0.11041E+01	0.13441E-01	0.13505E+01	0.37476E+00	0.13164E+01	-0.10025E+00	0.13463E+01	-0.35811E+00
26	0.91127E+00	0.13447E+01	-0.11917E+00	-0.12639E+01	0.47270E+00	-0.12106E+01	0.51675E+00	-0.13460E+01	-0.93324E-01	-0.12191E+01

27 0.13487E+01 0.57544E+00-0.12235E+01-0.87808E+00-0.10269E+01-0.79576E+00-0.11375E+01 0.10021E+00-0.13463E+01 0.78099E+00
 28 0.82231E+00-0.76920E+00-0.11044E+01 0.66327E+00-0.11751E+01 0.93439E+00-0.91116E+00 0.13458E+01 0.93414E-01 0.94836E+00
 29 -0.29158E+00-0.13446E+01 0.11935E+00 0.13316E+00 0.22374E+00 0.11205E+01 0.82131E+00-0.10013E+00 0.13465E+01-0.11102E+01
 30 -0.11971E+01-0.57568E+00 0.12236E+01 0.24769E+00 0.13282E+01-0.54523E+00 0.11960E+01-0.13457E+01-0.93616E-01-0.56323E+00
 31 -0.12473E+01 0.76878E+00 0.11043E+01-0.11621E+01 0.68442E+00-0.13102E+01-0.40635E+00 0.99706E-01-0.13466E+01 0.13052E+01
 32 -0.40638E+00 0.13447E+01-0.11944E+00-0.10426E+01-0.86047E+00 0.90365E-01-0.13371E+01 0.13451E+01 0.94034E-01 0.11084E+00
 33 0.72507E+00 0.57555E+00-0.12238E+01 0.44883E+00-0.12725E+01 0.13412E+01-0.57761E-01-0.99027E-01 0.13462E+01-0.13441E+01
 34 0.13384E+01-0.76861E+00-0.11043E+01 0.13495E+01-0.96759E-02 0.37584E+00 0.13169E+01-0.13453E+01-0.93731E-01 0.35592E+00
 35 0.99546E+00-0.13445E+01 0.11961E+00 0.47455E+00 0.12658E+01-0.12104E+01 0.51501E+00 0.98451E-01-0.13460E+01 0.12207E+01
 36 -0.58780E-01-0.57595E+00 0.12237E+01-0.10250E+01 0.87535E+00-0.79670E+00-0.11384E+01 0.13456E+01 0.93360E-01-0.77994E+00
 21 22 23 24 25 26 27 28 29 30
 1 0.93780E+00 0.11609E+01-0.69536E+00 0.96436E+00 0.91355E+00-0.12950E+01 0.38999E+00 0.78115E+00 0.10777E+01 0.13455E+01
 2 0.79216E+00-0.10506E+01-0.84941E+00-0.13018E+01 0.40285E+00 0.11281E+01 0.73898E+00 0.10827E+00-0.13393E+01-0.11377E+01
 3 -0.12126E+01-0.43848E+00 0.12747E+01 0.34040E+00-0.13178E+01-0.16406E+00-0.13357E+01-0.94698E+00 0.96656E+00 0.62781E+00
 4 -0.37137E+00 0.13493E+01-0.21786E-01 0.95084E+00 0.91537E+00-0.91391E+00 0.97719E+00 0.13431E+01-0.13882E+00 0.50561E-01
 5 0.13422E+01-0.48543E+00-0.12604E+01-0.13028E+00 0.40233E+00 0.13400E+01 0.79914E-01-0.11108E-01-0.75512E+00-0.71767E+00
 6 -0.95624E-01-0.10161E+01 0.68465E+00 0.34311E+00-0.13178E+01-0.80806E+00-0.10810E+01 0.35815E+00 0.12984E+01 0.11936E+01
 7 -0.13092E+01 0.11812E+01 0.65567E+00 0.96142E+00 0.91496E+00-0.30280E+00 0.13092E+01 0.56265E+00-0.12338E+01-0.13473E+01
 8 0.55116E+00 0.20633E+00-0.13344E+01-0.13072E+01 0.40318E+00 0.12009E+01-0.60134E+00-0.12203E+01 0.59029E+00 0.11359E+01
 9 0.11173E+01-0.13213E+01 0.25829E+00 0.34704E+00-0.13177E+01-0.12409E+01-0.53620E+00 0.13068E+01 0.33033E+00-0.61760E+00
 10 -0.93878E+00 0.69616E+00 0.11573E+01 0.95954E+00 0.91407E+00 0.39335E+00 0.12909E+01-0.78200E+00-0.110974E+01-0.67788E-01
 11 -0.79185E+00 0.84654E+00-0.10498E+01-0.13046E+01 0.40363E+00 0.13429E+00-0.11242E+01-0.10823E+00 0.13542E+01-0.73691E+00
 12 0.12141E+01-0.12756E+01-0.43935E+00 0.34298E+00 0.13175E+01-0.13355E+01 0.15490E+00 0.94769E+00-0.98075E+00-0.12100E+01
 13 0.37046E+00 0.24531E-01 0.13438E+01 0.96117E+00 0.91415E+00 0.98154E+00 0.92587E+00-0.13438E+01 0.14820E+00 0.13577E+01
 14 -0.13421E+01 0.12582E+01-0.40481E+00-0.13050E+01 0.40338E+00 0.76291E-01-0.13455E+01 0.11112E+01 0.75275E+00-0.11429E+01
 15 0.94202E-01-0.88197E+00-0.10151E+01 0.34711E+00-0.13183E+01-0.10930E+01 0.80269E+00-0.35807E+00-0.12986E+01 0.62572E+00
 16 0.13105E+01-0.65681E+00 0.11786E+01 0.95589E+00 0.91567E+00 0.13165E+01 0.31434E+00-0.56099E+00 0.12357E+01 0.56744E-01
 17 -0.55020E+00 0.13321E+01 0.21956E+00-0.15010E+01 0.40208E+00-0.60957E+00-0.12075E+01 0.12184E+01-0.59382E+00-0.72207E+00
 18 -0.11188E+01-0.25477E+00-0.13234E+01 0.34287E+00 0.13172E+01-0.53213E+00 0.12390E+01-0.13057E+01-0.32691E+00 0.11919E+01
 19 0.93892E+00-0.11587E+01 0.69425E+00 0.95788E+00 0.91512E+00 0.12938E+01-0.38551E+00 0.78192E+00 0.10945E+01-0.13428E+01
 20 0.79185E+00 0.10489E+01 0.84972E+00-0.12985E+01 0.40182E+00-0.11325E+01-0.74416E+00 0.10772E+00-0.13491E+01 0.11360E+01
 21 -0.12139E+01 0.44102E+00-0.12758E+01 0.33990E+00-0.13165E+01 0.16141E+00 0.13423E+01-0.94692E+00 0.97387E+00-0.62460E+00
 22 -0.36991E+00-0.13508E+01 0.22733E-01 0.95784E+00 0.91424E+00 0.92590E+00-0.98178E+00 0.13429E+01-0.14505E+00-0.55617E-01
 23 0.13420E+01 0.48280E+00 0.12605E+01-0.12968E+01 0.40237E+00-0.13508E+01-0.79655E-01-0.11108E+01-0.75096E+00 0.72125E+00
 24 -0.95155E-01 0.10191E+01-0.88593E+00 0.33637E+00-0.13166E+01 0.81073E+00 0.10851E+01 0.35921E+00 0.12944E+01-0.11950E+01
 25 -0.13096E+01-0.11786E+01-0.65366E+00 0.96264E+00 0.91457E+00 0.30787E+00-0.13159E+01 0.56063E+00-0.12319E+01 0.13499E+01
 26 0.55002E+00-0.21317E+00 0.13331E+01-0.12990E+01 0.40137E+00-0.12057E+01 0.60645E+00-0.12183E+01 0.59412E+00-0.11433E+01
 27 0.11184E+01 0.13247E+01-0.25838E+00 0.33577E+00-0.13151E+01 0.12404E+01 0.53550E+00 0.13059E+01 0.32156E+00 0.63050E+00
 28 -0.93868E+00-0.69293E+00-0.11560E+01 0.96319E+00 0.91310E+00-0.30674E+00-0.12943E+01-0.78230E+00-0.10874E+01 0.50609E-01
 29 -0.79186E+00-0.85115E+00 0.10439E+01-0.12987E+01 0.40219E+00-0.74431E+00 0.11286E+01-0.10787E+00 0.13455E+01-0.71775E+00
 30 0.12134E+01 0.12755E+01 0.43878E+00 0.33594E+00-0.13154E+01 0.13427E+01-0.15668E+00 0.94809E+00-0.97472E+00 0.11926E+01
 31 0.37025E+00-0.20466E-01-0.13491E+01 0.95291E+00 0.91325E+00-0.98096E+00-0.92789E+00-0.13447E+01 0.14920E+00-0.13467E+01
 32 -0.13419E+01-0.12623E+01 0.48339E+00-0.12990E+01 0.40224E+00-0.81995E-01 0.13505E+01 0.11123E+01 0.74542E+00 0.11387E+01
 33 0.95852E-01 0.88389E+00 0.10192E+01 0.33589E+00-0.13157E+01 0.10858E+00-0.80919E+00-0.35988E+00-0.12918E+01-0.62452E+00
 34 0.13084E+01 0.65795E+00-0.11808E+01 0.96303E+00 0.91354E+00-0.13124E+01-0.30972E+00-0.56047E+00 0.12354E+01-0.57342E-01
 35 -0.55000E+00-0.13338E+01-0.21139E+00-0.12984E+01 0.40210E+00 0.59998E+00 0.12074E+01 0.12182E+01-0.60294E+00 0.72330E+00
 36 -0.11175E+01 0.25383E+00 0.13256E+01 0.33483E+00-0.13156E+01 0.54123E+00-0.12425E+01-0.13053E+01-0.30965E+00-0.11947E+01
 31 32 33 34 35 36
 1 -0.14069E-01-0.34081E+00 0.13110E+01-0.83659E+00-0.11319E+01 0.92000E+00
 2 -0.66413E+00-0.12708E+00-0.13428E+01 0.10125E+01 0.98694E+00-0.91383E+00
 3 0.11633E+01 0.57870E+00 0.12075E+01-0.11597E+01-0.80667E+00 0.91583E+00

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4 -0.13505E+01-0.35997E+00-0.92530E+00 0.12722E+01 0.60042E+00-0.91974E+00
5 0.11761E+01 0.12251E+01 0.53087E+00-0.13443E+01-0.37580E+00 0.92111E+00
6 -0.68635E+00-0.13422E+01-0.71128E-01 0.13742E+01 0.13882E+00-0.92083E+00
7 0.13942E-01 0.12977E+01-0.39483E+00 0.13640E+01 0.10016E+00 0.92137E+00
8 0.66078E+00-0.10965E+01 0.80976E+00 0.13151E+01-0.33330E+00-0.92366E+00
9 -0.11580E+01 0.76288E+00-0.11256E+01-0.12268E+01 0.55567E+00 0.92645E+00
10 0.13442E+01-0.33732E+00 0.13059E+01 0.11015E+01-0.76143E+00-0.92941E+00
11 -0.11686E+01-0.12928E+00-0.13281E+01-0.94409E+00 0.94318E+00 0.93293E+00
12 0.67932E+00 0.58070E+00 0.11902E+01 0.75830E+00-0.10958E+01-0.93703E+00
13 -0.92420E-02 0.96198E+00-0.91169E+00-0.54743E+00 0.12173E+01 0.93992E+00
14 -0.66328E+00 0.12271E+01 0.52319E+00 0.32079E+00-0.13017E+01-0.94364E+00
15 0.11598E+01-0.13442E+01-0.68028E+01-0.88033E-01 0.13439E+01 0.95034E+00
16 -0.13467E+01 0.12990E+01-0.39717E+00-0.14504E+00-0.13440E+01-0.95834E+00
17 0.11737E+01-0.10967E+01 0.81619E+00 0.37193E+00 0.13022E+01 0.96710E+00
18 -0.68728E+00 0.76172E+00-0.11391E+01-0.58574E+00-0.12192E+01-0.97587E+00
19 0.16216E-01-0.33424E+00 0.13249E+01 0.78229E+00 0.10997E+01 0.98217E+00
20 0.66065E+00-0.13380E+00-0.13492E+01-0.95713E+00-0.94990E+00-0.98541E+00
21 -0.11609E+01 0.58557E+00 0.12118E+01 0.11031E+01 0.77323E+00 0.98717E+00
22 0.13499E+01-0.96662E+00-0.93028E+00-0.12148E+01-0.57369E+00-0.98781E+00
23 -0.11770E+01 0.12314E+01 0.53721E+00 0.12809E+01 0.35647E+00 0.98708E+00
24 0.68773E+00-0.13478E+01-0.81135E-01-0.13220E+01-0.12668E+00-0.98651E+00
25 -0.13230E-01 0.13014E+01-0.38379E+00 0.13139E+01-0.10739E+00 0.98672E+00
26 -0.66483E+00-0.10980E+01 0.80310E+00-0.12556E+01 0.33773E+00-0.98637E+00
27 0.11648E+01 0.76253E+00-0.11253E+01 0.11776E+01-0.55784E+00 0.98504E+00
28 -0.13530E+01-0.33542E+00 0.13120E+01-0.10528E+01 0.76088E+00-0.98299E+00
29 0.11788E+01-0.13231E+00-0.13418E+01 0.89515E+00-0.94070E+00 0.97989E+00
30 -0.68864E+00 0.58418E+00 0.12118E+01-0.70977E+00 0.10914E+01-0.97517E+00
31 0.14013E-01-0.96520E+00-0.93623E+00 0.50223E+00-0.12098E+01 0.96940E+00
32 0.66426E+00 0.12296E+01 0.54779E+00-0.27670E+00 0.12933E+01-0.96327E+00
33 -0.11645E+01-0.13464E+01-0.93258E-01 0.45604E-01-0.13396E+01 0.95695E+00
34 0.13528E+01 0.13022E+01-0.37295E+00 0.18997E+00 0.13467E+01-0.94962E+00
35 -0.11785E+01-0.11016E+01 0.79456E+00-0.42032E+00-0.13138E+01 0.94067E+00
36 0.68856E+00 0.76773E+00-0.11200E+01 0.63812E+00 0.12411E+01-0.93066E+00
+++ CLOSE, 4
+++ OPEN, 3 = DIRTY:CYL.DAA , Acc= DIRECT , Stat= NEW

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MATRIX APPEARING IN DAA EQUATIONS:

	1	2	3	4	5	6	7	8	9	10
1	0.27090E+00-0.10410E+00-0.97853E-02-0.63421E-02-0.35930E-02-0.23378E-02-0.16694E-02-0.12965E-02-0.10238E-02-0.84159E-03									
2	-0.10410E+00 0.27089E+00-0.10410E+00-0.97804E-02-0.63444E-02-0.35922E-02-0.23378E-02-0.16689E-02-0.12957E-02-0.10252E-02									
3	-0.97853E-02-0.10410E+00 0.27090E+00-0.10410E+00-0.97815E-02-0.63429E-02-0.35911E-02-0.23372E-02-0.16727E-02-0.12941E-02									
4	-0.63421E-02-0.97804E-02-0.10410E+00 0.27090E+00-0.10410E+00-0.97840E-02-0.63429E-02-0.35942E-02-0.23338E-02-0.16719E-02									
5	-0.35930E-02-0.63444E-02-0.97815E-02-0.10410E+00 0.27090E+00-0.10410E+00-0.97839E-02-0.63429E-02-0.35949E-02-0.23348E-02									
6	-0.23378E-02-0.35922E-02-0.63429E-02-0.97840E-02-0.10410E+00 0.27090E+00-0.10410E+00-0.97807E-02-0.63405E-02-0.35958E-02									
7	-0.16694E-02-0.23378E-02-0.35911E-02-0.63429E-02-0.97807E-02-0.10410E+00 0.27090E+00-0.10410E+00-0.97861E-02-0.63397E-02									
8	-0.12965E-02-0.16689E-02-0.23372E-02-0.35942E-02-0.63429E-02-0.97807E-02-0.10410E+00 0.27090E+00-0.10410E+00-0.97829E-02									
9	-0.10238E-02-0.12957E-02-0.16727E-02-0.23338E-02-0.35949E-02-0.63405E-02-0.97861E-02-0.10410E+00 0.27090E+00-0.10410E+00									
10	-0.84159E-03-0.10252E-02-0.12941E-02-0.16719E-02-0.23348E-02-0.35958E-02-0.63397E-02-0.97829E-02-0.10410E+00 0.27090E+00									
11	-0.72965E-03-0.84167E-03-0.10249E-02-0.12960E-02-0.16698E-02-0.23363E-02-0.35959E-02-0.63405E-02-0.97820E-02-0.10410E+00									
12	-0.62715E-03-0.72974E-03-0.84345E-03-0.10233E-02-0.12957E-02-0.16707E-02-0.23336E-02-0.35965E-02-0.63423E-02-0.97821E-02									

13 -0.57183E-03-0.62780E-03-0.72690E-03-0.84285E-03-0.10250E-02-0.12948E-02-0.16717E-02-0.23363E-02-0.35924E-02-0.63415E-02
14 -0.50721E-03-0.56815E-03-0.63017E-03-0.72722E-03-0.84418E-03-0.10237E-02-0.12944E-02-0.16712E-02-0.23366E-02-0.35942E-02
15 -0.48505E-03-0.51023E-03-0.56517E-03-0.63146E-03-0.72721E-03-0.84447E-03-0.10237E-02-0.12954E-02-0.16689E-02-0.23381E-02
16 -0.45271E-03-0.48327E-03-0.51233E-03-0.56698E-03-0.62673E-03-0.72934E-03-0.84446E-03-0.10230E-02-0.12978E-02-0.16692E-02
17 -0.43767E-03-0.45248E-03-0.48447E-03-0.50889E-03-0.56996E-03-0.62712E-03-0.72820E-03-0.84378E-03-0.10230E-02-0.12964E-02
18 -0.42590E-03-0.43612E-03-0.45290E-03-0.48355E-03-0.50894E-03-0.56780E-03-0.62927E-03-0.72841E-03-0.84448E-03-0.10229E-02
19 -0.42270E-03-0.42825E-03-0.43478E-03-0.45428E-03-0.48487E-03-0.51118E-03-0.56673E-03-0.62782E-03-0.72814E-03-0.84370E-03
20 -0.42591E-03-0.42613E-03-0.42621E-03-0.43421E-03-0.45397E-03-0.48289E-03-0.50998E-03-0.56920E-03-0.62878E-03-0.72833E-03
21 -0.43767E-03-0.42579E-03-0.42515E-03-0.42723E-03-0.43571E-03-0.45282E-03-0.48400E-03-0.50879E-03-0.56920E-03-0.62811E-03
22 -0.45270E-03-0.43394E-03-0.43067E-03-0.42273E-03-0.42575E-03-0.43587E-03-0.45452E-03-0.48420E-03-0.51021E-03-0.56800E-03
23 -0.48506E-03-0.45525E-03-0.43092E-03-0.43048E-03-0.4270E-03-0.42782E-03-0.43561E-03-0.45277E-03-0.48277E-03-0.51044E-03
24 -0.50719E-03-0.48323E-03-0.45587E-03-0.43424E-03-0.42754E-03-0.42560E-03-0.42507E-03-0.43581E-03-0.45392E-03-0.48536E-03
25 -0.57185E-03-0.50849E-03-0.48273E-03-0.45286E-03-0.43692E-03-0.42547E-03-0.42626E-03-0.42695E-03-0.43423E-03-0.45297E-03
26 -0.62714E-03-0.57049E-03-0.50847E-03-0.48517E-03-0.45309E-03-0.43520E-03-0.42430E-03-0.42818E-03-0.42710E-03-0.43338E-03
27 -0.72967E-03-0.62601E-03-0.57106E-03-0.50836E-03-0.48364E-03-0.45372E-03-0.43761E-03-0.42538E-03-0.42322E-03-0.42866E-03
28 -0.84157E-03-0.73600E-03-0.62586E-03-0.57066E-03-0.50711E-03-0.48689E-03-0.45122E-03-0.43417E-03-0.42859E-03-0.42647E-03
29 -0.10238E-02-0.84305E-03-0.73066E-03-0.62540E-03-0.57095E-03-0.50689E-03-0.48671E-03-0.45377E-03-0.43356E-03-0.42660E-03
30 -0.12965E-02-0.10215E-02-0.84455E-03-0.72949E-03-0.62869E-03-0.56625E-03-0.51059E-03-0.48394E-03-0.45552E-03-0.43244E-03
31 -0.16694E-02-0.12977E-02-0.10209E-02-0.84432E-03-0.72860E-03-0.62559E-03-0.56888E-03-0.50674E-03-0.48522E-03-0.43459E-03
32 -0.23378E-02-0.16694E-02-0.12969E-02-0.10234E-02-0.84306E-03-0.72966E-03-0.62618E-03-0.57198E-03-0.50714E-03-0.48299E-03
33 -0.35930E-02-0.23386E-02-0.16683E-02-0.12966E-02-0.10220E-02-0.84498E-03-0.72172E-03-0.62645E-03-0.57020E-03-0.51034E-03
34 -0.63421E-02-0.35899E-02-0.23398E-02-0.16695E-02-0.12992E-02-0.10197E-02-0.84420E-03-0.72973E-03-0.62901E-03-0.56920E-03
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36 -0.10410E+00-0.97871E-02-0.63404E-02-0.35919E-02-0.23355E-02-0.16734E-02-0.12951E-02-0.10224E-02-0.84245E-03-0.72920E-03

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27 -0.43487E-03-0.45559E-03-0.48254E-03-0.50902E-03-0.56873E-03-0.62730E-03-0.73139E-03-0.83984E-03-0.10267E-02-0.12925E-02
28 -0.42692E-03-0.43292E-03-0.45451E-03-0.48447E-03-0.50875E-03-0.56856E-03-0.62795E-03-0.73003E-03-0.84261E-03-0.10246E-02
29 -0.42271E-03-0.43053E-03-0.43452E-03-0.45522E-03-0.48294E-03-0.50845E-03-0.56896E-03-0.62831E-03-0.72785E-03-0.84402E-03
30 -0.43027E-03-0.42158E-03-0.42837E-03-0.43372E-03-0.45611E-03-0.48317E-03-0.50917E-03-0.56893E-03-0.62807E-03-0.72813E-03
31 -0.43332E-03-0.42822E-03-0.42612E-03-0.42660E-03-0.43184E-03-0.45593E-03-0.48536E-03-0.50827E-03-0.56854E-03-0.62756E-03
32 -0.45637E-03-0.43461E-03-0.42584E-03-0.42655E-03-0.43137E-03-0.45247E-03-0.48551E-03-0.50902E-03-0.51106E-03
33 -0.48324E-03-0.45375E-03-0.43391E-03-0.43089E-03-0.42276E-03-0.42715E-03-0.43336E-03-0.45609E-03-0.48250E-03-0.51106E-03
34 -0.50842E-03-0.48206E-03-0.45571E-03-0.43418E-03-0.42616E-03-0.42750E-03-0.42817E-03-0.43064E-03-0.45732E-03-0.47994E-03
35 -0.56711E-03-0.51320E-03-0.48140E-03-0.45457E-03-0.43370E-03-0.42736E-03-0.42426E-03-0.43025E-03-0.43141E-03-0.45698E-03
36 -0.63116E-03-0.56578E-03-0.51115E-03-0.48152E-03-0.45764E-03-0.43200E-03-0.42856E-03-0.42328E-03-0.42974E-03-0.43324E-03
21 22 23 24 25 26 27 28 29 30
1 -0.43767E-03-0.45270E-03-0.48506E-03-0.50719E-03-0.57165E-03-0.62714E-03-0.72967E-03-0.84157E-03-0.10238E-02-0.12965E-02
2 -0.42579E-03-0.43394E-03-0.45525E-03-0.48323E-03-0.50849E-03-0.57049E-03-0.62601E-03-0.73060E-03-0.84305E-03-0.10215E-02
3 -0.42515E-03-0.43067E-03-0.43092E-03-0.45587E-03-0.48273E-03-0.50847E-03-0.57106E-03-0.62586E-03-0.73066E-03-0.84455E-03
4 -0.42723E-03-0.42733E-03-0.43048E-03-0.43424E-03-0.45286E-03-0.48517E-03-0.50836E-03-0.57066E-03-0.62540E-03-0.72949E-03
5 -0.43571E-03-0.42575E-03-0.42370E-03-0.42754E-03-0.43692E-03-0.45309E-03-0.48364E-03-0.50711E-03-0.57095E-03-0.62859E-03
6 -0.45282E-03-0.43587E-03-0.42782E-03-0.42560E-03-0.42547E-03-0.43520E-03-0.45372E-03-0.48689E-03-0.50689E-03-0.56625E-03
7 -0.48400E-03-0.45452E-03-0.43561E-03-0.42507E-03-0.42626E-03-0.42430E-03-0.43761E-03-0.45122E-03-0.48671E-03-0.51059E-03
8 -0.50879E-03-0.48420E-03-0.45278E-03-0.43581E-03-0.42695E-03-0.42818E-03-0.42538E-03-0.43417E-03-0.45377E-03-0.48394E-03
9 -0.56920E-03-0.51021E-03-0.48277E-03-0.45392E-03-0.43423E-03-0.42710E-03-0.42322E-03-0.42859E-03-0.43356E-03-0.45552E-03
10 -0.62811E-03-0.56800E-03-0.51044E-03-0.48536E-03-0.45297E-03-0.43338E-03-0.42866E-03-0.42647E-03-0.42660E-03-0.43244E-03
11 -0.72311E-03-0.62790E-03-0.56928E-03-0.50782E-03-0.48613E-03-0.45280E-03-0.43487E-03-0.42692E-03-0.42271E-03-0.43027E-03
12 -0.84395E-03-0.72801E-03-0.62940E-03-0.56729E-03-0.50711E-03-0.48613E-03-0.43559E-03-0.42322E-03-0.43053E-03-0.42158E-03
13 -0.10234E-02-0.84192E-03-0.72800E-03-0.62902E-03-0.57135E-03-0.50677E-03-0.48254E-03-0.45451E-03-0.43452E-03-0.42837E-03
14 -0.12944E-02-0.10272E-02-0.84172E-03-0.72807E-03-0.62734E-03-0.57012E-03-0.50902E-03-0.43447E-03-0.45522E-03-0.43372E-03
15 -0.16699E-02-0.12946E-02-0.10232E-02-0.84404E-03-0.72813E-03-0.62853E-03-0.56873E-03-0.50875E-03-0.48294E-03-0.45611E-03
16 -0.23381E-02-0.16702E-02-0.12969E-02-0.10232E-02-0.84420E-03-0.72938E-03-0.62730E-03-0.56856E-03-0.50845E-03-0.48317E-03
17 -0.35930E-02-0.23364E-02-0.16699E-02-0.12965E-02-0.10225E-02-0.84208E-03-0.73139E-03-0.62795E-03-0.56896E-03-0.50917E-03
18 -0.63432E-02-0.35030E-02-0.23369E-02-0.16704E-02-0.12967E-02-0.10243E-02-0.83984E-03-0.73003E-03-0.62831E-03-0.56893E-03
19 -0.97835E-02-0.63424E-02-0.35928E-02-0.23366E-02-0.16700E-02-0.12949E-02-0.10267E-02-0.84261E-03-0.72785E-03-0.62807E-03
20 -0.10410E-02-0.63427E-02-0.35932E-02-0.23369E-02-0.16715E-02-0.12925E-02-0.10246E-02-0.84402E-03-0.72813E-03
21 -0.27090E-02-0.10410E-02-0.97833E-02-0.63424E-02-0.35925E-02-0.23349E-02-0.16733E-02-0.12962E-02-0.10228E-02-0.84415E-03
22 -0.10410E-02-0.27090E-02-0.10410E-02-0.97839E-02-0.63428E-02-0.35940E-02-0.23357E-02-0.16698E-02-0.12960E-02-0.10219E-02
23 -0.97833E-02-0.10410E-02-0.27090E-02-0.10410E-02-0.97833E-02-0.63428E-02-0.35933E-02-0.23365E-02-0.16691E-02-0.12987E-02
24 -0.63424E-02-0.97839E-02-0.10410E-02-0.27090E-02-0.10410E-02-0.97845E-02-0.63427E-02-0.35932E-02-0.23379E-02-0.16693E-02
25 -0.35925E-02-0.63428E-02-0.97833E-02-0.10410E-02-0.27089E-02-0.10410E-02-0.97819E-02-0.63432E-02-0.35927E-02-0.23376E-02
26 -0.23343E-02-0.35940E-02-0.63428E-02-0.97845E-02-0.10410E-02-0.27089E-02-0.10410E-02-0.97815E-02-0.63459E-02-0.35899E-02
27 -0.16733E-02-0.23357E-02-0.35926E-02-0.63427E-02-0.97819E-02-0.10410E-02-0.27090E-02-0.10410E-02-0.97814E-02-0.63455E-02
28 -0.12962E-02-0.16698E-02-0.23365E-02-0.35932E-02-0.63432E-02-0.97815E-02-0.10410E-02-0.27090E-02-0.10410E-02-0.97811E-02
29 -0.10228E-02-0.12960E-02-0.16691E-02-0.23379E-02-0.35927E-02-0.63459E-02-0.97814E-02-0.10410E-02-0.27090E-02-0.10410E-02
30 -0.84415E-03-0.10219E-02-0.12987E-02-0.16693E-02-0.23376E-02-0.35939E-02-0.63455E-02-0.97811E-02-0.10410E-02-0.27090E-02
31 -0.72954E-03-0.84593E-03-0.10199E-02-0.12958E-02-0.16717E-02-0.23374E-02-0.35917E-02-0.63431E-02-0.97846E-02-0.10410E-02
32 -0.62600E-03-0.72622E-03-0.84002E-03-0.10207E-02-0.12951E-02-0.16701E-02-0.23390E-02-0.35919E-02-0.63407E-02-0.97854E-02
33 -0.56754E-03-0.62818E-03-0.72629E-03-0.84748E-03-0.10220E-02-0.12963E-02-0.16694E-02-0.23380E-02-0.35941E-02-0.63408E-02
34 -0.50987E-03-0.57176E-03-0.62711E-03-0.72770E-03-0.84564E-03-0.10208E-02-0.12960E-02-0.16704E-02-0.23374E-02-0.35944E-02
35 -0.48360E-03-0.50899E-03-0.56797E-03-0.62886E-03-0.72558E-03-0.84816E-03-0.10209E-02-0.12954E-02-0.16700E-02-0.23361E-02
36 -0.45526E-03-0.48134E-03-0.51261E-03-0.56646E-03-0.63044E-03-0.72506E-03-0.84681E-03-0.10238E-02-0.12951E-02-0.16698E-02
31 32 33 34 35 36
1 -0.16694E-02-0.23378E-02-0.35930E-02-0.63421E-02-0.97853E-02-0.10410E-02
2 -0.12977E-02-0.16694E-02-0.23386E-02-0.35899E-02-0.63420E-02-0.97871E-02
3 -0.10209E-02-0.12969E-02-0.16683E-02-0.23398E-02-0.35931E-02-0.63404E-02

APPENDIX D
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.

