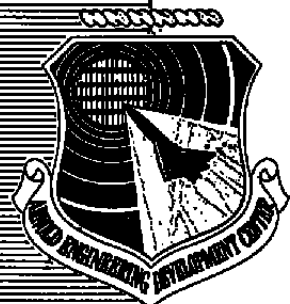


cy.8



A METHOD OF CHARACTERISTICS COMPUTER PROGRAM FOR THREE-DIMENSIONAL SUPERSONIC INTERNAL FLOWS

**W. C. Armstrong
ARO, Inc., a Sverdrup Corporation Company**

**ENGINE TEST FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE 37389**

January 1979

Final Report for Period October 1977 — September 1978

Approved for public release; distribution unlimited.

Property of U. S. Air Force
AEDC LIBRARY
F40600-77-C-0003

Prepared for

**ARNOLD ENGINEERING DEVELOPMENT CENTER/DOTR
ARNOLD AIR FORCE STATION, TENNESSEE 37389**

NOTICES

When U. S. Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, or in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Qualified users may obtain copies of this report from the Defense Documentation Center.

References to named commercial products in this report are not to be considered in any sense as an indorsement of the product by the United States Air Force or the Government.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

APPROVAL STATEMENT

This report has been reviewed and approved.



ELTON R. THOMPSON
Project Manager, Research Division
Directorate of Test Engineering

Approved for publication:

FOR THE COMMANDER



ROBERT W. CROSSLEY, Lt Colonel, USAF
Acting Director of Test Engineering
Deputy for Operations

UNCLASSIFIED

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM								
1. REPORT NUMBER AEDC-TR-78-68	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER								
4. TITLE (and Subtitle) A METHOD OF CHARACTERISTICS COMPUTER PROGRAM FOR THREE-DIMENSIONAL SUPERSONIC INTERNAL FLOWS	5. TYPE OF REPORT & PERIOD COVERED Final Report - October 1977 - September 1978									
	6. PERFORMING ORG. REPORT NUMBER									
7. AUTHOR(s) W. C. Armstrong, ARO, Inc.	8. CONTRACT OR GRANT NUMBER(s)									
9. PERFORMING ORGANIZATION NAME AND ADDRESS Arnold Engineering Development Center/DOTR Air Force Systems Command Arnold Air Force Station, Tennessee 37389	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element 65807F									
11. CONTROLLING OFFICE NAME AND ADDRESS Arnold Engineering Development Center/OIS Air Force Systems Command Arnold Air Force Station, Tennessee 37389	12. REPORT DATE January 1979									
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. NUMBER OF PAGES 94									
	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 Available in DDC										
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">computer programs</td> <td style="width: 50%;">flow (shock-free)</td> </tr> <tr> <td>three dimensional</td> <td>nozzles</td> </tr> <tr> <td>supersonic flow (internal)</td> <td>axially symmetric flow</td> </tr> <tr> <td>transonic flow</td> <td></td> </tr> </table>			computer programs	flow (shock-free)	three dimensional	nozzles	supersonic flow (internal)	axially symmetric flow	transonic flow	
computer programs	flow (shock-free)									
three dimensional	nozzles									
supersonic flow (internal)	axially symmetric flow									
transonic flow										
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The reference-plane method of characteristics is applied to the computation of the supersonic flow in a three-dimensional (3-D) channel such as a propulsion nozzle. The fluid is assumed to be an inviscid ideal gas and the flow is assumed to be shock-free, although it can be rotational. Both the basic equations and the numerical procedures are described, as is the computer program, which was written in FORTRAN IV language for the IBM 370/165										

UNCLASSIFIED

UNCLASSIFIED

20. ABSTRACT (Continued)

computer. The validity of the computer program was established by computing, in various ways, an axisymmetric nozzle flow as a three-dimensional flow; the numerical results are in good agreement with the results from a well-established computer program for axisymmetric flow.

PREFACE

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC). The results presented were obtained by ARO, Inc., AEDC Division (a Sverdrup Corporation Company), operating contractor for the AEDC, AFSC, Arnold Air Force Station, Tennessee. Elton R. Thompson was the Air Force project manager. The work was done under ARO Project No. E32A-POA, and the manuscript was submitted for publication on October 5, 1978.

The author of this report is a Computer Applications Analyst in the Computational Services Branch, Facility Support Department, ARO, Inc.

CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	5
2.0 GOVERNING EQUATIONS	
2.1 Equations of Motion	6
2.2 Characteristic Equations	7
2.3 Compatibility Equations	8
3.0 NUMERICAL PROCEDURE	
3.1 Method of Solution	9
3.2 Working Equations	11
4.0 RESULTS AND DISCUSSION	19
5.0 CONCLUDING REMARKS	21
REFERENCES	22

ILLUSTRATIONS

Figure

1. Coordinate System	8
2. Field Point Network	10
3. Body Point Network	18
4. Geometry for Test Cases	19
5. Results for z Axis Aligned with Nozzle Centerline	20
6. Results of 3-D MOC Program	21

APPENDIXES

A. DESCRIPTION OF COMPUTER PROGRAM	23
B. EXAMPLE PROBLEM	70
NOMENCLATURE	93

1.0 INTRODUCTION

Theoretical calculations of exhaust nozzle performance are often required to aid in the evaluation of engines tested at the Arnold Engineering Development Center (AEDC). In the past, most propulsion nozzles have been axisymmetric and well-established computer programs are available for computing the flow field in such nozzles. However, future tests at AEDC will involve engines with three-dimensional (3-D) exhaust nozzles, and no programs have been available for computing the flow field in 3-D nozzles. Consequently, development of 3-D computer programs for both the transonic and supersonic portions of the flow was initiated. This report describes the supersonic computer program, which is based on the method of characteristics (MOC).---Of course, the computer program described herein is not limited to computation of propulsion nozzle performance, but is also applicable to many other 3-D supersonic internal flows.

Except for the boundary-layer region near the wall, supersonic nozzle flow can be computed with adequate accuracy by assuming the fluid to be inviscid and adiabatic. In addition, most nozzle flows do not contain strong shock waves, so the nozzle performance can be adequately predicted by assuming the flow to be shock-free. However, because of flow phenomena upstream of the nozzle entrance, the flow in propulsion nozzles is often significantly rotational. The rotationality of the flow entering the supersonic region persists throughout the flow field.

In this study, the rotational MOC was chosen as the basis of the numerical analysis. The mathematical theory of characteristics is well established, and many computer programs have been based on the method, particularly for planar and axisymmetric flow. Several programs have been developed to compute the flow over 3-D bodies (e.g., Refs. 1 and 2) and special types of 3-D internal flow have been solved with the method (Ref. 3). However, few attempts have been made to compute general 3-D supersonic internal flows with the MOC.

2.0 GOVERNING EQUATIONS

In this section, the governing flow equations and the resulting characteristic equations are presented. These equations are well documented in the literature (e.g., see Ref. 1); therefore, no development will given.

2.1 EQUATIONS OF MOTION

The steady, inviscid, 3-D flow equations for an ideal gas are:

Continuity:

$$u \frac{\partial \rho}{\partial x} + v \frac{\partial \rho}{\partial y} + w \frac{\partial \rho}{\partial z} + \rho \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} \right) = 0 \quad (1)$$

Momentum:

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + w \frac{\partial u}{\partial z} + \frac{1}{\rho} \frac{\partial p}{\partial x} = 0 \quad (2)$$

$$u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + w \frac{\partial v}{\partial z} + \frac{1}{\rho} \frac{\partial p}{\partial y} = 0 \quad (3)$$

$$u \frac{\partial w}{\partial x} + v \frac{\partial w}{\partial y} + w \frac{\partial w}{\partial z} + \frac{1}{\rho} \frac{\partial p}{\partial z} = 0 \quad (4)$$

Energy:

$$u \frac{\partial h}{\partial x} + v \frac{\partial h}{\partial y} + w \frac{\partial h}{\partial z} - \frac{1}{\rho} \left(u \frac{\partial p}{\partial x} + v \frac{\partial p}{\partial y} + w \frac{\partial p}{\partial z} \right) = 0 \quad (5)$$

State:

$$p = \rho RT \quad (6)$$

2.2 CHARACTERISTIC EQUATIONS

The equations of motion give rise to two sets of characteristic surfaces. The defining equations are

$$(uf_x + vf_y + wf_z)^2 = 0 \quad (7)$$

and

$$(ug_x + vg_y + wg_z)^2 - a^2 (g_x^2 + g_y^2 + g_z^2) = 0 \quad (8)$$

where $f(x, y, z) = 0$ and $g(x, y, z) = 0$ are the characteristic surfaces. The first surface is composed of streamlines and the second is the Mach conoid. The equation of a ray, or bicharacteristic, of the Mach conoid may be expressed as

$$dx = (\cos \beta \sin \theta - \sin \beta \cos \theta \cos \delta) dL \quad (9)$$

$$dy = (\cos \beta \cos \theta \sin \psi - \sin \beta (\sin \theta \sin \psi \cos \delta - \cos \psi \sin \delta)) dL \quad (10)$$

$$dz = (\cos \beta \cos \theta \cos \psi - \sin \beta (\sin \theta \cos \psi \cos \delta + \sin \psi \sin \delta)) dL \quad (11)$$

where β is the Mach angle, dL is the distance along the bicharacteristic, δ is a parametric angle, and θ and ψ are related to the velocity vector by

$$u = q \sin \theta \quad (12)$$

$$v = q \cos \theta \sin \psi \quad (13)$$

$$w = q \cos \theta \cos \psi \quad (14)$$

The parametric angle δ lies in a plane normal to the velocity vector and is measured from the plane containing $\bar{q}$ and x . The relationships between the variables are shown in Fig. 1.

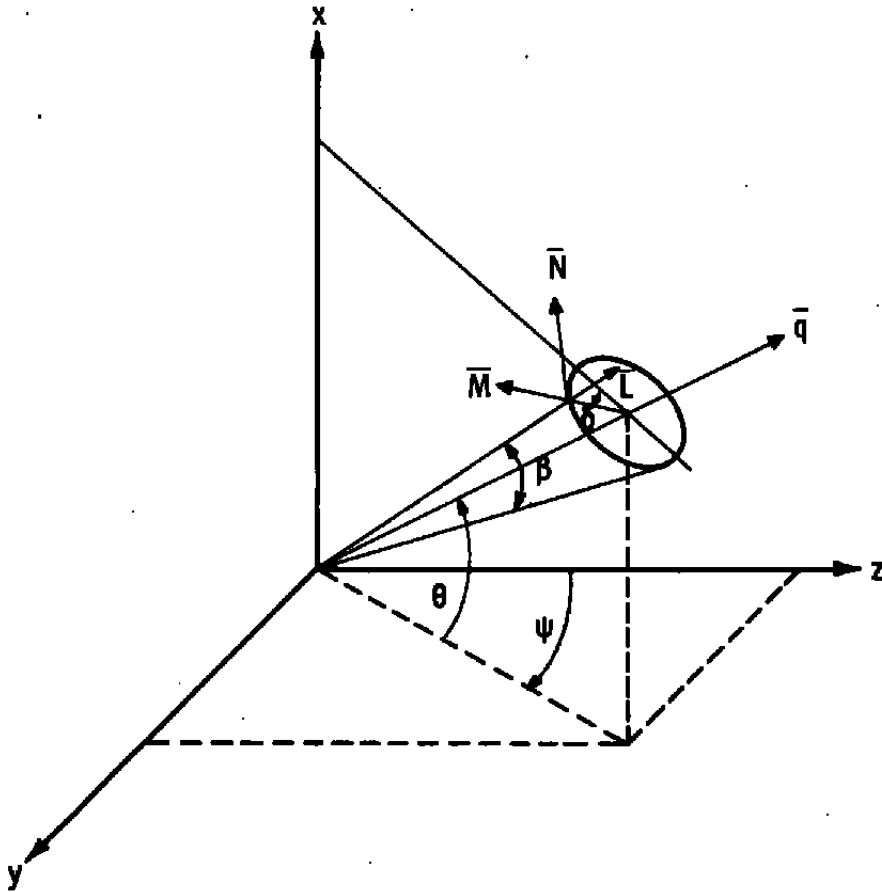


Figure 1. Coordinate system.

2.3 COMPATIBILITY EQUATIONS

The compatibility equations are determined by the flow equations and the requirement that the derivatives in a direction normal to the characteristic surface disappear. The compatibility equation which applies along the Mach conoid is

$$\frac{\cot \beta}{\rho q^2} \frac{\partial p}{\partial L} + \cos \delta \frac{\partial \theta}{\partial L} + \cos \theta \sin \delta \frac{\partial \psi}{\partial L} - \sin \rho \left(\cos \theta \cos \delta \frac{\partial \psi}{\partial N} - \sin \delta \frac{\partial \theta}{\partial N} \right) = 0 \quad (15)$$

where $\frac{\partial}{\partial L}$ and $\frac{\partial}{\partial N}$ are derivatives along and normal to the bicharacteristic.

The compatibility equations along a streamline are

$$\frac{\gamma}{\gamma - 1} R dT = \frac{1}{\rho} dp \quad (16)$$

and

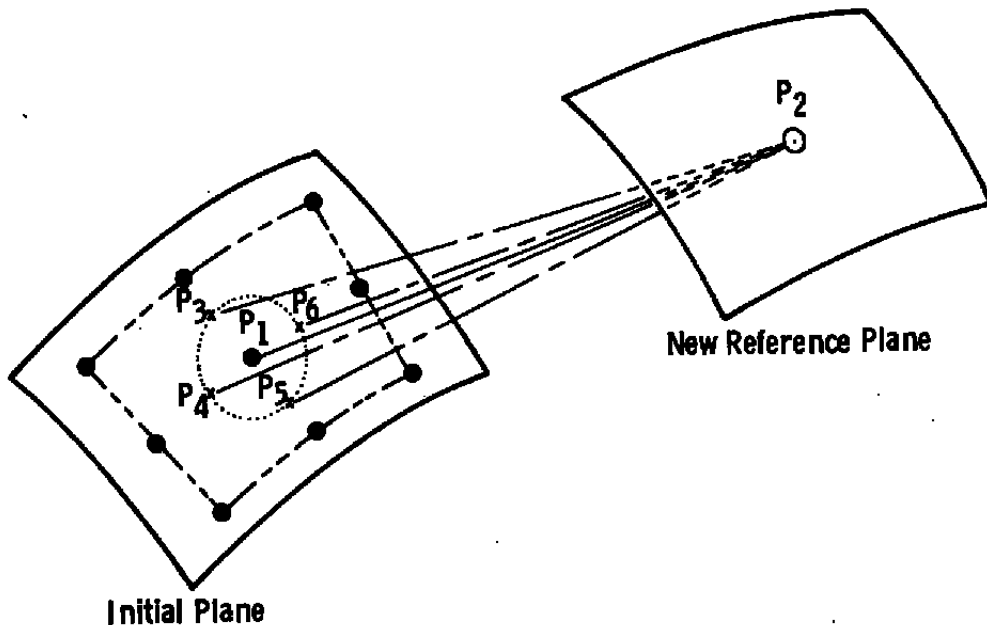
$$\frac{1}{\rho} dp = -q dq \quad (17)$$

3.0 NUMERICAL PROCEDURE

The numerical procedure is similar to the one developed by Strom (Ref. 1) for external flow. The method traces streamlines from a known reference plane to the next reference plane as illustrated in Fig. 2 for a field point. The flow properties at approximately equally spaced points on an initial plane normal to the z axis are assumed known. The reference planes throughout the flow field are assumed to be normal to the z axis.

3.1 METHOD OF SOLUTION

A new reference plane is located a distance dz from the initial plane. This distance must be determined such that the Courant-Friedrichs-Lewy (C-F-L) stability conditions are satisfied (Refs. 1 and 4). The C-F-L stability conditions are satisfied if dz is smaller than the minimum intersection distance of the Mach conoids from the initial points.



- Known Points in Initial Plane
- Point in New Reference Plane (P_2)
- x Points in Initial Plane on Bicharacteristics from P_2
- Streamline
- Bicharacteristic
- Domain of Dependence of Difference Network
- Domain of Dependence of Differential Equations

For the C-F-L stability conditions to be satisfied, the domain of dependence of the differential equations must be contained within the domain of dependence of the difference network.

Figure 2. Field point network.

The intersection of a streamline from a point P_1 in the initial plane with the new reference plane locates point P_2 . Four bicharacteristics, 90 deg apart, from P_2 to the initial plane yield points P_3 , P_4 , P_5 , and P_6 .

The properties at P_1 and eight surrounding neighbors in the initial plane are surface fitted. The flow conditions at points $P_3 - P_6$ are evaluated from the surface fit. The compatibility equations are applied

along the bicharacteristics and the streamline to obtain the flow conditions at P_2 . This procedure is iterated until the flow conditions at P_2 converge. When all points on the new plane are determined, the new plane becomes the initial plane for the next calculation.

3.2 WORKING EQUATIONS

Several of the computational steps are the same for both field points and body points. These common phases of the procedure will be discussed first. Then the computational steps required for field and body points will be presented individually.

3.2.1 Common Procedures

The surface fit of the flow properties at P_1 and eight neighboring points in the initial plane is made once in the iteration procedure to obtain P_2 and its properties. The fit chosen is a spline surface fit (Ref. 5) which fits a variable w as a function of x and y :

$$w(x,y) = a_0 + a_1 x + a_2 y + \sum_{i=1}^9 b_i r_i^2 \ln r_i^2 \quad (18)$$

where

$$r_i^2 = (x - x_i)^2 + (y - y_i)^2$$

Five variables are fit: p , ρ , q , θ , and ψ . The surface fit is used to evaluate the variables at $P_3 - P_6$. The partial derivatives $\frac{\partial}{\partial x}$ and $\frac{\partial}{\partial y}$ are also evaluated using this fit:

$$\frac{\partial w}{\partial x} = a_1 + 2 \sum_{i=1}^9 b_i (1 + \ln r_i^2) (x - x_i) \quad (19)$$

$$\frac{\partial w}{\partial y} = a_2 + 2 \sum_{i=1}^9 b_i (1 + \ln r_i^2)(y - y_i) \quad (20)$$

The derivatives $\frac{\partial \theta}{\partial N}$ and $\frac{\partial \psi}{\partial N}$ used in the compatibility equation along a bicharacteristic must be obtained. The procedure for evaluating them is the same; therefore, only the procedure to obtain $\frac{\partial \theta}{\partial N}$ will be given. Write $\frac{\partial \theta}{\partial N}$ as

$$\left(\frac{\partial \theta}{\partial N}\right)_i = \left(\frac{\partial \theta}{\partial x}\right)_i \left(\frac{\partial x}{\partial N}\right)_i + \left(\frac{\partial \theta}{\partial y}\right)_i \left(\frac{\partial y}{\partial N}\right)_i + \left(\frac{\partial \theta}{\partial z}\right)_i \left(\frac{\partial z}{\partial N}\right)_i \quad (21)$$

The derivatives $\frac{\partial \theta}{\partial x}$ and $\frac{\partial \theta}{\partial y}$ are obtained from the surface fit. Then, $\frac{\partial \theta}{\partial z}$ is obtained by writing the equation as a difference equation and solving for $\frac{\partial \theta}{\partial z}$:

$$\theta_2 - \theta_1 = \left(\frac{\partial \theta}{\partial x}\right)_i (x_2 - x_1) + \left(\frac{\partial \theta}{\partial y}\right)_i (y_2 - y_1) + \left(\frac{\partial \theta}{\partial z}\right)_i dz \quad (22)$$

The derivatives normal to the bicharacteristic are obtained from the coordinate transformation as

$$\left(\frac{\partial x}{\partial N}\right)_i = -\cos \theta \sin \delta_i \quad (23)$$

$$\left(\frac{\partial y}{\partial N}\right)_i = \sin \theta \sin \psi \sin \delta_i + \cos \psi \cos \delta_i \quad (24)$$

$$\left(\frac{\partial z}{\partial N}\right)_i = \sin \theta \cos \psi \sin \delta_i - \sin \psi \cos \delta_i \quad (25)$$

The final form of $\frac{\partial \theta}{\partial N}$ becomes

$$\begin{aligned} \left(\frac{\partial \theta}{\partial N}\right)_i &= \left(\frac{\partial \theta}{\partial x}\right)_i \left(\frac{\partial x}{\partial N}\right)_i + \left(\frac{\partial \theta}{\partial y}\right)_i \left(\frac{\partial y}{\partial N}\right)_i \\ &- \left[\theta_1 + \left(\frac{\partial \theta}{\partial x}\right)_i (x_2 - x_1) + \left(\frac{\partial \theta}{\partial y}\right)_i (y_2 - y_1) \right] \left(\frac{\partial z}{\partial N}\right)_i / dz + \theta_2 \left(\frac{\partial z}{\partial N}\right)_i / dz \end{aligned} \quad (26)$$

For the first iteration, the flow properties at P_2 are assumed to be the same as at P_1 . Thereafter, the last computed values are used. In the sections on the field point and body point, the average values of flow properties are the averages of the two points involved in the calculation (for example, $\theta = (\theta_1 + \theta_2)/2$).

3.2.2 Field Point Routine

Given an initial field point P_1 and eight neighboring points in the initial plane (Fig. 2), spline surface fits of p , ρ , q , θ , and ψ as functions of x and y are made. The iteration for the point P_2 and its flow properties consists of the following steps.

Step 1.

The intersection of the streamline from P_1 with the new reference plane locates the new field point P_2 .

$$x_2 = x_1 - \sin \theta \, dz / (\cos \theta \cos \psi) \quad (27)$$

$$y_2 = y_1 + \sin \psi \, dz / \cos \psi \quad (28)$$

$$z_2 = z_1 + dz \quad (29)$$

Initially θ and ψ are the values at P_1 . Successive iterations use the average of θ and ψ at P_1 and P_2 .

Step 2

Four bicharacteristics extended from P_2 to the initial plane give the base points P_3 , P_4 , P_5 , and P_6 . The flow properties at P_2 are

assumed to be the same as those at P_1 for the first iteration. Thereafter, the flow properties at P_2 are the last values computed. The bicharacteristics are located at the parametric angles $\delta = 0, \frac{\pi}{2}, \pi$, and $\frac{3\pi}{2}$. The equations for the base points are

$$x_i = x_2 - (\cos \beta \sin \theta + \sin \beta \cos \theta \cos \delta_i) dL_i \quad (30)$$

$$y_i = y_2 - [\cos \beta \cos \theta \sin \psi - \sin \beta (\sin \theta \sin \psi \cos \delta_i - \cos \psi \sin \delta_i)] dL_i \quad (31)$$

$$z_i = z_1 \quad (32)$$

$$dL_i = dz / [\cos \beta \cos \theta \cos \psi - \sin \beta (\sin \theta \cos \psi \cos \delta_i + \sin \psi \sin \delta_i)] \quad (33)$$

For the first iteration, the angles β , θ , ψ , and δ are those at P_2 . Successive iterations use the average of the values at P_2 and P_1 .

Step 3

The compatibility equations along the bicharacteristics are solved for p , θ , and ψ at P_2 . Only three of the bicharacteristics are required; however, to improve accuracy, four solutions are obtained using three bicharacteristics at a time. The results of the four solutions are averaged to obtain the values of p , θ , and ψ . The compatibility equation in difference form is

$$\begin{aligned} \frac{\cot \beta_i}{\rho_i q_i^2} (P_2 - P_i) + \cos \delta_i (\theta_2 - \theta_i) + \cos \theta_i \sin \delta_i (\psi_2 - \psi_i) \\ + \sin \beta_i \left(\cos \theta_i \cos \delta_i \left(\frac{\partial \psi}{\partial N} \right)_i - \sin \delta_i \left(\frac{\partial \theta}{\partial N} \right)_i \right) dL_i = 0 \end{aligned} \quad (34)$$

The equation contains the three unknowns P_2 , θ_2 , and ψ_2 . The compatibility equations using P_3 , P_4 , and P_5 are solved simultaneously for P_{21} , θ_{21} , and ψ_{21} - similarly, (P_4, P_5, P_6) , (P_5, P_6, P_3) , and (P_6, P_3, P_4) are used to obtain values of p , θ , and ψ . Thus, $P_2 = (P_{21} + P_{22} + P_{23} + P_{24})/4$. In the compatibility equation, β_i , ρ_i , q_i , and δ_i are the average of the values at P_2 and P_i .

The variables ρ_2 , T_2 , and q_2 are obtained from the compatibility equations along the streamline. The flow along a streamline without shocks is isentropic. Therefore, the equations integrate to the following forms for an ideal gas:

$$T_2 = T_{ts} \left(\frac{p_2}{p_{ts}} \right)^{\frac{\gamma-1}{\gamma}} \quad (35)$$

$$\rho_2 = R T_2 / P_2 \quad (36)$$

$$q_2 = \sqrt{2 \frac{\gamma}{\gamma-1} (T_{ts} - T_2)} \quad (37)$$

where T_{ts} and p_{ts} are the stagnation values for the streamline.

Step 4

The preceding steps are repeated until the flow conditions at P_2 converge. If there is no convergence after 25 iterations, the results are checked with a reduced convergence criterion. If this is satisfied, the point is accepted and a message printed. Otherwise, the program terminates.

3.2.3 Body Point Routine

Given the properties of an initial body point P_1 and those of eight neighboring points on the initial plane (Fig. 3), spline surface fits are made. The body surface is assumed to be given by

$$B(x, y, z) = 0 \quad (38)$$

where B is either a known function or a surface fitting element in the region of the body point. The iteration for the new body point P_2 , in the new reference plane, and its flow properties consists of the following steps:

Step 1

The new body point P_2 is located at the intersection of a plane through P_1 , defined by the body unit normal and the unit velocity vector tangent to the body at P_1 , with the body surface at the new reference plane. This requires the simultaneous solution of the following equations:

$$B(x, y, z) = 0 \quad (39)$$

and

$$\begin{aligned} (n_3 \cos \theta \cos \psi - n_1 \cos \theta \sin \psi)(x - x_1) + (n_1 \sin \theta \\ - n_2 \cos \theta \cos \psi)(y - y_1) = (n_3 \sin \theta - n_1 \cos \theta \sin \psi) dz \end{aligned} \quad (40)$$

where n_1 , n_2 , and n_3 are unit normals to the body surface. The first iteration uses the values of θ , ψ , n_1 , n_2 , and n_3 , at P_1 . Successive iterations use the averages of the properties at P_1 and P_2 .

Step 2

This step is similar to Step 2 of the field point routine. However, only three bicharacteristics are used for the body point calculations. The parametric angles used are

$$\delta_3 = \arccos(-n_1 \sin \theta \cos \psi + n_2 \cos \theta - n_3 \sin \theta \sin \psi) \quad (41)$$

$$\delta_4 = \delta_3 - \pi/2 \quad (42)$$

$$\delta_5 = \delta_3 - \pi/2 \quad (43)$$

Step 3

The compatibility equations along two bicharacteristics are solved simultaneously with the condition for flow tangency to the surface at P_2 . The equation for flow tangency, which provides an additional relationship between θ_2 and ψ_2 may be expressed as

$$n_{12} \cos \theta_2 \cos \psi_2 + n_{22} \sin \theta_2 + n_{32} \cos \theta_2 \sin \psi_2 = 0 \quad (44)$$

where n_{12} , n_{22} , and n_{32} are unit normals to the body at P_2 . A Newton-Raphson routine is used to solve this system of equations. The base points P_3 and P_4 are used to obtain p_{21} , θ_{21} , and ψ_{21} ; P_3 and P_5 are used to obtain p_{22} , θ_{22} , and ψ_{22} . These two results are averaged to obtain the values at p_2 ($p_2 = (p_{21} + p_{22})/2$).

The compatibility equations along the streamline are solved the same way as for the body point yielding ρ_2 , q_2 , and T_2 .

Step 4

The iteration procedure for the body point is the same as the procedure used for the field point.