A U G M A T

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117			WAS CREATED BY BUFFERED FORTRAN WRITE
118			STATEMENTS, OTHERWISE FALSE
119			
120	SYMCON	L	TRUE IF TRANSLATIONAL CONSTRAINTS MUST BE
121			APPLIED TO STRUCTURAL NODES DUE TO
122			SYMMETRY CONDITIONS IF HALF OR QUARTER
123			MODELS ARE BEING USED, OTHERWISE FALSE.
124			CONSTRAINTS ON ROTATIONAL STRUCTURAL
125			FREEDOMS DO NOT ENTER THE AUGMENTED
126			MATRICES. CONSTRAINTS MUST BE APPLIED ONLY
127			IF NOICOS = 0 (SEE BELOW)
128			
129	PRTAUG	L	TRUE IF AUGMENTED FORM OF MATRICES
130			APPEARING IN THE FLUID EQUATIONS ARE TO BE
131			PRINTED IN FULL, OTHERWISE FALSE IN WHICH
132			CASE ONLY THE MATRIX MASTER RECORD AND THE
133			DIAGONAL TERMS ARE PRINTED, THE FIRST
134			MATRIX SHOWN IS THE INVERSE FORM OF THE
135			STRUCTURAL MASS AND IT IS THE ONLY SPARSE
136			MATRIX IN THE FLUID EQUATIONS, HENCE A MAP
137			OF ITS CONNECTIVITY IS ALWAYS SHOWN. THE
138			NEXT MATRIX IS A COMBINATION OF BOTH THE
139			FLUID AND STRUCTURE INVERSE MASS MATRICES.
140			FOR DAA2 RUNS TWO ADDITIONAL MATRICES
141			APPEAR THAT INVOLVE ONLY THE FLUID MASS
142			INVERSE. THE FIRST COMES DIRECTLY FROM THE
143			DAA1 EQUATION WHILE THE SECOND IS ITS
144			ITERATED FORM THAT APPEARS IN THE DAA2
145			EQUATION. IT IS RECOMMENDED THAT A VALUE
146			OF FALSE BE USED UNDER NORMAL CONDITIONS
147			
148	PRTGMT	L	TRUE IF FLUID MESH GEOMETRY DATA IS TO BE
149			LISTED, OTHERWISE FALSE
150			
151	PRTTRN	L	TRUE IF FLUID-STRUCTURE TRANSFORMATION
152			DATA IS TO BE LISTED, OTHERWISE FALSE
153			
154	PRTSTF	L	TRUE IF SKYLINE STRUCTURAL STIFFNESS
155			MATRIX IS TO BE DISPLAYED, OTHERWISE
156			FALSE. WHEN INTERFACING WITH STAGS THIS
157			VARIABLE MUST ALWAYS BE TAKEN AS FALSE
158			SINCE THE GLOBAL STIFFNESS OPERATOR DOES
159			NOT EXIST IN THE SAME FORM AS THAT FOR USA
160			IN THE STAND ALONE CONFIGURATION
161			
162	DAA2	E,F	A PARAMETER BOUNDED BY ZERO AND UNITY THAT
163			GOVERNS THE USE OF THE IMPROVED DOUBLY
164			ASYMPTOTIC APPROXIMATION. A VALUE OF ZERO
165			REDUCES THE FLUID SOLUTION TO THE STANDARD
166			DOUBLY ASYMPTOTIC APPROXIMATION, HOWEVER A
167			PRECISE CHOICE FOR THIS PARAMETER IS NOT
168			GIVEN BY ANY FUNDAMENTAL PRINCIPLE. IT HAS
169			BEEN OBSERVED THAT A VALUE OF 1.0 LEADS TO
170			THE BEST ACCURACY FOR A SPHERICAL SHELL
171			WHILE A VALUE OF 0.5 SEEMS TO BE BEST FOR
172			THE INFINITE CYLINDRICAL SHELL. IT CAN BE
173			SHOWN THAT THIS SCALAR PARAMETER DOES HAVE
174			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 RERUN
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 PRI 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

233 FLUID-STRUCTURE CONTACT BOUNDARY
 234 3 - LOCAL COORDINATES WITH THE THIRD
 235 DEGREE OF FREEDOM NORMAL TO THE
 236 FLUID-STRUCTURE CONTACT BOUNDARY
 237
 238 AT THIS TIME OPTIONS 1, 2, OR 3 MAY BE
 239 USED ONLY FOR RIGHT CIRCULAR CYLINDERS OR
 240 SPHERES. MORE LATITUDE IN THESE CHOICES IS
 241 ULTIMATELY PLANNED. FOR USAGE WITH STAGS A
 242 VALUE OF 0 MUST ALWAYS BE USED AS STAGS
 243 CARRIES OUT ITS OWN GLOBAL TO LOCAL
 244 TRANSFORMATION. GLOBAL COORDINATES ARE
 245 AUTOMATICALLY SET IN THIS PROCESSOR FOR
 246 ALL SURFACE OF REVOLUTION FLUID ELEMENTS
 247
 248 FIRST OF ONE OR MORE FLUID ELEMENTS HAVING
 249 THE SAME VALUE OF NOICOS
 250
 251 LAST OF ONE OR MORE FLUID ELEMENTS HAVING
 252 THE SAME VALUE OF NOICOS
 253
 254 INCREMENT TO BE APPLIED IN ASSIGNING THE
 255 VALUE OF NOICOS TO FLUID ELEMENTS IN THE
 256 RANGE FROM JSTART TO JSTOP
 257
 258 NUMBER OF DATA SETS REQUIRED TO DEFINE THE
 259 CONSTRAINTS TO BE APPLIED TO TRANSLATIONAL
 260 STRUCTURAL DEGREES OF FREEDOM DUE TO
 261 SYMMETRY CONDITIONS. THESE CONSTRAINTS
 262 NEED BE APPLIED ONLY TO STRUCTURAL NODES
 263 ON THE WET SURFACE
 264
 265 I WILL HAVE THE VALUE 1, 2, OR 3 DEPENDING
 266 UPON WHETHER THE TRANSLATIONAL CONSTRAINT
 267 IS TO BE APPLIED IN THE X, Y, OR Z GLOBAL
 268 COORDINATE DIRECTION. ONLY ONE CONSTRAINT
 269 IS ALLOWABLE AT A STRUCTURAL NODE AT THIS
 270 TIME HOWEVER THIS LIMITATION IS NOT
 271 PARTICULARLY RESTRICTIVE. CONSTRAINTS TO
 272 THE AUGMENTED MATRICES ARE REQUIRED ONLY
 273 IF A FLUID ELEMENT ASSOCIATED WITH A
 274 PARTICULAR STRUCTURAL NODE IS ORIENTED
 275 SUCH THAT THE UNIT OUTWARD NORMAL VECTOR
 276 OF THE FLUID ELEMENT HAS A COMPONENT
 277 PERPENDICULAR TO THE SYMMETRY PLANE. FOR
 278 EXAMPLE, A QUARTER CYLINDER MODEL WOULD
 279 REQUIRE A CIRCUMFERENTIAL CONSTRAINT BUT
 280 NOT AN AXIAL ONE
 281
 282 FIRST OF ONE OR MORE STRUCTURAL NODES
 283 HAVING THE SAME VALUE OF ICON
 284
 285 LAST OF ONE OR MORE STRUCTURAL NODES
 286 HAVING THE SAME VALUE OF ICON
 287
 288 INCREMENT TO BE APPLIED IN ASSIGNING THE
 289 VALUE OF ICON TO STRUCTURAL NODES IN THE
 290 RANGE FROM NSTART TO NSTOP

```

291          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          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          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          I      INDEX OF FIRST MATRIX VALUE RECORD TO BE
313          DISPLAYED. UNDER NORMAL CONDITIONS USE A
314          VALUE OF ZERO AND THE CODE WILL START THE
315          DISPLAY AT THE BEGINNING OF THE MATRIX.
316          USE A NON-ZERO VALUE ONLY WHEN A SPECIFIC
317          SET OF BLOCKS IS TO BE PRINTED FOR SOME
318          DIAGNOSTIC REASON
319
320          I      INDEX OF LAST MATRIX VALUE RECORD TO BE
321          DISPLAYED. UNDER NORMAL CONDITIONS USE A
322          VALUE OF ZERO AND THE CODE WILL DISPLAY TO
323          THE END OF THE MATRIX. USE A NON-ZERO
324          VALUE ONLY WHEN A SPECIFIC SET OF BLOCKS
325          IS TO BE PRINTED FOR SOME DIAGNOSTIC
326          REASON
327
328          * * * * * " * * * * * * * * * * * * * * * * *
329          I N P U T   D A T A       C A R D   D E C K
330
331          * * * * *
332
333          ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
334          IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD
335          ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
336          FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
337          EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
338          CHARACTERS MAY BE USED FOR CDC OPERATION
339
340          GENERAL PROBLEM DEFINITION (MAIN PROGRAM PREPROC):
341          -----
342
343          72 COLUMN ALPHANUMERIC TITLE
344          STRNAM      FLUNAM              GEONAM              PRENAM
345          FRWTST     SYMCON    PRTAUG
346          PRTGMT     PRTRTN    PRTSTF
347          DAA2
348          NSFR      NSFR      NFRE      NFTR

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349      MXWD
350
351      IF PRISTF = .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 PRISTF = .TRUE. INCLUDE THE FOLLOWING CARDS
377
378      PRTPNT  PRIVAL  NAPVAL
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 C) 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 during the STAGS1 preprocessing. 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 various fluid matrices may then be displayed. 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.

The following input and output for the infinite circular cylindrical shell problem contain some minor differences due to the fact that the input is appropriate to the standard CDC or UNIVAC USA-STAGS version 3 whereas the output is from the VAX virtual memory machine. The basic reason for this is that the VAX version does not explicitly process the fluid equation system in a multi-block, out-of-core mode in contrast to the CDC and UNIVAC versions. In addition, permanent file naming conventions differ slightly; however it is anticipated that these differences should not prove to be a difficulty for the user.

	AUGMAT RUN FOR INFINITE CYLINDER SIMULATION				
	STG*CYLMAS	CYL*DAAM		CYL*GEOM	CYL*PREP
1					
2	T	F	F		
3	T	T	F		
4					
5	O				
6	72	432	6	3	
7	448				
8	1				
9	O	1	36	1	

AUGMAT RUN FOR INFINITE CYLINDER SIMULATION

USER OPTIONS FOR THIS RUN:

FRUITGE F FRUITST T FRUITFL F
 FLUSKY F DAAFRM F SYMCOM F
 PRIGMT T PRTRN T PRSTF F

THIS IS A DAA1 RUN

+++ OPEN, 14 = CYL.GEO , Acc= DIRECT , Stat= OLD

FLUID MASS DENSITY = 0.1000000E+01

FLUID SOUND SPEED = 0.1000000E+01

2628 WORDS OF STORAGE REQUIRED FOR THIS RUN

+++ OPEN, 16 = CYL.PRE Acc= DIRECT , Stat= NEW

+++++
 + AUXILIARY STORAGE TABLE +
 ++++++
 +
 +LDI Ext-filnam Unit EC Opt PRU Cdlac Next Limit Read Written +
 + 12 CYL.GEO 14 1 AX 64 19 10000 100000 763 0 +
 + 14 CYL.PRE 16 1 UPR 64 4 0 100000 0 0 +
 +
 + 2 Active devices (0 full)
 + 0 To ops, 0 Writes, 13 Reads 763 Words XFD +
 ++++++

+++ CLOSE, 14

FLUID MESH GEOMETRIC ARRAYS:

N	NTRA	X	Y	Z	NX	NY	NZ	AOO
1	2	0.1000000E+01	0.0000000E+00	0.0000000E+00	0.1000000E+01	0.0000000E+00	0.0000000E+00	0.30504508E-01
2	2	0.98480773E+00	0.17364818E+00	0.0000000E+00	0.98480773E+00	0.17364818E+00	0.0000000E+00	0.30504508E-01

3	2	0.93969262E+00	0.34202012E+00	0.00000000E+00	0.93969262E+00	0.34202012E+00	0.00000000E+00	0.30594508E-01
4	2	0.86602539E+00	0.50000000E+00	0.00000000E+00	0.86602539E+00	0.50000000E+00	0.00000000E+00	0.30504508E-01
5	2	0.76604444E+00	0.64278758E+00	0.00000000E+00	0.76604444E+00	0.64278758E+00	0.00000000E+00	0.30504508E-01
6	2	0.64278758E+00	0.76604444E+00	0.00000000E+00	0.64278758E+00	0.76604444E+00	0.00000000E+00	0.30504508E-01
7	2	0.49999997E+00	0.86602545E+00	0.00000000E+00	0.49999997E+00	0.86602545E+00	0.00000000E+00	0.30504508E-01
8	2	0.34202015E+00	0.93969262E+00	0.00000000E+00	0.34202015E+00	0.93969262E+00	0.00000000E+00	0.30504508E-01
9	2	0.17364822E+00	0.98480773E+00	0.00000000E+00	0.17364822E+00	0.98480773E+00	0.00000000E+00	0.30504508E-01
10	2	0.75669959E-07	0.10000000E+01	0.00000000E+00	0.75669959E-07	0.10000000E+01	0.00000000E+00	0.30504508E-01
11	2	0.17364819E+00	0.98480773E+00	0.00000000E+00	0.17364819E+00	0.98480773E+00	0.00000000E+00	0.30504508E-01
12	2	0.34202012E+00	0.93969262E+00	0.00000000E+00	0.34202012E+00	0.93969262E+00	0.00000000E+00	0.30504508E-01
13	2	0.50000006E+00	0.86602539E+00	0.00000000E+00	0.50000006E+00	0.86602539E+00	0.00000000E+00	0.30504508E-01
14	2	0.64278764E+00	0.76604444E+00	0.00000000E+00	0.64278764E+00	0.76604444E+00	0.00000000E+00	0.30504508E-01
15	2	0.76604444E+00	0.64278764E+00	0.00000000E+00	0.76604444E+00	0.64278764E+00	0.00000000E+00	0.30504508E-01
16	2	0.86602539E+00	0.50000006E+00	0.00000000E+00	0.86602539E+00	0.50000006E+00	0.00000000E+00	0.30504508E-01
17	2	0.93969262E+00	0.34202012E+00	0.00000000E+00	0.93969262E+00	0.34202012E+00	0.00000000E+00	0.30504508E-01
18	2	0.98480773E+00	0.17364830E+00	0.00000000E+00	0.98480773E+00	0.17364830E+00	0.00000000E+00	0.30504508E-01
19	2	0.10000000E+01	0.15087426E-06	0.00000000E+00	0.10000000E+01	0.15087426E-06	0.00000000E+00	0.30504508E-01
20	2	0.98480779E+00	0.17364800E+00	0.00000000E+00	0.98480779E+00	0.17364800E+00	0.00000000E+00	0.30504508E-01
21	2	0.93969262E+00	0.34202015E+00	0.00000000E+00	0.93969262E+00	0.34202015E+00	0.00000000E+00	0.30504508E-01
22	2	0.86602539E+00	0.49999997E+00	0.00000000E+00	0.86602539E+00	0.49999997E+00	0.00000000E+00	0.30504508E-01
23	2	0.76604450E+00	0.64278758E+00	0.00000000E+00	0.76604450E+00	0.64278758E+00	0.00000000E+00	0.30504508E-01
24	2	0.64278758E+00	0.76604426E+00	0.00000000E+00	0.64278758E+00	0.76604426E+00	0.00000000E+00	0.30504508E-01
25	2	0.49999991E+00	0.86602545E+00	0.00000000E+00	0.49999991E+00	0.86602545E+00	0.00000000E+00	0.30504508E-01
26	2	0.34202006E+00	0.93969262E+00	0.00000000E+00	0.34202006E+00	0.93969262E+00	0.00000000E+00	0.30504508E-01
27	2	0.17364813E+00	0.98480779E+00	0.00000000E+00	0.17364813E+00	0.98480779E+00	0.00000000E+00	0.30504508E-01
28	2	0.11924880E-07	0.10000000E+01	0.00000000E+00	0.11924880E-07	0.10000000E+01	0.00000000E+00	0.30504508E-01
29	2	0.17364815E+00	0.98480773E+00	0.00000000E+00	0.17364815E+00	0.98480773E+00	0.00000000E+00	0.30504508E-01
30	2	0.34202009E+00	0.93969262E+00	0.00000000E+00	0.34202009E+00	0.93969262E+00	0.00000000E+00	0.30504508E-01
31	2	0.49999991E+00	0.86602545E+00	0.00000000E+00	0.49999991E+00	0.86602545E+00	0.00000000E+00	0.30504508E-01
32	2	0.64278752E+00	0.76604450E+00	0.00000000E+00	0.64278752E+00	0.76604450E+00	0.00000000E+00	0.30504508E-01
33	2	0.76604432E+00	0.64278775E+00	0.00000000E+00	0.76604432E+00	0.64278775E+00	0.00000000E+00	0.30504508E-01
34	2	0.86602533E+00	0.50000018E+00	0.00000000E+00	0.86602533E+00	0.50000018E+00	0.00000000E+00	0.30504508E-01
35	2	0.93969256E+00	0.34202036E+00	0.00000000E+00	0.93969256E+00	0.34202036E+00	0.00000000E+00	0.30504508E-01
36	2	0.98480773E+00	0.17364845E+00	0.00000000E+00	0.98480773E+00	0.17364845E+00	0.00000000E+00	0.30504508E-01

LOCAL FLUID-STRUCTURE TRANSFORMATION COEFFICIENTS:

NFLU	NSTR
1	1 0.50000E+00 0.50000E+00 37
2	2 0.50000E+00 0.50000E+00 38
3	3 0.50000E+00 0.50000E+00 39
4	4 0.50000E+00 0.50000E+00 40
5	5 0.50000E+00 0.50000E+00 41
6	6 0.50000E+00 0.50000E+00 42

7	7	43	0.50000E+00	0.50000E+00
8	8	44	0.50000E+00	0.50000E+00
9	9	45	0.50000E+00	0.50000E+00
10	10	46	0.50000E+00	0.50000E+00
11	11	47	0.50000E+00	0.50000E+00
12	12	48	0.50000E+00	0.50000E+00
13	13	49	0.50000E+00	0.50000E+00
14	14	50	0.50000E+00	0.50000E+00
15	15	51	0.50000E+00	0.50000E+00
16	16	52	0.50000E+00	0.50000E+00
17	17	53	0.50000E+00	0.50000E+00
18	18	54	0.50000E+00	0.50000E+00
19	19	55	0.50000E+00	0.50000E+00
20	20	56	0.50000E+00	0.50000E+00
21	21	57	0.50000E+00	0.50000E+00
22	22	58	0.50000E+00	0.50000E+00
23	23	59	0.50000E+00	0.50000E+00
24	24	60	0.50000E+00	0.50000E+00
25	25	61	0.50000E+00	0.50000E+00
26	26	62	0.50000E+00	0.50000E+00
27	27	63	0.50000E+00	0.50000E+00
28	28	64	0.50000E+00	0.50000E+00
29	29	65	0.50000E+00	0.50000E+00
30	30	66	0.50000E+00	0.50000E+00
31	31	67	0.50000E+00	0.50000E+00
32	32	68	0.50000E+00	0.50000E+00

33 0.5000E+00 0.5000E+00
33 69
34 0.5000E+00 0.5000E+00
34 70
35 0.5000E+00 0.5000E+00
35 71
36 0.5000E+00 0.5000E+00
36 72
0.5000E+00 0.5000E+00

FLUID ELEMENT LETTED FREEDOM INDICATOR:

1	2	3	4	5	6	7	8	9	10
0	0	0	0	0	0	0	0	0	0
11	12	13	14	15	16	17	18	19	20
0	0	0	0	0	0	0	0	0	0
21	22	23	24	25	26	27	28	29	30
0	0	0	0	0	0	0	0	0	0
31	32	33	34	35	36				
0	0	0	0	0	0				

GENERALIZED FLUID AREAS:

1	2	3	4	5	6	7	8	9	10
0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01
11	12	13	14	15	16	17	18	19	20
0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01
21	22	23	24	25	26	27	28	29	30
0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01
31	32	33	34	35	36				
0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01	0.3050E-01				

+++ OPEN, 2 = CYL.USD

+++ Form = UNFORMATTED

, Acc= SEQUENT, Stat= OLD

DIAGONAL STRUCTURAL MASS MATRIX:

1	2	3	4	5	6	7	8	9	10
0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06
11	12	13	14	15	16	17	18	19	20
0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02
21	22	23	24	25	26	27	28	29	30
0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06
31	32	33	34	35	36	37	38	39	40
0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06
41	42	43	44	45	46	47	48	49	50
0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02
51	52	53	54	55	56	57	58	59	60

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311	312	313	314	315	316	317	318	319	320
0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02
321	322	323	324	325	326	327	328	329	330
0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06
331	332	333	334	335	336	337	338	339	340
0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06
341	342	343	344	345	346	347	348	349	350
0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02
351	352	353	354	355	356	357	358	359	360
0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06
361	362	363	364	365	366	367	368	369	370
0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06
371	372	373	374	375	376	377	378	379	380
0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02
381	382	383	384	385	386	387	388	389	390
0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06
391	392	393	394	395	396	397	398	399	400
0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06
401	402	403	404	405	406	407	408	409	410
0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02
411	412	413	414	415	416	417	418	419	420
0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06
421	422	423	424	425	426	427	428	429	430
0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06	0.57841E-06	0.28534E-06	0.11973E-02	0.11973E-02	0.11973E-02	0.58291E-06
431	432								
0.57841E-06	0.28534E-06								

0.57841E-06 0.28534E-06

STRUCTURAL GRID POINT NUMBERS ASSOCIATED WITH INTERNAL SEQUENCE NUMBERS:

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

71 72

GRID POINT AND FREEDOM NUMBER FOR EACH ROW OF STIFFNESS MATRIX:

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	21	22	23	24
11	12	13	14	15	16	17	18	19	20
25	26	31	32	33	34	35	36	41	42
21	22	23	24	25	26	27	28	29	30
43	44	45	46	51	52	53	54	55	56
31	32	33	34	35	36	37	38	39	40
61	62	63	64	65	66	71	72	73	74
41	42	43	44	45	46	47	48	49	50
75	76	81	82	83	84	85	86	91	92
51	52	53	54	55	56	57	58	59	60
93	94	95	96	101	102	103	104	105	106
61	62	63	64	65	66	67	68	69	70
111	112	113	114	115	116	121	122	123	124
71	72	73	74	75	76	77	78	79	80
125	126	131	132	133	134	135	136	141	142
81	82	83	84	85	86	87	88	89	90
143	144	145	146	151	152	153	154	155	156
31	32	33	34	35	36	37	38	39	40
161	162	163	164	165	166	171	172	173	174
101	102	103	104	105	106	107	108	109	110
175	176	181	182	183	184	185	186	191	192
111	112	113	114	115	116	117	118	119	120
193	194	195	196	201	202	203	204	205	206
121	122	123	124	125	126	127	128	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	148	149	150
243	244	245	246	251	252	253	254	255	256
151	152	153	154	155	156	157	158	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

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								

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+++ CLOSE, 2
+++ OPEN, 12 = CYL.FLU , Acc= DIRECT , Stat= OLD
+++ CLOSE, 12

+++++
+ AUXILIARY STORAGE TABLE +
+++++
+
+LDI Ext-filnam Unit EC Opt PRU Cdlloc Next Limit Read Written +
+ 14 CYL.PRE 16 1 UPR 64 4 42 100000 73 2469 +
+
+ 1 Active devices ( 0 full)
+ 0 To ops, 9 Writes, 16 Reads 4601 Words XFD
+++++
+++ CLOSE, 16

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SUMMARY OF DATA STORED ON PERMANENT FILE
*** CYL.PRE ***

RECORD	RECORD DESCRIPTION	SECTOR LOCATION	NUMBER OF WORDS
1	FILE LIBRARY DATA	0	253
2	FLUID GEOMETRY AND TRANSFORMATION DATA	4	540
3	GENERALIZED FLUID AREAS	13	36
4	FREEDOM/EQUATION CORRESPONDENCE TABLE	14	432
5	DIAGONAL STRUCTURAL MASS INV	21	432
6	DIAGONAL POINTERS FOR DAA STRUCTURAL MASS INV	28	37
7	SKYLINE ENTRIES FOR DAA STRUCTURAL MASS INV	29	36
8	DIAGONAL POINTERS FOR DAA VIRTUAL MASS INV	30	37
9	SKYLINE ENTRIES FOR DAA VIRTUAL MASS INV	31	666

APPENDIX E
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.

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T I M I N T

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, 3251 HANOVER ST., PALO ALTO, CALIF. 94304 OR CALL 415-493-4411 EXT. 45069 OR 45133.

SEPTEMBER, 1980

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

MAXIMUM NUMBER OF INPUT PRESSURE DATA POINTS:

INFINITE FLUID 4 0 2
FREE SURFACE PROBLEM 2 0 1

MAXIMUM NUMBER OF CUBIC SPLINE TIME POINTS:

INFINITE FLUID 1 0 2
FREE SURFACE PROBLEM 5 1

MAXIMUM NUMBER OF DIFFERENT TIME STEP SIZES

MAXIMUM NUMBER OF PREVIOUS RESPONSE FILES 1 0

MAXIMUM NUMBER OF TRANSIENT RESPONSE DISPLAYS 9

1 0 0

R U N T I M E I N F O R M A T I O N

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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:

NSTEP	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
	$TCPU = TPRE + NTINC * (TFS + TFF) + NSTEP * (TAS + TAF) + TDISP$
TPRE	CPU TIME SPENT ON PRE-PROCESSING BEFORE TIME INTEGRATION COMMENCES
	$TPRE = 1000 * CS * (NSFR + NFLU)$
TFS	TIME REQUIRED TO FACTOR STRUCTURAL EQUATION SYSTEM
	$TFS = CS * NSFR * BRMS^{2/2}$
TAS	TIME REQUIRED FOR ADVANCEMENT OF ONE TIME STEP FOR STRUCTURAL SYSTEM
	$TAS = 3 * CS * NSFR * BAVE$
TFF	TIME REQUIRED TO FACTOR FLUID EQUATION SYSTEM
	$TFF = CS * NFLU^{3/6}$

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117 TAF      TIME REQUIRED FOR ADVANCEMENT OF ONE TIME STEP FOR
118 FLUID SYSTEM
119
120 TAF = CS*NFLU**2
121
122 TDISP     CPU TIME SPENT ON DISPLAY OF RESPONSE HISTORIES
123
124 TDISP = 500.*CS*NSTEP*NDISP
125
126 UNIT OPERATION CONSTANT IN SECONDS, CONSISTING OF A
127 FLOATING ADDITION, A FLOATING MULTIPLY, AND INDEXING
128
129 VALUES OF CONSTANT CS
130
131 OPERATING SYSTEM
132
133 PRECISION UNIVAC UNIVAC CDC
134          1108          1110          6600
135
136 SINGLE 5.5X10-6 3.2X10-6 1.5X10-6
137
138 DOUBLE 9.0X10-6 4.5X10-6 - - -
139
140 AT THIS TIME THE CODE OPERATES ONLY IN SINGLE
141 PRECISION
142
143 IN ADDITION TO BILLABLE CHARGES DUE TO EXECUTION OF THIS CODE
144 THERE WILL PROBABLY BE A DAILY CHARGE FOR PERMANENT FILE STORAGE.
145 RESPONSE AND RESTART FILES CREATED BY THIS CODE CAN BE EXTREMELY
146 LENGTHY HENCE SUCH OUTPUT FROM LARGE RUNS SHOULD BE TRANSFERRED TO
147 TAPE AT THE EARLIEST OPPORTUNITY TO MINIMIZE THESE CHARGES
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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.

WARNING FROM THE PROGRAMMER GENERAL

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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-DS 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
PRENAM	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

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

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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
DTTHIST	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
HYDPRE	E, F	VALUE OF HYDROSTATIC PRESSURE ACTING ON SUBMERGED STRUCTURE BEFORE SHOCK WAVE EXCITATION. THIS VARIABLE IS READ FOR USA-STAGS RUNS ONLY. IN THIS CASE A

291 STATIC ANALYSIS MUST FIRST BE PERFORMED
 292 WITH STAGS TO CREATE A RESIDUAL FILE
 293 CONTAINING THE DEFORMED INITIAL
 294 STRESS STATE THEN THE ANALYSIS ANALYSIS
 295 IS CARRIED OUT BY RESTARTING STAGS (REFER
 296 TO STAGS MANUAL FOR RESTART DETAILS)
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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. PNORM 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 DTHTST. 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

349	DELTIM	E.F	TIME STEP SIZE ASSOCIATED WITH STRTIM
350			ABOVE
351	FINTIM	E.F	TIME AT WHICH THE PRESENT ANALYSIS IS TO
352			BE TERMINATED
353	NSAVER	I	FREQUENCY OF SAVING SYSTEM RESPONSES ON
354			PERMANENT FILE POSNAM. NSAVER EXPRESSED IN
355			NUMBER OF TIME STEPS
356	NRESET	I	FREQUENCY OF SAVING RESTART INFORMATION
357			ON PERMANENT FILE RESNAM OR WRTNAM. NRESET
358			IS EXPRESSED IN NUMBER OF TIME STEPS
359	LOCBEG	I	LOCATION IN POSNAM FILE WHERE RESPONSES
360			FROM CURRENT RUN ARE TO BE PLACED. THIS
361			LOCATION IS MEASURED EITHER IN SECTORS
362			(28 WORDS) ON UNIVAC SYSTEMS OR PHYSICAL
363			RECORD UNITS (PRU OF 64 WORDS) ON CDC
364			HARDWARE. A ZERO VALUE IS THE DESIGNATION
365			OF THE BEGINNING OF THE FILE FOR EITHER
366			SYSTEM IN THIS CODE. IF LOCBEG = 0, A NEW
367			PERMANENT FILE IS ASSIGNED FOR THE RUN
368			WITH THE NAME DENOTED BY POSNAM, OTHERWISE
369			POSNAM IS TAKEN TO BE AN EXISTING FILE.
370			UNDER RESTART CONDITIONS THE APPROPRIATE
371			VALUE OF LOCBEG IS ASCERTAINED FROM
372			OUTPUT GENERATED DURING PRECEDING RUNS
373	LOCRES	I	LOCATION IN PERMANENT FILE RESNAM WHERE
374			RESTART DATA IS TO BE FOUND. SEE LOCBEG
375			FOR DEFINITION OF LOCATION. SET EQUAL TO
376			ZERO IF CURRENT RUN IS NOT A RESTART.
377			OTHERWISE APPROPRIATE VALUE OF LOCRES IS
378			ASCERTAINED FROM OUTPUT GENERATED DURING
379			PRECEDING RUNS
380	LOCWRT	I	LOCATION IN PERMANENT FILE RESNAM OR
381			WRTNAM WHERE NEW RESTART DATA GENERATED IN
382			THE CURRENT RUN IS TO BE WRITTEN. SEE
383			LOCBEG FOR DEFINITION OF LOCATION. IF
384			WRTNAM HAS BEEN LEFT BLANK (SEE ABOVE) THE
385			RESTART DATA IS WRITTEN ON THE SAME FILE
386			AS THAT CONTAINING THE DATA USED TO
387			RESTART THE CURRENT RUN. IN SUCH A CASE IT
388			IS IMPORTANT THAT LOCWRT BE CAREFULLY
389			CHOSEN SO THAT PREVIOUS DATA IS NOT
390			INADVERTENTLY OVERWRITTEN. AN APPROPRIATE
391			VALUE CAN BE FOUND FROM OUTPUT GENERATED
392			FROM PRECEDING RUNS. IF LOCWRT = ZERO, A
393			NEW PERMANENT FILE IS ASSIGNED FOR THE RUN
394			WITH THE NAME DENOTED BY WRTNAM, OTHERWISE
395			WRTNAM IS TAKEN TO BE AN EXISTING FILE
396	FORWRT	L	TRUE IF PERMANENT FILE DENOTED BY POSNAM
397			IS TO BE CREATED USING UNFORMATTED FORTRAN
398			WRITE. OTHERWISE FILE WILL BE CREATED BY
399			DIRECT TRANSFER USING THE DATA MANAGEMENT
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407			SYSTEM DMGASP	
408			TRUE IF SELECTED TRANSIENT RESPONSE	
409	DISPLA	L	HISTORIES ARE TO BE DISPLAYED. OTHERWISE	
410			FALSE	
411				
412				
413	NPREVT	I	NUMBER OF TIME STEPS PREVIOUSLY COMPUTED	
414			WITH RESPONSES SAVED IN PERMANENT FILE	
415			DENOTED BY POSNAM. NPREVT WILL BE NONZERO	
416			ONLY FOR RESTART RUNS BUT IT CAN BE ZERO	
417			UNDER RESTART CONDITIONS IF POSNAM DENOTES	
418			A NEW RESPONSE FILE. THE USE OF NPREVT	
419			ENSURES THAT ANY TRANSIENT RESPONSE	
420			DISPLAY MADE IN CONJUNCTION WITH THE TIME	
421			INTEGRATION RUN WILL INCLUDE THE ENTIRE	
422			HISTORY AVAILABLE FROM THAT FILE AND NOT	
423			JUST THE PORTION COMPUTED DURING THE	
424			CURRENT RUN. IF POSNAM CONTAINS THE	
425			COMPLETE TRANSIENT SOLUTION BACK TO TIME	
426			ZERO THEN NPREVT MUST BE THE NUMBER OF	
427			TIME STEPS PLUS ONE TO ACCOUNT FOR THE	
428			FACT THAT THE INITIAL CONDITIONS APPEAR IN	
429			THE FIRST RECORD. IF THIS RUN IS THE VERY	
430			FIRST OF A PARTICULAR SHOCK ANALYSIS THEN	
431			NPREVT WILL BE ZERO	
432				
433	NPREVF	I	NUMBER OF RESPONSE FILES FROM PREVIOUS	
434			RUNS THAT MAKE UP THE DESIRED TRANSIENT	
435			ANALYSIS DISPLAY. DO NOT ADD IN THE	
436			CURRENT RUN AS THIS IS DONE BY THE CODE.	
437			NPREVF PRESENTLY CANNOT EXCEED NINE (9)	
438				
439	NTIMES	I	THE NUMBER OF RESPONSE RECORDS THAT ARE	
440			STORED IN ANY PARTICULAR RESPONSE FILE.	
441			THESE MUST BE ORDERED CHRONOLOGICALLY FOR	
442			INPUT. NTIMES WILL GENERALLY BE THE NUMBER	
443			OF TIME STEPS MADE DURING THE TIME THE	
444			FILE WAS CREATED EXCEPT IF THE FILE GOES	
445			BACK TO TIME EQUAL TO ZERO. IN THIS CASE	
446			NTIMES IS EQUAL TO THE NUMBER OF TIME	
447			STEPS PLUS ONE TO ACCOUNT FOR THE FIRST	
448			RECORD THAT CONTAINS THE INITIAL	
449			CONDITIONS	
450	XVPNAM	A	NAMES OF PREVIOUS RESPONSE FILES THAT MAKE	
451			UP A CONTINUOUS SET OF TRANSIENT DATA.	
452			ORDERED CHRONOLOGICALLY. DO NOT INCLUDE	
453			POSNAM IN THIS LIST	
454				
455				
456				
457	LISTRE	L	TRUE IF TRANSIENT RESPONSE HISTORIES ARE	
458			TO BE LISTED IN TABULAR FORM. OTHERWISE	
459			FALSE	
460				
461	PRTPLT	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED	
462			FOR TRANSIENT RESPONSE HISTORIES.	
463			OTHERWISE FALSE	
464				

465	NWETHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER
466			DISPLACEMENTS OR VELOCITIES) TO BE
467			DISPLAYED FOR WHICH THE APPROPRIATE
468			STRUCTURAL FREEDOMS CAN BE IDENTIFIED
469			INTERNALLY THROUGH THE FREEDOM/EQUATION
470			CORRESPONDENCE TABLE. ALL STRUCTURAL NODES
471			WHICH PARTICIPATE IN THE FLUID-STRUCTURE
472			TRANSFORMATION WILL FALL INTO THIS
473			CATEGORY AS WELL AS ANY OTHERS WHOSE GRID
474			POINT COORDINATES WERE ENTERED AS DATA FOR
475			THE FLUID MASS PROCESSOR
476			
477			
478	NDRYHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER
479			DISPLACEMENTS OR VELOCITIES) TO BE
480			DISPLAYED FOR WHICH THE APPROPRIATE
481			STRUCTURAL FREEDOMS CANNOT BE IDENTIFIED
482			INTERNALLY THROUGH THE FREEDOM/EQUATION
483			CORRESPONDENCE TABLE. DRY STRUCTURE NODE
484			POINTS CAN FALL INTO THIS CATEGORY IF THE
485			USER DID NOT INCLUDE THEM IN THE DATA
486			STREAM FOR THE FLUID MASS PROCESSOR. IN
487			THIS CASE ONE MUST IDENTIFY THE INTERNAL
488			SEQUENCE NUMBER APPROPRIATE TO THE DESIRED
489			DEGREE OF FREEDOM BY A MYSTICAL PROCESS
490			WHICH INVOLVES THE INTIMATE KNOWLEDGE OF
491			THE ELIMINATION ORDER AND ANY REDUCTION
492			OF THE NUMBER OF ACTIVE FREEDOMS DUE TO
493			THE APPLICATION OF CONSTRAINTS. MORAL OF
494			THE STORY - RUN ALL STRUCTURAL GRID POINTS
495			THROUGH THE FLUID MASS PROCESSOR EVEN IF
496			THEY NEVER GET WET
497			
498	NUMSET	I	NUMBER OF DATA SETS USED TO DEFINE
499			RESPONSE DISPLAYS FOR SEVERAL DEGREES OF
500			FREEDOM THAT DIFFER BY A CONSTANT
501			INCREMENT. THIS FEATURE CAN BE USED TO
502			SIMPLIFY INPUT DATA TO SHOW A NUMBER OF
503			TRANSIENT RESULTS AT DIFFERENT PLACES
504			ALONG A GENERATOR OF A CYLINDER OR, AROUND
505			THE CIRCUMFERENCE AT ANY AXIAL STATION
506			
507	NODOUT	I	EXTERNAL IDENTIFICATION NUMBER OF
508			STRUCTURAL NODE FOR WHICH A TIME HISTORY
509			DISPLAY IS DESIRED
510			
511	NFROUT	I	STRUCTURAL DEGREE OF FREEDOM NUMBER FOR
512			WHICH A TIME HISTORY DISPLAY IS DESIRED
513			
514	NEQHST	I	INTERNAL SEQUENCE NUMBER DETERMINED BY
515			HAND FOR STRUCTURAL DEGREES OF FREEDOM
516			WHICH ARE TO BE DISPLAYED AND ARE NOT
517			INCLUDED IN THE FREEDOM/EQUATION
518			CORRESPONDENCE TABLE FOR REASONS KNOWN
519			ONLY TO THE USER
520	NODFIR	I	FIRST OF SEVERAL EQUALLY INCREMENTED NODE
521			NUMBERS AT WHICH OUTPUT IS DESIRED
522			

```

523 NODLAS      I      LAST OF SEVERAL EQUALLY INCREMENTED NODE
524          NUMBERS AT WHICH OUTPUT IS DESIRED
525
526 NODINC      I      INCREMENT TO BE APPLIED IN ASSIGNING NODE
527          NUMBERS FOR OUTPUT
528
529
530 NPREHS      I      NUMBER OF FLUID PRESSURE HISTORIES TO BE
531          DISPLAYED
532
533 NEOHPR      I      FLUID CONTROL POINT NUMBER FOR WHICH A
534          TIME HISTORY DISPLAY IS DESIRED FOR THE
535          TOTAL PRESSURE
536
537 SCALEF      L      TRUE IF MULTIPLICATIVE CONSTANT FACTORS
538          ARE TO BE APPLIED TO THE DISPLAYED VALUES
539          OF THE STRUCTURAL DISPLACEMENTS AND
540          VELOCITIES. TOTAL FLUID PRESSURES AND/OR
541          TIME, OTHERWISE FALSE. SUCH FACTORS ARE
542          NOT APPLIED TO THE PERMANENT FILES
543          CONTAINING THE RESPONSE HISTORIES
544
545 RESFAC      E,F     MULTIPLICATIVE LENGTH CONVERSION FACTOR TO
546          BE APPLIED TO THE DISPLAYED VALUES OF THE
547          STRUCTURAL DISPLACEMENT AND VELOCITY
548          HISTORIES
549
550 PREFAC      E,F     MULTIPLICATIVE PRESSURE CONVERSION FACTOR
551          TO BE APPLIED TO THE DISPLAYED VALUES OF
552          THE TOTAL PRESSURE HISTORIES
553
554 TIMFAC      E,F     MULTIPLICATIVE TIME CONVERSION FACTOR TO
555          BE APPLIED TO THE DISPLAYED VALUES OF THE
556          TIME AXIS FOR ALL THE TRANSIENT RESPONSE
557          HISTORIES
558
559
560
561
562
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564
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580

```

* * * * * I N P U T D A T A C A R D D E C K * * * * *

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

GENERAL PROBLEM DEFINITION (SUBROUTINE INPDAT):

```

72 COLUMN ALPHANUMERIC TITLE
PRENAM      POSNAM      STRNEW
RESNAM      YC          ZC
SX          SY          SZ
EXPWAV      SPLINE

```

```

581 JPHIST
582 PNORM HYDPRE
583
584 IF SPLINE = .FALSE. READ THE FOLLOWING CARD
585
586 DTHIST
587
588 IF EXPWAV = .FALSE. READ THE FOLLOWING CARDS
589
590 PHIST(1), I=1,JPHIST
591
592 IF EXPWAV = .TRUE. READ THE FOLLOWING CARD
593
594 PZERO DECAY
595
596 CURIC SPLINE INCIDENT PRESSURE HISTORY DATA (SUBROUTINE CSPRES):
597 -----
598 IF SPLINE = .TRUE. READ THE FOLLOWING CARDS
599
600 TIMES(1), I=1,JPHIST
601 PHIST(1), I=1,JPHIST
602
603 GENERAL PROBLEM DEFINITION (SUBROUTINE INPDAT):
604 -----
605
606 NTINT
607 STRTIM DELTIM )
608 ) TOTAL = NTINT
609 )
610
611 FINTM
612 NSAVR NRESET
613 LOCBEQ LOCRES LOCWRT
614 FORWRT
615
616 POST PROCESSING (SUBROUTINE POSTRE):
617 -----
618
619 DISPLA
620
621 IF DISPLA = .FALSE. THIS TERMINATES THE INPUT DATA DECK
622
623 NPREV NPREFV
624
625 IF NPREFV NOT = 0 READ THE FOLLOWING CARDS
626
627 NTIMES(1), I=1,NPREVF
628 XVFNAM(1), I=1,NPREVF
629
630 POST PROCESSING (SUBROUTINE RESDSP):
631 -----
632
633 LISTRE PRIPLT
634
635 POST PROCESSING (SUBROUTINE STRDSP):
636 -----
637
638 NWETHS NDRYHS NUMSET

```


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, USAS. 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 F for this sample problem.

The following input and output for the infinite circular cylindrical shell problem contain some minor differences due to the fact that the input is appropriate to the standard CDC or UNIVAC USA-STAGS version 3 whereas the output is from the VAX virtual memory machine. The basic reason for this is that the VAX version does not explicitly process the fluid equation system in a multi-block, out-of-core mode in contrast to the CDC and UNIVAC versions. In addition, permanent file naming conventions differ slightly; however it is anticipated that these differences should not prove to be a difficulty for the user.

STAGS1 PREPROCESSING FOR USA-STAGS RUNS. FULL CYLINDER

1	6	0	0	1	-1	\$	B-1
2	1	0	0	1	\$	B-2	
3	1	0	1	\$	B-2		
4	1	0	1	\$	E-3		
5	1						
6	0						
7	0	100	0	2			
8	0	1000		.05	.1		
9	0	1					
10	2	37	\$	F-1			
11	1	4	1	2	\$	G-1	
12	1	0	\$	I-1			
13	98	125	.3	0	7.85	\$	
14	1	1	1	\$	K-1		
15	1	.01					
16	5	4					
17	0	.1750		0	360	1	
18	0	0	0				
19	0	90	0				
20	1	0	0	0	1	\$	
21	410						
22	4	6	4	3	\$	P-1	
23	0						
24	0						

CLOSED SHELL CONDITION

BOUNDARY CONDITIONS

TIMINT RUN FOR INFINITE CYLINDER SIMULATION
 CYL*PREP
 CYL*REST
 CYL*POST

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

10000
 1.
 F
 2
 1.
 50.
 1.
 1.
 0.
 .25
 1
 1
 0
 F
 T
 T
 0
 T
 T
 2
 10
 10
 4
 1
 10
 10
 19
 3
 1
 10
 19
 F

<> CLOCK INITIALIZED ...

CASE TITLE READ FROM STAGS1 FILE

STAGS1 DATA FOR FULL CYLINDER

14 RECORDS READ FROM FT02
BLANK COMMON BUFFER DIMENSION (NSPACE)

DECIMAL HEX
60000 EA60

WORKING SPACE STORAGE ASSIGNMENTS

NEQ	VMBUFR	PAGESZ	NPAGE	FMBUFR	NLMDD	NUMTX	NSTIFF	MASSEM
216	11520	1280	9	48235	5003	9534	3	8

USAS RUN FOR INFINITE CYLINDER SIMULATION

```
+++ OPEN, 16 = DIRTY:CYL.PRE
, Acc= DIRECT , Stat= OLD
```

THIS IS A DAA1 RUN

CHARGE LOCATION DATA:

$$XC = 0.1000000E+05$$
$$YC = 0.000000E+00$$
$$ZC = 0.000000E+00$$
$$SC = 0.9399000E+04$$

PRESSURE HISTORY DATA: DTHIST = 0.5000000E+02

1 2
0.10000E+01 0.10000E+01

TIME STEP DATA:

N	TS	DT
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9
10	10	10
11	11	11
12	12	12
13	13	13
14	14	14
15	15	15
16	16	16
17	17	17
18	18	18
19	19	19
20	20	20
21	21	21
22	22	22
23	23	23
24	24	24
25	25	25
26	26	26
27	27	27
28	28	28
29	29	29
30	30	30
31	31	31
32	32	32
33	33	33
34	34	34
35	35	35
36	36	36
37	37	37
38	38	38
39	39	39
40	40	40
41	41	41
42	42	42
43	43	43
44	44	44
45	45	45
46	46	46
47	47	47
48	48	48
49	49	49
50	50	50
51	51	51
52	52	52
53	53	53
54	54	54
55	55	55
56	56	56
57	57	57
58	58	58
59	59	59
60	60	60
61	61	61
62	62	62
63	63	63
64	64	64
65	65	65
66	66	66
67	67	67
68	68	68
69	69	69
70	70	70
71	71	71
72	72	72
73	73	73
74	74	74
75	75	75
76	76	76
77	77	77
78	78	78
79	79	79
80	80	80
81	81	81
82	82	82
83	83	83
84	84	84
85	85	85
86	86	86
87	87	87
88	88	88
89	89	89
90	90	90
91	91	91
92	92	92
93	93	93
94	94	94
95	95	95
96	96	96
97	97	97
98	98	98
99	99	99
100	100	100

1	0.00000E+00	0.25000E-01
2	0.10000E+01	0.50000E-01
3	0.20000E+01	0.10000E+00
4	0.50000E+01	

INCIDENT PRESSURE AND PARTICLE VELOCITY:

	1	2	3	4	5	6	7	8	9	10
T	0.0000E+00	0.41667E+00	0.83333E+00	0.12500E+00	0.16667E+01	0.20833E+01	0.25000E+01	0.29167E+01	0.33333E+01	0.37500E+01
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10000E+01	0.10000E+01	0.10001E+01	0.10001E+01	0.10002E+01	0.10002E+01	0.10002E+01	0.10003E+01	0.10003E+01	0.10004E+01

	11	12	13	14	15	16	17	18	19	20
T	0.41667E+01	0.45833E+01	0.50000E+01	0.54167E+01	0.58333E+01	0.62500E+01	0.66667E+01	0.70833E+01	0.75000E+01	0.79167E+01
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10004E+01	0.10005E+01	0.10005E+01	0.10005E+01	0.10005E+01	0.10006E+01	0.10007E+01	0.10007E+01	0.10008E+01	0.10008E+01

	21	22	23	24	25	26	27	28	29	30
T	0.83333E+01	0.87500E+01	0.91667E+01	0.95833E+01	0.10000E+02	0.10417E+02	0.10833E+02	0.11250E+02	0.11667E+02	0.12083E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10008E+01	0.10009E+01	0.10009E+01	0.10010E+01	0.10010E+01	0.10010E+01	0.10011E+01	0.10011E+01	0.10012E+01	0.10012E+01

	31	32	33	34	35	36	37	38	39	40
T	0.12500E+02	0.12917E+02	0.13333E+02	0.13750E+02	0.14167E+02	0.14583E+02	0.15000E+02	0.15417E+02	0.15833E+02	0.16250E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10013E+01	0.10013E+01	0.10013E+01	0.10014E+01	0.10014E+01	0.10015E+01	0.10015E+01	0.10015E+01	0.10015E+01	0.10016E+01

	41	42	43	44	45	46	47	48	49	50
T	0.16667E+02	0.17083E+02	0.17500E+02	0.17917E+02	0.18333E+02	0.18750E+02	0.19167E+02	0.19583E+02	0.20000E+02	0.20417E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10017E+01	0.10017E+01	0.10018E+01	0.10018E+01	0.10018E+01	0.10019E+01	0.10019E+01	0.10020E+01	0.10020E+01	0.10020E+01

	51	52	53	54	55	56	57	58	59	60
T	0.20833E+02	0.21250E+02	0.21667E+02	0.22083E+02	0.22500E+02	0.22917E+02	0.23333E+02	0.23750E+02	0.24167E+02	0.24583E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10021E+01	0.10021E+01	0.10022E+01	0.10022E+01	0.10023E+01	0.10023E+01	0.10023E+01	0.10024E+01	0.10024E+01	0.10025E+01

	61	62	63	64	65	66	67	68	69	70
T	0.25000E+02	0.25417E+02	0.25833E+02	0.26250E+02	0.26667E+02	0.27083E+02	0.27500E+02	0.27917E+02	0.28333E+02	0.28750E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10025E+01	0.10025E+01	0.10026E+01	0.10026E+01	0.10027E+01	0.10027E+01	0.10028E+01	0.10028E+01	0.10028E+01	0.10029E+01

	71	72	73	74	75	76	77	78	79	80
T	0.29167E+02	0.29583E+02	0.30000E+02	0.30417E+02	0.30833E+02	0.31250E+02	0.31667E+02	0.32083E+02	0.32500E+02	0.32917E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10029E+01	0.10030E+01	0.10030E+01	0.10030E+01	0.10031E+01	0.10031E+01	0.10032E+01	0.10032E+01	0.10033E+01	0.10033E+01

	81	82	83	84	85	86	87	88	89	90
T	0.33333E+02	0.33750E+02	0.34167E+02	0.34583E+02	0.35000E+02	0.35417E+02	0.35833E+02	0.36250E+02	0.36667E+02	0.37083E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10033E+01	0.10034E+01	0.10034E+01	0.10035E+01	0.10035E+01	0.10035E+01	0.10036E+01	0.10036E+01	0.10037E+01	0.10037E+01

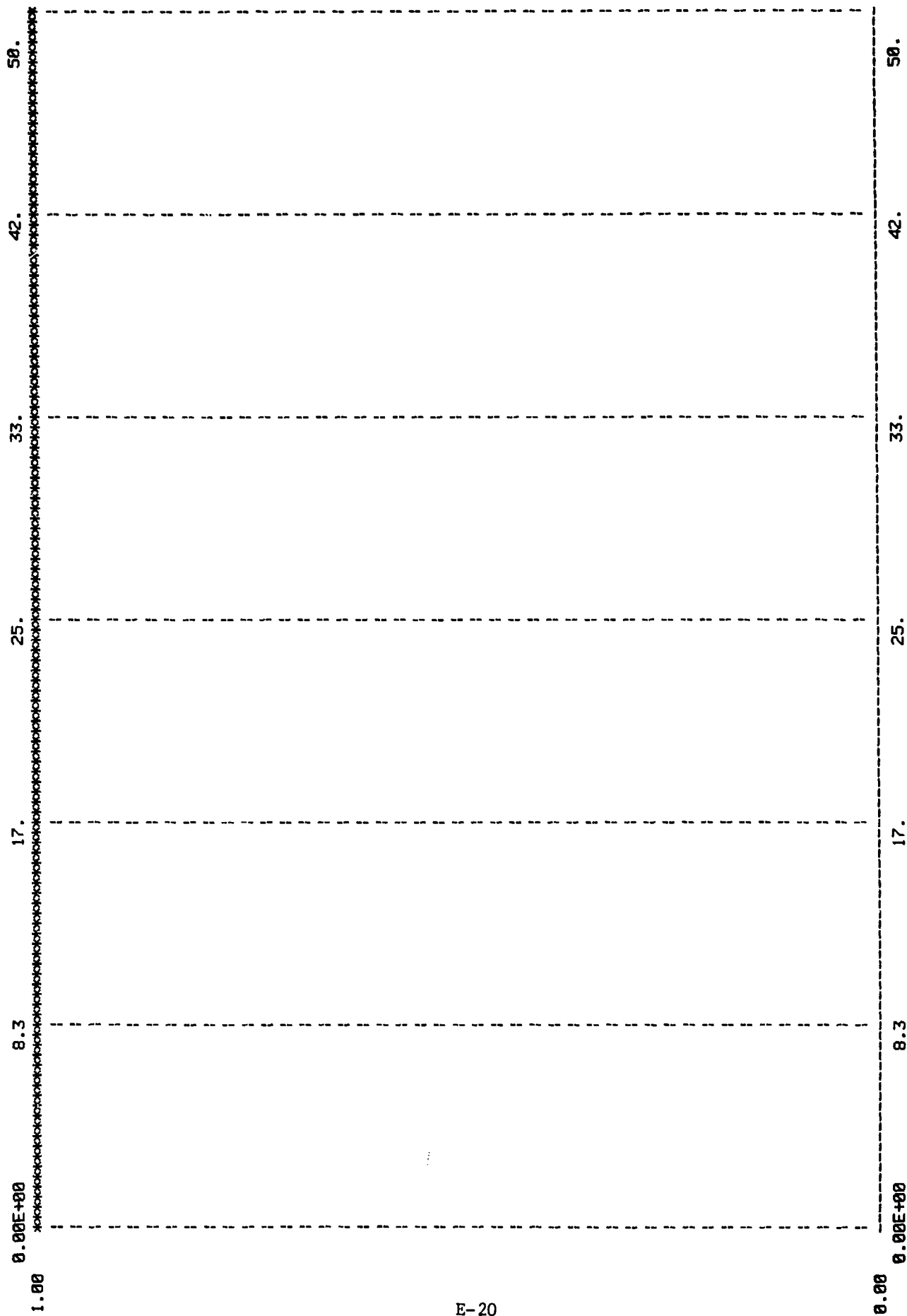
	91	92	93	94	95	96	97	98	99	100
T	0.37500E+02	0.37917E+02	0.38333E+02	0.38750E+02	0.39167E+02	0.39583E+02	0.40000E+02	0.40417E+02	0.40833E+02	0.41250E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10038E+01	0.10038E+01	0.10038E+01	0.10039E+01	0.10039E+01	0.10040E+01	0.10040E+01	0.10040E+01	0.10041E+01	0.10041E+01

	101	102	103	104	105	106	107	108	109	110
T	0.41667E+02	0.42083E+02	0.42500E+02	0.42917E+02	0.43333E+02	0.43750E+02	0.44167E+02	0.44583E+02	0.45000E+02	0.45417E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10042E+01	0.10042E+01	0.10043E+01	0.10043E+01	0.10043E+01	0.10044E+01	0.10044E+01	0.10045E+01	0.10045E+01	0.10045E+01

	111	112	113	114	115	116	117	118	119	120
T	0.45833E+02	0.46250E+02	0.46667E+02	0.47083E+02	0.47500E+02	0.47917E+02	0.48333E+02	0.48750E+02	0.49167E+02	0.49583E+02
P	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01	0.10000E+01
V	0.10046E+01	0.10046E+01	0.10047E+01	0.10047E+01	0.10048E+01	0.10048E+01	0.10048E+01	0.10049E+01	0.10049E+01	0.10050E+01

	121
T	0.50000E+02
P	0.10000E+01
V	0.10050E+01

INCIDENT PRESSURE PULSE:



INCIDENT PARTICLE VELOCITY:

1.01	0.00E+00	8.3	17.	25.	33.	42.	50.
0.00	0.00E+00	8.3	17.	25.	33.	42.	50.
+++ OPEN.	1 = FOR001		Acc= DIRECT	Stat= SCRATCH			

4500 WORDS OF STORAGE REQUIRED FOR THIS RUN

ICOMF	IDFL	ICOMJ	IN1	ICOMT
223	223	363	3267	3267

T	DT	DTC	KET	NOR	KSP	INX
0.250000E-01	0.250000E-01	0.125000E-01	1	1	1	0

FM VECTOR 4

[illegible]

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
13.560	0.386458E+00	39	179670	90890

ELEMENT STIFFNESS MATRICES COMPUTED FOR UNIT 1 (SHELL)

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
28.190	0.712826E+00	39	179670	90880

ASSEMBLY OF TOTAL STIFFNESS MATRIX COMPLETED.

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
28.460 0.717643E+00 39 179670 90880

DETERMINANT OF STIFFNESS MATRIX= 0.1167315E+07*10.** 60. NUMBER OF NEGATIVE ROOTS = 0
216 EQUATIONS. AVERAGE BAND WIDTH = 15
MATRIX DECOMPOSITION COMPLETED.

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
29.150 0.734831E+00 39 179670 90880

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
30.280 0.756836E+00 39 179670 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
32.450 0.825130E+00 43 297100 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
35.300 0.930143E+00 47 414530 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
37.850 0.100547E+01 51 531960 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
40.070 0.109928E+01 55 649390 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED

42.290 0.116849E+01 59 766820 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
44.550 0.124082E+01 63
WORDS TRANSFERRED 884250
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
46.840 0.131712E+01 67
WORDS TRANSFERRED 1001680
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
49.130 0.148066E+01 71
WORDS TRANSFERRED 1119110
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
51.400 0.193301E+01 75
WORDS TRANSFERRED 1236540
WORDS STORED 90880

F 24

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
53.720 0.209883E+01 79
WORDS TRANSFERRED 1353970
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
56.040 0.236263E+01 83
WORDS TRANSFERRED 1471400
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267
CP TIME ELAPSED TIME I/O REQUESTS
58.570 0.262363E+01 87
WORDS TRANSFERRED 1588630
WORDS STORED 90880

ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
60.890	0.285547E+01		91		1706260	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
63.170	0.296563E+01		95		1823690	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
65.410	0.304701E+01		99		1941120	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
67.730	0.312617E+01		103		2050550	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
70.090	0.321001E+01		107		2175980	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
72.400	0.351595E+01		111		2293410	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		
223	223	363	3267	3267		
CP TIME	ELAPSED TIME		I/O REQUESTS		WORDS TRANSFERRED	WORDS STORED
74.740	0.370951E+01		115		2410840	90880
ICOMF	IDFL	ICOMJ	IN1	ICOMT		

223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 77.110 0.389596E+01 119 2528270 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 79.400 0.409948E+01 123 2645700 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 81.730 0.420228E+01 127 2763130 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 84.070 0.430599E+01 131 2880560 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 86.430 0.441582E+01 135 2997990 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 88.670 0.452031E+01 139 3115420 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
 91.060 0.463464E+01 143 3232850 90880

ICOMF IDFL ICOMJ INI ICOMT
 223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
93.530 0.473965E+01 147 3350280 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
95.950 0.482682E+01 151 3467710 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
98.150 0.493249E+01 155 3585140 90880

RESTART DATA FOR T = 0.750000 WRITTEN AT LOCATION 0 ON PERMANENT FILE DIRTY*CYL.RST

POST PROCESSING RESPONSE FILE LOCATION IS 465

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
100.860 0.505150E+01 159 3702570 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
103.100 0.515462E+01 163 3820000 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
105.580 0.528581E+01 167 3937430 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
107.870 0.541764E+01 171 4054860 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
110.160 0.551882E+01 175

WORDS TRANSFERRED 4172290
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
112.410 0.559531E+01 179

WORDS TRANSFERRED 4289720
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
114.660 0.570866E+01 183

WORDS TRANSFERRED 4407150
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
116.880 0.578698E+01 187

WORDS TRANSFERRED 4524580
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
119.260 0.586328E+01 191

WORDS TRANSFERRED 4642010
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

TIME INCREMENT HAS BEEN CHANGED TO 0.500000E-01

T DT DTC KET NDR KSP INX
0.105000E+01 0.500000E-01 0.250000E-01 1 1 1 0
0.4000E+02 -0.4000E+02 0.0000E+00 -0.1000E+01

FM VECTOR 4

0.1197E-02 0.1197E-02 0.5829E-06 0.1197E-02 0.1197E-02 0.1197E-02 0.5829E-06 0.1197E-02
0.1197E-02 0.5829E-06 0.1197E-02 0.1197E-02 0.5829E-06 0.1197E-02 0.5829E-06 0.1197E-02
0.5829E-06 0.1197E-02 0.1197E-02 0.5829E-06 0.1197E-02 0.1197E-02 0.1197E-02 0.5829E-06

[illegible]

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
121.790	0.596562E+01	195	4759440	90880

ICOMF	IDFL	ICOMJ	INI	ICOMT
223	223	363	3267	3267

1
ELEMENT STIFFNESS MATRICES COMPUTED FOR UNIT 1 (SHELL)
29

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
140.120	0.637096E+01	203	4896885	90880

ASSEMBLY OF TOTAL STIFFNESS MATRIX COMPLETED.

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
140.370	0.637832E+01	203	4896846	90890

```

DETERMINANT OF STIFFNESS MATRIX= 0.2157060E-04*10.**
216 EQUATIONS. AVERAGE BAND WIDTH = 15
MATRIX DECOMPOSITION COMPLETED.
-10. NUMBER OF NEGATIVE ROOTS = 0

```

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
141.070	0.639063E+01	203	4896886	90880

CP TIME	ELAPSED TIME	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED
141.470	0.639766E+01	203	4896886	90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 143.710 0.647767E+01 207
 WORDS TRANSFERRED 5014316
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 145.970 0.658633E+01 211
 WORDS TRANSFERRED 5131746
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 148.320 0.670195E+01 215
 WORDS TRANSFERRED 5249176
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 150.830 0.682845E+01 219
 WORDS TRANSFERRED 5366606
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 153.220 0.694850E+01 223
 WORDS TRANSFERRED 5484036
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 155.490 0.702917E+01 227
 WORDS TRANSFERRED 5601466
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 157.770 0.710898E+01 231
 WORDS TRANSFERRED 5718896
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
160.130 0.718900E+01 235 5836326 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
162.420 0.731497E+01 239 5953756 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
164.930 0.745182E+01 243 6071186 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
167.210 0.756550E+01 247 6188616 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
169.540 0.763932E+01 251 6306046 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
171.790 0.771048E+01 255 6423476 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
174.130 0.778750E+01 259 6540906 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED

[illegible]

```
CP TIME ELAPSED TIME
185.870 0.820579E+01
```

I/O REQUESTS 279

WORDS TRANSFERRED
7128056

WORDS STORED 90880

RESTART DATA FOR T = 2.000000 WRITTEN AT LOCATION

54 ON PERMANENT FILE DIRTY*CYL:RST

POST PROCESSING RESPONSE FILE LOCATION IS 915

ICOMF	IDFL	ICOMJ	INI	ICOMT
223	223	363	3267	3267

ELEMENT STIFFNESS MATRICES COMPUTED FOR UNIT 1 (SHELL)

```
CP TIME      ELAPSED TIME      I/O REQUESTS      WORDS TRANSFERRED
203.210      0.857448E+01      287                7265502
```

WORDS STORED
90880

ET-33 ASSEMBLY OF TOTAL STIFFNESS MATRIX COMPLETED.