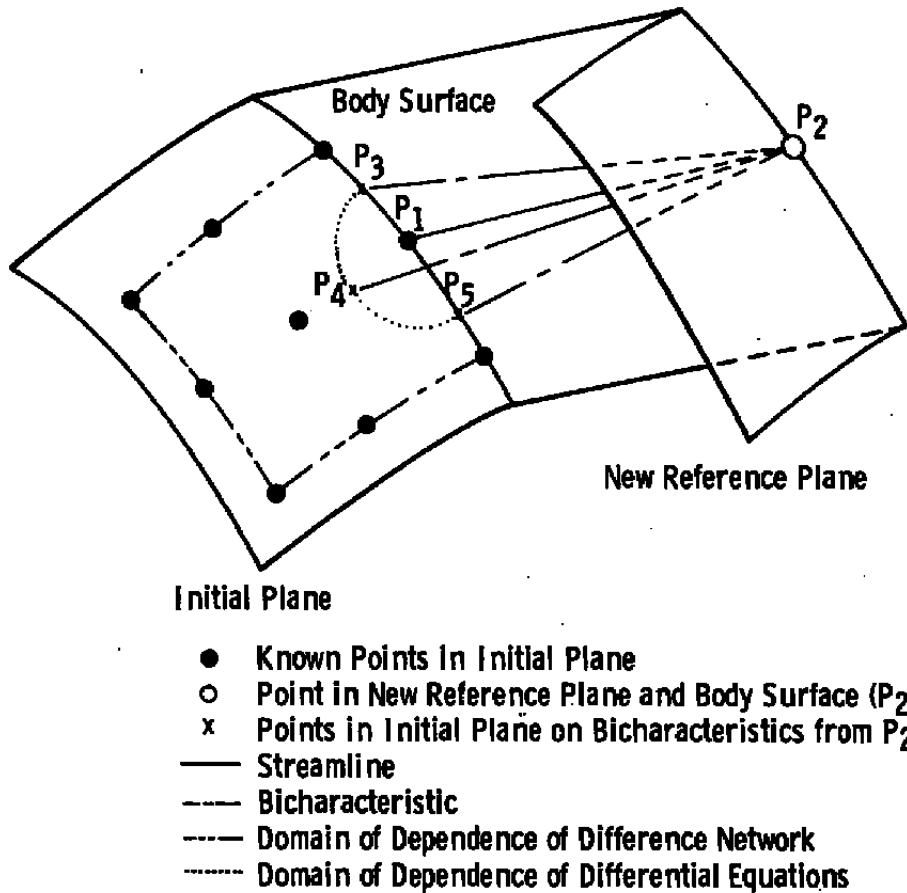


Figure 3. Body point network.

3.2.4 Computer Program

The preceding equations were programmed in FORTRAN IV language for solution on an IBM 370/165 computer. A description and listing of the program is given in Appendix A, and an example problem is given in Appendix B. The program requires a storage capacity of approximately 192,000 bytes.

4.0 RESULTS AND DISCUSSION

The present 3-D MOC program was evaluated by computing the flow in a typical axisymmetric nozzle. With $\gamma = 1.24$ and uniform flow in the throat, the nozzle produces an exit Mach number of 4.1. The 3-D MOC computations were done in three different ways (see 4).

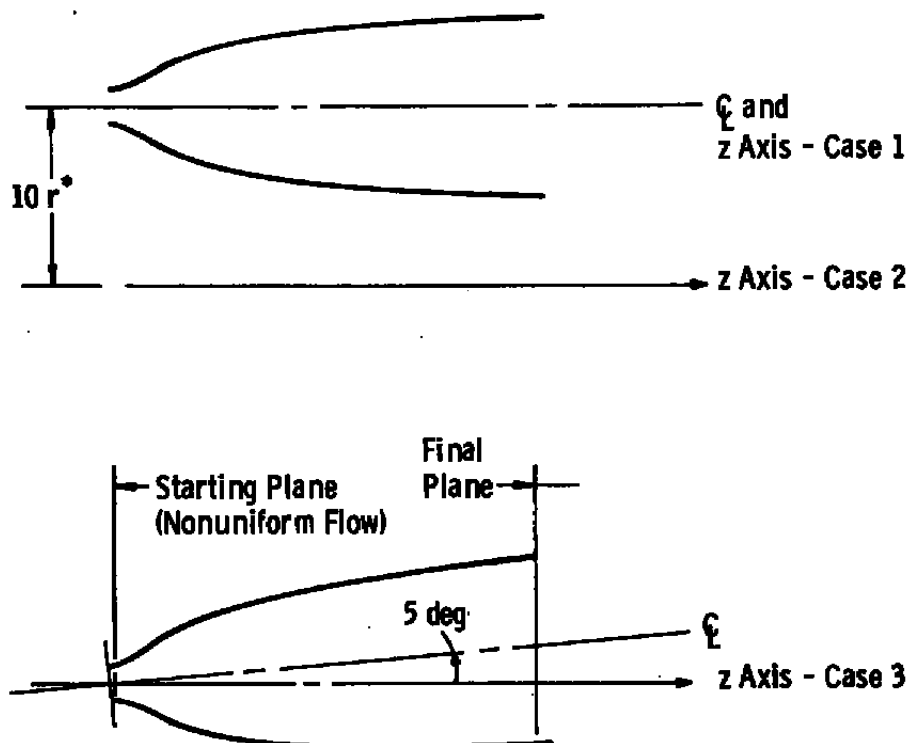


Figure 4. Geometry for test cases.

Case 1 - The z axis was aligned with the geometric centerline of the nozzle.

Case 2 - The z axis was parallel to the nozzle centerline but was displaced by a distance of 10 nozzle throat radii; thus, the z axis for the flow field is completely outside the nozzle.

Case 3 - The z axis was rotated 5 deg relative to the nozzle centerline. In this case, the flow in the starting plane is nonuniform and was obtained by interpolation from the flow field predicted for case 1.

The predicted wall Mach number distribution for case 1 is shown in Fig. 5 along with the predictions of the Lockheed axisymmetric MOC computer program (Ref. 6) which is well verified and widely used. The results from the two programs are in good agreement. At the nozzle exit plane, the circumferential variation of wall Mach number calculated by the 3-D MOC program is much less than one percent.

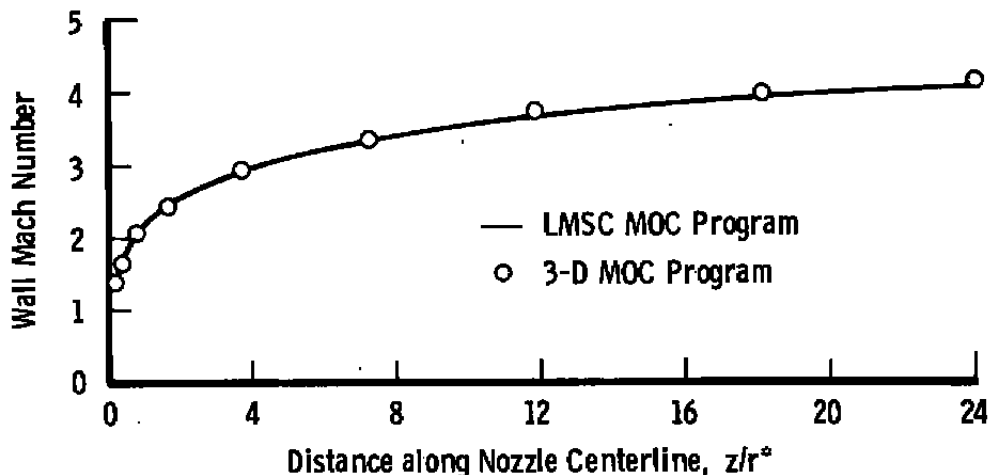


Figure 5. Results for z axis aligned with nozzle centerline.

The results of the three 3-D computations are compared in Fig. 6 where it is seen that the three predicted wall Mach number distributions are essentially identical.

These computations of axisymmetric nozzle flow, done the "hard way" with the 3-D MOC program, indicate that the program is acceptably accurate and is capable of computing the supersonic flow in complex configurations.

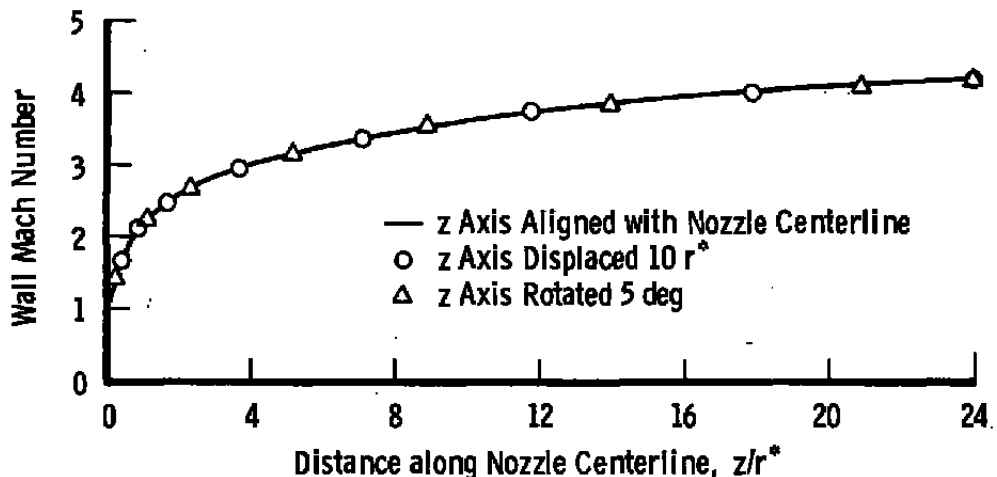


Figure 6. Results of 3-D MOC program.

In each of the test cases, 346 streamlines were traced throughout the flow field. For cases 1 and 2, 78 reference planes were computed which required a CPU time of approximately 25 min. Fewer reference planes were computed for case 3, with a corresponding reduction in CPU time.

5.0 CONCLUDING REMARKS

The results obtained for an axisymmetric nozzle with the 3-D MOC computer program are acceptably accurate. However, additional verification of the program is clearly required. The predictions of the code should be compared with experimental results for 3-D supersonic flows, whenever adequately detailed experimental results become available.

Two extensions of the 3-D MOC computer program are recommended. First, the program should be modified to include a constant-pressure free boundary condition for part of the flow field. This modification would permit the computation of the exhaust plume from a 3-D nozzle. The second recommended modification is the inclusion of shock formation, both within the nozzle and in the exhaust plume.

REFERENCES

1. Strom, Charles R. "The Method of Characteristics for Three-Dimensional Real Gas Flows." AFFDL-TR-67-47 (AD661342), July 1967.
2. Tsung, Cheng Chin. "Study of Three-Dimensional Supersonic Flow Problems by a Numerical Method Based on the Method of Characteristics." Ph.D. Thesis, University of Illinois, 1960.
3. Armstrong, W. C. and Bauer, R. C. "Analysis of Three-Dimensional Inviscid Supersonic Flow Between a Body and an Outer Wall (With Application to a Jet Stretcher System)." AEDC-TR-76-103 (ADA029123), August 1976.
4. Courant, R. and Hilbert, D. Methods of Mathematical Physics, Volume II, Partial Differential Equations. Interscience Publishers, New York and London, 1962.
5. Harder, Robert L. and Demarais, Robert N. "Interpolation Using Surface Splines." Journal of Aircraft, Volume 9, No. 2, February 1972, pp. 189-191.
6. Prozan, R. J. "Development of a Method of Characteristics Solution for Supersonic Flow of an Ideal, Frozen, or Equilibrium Reacting Gas Mixture." Technical Report LMSC/HREC A782535, Lockheed Missiles and Space Co., April 1966.

APPENDIX A DESCRIPTION OF COMPUTER PROGRAM

DESCRIPTION OF ROUTINES

NAME	FUNCTION
MAIN	CALLS CARDIN, INGEOM, INPUT, AND THREED
BDYFIT	CURVE FITS BODY IN AREA OF INTEREST
BODY	BODY POINT ROUTINE
CARDIN	READS AND PRINTS INPUT CARD IMAGES
CUT	INTERPOLATES THE BODY GEOMETRY IN CURRENT PLANE
DELTAF	COMPUTES THE BICHARACTERISTIC ANGLE DELTA
DIST	COMPUTES MIN. DIST. OF CHARACTERISTIC INTERSECTIONS
FIELD	FIELD POINT ROUTINE
FIND	LOCATES POINTS NEAREST TO GIVEN POINT
FINDBP	LOCATES BODY GEOMETRY POINT NEAREST GIVEN POINT
FIT	SURFACE FIT ROUTINE
IDENT	WRITES HEADER AND TRAILER LABELS ON PLOTS
INGEOM	READS GEOMETRY INPUT
INPUT	READS STARTING PLANE INPUT
NEIGH	LOCATES (OR READS) 8 NEIGHBORS OF EACH INPUT POINT
NEWRAP	NEWTON-RAPHSON ROUTINE
NORMAL	COMPUTES THE NORMAL VECTOR TO THE BODY SURFACE
OUTPUT	CONTROLS PRINTED, PLOTTED, AND TAPE OUTPUT
SIMQ	SOLVES SYSTEM OF SIMULTANECUS LINEAR EQUATIONS
SOLVBP	SOLVES FOR THE LOCATION OF A BODY POINT
SORT	SORT ROUTINE
THREED	CONTROLS THE 3-D CALCULATIONS

INPUT NOMENCLATURE

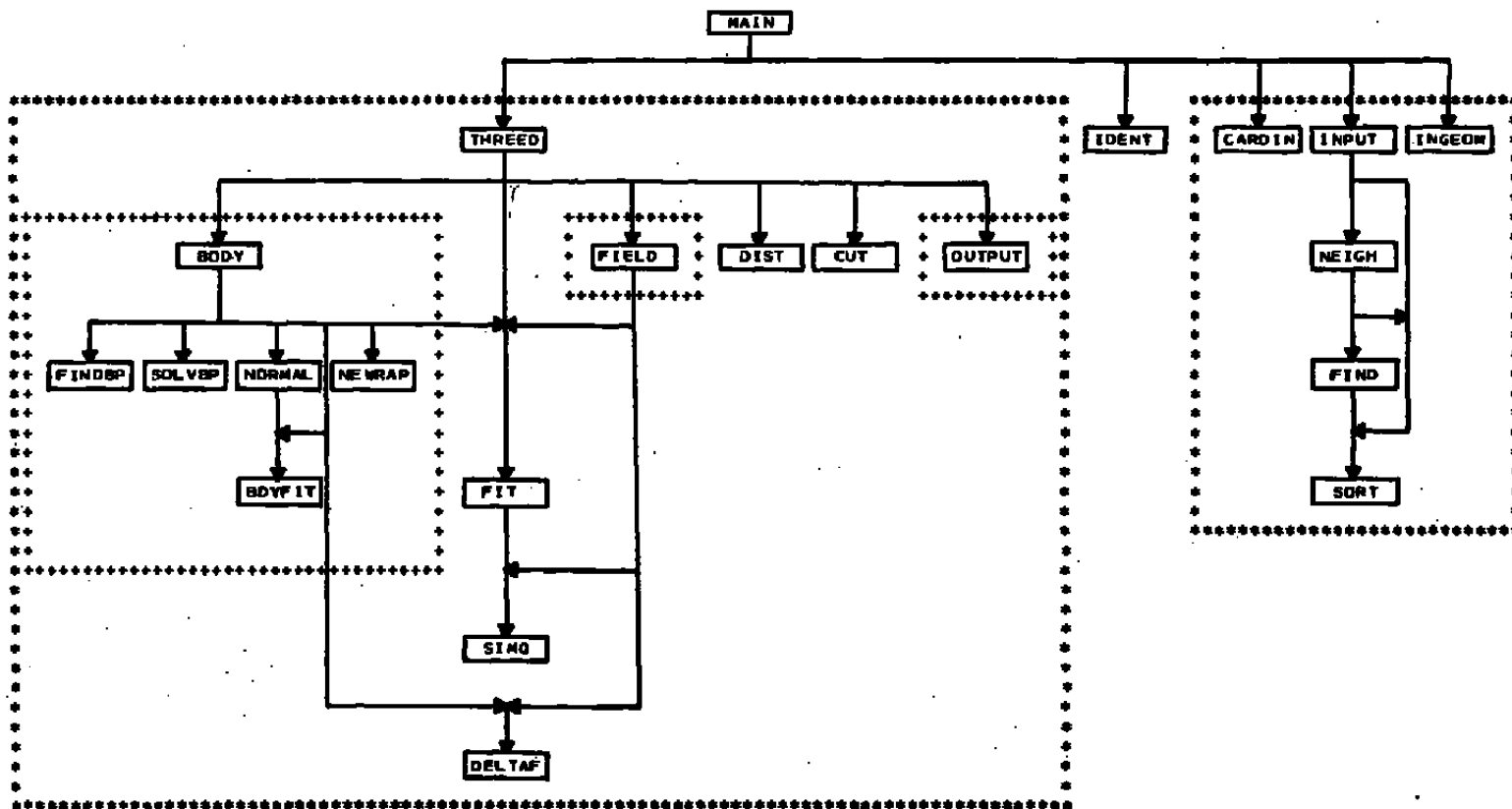
G RATIO OF SPECIFIC HEATS
HEAD PROBLEM DESCRIPTION
IDBUG(I) SPECIAL PRINT FLAGS =0 NO PRINT; =1 PRINT
 IDBUG(1) PRINT INPUT GEOMETRY
 IDBUG(2) PRINT FINAL GEOMETRY
 IDBUG(3) PRINT INITIAL PLANE INPUT
 IDBUG(4) PRINT FINAL INITIAL PLANE DATA
 IDBUG(5) PRINT NEIGHBORS
 IDBUG(11) PRINT NORMAL CALCULATION
IMV INITIAL PLANE DATA TYPE
 IMV=0 Q THETA PSI
 IMV=1 M THETA PSI
 IMV=2 W U V
INEIGH NEIGHBOR CONTROL
 INEIGH=0 NEAREST POINTS ARE NEIGHBORS
 INEIGH=1 SPECIAL COMPUTATION OF NEIGHBORS
 INEIGH=2 READ NEIGHBORS FROM CARDS
 IF ITYPE=0 AND INEIGH=0, INEIGH IS SET TO 1
IPLOT =0 NO PLOTS; =1 PLOTS
IT(I) COORDINATE SYSTEM FOR BODY POINTS AT THIS STATION
 IT(I)=0 RECTANGULAR COORDINATES
 IT(I)=1 PCLAR CCOORDINATES
 IT(I)=2 PCLAR CCOORDINATES - AXISYMMERIC
ITYPE COORDINATE SYSTEM FOR STARTING PLANE INPUT
 ITYPE=0 PCLAR CCOORDINATES - AXISYMMETRIC
 ITYPE=1 PCLAR COORDINATES
 ITYPE=2 RECTANGULAR COORDINATES
IT11 FLOW FIELD TAPE OUTPUT IT11=0 NO TAPE; IT11=1 TAPE
IT12 BODY DATA TAPE OUTPUT IT12=0 NO TAPE; IT12=1 TAPE
IV(I) NO. OF BODY PCINTS AT THIS STATION
JMAX MAXIMUM NO. OF PLANES TO BE COMPUTED
JPT PRINT EVERY JPT PLANES
NBT =0 INPUT FOR FIELD PCINT; =1 INPUT FOR BODY POINT
NE(J,K) THE J-TH NEIGHBOR OF THE K-TH POINT
NPTS TOTAL NO. OF POINTS IN STARTING PLANE
 IF ITYPE=0 NO. OF POINTS ON A RAY
NRAYS NO. OF RAYS IF ITYPE=0; OTHERWISE NOT USED
NS NO. OF STATIONS OF BODY GEOMETRY INPUT

INPUT NOMENCLATURE (CONT.)

P(I)	PRESSURE
PSI(I)	ANGLE SHOWN IN FIG. 1; OR Y IF IMV=2
PTO(I)	TOTAL PRESSURE AT POINT (IF 0.0, SET TO PT0)
PT0	TOTAL PRESSURE FOR IRROTATIONAL FLOW
Q(I)	VELOCITY IF IMV=0; MACH NUMBER IF IMV=1; W IF IMV=2
RO	GAS CONSTANT
THETA(I)	ANGLE SHOWN IN FIG. 1; OR U IF IMV=2
TTO	TOTAL TEMPERATURE
X(I)	POINT IN STARTING PLANE X IF ITYPE=2; R IF ITYPE=0 OR 1
XC(J,I)	BODY POINT X IF IT(I)=0; R IF IT(I)=1 OR 2
Y(I)	POINT IN STARTING PLANE Y IF ITYPE=2; ANGLE IF ITYPE=0 OR 1
YC(J,I)	BODY POINT Y IF IT(I)=0; ANGLE IF IT(I)=1 OR 2
ZC(I)	Z LOCATION OF BODY STATION
ZMAX	MAXIMUM Z LOCATION FOR CALCULATIONS
Z0	Z LOCATION OF STARTING PLANE

INPUT CARDS IN ORDER READ

CARD	FORMAT	CONTENTS
1	(20A4)	(HEAD(I),I=1,20)
2	(80I1)	(IDBUG(I),I=1,80)
3	(I5)	NS
4	(2I5,E10.0)	IV(I),IT(I),ZC(I)
5	(8E10.0)	(XC(J,I),YC(J,I),J=1,IV(I)) READ CARDS 4 AND 5 NS TIMES
6	(4E10.0)	G,PT0,TT0,R0
7	(2E10.0,10I5)	Z0,ZMAX,ITYPE,IMV,NPTS,NRAYS,JMAX, JPT,IPL0T,IT11,IT12,INEIGH
8	(7E10.0,I5)	X(I),Y(I),P(I),Q(I),THETA(I),PSI(I), PT0(I),NBP -- READ NPTS CARDS
9	(9I10)	(K,(NE(J,K),J=1,8),I=1,NPTS) READ CARD 9 ONLY IF INEIGH=2



***** PRIMARY OVERLAY
 ***** SECONDARY OVERLAY

```

C      THREE DIMENSIONAL DUCT FLOW      SRR00886
C      SIMPLIFIED VERSION WITH FOLLOWING ASSUMPTIONS
C      NO INTERNAL SHOCKS
C      IDEAL GAS
C      UNIT      FUNCTION
C      5          CARD INPUT
C      6          PRINTED OUTPUT
C      10         PLOTTED OUTPUT
C      11         FLOW FIELD OUTPUT
C      12         BODY OUTPUT
C      8          WORK DATA SET
C      OVERLAY STRUCTURE
C      OVERLAY A
C      INSERT CARDIN,INGEOM,INPUT,NEIGH,FIND, SORT
C      OVERLAY A
C      INSERT THREED,CUT,FIT,DIST,SINQ,DELTA F
C      OVERLAY B
C      INSERT FIELD
C      OVERLAY B
C      INSERT BODY,FINDBP,SOLVBP,NORMAL,BDYFIT,NEW RAP
C      OVERLAY B
C      INSERT OUTPUT
COMMON /TITLE/HEAD(20)
COMMON/IDBUG/IDBUG(80)
COMMON /STAG/DUMMY(1207),IPL0T,IT11,IT12
DATA ISTRP/0/
1  FORMAT(20A4)
2  FORMAT(80I1)
CALL CARDIN
20 CONTINUE
READ(8,1,END=99)HEAD
READ(8,2)IDBUG
CALL INGEOM
CALL INPUT
IF(IPL0T.EQ.0) GO TO 21
IF(ISTRP.NE.0) GO TO 21
ISTRP=1
CALL IDENT(1)
21 CONTINUE
CALL THREED
GO TO 20
99 CONTINUE
IF(ISTRP.NE.0) CALL IDENT(2)
STOP
END

```

```

SUBROUTINE BDYFIT(A,B,C,XB,YB,I,IT)
IMPLICIT REAL*8(A-H,O-Z)
REAL*4 DUMMY(5051),XB(50),YB(50)
COMMON /GEOM/DUMMY,NP
C      IT=1      X=C
C      IT=2      Y=C
C      IT=3      AX+BY=C
C      IT=4      (X-A)**2+(Y-B)**2=C

IM1=I-1
IF(I.EQ.1) IM1=NP
X1=XB(IM1)
Y1=YB(IM1)
X2=XB(I)
Y2=YB(I)
IP1=I+1
IF(I.EQ.NP) IP1=1
X3=XB(IP1)
Y3=YB(IP1)
IF((X1.NE.X2).OR.(X1.NE.X3)) GO TO 21
IT=1
A=1.0
B=0.0
C=X2
RETURN
21 CONTINUE
IF((Y1.NE.Y2).OR.(Y1.NE.Y3)) GO TO 22
IT=2
A=0.0
B=1.0
C=Y2
RETURN
22 CONTINUE
R1=X1**2+Y1**2
R2=X2**2+Y2**2
R3=X3**2+Y3**2
DX21=2.00*(X2-X1)
DY21=2.00*(Y2-Y1)
DX32=2.00*(X3-X2)
DY32=2.00*(Y3-Y2)
IF(DX21.NE.0.00) GO TO 23
DX21=2.00*(X3-X1)
DX32=-DX32
DY21=2.00*(Y3-Y1)
DY32=-DY32
H=R2
R2=R3
R3=H
GO TO 24
23 CONTINUE
IF(DX32.EQ.0.00) GO TO 24

```

```
      IF((DY21/DX21).NE.(DY32/DX32)) GO TO 24
      IT=3
      A=-DY21/DX21
      B=1.00
      C=Y1+X1*A
      RETURN
24  CONTINUE
      IT=4
      A=(R2-R1)/DX21
      B=R3-R2
      C=DY21/DX21
      H=DY32
      IF(DX32.EQ.0.00) GO TO 25
      B=B/DX32-A
      H=H/DX32-C
25  CONTINUE
      B=B/H
      A=A-B*C
      C=R1-2.00*(A*X1+B*Y1)
      C=C+B**2+A**2
      RETURN
      END
```

```

SUBROUTINE BODY(I)
  IMPLICIT REAL*8(A-H,O-Z)
  REAL*8 ZD,XN(1000),YN(1000),PN(1000),RN(1000),QN(1000),
  *PSN(1000),ZE,X(1000),Y(1000),P(1000),RHO(1000),
  *Q(1000),THETA(1000),XB(50),YB(50),XBO(50),YBO(50),
  *TN(1000),PSI(1000)
  COMMON /NVALU/ZD,XN,YN,PN,RN,QN,TN,PSN
  COMMON /VALUE/ZE,X,Y,P,RHO,Q,THETA,PSI,N
  COMMON /BCUT/XB ,YB
  COMMON /OCUT/XBO,YBO
  COMMON /DGAS/DZ,G,RO,GM1,GM1H,GM1G,GGM1,GP1,GPGM
  COMMON /IDBUG/IDBUG(80)
  REAL*8 N11,N21,N31,N12,N22,N32,N1,N2,N3
  COMMON /POINT/X1,Y1,P1,R1,Q1,T1,TH1,PS1,BE1,X2,Y2,P2,
  *R2,Q2,T2,TH2,PS2,BE2,P2O,T2O,PSO,OEL(4),PI(4),THI(4),
  *PII(4),BEI(4),XI(4),YI(4),DEI(4),DX(4),DY(4),DL(4),
  *PP(5,4),T12,P12,B12,T2I(4),P2I(4),B2I(4),D2I(4)
  COMMON /FLOBDY/SINT12,COST12,SINP12,COSP12,SINB12,
  *COSB12,SIND2I(4),COSD2I(4),SINT2I(4),COST2I(4),
  *SINP2I(4),COSP2I(4),SINB2I(4),COSB2I(4),DXDN(4),
  *DYDN(4),DZDN(4),DTEX(4),DTEY(4),DTEZ(4),DPDX(4),
  *DPDY(4),DPDZ(4),DER(2,5),AL(3,4),CR(4),AM(3,3),CM(3,4)
  1 FORMAT('0 FAILED IN BODY AT POINT',I5,5X,'Z1=',
  *IPE12,5,5X,'DZ=',E12,5//5X,'X1=',E12,5,5X,'Y1=',E12,5,
  *5X,'P1=',E12,5,5X,'T1=',E12,5,5X,'PS1=',E12,5/5X,'X2=',
  *,E12,5,5X,'Y2=',E12,5,5X,'P2=',E12,5,5X,'T2=',E12,5,5X
  *, 'PS2=',E12,5/45X,'P2O=',E12,5,4X,'T2O=',E12,5,4X,
  * 'PS2O=',E12,5//)
  X1=X(I)
  Y1=Y(I)
  P1=P(I)
  R1=RHO(I)
  Q1=Q(I)
  TH1=THETA(I)
  PS1=PSI(I)
  T1=P1/(R0*R1)
  SINT1=DSIN(TH1)
  COST1=DCOS(TH1)
  SINP1=DSIN(PS1)
  COSP1=DCOS(PS1)
  BE1=DARSIN(DSORT(G*P1/R1)/Q1)
  P2=P1
  R2=R1
  Q2=Q1
  TH2=TH1
  PS2=PS1
  T2=T1
  BE2=BE1
  CALL FINDBP(X1,Y1,XBO,YBO,IBP1)
  CALL BDYFIT(A1,B1,C1,XBO,YBO,IBP1,IT1)