```
CP TIME      ELAPSED TIME      I/O REQUESTS
203.490      0.858047E+01      287
```

WORDS STORED 90880

DETERMINANT OF STIFFNESS MATRIX= 0.2017339E+00*10.**
216 EQUATIONS. AVERAGE BAND WIDTH = 15
MATRIX DECOMPOSITION COMPLETED. -80. NUMBER OF NEGATIVE ROOTS = 0

```
CP TIME      ELAPSED TIME      I/O REQUESTS
204.220      0.859681E+01      287
```

WORDS TRANSFERRED
72655502

WORDS STORED 90880

```
CP TIME      ELAPSED TIME      I/O REQUESTS
204.650      0.860762E+01      287
```

WORDS TRANSFERRED
7265502

WORDS STORED 90880

ICOMF	IDFL	ICOMJ	INI	ICOMT
223	223	363	3267	3267

```
CP TIME      ELAPSED TIME      I/O REQUESTS
206.970      0.869798E+01      291
```

WORDS TRANSFERRED
7382932

WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
209.350 0.877663E+01 295

WORDS TRANSFERRED 7500362
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
211.630 0.885716E+01 299

WORDS TRANSFERRED 7617792
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
213.930 0.892845E+01 303

WORDS TRANSFERRED 7735222
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
216.240 0.899980E+01 307

WORDS TRANSFERRED 7852652
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
218.420 0.907266E+01 311

WORDS TRANSFERRED 7970082
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
220.780 0.915417E+01 315

WORDS TRANSFERRED 8087512
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS
223.080 0.924147E+01 319

WORDS TRANSFERRED 8204942
WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT

223	223	363	3267	3267			
CP TIME	ELAPSED TIME	IN1	ICOMT	I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
225.330	0.931894E+01			323	8322372	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			
CP TIME	ELAPSED TIME			I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
227.410	0.941667E+01			327	8439802	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			
CP TIME	ELAPSED TIME			I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
229.710	0.950195E+01			331	8557232	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			
CP TIME	ELAPSED TIME			I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
232.120	0.958678E+01			335	8674662	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			
CP TIME	ELAPSED TIME			I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
234.470	0.966113E+01			339	8792092	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			
CP TIME	ELAPSED TIME			I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
236.790	0.978346E+01			343	8909522	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			
CP TIME	ELAPSED TIME			I/O REQUESTS	WORDS TRANSFERRED	WORDS STORED	
239.180	0.987767E+01			347	9026952	90880	
ICOMF	IDFL	ICOMJ	IN1	ICOMT			
223	223	363	3267	3267			

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
241.700 0.996445E+01 351 9144382 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
244.050 0.100493E+02 355 9261812 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
246.440 0.101296E+02 359 9379242 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
246.540 0.102105E+02 363 9496672 90880

1-36

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
251.310 0.102848E+02 367 9614102 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
253.540 0.103596E+02 371 9731532 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
255.920 0.104507E+02 375 9848962 90880

ICOMF IDFL ICOMJ IN1 ICOMT
223 223 363 3267 3267

CP TIME ELAPSED TIME I/O REQUESTS WORDS TRANSFERRED WORDS STORED
258.400 0.105355E+02 379 9966392 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 260.800 0.106170E+02 383
 WORDS TRANSFERRED 10083822
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 263.200 0.106955E+02 387
 WORDS TRANSFERRED 10201252
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 265.490 0.107757E+02 391
 WORDS TRANSFERRED 10318682
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 267.960 0.108583E+02 395
 WORDS TRANSFERRED 10436112
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 270.320 0.109418E+02 399
 WORDS TRANSFERRED 10553542
 WORDS STORED 90880

ICOMF IDFL ICOMJ IN1 ICOMT
 223 223 363 3267 3267
 CP TIME ELAPSED TIME I/O REQUESTS
 272.760 0.110248E+02 403
 WORDS TRANSFERRED 10670972
 WORDS STORED 90880

RESTART DATA FOR T = 5.000000 WRITTEN AT LOCATION 108 ON PERMANENT FILE DIRTY*CYL.RST

POST PROCESSING RESPONSE FILE LOCATION IS 1365

SECTOR ADDRESS OF RESPONSE FILE DIRTY*CYL.POS AT EXIT IS 1365

SECTOR ADDRESS OF RESTART FILE DIRTY*CYL.RST AT EXIT IS 162

```

+++++
+ AUXILIARY STORAGE TABLE +
+++++
+
+ LDI Ext-filnam Unit EC Opt PRU Cdlac Next Limit Read Written +
+ 1 FOR001 1 1 T 64 33 20000 247068 120477 +
+ 10 DIRTY:CYL.PO 12 1 UP 64 1365 20000 0 82173 +
+ S
+ 12 DIRTY:CYL.RS 14 1 UP 64 162 20000 0 9939 +
+ T
+ 14 DIRTY:CYL.PR 16 1 AX 64 28 20000 20000 152178 0 +
+ E
+
+
+ 4 Active devices ( 0 full )
+ 0 To ops, 1194 Writes, 565 Reads 611835 Words XFD +
+++++
+++ CLOSE, 12
+++ CLOSE, 14
+++ OPEN, 12 = DIRTY:CYL.POS , Acc= DIRECT , Stat= OLD
+++ CLOSE, 12

```

TRANSIENT RESPONSE HISTORIES:

	1	2	3	4	5	6	7	8	9	10
T	0.00000E+00	0.25000E-01	0.50000E-01	0.75000E-01	0.10000E+00	0.12500E+00	0.15000E+00	0.17500E+00	0.20000E+00	0.22500E+00
10/3 D	0.00000E+00	0.12200E-05	0.74684E-05	0.23222E-04	0.50250E-04	0.86229E-04	0.12524E-03	0.15897E-03	0.17775E-03	0.17111E-03
10/2 D	0.00000E+00	0.27946E-08	0.28548E-08	0.14795E-06	0.51685E-06	0.14126E-05	0.32386E-05	0.65662E-05	0.12312E-04	0.22358E-04
1/3 V	0.00000E+00	0.27830E+00	0.72955E+00	0.10586E+01	0.12946E+01	0.14646E+01	0.15883E+01	0.16793E+01	0.17468E+01	0.17971E+01
10/3 V	0.00000E+00	0.97600E-04	0.40227E-03	0.85804E-03	0.13042E-02	0.15740E-02	0.15469E-02	0.11517E-02	0.35029E-03	0.88132E-03
10/2 V	0.00000E+00	0.22357E-06	0.18367E-05	0.76435E-05	0.21940E-04	0.49719E-04	0.96365E-04	0.16984E-03	0.28983E-03	0.51388E-03
19/3 V	0.00000E+00	0.48206E-04	0.19742E-03	0.41794E-03	0.63015E-03	0.75254E-03	0.72692E-03	0.52096E-03	0.11950E-03	0.48358E-03
1/0 P	0.11765E+00	0.16339E+01	0.12203E+01	0.89905E+00	0.67930E+00	0.53466E+00	0.44023E+00	0.37910E+00	0.34005E+00	0.31600E+00
10/0 P	0.00000E+00	0.61501E-03	0.13112E-02	0.15903E-02	0.12989E-02	0.55402E-03	0.47723E-03	0.16613E-02	0.29301E-02	0.42472E-02
19/0 P	0.00000E+00	0.30375E-03	0.63956E-03	0.76422E-03	0.60985E-03	0.23282E-03	0.28114E-03	0.86254E-03	0.14824E-02	0.21231E-02

	11	12	13	14	15	16	17	18	19	20
T	0.25000E+00	0.27500E+00	0.30000E+00	0.32500E+00	0.35000E+00	0.37500E+00	0.40000E+00	0.42500E+00	0.45000E+00	0.47500E+00
10/3 D	0.12824E-03	0.38131E-04	0.11095E-03	0.33286E-03	0.64611E-03	0.10774E-02	0.16658E-02	0.24671E-02	0.35567E-02	0.50289E-02
10/2 D	0.41273E-04	0.80347E-04	0.16579E-03	0.35305E-03	0.74836E-03	0.15353E-02	0.29997E-02	0.55406E-02	0.96532E-02	0.15873E-01
1/3 V	0.18348E+01	0.18633E+01	0.18852E+01	0.19020E+01	0.19150E+01	0.19250E+01	0.19328E+01	0.19391E+01	0.19442E+01	0.19484E+01
10/3 V	0.25484E-02	0.46603E-02	0.72661E-02	0.10487E-01	0.14574E-01	0.19931E-01	0.27141E-01	0.36961E-01	0.50207E-01	0.67569E-01
10/2 V	0.99926E-03	0.21267E-02	0.47085E-02	0.10273E-01	0.21351E-01	0.41603E-01	0.75548E-01	0.12773E+00	0.20128E+00	0.23632E+00
19/3 V	0.12814E-02	0.22581E-02	0.33950E-02	0.46717E-02	0.60701E-02	0.75660E-02	0.91321E-02	0.10746E-01	0.12389E-01	0.14043E-01
1/0 P	0.30265E+00	0.29674E+00	0.29607E+00	0.29894E+00	0.30425E+00	0.31144E+00	0.31984E+00	0.32892E+00	0.33826E+00	0.34771E+00
10/0 P	0.54631E-02	0.65645E-02	0.74057E-02	0.78132E-02	0.75270E-02	0.59570E-02	0.26023E-02	0.31738E-02	0.12037E-01	0.24399E-01
19/0 P	0.27315E-02	0.33140E-02	0.38574E-02	0.43731E-02	0.48708E-02	0.53121E-02	0.57207E-02	0.61111E-02	0.64931E-02	0.68676E-02

	21	22	23	24	25	26	27	28	29	30
T	0.50000E+00	0.52500E+00	0.55000E+00	0.57500E+00	0.60000E+00	0.62500E+00	0.65000E+00	0.67500E+00	0.70000E+00	0.72500E+00
10/3 D	0.69913E-02	0.95550E-02	0.12822E-01	0.16871E-01	0.21752E-01	0.27485E-01	0.34070E-01	0.41470E-01	0.49688E-01	0.58710E-01
10/2 D	0.24687E-01	0.36427E-01	0.51189E-01	0.68813E-01	0.88939E-01	0.11113E+00	0.13500E+00	0.16033E+00	0.18709E+00	0.21537E+00
1/3 V	0.19519E+01	0.19545E+01	0.19565E+01	0.19581E+01	0.19594E+01	0.19606E+01	0.19619E+01	0.19630E+01	0.19640E+01	0.19648E+01
10/3 V	0.89425E-01	0.11567E+00	0.14565E+00	0.17827E+00	0.21224E+00	0.24637E+00	0.27990E+00	0.31264E+00	0.34482E+00	0.37695E+00
10/2 V	0.40877E+00	0.53040E+00	0.65059E+00	0.75938E+00	0.85070E+00	0.92430E+00	0.98528E+00	0.10415E+01	0.10996E+01	0.11625E+01
19/3 V	0.15689E-01	0.17310E-01	0.18806E-01	0.20399E-01	0.21833E-01	0.23179E-01	0.24449E-01	0.25686E-01	0.26982E-01	0.28509E-01
1/0 P	0.35727E+00	0.36690E+00	0.37657E+00	0.38611E+00	0.39535E+00	0.40422E+00	0.41267E+00	0.42089E+00	0.42893E+00	0.43675E+00
10/0 P	0.40271E-01	0.59138E-01	0.80147E-01	0.10204E+00	0.12350E+00	0.14387E+00	0.16195E+00	0.17792E+00	0.19187E+00	0.20422E+00
19/0 P	0.72324E-02	0.75914E-02	0.79259E-02	0.82302E-02	0.84876E-02	0.86540E-02	0.87115E-02	0.85390E-02	0.80027E-02	0.68653E-02

	31	32	33	34	35	36	37	38	39	40
T	0.75000E+00	0.77500E+00	0.80000E+00	0.82500E+00	0.85000E+00	0.87500E+00	0.90000E+00	0.92500E+00	0.95000E+00	0.97500E+00
10/3 D	0.68541E-01	0.79196E-01	0.90699E-01	0.10308E+00	0.11640E+00	0.13069E+00	0.14603E+00	0.16241E+00	0.17943E+00	0.19640E+00
10/2 D	0.24525E+00	0.27677E+00	0.30893E+00	0.34430E+00	0.38000E+00	0.41711E+00	0.45544E+00	0.49514E+00	0.53622E+00	0.57863E+00
1/3 V	0.19656E+01	0.19668E+01	0.19686E+01	0.19711E+01	0.19741E+01	0.19776E+01	0.19813E+01	0.19853E+01	0.19898E+01	0.19949E+01
10/3 V	0.40951E+00	0.44287E+00	0.47738E+00	0.51347E+00	0.55151E+00	0.59196E+00	0.63547E+00	0.67459E+00	0.68711E+00	0.67059E+00
10/2 V	0.12283E+01	0.12927E+01	0.13521E+01	0.14058E+01	0.14562E+01	0.15067E+01	0.15599E+01	0.16155E+01	0.16708E+01	0.17223E+01
19/3 V	0.30558E-01	0.33565E-01	0.38150E-01	0.45111E-01	0.55339E-01	0.70028E-01	0.89940E-01	0.11581E+00	0.14783E+00	0.18557E+00
1/0 P	0.44414E+00	0.45086E+00	0.45677E+00	0.46190E+00	0.46644E+00	0.47059E+00	0.47447E+00	0.47801E+00	0.48104E+00	0.48342E+00
10/0 P	0.21524E+00	0.22466E+00	0.23182E+00	0.23594E+00	0.23803E+00	0.23734E+00	0.23414E+00	0.27925E+00	0.41465E+00	0.47416E+00
19/0 P	0.47841E-02	0.12696E-02	0.43246E-02	0.12773E-01	0.24945E-01	0.41650E-01	0.63523E-01	0.90840E-01	0.12335E+00	0.16017E+00

	T	0.	10000E+01	0.	10500E+01	0.	11000E+01	0.	11500E+01	0.	12000E+01	0.	12500E+01	0.	13000E+01	0.	13500E+01	0.	14000E+01	0.	14500E+01	0.	15000E+01
0/3	D	0.	21246E+00	0.	23923E+00	0.	25785E+00	0.	26807E+00	0.	27113E+00	0.	26905E+00	0.	26328E+00	0.	25439E+00	0.	24517E+00	0.	23464E+00	0.	22440E+00
0/2	D	0.	62226E+00	0.	71268E+00	0.	80700E+00	0.	90491E+00	0.	10056E+01	0.	11075E+01	0.	12086E+01	0.	13071E+01	0.	14011E+01	0.	14834E+01	0.	15657E+01
1/3	V-	0.	20006E+01	-0.	20130E+01	-0.	20254E+01	-0.	20366E+01	-0.	20478E+01	-0.	20591E+01	-0.	20693E+01	-0.	20775E+01	-0.	20844E+01	-0.	20914E+01	-0.	20981E+01
0/3	V	0.	61410E+00	0.	43669E+00	0.	28815E+00	0.	12049E+00	0.	18327E-02	0.	84766E-01	-0.	14612E+00	-0.	18562E+00	-0.	20684E+00	-0.	21445E+00	-0.	22227E+00
0/2	V	0.	17681E+01	0.	18487E+00	0.	19242E+01	0.	19923E+01	0.	20351E+01	0.	20395E+01	0.	20055E+01	0.	19337E+01	0.	18271E+01	0.	17468E+01	0.	16600E+01
19/3	V	0.	22877E+00	0.	32514E+00	0.	41575E+00	0.	48412E+00	0.	54121E+00	0.	59306E+00	0.	64463E+00	0.	69533E+00	0.	74231E+00	0.	78542E+00	0.	82651E+00
1/0	P	0.	48514E+00	0.	49770E+00	0.	49086E+00	0.	49474E+00	0.	49842E+00	0.	50157E+00	0.	50509E+00	0.	50977E+00	0.	51511E+00	0.	51992E+00	0.	52473E+00
10/0	P	0.	67733E+00	0.	63492E+00	0.	73815E+00	0.	65764E+00	0.	61760E+00	0.	59809E+00	0.	59183E+00	0.	59729E+00	0.	61310E+00	0.	63636E+00	0.	65553E+00
19/0	P	0.	19980E+00	0.	27863E+00	0.	34637E+00	0.	39752E+00	0.	43491E+00	0.	46611E+00	0.	49614E+00	0.	52419E+00	0.	54739E+00	0.	56553E+00	0.	58476E+00
	T	0.	15000E+01	0.	15500E+01	0.	16000E+01	0.	16500E+01	0.	17000F+01	0.	17500E+01	0.	18000E+01	0.	18500E+01	0.	19000E+01	0.	19500E+01	0.	20000E+01
10/3	D	0.	22393E+00	0.	21327E+00	0.	20259E+00	0.	19164E+00	0.	18021E+00	0.	16827E+00	0.	15595E+00	0.	14345E+00	0.	13089E+00	0.	11831E+00	0.	10573E+00
10/2	D	0.	15722E+01	0.	16512E+01	0.	17280E+01	0.	18065E+01	0.	18849E+01	0.	19628E+01	0.	20390E+01	0.	21129E+01	0.	21857E+01	0.	22587E+01	0.	23277E+01
1/3	V-	0.	20995E+01	-0.	21060E+01	-0.	21153E+01	-0.	21215E+01	-0.	21225E+01	-0.	21155E+01	-0.	20970E+01	-0.	20652E+01	-0.	20225E+01	-0.	19752E+01	-0.	18952E+01
10/3	V-	0.	21413E+00	-0.	21237E+00	-0.	21479E+00	-0.	22303E+00	-0.	23416E+00	-0.	24361E+00	-0.	24897E+00	-0.	25100E+00	-0.	25162E+00	-0.	25159E+00	-0.	25159E+00
10/2	V	0.	16062E+01	0.	15538E+01	0.	15474E+01	0.	15633E+01	0.	15707E+01	0.	15477E+01	0.	14993E+01	0.	14582E+01	0.	14520E+01	0.	14697E+01	0.	14755E+01
19/3	V	0.	82766E+00	0.	87098E+00	0.	91413E+00	0.	95553E+00	0.	99617E+00	0.	10386E+01	0.	10842E+01	0.	11328E+01	0.	11855E+01	0.	12475E+01	0.	13066E+01
1/0	P	0.	52368E+00	0.	52741E+00	0.	53266E+00	0.	54122E+00	0.	55547E+00	0.	57819E+00	0.	61181E+00	0.	65652E+00	0.	70865E+00	0.	76096E+00	0.	81441E+00
10/0	P	0.	66173E+00	0.	68457E+00	0.	69997E+00	0.	70775E+00	0.	71154E+00	0.	71599E+00	0.	72310E+00	0.	73162E+00	0.	73921E+00	0.	74481E+00	0.	75336E+00
19/0	P	0.	58095E+00	0.	59585E+00	0.	60895E+00	0.	61803E+00	0.	62406E+00	0.	62842E+00	0.	63143E+00	0.	6369E+00	0.	64269E+00	0.	64854E+00	0.	65439E+00
	T	0.	20000E+01	0.	21000E+01	0.	22000E+01	0.	23000E+01	0.	24000E+01	0.	25000E+01	0.	26000E+01	0.	27000E+01	0.	28000E+01	0.	29000E+01	0.	30000E+01
10/3	D	0.	10577E+00	0.	81803E-01	0.	60596E-01	0.	43010E-01	0.	29100E-01	0.	18356E-01	0.	93135E-02	0.	48520E-03	0.	80781E-02	0.	15453E-01	0.	39237E-01
10/2	D	0.	23324E+01	0.	24801E+01	0.	26325E+01	0.	27985E+01	0.	29804E+01	0.	31721E+01	0.	33658E+01	0.	35546E+01	0.	37383E+01	0.	39237E+01	0.	41086E+01
1/3	V-	0.	19310E+01	-0.	18648E+01	-0.	18414E+01	-0.	18273E+01	-0.	18039E+01	-0.	18077E+01	-0.	18300E+01	-0.	18344E+01	-0.	18222E+01	-0.	18206E+01	-0.	18180E+01
10/3	V-	0.	24972E+00	-0.	22971E+00	-0.	19444E+00	-0.	15727E+00	-0.	12094E+00	-0.	93940E-01	-0.	86908E-01	-0.	89557E-01	-0.	81608E-01	-0.	65886E-01	-0.	50829E+01
10/2	V	0.	14773E+01	0.	14767E+01	0.	15705E+01	0.	17511E+01	0.	18867E+01	0.	19461E+01	0.	19284E+01	0.	18478E+01	0.	18251E+01	0.	18829E+01	0.	19413E+01
19/3	V	0.	13092E+01	0.	13857E+01	0.	14146E+01	0.	14242E+01	0.	14282E+01	0.	14370E+01	0.	14617E+01	0.	15033E+01	0.	15585E+01	0.	16143E+01	0.	16843E+01
1/0	P	0.	80474E+00	0.	85211E+00	0.	86783E+00	0.	87730E+00	0.	88971E+00	0.	89062E+00	0.	87826E+00	0.	87268E+00	0.	87976E+00	0.	88583E+00	0.	89336E+00
10/0	P	0.	74787E+00	0.	75995E+00	0.	78324E+00	0.	81402E+00	0.	84698E+00	0.	87296E+00	0.	88300E+00	0.	88216E+00	0.	88521E+00	0.	89536E+00	0.	90446E+00
19/0	P	0.	63766E+00	0.	71377E+00	0.	74853E+00	0.	76429E+00	0.	77327E+00	0.	78563E+00	0.	81098E+00	0.	85252E+00	0.	90670E+00	0.	95946E+00	0.	10146E+00
	T	0.	30000E+01	0.	31000E+01	0.	32000E+01	0.	33000E+01	0.	34000E+01	0.	35000E+01	0.	36000E+01	0.	37000E+01	0.	38000E+01	0.	39000E+01	0.	40000E+01
10/3	D	0.	21583E-01	-0.	26946F-01	-0.	31417E-01	-0.	34489E-01	-0.	36088E-01	-0.	37083E-01	-0.	38725E-01	-0.	41200E-01	-0.	43730E-01	-0.	45945E-01	-0.	48700E-01
10/2	D	0.	41112E+01	0.	42919E+01	0.	44609E+01	0.	46221E+01	0.	47789E+01	0.	49338E+01	0.	50911E+01	0.	52547E+01	0.	54231E+01	0.	55910E+01	0.	57600E+01
1/3	V-	0.	18230E+01	-0.	18147E+01	-0.	18142E+01	-0.	18282E+01	-0.	18309E+01	-0.	18129E+01	-0.	17834E+01	-0.	17413E+01	-0.	16981E+01	-0.	16857E+01	-0.	16784E+01
10/3	V-	0.	56714E-01	-0.	50145E-01	-0.	38866E-01	-0.	22572E-01	-0.	94119E-02	-0.	10496E-01	-0.	22747E-01	-0.	27149E-01	-0.	23453E-01	-0.	20843E-01	-0.	16642E+01
10/2	V	0.	18682E+01	0.	17446E+01	0.	16366E+01	0.	15864E+01	0.	15515E+01	0.	15461E+01	0.	15995E+01	0.	16725E+01	0.	16947E+01	0.	16643E+01	0.	16443E+01
19/3	V	0.	16447E+01	0.	16423E+01	0.	16284E+01	0.	16260E+01	0.	16391E+01	0.	16501E+01	0.	16433E+01	0.	16301E+01	0.	16312E+01	0.	16443E+01	0.	16443E+01
1/0	P	0.	88551E+00	0.	88844E+00	0.	88966E+00	0.	88641E+00	0.	88668E+00	0.	91067E+00	0.	94286E+00	0.	98239E+00	0.	10171E+01	0.	10268E+01	0.	10268E+01
10/0	P	0.	90497E+00	0.	91228E+00	0.	92237E+00	0.	93802E+00	0.	95359E+00	0.	95825E+00	0.	95158E+00	0.	94559E+00	0.	94651E+00	0.	95158E+00	0.	95158E+00
19/0	P	0.	98903E+00	0.	98637E+00	0.	96595E+00	0.	95147E+00	0.	9347E+00	0.	96032E+00	0.	95564E+00	0.	94186E+00	0.	93482E+00	0.	93967E+00	0.	93967E+00
	T	0.	40000E+01	0.	41000E+01	0.	42000E+01	0.	43000E+01	0.	44000E+01	0.	45000E+01	0.	46000E+01	0.	47000E+01	0.	48000E+01	0.	49000E+01	0.	50000E+01
10/3	D	0.	47842E-01	-0.	49326E-01	-0.	50615E-01	-0.	51914E-01	-0.	52936E-01	-0.	53782E-01	-0.	55296E-01	-0.	57776E-01	-0.	60327E-01	-0.	62096E-01	-0.	64000E-01
10/2	D	0.	57561E+01	0.	55311E+01	0.	51134E+01	0.	46833E+01	0.	40833E+01	0.	34833E+01	0.	28833E+01	0.	22833E+01	0.	16833E+01	0.	10833E+01	0.	4833E+01

1/3 V-0.17076E+01-0.17360E+01-0.17580E+01-0.17641E+01-0.17474E+01-0.17285E+01-0.17465E+01-0.17576E+01-0.17611E+01
 10/3 V-0.17097E-01-0.12589E-01-0.13194E-01-0.12773E-01-0.12773E-01-0.92522E-02-0.21027E-01-0.28581E-01-0.22423E-01-0.12957E-01
 10/2 V 0.16780E+01 0.17808E+01 0.18662E+01 0.18575E+01 0.18169E+01 0.17769E+01 0.17315E+01 0.17203E+01 0.17257E+01 0.16947E+01
 19/3 V 0.16511E+01 0.16479E+01 0.16553E+01 0.16776E+01 0.16942E+01 0.17029E+01 0.17235E+01 0.17491E+01 0.17569E+01 0.17479E+01
 1/0 P 0.10076E+01 0.97000E+00 0.95670E+00 0.95354E+00 0.96907E+00 0.98644E+00 0.98473E+00 0.96610E+00 0.94993E+00 0.94682E+00
 10/0 P 0.95988E+00 0.96659E+00 0.97138E+00 0.97555E+00 0.98066E+00 0.98068E+00 0.97252E+00 0.96502E+00 0.96802E+00 0.97787E+00
 19/0 P 0.94507E+00 0.94333E+00 0.94608E+00 0.95932E+00 0.97372E+00 0.98396E+00 0.99812E+00 0.10149E+01 0.10212E+01 0.10117E+01

91

T 0.50000E+01
 10/3 D-0.63325E-01
 10/2 D 0.75225E+01
 1/3 V-0.17631E+01
 10/3 V-0.11638E-01
 10/2 V 0.16685E+01
 19/3 V 0.17350E+01
 1/0 P 0.95402E+00
 10/0 P 0.98446E+00
 19/0 P 0.99407E+00

APPENDIX F
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.

P O S T P R

THIS FUNCTIONAL COMPONENT OF THE UNDERWATER SHOCK ANALYSIS CODE IS RESPONSIBLE FOR THE TABULATION AND PRINTER-PLOT GRAPHIC DISPLAY OF SELECTED TRANSIENT RESPONSES AND PSEUDO-VELOCITY SHOCK SPECTRA UPON COMPLETION OF AN UNDERWATER SHOCK ANALYSIS OF A SUBMERGED STRUCTURE. IT CAN ALSO CREATE A PERMANENT FILE CONTAINING A SERIES OF SNAPSHOTS OF THE DEFORMED STRUCTURE AT USER SPECIFIED TIMES

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, 3251 HANOVER ST., PALO ALTO, CALIF., 94304 OR CALL 415-493-4411 EXTS. 45069 OR 45133. SEPTEMBER, 1980

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 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. 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 USERS ID, WHICH IN MOST INSTALLATIONS CAN BE SELECTED ALMOST ARBITRARILY. ON CDC NOS, THE QUALIFIER IS INTERPRETED AS THE USERS 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

117			WERE CREATED USING UNFORMATTED FORTRAN
118			WRITE. OTHERWISE FILES WERE CREATED BY
119			DIRECT TRANSFER USING THE DATA MANAGEMENT
120			SYSTEM DMGASP
121			
122	DISPLA	L	TRUE IF SELECTED TRANSIENT RESPONSE
123			HISTORIES ARE TO BE DISPLAYED, OTHERWISE
124			FALSE. THIS VARIABLE MUST BE TRUE EVEN IF
125			PSEUDO-VELOCITY SHOCK SPECTRA ARE THE ONLY
126			ONLY OUTPUT DESIRED SINCE STRUCTURAL
127			VELOCITY HISTORIES MUST BE USED FOR THIS
128			COMPUTATION
129			
130	DEFORM	L	TRUE IF A PERMANENT FILE IS TO BE CREATED
131			THAT CONTAINS A CHRONOLOGICAL SUCCESSION
132			OF RECORDS EACH OF WHICH CONSISTS OF THE
133			COMPLETE DISPLACEMENT FIELD AT SPECIFIC
134			TIMES WITHOUT ANY EXTRANEIOUS TIME OR
135			BOOKKEEPING DATA. SUCH A FILE CAN BE
136			IMAGINED AS A SERIES OF SNAPSHOTS OF THE
137			DEFORMED STRUCTURE THROUGHOUT THE SHOCK
138			ANALYSIS. THIS CAPABILITY CANNOT BE USED
139			IF FORWRT IS TRUE
140			
141	LISTRE	L	TRUE IF TRANSIENT RESPONSE HISTORIES ARE
142			TO BE LISTED IN TABULAR FORM, OTHERWISE
143			FALSE
144			
145	PRITPLT	L	TRUE IF PRINTER PLOTS ARE TO BE GENERATED
146			FOR TRANSIENT RESPONSE HISTORIES.
147			OTHERWISE FALSE
148			
149	VECPLOT	L	TRUE IF PLOTS ARE TO BE GENERATED FOR
150			TRANSIENT RESPONSE HISTORIES. OTHERWISE
151			FALSE. A PLOT PACKAGE IS NOT PROVIDED WITH
152			THE USA CODE AND IT IS THE USERS
153			RESPONSIBILITY TO COMPLETE THIS FEATURE IN
154			A CALL FROM SUBROUTINE RESCHK IF DESIRED.
155			THE EXISTING CALL USES 'DISPLA' SOFTWARE
156			
157	NWETHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER
158			DISPLACEMENTS OR VELOCITIES) TO BE
159			DISPLAYED FOR WHICH THE APPROPRIATE
160			STRUCTURAL FREEDOMS CAN BE IDENTIFIED
161			INTERNALLY THROUGH THE FREEDOM/EQUATION
162			CORRESPONDENCE TABLE. ALL STRUCTURAL NODES
163			WHICH PARTICIPATE IN THE FLUID-STRUCTURE
164			TRANSFORMATION WILL FALL INTO THIS
165			CATEGORY AS WELL AS ANY OTHERS WHOSE GRID
166			POINT COORDINATES WERE ENTERED AS DATA FOR
167			THE FLUID MASS PROCESSOR
168			
169	NDRYHS	I	NUMBER OF STRUCTURAL HISTORIES (EITHER
170			DISPLACEMENTS OR VELOCITIES) TO BE
171			DISPLAYED FOR WHICH THE APPROPRIATE
172			STRUCTURAL FREEDOMS CANNOT BE IDENTIFIED
173			INTERNALLY THROUGH THE FREEDOM/EQUATION
174			CORRESPONDENCE TABLE. DRY STRUCTURE NODE

175			POINTS CAN FALL INTO THIS CATEGORY IF THE
176			USER DID NOT INCLUDE THEM IN THE DATA
177			STREAM FOR THE FLUID MASS PROCESSOR. IN
178			THIS CASE ONE MUST IDENTIFY THE INTERNAL
179			SEQUENCE NUMBER APPROPRIATE TO THE DESIRED
180			DEGREE OF FREEDOM BY A MYSTICAL PROCESS
181			WHICH INVOLVES THE INTIMATE KNOWLEDGE OF
182			THE ELIMINATION ORDER AND ANY REDUCTION
183			OF THE NUMBER OF ACTIVE FREEDOMS DUE TO
184			THE APPLICATION OF CONSTRAINTS. MORAL OF
185			THE STORY - RUN ALL STRUCTURAL GRID POINTS
186			THROUGH THE FLUID MASS PROCESSOR EVEN IF
187			THEY NEVER GET WET
188			
189			
190			
191			
192			
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231			
232			

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
NFRGUT	I	STRUCTURAL DEGREE OF FREEDOM NUMBER FOR WHICH A TIME HISTORY DISPLAY IS DESIRED
NEQST	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 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 VECPLT)
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 ON 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			