```

```

CALL BDYFIT(A2,B2,C2,XB,YB,IBP1,IT2)
CALL NORMAL(X1,Y1,ZE,A1,B1,C1,N11,N21,N31,IT1,IBP1)
CALL NORMAL(X1,Y1,ZE+DZ,A2,B2,C2,N12,N22,N32,IT2,IBP1)
DEL(1)=DARCOS(-N11*SINT1*COSP1+N21*COST1-N31*SINT1*
*SINP1)
IF(N31.LT.0.00) DEL(1)=6.28318530700-DEL(1)
DEL(2)=DEL(1)-1.57079632700
IF(DEL(2).LT.0.00) DEL(2)=6.28318530700+DEL(2)
DEL(3)=DEL(1)+1.57079632700
IF(DEL(3).GE.6.28318530700)
*DEL(3)=DEL(3)-6.28318530700
DO 21 IT=1,4
TH1(IT)=TH1
P11(IT)=PS1
BE1(IT)=BE1
DE1(IT)=DEL(IT)
21 CONTINUE
IBP2=IBP1
Y2=Y1
DO 25 IT=1,25
T12=0.500*(TH1+TH2)
P12=0.500*(PS1+PS2)
B12=0.500*(BE1+BE2)
SINT12=DSIN(T12)
COST12=DCOS(T12)
SINP12=DSIN(P12)
COSP12=DCOS(P12)
SINB12=DSIN(B12)
COSB12=DCOS(B12)
N1=0.500*(N11+N12)
N2=0.500*(N21+N22)
N3=0.500*(N31+N32)
CC1=N3*COST12*COSP12-N1*COST12*SINP12
CC2=N1*SINT12-N2*COST12*COSP12
CC3=(N3*SINT12-N2*COST12*SINP12)*DZ+CC1*X1+CC2*Y1
Y20=Y2
IBP=IBP2
X20=X2
CALL SOLVBP(X2,Y2,CC1,CC2,CC3,A2,B2,C2,IT2,X20,Y20)
CALL CKBDYP(X2,Y2,XB,YB,IBP2)
IF(IBP.NE.1BP2) CALL BDYFIT(A2,B2,C2,XB,YB,IBP2,IT2)
CALL NORMAL(X2,Y2,ZE+DZ,A2,B2,C2,N12,N22,N32,IT2,IBP2)
SINT2=DSIN(TH2)
COST2=DCOS(TH2)
SINP2=DSIN(PS2)
COSP2=DCOS(PS2)
DEL(1)=DARCOS(-N12*SINT2*COSP2+N22*COST2-N32*SINT2*
*SINP2)
IF(N32.LT.0.00) DEL(1)=6.28318530700-DEL(1)
DEL(2)=DEL(1)-1.57079632700

```

```

      IF(DEL(2).LT.0.D0) DEL(2)=6.283185307D0+DEL(2)
      DEL(3)=DEL(1)+1.570796327D0
      IF(DEL(3).GT.6.283185307D0)
      *DEL(3)=DEL(3)-6.283185307D0
      DO 23 J=1,3
      T2I(J)=0.500*(TH2+THI(J))
      P2I(J)=0.500*(PS2+PII(J))
      B2I(J)=0.500*(BE2+BEI(J))
      D2I(J)=0.500*(DEL(J)+DEI(J))
      D2I(J)=D2I(J)-3.141592654D0
      IF(D2I(J).LT.0.D0) D2I(J)=6.283185307D0+D2I(J)
      SINT2I(J)=DSIN(T2I(J))
      COST2I(J)=DCOS(T2I(J))
      SINP2I(J)=DSIN(P2I(J))
      COSP2I(J)=DCOS(P2I(J))
      SINB2I(J)=DSIN(B2I(J))
      COSB2I(J)=DCOS(B2I(J))
      SIND2I(J)=DSIN(D2I(J))
      COSD2I(J)=DCOS(D2I(J))
      F1=SINB2I(J)*COSD2I(J)
      F2=SINB2I(J)*SIND2I(J)
      F3=COSB2I(J)*COST2I(J)-F1*SINT2I(J)
      DL(J)=DZ/(F3*COSP2I(J)-F2*SINP2I(J))
      DX(J)=SINT2I(J)*COSB2I(J)+F1*COST2I(J)
      DY(J)=F3*SINP2I(J)+F2*COSP2I(J)
      XI(J)=X2-DX(J)*DL(J)
      YI(J)=Y2-DY(J)*DL(J)
      CALL GETPT(XI(J),YI(J),PP(1,J))
      RAD=DSQRT(G*PP(1,J)/PP(2,J))/PP(3,J)
      IF((RAD.GE.0.D0).AND.(RAD.LE.1.D0)) GO TO 22
      WRITE(6,2)I,J,P1,R1,Q1,TH1,PS1,BE1,P2,R2,Q2,TH2,PS2,
      *BE2,P20,R20,Q20,T20,PS0,DEL(1),DEL(2),DEL(3),N11,N21,
      *N31,N12,N22,N32,N1,N2,N3,DL(J),DX(J),DY(J),DEI(J),
      *PP(1,J),PP(2,J),PP(3,J),PP(4,J),PP(5,J),THI(J),PII(J),
      *BEI(J)
      2 FORMAT('1 FAILED IN BODY AT I=',I3.5X,'J=',I3//
      *1P6E14.5/6E14.5/5E14.5/3E14.5/9E14.5/4E14.5/8E14.5)
      STOP
22 CONTINUE
      CALL DELTAF(J,DEL(J),DEI(J))
      IF(DABS(DEI(J)).LE.1.0-8) DEI(J)=0.D0
      CALL GETDER(XI(J),YI(J),DER)
      PI(J)=PP(1,J)
      THI(J)=PP(4,J)
      PII(J)=PP(5,J)
      BEI(J)=DARSIN(DSQRT(G*PP(1,J)/PP(2,J))/PP(3,J))
      T2I(J)=0.500*(TH2+THI(J))
      P2I(J)=0.500*(PS2+PII(J))
      B2I(J)=0.500*(BE2+BEI(J))
      D2I(J)=0.500*(DEL(J)+DEI(J))

```

```

D2I(J)=D2I(J)-3.141592654*D0
IF(D2I(J).LT.0.D0) D2I(J)=6.283185307*D0+D2I(J)
SINT2I(J)=DSIN(T2I(J))
COST2I(J)=DCOS(T2I(J))
SINP2I(J)=DSIN(P2I(J))
COSP2I(J)=DCOS(P2I(J))
SINB2I(J)=DSIN(B2I(J))
COSB2I(J)=DCOS(B2I(J))
SIND2I(J)=DSIN(D2I(J))
COSD2I(J)=DCOS(D2I(J))
OTDX(J)=DER(1,4)
DPDX(J)=DER(1,5)
OTDY(J)=DER(2,4)
DPDY(J)=DER(2,5)
F1=COST2I(J)*SIND2I(J)
F2=SINT2I(J)*SIND2I(J)
F3=SINB2I(J)*DL(J)
F4=COST2I(J)*COSD2I(J)
DXDN(J)=-F1
DYDN(J)=F2*SINP2I(J)+COSP2I(J)*COSD2I(J)
DZDN(J)=F2*COSP2I(J)-SINP2I(J)*COSD2I(J)
F5=XI(J)-X2
F6=YI(J)-Y2
DTDZ(J)=(OTDX(J)*F5+OTDY(J)*F6)/DZ
DPDZ(J)=(DPDX(J)*F5+DPDY(J)*F6)/DZ
AL(1,J)=COSB2I(J)/(SINB2I(J)*PP(2,J)*PP(3,J)**2)
AL(2,J)=COSD2I(J)-F3*SIND2I(J)*DZDN(J)/DZ
AL(3,J)=F1+F3*F4*DZDN(J)/DZ
CR(J)=F3*(SIND2I(J)*(OTDX(J)*DXDN(J)+OTDY(J)*DYDN(J)+
*DTDZ(J)*DZDN(J))-F4*(DPDX(J)*DXDN(J)+DPDY(J)*DYDN(J)+
*DPDZ(J)*DZDN(J))+AL(1,J)*PI(J)+AL(2,J)*THI(J)+AL(3,J)
**PII(J)
23 CONTINUE
A1=AL(2,1)*AL(1,2)-AL(1,1)*AL(2,2)
B1=AL(3,1)*AL(1,2)-AL(1,1)*AL(3,2)
C1=CR(1)*AL(1,2)-AL(1,1)*CR(2)
AM(2,1)=TH2
AM(3,1)=PS2
CALL NEWRAP(AM(2,1),AM(3,1),A1,B1,C1,N12,N22,N32)
A1=AL(2,2)*AL(1,3)-AL(1,2)*AL(2,3)
B1=AL(3,2)*AL(1,3)-AL(1,2)*AL(3,3)
C1=CR(2)*AL(1,3)-AL(1,2)*CR(3)
AM(2,2)=TH2
AM(3,2)=PS2
CALL NEWRAP(AM(2,2),AM(3,2),A1,B1,C1,N12,N22,N32)
A1=AL(2,3)*AL(1,1)-AL(1,3)*AL(2,1)
B1=AL(3,3)*AL(1,1)-AL(1,3)*AL(3,1)
C1=CR(3)*AL(1,1)-AL(1,3)*CR(1)
AM(2,3)=TH2
AM(3,3)=PS2

```

```

CALL NEWRAP(AM(2,3),AM(3,3),A1,B1,C1,N12,N22,N32)
AM(1,1)=(CR(1)-AL(2,1)*AM(2,1)-AL(3,1)*AM(3,1))/AL(1,1)
AM(1,2)=(CR(2)-AL(2,2)*AM(2,2)-AL(3,2)*AM(3,2))/AL(1,2)
AM(1,3)=(CR(3)-AL(2,3)*AM(2,3)-AL(3,3)*AM(3,3))/AL(1,3)
P2=0.500*(AM(1,1)+AM(1,3))
TH2=0.500*(AM(2,1)+AM(2,3))
PS2=0.500*(AM(3,1)+AM(3,3))
T2=TTOD*(P2/PTOD(I))*GMI
R2=P2/(R0*T2)
Q2=DSQRT(2.00*GMI*R0*(TTOD-T2))
IF(IT.EQ.1) GO TO 24
IF(DABS((P2-P20)/P2).LE.1.0-7) GO TO 26
IF(IT.EQ.25) GO TO 25
24 CONTINUE
P20=P2
R20=R2
Q20=Q2
T20=TH2
PS0=PS2
BE2=DARSIN(DSQRT(G*P2/R2)/Q2)
25 CONTINUE
IF(DABS((P2-P20)/P2).LE.1.0-5) GO TO 26
WRITE(6,1)I,ZE,DZ,X1,Y1,P1,TH1,PS1,X2,Y2,P2,TH2,PS2,
*P20,T20,PS0
IF(DABS((P2-P20)/P2).GT.1.0-4) STOP
26 CONTINUE
XN(I)=X2
YN(I)=Y2
PN(I)=P2
RN(I)=R2
QN(I)=Q2
TN(I)=TH2
PSN(I)=PS2
RETURN
END

```

```
SUBROUTINE CARDIN
  DIMENSION A(20)
  1 FORMAT(20A4)
  2 FORMAT(5X,20A4)
  3 FORMAT('1',38X,'INPUT CARDS')
  4 FORMAT('0',4X,9('0'),10('1'),10('2'),10('3'),10('4'),
    *10('5'),10('6'),10('7'),'8'/5X,8('1234567890')/)
  IP=50
  WRITE(6,3)
  WRITE(6,4)
20 CONTINUE
  READ(5,1,END=99)A
  IF(IP.NE.0) GO TO 21
  WRITE(6,4)
  WRITE(6,3)
  WRITE(6,4)
  IP=50
21 CONTINUE
  WRITE(6,2)A
  WRITE(8,1)A
  IP=IP-1
  GO TO 20
99 CONTINUE
  REWIND 8
  WRITE(6,4)
  RETURN
  END
```

```

SUBROUTINE CUT(ZB)
COMMON /BCUT/XB(50),YB(50)
COMMON /GEOM/ZC(50),XC(50,50),YC(50,50),NS,NP
REAL*4 A(3,3)
Z=ZB
DO 21 I=2,NS
  IF(ZB.LE.ZC(I)) GO TO 22
21 CONTINUE
  I=NS-1
22 CONTINUE
  IF(I.EQ.NS) I=NS-1
  IP=I+1
  IM=I-1
  ZO=ZC(IM)
  ZI=ZC(I)
  Z2=ZC(IP)
  Z10=1.0/(ZI-ZO)
  Z20= 1.0/(Z2-ZO)
  Z21=1.0/(Z2-ZI)
  ZP1=ZO+ZI
  A(3,1)=Z21*(Z10-Z20)
  A(3,2)=-Z21*Z10
  A(3,3)= Z21*Z20
  A(2,1)=-Z10-ZP1*A(3,1)
  A(2,2)= Z10-ZP1*A(3,2)
  A(2,3)= -ZP1*A(3,3)
  A(1,1)=-ZO*(A(2,1)+A(3,1)*ZO)+1.0
  A(1,2)=-ZO*(A(2,2)+A(3,2)*ZO)
  A(1,3)=-ZO*(A(2,3)+A(3,3)*ZO)
  DO 23 J=1,NP
    B=A(1,1)*XC(J,IM)+A(1,2)*XC(J,I)+A(1,3)*XC(J,IP)
    C=A(2,1)*XC(J,IM)+A(2,2)*XC(J,I)+A(2,3)*XC(J,IP)
    D=A(3,1)*XC(J,IM)+A(3,2)*XC(J,I)+A(3,3)*XC(J,IP)
    XB(J)=B+(C+D*Z)*Z
    B=A(1,1)*YC(J,IM)+A(1,2)*YC(J,I)+A(1,3)*YC(J,IP)
    C=A(2,1)*YC(J,IM)+A(2,2)*YC(J,I)+A(2,3)*YC(J,IP)
    D=A(3,1)*YC(J,IM)+A(3,2)*YC(J,I)+A(3,3)*YC(J,IP)
    YB(J)=B+(C+D*Z)*Z
23 CONTINUE
  RETURN
END

```

```

SUBROUTINE DELTAF(J,DEL,DELI)
  IMPLICIT REAL*8(A-H,O-Z)
  COMMON /FLDBDY/DUMMY(14),SINTI(4),COSTI(4),SINPI(4),
  *COSPI(4),SINBI(4),COSBI(4)
  A=SINTI(J)*COSPI(J)*SINBI(J)
  B=SINPI(J)*SINBI(J)
  C=-0.500*COSTI(J)*COSPI(J)*(SINBI(J)+COSBI(J))
  SIND=DSIN(DEL)
  COSD=DCOS(DEL)
  DELI=DEL
  ASBS=A**2+B**2
  RAD=ASBS-C**2
  IF(RAD.LT.0.00) RETURN
  RAD=DSQRT(RAD)/ASBS
  SINI=B*C/ASBS
  SINI1=SINI+A*RAD
  SINI2=SINI-A*RAD
  IF(DABS(SIND-SINI2).LT.DABS(SIND-SINI1)) GO TO 21
  SINI=SINI1
  IF(DABS(SINI).LE.1.00) GO TO 22
21 CONTINUE
  SINI=SINI2
  IF(DABS(SINI).GT.1.00) SINI=SINI1
  IF(DABS(SINI).GT.1.00) RETURN
22 CONTINUE
  COSI=A*C/ASBS
  COSI1=COSI+B*RAD
  COSI2=COSI-B*RAD
  IF(DABS(COSD-COSI2).LT.DABS(COSD-COSI1)) GO TO 23
  COSI=COSI1
  IF(DABS(COSI).LE.1.00) GO TO 24
23 CONTINUE
  COSI=COSI2
  IF(DABS(COSI).GT.1.00) COSI=COSI1
  IF(DABS(COSI).GT.1.00) RETURN
24 CONTINUE
  DELI=DATAN2(SINI,COSI)
  IF(DELI.LT.0.00) DELI=6.28318530700+DELI
  RETURN
END

```

```

SUBROUTINE DIST(DELS)
COMMON /GAS/G,RO,GM1,GM1H,GM1G,GGM1,GP1,GPGM
COMMON/VALUE/ZE,X(1000),Y(1000),P(1000),RHO(1000) ,
*Q(1000),THETA(1000),PSI(1000),N
INTEGER*2 NE(8,1000)
COMMON /NEAR/NE,DMIN
DMIN=1.E10
QMIN=1.E10
AMAX=0.0
DO 22 I=1,N
A=P(I)/RHO(I)
IF(A.GT.AMAX) AMAX=A
IF(Q(I).LT.QMIN) QMIN=Q(I)
DO 21 J=1,8
K=NE(J,I)
D=(X(I)-X(K))**2+(Y(I)-Y(K))**2
IF(D.LT.DMIN) DMIN=D
21 CONTINUE
22 CONTINUE
AMAX=SQRT(G*AMAX)
DELS=QMIN*SQRT(DMIN)/AMAX
DELS=SQRT(DMIN*ABS((QMIN/AMAX)**2-1.0))
RETURN
END

```

```

SUBROUTINE FIELD(I)
  IMPLICIT REAL*8(A-H,O-Z)
  REAL*4 ZD,XN(1000),YN(1000),PN(1000),RN(1000),QN(1000),
  *PSN(1000),ZE,X(1000),Y(1000),P(1000),RHO(1000),
  *TN(1000),PSI(1000),Q(1000),THETA(1000)
  COMMON /NVALU/ZD,XN,YN,PN,RN,QN,TN,PSN
  COMMON /VALUE/ZE,X,Y,P,RHO,Q,THETA,PSI,N
  COMMON /DGAS/DZ,G,RO,GM1,GM1H,GM1G,GGM1,GP1,GPGM
  COMMON/DSTAG/PTOD(1000),TTOD,ATOD
  COMMON/IDEBUG/IDBUG(80)
  COMMON /POINT/X1,Y1,P1,R1,Q1,T1,TH1,PS1,BE1,X2,Y2,P2,
  *R2,Q2,T2,TH2,PS2,BE2,P2O,T2O,PSO,DEL(4),P1(4),TH1(4),
  *P11(4),BE1(4),X1(4),Y1(4),DE1(4),DX(4),DY(4),DL(4),
  *PP(5,4),T12,P12,B12,T21(4),P21(4),B21(4),D21(4)
  COMMON /FLDBDY/SINT12,COST12,SINP12,COSP12,SINB12,
  *COSB12,SIND21(4),COSD21(4),SINT21(4),COST21(4),
  *SINP21(4),COSP21(4),SINB21(4),COSB21(4),DXDN(4),
  *DYDN(4),DZDN(4),DTDX(4),DTDY(4),DTDZ(4),DPDX(4),
  *DPDY(4),DPDZ(4),DER(2,5),AL(3,4),CR(4),AM(3,3),CM(3,4)
1  FORMAT('0  FAILED IN FIELD AT POINT',I5,5X,'Z1=',
  *IPE12.5,5X,'DZ=',E12.5/5X,'X1=',E12.5,5X,'Y1=',E12.5,
  *5X,'P1=',E12.5,5X,'T1=',E12.5,5X,'PS1=',E12.5/5X,'X2=',
  *,E12.5,5X,'Y2=',E12.5,5X,'P2=',E12.5,5X,'T2=',E12.5,5X
  *,',PS2=',E12.5/45X,'P2O=',E12.5,4X,'T2O=',E12.5,4X,
  *',PS2O=',E12.5//)
  X1=X(I)
  Y1=Y(I)
  DEL(1)=0.D0
  IF(X1.NE.0.D0.OR.Y1.NE.0.D0) DEL(1)=DATAN2(Y1,X1)
  IF(DEL(1).LT.0.D0) DEL(1)=6.28318530700+DEL(1)
  DE1(1)=DEL(1)
  DO 20 IT=2,4
  DEL(IT)=DEL(IT-1)+1.57079632700
  IF(DEL(IT).GE.6.28318530700)
  *DEL(IT)=DEL(IT)-6.28318530700
  DE1(IT)=DEL(IT)
20 CONTINUE
  P1=P(I)
  R1=RHO(I)
  Q1=Q(I)
  TH1=THETA(I)
  PS1=PSI(I)
  T1=P1/(R0*R1)
  P2=P1
  R2=R1
  Q2=Q1
  TH2=TH1
  PS2=PS1
  T2=T1
  BE1=DARSIN(DSQRT(G*P1/R1)/Q1)

```

```

BE2=BE1
DO 21 IT=1,4
  TH1(IT)=TH1
  P11(IT)=PS1
  BE1(IT)=BE1
21 CONTINUE
DO 26 IT=1,25
  T12=0.5D0*(TH1+TH2)
  P12=0.5D0*(PS1+PS2)
  B12=0.5D0*(BE1+BE2)
  SINT12=DSIN(T12)
  COST12=DCOS(T12)
  SINP12=DSIN(P12)
  COSP12=DCOS(P12)
  SINB12=DSIN(B12)
  COSB12=DCOS(B12)
  X2=X1+SINT12*DZ/(COST12*COSP12)
  Y2=Y1+SINP12*DZ/COSP12
DO 22 J=1,4
  T2I(J)=0.5D0*(TH2+TH1(J))
  P2I(J)=0.5D0*(PS2+P1I(J))
  B2I(J)=0.5D0*(BE2+BE1(J))
  D2I(J)=0.5D0*(DEL(J)+DEI(J))
  SINT2I(J)=DSIN(T2I(J))
  COST2I(J)=DCOS(T2I(J))
  SINP2I(J)=DSIN(P2I(J))
  COSP2I(J)=DCOS(P2I(J))
  SINB2I(J)=DSIN(B2I(J))
  COSB2I(J)=DCOS(B2I(J))
  SIND2I(J)=DSIN(D2I(J))
  COSD2I(J)=DCOS(D2I(J))
  F1=SINB2I(J)*COSD2I(J)
  F2=SINB2I(J)*SIND2I(J)
  F3=COSB2I(J)*COST2I(J)-F1*SINT2I(J)
  DL(J)=DZ/(F3*COSP2I(J)-F2*SINP2I(J))
  DX(J)=SINT2I(J)*COSB2I(J)+F1*COST2I(J)
  DY(J)=F3*SINP2I(J)+F2*COSP2I(J)
  XI(J)=X2-DX(J)*DL(J)
  YI(J)=Y2-DY(J)*DL(J)
  CALL GETPT(XI(J),YI(J),PP(1,J))
  IF(DABS(PP(4,J)).LT.1.D-8) PP(4,J)=0.00
  IF(DABS(PP(5,J)).LT.1.D-8) PP(5,J)=0.00
  CALL DELTAF(J,DEL(J),DEI(J))
  IF(DABS(DEI(J)).LE.1.0-8) DEI(J)=0.00
  CALL GETDER(XI(J),YI(J),DER)
  P1(J)=PP(1,J)
  TH1(J)=PP(4,J)
  P11(J)=PP(5,J)
  BE1(J)=DARSIN(DSORT(G*PP(1,J)/PP(2,J))/PP(3,J))
  T2I(J)=0.5D0*(TH2+TH1(J))

```

```

P2I(J)=0.5D0*(PS2+PII(J))
B2I(J)=0.5D0*(BE2+BEI(J))
D2I(J)=0.5D0*(DEL(J)+DEI(J))
SINT2I(J)=DSIN(T2I(J))
COST2I(J)=DCOS(T2I(J))
SINP2I(J)=DSIN(P2I(J))
COSP2I(J)=DCOS(P2I(J))
SINB2I(J)=DSIN(B2I(J))
COSB2I(J)=DCOS(B2I(J))
SIND2I(J)=DSIN(D2I(J))
COSD2I(J)=DCOS(D2I(J))
DTDX(J)=DER(1,4)
DPDX(J)=DER(1,5)
DTDY(J)=DER(2,4)
DPDY(J)=DER(2,5)
F1=COST2I(J)*SIND2I(J)
F2=SINT2I(J)*SIND2I(J)
F3=SINB2I(J)*DL(J)
F4=COST2I(J)*COSD2I(J)
DXDN(J)=-F1
DYDN(J)=F2*SINP2I(J)+COSP2I(J)*COSD2I(J)
DZDN(J)=F2*COSP2I(J)-SINP2I(J)*COSD2I(J)
F5=XI(J)-X2
F6=YI(J)-Y2
DTDZ(J)=(DTDX(J)*F5+DTDY(J)*F6)/DZ
DPDZ(J)=(DPDX(J)*F5+DPDY(J)*F6)/DZ
AL(1,J)=COSB2I(J)/(SINB2I(J)*PP(2,J)*PP(3,J)**2)
AL(2,J)=COSD2I(J)-F3*SIND2I(J)*DZDN(J)/DZ
AL(3,J)=F1+F3*F4*DZDN(J)/DZ
CR(J)=F3*(SIND2I(J)*(DTDX(J)*DXDN(J)+DTDY(J)*DYDN(J)+
*DTDZ(J)*DZDN(J))-F4*(DPDX(J)*DXDN(J)+DPDY(J)*DYDN(J)+
*DPDZ(J)*DZDN(J))+AL(1,J)*PI(J)+AL(2,J)*THI(J)+AL(3,J)
**PII(J)

```

22 CONTINUE

DO 24 M=1,4

L=M

DO 23 J=1,3

AM(J,1)=AL(1,L)

AM(J,2)=AL(2,L)

AM(J,3)=AL(3,L)

CM(J,M)=CR(L)

L=L+1

IF(L.GT.4) L=1

23 CONTINUE

CALL SIMQ(AM,CM(1,M),3,1)

24 CONTINUE

P2 =0.25D0*(CM(1,1)+CM(1,2)+CM(1,3)+CM(1,4))

TH2=0.25D0*(CM(2,1)+CM(2,2)+CM(2,3)+CM(2,4))

PS2=0.25D0*(CM(3,1)+CM(3,2)+CM(3,3)+CM(3,4))

T2=TTOD*(P2/PTOD(I))**GMIG

```

R2=P2/(R0*T2)
Q2=DSQRT(2.00*GGM1*R0*(TT00-T2))
IF(IT.EQ.1) GO TO 25
IF(DABS((P2-P20)/P2).LE.1.D-7) GO TO 27
IF(IT.EQ.25) GO TO 26
25 CONTINUE
P20=P2
R20=R2
Q20=Q2
T20=TH2
PS0=PS2
BE2=DARSIN(DSQRT(G*P2/R2)/Q2)
26 CONTINUE
IF(DABS((P2-P20)/P2).LE.1.D-5) GO TO 27
WRITE(6,1)I,ZE,OZ,X1,Y1,P1,TH1,PS1,X2,Y2,P2,TH2,PS2,
*P20,T20,PS0
IF(DABS((P2-P20)/P2).GT.1.D-4) STOP
27 CONTINUE
XN(I)=X2
YN(I)=Y2
PN(I)=P2
RN(I)=R2
QN(I)=Q2
TN(I)=TH2
PSN(I)=PS2
RETURN
END

```

```
SUBROUTINE FIND(I,L1,L3,NE)
  INTEGER*2 NE(1)
  REAL*4 DIST(3)
  COMMON/VALUE/ZE,X(1000),Y(1000)
  L2=L1+L3
  J=0
  DO 22 L=L1,L2
    D=(X(I)-X(L))*2+(Y(I)-Y(L))*2
    IF(J.EQ.3) GO TO 21
    J=J+1
    NE(J)=L
    DIST(J)=D
    IF(J.NE.3) GO TO 22
    CALL SORT(DIST,NE,3)
    GO TO 22
21 CONTINUE
    IF(D.GE.DIST(3)) GO TO 22
    DIST(3)=D
    NE(3)=L
    CALL SORT(DIST,NE,3)
22 CONTINUE
  RETURN
  END
```

```

SUBROUTINE FINDBP(X1,Y1,XB,YB,IPOINT)
COMMON /GEOM/ZC(50),XC(50,50),YC(50,50),NS,NP
DIMENSION XB(50),YB(50)
20 CONTINUE
IPOINT=1
DMIN=(X1-XB(1))**2+(Y1-YB(1))**2
DO 21 J=2,NP
D=(X1-XB(J))**2+(Y1-YB(J))**2
IF(D.GE.DMIN) GO TO 21
IPOINT=J
DMIN=D
21 CONTINUE
RETURN
ENTRY CKBDYP(X1,Y1,XB,YB,IPOINT)
J=IPOINT
DMIN=(X1-XB(J))**2+(Y1-YB(J))**2
J=J-1
IF(J.EQ.0) J=NP
D=(X1-XB(J))**2+(Y1-YB(J))**2
IF(D.LT.DMIN) GO TO 20
J=IPOINT+1
IF(J.GT.NP) J=1
D=(X1-XB(J))**2+(Y1-YB(J))**2
IF(D.LT.DMIN) GO TO 20
RETURN
END

```

```

SUBROUTINE FIT(I)
COMMON/VALUE/ZE,X(1000),Y(1000),P(1000),RHO(1000) ,
*Q(1000),THETA(1000),PSI(1000),N
INTEGER*2 NE(8,1000)
COMMON /NEAR /NE
REAL*8 R,B(12,12),C(12,5),VAL(5),DER(2,5),DX,DY,FAC
DO 22 J=1,12
IF(J.GT.9) GO TO 21
B(1,J)=1.00
K=1
IF(J.NE.1) K=NE(J-1,1)
B(2,J)=X(K)
B(3,J)=Y(K)
GO TO 22
21 CONTINUE
B(1,J)=0.00
B(2,J)=0.00
B(3,J)=0.00
22 CONTINUE
DO 24 JJ=4,11
J=13-JJ
KL=J-1
K1=1
IF(J.NE.1) K1=NE(KL,1)
DO 23 K=1,KL
K2=1
IF(K.NE.1) K2=NE(K-1,1)
R=(X(K1)-X(K2))**2+(Y(K1)-Y(K2))**2
B(JJ,K)=R*DLOG(R)
23 CONTINUE
B(JJ,J)=0.00
24 CONTINUE
B(12,1)=0.00
DO 26 J=1,11
K=13-J
KL=K-1
DO 25 L=1,KL
B(K,13-L)=B(L,J)
25 CONTINUE
26 CONTINUE
DO 29 J=1,12
IF(J.GT.3) GO TO 28
DO 27 K=1,5
C(J,K)=0.00
27 CONTINUE
GO TO 29
28 CONTINUE
KL=13-J
K=1
IF(KL.NE.1) K=NE(KL-1,1)

```

```

      C(J,1)=P(K)
      C(J,2)=RHO(K)
      C(J,3)=Q(K)
      C(J,4)=THETA(K)
      C(J,5)=PSI(K)
29  CONTINUE
      CALL SIMQ(B,C,12,5)
      RETURN
      ENTRY GETPT(X1,Y1,VAL)
      DO 30 J=1,5
        VAL(J)=C(12,J)+C(11,J)*X1+C(10,J)*Y1
30  CONTINUE
      DO 32 J=1,9
        K=1
        IF(J.NE.1) K=NE(J-1,1)
        R=(X1-X(K))**2+(Y1-Y(K))**2
        IF(R.EQ.0.D0) GO TO 32
        DO 31 L=1,5
          VAL(L)=VAL(L)+C(J,L)*R*DLOG(R)
31  CONTINUE
32  CONTINUE
      RETURN
      ENTRY GETDER(X1,X2,DER)
      DO 33 J=1,5
        DER(1,J)=C(11,J)
        DER(2,J)=C(10,J)
33  CONTINUE
      DO 35 J=1,9
        K=1
        IF(J.NE.1) K=NE(J-1,1)
        DX=X1-X(K)
        DY=Y1-Y(K)
        R=DX**2+DY**2
        IF(R.EQ.0.D0) GO TO 35
        DO 34 L=1,5
          FAC=2.D0*C(J,L)*(1.D0+DLOG(R))
          DER(1,L)=DER(1,L)+FAC*DX
          DER(2,L)=DER(2,L)+FAC*DY
34  CONTINUE
35  CONTINUE
      RETURN
      END

```

```
SUBROUTINE IDENT(I)
  IF(I.EQ.2) GO TO 21
  CALL CALCMP(15.0,2.0,10.0)
  CALL SYMBOL(0.5,7.5,0.84,'FOLLOWING PLOTS FOR',0.0,19)
  CALL SYMBOL(1.2,5.5,0.98,'W. C. ARMSTRONG',0.0,15)
  CALL SYMBOL(5.5,3.5,0.84,'CSB-EAD',0.0,7)
  CALL CLASS(1,3,0,0)
  CALL CALCMP(0.5,0.5,0.3)
  RETURN
21 CONTINUE
  CALL CALCMP(0.0,0.0,0.3)
  CALL CLASS(4,3,0,0)
  CALL SYMBOL(.08,7.5,0.84,'PRECEEDING PLOTS FOR',0.0,20)
  CALL SYMBOL(1.2,5.5,0.98,'W. C. ARMSTRONG',0.0,15)
  CALL SYMBOL(5.5,3.5,0.84,'CSB-EAD',0.0,7)
  CALL CALCMP(0.0,0.0,9999.2)
  RETURN
END
```

```

SUBROUTINE INGEOM
COMMON /TITLE/HEAD(20)
COMMON /GEOM/ZC(50),XC(50,50),YC(50,50),NS,NP
COMMON/IDEBUG/IDBUG(80)
COMMON/VALUE/X(50,50),Y(50,50),S(50),IT(50),IV(50)
1 FORMAT('1',10X,20A4//20X,'GEOMETRY INPUT',10X,
  *'NO. OF STATIONS =' ,I3/)
2 FORMAT('0  Z =' ,1PE13.5,5X,'IV =' ,I3,5X,'IT =' ,I2//
  *8X,'X',14X,'Y'//)
3 FORMAT(1P2E15.5)
4 FORMAT('1',10X,20A4//20X,'CONVERTED GEOMETRY'//)
5 FORMAT(2I5,E10.0)
6 FORMAT(8E10.0)
C      IV= NO. OF POINTS AT THIS STATION
C      IT= 1 - ALL POINTS GIVEN IN RECTANGULAR COORDINATES
C          2 - ALL POINTS GIVEN IN POLAR COORDINATES
C          3 - ONE POINT GIVEN IN POLAR COORDINATES
      READ(8,5)NS
      IF(IDBUG( 1),NE.0)
        *WRITE(6,1)HEAD,NS
        DO 21 I=1,NS
          READ(8,5)IV(I),IT(I),ZC(I)
          IF(IDBUG( 1),NE.0)
            *WRITE(6,2)ZC(I),IV(I),IT(I)
            N=IV(I)
            IF(IT(I).EQ.3) N=1
            READ(8,6)(X(J,I),Y(J,I),J=1,N)
            IF(IDBUG( 1),NE.0)
              *WRITE(6,3)(X(J,I),Y(J,I),J=1,N)
21 CONTINUE
          DO 26 I=1,NS
            IF(IDBUG( 2),NE.0)
              *WRITE(6,4)HEAD
              IF(IDBUG( 2),NE.0)
                *WRITE(6,2)ZC(I),IV(I),IT(I)
                N=IV(I)
                IF(IT(I).EQ.1) GO TO 25
                IF(IT(I).EQ.2) GO TO 23
                DT=360.0/N
                Y(1,I)=0.0
                DO 22 J=2,N
                  X(J,I)=X(1,I)
                  Y(J,I)=(J-1)*DT
22 CONTINUE
23 CONTINUE
                DO 24 J=1,N
                  XX=X(J,I)*COS(0.01745329*Y(J,I))
                  Y(J,I)=X(J,I)*SIN(0.01745329*Y(J,I))
                  X(J,I)=XX
24 CONTINUE

```

```

25 CONTINUE
  IF(IDBUG( 2).NE.0)
    *WRITE(6,3)(X(J,I),Y(J,I),J=1,N)
26 CONTINUE
  NP=IV(1)
  DO 27 I=2,NS
    IF(NP.GE.IV(I)) GO TO 27
    NP=IV(I)
27 CONTINUE
  NPM=NP-1
  FAC=1.0/NPM
  DO 33 I=1,NS
    N=IV(I)
    S(1)=0.0
    DO 28 J=2,N
      S(J)=S(J-1)+SQRT((X(J,I)-X(J-1,I))**2+
        *(Y(J,I)-Y(J-1,I))**2)
28 CONTINUE
    DS=S(N)*FAC
    XC(1,I)=X(1,I)
    YC(1,I)=Y(1,I)
    XC(NP,I)=X(N,I)
    YC(NP,I)=Y(N,I)
    KL=2
    DO 32 J=2,NPM
      SP=DS*(J-1)
      DO 29 K=KL,N
        IF(SP-S(K))31,30,29
29 CONTINUE
      K=N
30 CONTINUE
      XC(J,I)=X(K,I)
      YC(J,I)=Y(K,I)
      KL=K
      GO TO 32
31 CONTINUE
      RAT=(SP-S(K-1))/(S(K)-S(K-1))
      XC(J,I)=X(K-1,I)+(X(K,I)-X(K-1,I))*RAT
      YC(J,I)=Y(K-1,I)+(Y(K,I)-Y(K-1,I))*RAT
      KL=K
32 CONTINUE
33 CONTINUE
  RETURN
  END

```

```

SUBROUTINE INPUT
COMMON /TITLE/HEAD(20)
COMMON/VALUE/ZE,X(1000),Y(1000),P(1000),RHO(1000) ,
*Q(1000),THETA(1000),PSI(1000),N
COMMON /STAG/PTO(1000),TTC,ATOT,ZO,ZMAX,NB(200),
*NBO(200),JMAX,JPT,IB,IPLT,IT11,IT12
COMMON /GAS/G,RO,GM1,GM1H,GM1G,GGM1,GP1,GPGM
COMMON/IDBUG/IDBUG(80)
INTEGER*2 NB,NBO
COMMON/NVALU/XR(20),YR(20),PR(20),THR(20),PSR(20),
*QR(20),PTR(20)
1 FORMAT('1',10X,20A4//20X,'STARTING PLANE INPUT'//5X,
*'GAMMA =' ,F5.3,5X,'PTO =' ,1PE12.5,5X,'TTC =' ,E12.5,
*5X,'R =' ,E12.5)
2 FORMAT('0 ZO=' ,1PE12.5,5X,'ZMAX=' ,E12.5,5X,' ITYPE=' ,
*I2,5X,'IMV=' ,I2,5X,'NPTS=' ,I5,5X,'NRAYS=' ,I3,5X,
*'JMAX=' ,I5,5X,'JPT=' ,I5/44X,'IPLT=' ,I2,4X,' IT11=' ,I2,
*5X,'IT12=' ,I2,7X,'INEIGH=' ,I2//8X,'X' ,14X,'Y' ,14X,'P' ,
*14X,'Q' ,12X,'THETA' ,11X,'PSI' ,12X,'PTO'//)
3 FORMAT(1P7E15.5)
4 FORMAT(7E10.0,I5)
5 FORMAT(2E10.0,I0I5)
6 FORMAT('1',10X,20A4//20X,'STARTING PLANE VALUES'//8X,
*'X' ,14X,'Y' ,14X,'P' ,13X,'RHO' ,13X,'Q' ,13X,'THR' ,12X,
*'PSI' ,12X,'PTO'//(1P8E15.5))
7 FORMAT('0 TOO MANY BODY POINTS')
C          IMV=0      Q(I)=Q      THETA(I)=THETA(I)      PSI(I)=PSI
C          IMV=1      Q(I)=M      THETA(I)=THETA      PSI(I)=PSI
C          IMV=2      Q(I)=W      THETA(I)=U      PSI(I)=V
C          ITYPE=0      ONE RAY GIVEN IN POLAR COORDINATES
C          ITYPE=1      PLANE GIVEN IN POLAR COORDINATES
C          ITYPE=2      PLANE GIVEN IN RECTANGULAR COORDINATES
READ(8,4)G,PTO,TTC,RO
WRITE(6,1)HEAD,G,PTO,TTC,RO
READ(8,5)ZO,ZMAX,ITYPE,IMV,NPTS,NRAYS,JMAX,JPT,IPLT,
*IT11,IT12,INEIGH
WRITE(6,2)ZO,ZMAX,ITYPE,IMV,NPTS,NRAYS,JMAX,JPT,IPLT,
*IT11,IT12,INEIGH
N=NPTS
IB=0
DO 20 I=1,N
READ(8,4)X(I),Y(I),P(I),Q(I),THETA(I),PSI(I),PTO(I),NBP
IF(PTO(I).EQ.0.0) PTO(I)=PTO
IF(IMV.EQ.2) GO TO 19
THETA(I)=0.01745329*THETA(I)
PSI(I)=0.01745329*PSI(I)
19 CONTINUE
IF(NBP.EQ.0) GO TO 20
IB=IB+1
IF(IB.GT.200) GO TO 99

```

```

      NB(IB)=I
20  CONTINUE
      IF(IDBUG( 3).NE.0)
      *WRITE(6,3)(X(I),Y(I),P(I),Q(I),THETA(I),PSI(I),
      *PTO(I),I=1,N)
      IF(ITYPE.EQ.1)  GO TO 24
      IF(ITYPE.EQ.2)  GO TO 26
      DO 21 I=1,N
      XR(I)=X(I)
      YR(I)=Y(I)
      PR(I)=P(I)
      QR(I)=Q(I)
      THR(I)=THETA(I)
      PSR(I)=PSI(I)
      PTR(I)=PTO(I)
21  CONTINUE
      IB=1
      J=0
      NBI=NB(1)
      DO 23 I=1,N
      J=J+1
      X(J)=XR(I)
      Y(J)=YR(I)
      P(J)=PR(I)
      Q(J)=QR(I)
      THETA(J)=THR(I)
      PSI(J)=PSR(I)
      PTO(J)=PTR(I)
      IF(I.EQ.1)  GO TO 23
      NPTS=3.141593/ARSIN(0.5/FLOAT(I-1))+0.5
      DT=360.0/NPTS
      NPTS=NPTS-1
      IF(NBI.EQ.1)  NB(IB)=J
      DO 22 K=1,NPTS
      J=J+1
      X(J)=XR(I)
      Y(J)=YR(I)+FLOAT(K)*DT
      P(J)=PR(I)
      Q(J)=QR(I)
      THETA(J)=THR(I)
      PSI(J)=PSR(I)
      PTO(J)=PTR(I)
      IF(NBI.NE.I)  GO TO 22
      IB=IB+1
      IF(IB.GT.200)  GO TO 99
      NB(IB)=J
22  CONTINUE
23  CONTINUE
      N=J
24  CONTINUE

```

```

DO 25 I=1,N
ST=SIN(0.01745329*Y(I))
CT=COS(0.01745329*Y(I))
Y(I)=X(I)*ST
X(I)=X(I)*CT
TANP=SQRT(TAN(THETA(I))**2+TAN(PSI(I))**2)
PSI(I)=ATAN(TANP*ST)
THETA(I)=ATAN(TANP*CT*COS(PSI(I)))
25 CONTINUE
26 CONTINUE
ATOT=SQRT(G*RO*TTC)
GM1=G-1.0
GM1G=GM1/G
GP1=G+1.0
GM1H=0.5*GM1
GPGM=GP1/GM1
GGM1=G/GM1
XNB=0.0
YNB=0.0
DO 261 I=1,IB
J=NB(I)
XNB=XNB+X(J)
YNB=YNB+Y(J)
261 CONTINUE
XNB=XNB/IB
YNB=YNB/IB
DO 27 I=1,IB
J=NB(I)
RHO(I)=ATAN2(Y(J)-YNB,X(J)-XNB)
IF(RHO(I).LT.0.0) RHO(I)=6.283185+RHO(I)
NBO(I)=J
27 CONTINUE
CALL SORT(RHO,NBO,IB)
NB(IB+1)=0
NBO(IB+1)=0
DO 30 I=1,N
IF(IMV.EQ.1) GO TO 28
V=Q(I)
IF(IMV.EQ.2) V=SQRT(V**2+THETA(I)**2+PSI(I)**2)
SM=(V/ATOT)**2
SM=SQRT(SM/(1.0-GM1H*SM))
IF(IMV.EQ.0) GO TO 29
PSI(I)=ATAN2(PSI(I),Q(I))
THETA(I)=ATAN2(THETA(I),Q(I)/COS(PSI(I)))
Q(I)=V
GO TO 29
28 CONTINUE
SM=Q(I)
Q(I)=SM*ATOT/SQRT(1.0+GM1H*SM**2)
29 CONTINUE

```

```
SMS=SM**2
SMFAC=1.0+GM1H*SMS
T=TTO/SMFAC
RHO(I)=P(I)/(RO*T)
30 CONTINUE
  IF(IDBUG( 4).NE.0)
    *WRITE(6,6)HEAD,(X(I),Y(I),P(I),RHO(I),Q(I),THETA(I),
    *PSI(I),PTO(I),I=1,N)
    IF((ITYPE.EQ.0).AND.(INEIGH.EQ.0)) INEIGH=1
    IF(INEIGH.EQ.0) CALL NEIGH
    IF(INEIGH.EQ.1) CALL RNEIG
    IF(INEIGH.EQ.2) CALL READNE
    RETURN
99 CONTINUE
  WRITE(6,7)
  STOP
END
```

```

SUBROUTINE NEIGH
COMMON/VALUE/ZE,X(1000),Y(1000),P(1000),RHO(1000) ,
*Q(1000),THETA(1000),PSI(1000),N
INTEGER*2 NE(8,1000)
COMMON /NEAR/NE,DMIN
COMMON/IDBUG/IDBUG(80)
DIMENSION LIST(19),LONG(19)
DATA LIST/1,2,8,20,39,64,95,133,177,227,284,347,416,
*491,573,661,755,856,963/
DATA LONG/0.5,11,18,24,30,37,43,49,56,62,68,74,81,87,
*93,100,106,0/
1 FORMAT('1',20X,'NEIGHBORS',5X,'DMIN =',1PE12.4
*/6X,'BASE',9X,'1',9X,'2',9X,'3',9X,'4',
*9X,'5',9X,'6',9X,'7',9X,'8'//)
2 FORMAT(9I10)
DIMENSION DXM(8)
DMIN=1.E10
DO 23 I=1,N
IC=0
DO 22 J= 1,N
IF(I.EQ.J) GO TO 22
D=(X(I)-X(J))*2+(Y(I)-Y(J))*2
IF(IC.EQ.8) GO TO 21
IC=IC+1
NE(IC,I)=J
DXM(IC)=D
IF(IC.EQ.8) CALL SORT(DXM,NE(1,I),8)
GO TO 22
21 CONTINUE
IF(D.GE.DXM(8)) GO TO 22
NE(8,I)=J
DXM(8)=D
CALL SORT(DXM,NE(1,I),8)
22 CONTINUE
IF(DXM(1).LT.DMIN) DMIN=DXM(1)
23 CONTINUE
GO TO 29
ENTRY RNEIG
J=1
DO 28 I=1,N
IF(1.GE.LIST(J+1)) J=J+1
IF(J.NE.1) GO TO 25
DO 24 K=1,6
NE(K,I)=K+1
24 CONTINUE
NE(7,I)=11
NE(8,I)=17
GO TO 28
25 CONTINUE
LL=I-1

```

```

      IF(LL.LT.LIST(J)) LL=LIST(J+1)-1
      LH=LH+1
      IF(LH.GE.LIST(J+1)) LH=LIST(J)
      NE(1,I)=LL
      NE(2,I)=LH
      IF(J.NE.2) GO TO 26
      LL=LL-1
      IF(LL.LT.LIST(J)) LL=LIST(J+1)-1
      LH=LH+1
      IF(LH.GE.LIST(J+1)) LH=LIST(J)
      NE(3,I)=LL
      NE(4,I)=1
      NE(5,I)=LH
      K=J+1
      GO TO 27
26 CONTINUE
      CALL FIND(I,LIST(J-1),LONG(J-1),NE(3,I))
      K=J+1
      IF(N.LT.LIST(K)) K=J-2
27 CONTINUE
      CALL FIND(I,LIST(K),LONG(K),NE(6,I))
28 CONTINUE
      GO TO 29
      ENTRY READNE
      READ(8,2)(K, (NE(J,K), J=1,8), I=1,N)
29 CONTINUE
      IF(1DEBUG(5).NE.0)
      *WRITE(6,1)DMIN
      IF(1DEBUG(5).NE.0)
      *WRITE(6,2)(I, (NE(J,I), J=1,8), I=1,N)
      RETURN
      END

```

```

SUBROUTINE NEWRAP(T,P,A,B,C,N1,N2,N3)
IMPLICIT REAL*8(A-H,O-Z)
REAL*8 N1,N2,N3,J
1 FORMAT('0 FAILED TO CONVERGE IN NEWRAP  T=',1PE12.5,
*5X,'TN=',E12.5,6X,'P=',E12.5,5X,'PN=',E12.5,5X,'TO=',
*E12.5,5X,'PO=',E12.5,6X,'A=',E12.5,6X,'B=',E12.5,6X,
*'C=',E12.5,5X,'N1=',E12.5,5X,'N2=',E12.5,5X,'N3=',
*E12.5)
TO=T
PO=P
DO 22 I=1,50
SINT=DSIN(T)
COST=DCOS(T)
SINP=DSIN(P)
COSP=DCOS(P)
F=A*T+B*P-C
G=N1*COST*COSP+N2*SINT+N3*COST*SINP
DGT=-N1*SINT*COSP+N2*COST-N3*SINT*SINP
DGP=-N1*COST*SINP+N3*COST*COSP
J=A*DGP-B*DGT
TN=T-(F*DGP-G*B)/J
PN=P+(F*DGT-G*A)/J
IF(DABS((T-TN)).GT.1.D-6) GO TO 21
IF(DABS((P-PN)).LE.1.D-6) GO TO 23
21 CONTINUE
IF(I.EQ.50) GO TO 22
T=0.5D0*(T+TN)
P=0.5D0*(P+PN)
22 CONTINUE
WRITE(6,1)T,TN,P,PN,TO,PO,A,B,C,N1,N2,N3
CALL ERRWCA
STOP
23 CONTINUE
T=TN
P=PN
RETURN
END

```

```

SUBROUTINE NORMAL(X,Y,Z,A,B,C,N1,N2,N3,IT,IB)
IMPLICIT REAL*8(A-H,O-Z)
REAL*4 ZC,XC,YC
COMMON /GEOM/ZC(50),XC(50,50),YC(50,50),NS,NP
REAL*8 N1,N2,N3
COMMON/IDEBUG/IDBUG(80)
REAL*8 F(3,5),FA(5),FB(5),FC(5)
1 FORMAT('0 NORMAL X=',1PE12.5,5X,'Y=',1PE12.5,5X,'Z=',
  *E12.5,5X,2HA=',E12.5,5X,'B=',1PE12.5,5X,'C=',1PE12.5)
2 FORMAT(8X,'T1',12X,'T2',12X,'A2',12X,'B2',12X,'C2',
  *12X,'N1',12X,'N2',12X,'N3'/1PE14.5)
  IF(IDBUG(11).NE.0)
    *WRITE(6,1)X,Y,Z,A,B,C
    NSM=NS-1
    DO 21 I=2,NSM
      IF(Z.LE.ZC(I)) GO TO 22
21 CONTINUE
      I=NSM
22 CONTINUE
      CALL BODYFIT(A1,B1,C1,XC(1,I-1),YC(1,I-1),IB,IT1)
      CALL BODYFIT(A2,B2,C2,XC(1,I),YC(1,I),IB,IT2)
      CALL BODYFIT(A3,B3,C3,XC(1,I+1),YC(1,I+1),IB,IT3)
      IF(IT2.EQ.4) GO TO 23
      IF((IT1.LE.IT2).AND.(IT3.LE.IT2)) GO TO 24
      GO TO 27
23 CONTINUE
      IF((IT1.NE.IT2).OR.(IT3.NE.IT2)) GO TO 27
24 CONTINUE
      FAC1=1.D0/(ZC(I)-ZC(I-1))
      FAC2=1.D0/(ZC(I+1)-ZC(I-1))
      FAC3=1.D0/(ZC(I+1)-ZC(I))
      FAC4=ZC(I-1)+ZC(I)
      A2=(A2-A1)*FAC1
      B2=(B2-B1)*FAC1
      C2=(C2-C1)*FAC1
      A3=(A3-A1)*FAC2
      B3=(B3-B1)*FAC2
      C3=(C3-C1)*FAC2
      A3=(A3-A2)*FAC3
      B3=(B3-B2)*FAC3
      C3=(C3-C2)*FAC3
      A2=A2-A3*FAC4
      B2=B2-B3*FAC4
      C2=C2-C3*FAC4
      A1=A1-(A2+A3*ZC(I-1))*ZC(I-1)
      B1=B1-(B2+B3*ZC(I-1))*ZC(I-1)
      C1=C1-(C2+C3*ZC(I-1))*ZC(I-1)
      AX=A1+(A2+A3*Z)*Z
      BY=B1+(B2+B3*Z)*Z
      IF(IT2.NE.4) GO TO 25

```

```

N2=-2.00*(X-A1-(A2+A3*Z)*Z)
N2=-DABS(N2)*DSIGN(1.00,X-AX)
N3=-2.00*(Y-B1-(B2+B3*Z)*Z)
N3=-DABS(N3)*DSIGN(1.00,Y-BY)
N1=-N2*(A2+2.00*A3*Z)- N3*(B2+2.00*B3*Z)+C2+2.00*C3*Z
GO TO 26
25 CONTINUE
N2=-DABS(AX)*DSIGN(1.00,X-AX)
N3=-DABS(BY)*DSIGN(1.00,Y-BY)
N1=-(A2+2.00*A3*Z)*X-(B2+2.00*B3*Z)*Y+(C2+2.00*C3*Z)
26 CONTINUE
D=DSQRT(N1**2+N2**2+N3**2)
N1=N1/D
N2=N2/D
N3=N3/D
IF(10BUG(11).NE.0)
*WRITE(6,2)T1,T2,A2,B2,C2,N1,N2,N3
RETURN
27 CONTINUE
IF(1T1.EQ.4) GO TO 29
F(1,1)=0.00
F(1,2)=A1
F(1,3)=0.00
F(1,4)=B1
F(1,5)=C1
GO TO 30
29 CONTINUE
F(1,1)=1.00
F(1,2)=-2.00*A1
F(1,3)=1.00
F(1,4)=-2.00*B1
F(1,5)=C1-A1**2-B1**2
30 CONTINUE
IF(1T2.EQ.4) GO TO 31
F(2,1)=0.00
F(2,2)=A2
F(2,3)=0.00
F(2,4)=B2
F(2,5)=C2
GO TO 32
31 CONTINUE
F(2,1)=1.00
F(2,2)=-2.00*A2
F(2,3)=1.00
F(2,4)=-2.00*B2
F(2,5)=C2-A2**2-B2**2
32 CONTINUE
IF(1T3.EQ.4) GO TO 33
F(3,1)=0.00
F(3,2)=A3

```

```

      F(3,3)=0.00
      F(3,4)=B3
      F(3,5)=C3
      GO TO 34
33 CONTINUE
      F(3,1)=1.00
      F(3,2)=-2.00*A3
      F(3,3)=1.00
      F(3,4)=-2.00*B3
      F(3,5)=C3-A3**2-B3**2
34 CONTINUE
      DZ21=Z2-Z1
      DZ31=Z3-Z1
      DZ32=Z3-Z2
      Z12=Z1+Z2
      DO 35 K=1,5
      FB(K)=(F(2,K)-F(1,K))/DZ21
      FC(K)=(F(3,K)-F(1,K))/DZ31-FB(K)/DZ32
      FB(K)=FB(K)-FC(K)*Z12
      FA(K)=F(1,K)-(FB(K)+FC(K)*Z1)*Z1
35 CONTINUE
      N2=2.00*(FA(1)+(FB(1)+FC(1)*Z)*Z)*X+FA(2)+(FB(2)+FC(2)*Z)*Z
      N3=2.00*(FA(3)+(FB(3)+FC(3)*Z)*Z)*Y+FA(4)+(FB(4)+FC(4)*Z)*Z
      N1=-(FB(1)+2.00*FC(1)*Z)*X**2-(FB(2)+2.00*FC(2)*Z)*X
      *   -(FB(3)+2.00*FC(3)*Z)*Y**2-(FB(4)+2.00*FC(4)*Z)*Y
      *   +(FB(5)+2.00*FC(5)*Z)
      AX=FA(1)+(FB(1)+FC(1)*Z)*Z
      IF(AX.EQ.0.00) AX=-2.00
      AX=-2.00*(FA(2)+(FB(2)+FC(2)*Z)*Z)/AX
      BY=FA(3)+(FB(3)+FC(3)*Z)*Z
      IF(BY.EQ.0.00) BY=-2.00
      BY=-2.00*(FA(4)+(FB(4)+FC(4)*Z)*Z)/BY
      N2=-DABS(N2)*DSIGN(1.00,X-AX)
      N3=-DABS(N3)*DSIGN(1.00,Y-BY)
      GO TO 26
      END

```

```

SUBROUTINE OUTPUT(IT)
COMMON /TITLE/HEAD(20)
COMMON/VALUE/ZE,X(1000),Y(1000),P(1000),RHO(1000) ,
*Q(1000),THETA(1000),PSI(1000),N
COMMON /STAG/PTQ(1000),TTO,ATOT,ZO,ZMAX,NB(200),
*NBO(200),JMAX,JPT,IB,IPLLOT,IT11,IT12
COMMON /GAS/G,RO,GM1,GM1H,GM1G,GGM1,GP1,GPGM
INTEGER*2 NB,NBC
1 FORMAT('1',20X,20A4//30X,'ZE =',1PE12.5,15X,'STEP NO.',
*.15//2X,'NO.',8X,'X',14X,'Y',14X,'P',13X,'RHO',13X,'Q',
*.12X,'THETA',11X,'PSI',13X,'M',8X,'BODY'//)
2 FORMAT(1X,I4,1P8E15.5,1X,A4)
3 FORMAT('1',20X,20A4//10X,'BODY POINTS AT ZE =',1PE12.5
*.15X,'STEP NO.',15//2X,'NO.',8X,'X',14X,'Y',14X,'P',
*.13X,'RHO',13X,'Q',12X,'THETA',11X,'PSI',13X,'M'//)
4 FORMAT(1X,I4,1P8E15.5)
DATA NES/' YES'/,NO/' '/
DIMENSION XP(1002),YP(1002)
DATA XO/0.0/,DX/25.0/,YO/10.0/,DY/5.0/
IF(IPLLOT.EQ.0) GO TO 21
F=0.0
DO 20 I=1,N
XP(I)=F
YP(I)=P(I)
F=F+1.0
20 CONTINUE
XP(N+1)=XO
XP(N+2)=DX
YP(N+1)=YO
YP(N+2)=DY
CALL AXIS(0.0,0.0,'POINT',-5,14.0,0.0,XO,DX,10.0)
CALL AXIS(0.0,0.0,'P',1,10.0,90.0,YO,DY,10.0)
CALL LINE(XP,YP,N,1.0,1)
CALL SYMBOL(8.0,8.0,0.15,'STEP ',0.0,5)
CALL NUMBER(999.0,999.0,0.15,FLOAT(IT),0.0,-1)
CALL CALCMP(0.0,0.0,0.2)
21 CONTINUE
IF(IT11.EQ.0) GO TO 22
WRITE(11)ZE,N,IB,NB,NBO,(X(J),Y(J),P(J),RHO(J),Q(J),
*THETA(J),PSI(J),PTQ(J),J=1,N)
22 CONTINUE
IF(IT12.EQ.0) GO TO 24
WRITE(12)ZE,N,IB,NB,NBO
DO 23 J=1,IB
K=NBO(J)
WRITE(12)X(K),Y(K),P(K),RHO(K),Q(K),THETA(K),PSI(K)
23 CONTINUE
24 CONTINUE
IF(JPT.EQ.1) GO TO 25
IF((IT.EQ.JMAX).OR.(ZE.EQ.ZMAX)) GO TO 25