```

2931      * * * * * I N P U T      D A T A      C A R D      D E C K      * * * * *
2932
2933
2934
2935
2936
2937      ALL INPUT DATA EXCEPT ALPHANUMERIC DATA MUST BE RIGHT JUSTIFIED
2938      IN EIGHT (8) COLUMN FIELDS WHICH CAN OCCUPY THE ENTIRE CARD.
2939      ALPHANUMERIC DATA MUST BE LEFT JUSTIFIED IN TWENTY (20) COLUMN
2940      FIELDS. FILE NAME PLUS QUALIFIER IS CURRENTLY RESTRICTED TO
2941      EIGHTEEN (18) CHARACTERS FOR UNIVAC OPERATION WHILE NINETEEN (19)
2942      CHARACTERS MAY BE USED FOR CDC OPERATION
2943
2944      TASK DEFINITION (MAIN PROGRAM POSTPR):
2945      -----
2946      72 COLUMN ALPHANUMERIC TITLE. ONLY THE FIRST 48 WILL APPEAR ON PLOTS
2947      NFILES
2948      NFILES(I), I=1,NFILES
2949      PRENAM
2950      XVPNAM(I), I=1,NFILES
2951      FORWRT DISPLA DEFORM
2952
2953      TRANSIENT RESPONSE DISPLAY (SUBROUTINE RESSHK):
2954      -----
2955
2956      IF DISPLA = .FALSE. SKIP ALL INPUT FROM HERE TO SUBROUTINE SNAPPY
2957
2958      LISTRE PRTPLT VECPLT
2959
2960      TRANSIENT RESPONSE DISPLAY (SUBROUTINE STRDSP):
2961      -----
2962
2963      NWETHS NDRYHS NUMSET      )
2964      NODOUT NFROUT      )      ) TOTAL = NWETHS
2965      .      .      .      )
2966      NODOUT NFROUT NEOHST      )
2967      .      .      .      )      ) TOTAL = NDRYHS
2968      .      .      .      )      )
2969      .      .      .      )      )
2970      .      .      .      )      )
2971      IF NUMSET = 0 OMIT THE FOLLOWING CARD
2972      )
2973      NFROUT NODFIR NOOLAS NODINC      )
2974      )
2975      NWETHS NDRYHS NUMSET      )
2976      NODOUT NFROUT      )      ) TOTAL = NWETHS
2977      .      .      .      )
2978      .      .      .      )
2979      NODOUT NFROUT NEOHST      )
2980      .      .      .      )      ) TOTAL = NDRYHS
2981      .      .      .      )
2982      .      .      .      )
2983      IF NUMSET = 0 OMIT THE FOLLOWING CARD
2984      )
2985      NFROUT NODFIR NOOLAS NODINC      )
2986      )
2987      TRANSIENT RESPONSE DISPLAY (SUBROUTINE RESSHK):
2988      -----

```

```

349 NPREHS NUMSET
350 NEQHPR )
351 ) )
352 ) ) TOTAL = NPREHS
353 ) )
354
355 IF NUMSET = 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 SHPRPL SHVCPL
376 FREQLW FREQUF 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 ) ) TOTAL = NSNAP
388 )

```

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 users 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 -STAGS.

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 E except that the first row is now frequency rather than time.

The following input and output for the infinite circular cylindrical shell problem contain some minor differences due to the fact that the input is appropriate to the standard CDC or UNIVAC USA-STAGS version 3 whereas the output is from the VAX virtual memory machine. The basic reason for this is that the VAX version does not explicitly process the fluid equation system in a multi-block, out-of-core mode in contrast to the CDC and UNIVAC versions. In addition, permanent file naming conventions differ slightly; however it is anticipated that these differences should not prove to be a difficulty for the user.

INFINITE CYLINDER, PLANE STEP WAVE

1	1		
2	91		
3	CYL*PREP		
4	CYL*POST		
5	F	T	F
6	T	T	T
7	T	0	0
8	2	3	
9	10	2	
10	10	0	0
11	4	3	
12	1	3	
13	19	2	
14	10	3	
15	19	0	
16	3		
17	1		
18	10		
19	19		
20	F	0	
21	1		
22	T	T	T
23	T	3.	.025
24	0.		

INFINITE CYLINDER, PLANE STEP WAVE