```

```

      IF(MOD(IT,JPT).NE.0) RETURN
25 CONTINUE
      L=1
      DO 28 J=1,N,50
      N2=J+49
      IF(N2.GT.N) N2=N
      WRITE(6,1)HEAD,ZE,IT
      DO 27 K=J,N2
      SM=Q(K)/SQRT(G*P(K)/RHO(K))
      IN=NO
      IF(NB(L).NE.K) GO TO 26
      IN=NE S
      L=L+1
26 CONTINUE
      WRITE(6,2)K,X(K),Y(K),P(K),RHO(K),Q(K),THETA(K),
      *PSI(K),SM,IN
27 CONTINUE
28 CONTINUE
      WRITE(6,3)HEAD,ZE,IT
      DO 29 J=1,18
      K=NB0(J)
      SM=Q(K)/SQRT(G*P(K)/RHO(K))
      WRITE(6,4)K,X(K),Y(K),P(K),RHO(K),Q(K),THETA(K),
      *PSI(K),SM
29 CONTINUE
      RETURN
      END

```

```

SUBROUTINE SIMQ(A,R,M,N)
IMPLICIT REAL*8(A-H,O-Z)
DIMENSION A(1),R(1)
DATA EPS/1.D-5/
111 FORMAT('0 SINGULAR MATRIX IN SIMQ')
IF(M)23,23,1
C SEARCH FOR GREATEST ELEMENT IN MATRIX A
1 IER=0
PIV=0.00
MM=M*M
NM=N*M
DO 3 L=1,MM
TB=DABS(A(L))
IF(TB-PIV)3,3,2
2 PIV=TB
I=L
3 CONTINUE
TOL=EPS*PIV
C A(I) IS PIVOT ELEMENT. PIV CONTAINS /A(I)/.
C START ELIMINATION LOOP
LST=1
DO 17 K=1,M
C TEST ON SINGULARITY
IF(PIV)23,23,4
4 IF(IER)7,5,7
5 IF(PIV-TOL)6,6,7
6 IER=K-1
7 PIVI=1.00/A(I)
J=(I-1)/M
I=I-J*M-K
J=J+1-K
C I+K IS ROW-INDEX, J+K COLUMN-INDEX OF PIVOT ELEMENT
C PIVOT ROW REDUCTION AND ROW INTERCHANGE IN R.
DO 8 L=K,NM,M
LL=L+I
TB=PIVI*R(LL)
R(LL)=R(L)
8 R(L)=TB
C IS ELIMINATION TERMINATED
IF(K-M)9,18,18
C COLUMN INTERCHANGE IN MATRIX A
9 LEND=LST+M-K
IF(J)12,12,10
10 II=J*M
DO 11 L=LST,LEND
TB=A(L)
LL=L+II
A(L)=A(LL)
11 A(LL)=TB
C ROW INTERCHANGE AND PIVOT ROW REDUCTION IN MATRIX A

```

```

12 DO 13 L=LST,MM,M
    LL=L+1
    TB=PIVI*A(LL)
    A(LL)=A(L)
13 A(L)=TB
C    SAVE COLUMN INTERCHANGE INFORMATION
    A(LST)=J
C    ELEMENT REDUCTION AND NEXT PIVOT SEARCH
    PIV=0.00
    LST=LST+1
    J=0
    DO 16 II=LST,LEND
        PIVI=-A(II)
        IST=II+M
        J=J+1
    DO 15 L=IST,MM,M
        LL=L-J
        A(L)=A(L)+PIVI*A(LL)
        TB=DABS(A(L))
        IF(TB-PIV)15,15,14
14 PIV=TB
    I=L
15 CONTINUE
    DO 16 L=K,NM,M
        LL=L+J
16 R(LL)=R(LL)+PIVI*R(L)
17 LST=LST+M
C    END OF ELIMINATION LOOP
C    BACK SUBSTITUTION AND BACK INTERCHANGE
18 IF(M-1)23,22,19
19 IST=MM+M
    LST=M+1
    DO 21 I=2,M
        II=LST-I
        IST=IST-LST
        L=IST-M
        L=A(L)+0.5D0
        DO 21 J=II,NM,M
            TB=R(J)
            LL=J
            DO 20 K=IST,MM,M
                LL=LL+1
20 TB=TB-A(K)*R(LL)
            K=J+L
            R(J)=R(K)
21 R(K)=TB
22 RETURN
C    ERROR RETURN
23 IER=-1
    WRITE(6,111)
    STOP
    END

```

```

SUBROUTINE SOLVBP(X,Y,A,B,C,A1,B1,C1,IT,X1,Y1)
IMPLICIT REAL*8(A-H,O-Z)
1 FORMAT('0 NEGATIVE RADICAL IN SOLVBP')
GO TO(21,22,23,24),IT
21 CONTINUE
X=C1
Y=(C-A*X)/B
RETURN
22 CONTINUE
Y=C1
X=(C-B*Y)/A
RETURN
23 CONTINUE
Y=(A*C1-C*A1)/(A*B1-B*A1)
X=(C-B*Y)/A
RETURN
24 CONTINUE
IF(DABS(B).GT.DABS(A)) GO TO 26
D1=1.D0+(B/A)**2
D2=C/A-A1
D3=(D2**2+B1**2-C1)/D1
D2=(B*D2/A+B1)/D1
RAD=D2**2-D3
IF(RAD.GE.0.D0) GO TO 25
WRITE(6,1)
WRITE(6,2)X,Y,A,B,C,A1,B1,C1,IT,X1,Y1,D1,D2,D3
2 FORMAT('0 X=',1PE12.5,5X,'Y=',E12.5/3X,'A=',E12.5,5X,
*'B=',E12.5,5X,'C=',E12.5/2X,'A1=',E12.5,4X,'B1=',E12.5,
*4X,'C1=',E12.5/2X,'IT=',I2,14X,'X1=',E12.5,4X,'Y1=',
*E12.5/2X,'D1=',E12.5,4X,'D2=',E12.5,4X,'D3=',E12.5)
CALL ERRWCA
STOP
25 CONTINUE
RAD=DSQRT(RAD)
Y=D2+RAD
IF(DABS(Y1-Y).GE.DABS(Y1-D2+RAD)) Y=D2-RAD
X=(C-B*Y)/A
RETURN
26 CONTINUE
D1=1.D0+(A/B)**2
D2=C/B-B1
D3=(D2**2+A1**2-C1)/D1
D2=(A*D2/B+A1)/D1
RAD=D2**2-D3
IF(RAD.GE.0.D0) GO TO 27
WRITE(6,1)
WRITE(6,2)X,Y,A,B,C,A1,B1,C1,IT,X1,Y1,D1,D2,D3
CALL ERRWCA
STOP
27 CONTINUE

```

```
RAD=DSQRT(RAD)
X=D2+RAD
IF(DABS(X1-X),GT.DABS(X1-D2+RAD)) X=D2-RAD
Y=(C-A*X)/B
RETURN
END
```

```
SUBROUTINE SORT(DN,NE,N)
DIMENSION DN(N)
INTEGER*2 NE(N)
N1=1
N2=N
20 CONTINUE
  DMIN=DN(N1)
  DMAX=DN(N2)
  IF(DMIN.LE.DMAX) GO TO 21
  D=DN(N1)
  DN(N1)=DN(N2)
  DN(N2)=D
  M=NE(N1)
  NE(N1)=NE(N2)
  NE(N2)=M
  GO TO 20
21 CONTINUE
  N1=N1+1
  N2=N2-1
  IF(N1.GT.N2) GO TO 24
  DO 23 I=N1,N2
    IF(DN(I).GE.DMIN) GO TO 22
    DN(N1-1)=DN(I)
    DN(I)=DMIN
    DMIN=DN(N1-1)
    M=NE(I)
    NE(I)=NE(N1-1)
    NE(N1-1)=M
    GO TO 23
22 CONTINUE
  IF(DN(I).LE.DMAX) GO TO 23
  DN(N2+1)=DN(I)
  DN(I)=DMAX
  DMAX=DN(N2+1)
  M=NE(I)
  NE(I)=NE(N2+1)
  NE(N2+1)=M
23 CONTINUE
  GO TO 20
24 CONTINUE
  RETURN
END
```

```

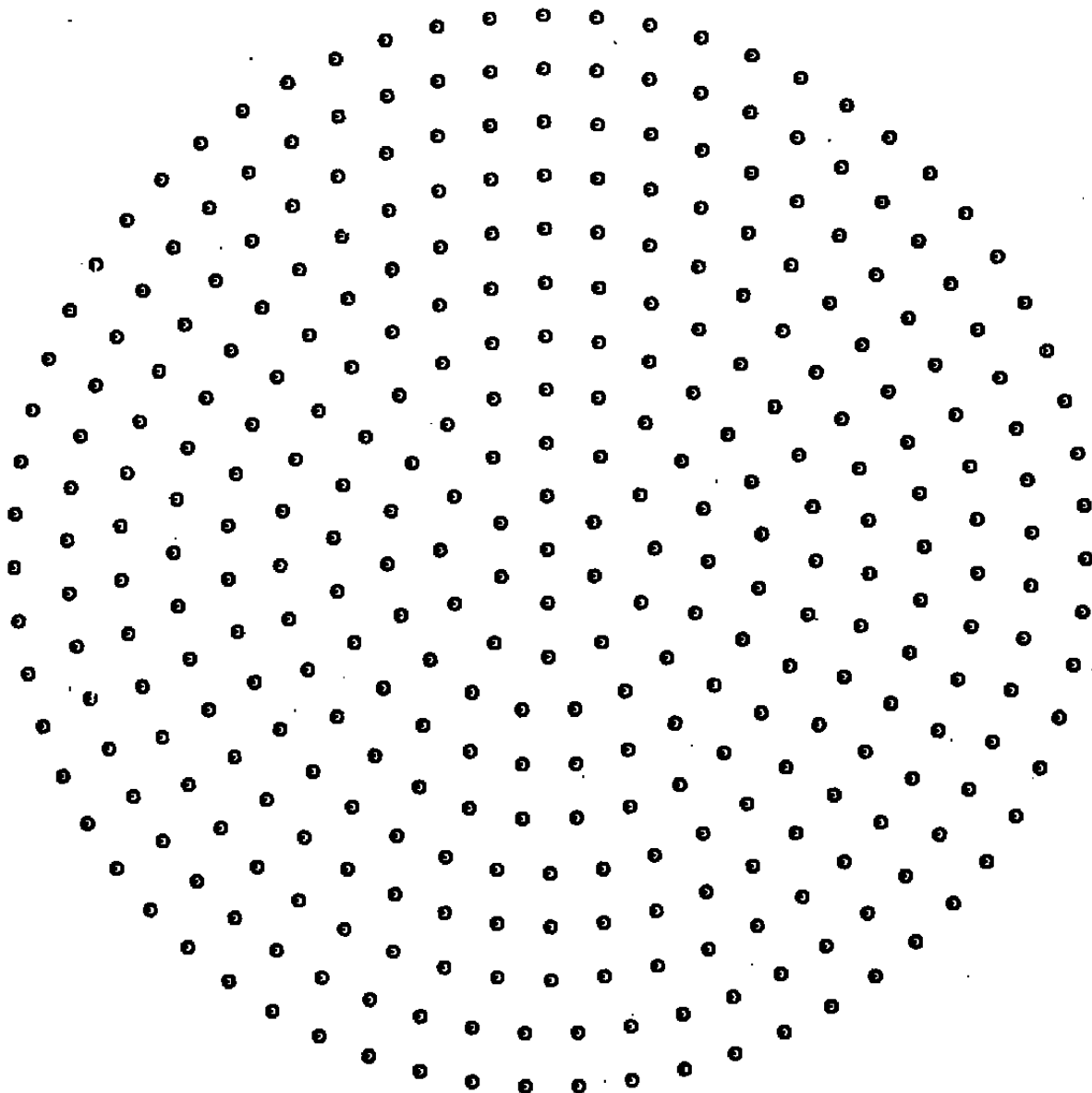
SUBROUTINE THREEED
COMMON/VALUE/ZE,X(1000),Y(1000),P(1000),RHO(1000) ,
*Q(1000),THETA(1000),PSI(1000),N
COMMON /GAS/G,RQ,GM1,GM1H,GM1G,GGM1,GP1,GPGM
COMMON/NVALU/DZ,XN(1000),YN(1000),PN(1000),RN(1000),
*QN(1000),TN(1000),PSN(1000)
COMMON /BCUT/XB(50),YB(50)
COMMON /OCUT/XBO(50),YBO(50)
COMMON /STAG/PTO(1000),TTO,ATOT,ZO,ZMAX,NB(200),
*NBO(200),JMAX,JPT ,IB
INTEGER*2 NB,NBO
REAL*8 ZO,DG,DRC,DGM1,DGM1H,DGM1G,DGGM1,DGP1,DGPGM
COMMON /DGAS/ZO,DG,DRO,DGM1,DGM1H,DGM1G,DGGM1,DGP1,
*DGPGM
REAL*8 PTOD,TTOD,ATOD
COMMON /DSTAG/PTOD(1000),TTOD,ATOD
DO 19 I=1,N
PTOD(I)=PTC(I)
19 CONTINUE
TTOD=TTO
ATOD=ATOT
DG=G
DRO=RO
DGM1=DG-1.00
DGM1H=0.500*DGM1
DGM1G=DGM1/DG
DGGM1=1.00/DGM1G
DGP1=DG+1.00
DGPGM=DGP1/DGM1
CALL CUT(ZO)
ZE=ZO
DO 20 I=1,50
XBO(I)=XB(I)
YBO(I)=YB(I)
20 CONTINUE
DO 26 J=1,JMAX
CALL OUTPUT(J-1)
CALL DIST(DS)
DZ= 0.5*DS
IF((ZE+DZ).LE.ZMAX) GO TO 21
IF(ZE.GE.ZMAX) RETURN
DZ=ZMAX-ZE
21 CONTINUE
ZO=DZ
CALL CUT(ZE+DZ)
K=1
DO 23 I=1,N
CALL FIT(I)
IF(NB(K).EQ.I) GO TO 22
CALL FIELD(I)

```

```
      GO TO 23
22  CONTINUE
      CALL BODY(I)
      K=K+1
23  CONTINUE
      ZE=ZE+DZ
      DO 24 I=1,N
        X(I)=XN(I)
        Y(I)=YN(I)
        P(I)=PN(I)
        RHO(I)=RN(I)
        Q(I)=QN(I)
        THETA(I)=TN(I)
        PSI(I)=PSN(I)
24  CONTINUE
      DO 25 I=1,50
        XB0(I)=XB(I)
        YB0(I)=YB(I)
25  CONTINUE
26  CONTINUE
      CALL OUTPUT(JMAX)
      RETURN
      END
```

APPENDIX B EXAMPLE PROBELM

THE SAMPLE PROBLEM IS FOR $M = 4.1$ AXISYMMETRIC NOZZLE WITH $\gamma = 1.2$. THE NOZZLE AXIS IS ALIGNED WITH THE z AXIS. THERE ARE 48 STATIONS FOR THE BODY GEOMETRY. THE STARTING PLANE INPUT HAS ONE RAY WITH 11 POINTS. THE COMPLETE STARTING PLANE IS GENERATED FROM THESE 11 POINTS TO A TOTAL OF 346 NEARLY EQUALLY SPACED POINTS. THE ARRANGEMENT OF THESE POINTS IS SHOWN BELOW.



INPUT CARDS

```
0000000001111111112222222223333333334444444445555555556666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890
```

MACH & NOZZLE (G=1.24)

```
0
45
36 3 0.205
1.01532 0.0
36 3 0.25
1.02299 0.0
36 3 0.30
1.03344 0.0
36 3 0.35
1.04594 0.0
36 3 0.40
1.06051 0.0
36 3 0.45
1.07710 0.0
36 3 0.50
1.09561 0.0
36 3 0.55
1.11586 0.0
36 3 0.60
1.13762 0.0
36 3 0.65
1.16058 0.0
36 3 0.70
1.18442 0.0
36 3 0.80
1.23355 0.0
36 3 0.90
1.28315 0.0
36 3 1.00
1.33273 0.0
36 3 1.10
1.38226 0.0
36 3 1.20
1.43171 0.0
36 3 1.30
1.48105 0.0
36 3 1.40
1.53028 0.0
36 3 1.50
1.57936 0.0
36 3 1.60
1.62831 0.0
36 3 1.70
1.67711 0.0
36 3 1.80
1.72574 0.0
36 3 1.93260
1.78990 0.0
36 3 2.09378
```

```
0000000001111111112222222223333333334444444445555555556666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890
```

INPUT CARDS

```
0000000011111111222222223333333344444444555555556666666677777777778
1234567890123456789012345678901234567890123456789012345678901234567890
```

```
1.86711 0.0
36 3 2.28244
1.95576 0.0
36 3 2.50060
2.05562 0.0
36 3 2.75167
2.16697 0.0
36 3 3.04016
2.29026 0.0
36 3 3.37131
2.42576 0.0
36 3 3.75138
2.57362 0.0
36 3 4.16794
2.73284 0.0
36 3 4.68976
2.90607 0.0
36 3 5.28701
3.08965 0.0
36 3 5.93207
3.28351 0.0
36 3 6.69778
3.48569 0.0
36 3 7.57930
3.69348 0.0
36 3 8.59135
3.92291 0.0
36 3 9.74737
4.10866 0.0
36 3 11.0567
4.30501 0.0
36 3 12.5192
4.48414 0.0
36 3 14.1196
4.63912 0.0
36 3 15.8202
4.76413 0.0
36 3 17.5562
4.85610 0.0
36 3 19.2369
4.91634 0.0
36 3 20.7600
4.95043 0.0
36 3 22.0350
4.98647 0.0
36 3 23.0095
4.97238 0.0
36 3 24.0
4.97416 0.0
1.24 100.0 100.0 1710.0
```

```
0000000011111111222222223333333344444444555555556666666677777777778
1234567890123456789012345678901234567890123456789012345678901234567890
```

INPUT CARDS

```
000000000111111112222222222333333333444444445555555556666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890
```

0.205	24.0	0	1	11	36	100	100				
0.0	0.0	55.035	1.0105	0.0	0.0	0.0	0.0	0			
0.10153	0.0	54.887	1.01291	0.22466	0.0	0.0	0.0	0			
0.20306	0.0	54.439	1.02022	0.47564	0.0	0.0	0.0	0			
0.30460	0.0	53.676	1.03271	0.77981	0.0	0.0	0.0	0			
0.40613	0.0	52.571	1.05091	1.16897	0.0	0.0	0.0	0			
0.50766	0.0	51.079	1.07571	1.68158	0.0	0.0	0.0	0			
0.60919	0.0	49.127	1.10859	2.36939	0.0	0.0	0.0	0			
0.71072	0.0	46.613	1.15183	3.30375	0.0	0.0	0.0	0			
0.81226	0.0	43.385	1.20905	4.58134	0.0	0.0	0.0	0			
0.91379	0.0	39.245	1.28600	6.32552	0.0	0.0	0.0	0			
1.01532	0.0	33.953	1.39283	8.67814	0.0	0.0	0.0	1			

```
000000000111111112222222222333333333444444445555555556666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890
```

MACH & NOZZLE (G=1.24)

STARTING PLANE INPUT

GAMMA = 1.240	PTD = 1.00000E 02	TTO = 1.00000E 02	R = 1.71600E 03			
ZD= 2.05000E-01	ZMAX= 2.40000E 01	ITYPE= 0	IMV= 1	NPTS= 11	NRAYS= 36	JMAX= 100
		IPLOT= 0	IT11= 0	IT12= 0	INEIGH= 0	JPT= 100
X	Y	P	Q	THETA	PSI	PTD

WACH 4 NOZZLE (G=1.24)

ZE = 2.05300E-01

STEP NO. 0

NO.	X	Y	P	RHO	Q	THETA	PSI	W	BODY
1	0.0	0.0	5.50350E-01	3.50015E-04	4.39952E-02	0.0	0.0	1.01050E-00	00
2	1.01530E-01	0.0	5.48870E-01	3.59234E-04	4.40887E-02	3.92105E-03	0.0	1.01291E-00	00
3	5.07651E-02	8.79274E-02	5.48870E-01	3.59234E-04	4.40887E-02	1.96053E-03	3.39573E-03	1.01291E-00	00
4	-5.07648E-02	8.79276E-02	5.48870E-01	3.59234E-04	4.40887E-02	-1.96052E-03	3.39574E-03	1.01291E-00	00
5	-1.01530E-01	1.60670E-07	5.48870E-01	3.59234E-04	4.40887E-02	-3.92105E-03	6.20155E-09	1.01291E-00	00
6	-5.07651E-02	-8.79274E-02	5.48870E-01	3.59234E-04	4.40887E-02	-1.96053E-03	-3.39573E-03	1.01291E-00	00
7	5.07648E-02	-8.79276E-02	5.48870E-01	3.59234E-04	4.40887E-02	1.96052E-03	-3.39574E-03	1.01291E-00	00
8	2.03060E-01	0.0	5.44390E-01	3.56867E-04	4.43717E-02	8.29798E-03	0.0	1.02022E-00	00
9	1.75855E-01	1.71530E-01	5.44390E-01	3.56867E-04	4.43717E-02	7.18623E-03	4.14905E-03	1.02022E-00	00
10	1.01530E-01	1.75855E-01	5.44390E-01	3.56867E-04	4.43717E-02	4.14896E-03	7.18629E-03	1.02022E-00	00
11	2.57403E-07	2.03060E-01	5.44390E-01	3.56867E-04	4.43717E-02	1.05185E-08	8.29798E-03	1.02022E-00	00
12	-1.01530E-01	1.75855E-01	5.44390E-01	3.56867E-04	4.43717E-02	-4.14894E-03	7.18630E-03	1.02022E-00	00
13	-1.75855E-01	1.01530E-01	5.44390E-01	3.56867E-04	4.43717E-02	-7.18623E-03	4.14907E-03	1.02022E-00	00
14	-2.03060E-01	3.21159E-07	5.44390E-01	3.56867E-04	4.43717E-02	-8.29798E-03	1.31244E-08	1.02022E-00	00
15	-1.75855E-01	-1.01530E-01	5.44390E-01	3.56867E-04	4.43717E-02	-7.18624E-03	-4.14905E-03	1.02022E-00	00
16	-1.01530E-01	-1.75855E-01	5.44390E-01	3.56867E-04	4.43717E-02	-4.14896E-03	-7.18629E-03	1.02022E-00	00
17	-3.84916E-07	-2.03060E-01	5.44390E-01	3.56867E-04	4.43717E-02	-1.05185E-08	-8.29798E-03	1.02022E-00	00
18	-1.01530E-01	-1.75855E-01	5.44390E-01	3.56867E-04	4.43717E-02	-4.14893E-03	-7.18630E-03	1.02022E-00	00
19	1.75855E-01	-1.01530E-01	5.44390E-01	3.56867E-04	4.43717E-02	7.18623E-03	-4.14907E-03	1.02022E-00	00
20	3.04600E-01	0.0	5.36760E-01	3.52828E-04	4.48536E-02	1.36102E-02	0.0	1.03271E-00	00
21	2.68096E-01	9.89033E-02	5.36760E-01	3.52828E-04	4.48536E-02	1.28728E-02	4.41947E-03	1.03271E-00	00
22	2.40372E-01	1.87089E-01	5.36760E-01	3.52828E-04	4.48536E-02	1.07403E-02	8.35989E-03	1.03271E-00	00
23	1.66601E-01	2.55001E-01	5.36760E-01	3.52828E-04	4.48536E-02	7.44394E-03	1.13942E-02	1.03271E-00	00
24	7.47754E-02	2.95270E-01	5.36760E-01	3.52828E-04	4.48536E-02	3.34104E-03	1.31936E-02	1.03271E-00	00
25	-2.51531E-02	3.03560E-01	5.36760E-01	3.52828E-04	4.48536E-02	-1.12387E-03	1.35638E-02	1.03271E-00	00
26	-1.22356E-01	2.78945E-01	5.36760E-01	3.52828E-04	4.48536E-02	-5.46699E-03	1.24440E-02	1.03271E-00	00
27	-3.06299E-01	2.24102E-01	5.36760E-01	3.52828E-04	4.48536E-02	-9.21778E-03	1.00137E-02	1.03271E-00	00
28	-2.67997E-01	1.44974E-01	5.36760E-01	3.52828E-04	4.48536E-02	-1.19697E-02	6.47810E-03	1.03271E-00	00
29	-3.00445E-01	5.01366E-02	5.36760E-01	3.52828E-04	4.48536E-02	-1.34248E-02	2.24035E-03	1.03271E-00	00
30	-3.00446E-01	-5.01365E-02	5.36760E-01	3.52828E-04	4.48536E-02	-1.34246E-02	-2.24026E-03	1.03271E-00	00
31	-2.67888E-01	-1.44972E-01	5.36760E-01	3.52828E-04	4.48536E-02	-1.19698E-02	-6.47801E-03	1.03271E-00	00
32	-2.06301E-01	-2.24101E-01	5.36760E-01	3.52828E-04	4.48536E-02	-9.21784E-03	-1.00136E-02	1.03271E-00	00
33	-1.22358E-01	-2.78944E-01	5.36760E-01	3.52828E-04	4.48536E-02	-5.46708E-03	-1.24440E-02	1.03271E-00	00
34	-2.51555E-02	-3.03559E-01	5.36760E-01	3.52828E-04	4.48536E-02	-1.12397E-03	-1.35637E-02	1.03271E-00	00
35	7.47725E-02	-2.95280E-01	5.36760E-01	3.52828E-04	4.48536E-02	3.34001E-03	-1.31938E-02	1.03271E-00	00
36	1.66599E-01	-2.55002E-01	5.36760E-01	3.52828E-04	4.48536E-02	7.44386E-03	-1.13943E-02	1.03271E-00	00
37	2.42371E-01	-1.87091E-01	5.36760E-01	3.52828E-04	4.48536E-02	1.07402E-02	-8.35990E-03	1.03271E-00	00
38	2.88095E-01	-9.89060E-02	5.36760E-01	3.52828E-04	4.48536E-02	1.28727E-02	-4.41960E-03	1.03271E-00	00
39	4.06130E-01	0.0	5.25710E-01	3.46959E-04	4.55523E-02	2.04024E-02	0.0	1.05091E-00	00
40	3.93371E-01	1.01000E-01	5.25710E-01	3.46959E-04	4.55523E-02	1.97613E-02	5.07451E-03	1.05091E-00	00
41	3.55894E-01	1.95654E-01	5.25710E-01	3.46959E-04	4.55523E-02	1.78784E-02	9.82995E-03	1.05091E-00	00
42	2.98056E-01	2.78015E-01	5.25710E-01	3.46959E-04	4.55523E-02	1.48722E-02	1.39674E-02	1.05091E-00	00
43	2.17615E-01	3.42907E-01	5.25710E-01	3.46959E-04	4.55523E-02	1.09316E-02	1.72270E-02	1.05091E-00	00
44	1.25502E-01	3.86252E-01	5.25710E-01	3.46959E-04	4.55523E-02	6.30430E-03	1.94040E-02	1.05091E-00	00
45	2.55016E-02	4.05329E-01	5.25710E-01	3.46959E-04	4.55523E-02	1.28101E-03	2.03621E-02	1.05091E-00	00
46	-7.61006E-02	3.98936E-01	5.25710E-01	3.46959E-04	4.55523E-02	-3.82274E-03	2.00411E-02	1.05091E-00	00
47	-1.72921E-01	3.67478E-01	5.25710E-01	3.46959E-04	4.55523E-02	-8.68639E-03	1.84811E-02	1.05091E-00	00
48	-2.58877E-01	1.12929E-01	5.25710E-01	3.46959E-04	4.55523E-02	-1.30044E-02	1.57212E-02	1.05091E-00	00
49	-3.28566E-01	2.38718E-01	5.25710E-01	3.46959E-04	4.55523E-02	-1.65084E-02	1.14933E-02	1.05091E-00	00
50	-3.77610E-01	1.49570E-01	5.25710E-01	3.46959E-04	4.55523E-02	-1.89694E-02	7.51184E-03	1.05091E-00	00

MACH 4 NOZZLE (G=1.24)

ZC = 2.05000E-01

STEP NO. 0

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BOOV
51	-4.02927E-01	3.05022E-02	5.25710E 01	3.46959E-04	4.55523E 02	-2.02414E-02	2.55747E-03	1.05091E 00	
52	-4.02928E-01	-5.09000E-02	5.25710E 01	3.46959E-04	4.55523E 02	-2.02415E-02	-2.55741E-03	1.05091E 00	
53	-3.77610E-01	-1.49506E-01	5.25710E 01	3.46959E-04	4.55523E 02	-1.89609E-02	-7.51140E-03	1.05091E 00	
54	-3.28567E-01	-2.38716E-01	5.25710E 01	3.46959E-04	4.55523E 02	-1.65059E-02	-1.19933E-02	1.05091E 00	
55	-2.58878E-01	-3.12928E-01	5.25710E 01	3.46959E-04	4.55523E 02	-1.30044E-02	-1.57211E-02	1.05091E 00	
56	-1.72922E-01	-3.67477E-01	5.25710E 01	3.46959E-04	4.55523E 02	-8.68644E-03	-1.84410E-02	1.05091E 00	
57	-7.61023E-02	-3.98936E-01	5.25710E 01	3.46959E-04	4.55523E 02	-3.82282E-03	-2.00411E-02	1.05091E 00	
58	2.54992E-02	-4.08329E-01	5.25710E 01	3.46959E-04	4.55523E 02	1.28089E-03	-2.03621E-02	1.05091E 00	
59	1.25498E-01	-3.86283E-01	5.25710E 01	3.46959E-04	4.55523E 02	6.30414E-03	-1.94041E-02	1.05091E 00	
60	2.17614E-01	-3.42908E-01	5.25710E 01	3.46959E-04	4.55523E 02	1.09313E-02	-1.72270E-02	1.05091E 00	
61	2.96054E-01	-2.78017E-01	5.25710E 01	3.46959E-04	4.55523E 02	1.48721E-02	-1.39675E-02	1.05091E 00	
62	3.55894E-01	-1.95656E-01	5.25710E 01	3.46959E-04	4.55523E 02	1.78784E-02	-9.83081E-03	1.05091E 00	
63	3.93370E-01	-1.01002E-01	5.25710E 01	3.46959E-04	4.55523E 02	1.97613E-02	-5.07462E-03	1.05091E 00	
64	5.07660E-01	0.0	5.10790E 01	3.38996E-04	4.64975E 02	2.93491E-02	0.0	1.07571E 00	
65	4.97268E-01	1.02191E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.87481E-02	5.90955E-03	1.07571E 00	
66	4.68518E-01	2.00198E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.69700E-02	1.15768E-02	1.07571E 00	
67	4.16669E-01	2.90010E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.40875E-02	1.67654E-02	1.07571E 00	
68	3.49741E-01	3.67948E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.02190E-02	2.12749E-02	1.07571E 00	
69	2.68534E-01	4.30822E-01	5.10790E 01	3.38996E-04	4.64975E 02	1.55230E-02	2.49989E-02	1.07571E 00	
70	1.76313E-01	4.76059E-01	5.10790E 01	3.38996E-04	4.64975E 02	1.01918E-02	2.75231E-02	1.07571E 00	
71	7.68746E-02	5.01806E-01	5.10790E 01	3.38996E-04	4.64975E 02	4.44368E-03	2.90188E-02	1.07571E 00	
72	-2.57118E-02	5.07008E-01	5.10790E 01	3.38996E-04	4.64975E 02	-1.48625E-03	2.93114E-02	1.07571E 00	
73	-1.27245E-01	4.91454E-01	5.10790E 01	3.38996E-04	4.64975E 02	-7.35538E-03	2.84127E-02	1.07571E 00	
74	-2.23570E-01	4.55780E-01	5.10790E 01	3.38996E-04	4.64975E 02	-1.29236E-02	2.63512E-02	1.07571E 00	
75	-3.10741E-01	4.01446E-01	5.10790E 01	3.38996E-04	4.64975E 02	-1.79631E-02	2.32111E-02	1.07571E 00	
76	-3.85191E-01	3.30676E-01	5.10790E 01	3.38996E-04	4.64975E 02	-2.22675E-02	1.91204E-02	1.07571E 00	
77	-4.43870E-01	2.46369E-01	5.10790E 01	3.38996E-04	4.64975E 02	-2.56604E-02	1.42463E-02	1.07571E 00	
78	-4.84378E-01	1.51976E-01	5.10790E 01	3.38996E-04	4.64975E 02	-2.80027E-02	8.78839E-03	1.07571E 00	
79	-5.05055E-01	5.13651E-02	5.10790E 01	3.38996E-04	4.64975E 02	-2.91989E-02	2.97010E-03	1.07571E 00	
80	-5.05055E-01	-5.13581E-02	5.10790E 01	3.38996E-04	4.64975E 02	-2.91989E-02	-2.96998E-03	1.07571E 00	
81	-4.84379E-01	-1.51974E-01	5.10790E 01	3.38996E-04	4.64975E 02	-2.80028E-02	-8.78827E-03	1.07571E 00	
82	-4.43871E-01	-2.46367E-01	5.10790E 01	3.38996E-04	4.64975E 02	-2.56604E-02	-1.42462E-02	1.07571E 00	
83	-3.85192E-01	-3.30675E-01	5.10790E 01	3.38996E-04	4.64975E 02	-2.22675E-02	-1.91203E-02	1.07571E 00	
84	-3.10742E-01	-4.01445E-01	5.10790E 01	3.38996E-04	4.64975E 02	-1.79632E-02	-2.32110E-02	1.07571E 00	
85	-2.23572E-01	-4.55779E-01	5.10790E 01	3.38996E-04	4.64975E 02	-1.29237E-02	-2.63512E-02	1.07571E 00	
86	-1.27247E-01	-4.91454E-01	5.10790E 01	3.38996E-04	4.64975E 02	-7.35547E-03	-2.84127E-02	1.07571E 00	
87	-2.57144E-02	-5.07008E-01	5.10790E 01	3.38996E-04	4.64975E 02	-1.48640E-03	-2.93114E-02	1.07571E 00	
88	7.68710E-02	-5.01806E-01	5.10790E 01	3.38996E-04	4.64975E 02	4.44348E-03	-2.90109E-02	1.07571E 00	
89	1.76311E-01	-4.76060E-01	5.10790E 01	3.38996E-04	4.64975E 02	1.01917E-02	-2.75232E-02	1.07571E 00	
90	2.68532E-01	-4.30824E-01	5.10790E 01	3.38996E-04	4.64975E 02	1.55229E-02	-2.49989E-02	1.07571E 00	
91	3.49760E-01	-3.67949E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.02190E-02	-2.12750E-02	1.07571E 00	
92	4.16667E-01	-2.90012E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.40874E-02	-1.67654E-02	1.07571E 00	
93	4.68517E-01	-2.00200E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.69699E-02	-1.15768E-02	1.07571E 00	
94	4.97268E-01	-1.02194E-01	5.10790E 01	3.38996E-04	4.64975E 02	2.87481E-02	-5.90970E-03	1.07571E 00	
95	6.09190E-01	0.0	4.91270E 01	3.28508E-04	4.77384E 02	4.13536E-02	0.0	1.10859E 00	
96	6.00881E-01	1.00269E-01	4.91270E 01	3.28508E-04	4.77384E 02	4.07893E-02	6.81035E-03	1.10859E 00	
97	5.76182E-01	1.97883E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.91111E-02	1.34343E-02	1.10859E 00	
98	5.35767E-01	2.89942E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.63671E-02	1.96808E-02	1.10859E 00	
99	4.80737E-01	3.74172E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.26303E-02	2.54889E-02	1.10859E 00	
100	4.12593E-01	4.48195E-01	4.91270E 01	3.28508E-04	4.77384E 02	2.80037E-02	3.04328E-02	1.10859E 00	

MACH 4 NOZZLE (G=1.24)

ZE = 2.05000E-01

STEP NO. 0

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
101	3.33196E-01	5.09993E-01	4.91270E 01	3.28508E-04	4.77384E 02	2.26138E-02	3.46258E-02	1.10859E 00	
102	2.44709E-01	5.57880E-01	4.91270E 01	3.28508E-04	4.77384E 02	1.66076E-02	3.78740E-02	1.10859E 00	
103	1.49548E-01	5.90549E-01	4.91270E 01	3.28508E-04	4.77384E 02	1.01490E-02	4.00896E-02	1.10859E 00	
104	5.03070E-02	6.07109E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.41402E-03	4.12126E-02	1.10859E 00	
105	-5.03061E-02	6.07109E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.41396E-03	4.12126E-02	1.10859E 00	
106	-1.49546E-01	5.90549E-01	4.91270E 01	3.28508E-04	4.77384E 02	-1.01489E-02	4.00896E-02	1.10859E 00	
107	-2.44708E-01	5.57880E-01	4.91270E 01	3.28508E-04	4.77384E 02	-1.66075E-02	3.78741E-02	1.10859E 00	
108	-3.33195E-01	5.09994E-01	4.91270E 01	3.28508E-04	4.77384E 02	-2.26137E-02	3.46258E-02	1.10859E 00	
109	-4.12593E-01	4.48196E-01	4.91270E 01	3.28508E-04	4.77384E 02	-2.80037E-02	3.04329E-02	1.10859E 00	
110	-4.80736E-01	3.74173E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.26303E-02	2.54090E-02	1.10859E 00	
111	-5.35766E-01	2.89943E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.63670E-02	1.96910E-02	1.10859E 00	
112	-5.76182E-01	1.97805E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.91118E-02	1.34344E-02	1.10859E 00	
113	-6.00881E-01	1.00270E-01	4.91270E 01	3.28508E-04	4.77384E 02	-4.07893E-02	6.81042E-03	1.10859E 00	
114	-6.09190E-01	9.63492E-02	4.91270E 01	3.28508E-04	4.77384E 02	-4.13536E-02	6.54421E-03	1.10859E 00	
115	-6.00882E-01	-1.00268E-01	4.91270E 01	3.28508E-04	4.77384E 02	-4.07893E-02	-6.81030E-03	1.10859E 00	
116	-5.76183E-01	-1.97802E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.91118E-02	-1.34343E-02	1.10859E 00	
117	-5.35767E-01	-2.89941E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.63671E-02	-1.96908E-02	1.10859E 00	
118	-4.80737E-01	-3.74171E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.26304E-02	-2.54089E-02	1.10859E 00	
119	-4.12594E-01	-4.48195E-01	4.91270E 01	3.28508E-04	4.77384E 02	-2.80038E-02	-3.04328E-02	1.10859E 00	
120	-3.33197E-01	-5.09992E-01	4.91270E 01	3.28508E-04	4.77384E 02	-2.26139E-02	-3.46267E-02	1.10859E 00	
121	-2.44710E-01	-5.57879E-01	4.91270E 01	3.28508E-04	4.77384E 02	-1.66077E-02	-3.78740E-02	1.10859E 00	
122	-1.49549E-01	-5.90549E-01	4.91270E 01	3.28508E-04	4.77384E 02	-1.01491E-02	-4.00896E-02	1.10859E 00	
123	-5.03103E-02	-6.07109E-01	4.91270E 01	3.28508E-04	4.77384E 02	-3.41424E-03	-4.12125E-02	1.10859E 00	
124	5.03051E-02	-6.07109E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.41389E-03	-4.12126E-02	1.10859E 00	
125	1.49548E-01	-5.90549E-01	4.91270E 01	3.28508E-04	4.77384E 02	1.01489E-02	-4.00896E-02	1.10859E 00	
126	2.44707E-01	-5.57881E-01	4.91270E 01	3.28508E-04	4.77384E 02	1.66074E-02	-3.78741E-02	1.10859E 00	
127	3.33192E-01	-5.09995E-01	4.91270E 01	3.28508E-04	4.77384E 02	2.26136E-02	-3.46259E-02	1.10859E 00	
128	4.12590E-01	-4.48196E-01	4.91270E 01	3.28508E-04	4.77384E 02	2.80035E-02	-3.04330E-02	1.10859E 00	
129	4.80735E-01	-3.74173E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.26302E-02	-2.54090E-02	1.10859E 00	
130	5.35766E-01	-2.89944E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.63670E-02	-1.96910E-02	1.10859E 00	
131	5.76181E-01	-1.97807E-01	4.91270E 01	3.28508E-04	4.77384E 02	3.91117E-02	-1.34344E-02	1.10859E 00	
132	6.00881E-01	-1.00273E-01	4.91270E 01	3.28508E-04	4.77384E 02	4.07893E-02	-6.81061E-03	1.10859E 00	
133	7.10720E-01	0.0	4.66130E 01	3.14883E-04	4.93489E 02	5.76613E-02	0.0	1.15183E 00	
134	7.03486E-01	1.01146E-01	4.66130E 01	3.14883E-04	4.93489E 02	5.70737E-02	8.21497E-03	1.15183E 00	
135	6.81931E-01	2.00233E-01	4.66130E 01	3.14883E-04	4.93489E 02	5.53232E-02	1.62616E-02	1.15183E 00	
136	6.46494E-01	2.95243E-01	4.66130E 01	3.14883E-04	4.93489E 02	5.24455E-02	2.39783E-02	1.15183E 00	
137	5.97896E-01	3.84244E-01	4.66130E 01	3.14883E-04	4.93489E 02	4.84999E-02	3.11985E-02	1.15183E 00	
138	5.37126E-01	4.65422E-01	4.66130E 01	3.14883E-04	4.93489E 02	4.35671E-02	3.77840E-02	1.15183E 00	
139	4.65423E-01	5.37120E-01	4.66130E 01	3.14883E-04	4.93489E 02	3.77482E-02	4.35982E-02	1.15183E 00	
140	3.84244E-01	5.97895E-01	4.66130E 01	3.14883E-04	4.93489E 02	3.11618E-02	4.85234E-02	1.15183E 00	
141	2.95244E-01	6.46493E-01	4.66130E 01	3.14883E-04	4.93489E 02	2.39424E-02	5.24605E-02	1.15183E 00	
142	2.00233E-01	6.81931E-01	4.66130E 01	3.14883E-04	4.93489E 02	1.62368E-02	5.53304E-02	1.15183E 00	
143	1.01147E-01	7.03486E-01	4.66130E 01	3.14883E-04	4.93489E 02	8.20165E-03	5.70756E-02	1.15183E 00	
144	9.09222E-02	7.10720E-01	4.66130E 01	3.14883E-04	4.93489E 02	7.30519E-03	5.76613E-02	1.15183E 00	
145	-1.01145E-01	7.03486E-01	4.66130E 01	3.14883E-04	4.93489E 02	-8.20150E-03	5.70757E-02	1.15183E 00	
146	-2.00232E-01	6.81931E-01	4.66130E 01	3.14883E-04	4.93489E 02	-1.62367E-02	5.53305E-02	1.15183E 00	
147	-2.95243E-01	6.46494E-01	4.66130E 01	3.14883E-04	4.93489E 02	-2.39423E-02	5.24606E-02	1.15183E 00	
148	-3.84243E-01	5.97896E-01	4.66130E 01	3.14883E-04	4.93489E 02	-3.11617E-02	4.85235E-02	1.15183E 00	
149	-4.65422E-01	5.37127E-01	4.66130E 01	3.14883E-04	4.93489E 02	-3.77481E-02	4.35982E-02	1.15183E 00	
150	-5.37126E-01	4.65423E-01	4.66130E 01	3.14883E-04	4.93489E 02	-4.35671E-02	3.77841E-02	1.15183E 00	

77

MACH 4 NOZZLE (G=1.74)

ZE = 2.05000E-01

STEP NO. 0

NO.	X	Y	P	RHD	Q	TNETA	PSI	M	BODY
151	-5.97595E-01	3.84245E-01	4.66130E 01	3.14883E-04	4.93489E 02	-4.84998E-02	3.11986E-02	1.15183E 00	
152	-6.46493E-01	2.95245E-01	4.66130F 01	3.14883E-04	4.93489E 02	-5.24455E-02	2.39754E-02	1.15183E 00	
153	-6.81930E-01	2.00234E-01	4.66130E 01	3.14883E-04	4.93489E 02	-5.53231E-02	1.62618E-02	1.15183E 00	
154	-7.03486E-01	1.01147E-01	4.66120E 01	3.14883E-04	4.93489E 02	-5.70737E-02	8.21504E-03	1.15183E 00	
155	-7.10720E-01	1.12407E-06	4.66130E 01	3.14883E-04	4.93489E 02	-5.76613E-02	9.12980E-08	1.15183E 00	
156	-7.07486E-01	-1.01145E-02	4.66130E 01	3.14883E-04	4.93489E 02	-5.70737E-02	-8.21486E-03	1.15183E 00	
157	-6.81931E-01	-2.00232E-01	4.66130E 01	3.14883E-04	4.93489E 02	-5.53232E-02	-1.62616E-02	1.15183E 00	
158	-6.46494E-01	-2.95243E-01	4.66130E 01	3.14883E-04	4.93489E 02	-5.24455E-02	-2.39753E-02	1.15183E 00	
159	-5.97596E-01	-3.84243E-01	4.66120E 01	3.14883E-04	4.93489E 02	-4.84999E-02	-3.11984E-02	1.15183E 00	
160	-5.37127E-01	-4.65421E-01	4.66120E 01	3.14883E-04	4.93489E 02	-4.35672E-02	-3.77839E-02	1.15183E 00	
161	-4.65424E-01	-5.37125E-01	4.66130F 01	3.14883E-04	4.93489E 02	-3.77482E-02	-4.35681E-02	1.15183E 00	
162	-3.84245E-01	-5.97595E-01	4.66130E 01	3.14883E-04	4.93489E 02	-3.11619E-02	-4.85234E-02	1.15183E 00	
163	-2.95245E-01	-6.46493E-01	4.66130E 01	3.14883E-04	4.93489E 02	-2.39425E-02	-5.24605E-02	1.15183E 00	
164	-2.00234E-01	-6.81930E-01	4.66130E 01	3.14883E-04	4.93489E 02	-1.62369E-02	-5.53304E-02	1.15183E 00	
165	-1.01148E-01	-7.03485E-01	4.66130E 01	3.14883E-04	4.93489E 02	-8.20179E-03	-5.70750E-02	1.15183E 00	
166	-4.73621E-06	-7.10720E-01	4.66130E 01	3.14883F-04	4.93489E 02	-3.84039E-07	-5.76613F-02	1.15183E 00	
167	1.01142E-01	-7.03486E-01	4.66130E 01	3.14883E-04	4.93489E 02	8.20130E-03	-5.70757E-02	1.15183E 00	
168	2.09230E-01	-6.81932E-01	4.66130E 01	3.14883E-04	4.93489E 02	1.62365E-02	-5.53305E-02	1.15183E 00	
169	2.95242E-01	-6.46494E-01	4.66130F 01	3.14883E-04	4.93489E 02	2.39422E-02	-5.24606E-02	1.15183E 00	
170	3.84241E-01	-5.97596F-01	4.66130E 01	3.14883E-04	4.93489E 02	3.11615E-02	-4.85236E-02	1.15183E 00	
171	4.65420E-01	-5.37129E-01	4.66130E 01	3.14883E-04	4.93489E 02	3.77479E-02	-4.35984E-02	1.15183E 00	
172	5.37125E-01	-4.65424E-01	4.66130F 01	3.14883E-04	4.93489E 02	4.35670E-02	-3.77842E-02	1.15183F 00	
173	5.97594E-01	-3.84246E-01	4.66130E 01	3.14883E-04	4.93489E 02	4.84998E-02	-3.11986E-02	1.15183E 00	
174	6.46492E-01	-2.95248E-01	4.66130E 01	3.14883E-04	4.93489E 02	5.24454E-02	-2.39757E-02	1.15183E 00	
175	6.81930E-01	-2.00236E-01	4.66130E 01	3.14883E-04	4.93489E 02	5.53231E-02	-1.62619E-02	1.15183E 00	
176	7.03485E-01	-1.01149E-01	4.66130F 01	3.14883E-04	4.93489E 02	5.70737E-02	-8.21519E-03	1.15183E 00	
177	8.12280E-01	0.0	4.33859E 01	2.97176E-04	5.14420E 02	7.99593E-02	0.0	1.20905E 00	
178	8.05855E-01	1.01803E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.93274E-02	1.00426E-02	1.20905E 00	
179	7.86741E-01	2.02001E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.74420E-02	1.99249E-02	1.20905E 00	
180	7.55220E-01	2.99013E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.43335E-02	2.94893E-02	1.20905E 00	
181	7.11789E-01	3.91309E-01	4.33850F 01	2.97176E-04	5.14420E 02	7.00514E-02	3.85838E-02	1.20905E 00	
182	6.57132E-01	4.77434E-01	4.33850E 01	2.97176E-04	5.14420E 02	6.46645E-02	4.78445E-02	1.20905E 00	
183	5.92112E-01	5.86039E-01	4.33850E 01	2.97176E-04	5.14420E 02	5.82587E-02	5.47979E-02	1.20905E 00	
184	5.17754E-01	6.25857E-01	4.33850E 01	2.97176E-04	5.14420E 02	5.09357E-02	6.16631E-02	1.20905E 00	
185	4.35231E-01	6.85813E-01	4.33850E 01	2.97176E-04	5.14420E 02	4.28118E-02	6.78532E-02	1.20905E 00	
186	3.45844E-01	7.34954E-01	4.33850E 01	2.97176E-04	5.14420E 02	3.40154E-02	7.23772E-02	1.20905E 00	
187	2.51003E-01	7.72505E-01	4.33850E 01	2.97176E-04	5.14420E 02	2.46851E-02	7.60612E-02	1.20905E 00	
188	1.52203E-01	7.97872E-01	4.33850E 01	2.97176E-04	5.14420E 02	1.49676E-02	7.85468E-02	1.20905E 00	
189	5.10032E-02	8.10637E-01	4.33850F 01	2.97176E-04	5.14420E 02	5.01545E-03	7.98022E-02	1.20905E 00	
190	-5.10012E-02	8.10637E-01	4.33850E 01	2.97176E-04	5.14420E 02	-5.01525E-03	7.98022E-02	1.20905E 00	
191	-1.52201E-01	7.97873E-01	4.33850E 01	2.97176E-04	5.14420E 02	-1.49674E-02	7.85469E-02	1.20905E 00	
192	-2.51001E-01	7.72505F-01	4.33850E 01	2.97176E-04	5.14420E 02	-2.46849E-02	7.60612E-02	1.20905E 00	
193	-3.45843E-01	7.34955E-01	4.33850F 01	2.97176E-04	5.14420E 02	-3.40152E-02	7.23773E-02	1.20905E 00	
194	-4.35230E-01	6.85814E-01	4.33850E 01	2.97176E-04	5.14420E 02	-4.28117E-02	6.75532E-02	1.20905E 00	
195	-5.17753E-01	6.25858E-01	4.33850E 01	2.97176E-04	5.14420E 02	-5.09356E-02	6.16631E-02	1.20905E 00	
196	-5.92111E-01	5.86031E-01	4.33850E 01	2.97176E-04	5.14420E 02	-5.82586E-02	5.47981E-02	1.20905E 00	
197	-6.57131E-01	4.77436E-01	4.33850E 01	2.97176E-04	5.14420E 02	-6.46644E-02	4.78647E-02	1.20905E 00	
198	-7.11788E-01	3.91310E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.00514E-02	3.85840E-02	1.20905E 00	
199	-7.55220E-01	2.99014E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.43334E-02	2.94865E-02	1.20905E 00	
200	-7.86741E-01	2.02002E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.74420E-02	1.99251E-02	1.20905E 00	

MACH 4 NOZZLE (G=1.24)

ZE = 2.05000E-01

STEP NO. 0

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
201	-8.05855E-01	1.01804E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.93274E-02	1.00425E-02	1.20905E 00	
202	-8.12240E-01	1.28467E-04	4.33850E 01	2.97176E-04	5.14420E 02	-7.99593E-02	1.26734E-07	1.20905E 00	
203	-8.05855E-01	-1.01802E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.93274E-02	-1.00425E-02	1.20905E 00	
204	-7.86742E-01	-2.02000E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.74420E-02	-1.99248E-02	1.20905E 00	
205	-7.55221E-01	-2.99012E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.43335E-02	-2.04892E-02	1.20905E 00	
206	-7.11790E-01	-3.91307E-01	4.33850E 01	2.97176E-04	5.14420E 02	-7.00516E-02	-3.85817E-02	1.20905E 00	
207	-6.57133E-01	-4.77433E-01	4.33850E 01	2.97176E-04	5.14420E 02	-6.46646E-02	-4.70644E-02	1.20905E 00	
208	-5.92113E-01	-5.56029E-01	4.33850E 01	2.97176E-04	5.14420E 02	-6.82588E-02	-5.47870E-02	1.20905E 00	
209	-5.17755E-01	-6.25856E-01	4.33850E 01	2.97176E-04	5.14420E 02	-6.09356E-02	-6.16630E-02	1.20905E 00	
210	-4.35232E-01	-6.85813E-01	4.33850E 01	2.97176E-04	5.14420E 02	-4.28119E-02	-6.75531E-02	1.20905E 00	
211	-3.45845E-01	-7.34954E-01	4.33850E 01	2.97176E-04	5.14420E 02	-3.40155E-02	-7.23772E-02	1.20905E 00	
212	-2.51004E-01	-7.72505E-01	4.33850E 01	2.97176E-04	5.14420E 02	-2.46851E-02	-7.60612E-02	1.20905E 00	
213	-1.52205E-01	-7.97872E-01	4.33850E 01	2.97176E-04	5.14420E 02	-1.49677E-02	-7.85488E-02	1.20905E 00	
214	-5.10033E-02	-8.10657E-01	4.33850E 01	2.97176E-04	5.14420E 02	-5.01566E-03	-7.98021E-02	1.20905E 00	
215	5.09943E-02	-8.10657E-01	4.33850E 01	2.97176E-04	5.14420E 02	5.01497E-03	-7.98022E-02	1.20905E 00	
216	1.52195E-01	-7.97872E-01	4.33850E 01	2.97176E-04	5.14420E 02	1.49670E-02	-7.85490E-02	1.20905E 00	
217	2.50997E-01	-7.72507E-01	4.33850E 01	2.97176E-04	5.14420E 02	2.46845E-02	-7.60614E-02	1.20905E 00	
218	3.45841E-01	-7.34956E-01	4.33850E 01	2.97176E-04	5.14420E 02	3.40151E-02	-7.23773E-02	1.20905E 00	
219	4.35228E-01	-6.85815E-01	4.33850E 01	2.97176E-04	5.14420E 02	4.28115E-02	-6.75533E-02	1.20905E 00	
220	5.17751E-01	-6.25859E-01	4.33850E 01	2.97176E-04	5.14420E 02	5.09354E-02	-6.16633E-02	1.20905E 00	
221	5.92109E-01	-5.56033E-01	4.33850E 01	2.97176E-04	5.14420E 02	5.82584E-02	-5.47883E-02	1.20905E 00	
222	6.57129E-01	-4.77439E-01	4.33850E 01	2.97176E-04	5.14420E 02	6.46642E-02	-4.70649E-02	1.20905E 00	
223	7.11787E-01	-3.91312E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.00513E-02	-3.85841E-02	1.20905E 00	
224	7.55219E-01	-2.99016E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.43334E-02	-2.04896E-02	1.20905E 00	
225	7.86740E-01	-2.02005E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.74419E-02	-1.99253E-02	1.20905E 00	
226	8.05854E-01	-1.01808E-01	4.33850E 01	2.97176E-04	5.14420E 02	7.93273E-02	-1.00431E-02	1.20905E 00	
227	9.13740E-01	0.0	3.92450E 01	2.74087E-04	5.41875E 02	1.10401E-01	0.0	1.28600E 00	
228	9.08244E-01	1.00524E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.09728E-01	1.21940E-02	1.28600E 00	
229	8.91673E-01	1.99828E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.07718E-01	2.42364E-02	1.28600E 00	
230	8.64278E-01	2.96707E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.04397E-01	3.99779E-02	1.28600E 00	
231	8.26393E-01	3.89848E-01	3.92450E 01	2.74087E-04	5.41875E 02	9.98049E-02	4.72736E-02	1.28600E 00	
232	7.78476E-01	4.78527E-01	3.92450E 01	2.74087E-04	5.41875E 02	9.40082E-02	5.79550E-02	1.28600E 00	
233	7.21109E-01	5.61261E-01	3.92450E 01	2.74087E-04	5.41875E 02	8.70550E-02	6.79816E-02	1.28600E 00	
234	6.54989E-01	6.37182E-01	3.92450E 01	2.74087E-04	5.41875E 02	7.99552E-02	7.71431E-02	1.28600E 00	
235	5.80918E-01	7.05369E-01	3.92450E 01	2.74087E-04	5.41875E 02	7.00994E-02	8.53603E-02	1.28600E 00	
236	4.99796E-01	7.64494E-01	3.92450E 01	2.74087E-04	5.41875E 02	6.02976E-02	9.25363E-02	1.28600E 00	
237	4.12607E-01	8.15332E-01	3.92450E 01	2.74087E-04	5.41875E 02	4.97692E-02	9.85872E-02	1.28600E 00	
238	3.20410E-01	8.55774E-01	3.92450E 01	2.74087E-04	5.41875E 02	3.86419E-02	1.03443E-01	1.28600E 00	
239	2.24323E-01	8.85828E-01	3.92450E 01	2.74087E-04	5.41875E 02	2.70502E-02	1.07049E-01	1.28600E 00	
240	1.25813E-01	9.05129E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.51339E-02	1.09363E-01	1.28600E 00	
241	2.51796E-02	9.13443E-01	3.92450E 01	2.74087E-04	5.41875E 02	3.03595E-03	1.10359E-01	1.28600E 00	
242	-7.54059E-02	9.10609E-01	3.92450E 01	2.74087E-04	5.41875E 02	-9.09838E-03	1.10027E-01	1.28600E 00	
243	-1.78183E-01	8.96841E-01	3.92450E 01	2.74087E-04	5.41875E 02	-2.11236E-02	1.08369E-01	1.28600E 00	
244	-2.72778E-01	8.72126E-01	3.92450E 01	2.74087E-04	5.41875E 02	-3.28982E-02	1.05405E-01	1.28600E 00	
245	-3.67064E-01	8.36823E-01	3.92450E 01	2.74087E-04	5.41875E 02	-4.42719E-02	1.01169E-01	1.28600E 00	
246	-4.56894E-01	7.91356E-01	3.92450E 01	2.74087E-04	5.41875E 02	-5.51162E-02	9.57072E-02	1.28600E 00	
247	-5.41178E-01	7.36301E-01	3.92450E 01	2.74087E-04	5.41875E 02	-6.52968E-02	8.90841E-02	1.28600E 00	
248	-6.18892E-01	6.72298E-01	3.92450E 01	2.74087E-04	5.41875E 02	-7.46900E-02	8.13763E-02	1.28600E 00	
249	-6.89094E-01	6.00134E-01	3.92450E 01	2.74087E-04	5.41875E 02	-8.31809E-02	7.26748E-02	1.28600E 00	
250	-7.50931E-01	5.20666E-01	3.92450E 01	2.74087E-04	5.41875E 02	-9.06849E-02	6.39898E-02	1.28600E 00	