```
+++ OPEN, 16 = DIRTY:CYL.PRE      , Acc= DIRECT , Stat= OLD
+++ CLOSE, 16
+++ OPEN, 12 = DIRTY:CYL.POS      , Acc= DIRECT , Stat= OLD
+++ CLOSE, 12
```

TRANSIENT RESPONSE HISTORIES:

	1	2	3	4	5	6	7	8	9	10
T	0.00000E+00	0.25000E+00	0.50000E-01	0.75000E-01	0.10000E+00	0.12500E+00	0.15000E+00	0.17500E+00	0.20000E+00	0.22500E+00
10/3 D	0.00000E+00	0.12200E-05	0.74584E-05	0.23222E-04	0.50250E-04	0.86229E-04	0.12524E-03	0.15897E-03	0.17775E-03	0.17111E-03
10/2 D	0.00000E+00	0.27946E-08	0.28548E-07	0.14705E-06	0.51685E-06	0.14126E-05	0.32386E-05	0.65662E-05	0.12312E-04	0.22358E-04
1/3 V	0.00000E+00	0.27830E+00	0.72955E+00	0.10586E+01	0.12946E+01	0.14646E+01	0.15883E+01	0.16793E+01	0.17312E+01	0.17971E+01
10/3 V	0.00000E+00	0.97600E-04	0.40227E-03	0.85804E-03	0.13042E-02	0.15740E-02	0.15469E-02	0.11517E-02	0.35029E-03	0.88132E-03
10/2 V	0.00000E+00	0.22357E-06	0.18367E-05	0.76435E-05	0.21940E-04	0.49719E-04	0.96365E-04	0.16984E-03	0.28983E-03	0.51388E-03
19/3 V	0.00000E+00	0.48206E-04	0.19742E-03	0.41794E-03	0.63015E-03	0.75254E-03	0.72692E-03	0.52096E-03	0.11950E-03	0.48358E-03
1/0 P	0.11765E+00	0.16339E+01	0.12203E+01	0.89055E+00	0.67930E+00	0.53466E+00	0.44023E+00	0.37910E+00	0.34005E+00	0.31600E+00
10/0 P	0.00000E+00	0.61501E-03	0.13112E-02	0.15903E-02	0.12989E-02	0.55402E-03	0.47723E-03	0.16613E-02	0.29301E-02	0.42472E-02
19/0 P	0.00000E+00	0.30375E-03	0.63956E-03	0.76422E-03	0.60985E-03	0.23282E-03	0.28114E-03	0.86254E-03	0.14824E-02	0.21231E-02
	11	12	13	14	15	16	17	18	19	20
T	0.25000E+00	0.27500E+00	0.30000E+00	0.32500E+00	0.35000E+00	0.37500E+00	0.40000E+00	0.42500E+00	0.45000E+00	0.47500E+00
10/3 D	0.12824E-03	0.38131E-04	0.11095E-03	0.33286E-03	0.64611E-03	0.10774E-02	0.16558E-02	0.24671E-02	0.35567E-02	0.50289E-02
10/2 D	0.41273E-04	0.80347E-04	0.16579E-03	0.35305E-03	0.74836E-03	0.15353E-02	0.29397E-02	0.55406E-02	0.96532E-02	0.15873E-01
1/3 V	0.18348E+01	0.18633E+01	0.18952E+01	0.19020E+01	0.19150E+01	0.19250E+01	0.19328E+01	0.19391E+01	0.19442E+01	0.19484E+01
10/3 V	0.25484E-02	0.45603E-02	0.72661E-02	0.10487E-01	0.14574E-01	0.19931E-01	0.27141E-01	0.36961E-01	0.50207E-01	0.67569E-01
10/2 V	0.99926E-03	0.21267E-02	0.47085E-02	0.10273E-01	0.21351E-01	0.41603E-01	0.75548E-01	0.12773E+00	0.20126E+00	0.29632E+00
19/3 V	0.12814E-02	0.22581E-02	0.33950E-02	0.46717E-02	0.60701E-02	0.75660E-02	0.91321E-02	0.10746E-01	0.12389E-01	0.14043E-01
1/0 P	0.30265E+00	0.29674E+00	0.29807E+00	0.29894E+00	0.30425E+00	0.31144E+00	0.31984E+00	0.32892E+00	0.33826E+00	0.34771E+00
10/0 P	0.54631E-02	0.65645E-02	0.74957E-02	0.78132E-02	0.75273E-02	0.59570E-02	0.26023E-02	0.31738E-02	0.12037E-01	0.24399E-01
19/0 P	0.27315E-02	0.33140E-02	0.38574E-02	0.43731E-02	0.48708E-02	0.53121E-02	0.57207E-02	0.61111E-02	0.64931E-02	0.68676E-02
	21	22	23	24	25	26	27	28	29	30
T	0.50000E+00	0.52500E+00	0.55000E+00	0.57500E+00	0.60000E+00	0.62500E+00	0.65000E+00	0.67500E+00	0.70000E+00	0.72500E+00
10/3 D	0.69913E-02	0.95550E-02	0.12822E-01	0.16871E-01	0.21752E-01	0.27485E-01	0.34063E-01	0.41470E-01	0.49688E-01	0.58710E-01
10/2 D	0.24687E-01	0.36427E-01	0.51189E-01	0.68813E-01	0.88939E-01	0.11113E+00	0.13500E+00	0.16033E+00	0.18709E+00	0.21537E+00
1/3 V	0.19519E+01	0.19545E+01	0.19565E+01	0.19581E+01	0.19594E+01	0.19606E+01	0.19619E+01	0.19630E+01	0.19640E+01	0.19648E+01
10/3 V	0.89425E-01	0.11567E+00	0.14565E+00	0.17827E+00	0.21224E+00	0.24637E+00	0.27990E+00	0.31264E+00	0.34482E+00	0.37695E+00
10/2 V	0.40877E+00	0.53040E+00	0.65059E+00	0.75938E+00	0.85070E+00	0.92430E+00	0.98528E+00	0.10415E+01	0.10996E+01	0.11625E+01
19/3 V	0.15689E-01	0.17310E-01	0.18886E-01	0.20399E-01	0.21833E-01	0.23179E-01	0.24449E-01	0.25686E-01	0.26982E-01	0.28509E-01
1/0 P	0.35727E+00	0.36690E+00	0.37657E+00	0.38611E+00	0.39535E+00	0.40422E+00	0.41267E+00	0.42089E+00	0.42893E+00	0.43675E+00
10/0 P	0.40271E-01	0.59138E-01	0.80147E-01	0.10204E+00	0.12358E+00	0.14387E+00	0.16195E+00	0.17792E+00	0.19187E+00	0.20422E+00
19/0 P	0.72324E-02	0.75914E-02	0.79259E-02	0.82302E-02	0.84876E-02	0.86540E-02	0.87115E-02	0.85390E-02	0.80027E-02	0.68653E-02
	31	32	33	34	35	36	37	38	39	40
T	0.75000E+00	0.77500E+00	0.80000E+00	0.82500E+00	0.85000E+00	0.87500E+00	0.90000E+00	0.92500E+00	0.95000E+00	0.97500E+00
10/3 D	0.68541E-01	0.79196E-01	0.90599E-01	0.10308E+00	0.11640E+00	0.13069E+00	0.14603E+00	0.16241E+00	0.17943E+00	0.19640E+00
10/2 D	0.24525E+00	0.27677E+00	0.30983E+00	0.34430E+00	0.38008E+00	0.41711E+00	0.45544E+00	0.49514E+00	0.53522E+00	0.57863E+00
1/3 V	0.19656E+01	0.19668E+01	0.19686E+01	0.19711E+01	0.19741E+01	0.19776E+01	0.19813E+01	0.19853E+01	0.19898E+01	0.19949E+01
10/3 V	0.40951E+00	0.44287E+00	0.47738E+00	0.51347E+00	0.55151E+00	0.59196E+00	0.63547E+00	0.67459E+00	0.68711E+00	0.67058E+00
10/2 V	0.12283E+01	0.12927E+01	0.13521E+01	0.14058E+01	0.14562E+01	0.15067E+01	0.15599E+01	0.16155E+01	0.16708E+01	0.17223E+01
19/3 V	0.30558E-01	0.33565E-01	0.38156E-01	0.45111E-01	0.55399E-01	0.70028E-01	0.89940E-01	0.11581E+00	0.14783E+00	0.18557E+00
1/0 P	0.44414E+00	0.45086E+00	0.45677E+00	0.46190E+00	0.46644E+00	0.47059E+00	0.47447E+00	0.47801E+00	0.48104E+00	0.48342E+00
10/0 P	0.21524E+00	0.22466E+00	0.23182E+00	0.23594E+00	0.23805E+00	0.23734E+00	0.23414E+00	0.22792E+00	0.21465E+00	0.20471E+00
19/0 P	0.47841E-02	0.12695E-02	0.43245E-02	0.12773E-01	0.24945E-01	0.41650E-01	0.63523E-01	0.90840E-01	0.12335E+00	0.16017E+00

T 0.10000E+01 0.10500E+01 0.11000E+01 0.11500E+01 0.12000E+01 0.12500E+01 0.13000E+01 0.13500E+01 0.14000E+01 0.14500E+01
 10/3 D 0.21246E+00 0.23923E+00 0.25785E+00 0.26807E+00 0.27113E+00 0.26905E+00 0.26328E+00 0.25499E+00 0.24517E+00 0.23464E+00
 10/2 D 0.62226E+00 0.71258E+00 0.80700E+00 0.90491E+00 0.10056E+01 0.11075E+01 0.12086E+01 0.13071E+01 0.14011E+01 0.14894E+01
 1/3 V-0.20006E+01-0.20130E+01-0.20254E+01-0.20366E+01-0.20478E+01-0.20591E+01-0.20693E+01-0.20775E+01-0.20844E+01-0.20914E+01
 10/3 V 0.61410E+00 0.45665E+00 0.28816E+00 0.12049E+00 0.18327E+02-0.84766E-01-0.14612E+00-0.18562E+00-0.20684E+00-0.21445E+00
 10/2 V 0.17601E+01 0.18487E+01 0.19242E+01 0.19923E+01 0.20351E+01 0.20395E+01 0.20439E+01 0.20555E+01 0.19337E+01 0.18271E+01
 19/3 V 0.22877E+00 0.32514E+00 0.41575E+00 0.48412E+00 0.54121E+00 0.59306E+00 0.64463E+00 0.69533E+00 0.74231E+00 0.78542E+00
 1/0 P 0.48514E+00 0.48770E+00 0.49086E+00 0.49474E+00 0.49842E+00 0.50157E+00 0.50509E+00 0.50977E+00 0.51511E+00 0.51992E+00