MACH 4 NOZZLE (G=1.24)

ZE = 2.05303E-01

STEP NO. 3

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
251	-8.03653E-01	4.34917E-01	3.92450E 01	2.74087E-04	5.41875E 02	-9.70498E-02	5.27109E-02	1.28600E 00	
252	-8.40620E-01	3.43869E-01	3.92450E 01	2.74087E-04	5.41875E 02	-1.02256E-01	4.16906E-02	1.28600E 00	
253	-8.79310E-01	2.48647E-01	3.92450E 01	2.74087E-04	5.41875E 02	-1.06219E-01	3.01542E-02	1.28600E 00	
254	-9.01327E-01	1.50406E-01	3.92450E 01	2.74087E-04	5.41875E 02	-1.08689E-01	1.82438E-02	1.28600E 00	
255	-9.12402E-01	5.03401E-02	3.92450E 01	2.74087E-04	5.41875E 02	-1.10233E-01	6.10647E-03	1.28600E 00	
256	-9.12403E-01	-5.03372E-02	3.92450E 01	2.74087E-04	5.41875E 02	-1.10233E-01	-6.10632E-03	1.28600E 00	
257	-9.01327E-01	-1.50403E-01	3.92450E 01	2.74087E-04	5.41875E 02	-1.08689E-01	-1.82434E-02	1.28600E 00	
258	-8.79311E-01	-2.48644E-01	3.92450E 01	2.74087E-04	5.41875E 02	-1.06219E-01	-3.01538E-02	1.28600E 00	
259	-8.46621E-01	-3.43867E-01	3.92450E 01	2.74087E-04	5.41875E 02	-1.02256E-01	-4.16902E-02	1.28600E 00	
260	-8.03655E-01	-4.34914E-01	3.92450E 01	2.74087E-04	5.41875E 02	-9.70500E-02	-5.27105E-02	1.28600E 00	
261	-7.50933E-01	-5.20663E-01	3.92450E 01	2.74087E-04	5.41875E 02	-9.06652E-02	-6.30802E-02	1.28600E 00	
262	-6.89096E-01	-6.00132E-01	3.92450E 01	2.74087E-04	5.41875E 02	-8.31611E-02	-7.26737E-02	1.28600E 00	
263	-6.18894E-01	-6.72296E-01	3.92450E 01	2.74087E-04	5.41875E 02	-7.46903E-02	-8.13760E-02	1.28600E 00	
264	-5.41180E-01	-7.36299E-01	3.92450E 01	2.74087E-04	5.41875E 02	-6.52971E-02	-8.90839E-02	1.28600E 00	
265	-4.56896E-01	-7.91364E-01	3.92450E 01	2.74087E-04	5.41875E 02	-5.51165E-02	-9.57070E-02	1.28600E 00	
266	-3.67067E-01	-8.36823E-01	3.92450E 01	2.74087E-04	5.41875E 02	-4.42723E-02	-1.01168E-01	1.28600E 00	
267	-2.72762E-01	-8.72125E-01	3.92450E 01	2.74087E-04	5.41875E 02	-3.28956E-02	-1.08405E-01	1.28600E 00	
268	-1.75186E-01	-8.96840E-01	3.92450E 01	2.74087E-04	5.41875E 02	-2.11240E-02	-1.08369E-01	1.28600E 00	
269	-7.54658E-02	-9.10666E-01	3.92450E 01	2.74087E-04	5.41875E 02	-9.09914E-03	-1.10827E-01	1.28600E 00	
270	2.51759E-02	-9.13443E-01	3.92450E 01	2.74087E-04	5.41875E 02	3.05849E-03	-1.10369E-01	1.28600E 00	
271	1.25507E-01	-9.05130E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.51331E-02	-1.09363E-01	1.28600E 00	
272	2.24319E-01	-8.85829E-01	3.92450E 01	2.74087E-04	5.41875E 02	2.78498E-02	-1.07849E-01	1.28600E 00	
273	3.20404E-01	-8.55776E-01	3.92450E 01	2.74087E-04	5.41875E 02	3.86412E-02	-1.03444E-01	1.28600E 00	
274	4.19604E-01	-8.15334E-01	3.92450E 01	2.74087E-04	5.41875E 02	4.97688E-02	-9.85274E-02	1.28600E 00	
275	4.99791E-01	-7.64997E-01	3.92450E 01	2.74087E-04	5.41875E 02	6.02970E-02	-9.28366E-02	1.28600E 00	
276	5.80916E-01	-7.05371E-01	3.92450E 01	2.74087E-04	5.41875E 02	7.00991E-02	-8.53605E-02	1.28600E 00	
277	6.54985E-01	-6.37186E-01	3.92450E 01	2.74087E-04	5.41875E 02	7.90347E-02	-7.71435E-02	1.28600E 00	
278	7.21107E-01	-5.61263E-01	3.92450E 01	2.74087E-04	5.41875E 02	8.70547E-02	-6.79818E-02	1.28600E 00	
279	7.78473E-01	-4.78531E-01	3.92450E 01	2.74087E-04	5.41875E 02	9.39998E-02	-5.79585E-02	1.28600E 00	
280	8.26391E-01	-3.89986E-01	3.92450E 01	2.74087E-04	5.41875E 02	9.98047E-02	-4.72739E-02	1.28600E 00	
281	8.64277E-01	-2.96712E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.04396E-01	-3.65785E-02	1.28600E 00	
282	8.91672E-01	-1.99835E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.07710E-01	-2.42372E-02	1.28600E 00	
283	9.08243E-01	-1.08529E-01	3.92450E 01	2.74087E-04	5.41875E 02	1.09720E-01	-1.21046E-02	1.28600E 00	
284	1.01532E 00	0.0	3.99530E 01	2.43870E-04	5.78388E 02	1.31462E-01	0.0	1.39203E 00	YES
285	1.01027E 00	1.01093E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.50703E-01	1.51959E-02	1.39203E 00	YES
286	9.95189E-01	2.01182E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.48436E-01	3.02340E-02	1.39203E 00	YES
287	9.70212E-01	2.90271E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.44684E-01	4.49564E-02	1.39203E 00	YES
288	9.35939E-01	3.94305E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.39487E-01	5.92170E-02	1.39203E 00	YES
289	8.91676E-01	4.88580E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.32900E-01	7.24670E-02	1.39203E 00	YES
290	8.38897E-01	5.71950E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.24991E-01	8.57891E-02	1.39203E 00	YES
291	7.77780E-01	6.52638E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.15842E-01	9.77962E-02	1.39203E 00	YES
292	7.08934E-01	7.26838E-01	3.99530E 01	2.43870E-04	5.78388E 02	1.05540E-01	1.08832E-01	1.39203E 00	YES
293	6.33642E-01	7.93890E-01	3.99530E 01	2.43870E-04	5.78388E 02	9.42137E-02	1.18770E-01	1.39203E 00	YES
294	5.50858E-01	8.52895E-01	3.99530E 01	2.43870E-04	5.78388E 02	8.19530E-02	1.27510E-01	1.39203E 00	YES
295	4.63201E-01	9.03504E-01	3.99530E 01	2.43870E-04	5.78388E 02	6.88892E-02	1.34996E-01	1.39203E 00	YES
296	3.70939E-01	9.45134E-01	3.99530E 01	2.43870E-04	5.78388E 02	5.51520E-02	1.41139E-01	1.39203E 00	YES
297	2.74991E-01	9.77371E-01	3.99530E 01	2.43870E-04	5.78388E 02	4.08770E-02	1.45882E-01	1.39203E 00	YES
298	1.76310E-01	9.99895E-01	3.99530E 01	2.43870E-04	5.78388E 02	2.62038E-02	1.49195E-01	1.39203E 00	YES
299	7.58799E-02	1.01248E 00	3.99530E 01	2.43870E-04	5.78388E 02	1.12759E-02	1.51845E-01	1.39203E 00	YES
300	-2.53109E-02	1.01500E 00	3.99530E 01	2.43870E-04	5.78388E 02	-3.76139E-03	1.51410E-01	1.39203E 00	YES

MACH 4 NOZZLE (G=1.24)

ZE = 2.05000E-01

STEP NO. 0

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
301	-1.26247E-01	1.00744E 00	3.39530E 01	2.43870E-04	5.78388E 02	-1.87623E-02	1.50304E-01	1.39203E 00	YES
302	-2.25920E-01	9.89864E-01	3.39530E 01	2.43870E-04	5.78388E 02	-3.35809E-02	1.47720E-01	1.39203E 00	YES
303	-3.23364E-01	9.82450E-01	3.39530E 01	2.43870E-04	5.78388E 02	-4.80726E-02	1.43686E-01	1.39203E 00	YES
304	-4.17586E-01	9.25471E-01	3.39530E 01	2.43870E-04	5.78388E 02	-6.20961E-02	1.38237E-01	1.39203E 00	YES
305	-5.07659E-01	8.79293E-01	3.39530E 01	2.43870E-04	5.78388E 02	-7.55132E-02	1.31420E-01	1.39203E 00	YES
306	-5.92688E-01	8.24377E-01	3.39530E 01	2.43870E-04	5.78388E 02	-8.81914E-02	1.23290E-01	1.39203E 00	YES
307	-6.71821E-01	7.61269E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.00004E-01	1.13944E-01	1.39203E 00	YES
308	-7.44281E-01	6.99594E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.10832E-01	1.03445E-01	1.39203E 00	YES
309	-8.09344E-01	6.13056E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.20566E-01	9.18998E-02	1.39203E 00	YES
310	-8.66362E-01	5.25425E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.29186E-01	7.94199E-02	1.39203E 00	YES
311	-9.14771E-01	4.40532E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.36363E-01	6.61277E-02	1.39203E 00	YES
312	-9.54088E-01	3.47261E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.42263E-01	5.21557E-02	1.39203E 00	YES
313	-9.83923E-01	2.50540E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.46744E-01	3.76453E-02	1.39203E 00	YES
314	-1.00398E 00	1.51327E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.49757E-01	2.27448E-02	1.39203E 00	YES
315	-1.01406E 00	5.06112E-02	3.39530E 01	2.43870E-04	5.78388E 02	-1.51272E-01	7.60813E-03	1.39203E 00	YES
316	-1.01406E 00	-5.06070E-02	3.39530E 01	2.43870E-04	5.78388E 02	-1.51272E-01	-7.60750E-03	1.39203E 00	YES
317	-1.00398E 00	-1.51323E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.49757E-01	-2.27442E-02	1.39203E 00	YES
318	-9.83924E-01	-2.50536E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.46744E-01	-3.76447E-02	1.39203E 00	YES
319	-9.54089E-01	-3.47257E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.42264E-01	-5.21551E-02	1.39203E 00	YES
320	-9.14773E-01	-4.40529E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.36364E-01	-6.61272E-02	1.39203E 00	YES
321	-8.66364E-01	-5.29422E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.29186E-01	-7.94154E-02	1.39203E 00	YES
322	-8.09346E-01	-6.13052E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.20566E-01	-9.18993E-02	1.39203E 00	YES
323	-7.44284E-01	-6.90591E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.10832E-01	-1.03445E-01	1.39203E 00	YES
324	-6.71824E-01	-7.61266E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.00004E-01	-1.13944E-01	1.39203E 00	YES
325	-5.92688E-01	-8.24376E-01	3.39530E 01	2.43870E-04	5.78388E 02	-8.81917E-02	-1.23298E-01	1.39203E 00	YES
326	-5.07662E-01	-8.79291E-01	3.39530E 01	2.43870E-04	5.78388E 02	-7.55138E-02	-1.31420E-01	1.39203E 00	YES
327	-4.17590E-01	-9.25469E-01	3.39530E 01	2.43870E-04	5.78388E 02	-6.20967E-02	-1.38236E-01	1.39203E 00	YES
328	-3.23368E-01	-9.82449E-01	3.39530E 01	2.43870E-04	5.78388E 02	-4.80732E-02	-1.43686E-01	1.39203E 00	YES
329	-2.25936E-01	-9.89862E-01	3.39530E 01	2.43870E-04	5.78388E 02	-3.35820E-02	-1.47720E-01	1.39203E 00	YES
330	-1.26254E-01	-1.00744E 00	3.39530E 01	2.43870E-04	5.78388E 02	-1.87633E-02	-1.50304E-01	1.39203E 00	YES
331	-2.53170E-02	-1.01500E 00	3.39520E 01	2.43870E-04	5.78388E 02	-3.76229E-03	-1.51410E-01	1.39203E 00	YES
332	7.58717E-02	-1.01248E 00	3.39530E 01	2.43870E-04	5.78388E 02	1.12753E-02	-1.51045E-01	1.39203E 00	YES
333	1.76302E-01	-9.99896E-01	3.39530E 01	2.43870E-04	5.78388E 02	2.62026E-02	-1.49155E-01	1.39203E 00	YES
334	2.74984E-01	-9.77373E-01	3.39530E 01	2.43870E-04	5.78388E 02	4.08760E-02	-1.46863E-01	1.39203E 00	YES
335	3.70934E-01	-9.45136E-01	3.39530E 01	2.43870E-04	5.78388E 02	5.51513E-02	-1.44113E-01	1.39203E 00	YES
336	4.63193E-01	-9.03508E-01	3.39530E 01	2.43870E-04	5.78388E 02	6.88881E-02	-1.34996E-01	1.39203E 00	YES
337	5.50853E-01	-8.52898E-01	3.39530E 01	2.43870E-04	5.78388E 02	8.19522E-02	-1.27519E-01	1.39203E 00	YES
338	6.33038E-01	-7.93812E-01	3.39530E 01	2.43870E-04	5.78388E 02	9.42131E-02	-1.18770E-01	1.39203E 00	YES
339	7.08931E-01	-7.28536E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.05548E-01	-1.08832E-01	1.39203E 00	YES
340	7.77776E-01	-6.52640E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.15842E-01	-9.77970E-02	1.39203E 00	YES
341	8.38893E-01	-5.71955E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.24990E-01	-8.87698E-02	1.39203E 00	YES
342	8.91674E-01	-4.85585E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.32900E-01	-7.88676E-02	1.39203E 00	YES
343	9.35590E-01	-3.94392E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.39487E-01	-5.92188E-02	1.39203E 00	YES
344	9.70210E-01	-2.99276E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.44684E-01	-4.44993E-02	1.39203E 00	YES
345	9.95188E-01	-2.71186E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.48436E-01	-3.02347E-02	1.39203E 00	YES
346	1.01027E 00	-1.01097E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.50703E-01	-1.61965E-02	1.39203E 00	YES

MACH 4 NOZZLE (G=1.24)

BODY POINTS AT ZE = 2.05000E-01				STEP NO.	0				
NO.	X	Y	P	RHO	Q	THETA	PSI	M	
284	1.01532E 00	0.0	3.39530E 01	2.43870E-04	5.78388E 02	1.51462E-01	0.0	1.39203E 00	
285	1.01027E 00	1.01093E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.50703E-01	1.51559E-02	1.39203E 00	
286	9.95189E-01	2.01182E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.48436E-01	3.02340E-02	1.39203E 00	
287	9.70212E-01	2.99271E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.44684E-01	4.49584E-02	1.39203E 00	
288	9.35593E-01	3.94385E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.39487E-01	5.92178E-02	1.39203E 00	
289	8.91676E-01	4.85580E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.32900E-01	7.28670E-02	1.39203E 00	
290	8.38897E-01	5.71950E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.24991E-01	8.57691E-02	1.39203E 00	
291	7.77780E-01	6.52635E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.15842E-01	9.77962E-02	1.39203E 00	
292	7.08934E-01	7.26833E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.05848E-01	1.08832E-01	1.39203E 00	
293	6.37042E-01	7.93809E-01	3.39530E 01	2.43870E-04	5.78388E 02	9.42137E-02	1.18770E-01	1.39203E 00	
294	5.50858E-01	8.52898E-01	3.39530E 01	2.43870E-04	5.78388E 02	8.19530E-02	1.27518E-01	1.39203E 00	
295	4.63201E-01	9.03504E-01	3.39530E 01	2.43870E-04	5.78388E 02	6.86802E-02	1.34906E-01	1.39203E 00	
296	3.70939E-01	9.45136E-01	3.39530E 01	2.43870E-04	5.78388E 02	5.51820E-02	1.41133E-01	1.39203E 00	
297	2.74991E-01	9.77371E-01	3.39530E 01	2.43870E-04	5.78388E 02	4.08770E-02	1.45582E-01	1.39203E 00	
298	1.76310E-01	9.99895E-01	3.39530E 01	2.43870E-04	5.78388E 02	2.62038E-02	1.49195E-01	1.39203E 00	
299	7.58759E-02	1.01248E 00	3.39530E 01	2.43870E-04	5.78388E 02	1.12759E-02	1.51045E-01	1.39203E 00	
300	-2.53109E-02	1.01590E 00	3.39530E 01	2.43870E-04	5.78388E 02	-3.76139E-03	1.51416E-01	1.39203E 00	
301	-1.26247E-01	1.00744E 00	3.39530E 01	2.43870E-04	5.78388E 02	-1.87623E-02	1.50304E-01	1.39203E 00	
302	-2.25929E-01	9.89864E-01	3.39530E 01	2.43870E-04	5.78388E 02	-3.35809E-02	1.47720E-01	1.39203E 00	
303	-3.23364E-01	9.62450E-01	3.39530E 01	2.43870E-04	5.78388E 02	-4.80726E-02	1.43666E-01	1.39203E 00	
304	-4.17586E-01	9.25471E-01	3.39530E 01	2.43870E-04	5.78388E 02	-6.20961E-02	1.38273E-01	1.39203E 00	
305	-5.07659E-01	8.79293E-01	3.39530E 01	2.43870E-04	5.78388E 02	-7.55132E-02	1.31420E-01	1.39203E 00	
306	-5.92685E-01	8.24377E-01	3.39530E 01	2.43870E-04	5.78388E 02	-8.81914E-02	1.23298E-01	1.39203E 00	
307	-6.71821E-01	7.61269E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.00004E-01	1.13944E-01	1.39203E 00	
308	-7.44281E-01	6.90594E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.10832E-01	1.03445E-01	1.39203E 00	
309	-8.09344E-01	6.13056E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.20566E-01	9.18568E-02	1.39203E 00	
310	-8.66362E-01	5.29425E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.29106E-01	7.94190E-02	1.39203E 00	
311	-9.14771E-01	4.40532E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.36383E-01	6.61277E-02	1.39203E 00	
312	-9.54088E-01	3.47261E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.42263E-01	5.21857E-02	1.39203E 00	
313	-9.83923E-01	2.50540E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.46744E-01	3.76453E-02	1.39203E 00	
314	-1.00398E 00	1.51327E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.49757E-01	2.27448E-02	1.39203E 00	
315	-1.01406E 00	5.06112E-02	3.39530E 01	2.43870E-04	5.78388E 02	-1.51272E-01	7.68817E-03	1.39203E 00	
316	-1.01406E 00	-5.06070E-02	3.39530E 01	2.43870E-04	5.78388E 02	-1.51272E-01	-7.68750E-03	1.39203E 00	
317	-1.00398E 00	-1.51323E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.49757E-01	-2.27442E-02	1.39203E 00	
318	-9.83924E-01	-2.50538E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.46744E-01	-3.76447E-02	1.39203E 00	
319	-9.54089E-01	-3.47257E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.42264E-01	-5.21851E-02	1.39203E 00	
320	-9.14773E-01	-4.40529E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.36364E-01	-6.61272E-02	1.39203E 00	
321	-8.66364E-01	-5.29422E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.29106E-01	-7.94194E-02	1.39203E 00	
322	-8.09346E-01	-6.13052E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.20566E-01	-9.18993E-02	1.39203E 00	
323	-7.44284E-01	-6.90591E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.10832E-01	-1.03448E-01	1.39203E 00	
324	-6.71824E-01	-7.61266E-01	3.39530E 01	2.43870E-04	5.78388E 02	-1.00004E-01	-1.13944E-01	1.39203E 00	
325	-5.92688E-01	-8.24376E-01	3.39530E 01	2.43870E-04	5.78388E 02	-8.81917E-02	-1.23298E-01	1.39203E 00	
326	-5.07662E-01	-8.79291E-01	3.39530E 01	2.43870E-04	5.78388E 02	-7.55138E-02	-1.31420E-01	1.39203E 00	
327	-4.17590E-01	-9.25469E-01	3.39530E 01	2.43870E-04	5.78388E 02	-6.20967E-02	-1.38273E-01	1.39203E 00	
328	-3.23368E-01	-9.62449E-01	3.39530E 01	2.43870E-04	5.78388E 02	-4.80732E-02	-1.43666E-01	1.39203E 00	
329	-2.25936E-01	-9.89862E-01	3.39530E 01	2.43870E-04	5.78388E 02	-3.35820E-02	-1.47720E-01	1.39203E 00	
330	-1.26254E-01	-1.00744E 00	3.39530E 01	2.43870E-04	5.78388E 02	-1.87633E-02	-1.50304E-01	1.39203E 00	
331	-2.53170E-02	-1.01590E 00	3.39530E 01	2.43870E-04	5.78388E 02	-3.76229E-03	-1.51416E-01	1.39203E 00	
332	7.58717E-02	-1.01248E 00	3.39530E 01	2.43870E-04	5.78388E 02	1.12753E-02	-1.51048E-01	1.39203E 00	
333	1.76302E-01	-9.99896E-01	3.39530E 01	2.43870E-04	5.78388E 02	2.62026E-02	-1.49195E-01	1.39203E 00	
334	2.74984E-01	-9.77373E-01	3.39530E 01	2.43870E-04	5.78388E 02	4.08760E-02	-1.45583E-01	1.39203E 00	
335	3.70934E-01	-9.45136E-01	3.39530E 01	2.43870E-04	5.78388E 02	5.51813E-02	-1.41136E-01	1.39203E 00	
336	4.63193E-01	-9.03508E-01	3.39530E 01	2.43870E-04	5.78388E 02	6.86801E-02	-1.34906E-01	1.39203E 00	

337	5.50853E-01	-8.52898E-01	3.39530E 01	2.43870E-04	5.78388E 02	8.19522E-02	-1.27519E-01	1.39203E 00
338	6.33038E-01	-7.93812E-01	3.39530E 01	2.43870E-04	5.78388E 02	9.42131E-02	-1.18770E-01	1.39203E 00
339	7.08931E-01	-7.26836E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.05548E-01	-1.08832E-01	1.39203E 00
340	7.77776E-01	-6.52640E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.15842E-01	-9.77970E-02	1.39203E 00
341	8.38893E-01	-5.71955E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.24990E-01	-8.57698E-02	1.39203E 00
342	8.91674E-01	-4.85585E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.32900E-01	-7.28676E-02	1.39203E 00
343	9.35590E-01	-3.94392E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.39487E-01	-5.92188E-02	1.39203E 00
344	9.70210E-01	-2.99276E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.44684E-01	-4.49593E-02	1.39203E 00
345	9.95188E-01	-2.01186E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.48436E-01	-3.02347E-02	1.39203E 00
346	1.01027E 00	-1.01097E-01	3.39530E 01	2.43870E-04	5.78388E 02	1.50703E-01	-1.51965E-02	1.39203E 00

MACH 4 NOZZLE (G=1.24)