 10/0 P 0.67733E+00 0.63492E+00 0.73815E+00 0.65764E+00 0.61760E+00 0.59035E+00 0.55918E+00 0.59729E+00 0.61310E+00 0.63636E+00
 19/0 P 0.19980E+00 0.27369E+00 0.34637E+00 0.39752E+00 0.43491E+00 0.46611E+00 0.49614E+00 0.52419E+00 0.54739E+00 0.56553E+00

T 0.15000E+01 0.15500E+01 0.16000E+01 0.16500E+01 0.17000E+01 0.17500E+01 0.18000E+01 0.18500E+01 0.19000E+01 0.19500E+01
 10/3 D 0.22393E+00 0.21327E+00 0.20259E+00 0.19164E+00 0.18021E+00 0.16827E+00 0.15595E+00 0.14345E+00 0.13089E+00 0.11831E+00
 10/2 D 0.15722E+01 0.15512E+01 0.17288E+01 0.18065E+01 0.18849E+01 0.19628E+01 0.20390E+01 0.21129E+01 0.21837E+01 0.22587E+01
 1/3 V-0.20995E+01-0.21080E+01-0.21159E+01-0.21215E+01-0.21225E+01-0.21155E+01-0.20970E+01-0.20652E+01-0.20225E+01-0.19752E+01
 10/3 V-0.21413E+00-0.21237E+00-0.21479E+00-0.22303E+00-0.23415E+00-0.24361E+00-0.24897E+00-0.25100E+00-0.25162E+00-0.25159E+00
 10/2 V 0.16062E+01 0.15538E+01 0.15474E+01 0.15633E+01 0.15707E+01 0.15477E+01 0.14993E+01 0.14582E+01 0.14520E+01 0.14697E+01
 19/3 V 0.82766E+00 0.87038E+00 0.91413E+00 0.95553E+00 0.99617E+00 0.10386E+01 0.10842E+01 0.11328E+01 0.11855E+01 0.12475E+01
 1/0 P 0.52368E+00 0.52741E+00 0.53266E+00 0.54122E+00 0.55547E+00 0.57819E+00 0.61118E+00 0.65652E+00 0.70865E+00 0.76096E+00
 10/0 P 0.65173E+00 0.68437E+00 0.69997E+00 0.70775E+00 0.71154E+00 0.71599E+00 0.72310E+00 0.73162E+00 0.73921E+00 0.74481E+00
 19/0 P 0.58095E+00 0.59585E+00 0.60895E+00 0.61803E+00 0.62406E+00 0.62842E+00 0.63143E+00 0.63069E+00 0.62469E+00 0.60854E+00

T 0.20000E+01 0.21000E+01 0.22000E+01 0.23000E+01 0.24000E+01 0.25000E+01 0.26000E+01 0.27000E+01 0.28000E+01 0.29000E+01
 10/3 D 0.10577E+00 0.81803E-01 0.60596E-01 0.43010E-01 0.29100E-01 0.18356E-01 0.93135E-02 0.48520E-03-0.80781E-02-0.15453E-01
 10/2 D 0.23324E+01 0.24801E+01 0.26325E+01 0.27985E+01 0.29804E+01 0.31721E+01 0.33658E+01 0.35546E+01 0.37383E+01 0.39237E+01
 1/3 V-0.19310E+01-0.18648E+01-0.18414E+01-0.18272E+01-0.18039E+01-0.18077E+01-0.18300E+01-0.18344E+01-0.18222E+01-0.18286E+01
 10/3 V-0.24972E+00-0.22971E+00-0.19444E+00-0.15727E+00-0.12094E+00-0.93940E-01-0.86908E-01-0.89657E-01-0.81608E-01-0.65886E-01
 10/2 V 0.14773E+01 0.14767E+01 0.15705E+01 0.17511E+01 0.18867E+01 0.19461E+01 0.19284E+01 0.18478E+01 0.18251E+01 0.18629E+01
 19/3 V 0.13092E+01 0.13857E+01 0.14146E+01 0.14242E+01 0.14262E+01 0.14370E+01 0.14617E+01 0.15033E+01 0.15585E+01 0.16143E+01
 1/0 P 0.80474E+00 0.85211E+00 0.86783E+00 0.87730E+00 0.88971E+00 0.89062E+00 0.87826E+00 0.87268E+00 0.87976E+00 0.89503E+00
 10/0 P 0.74787E+00 0.75995E+00 0.78324E+00 0.81402E+00 0.84698E+00 0.87296E+00 0.88300E+00 0.88216E+00 0.88521E+00 0.89536E+00
 19/0 P 0.63766E+00 0.71377E+00 0.74853E+00 0.76429E+00 0.77327E+00 0.78563E+00 0.78563E+00 0.85252E+00 0.90670E+00 0.95946E+00

T 0.30000E+01 0.31000E+01 0.32000E+01 0.33000E+01 0.34000E+01 0.35000E+01 0.36000E+01 0.37000E+01 0.38000E+01 0.39000E+01
 10/3 D-0.21583E-01-0.26946E-01-0.31417E-01-0.34489E-01-0.36088E-01-0.37083E-01-0.38725E-01-0.41200E-01-0.43738E-01-0.45945E-01
 10/2 D 0.41112E+01 0.42918E+01 0.44609E+01 0.46221E+01 0.47789E+01 0.49338E+01 0.50911E+01 0.52547E+01 0.54231E+01 0.55910E+01
 1/3 V-0.18230E+01-0.18147E+01-0.18142E+01-0.18282E+01-0.18309E+01-0.18129E+01-0.17834E+01-0.17413E+01-0.16981E+01-0.16857E+01
 10/3 V-0.56714E-01-0.50549E-01-0.38866E-01-0.22572E-01-0.94119E-02-0.10496E-01-0.22347E-01-0.27149E-01-0.23453E-01-0.20843E-01
 10/2 V 0.18682E+01 0.17445E+01 0.16366E+01 0.15864E+01 0.15515E+01 0.15461E+01 0.15995E+01 0.16725E+01 0.16947E+01 0.16642E+01
 19/3 V 0.16447E+01 0.16423E+01 0.16284E+01 0.16260E+01 0.16391E+01 0.16501E+01 0.16433E+01 0.16301E+01 0.16312E+01 0.16443E+01
 1/0 P 0.88551E+00 0.88844E+00 0.88956E+00 0.88641E+00 0.89068E+00 0.91067E+00 0.94286E+00 0.98239E+00 0.10171E+01 0.10268E+01
 10/0 P 0.90497E+00 0.91228E+00 0.92237E+00 0.93802E+00 0.95359E+00 0.95825E+00 0.95158E+00 0.94559E+00 0.94651E+00 0.95158E+00
 19/0 P 0.98903E+00 0.98637E+00 0.96595E+00 0.95147E+00 0.95347E+00 0.96032E+00 0.95564E+00 0.94186E+00 0.93482E+00 0.93967E+00

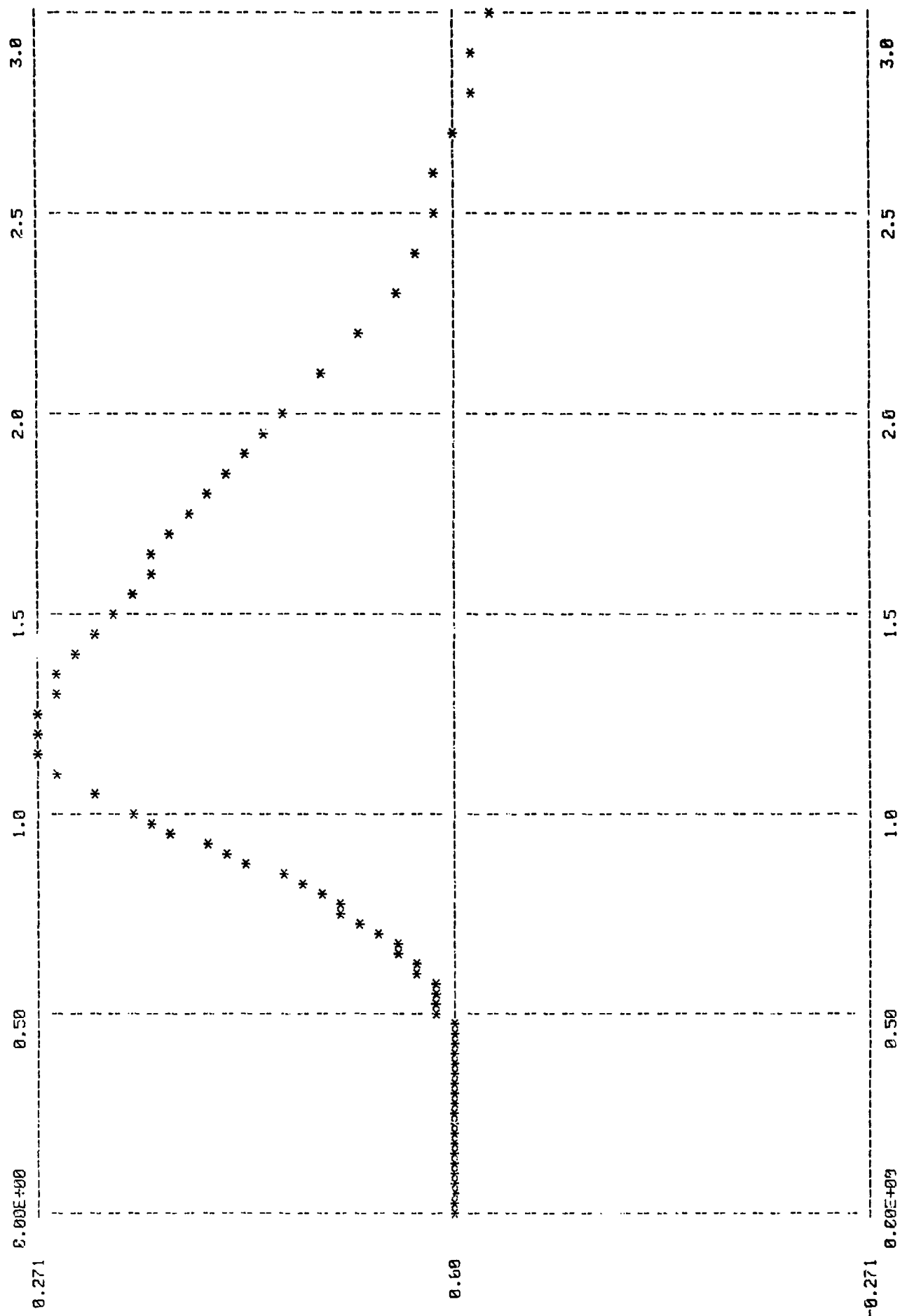
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 10/3 D-0.47842E-01-0.49326E-01-0.50615E-01-0.51914E-01-0.52936E-01-0.53782E-01-0.55296E-01-0.57776E-01-0.60327E-01-0.62896E-01
 10/2 D 0.57581E+01 0.59311E+01 0.61134E+01 0.62996E+01 0.64833E+01 0.66630E+01 0.68384E+01 0.70110E+01 0.71833E+01 0.73543E+01

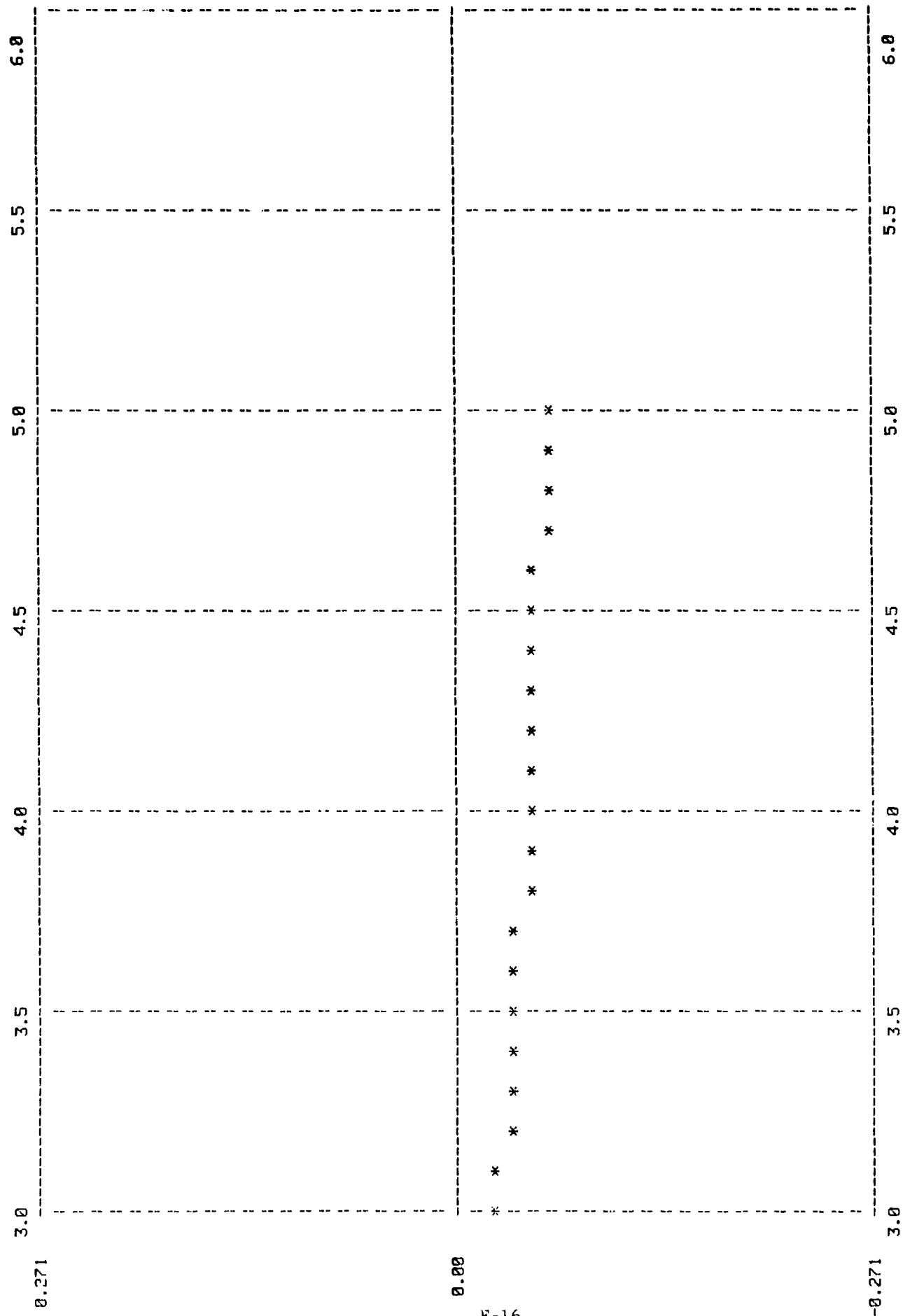
1/3 V-0.17076E+01-0.17360E+01-0.17580E+01-0.17641E+01-0.17474E+01-0.17263E+01-0.17285E+01-0.17465E+01-0.17576E+01-0.17511E+01
 10/3 V-0.17097E-01-0.12589E-01-0.13194E-01-0.12773E-01-0.76704E-02-0.92522E-02-0.21027E-01-0.28581E-01-0.22423E-01-0.12957E-01
 10/2 V 0.16780E+01 0.17808E+01 0.18662E+01 0.18575E+01 0.18169E+01 0.17759E+01 0.17315E+01 0.17203E+01 0.17257E+01 0.16947E+01
 19/3 V 0.16511E+01 0.16479E+01 0.16553E+01 0.16776E+01 0.16942E+01 0.17029E+01 0.17235E+01 0.17491E+01 0.17569E+01 0.17479E+01
 1/0 P 0.10076E+01 0.97200E+00 0.95670E+00 0.95354E+00 0.96907E+00 0.98644E+00 0.98473E+00 0.96610E+00 0.94993E+00 0.94682E+00
 10/0 P 0.95908E+00 0.96659E+00 0.97138E+00 0.97555E+00 0.98066E+00 0.98068E+00 0.97252E+00 0.96502E+00 0.96802E+00 0.97787E+00
 19/0 P 0.94507E+00 0.94303E+00 0.94608E+00 0.95932E+00 0.97372E+00 0.98396E+00 0.99812E+00 0.10149E+01 0.10212E+01 0.10117E+01

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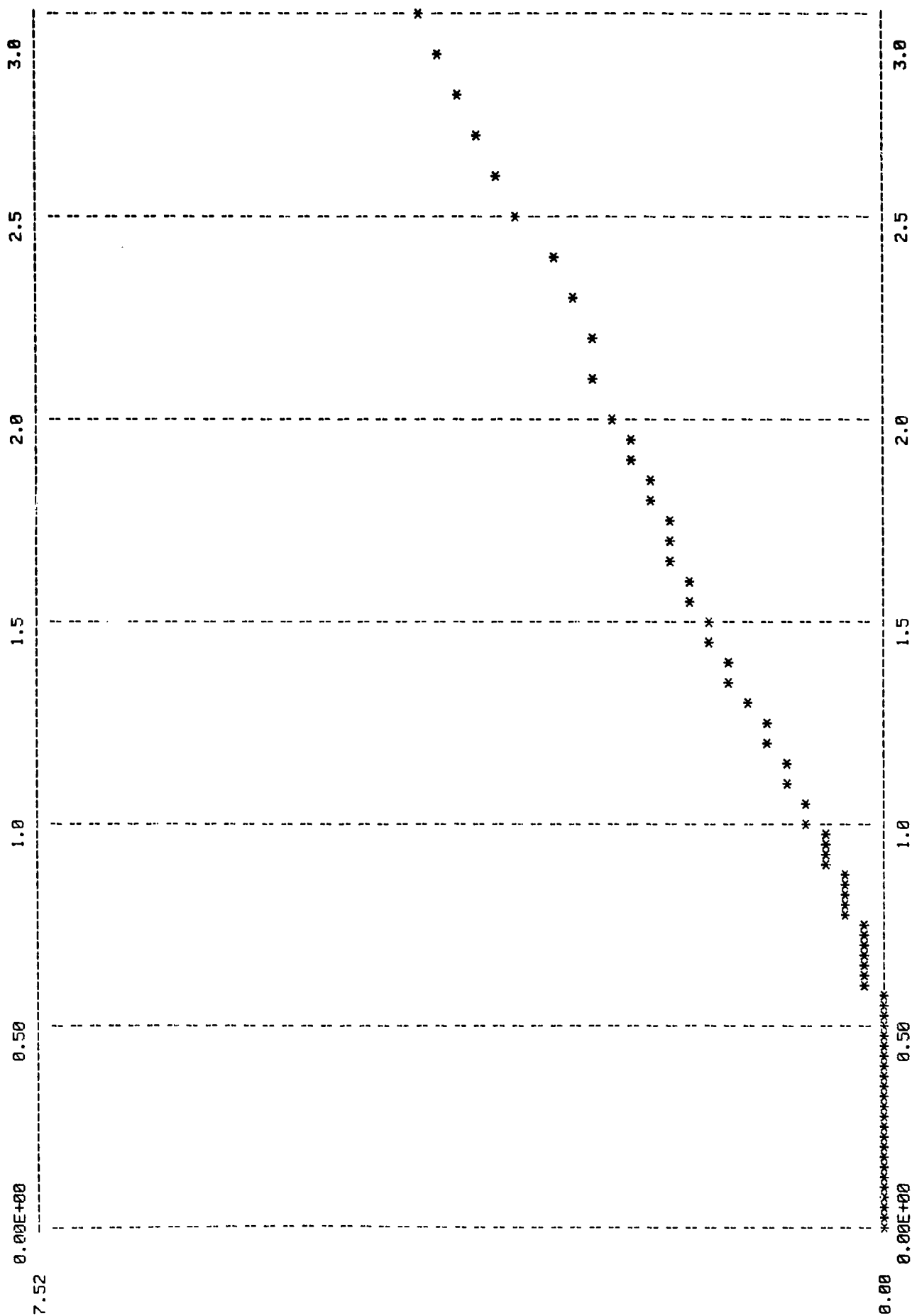
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 10/2 D 0.75225E+01
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 10/3 V-0.11638E-01
 10/2 V 0.16685E+01
 19/3 V 0.1750E+01
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 19/0 P 0.99407E+00

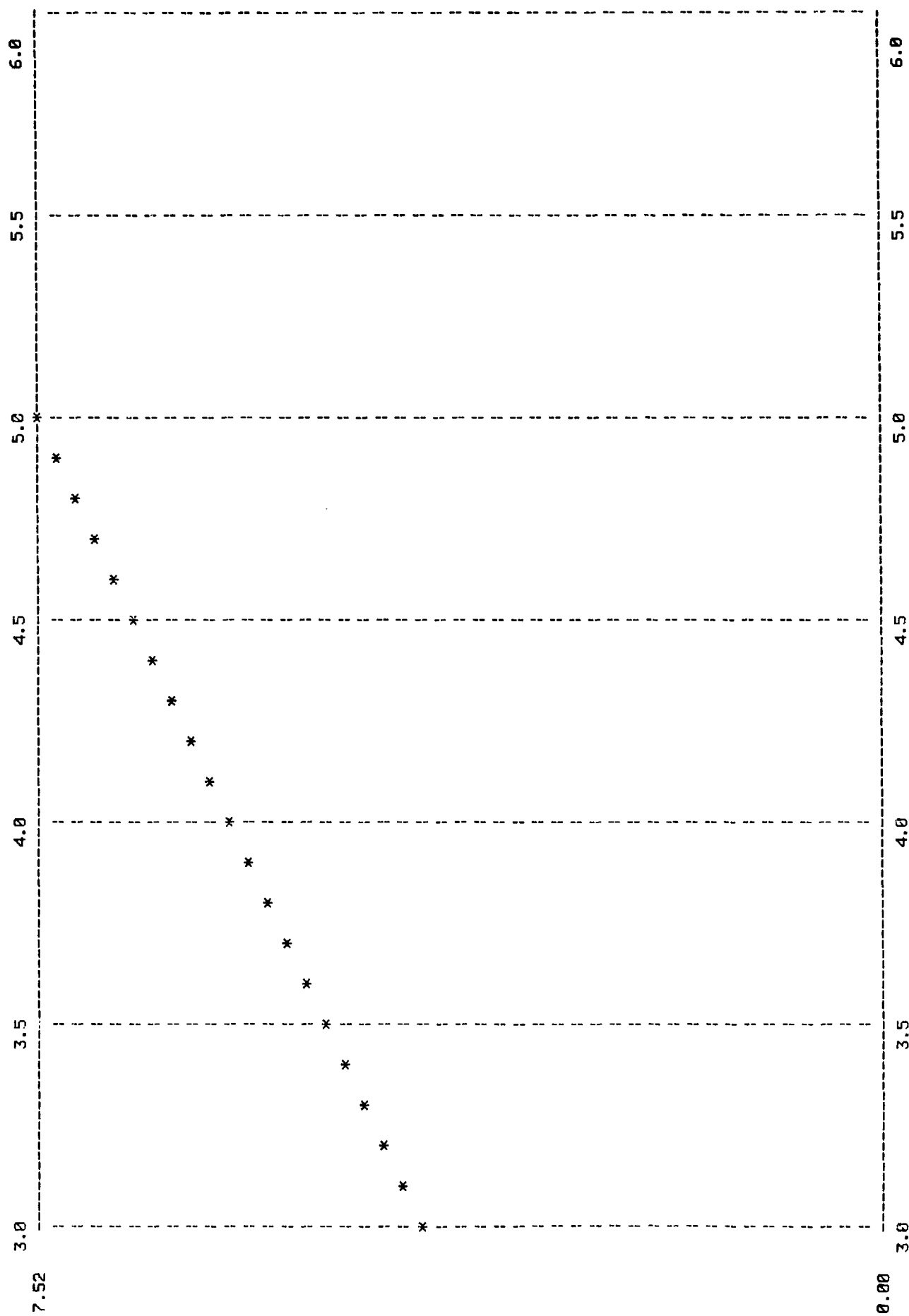
DISPLACEMENT RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 3:



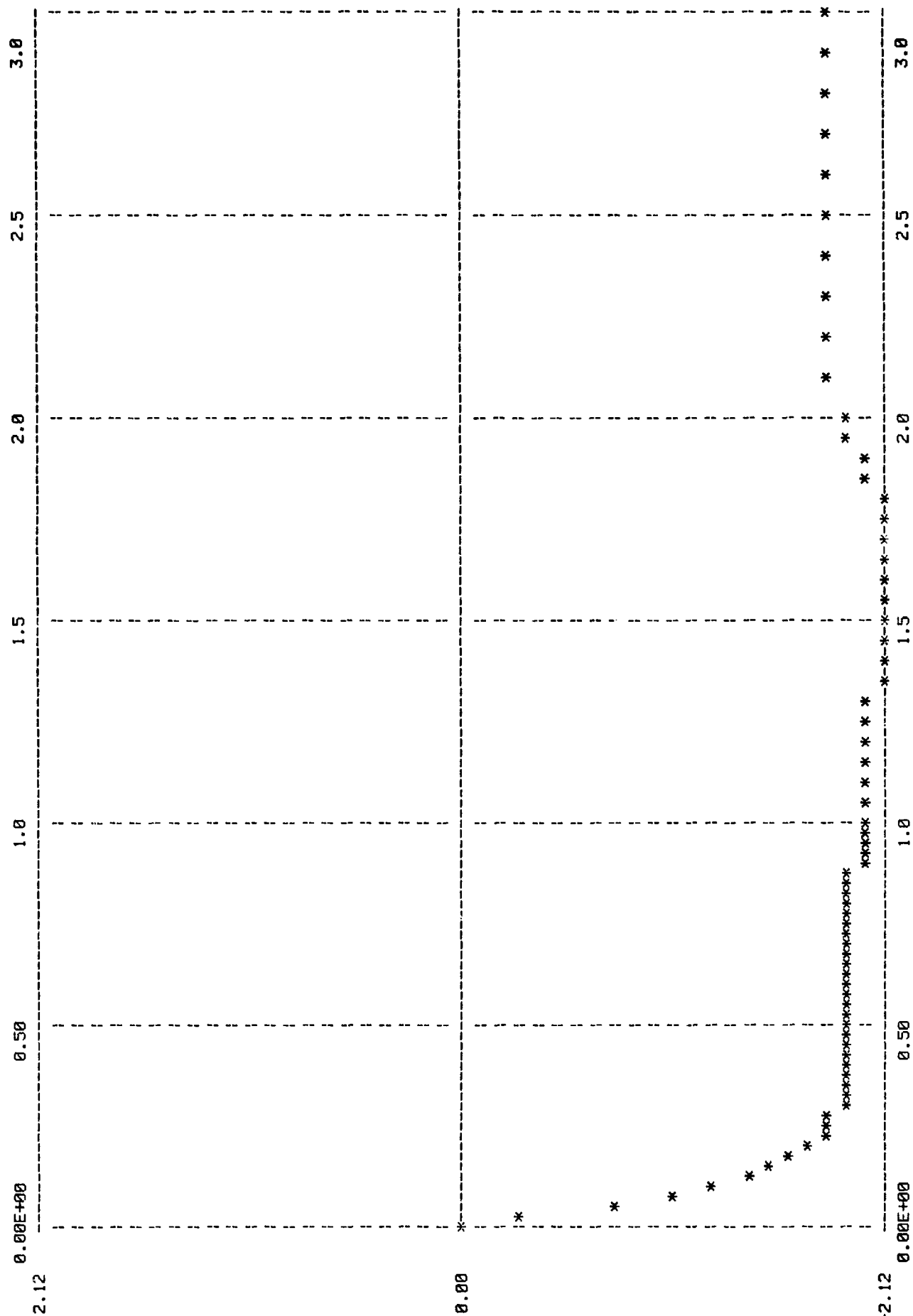


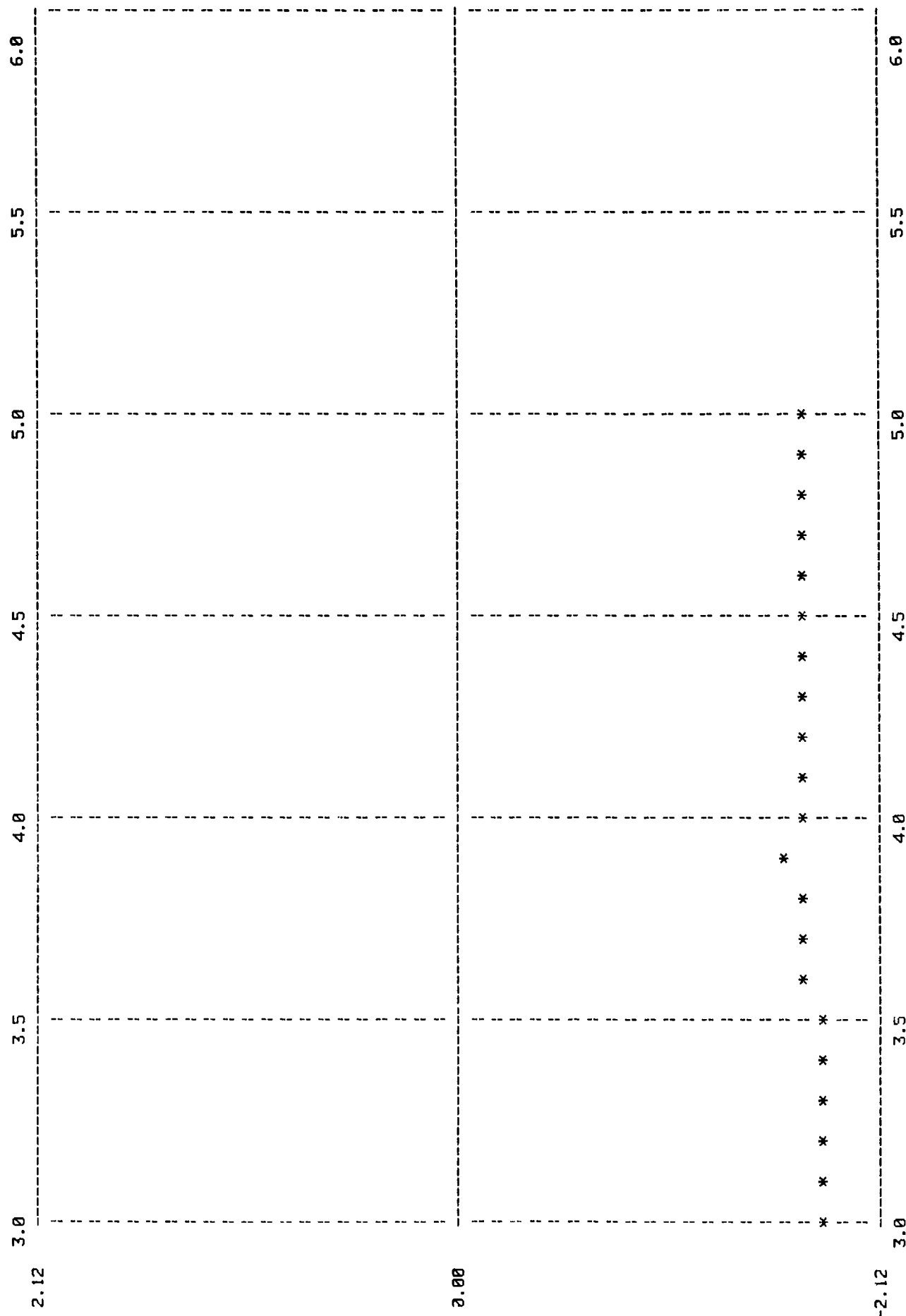
DISPLACEMENT RESPONSE OF STRUCTURAL NODE 10, FREEDOM NUMBER 2:





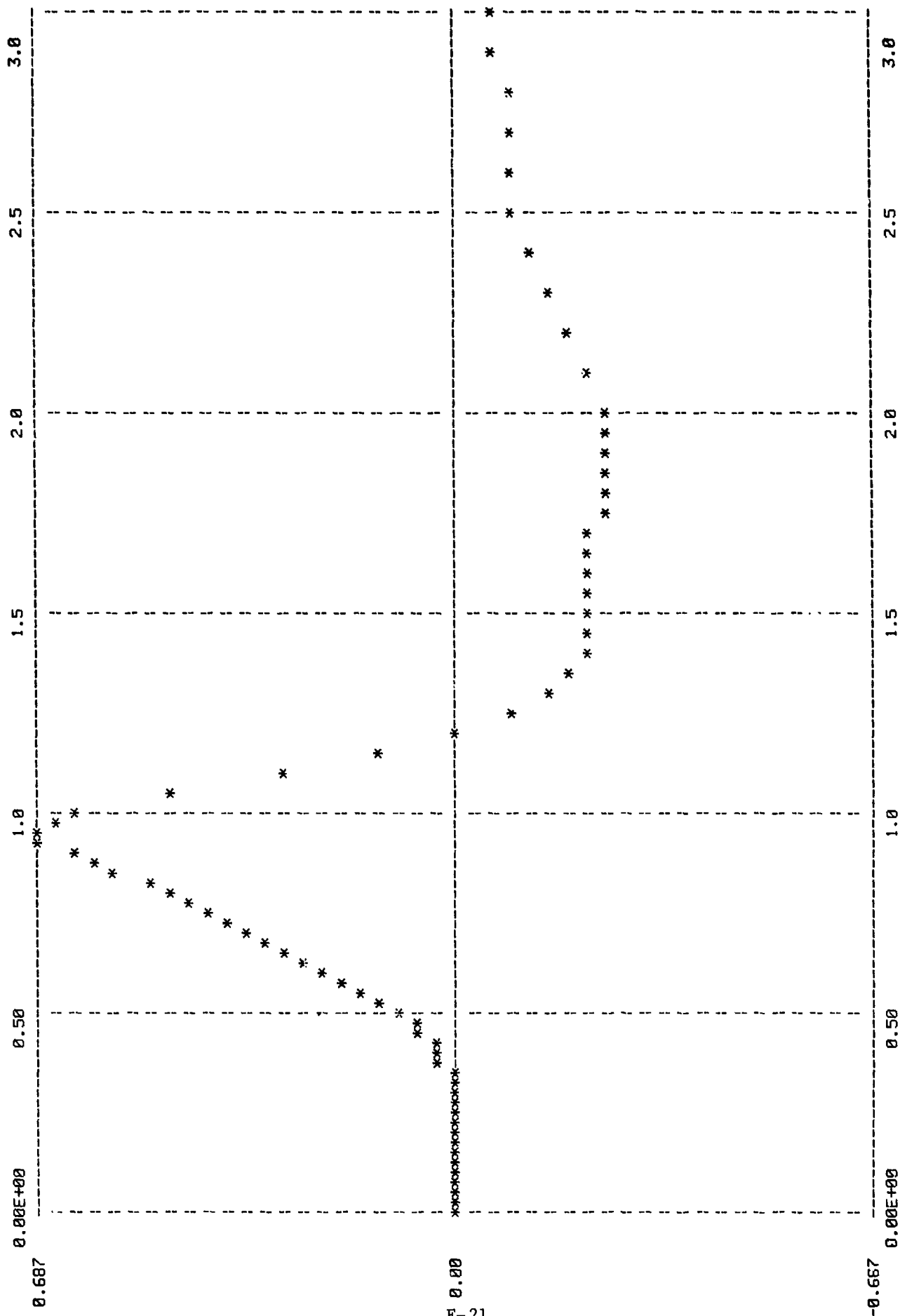
VELOCITY RESPONSE OF STRUCTURAL NODE 1, FREEDOM NUMBER 3:

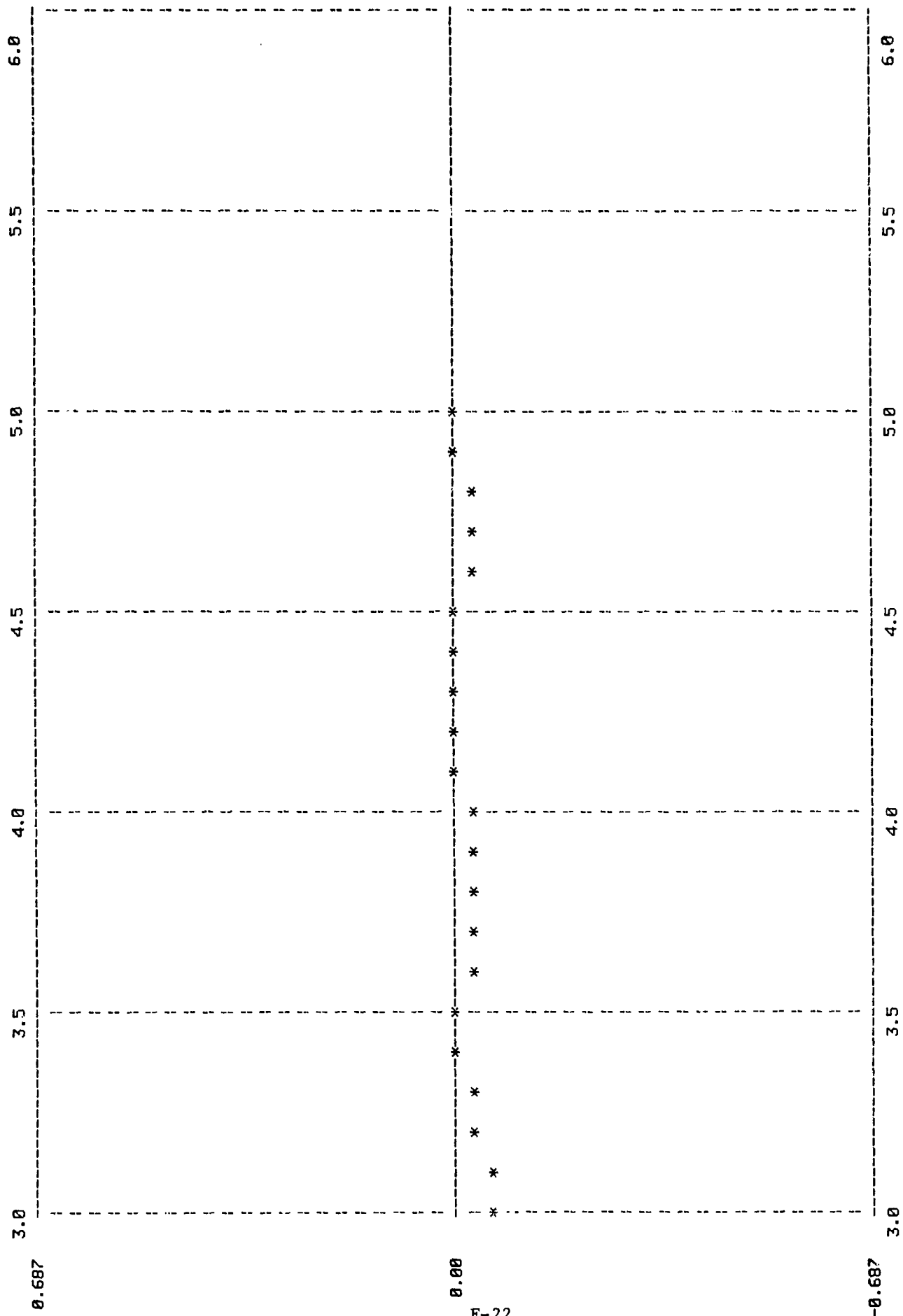




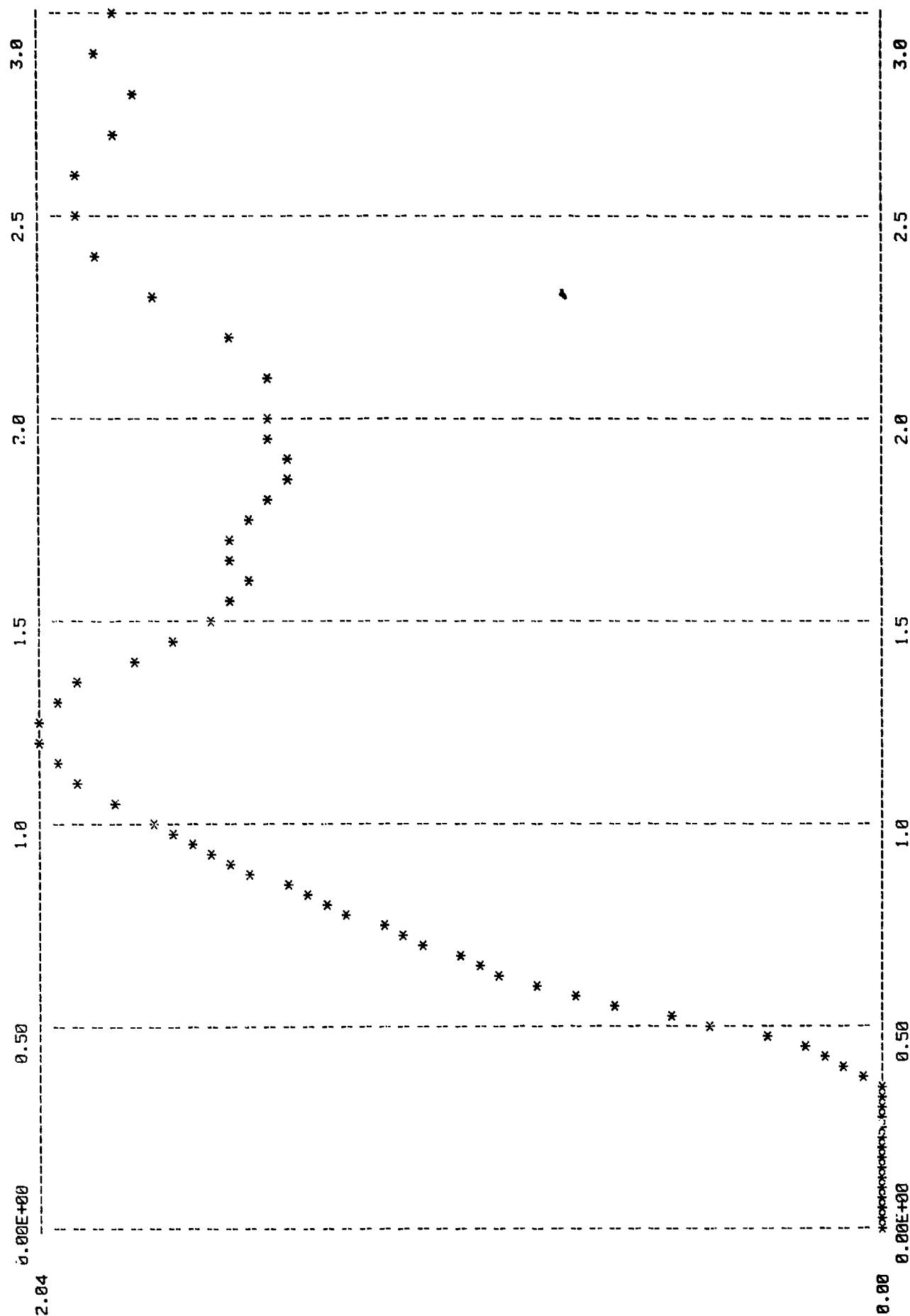
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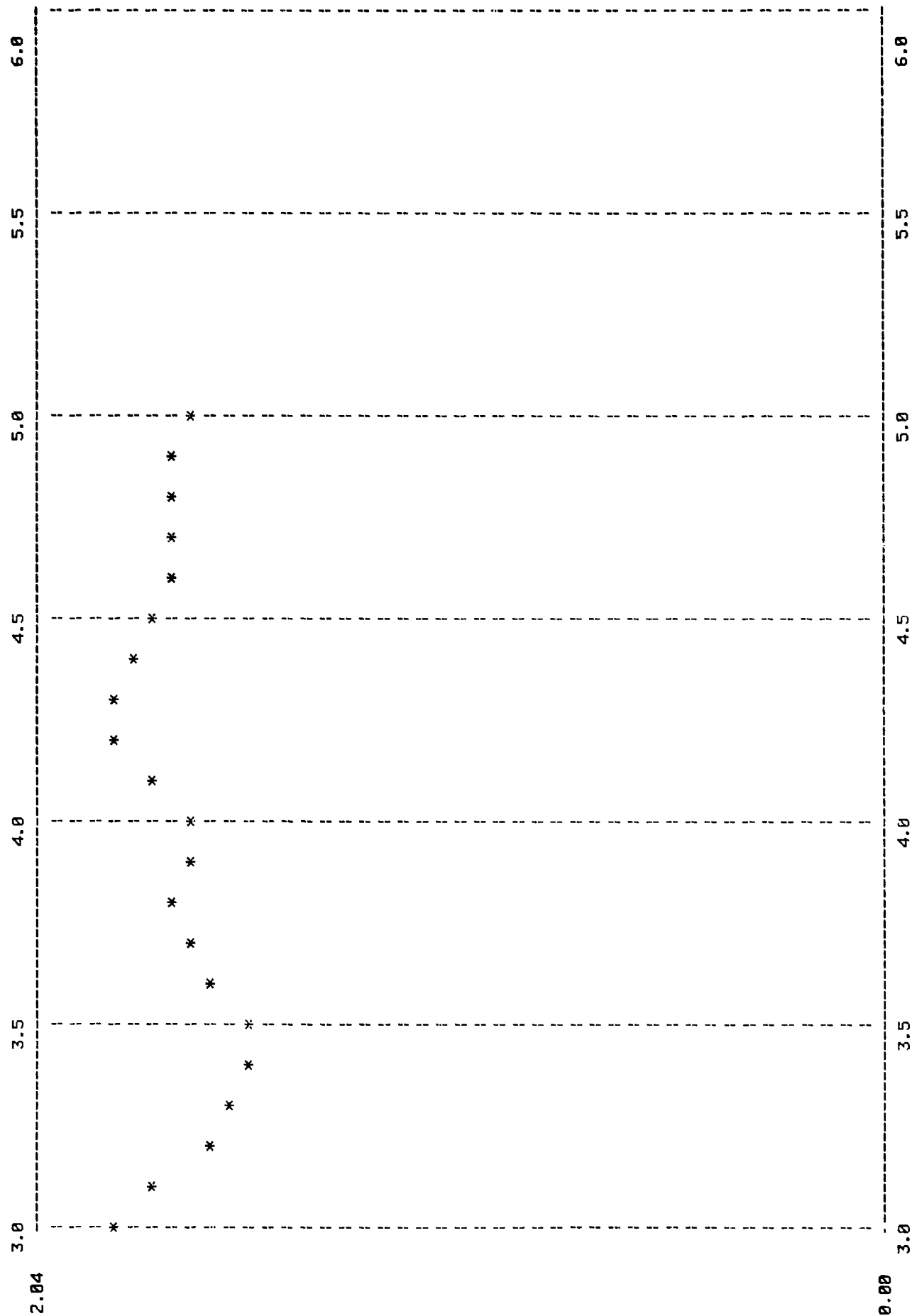
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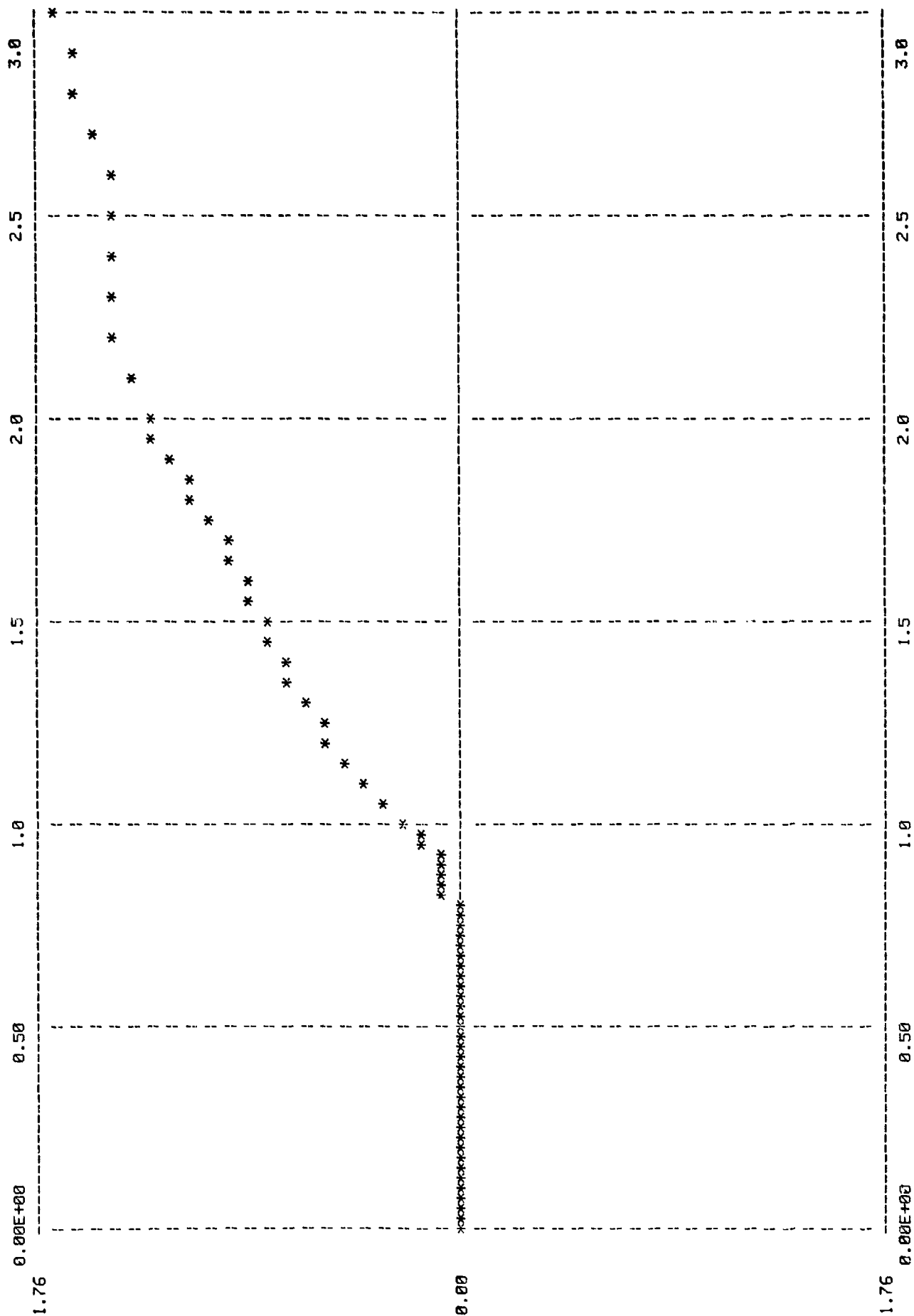


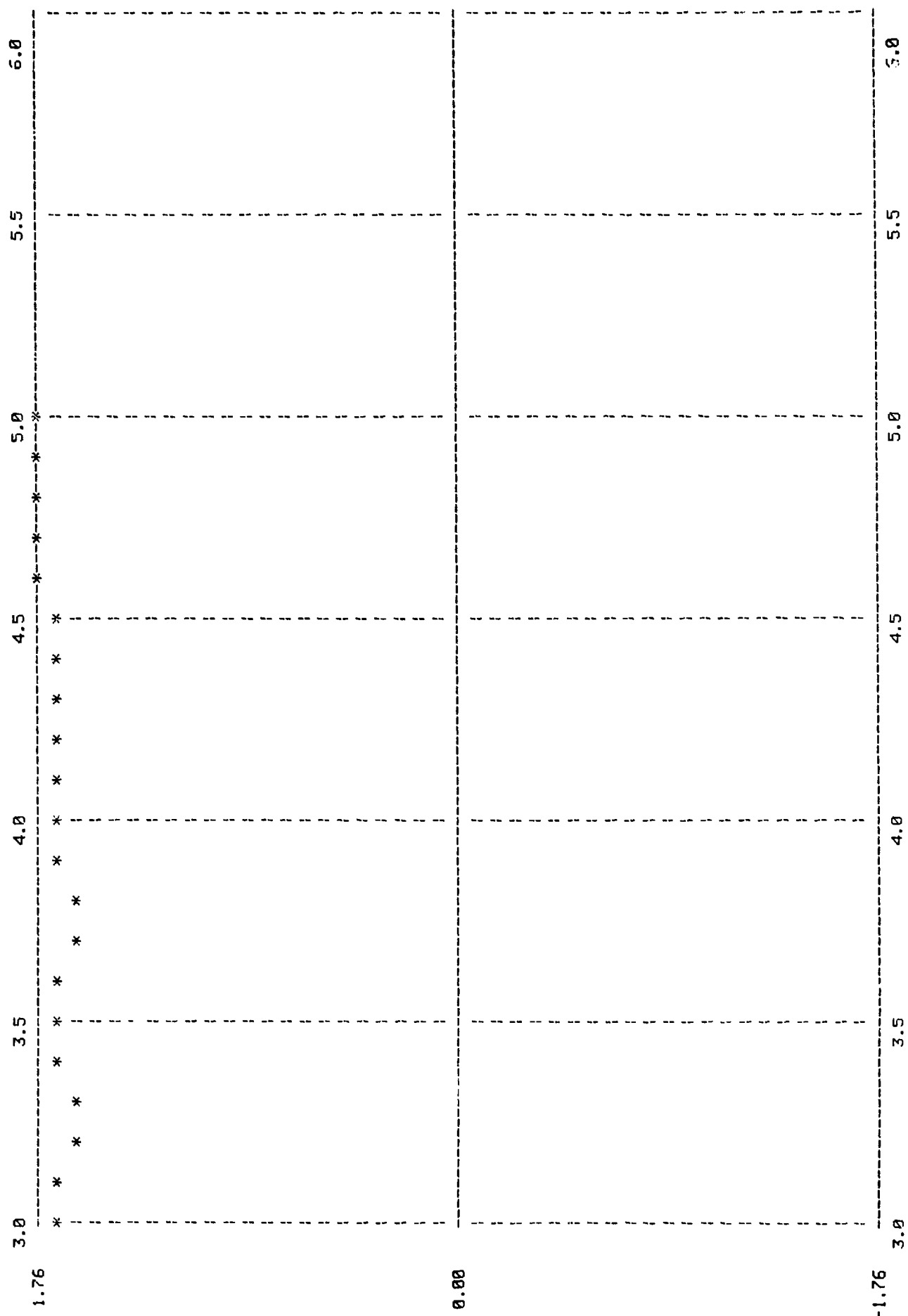
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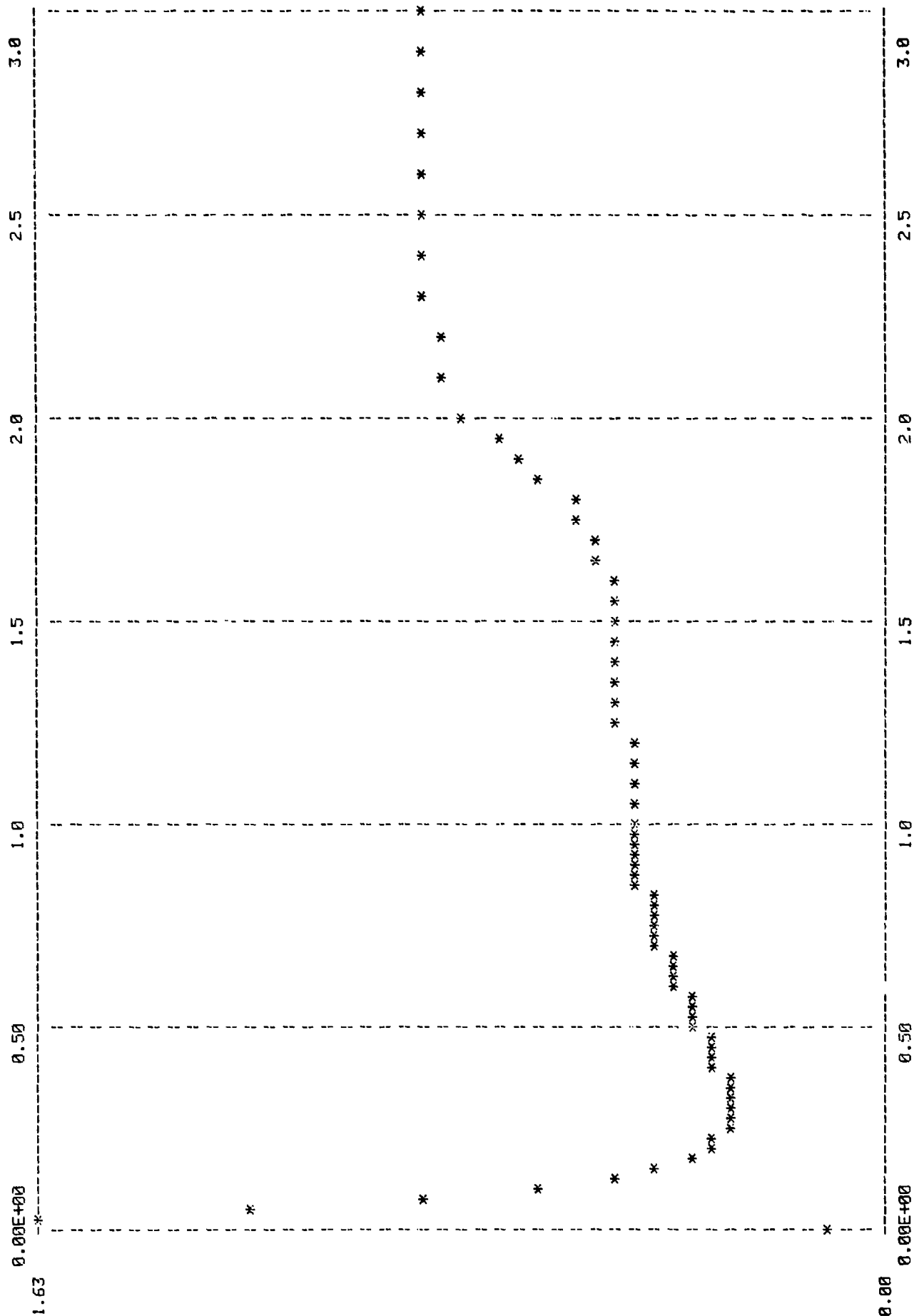


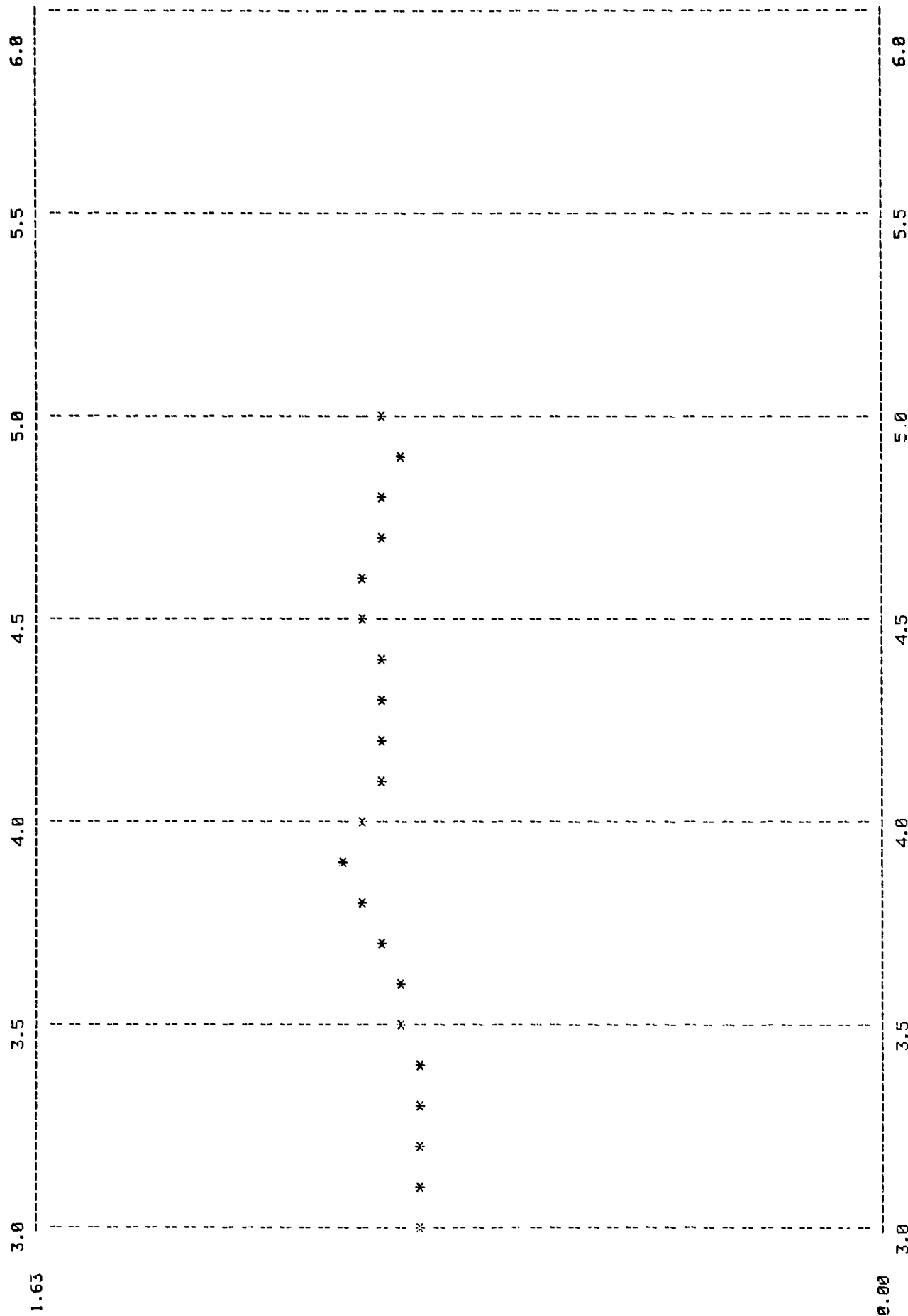
VELOCITY RESPONSE OF STRUCTURAL NODE 19, FREEDOM NUMBER 3:





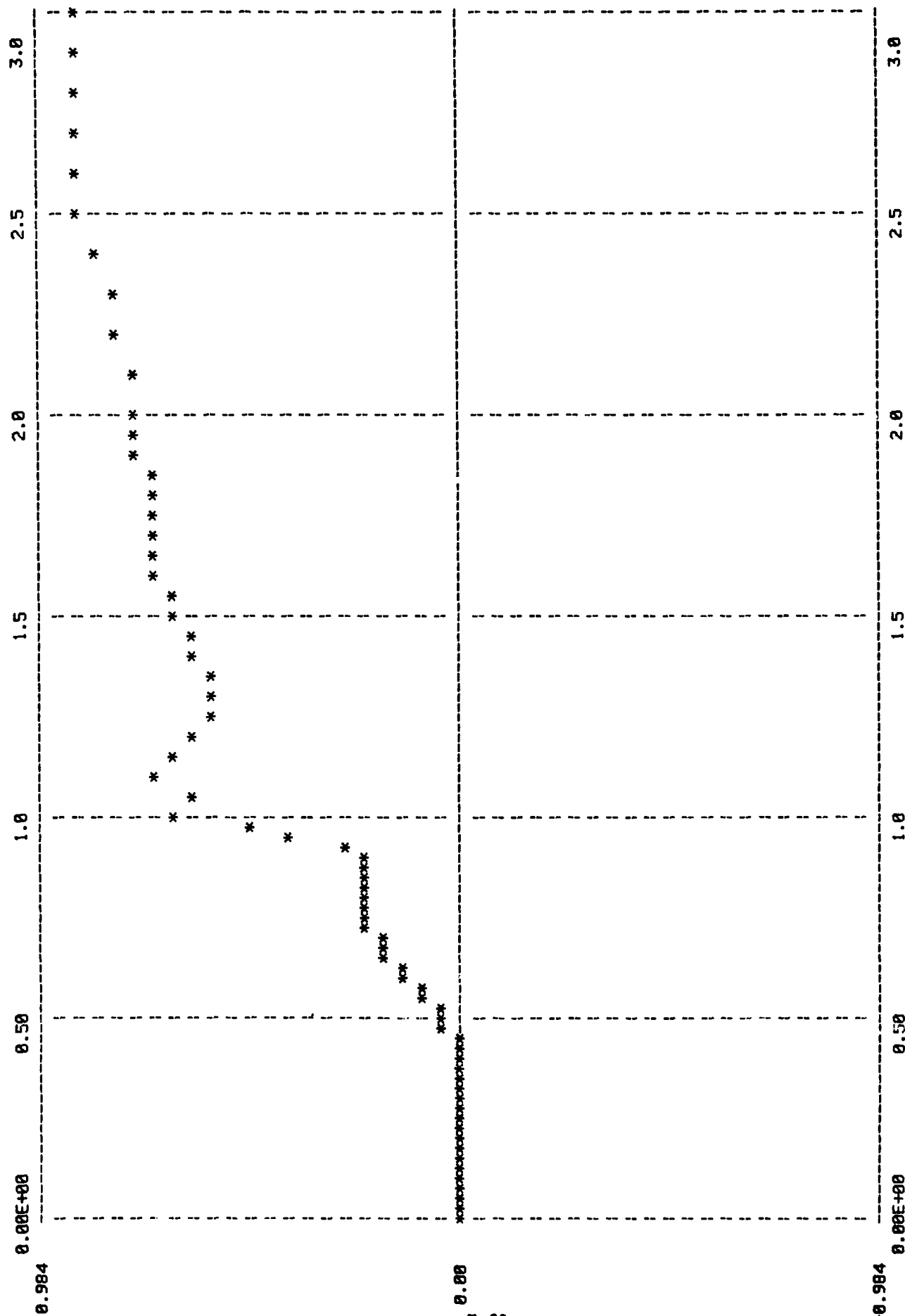
PRESSURE RESPONSE OF FLUID NODE 1:

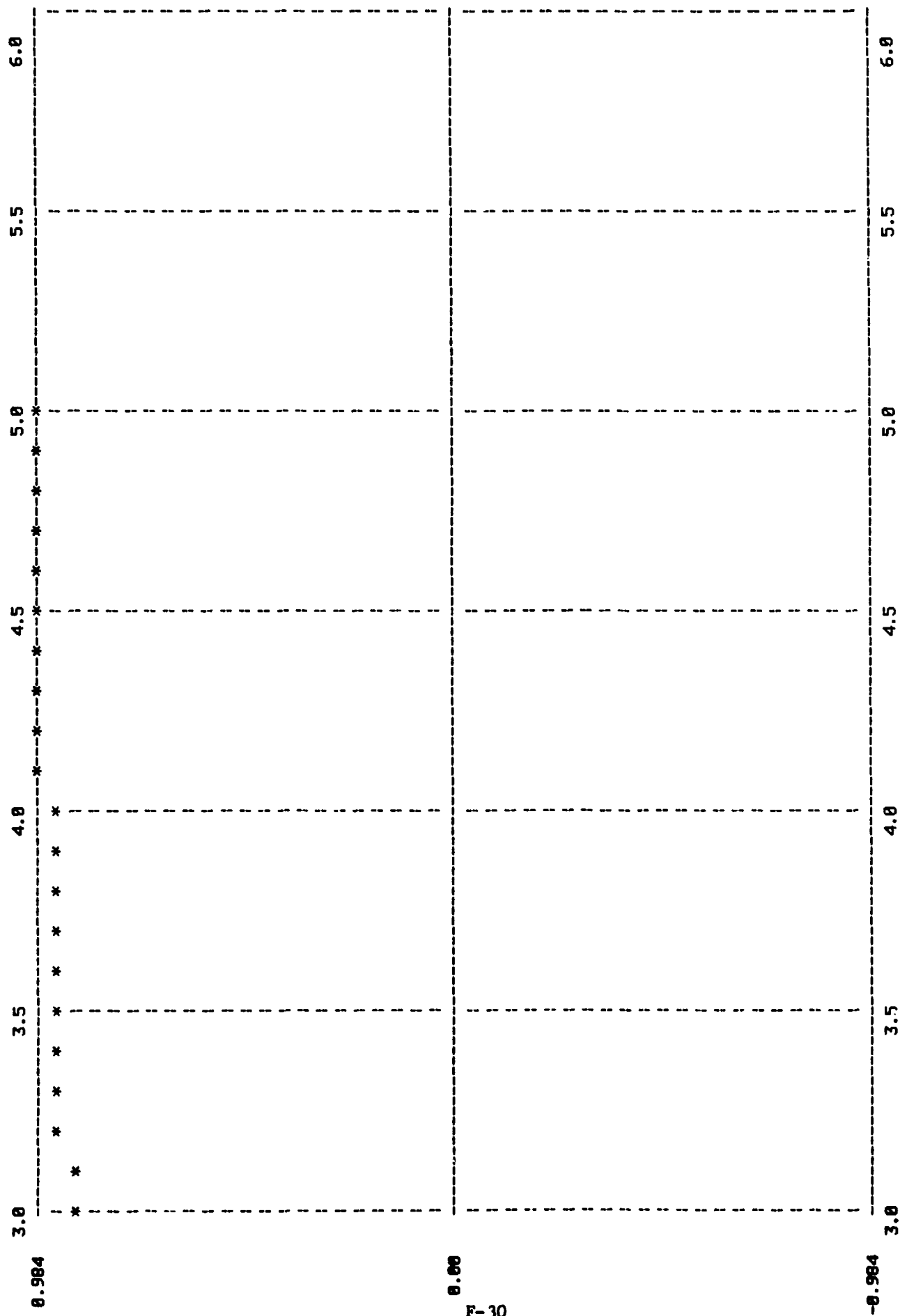




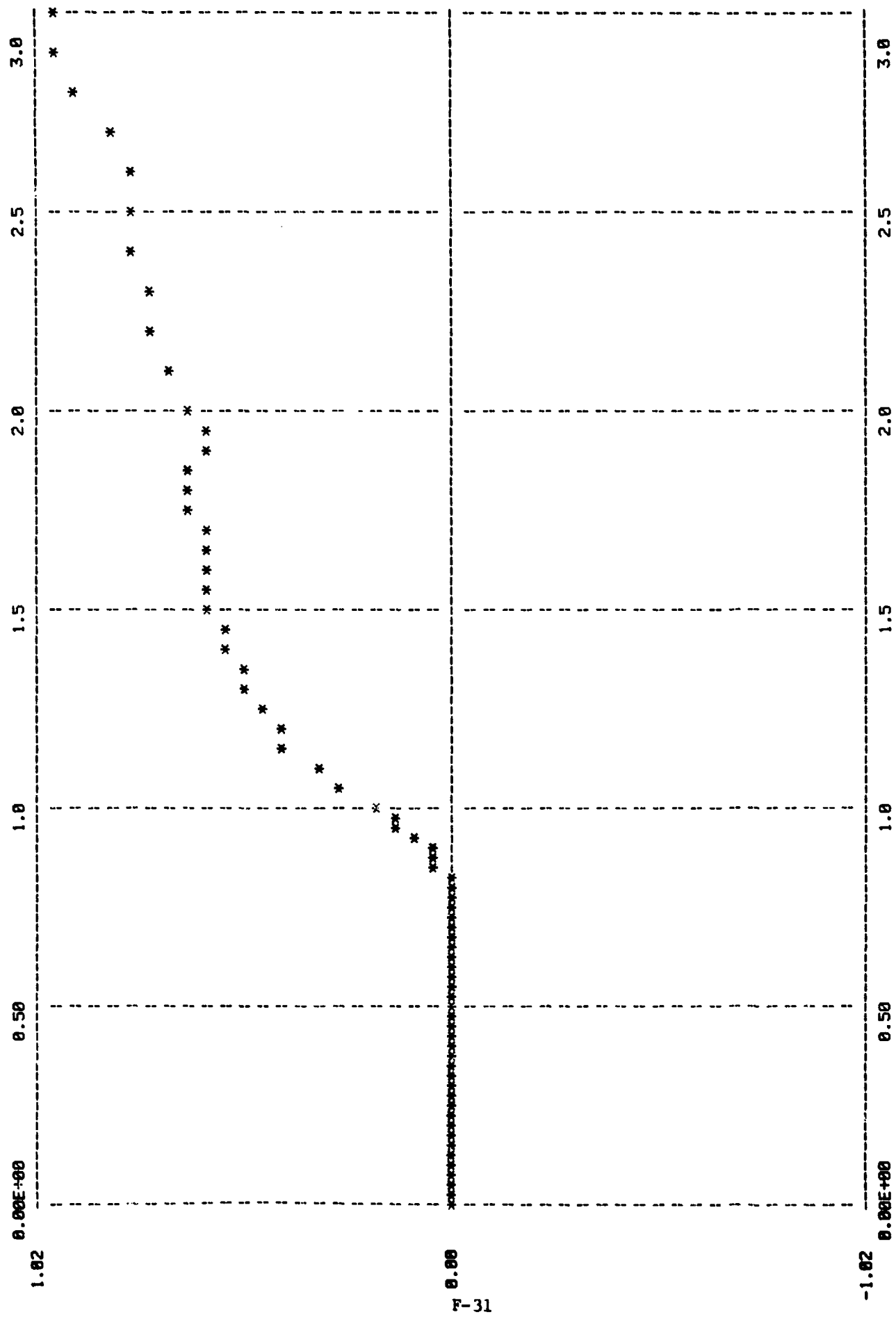
6

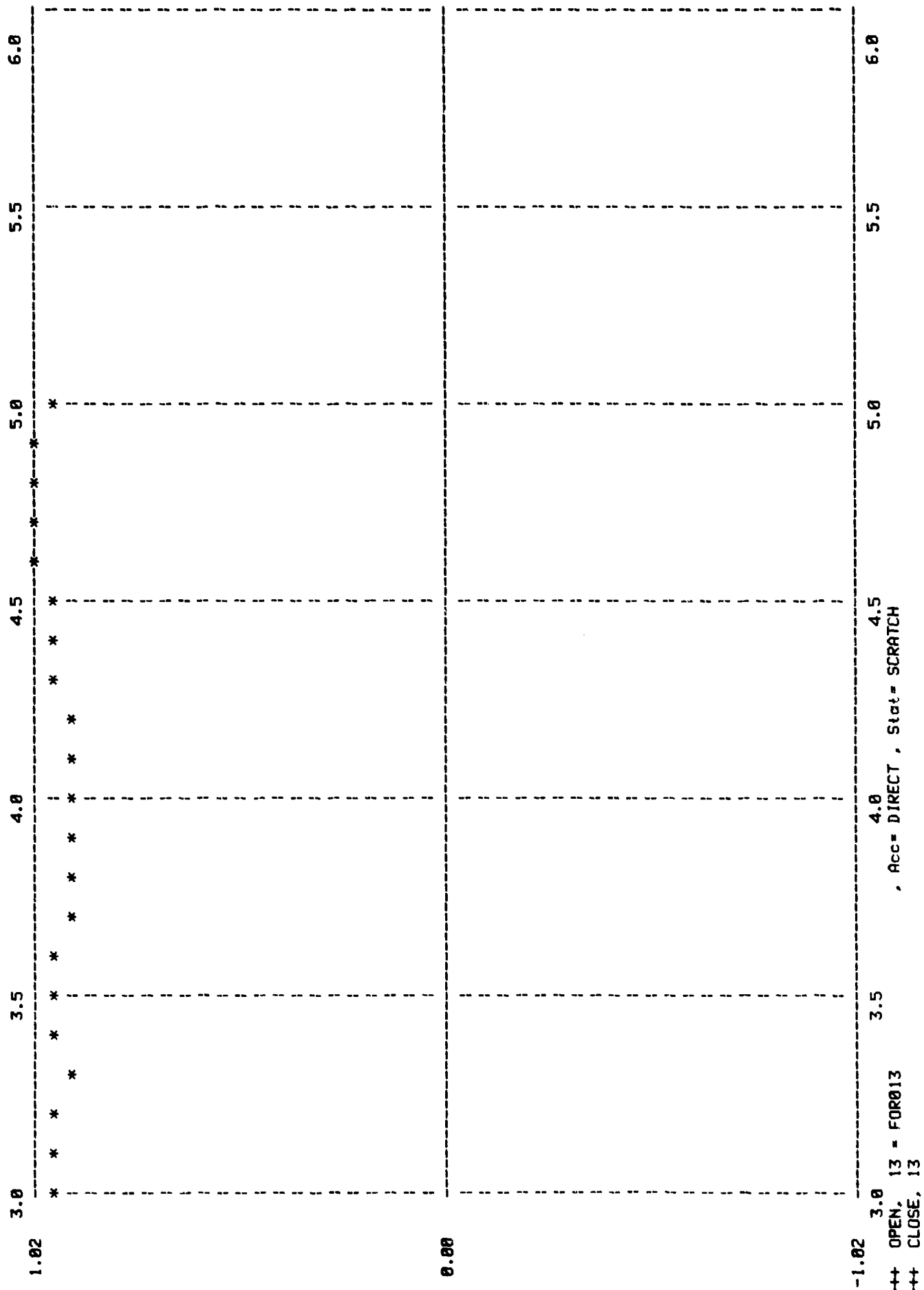
PRESSURE RESPONSE OF FLUID NODE 10:





PRESSURE RESPONSE OF FLUID NODE 19:





PSEUDO-VELOCITY SHOCK SPECTRA:

	1	2	3	4	5	6	7	8	9	10
F	0.00000E+00	0.25000E-01	0.50000E-01	0.75000E-01	0.10000E+00	0.12500E+00	0.15000E+00	0.17500E+00	0.20000E+00	0.22500E+00
1/3 S	0.00000E+00	0.12997E+01	0.18310E+01	0.19129E+01	0.19723E+01	0.20281E+01	0.21763E+01	0.22159E+01	0.22183E+01	0.22098E+01
10/3 S	0.00000E+00	0.42513E-01	0.84574E-01	0.12574E+00	0.16556E+00	0.20363E+00	0.25815E+00	0.32501E+00	0.39981E+00	0.49739E+00
10/2 S	0.00000E+00	0.10906E+01	0.16855E+01	0.16959E+01	0.17338E+01	0.16898E+01	0.16147E+01	0.16545E+01	0.16359E+01	0.17254E+01
19/3 S	0.00000E+00	0.84361E+00	0.14356E+01	0.16061E+01	0.15306E+01	0.14717E+01	0.14034E+01	0.13271E+01	0.12553E+01	0.12009E+01
	11	12	13	14	15	16	17	18	19	20
F	0.25000E+00	0.27500E+00	0.30000E+00	0.32500E+00	0.35000E+00	0.37500E+00	0.40000E+00	0.42500E+00	0.45000E+00	0.47500E+00
1/3 S	0.22133E+01	0.21915E+01	0.21484E+01	0.20949E+01	0.20151E+01	0.19286E+01	0.19149E+01	0.19086E+01	0.19028E+01	0.18963E+01
10/3 S	0.58027E+00	0.63643E+00	0.72682E+00	0.79727E+00	0.86301E+00	0.91530E+00	0.96104E+00	0.99818E+00	0.10339E+01	0.10744E+01
10/2 S	0.17551E+01	0.17786E+01	0.17912E+01	0.17905E+01	0.17764E+01	0.17595E+01	0.18044E+01	0.18899E+01	0.19330E+01	0.19911E+01
19/3 S	0.11514E+01	0.10983E+01	0.10410E+01	0.98543E+00	0.93036E+00	0.87506E+00	0.82726E+00	0.78822E+00	0.75531E+00	0.72635E+00
	21	22	23	24	25	26	27	28	29	30
F	0.50000E+00	0.52500E+00	0.55000E+00	0.57500E+00	0.60000E+00	0.62500E+00	0.65000E+00	0.67500E+00	0.70000E+00	0.72500E+00
1/3 S	0.18896E+01	0.18830E+01	0.18764E+01	0.18653E+01	0.18616E+01	0.18543E+01	0.18481E+01	0.19334E+01	0.20958E+01	0.21322E+01
10/3 S	0.11002E+01	0.11239E+01	0.11571E+01	0.11677E+01	0.11606E+01	0.11757E+01	0.11589E+01	0.11621E+01	0.11437E+01	0.11465E+01
10/2 S	0.21148E+01	0.22644E+01	0.24653E+01	0.26602E+01	0.27395E+01	0.27068E+01	0.26816E+01	0.25395E+01	0.23012E+01	0.20701E+01
19/3 S	0.70039E+00	0.57618E+00	0.65372E+00	0.63444E+00	0.61445E+00	0.59821E+00	0.58061E+00	0.56700E+00	0.55162E+00	0.53895E+00
	31	32	33	34	35	36	37	38	39	40
F	0.75000E+00	0.77500E+00	0.80000E+00	0.82500E+00	0.85000E+00	0.87500E+00	0.90000E+00	0.92500E+00	0.95000E+00	0.97500E+00
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10/3 S	0.11346E+01	0.11362E+01	0.11438E+01	0.11479E+01	0.11416E+01	0.11436E+01	0.11437E+01	0.11351E+01	0.11206E+01	0.11206E+01
10/2 S	0.19397E+01	0.15563E+01	0.14811E+01	0.13501E+01	0.12832E+01	0.11957E+01	0.11160E+01	0.10805E+01	0.10628E+01	0.10429E+01
19/3 S	0.52703E+00	0.51387E+00	0.50294E+00	0.49354E+00	0.48324E+00	0.47200E+00	0.46400E+00	0.45676E+00	0.44866E+00	0.44032E+00
	41	42	43	44	45	46	47	48	49	50
F	0.10000E+01	0.10250E+01	0.10500E+01	0.10750E+01	0.11000E+01	0.11250E+01	0.11500E+01	0.11750E+01	0.12000E+01	0.12250E+01
1/3 S	0.17671E+01	0.17573E+01	0.17280E+01	0.17328E+01	0.17077E+01	0.17058E+01	0.16558E+01	0.16865E+01	0.17199E+01	0.17733E+01
10/3 S	0.11136E+01	0.11001E+01	0.10802E+01	0.10695E+01	0.10614E+01	0.10484E+01	0.10676E+01	0.10631E+01	0.10521E+01	0.10692E+01
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19/3 S	0.43115E+00	0.42533E+00	0.45042E+00	0.48196E+00	0.49572E+00	0.53295E+00	0.52617E+00	0.52938E+00	0.53363E+00	0.49073E+00
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1/3 S	0.19317E+01	0.20119E+01	0.19824E+01	0.18517E+01	0.18143E+01	0.18068E+01	0.17082E+01	0.16845E+01	0.16514E+01	0.16355E+01
10/3 S	0.10460E+01	0.99032E+00	0.99714E+00	0.97172E+00	0.95411E+00	0.93672E+00	0.88445E+00	0.86135E+00	0.86929E+00	0.84635E+00
10/2 S	0.88312E+00	0.87039E+00	0.85773E+00	0.84851E+00	0.83845E+00	0.82759E+00	0.81596E+00	0.80637E+00	0.79834E+00	0.78967E+00
19/3 S	0.49809E+00	0.45509E+00	0.42975E+00	0.39761E+00	0.37303E+00	0.35758E+00	0.35016E+00	0.34363E+00	0.33999E+00	0.33596E+00
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19/3 S	0.33156E+00	0.32680E+00	0.32168E+00	0.31623E+00	0.31046E+00	0.30442E+00	0.29811E+00	0.29462E+00	0.29615E+00	0.28802E+00

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F	0.17500E+01	0.17750E+01	0.18000E+01	0.18250E+01	0.18500E+01	0.18750E+01	0.19000E+01	0.19250E+01	0.19500E+01	0.19750E+01
1/3 S	0.16076E+01	0.16605E+01	0.17015E+01	0.16541E+01	0.16802E+01	0.16412E+01	0.15784E+01	0.15746E+01	0.14925E+01	0.14622E+01
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10/2 S	0.14237E+01	0.13379E+01	0.13133E+01	0.11896E+01	0.10336E+01	0.99370E+00	0.91779E+00	0.81355E+00	0.69040E+00	0.65059E+00
19/3 S	0.28430E+00	0.28056E+00	0.27656E+00	0.27242E+00	0.26815E+00	0.26377E+00	0.25932E+00	0.25481E+00	0.25026E+00	0.24570E+00

	81	82	83	84	85	86	87	88	89	90
F	0.20000E+01	0.20250E+01	0.20500E+01	0.20750E+01	0.21000E+01	0.21250E+01	0.21500E+01	0.21750E+01	0.22000E+01	0.22250E+01
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10/2 S	0.62323E+00	0.61517E+00	0.61004E+00	0.60471E+00	0.59919E+00	0.59349E+00	0.58762E+00	0.58158E+00	0.57538E+00	0.56903E+00
19/3 S	0.24114E+00	0.23660E+00	0.23210E+00	0.22764E+00	0.22324E+00	0.21891E+00	0.21465E+00	0.21161E+00	0.20917E+00	0.21444E+00

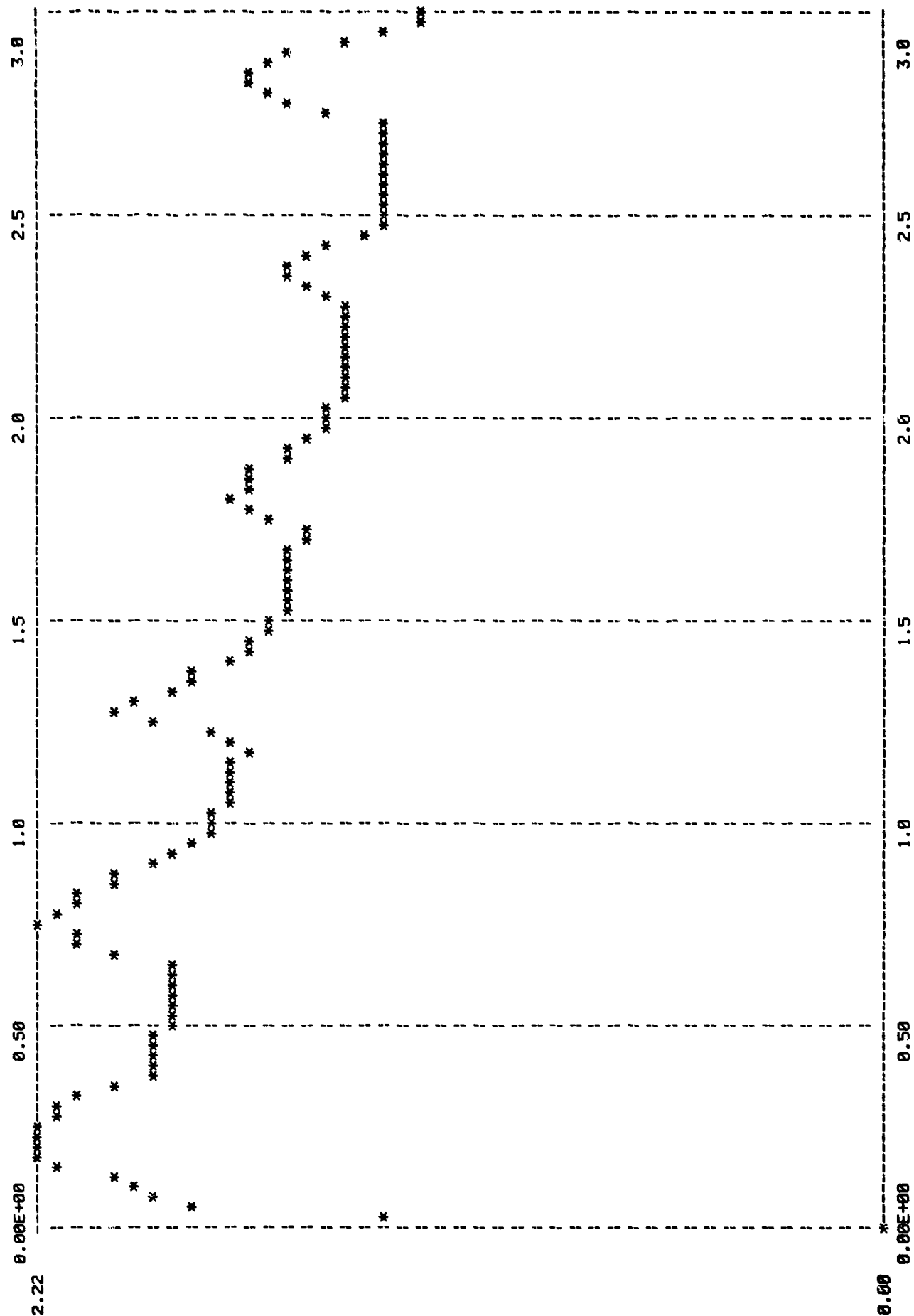
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10/2 S	0.56254E+00	0.55593E+00	0.54918E+00	0.54232E+00	0.53535E+00	0.52828E+00	0.52341E+00	0.51892E+00	0.50200E+00	0.67083E+00
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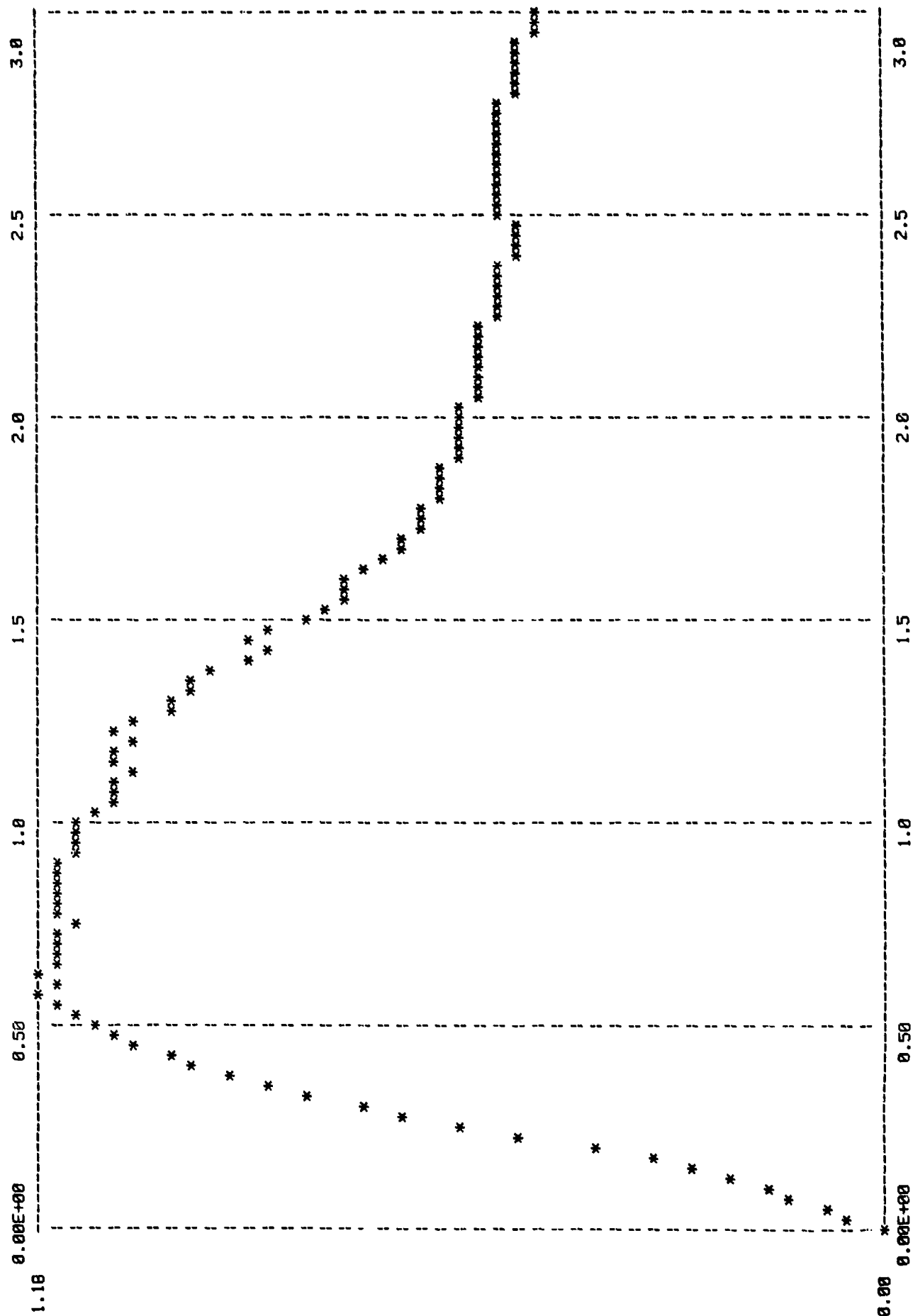
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1/3 S	0.14795E+01	0.15695E+01	0.16241E+01	0.16553E+01	0.16862E+01	0.16200E+01	0.15559E+01	0.14273E+01	0.12923E+01	0.12343E+01
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19/3 S	0.26033E+00	0.26250E+00	0.26151E+00	0.28051E+00	0.27826E+00	0.26352E+00	0.24387E+00	0.25793E+00	0.24550E+00	0.25616E+00

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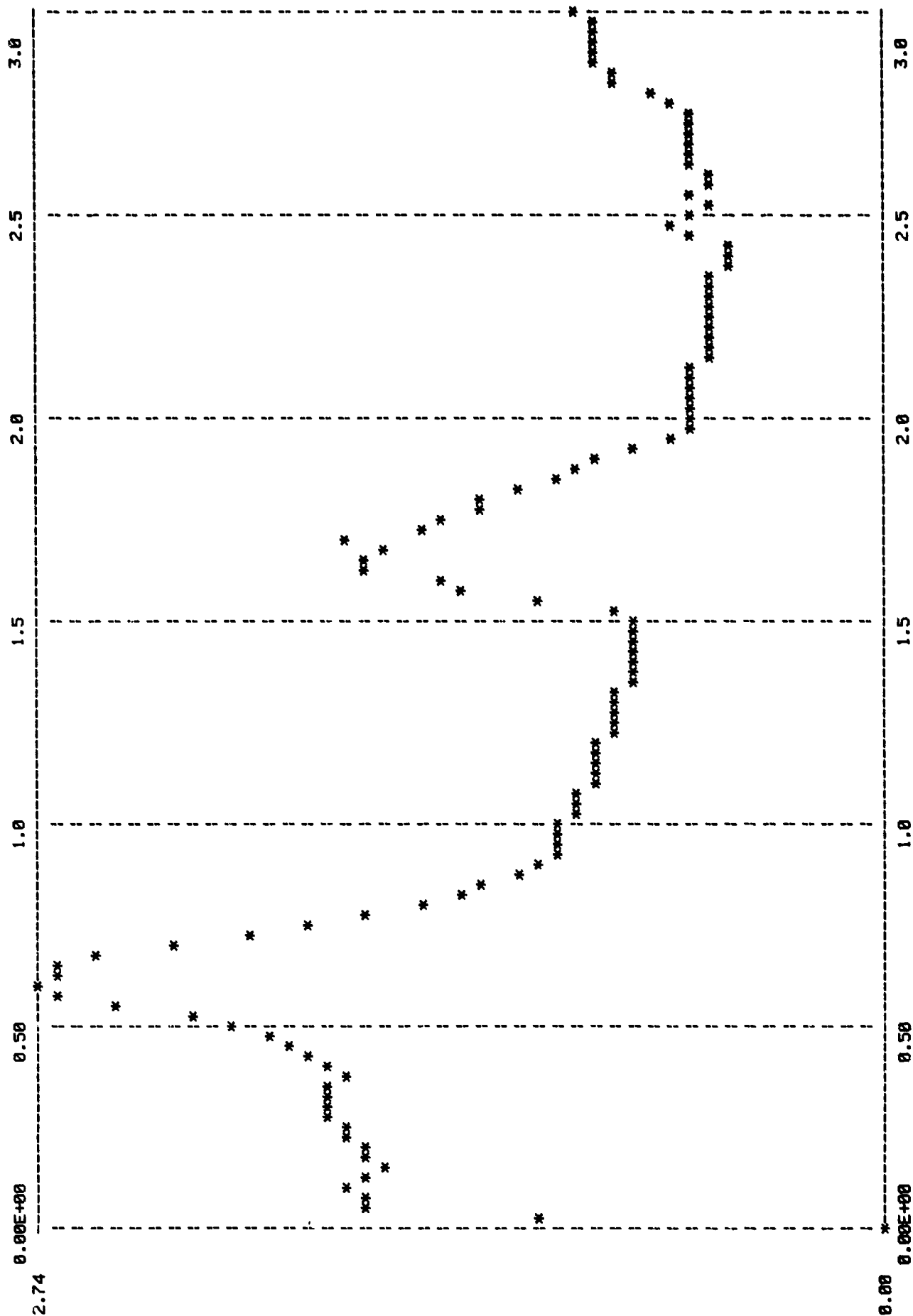
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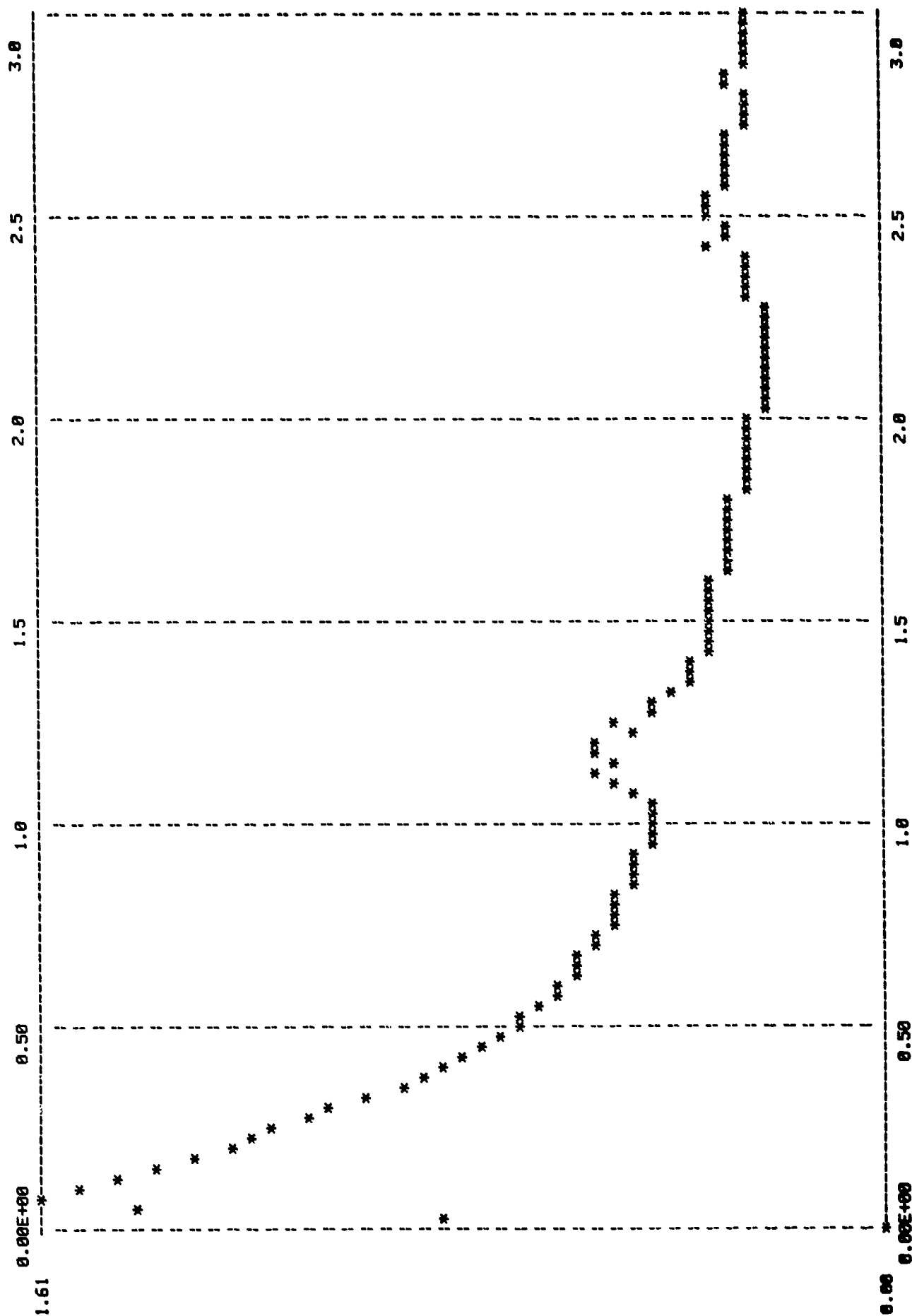
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