ZE = 2.40000E 01

STEP NO. 78

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
1	7.15121E-03	2.11067E-03	3.55088E-01	6.16520E-06	1.08538E 03	2.34800E-03	6.37419E-04	4.06140E 00	
2	4.49390E-01	-1.09172E-03	3.52214E-01	6.13894E-06	1.08566E 03	-4.22301E-04	-1.59911E-08	4.06453E 00	
3	7.21359E-01	3.71117E-01	3.52233E-01	6.13367E-06	1.08572E 03	-2.62734E-04	-2.81720E-03	4.06516E 00	
4	-2.19310E-01	3.79133E-01	3.52905E-01	6.13508E-06	1.08569E 03	7.10792E-03	-2.58816E-03	4.06490E 00	
5	-4.35019E-01	2.36759E-03	3.52267E-01	6.12567E-06	1.08580E 03	4.21596E-03	4.12436E-04	4.06612E 00	
6	-2.11052E-01	-3.70560E-01	3.52267E-01	6.12567E-06	1.08580E 03	3.23143E-03	4.47893E-03	4.06612E 00	
7	2.26198E-01	-3.75347E-01	3.52474E-01	6.12857E-06	1.08577E 03	2.67819E-04	2.95320E-03	4.06577E 00	
8	8.91646E-01	-1.95310E-03	3.30879E-01	5.82392E-06	1.08909E 03	-1.21533E-02	-3.60808E-04	4.10325E 00	
9	7.71970E-01	4.53792E-01	3.27348E-01	5.77375E-06	1.08965E 03	-1.19938E-02	-7.17210E-03	4.10962E 00	
10	4.47107E-01	7.69488E-01	3.28105E-01	5.78482E-06	1.08953E 03	-7.23445E-03	-1.18913E-02	4.10825E 00	
11	-9.97879E-04	8.86445E-01	3.27911E-01	5.78176E-06	1.08956E 03	-3.08736E-04	-1.66559E-02	4.10859E 00	
12	-4.42445E-01	7.61331E-01	3.29905E-01	5.81010E-06	1.08925E 03	6.40323E-03	-1.20227E-02	4.10500E 00	
13	-7.82609E-01	4.31777E-01	3.27866E-01	5.77714E-06	1.08961E 03	1.25721E-02	-8.54070E-03	4.10919E 00	
14	-8.85391E-01	-1.36001E-02	3.28467E-01	5.78966E-06	1.08948E 03	1.43852E-02	-1.16577E-03	4.10759E 00	
15	-7.73187E-01	-4.57101E-01	3.27371E-01	5.77408E-06	1.08965E 03	1.35367E-02	7.21503E-03	4.10958E 00	
16	-4.39390E-01	-7.69431E-01	3.27707E-01	5.77886E-06	1.08960E 03	7.64165E-03	1.33097E-02	4.10897E 00	
17	-8.67071E-03	-8.93179E-01	3.27483E-01	5.77567E-06	1.08963E 03	9.19032E-05	1.81125E-02	4.10937E 00	
18	4.45141E-01	-7.73438E-01	3.29345E-01	5.80214E-06	1.08934E 03	-7.43061E-03	1.11815E-02	4.10601E 00	
19	7.79180E-01	-4.58841E-01	3.27614E-01	5.77754E-06	1.08961E 03	-1.17406E-02	6.37510E-03	4.10914E 00	
20	1.37393E 00	-6.02873E-04	2.92100E-01	5.26691E-06	1.09550E 03	-3.43567E-02	-1.37879E-04	4.17747E 00	
21	1.30355E 00	4.43815E-01	2.89590E-01	5.23039E-06	1.09594E 03	-3.30819E-02	-1.12236E-02	4.18263E 00	
22	1.08626E 00	8.49938E-01	2.89182E-01	5.23444E-06	1.09601E 03	-2.82813E-02	-2.04840E-02	4.18368E 00	
23	7.45380E-01	1.15798E 00	2.90500E-01	5.24363E-06	1.09578E 03	-1.89456E-02	-2.80995E-02	4.18076E 00	
24	3.30012E-01	1.33611E 00	2.89275E-01	5.22579E-06	1.09599E 03	-8.48263E-03	-3.31504E-02	4.18328E 00	
25	-1.24906E-01	1.36749E 00	2.90252E-01	5.24003E-06	1.09582E 03	2.10963E-03	-3.68229E-02	4.18127E 00	
26	-5.68228E-01	1.26215E 00	2.90685E-01	5.24633E-06	1.09575E 03	1.39215E-02	-3.23131E-02	4.18038E 00	
27	-9.24966E-01	1.01912E 00	2.90505E-01	5.24457E-06	1.09577E 03	2.31800E-02	-2.66016E-02	4.18062E 00	
28	-1.20933E 00	6.41014E-01	2.91375E-01	5.25637E-06	1.09563E 03	3.04957E-02	-1.83587E-02	4.17890E 00	
29	-1.37389E 00	2.15042E-01	2.89631E-01	5.23098E-06	1.09593E 03	3.32379E-02	-6.21448E-03	4.18255E 00	
30	-1.37403E 00	-2.16651E-01	2.90050E-01	5.23708E-06	1.09586E 03	3.34291E-02	5.56077E-03	4.18188E 00	
31	-1.21308E 00	-6.43900E-01	2.91072E-01	5.25196E-06	1.09568E 03	3.07438E-02	1.72040E-02	4.17958E 00	
32	-9.30947E-01	-1.02529E 00	2.89832E-01	5.23391E-06	1.09589E 03	2.20946E-02	2.47825E-02	4.18713E 00	
33	-5.68897E-01	-1.26877E 00	2.89985E-01	5.23614E-06	1.09587E 03	1.36566E-02	3.10839E-02	4.18182E 00	
34	-1.22385E-01	-1.37337E 00	2.90329E-01	5.24114E-06	1.09581E 03	1.68000E-03	3.89319E-02	4.18111E 00	
35	3.33305E-01	-1.33783E 00	2.90150E-01	5.23855E-06	1.09584E 03	-8.97205E-03	3.33068E-02	4.18148E 00	
36	7.45776E-01	-1.15874E 00	2.91331E-01	5.25572E-06	1.09563E 03	-1.90110E-02	2.77816E-02	4.17905E 00	
37	1.08695E 00	-8.51287E-01	2.89637E-01	5.22961E-06	1.09595E 03	-2.82118E-02	2.06686E-02	4.18274E 00	
38	1.30326E 00	-4.44846E-01	2.89752E-01	5.23275E-06	1.09591E 03	-3.29875E-02	1.08670E-02	4.18230E 00	
39	1.91077E 00	-2.01963E-04	2.65173E-01	4.87174E-06	1.10034E 03	-4.99822E-02	-1.72503E-04	4.23535E 00	
40	1.84950E 00	4.67963E-01	2.64653E-01	4.86403E-06	1.1044E 03	-4.83892E-02	-1.33620E-02	4.23697E 00	
41	1.86717E 00	9.10665E-01	2.64457E-01	4.86111E-06	1.10047E 03	-4.41712E-02	-2.45085E-02	4.23701E 00	
42	1.38613E 00	1.29974E 00	2.65092E-01	4.87053E-06	1.10035E 03	-3.55629E-02	-3.37377E-02	4.23557E 00	
43	1.01865E 00	1.60685E 00	2.65262E-01	4.87305E-06	1.10032E 03	-2.82437E-02	-4.18661E-02	4.23519E 00	
44	5.01087E-01	1.81100E 00	2.64978E-01	4.86885E-06	1.10036E 03	-1.57913E-02	-4.66403E-02	4.23583E 00	
45	1.17238E-01	1.89194E 00	2.65057E-01	4.87001E-06	1.10036E 03	-5.30622E-03	-5.02086E-02	4.23565E 00	
46	-3.54398E-01	1.86033E 00	2.65462E-01	4.87601E-06	1.10029E 03	8.10364E-03	-4.91732E-02	4.23473E 00	
47	-8.18567E-01	1.73293E 00	2.64938E-01	4.86823E-06	1.10038E 03	2.04404E-02	-4.44373E-02	4.23592E 00	
48	-1.21907E 00	1.47052E 00	2.65172E-01	4.87172E-06	1.10034E 03	3.13729E-02	-3.86874E-02	4.23539E 00	
49	-1.53399E 00	1.10439E 00	2.65821E-01	4.88133E-06	1.10022E 03	4.86003E-02	-3.01450E-02	4.23392E 00	
50	-1.70978E 00	7.51317E-01	2.65806E-01	4.88110E-06	1.10022E 03	4.55838E-02	-1.76051E-02	4.23396E 00	

MACH 4 NOZZLE (G=1.24)

XE = 2.40000E 01

STEP NO. 78

NO.	X	Y	P	RHO	Q	THETA	PSI	N	BODY
51	-1.91144E 00	2.43526E-01	2.64780E-01	4.86591E-06	1.10041E 03	4.72112E-02	-5.05149E-03	4.23620E 00	
52	-1.91022E 00	-2.42252E-01	2.65205E-01	4.87220E-06	1.17033E 03	4.73993E-02	6.57225E-03	4.23531E 00	
53	-1.77231E 00	-7.02293E-01	2.66345E-01	4.88909E-06	1.10013E 03	4.54167E-02	1.48997E-02	4.23274E 00	
54	-1.53612E 00	-1.10458E 00	2.66492E-01	4.89126E-06	1.10009E 03	3.96638E-02	3.07424E-02	4.23241E 00	
55	-1.21983E 00	-4.47235E 00	2.65979E-01	4.88367E-06	1.17019E 03	3.05011E-02	3.79037E-02	4.23356E 00	
56	-8.15144E-01	-1.73403E 00	2.65615E-01	4.87828E-06	1.10026E 03	2.07655E-02	4.33870E-02	4.23439E 00	
57	-3.54879E-01	-1.86891E 00	2.66297E-01	4.88838E-06	1.10013E 03	9.37105E-03	4.78503E-02	4.23285E 00	
58	1.20738E-01	-1.86337E 00	2.65942E-01	4.88312E-06	1.10020E 03	-3.37556E-03	4.98235E-02	4.23365E 00	
59	5.92679E-01	-1.81334E 00	2.65778E-01	4.88069E-06	1.10023E 03	-1.49617E-02	4.70571E-02	4.23402E 00	
60	1.02051E 00	-1.60792E 00	2.65803E-01	4.88107E-06	1.10023E 03	-2.58776E-02	4.17460E-02	4.23396E 00	
61	1.38726E 00	-1.30085E 00	2.65239E-01	4.87271E-06	1.17033E 03	-3.54546E-02	3.34311E-02	4.23524E 00	
62	1.86778E 00	-9.11297E-01	2.64416E-01	4.86052E-06	1.10048E 03	-4.41680E-02	2.41376E-02	4.23710E 00	
63	1.84924E 00	-4.68487E-01	2.64636E-01	4.86377E-06	1.10044E 03	-4.83951E-02	1.29875E-02	4.23661E 00	
64	2.45512E 00	-3.43277E-05	2.55933E-01	4.73436E-06	1.10209E 03	-5.19372E-02	-1.37360E-04	4.25670E 00	
65	2.40397E 00	4.94343E-01	2.56087E-01	4.73666E-06	1.10206E 03	-5.88619E-02	-1.14523E-02	4.25634E 00	
66	2.24798E 00	9.63433E-01	2.56048E-01	4.73609E-06	1.10206E 03	-4.79407E-02	-2.18419E-02	4.25643E 00	
67	2.01151E 00	1.39257E 00	2.56247E-01	4.73904E-06	1.10203E 03	-4.04514E-02	-3.06176E-02	4.25596E 00	
68	1.68779E 00	1.76726E 00	2.56787E-01	4.74710E-06	1.10192E 03	-3.42293E-02	-3.79159E-02	4.25469E 00	
69	1.29912E 00	2.07357E 00	2.56955E-01	4.74960E-06	1.10189E 03	-2.64444E-02	-4.50277E-02	4.25430E 00	
70	8.54922E-01	2.28916E 00	2.57386E-01	4.75603E-06	1.10181E 03	-1.69407E-02	-4.93717E-02	4.25329E 00	
71	3.67935E-01	2.41757E 00	2.57179E-01	4.75294E-06	1.10185E 03	-7.54789E-03	-5.21747E-02	4.25370E 00	
72	-1.14333E-01	2.45449E 00	2.57287E-01	4.75456E-06	1.10183E 03	3.06675E-03	-5.04200E-02	4.25352E 00	
73	-5.96842E-01	2.37259E 00	2.57112E-01	4.75195E-06	1.10186E 03	1.35197E-02	-4.99019E-02	4.25393E 00	
74	-1.06641E 00	2.28393E 00	2.56902E-01	4.74881E-06	1.10190E 03	2.35597E-02	-4.63638E-02	4.25443E 00	
75	-1.48314E 00	1.93189E 00	2.57049E-01	4.75100E-06	1.10187E 03	3.28665E-02	-4.16342E-02	4.25408E 00	
76	-1.86095E 00	1.58202E 00	2.57003E-01	4.75032E-06	1.10188E 03	4.00320E-02	-3.34992E-02	4.25410E 00	
77	-2.14718E 00	1.19860E 00	2.57224E-01	4.75361E-06	1.10184E 03	4.45080E-02	-2.33250E-02	4.25367E 00	
78	-2.33705E 00	7.47516E-01	2.56664E-01	4.74526E-06	1.10195E 03	4.87368E-02	-1.39041E-02	4.25498E 00	
79	-2.43832E 00	2.58743E-01	2.56360E-01	4.74077E-06	1.10201E 03	5.13776E-02	-4.34443E-03	4.25670E 00	
80	-2.43460E 00	-2.69215E-01	2.56532E-01	4.74314E-06	1.10197E 03	5.18135E-02	4.75748E-03	4.25532E 00	
81	-2.33585E 00	-7.56766E-01	2.57081E-01	4.75029E-06	1.10186E 03	4.89333E-02	1.47347E-02	4.25420E 00	
82	-2.14591E 00	-1.28323E 00	2.57810E-01	4.76234E-06	1.10173E 03	4.41105E-02	2.40053E-02	4.25231E 00	
83	-1.85948E 00	-1.58581E 00	2.57567E-01	4.75873E-06	1.10177E 03	3.94973E-02	3.37318E-02	4.25287E 00	
84	-1.48250E 00	-1.93492E 00	2.57997E-01	4.76513E-06	1.10169E 03	3.23337E-02	4.10520E-02	4.25187E 00	
85	-1.06783E 00	-2.20772E 00	2.57670E-01	4.76035E-06	1.10175E 03	2.36212E-02	4.58252E-02	4.25262E 00	
86	-6.01614E-01	-2.37397E 00	2.57834E-01	4.76270E-06	1.10172E 03	1.41613E-02	4.91116E-02	4.25226E 00	
87	-1.16732E-01	-2.45119E 00	2.57946E-01	4.76438E-06	1.10176E 03	4.59947E-03	5.03361E-02	4.25198E 00	
88	3.62460E-01	-2.42311E 00	2.57606E-01	4.75931E-06	1.10177E 03	-6.18844E-03	5.12818E-02	4.25278E 00	
89	8.52137E-01	-2.28815E 00	2.57559E-01	4.75861E-06	1.10178E 03	-1.66009E-02	4.92900E-02	4.25289E 00	
90	1.29879E 00	-2.07310E 00	2.56970E-01	4.74983E-06	1.10189E 03	-2.63965E-02	4.47012E-02	4.25427E 00	
91	1.68864E 00	-1.76820E 00	2.56629E-01	4.74474E-06	1.10195E 03	-3.42484E-02	3.78997E-02	4.25506E 00	
92	2.01262E 00	-1.39315E 00	2.56092E-01	4.73674E-06	1.10206E 03	-4.09826E-02	3.03347E-02	4.25632E 00	
93	2.24874E 00	-9.63672E-01	2.55911E-01	4.73404E-06	1.10209E 03	-4.80036E-02	2.15704E-02	4.25675E 00	
94	2.40399E 00	-4.94404E-01	2.56033E-01	4.73586E-06	1.10207E 03	-5.07000E-02	1.11675E-02	4.25646E 00	
95	2.99219E 00	-1.02171E-04	2.58047E-01	4.76587E-06	1.10182E 03	-4.63597E-02	-1.04185E-04	4.25175E 00	
96	2.95125E 00	4.96638E-01	2.58323E-01	4.76998E-06	1.10183E 03	-4.52393E-02	-8.28931E-03	4.25111E 00	
97	2.83420E 00	9.79289E-01	2.58358E-01	4.77051E-06	1.10162E 03	-4.28231E-02	-1.59484E-02	4.25103E 00	
98	2.63923E 00	1.41850E 00	2.58471E-01	4.77219E-06	1.10169E 03	-3.98983E-02	-2.35512E-02	4.25076E 00	
99	2.34690E 00	1.83168E 00	2.58064E-01	4.76613E-06	1.10168E 03	-3.61458E-02	-2.92669E-02	4.25171E 00	
100	2.01923E 00	2.19701E 00	2.58773E-01	4.77668E-06	1.10154E 03	-3.15846E-02	-3.40566E-02	4.25066E 00	

MACH & NOZZLE (G=1.24)

ZE = 2.40000E D1

STEP NO. 78

NO.	X	Y	P	RHO	Q	THETA	PSI	N	BODY
101	1.63142E 00	2.59298E 00	2.59197E-01	4.76300E-06	1.10146E 03	-2.56352E-02	-3.69642E-02	4.24908E 00	
102	1.19560E 00	2.73810E 00	2.59830E-01	4.79254E-06	1.10134E 03	-1.82757E-02	-4.23128E-02	4.24759E 00	
103	7.34583E-01	2.69941E 00	2.59811E-01	4.79212E-06	1.10135E 03	-1.11491E-02	-4.49337E-02	4.24766E 00	
104	2.60394E-01	2.93566E 00	2.59712E-01	4.79066E-06	1.10137E 03	-2.75700E-03	-4.57713E-02	4.24788E 00	
105	-2.50528E-01	2.97544E 00	2.59232E-01	4.78352E-06	1.10146E 03	3.62993E-02	-4.53302E-02	4.24897E 00	
106	-7.36908E-01	2.89222E 00	2.59279E-01	4.78421E-06	1.10145E 03	1.05117E-02	-4.61350E-02	4.24899E 00	
107	-1.20667E 00	2.7351E 00	2.59686E-01	4.79028E-06	1.10137E 03	1.76396E-02	-4.23655E-02	4.24795E 00	
108	-1.64108E 00	2.50400E 00	2.59918E-01	4.79372E-06	1.10133E 03	2.49385E-02	-3.84367E-02	4.24741E 00	
109	-2.00742E 00	2.19708E 00	2.59692E-01	4.79036E-06	1.10137E 03	3.21249E-02	-3.38534E-02	4.24793E 00	
110	-2.15065E 00	1.84217E 00	2.58905E-01	4.77866E-06	1.10152E 03	3.72530E-02	-2.77692E-02	4.24975E 00	
111	-2.62492E 00	1.41409E 00	2.58829E-01	4.77732E-06	1.10153E 03	4.01884E-02	-2.20115E-02	4.24993E 00	
112	-2.83581E 00	9.61306E-01	2.58865E-01	4.77805E-06	1.10153E 03	4.32083E-02	-1.58448E-02	4.24985E 00	
113	-2.95737E 00	4.81946E-01	2.59295E-01	4.78446E-06	1.10148E 03	4.51838E-02	-8.67248E-03	4.24885E 00	
114	-2.99178E 00	-7.90806E-03	2.58652E-01	4.78076E-06	1.10138E 03	4.64739E-02	-8.24516E-04	4.24802E 00	
115	-2.96869E 00	-4.86750E-01	2.59859E-01	4.79284E-06	1.10134E 03	4.48528E-02	7.58553E-03	4.24754E 00	
116	-2.83334E 00	-9.65184E-01	2.59467E-01	4.78702E-06	1.10141E 03	4.32196E-02	1.55877E-02	4.24845E 00	
117	-2.63271E 00	-1.41863E 00	2.59366E-01	4.78848E-06	1.10139E 03	4.09382E-02	2.15070E-02	4.24823E 00	
118	-2.35059E 00	-1.84615E 00	2.59599E-01	4.78998E-06	1.10139E 03	3.79132E-02	2.76434E-02	4.24815E 00	
119	-2.00835E 00	-2.19900E 00	2.60449E-01	4.80162E-06	1.10123E 03	3.18221E-02	3.35800E-02	4.24618E 00	
120	-1.64277E 00	-2.50524E 00	2.60896E-01	4.80529E-06	1.10118E 03	2.48864E-02	3.78472E-02	4.24561E 00	
121	-1.20958E 00	-2.74011E 00	2.60344E-01	4.80005E-06	1.10125E 03	1.78203E-02	4.19701E-02	4.24642E 00	
122	-7.38603E-01	-2.89463E 00	2.59922E-01	4.79378E-06	1.10133E 03	1.09245E-02	4.52100E-02	4.24740E 00	
123	-2.52325E-01	-2.97180E 00	2.59635E-01	4.78951E-06	1.10138E 03	4.10726E-03	4.59745E-02	4.24806E 00	
124	-2.56225E-01	-2.99339E 00	2.59920E-01	4.79376E-06	1.10133E 03	-2.44007E-03	4.45502E-02	4.24792E 00	
125	7.29227E-01	-2.89453E 00	2.60004E-01	4.79499E-06	1.10131E 03	-1.07221E-02	4.44528E-02	4.24721E 00	
126	1.19175E 00	-2.73584E 00	2.59731E-01	4.79094E-06	1.10136E 03	-1.82417E-02	4.24296E-02	4.24784E 00	
127	1.62909E 00	-2.50339E 00	2.59101E-01	4.78156E-06	1.10148E 03	-2.56310E-02	3.88428E-02	4.24930E 00	
128	2.01829E 00	-2.19940E 00	2.58585E-01	4.77788E-06	1.10156E 03	-3.15871E-02	3.39175E-02	4.25050E 00	
129	2.34688E 00	-1.83327E 00	2.57881E-01	4.76340E-06	1.10171E 03	-3.61841E-02	2.91812E-02	4.25214E 00	
130	2.63953E 00	-1.41959E 00	2.58312E-01	4.76982E-06	1.10163E 03	-3.91407E-02	2.33701E-02	4.25113E 00	
131	2.83452E 00	-9.79782E-01	2.58244E-01	4.76881E-06	1.10165E 03	-4.28595E-02	1.57355E-02	4.25129E 00	
132	2.95119E 00	-4.96853E-01	2.58277E-01	4.76929E-06	1.10164E 03	-4.52087E-02	8.07531E-03	4.25122E 00	
133	3.51783E 00	3.65123E-05	2.66439E-01	4.89048E-06	1.10010E 03	-3.70423E-02	-9.57351E-05	4.23253E 00	
134	3.48026E 00	5.03517E-01	2.66583E-01	4.89262E-06	1.10008E 03	-3.63556E-02	-5.87225E-03	4.23220E 00	
135	3.37509E 00	9.98423E-01	2.66566E-01	4.89234E-06	1.10006E 03	-3.45446E-02	-1.09600E-02	4.23224E 00	
136	3.20977E 00	1.47986E 00	2.67365E-01	4.90418E-06	1.09993E 03	-3.17633E-02	-1.52266E-02	4.23045E 00	
137	2.94458E 00	1.90904E 00	2.66875E-01	4.89693E-06	1.10002E 03	-3.15948E-02	-2.89838E-02	4.23156E 00	
138	2.65765E 00	2.30379E 00	2.67349E-01	4.90394E-06	1.09994E 03	-2.83350E-02	-2.47566E-02	4.23048E 00	
139	2.30725E 00	2.65434E 00	2.67770E-01	4.91017E-06	1.09986E 03	-2.43063E-02	-2.80923E-02	4.22954E 00	
140	1.90269E 00	2.95348E 00	2.67873E-01	4.91169E-06	1.09984E 03	-1.96343E-02	-3.15468E-02	4.22931E 00	
141	1.46074E 00	3.19473E 00	2.68179E-01	4.91623E-06	1.09978E 03	-1.44950E-02	-3.39117E-02	4.22862E 00	
142	9.86767E-01	3.37433E 00	2.68142E-01	4.91568E-06	1.09979E 03	-9.85764E-03	-3.52610E-02	4.22870E 00	
143	4.95512E-01	3.49858E 00	2.68771E-01	4.92497E-06	1.09967E 03	-4.48553E-03	-3.88491E-02	4.22730E 00	
144	-6.43288E-04	3.51440E 00	2.68978E-01	4.91489E-06	1.09980E 03	9.43186E-04	-3.72948E-02	4.22882E 00	
145	-4.97104E-01	3.47886E 00	2.68101E-01	4.91586E-06	1.09980E 03	5.35749E-03	-3.67961E-02	4.22888E 00	
146	-9.84251E-01	3.37313E 00	2.68614E-01	4.91378E-06	1.09981E 03	1.04179E-02	-3.56933E-02	4.22879E 00	
147	-1.45646E 00	3.20166E 00	2.68071E-01	4.91463E-06	1.09980E 03	1.51779E-02	-3.30405E-02	4.22888E 00	
148	-1.90404E 00	2.96316E 00	2.68072E-01	4.91464E-06	1.09980E 03	1.94338E-02	-3.04893E-02	4.22888E 00	
149	-2.38609E 00	2.65903E 00	2.67992E-01	4.91346E-06	1.09982E 03	2.35221E-02	-2.79729E-02	4.22904E 00	
150	-2.66105E 00	2.29925E 00	2.67821E-01	4.91093E-06	1.09985E 03	2.76785E-02	-2.45705E-02	4.22942E 00	

MACH 4 NOZZLE (G=1.24)

ZE = 2.40000E 01

STEP NO. 78

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
151	-2.95086E 00	1.89456E 00	2.67652E-01	4.90842E-06	1.09988E 03	3.18086E-02	-2.09756E-02	4.22900E 00	
152	-3.20259E 00	1.46825E 00	2.67901E-01	4.91211E-06	1.09983E 03	3.33472E-02	-1.57789E-02	4.22924E 00	
153	-3.37892E 00	1.00084E 00	2.67666E-01	4.90863E-06	1.09988E 03	3.50332E-02	-1.05434E-02	4.22977E 00	
154	-3.48852E 00	5.08196E-01	2.67643E-01	4.90829E-06	1.09988E 03	3.58540E-02	-5.08993E-03	4.22982E 00	
155	-3.51996E 00	1.64540E-03	2.67622E-01	4.90798E-06	1.09988E 03	3.65005E-02	-3.27833E-05	4.22987E 00	
156	-3.49313E 00	-5.09308E-01	2.67922E-01	4.91243E-06	1.09983E 03	3.49128E-02	4.83723E-03	4.22920E 00	
157	-3.37626E 00	-1.00477E 00	2.67945E-01	4.91276E-06	1.09982E 03	3.45457E-02	1.02625E-02	4.22915E 00	
158	-3.19982E 00	-1.47115E 00	2.68392E-01	4.91937E-06	1.09974E 03	3.38482E-02	1.56731E-02	4.22814E 00	
159	-2.95066E 00	-1.89791E 00	2.68231E-01	4.91699E-06	1.09977E 03	3.15049E-02	2.08782E-02	4.22851E 00	
160	-2.66214E 00	-2.30267E 00	2.68479E-01	4.92065E-06	1.09973E 03	2.73474E-02	2.44485E-02	4.22795E 00	
161	-2.30723E 00	-2.65303E 00	2.68709E-01	4.92399E-06	1.09968E 03	2.32207E-02	2.77889E-02	4.22745E 00	
162	-1.90598E 00	-2.96385E 00	2.68813E-01	4.92659E-06	1.09966E 03	1.91970E-02	3.01228E-02	4.22721E 00	
163	-1.45887E 00	-3.20242E 00	2.68733E-01	4.92441E-06	1.09968E 03	1.50131E-02	3.27905E-02	4.22739E 00	
164	-9.83608E-01	-3.37482E 00	2.68774E-01	4.92501E-06	1.09967E 03	1.01960E-02	3.56674E-02	4.22729E 00	
165	-4.98253E-01	-3.48634E 00	2.68932E-01	4.92738E-06	1.09964E 03	4.46887E-03	3.65437E-02	4.22694E 00	
166	-1.78545E-02	-3.51548E 00	2.68910E-01	4.921112E-06	1.09972E 03	-9.63455E-04	3.72755E-02	4.22766E 00	
167	4.96384E-01	-3.49185E 00	2.68435E-01	4.92001E-06	1.09973E 03	-5.82267E-03	3.51213E-02	4.22805E 00	
168	9.84726E-01	-3.37029E 00	2.67984E-01	4.91334E-06	1.09982E 03	-9.88378E-03	3.51939E-02	4.22906E 00	
169	1.45889E 00	-2.9509E 00	2.67919E-01	4.91238E-06	1.09983E 03	-1.46873E-02	3.39810E-02	4.22920E 00	
170	1.89973E 00	-2.95831E 00	2.67633E-01	4.90815E-06	1.09988E 03	-1.98023E-02	3.13929E-02	4.22984E 00	
171	2.30542E 00	-2.65612E 00	2.67452E-01	4.90546E-06	1.09992E 03	-2.44397E-02	2.79268E-02	4.23025E 00	
172	2.65666E 00	-2.30489E 00	2.67048E-01	4.89949E-06	1.09996E 03	-2.84575E-02	2.45882E-02	4.23116E 00	
173	2.94436E 00	-1.90974E 00	2.66632E-01	4.89334E-06	1.10007E 03	-3.16847E-02	2.07467E-02	4.23209E 00	
174	3.20997E 00	-1.47975E 00	2.67187E-01	4.90184E-06	1.09997E 03	-3.18296E-02	1.58192E-02	4.23085E 00	
175	3.37531E 00	-9.98357E-01	2.66468E-01	4.89891E-06	1.10010E 03	-3.45889E-02	1.08857E-02	4.23246E 00	
176	3.48030E 00	-5.83418E-01	2.66545E-01	4.89205E-06	1.10008E 03	-3.63861E-02	5.67686E-03	4.23229E 00	
177	4.02885E 00	-7.55741E-05	2.78288E-01	5.06514E-06	1.09794E 03	-2.56541E-02	-7.36153E-05	4.20644E 00	
178	3.99537E 00	5.06424E-01	2.78341E-01	5.06500E-06	1.09793E 03	-2.84401E-02	-3.66967E-03	4.20433E 00	
179	3.89889E 00	1.00269E 00	2.78255E-01	5.06465E-06	1.09794E 03	-2.47326E-02	-7.09233E-03	4.20652E 00	
180	7.74375E 00	1.48774E 00	2.78659E-01	5.07858E-06	1.09787E 03	-2.33712E-02	-9.35900E-03	4.20565E 00	
181	3.52134E 00	1.96348E 00	2.79091E-01	5.07801E-06	1.09779E 03	-2.29264E-02	-1.11563E-02	4.20472E 00	
182	3.26940E 00	2.37937E 00	2.79618E-01	5.08464E-06	1.09770E 03	-2.06093E-02	-1.48288E-02	4.20359E 00	
183	2.94603E 00	2.75919E 00	2.79695E-01	5.08578E-06	1.09769E 03	-1.84672E-02	-1.75223E-02	4.20343E 00	
184	2.5720E 00	3.09900E 00	2.79640E-01	5.08497E-06	1.09770E 03	-1.60880E-02	-1.99323E-02	4.20354E 00	
185	2.15882E 00	3.39370E 00	2.79676E-01	5.08550E-06	1.09769E 03	-1.31684E-02	-2.22775E-02	4.20347E 00	
186	1.71666E 00	3.63330E 00	2.79787E-01	5.08712E-06	1.09775E 03	-1.01575E-02	-2.43966E-02	4.20323E 00	
187	1.24233E 00	3.81231E 00	2.79459E-01	5.08231E-06	1.09773E 03	-7.63105E-03	-2.68273E-02	4.20393E 00	
188	7.43042E-01	3.96175E 00	2.80275E-01	5.09427E-06	1.09758E 03	-6.75281E-03	-2.44274E-02	4.20219E 00	
189	2.35788E-01	4.03754E 00	2.80560E-01	5.09846E-06	1.09753E 03	-2.82516E-03	-2.41407E-02	4.20158E 00	
190	-2.50399E-01	4.03190E 00	2.80587E-01	5.09885E-06	1.09753E 03	1.94884E-03	-2.32675E-02	4.20152E 00	
191	-7.46426E-01	3.96091E 00	2.80377E-01	5.09577E-06	1.09756E 03	5.13914E-03	-2.48869E-02	4.20197E 00	
192	-1.22376E 00	3.83158E 00	2.80054E-01	5.09103E-06	1.09762E 03	8.59006E-03	-2.41898E-02	4.20266E 00	
193	-1.70206E 00	3.64652E 00	2.79931E-01	5.08924E-06	1.09784E 03	1.17779E-02	-2.30128E-02	4.20292E 00	
194	-2.14644E 00	3.39678E 00	2.79638E-01	5.08494E-06	1.09770E 03	1.45513E-02	-2.24007E-02	4.20355E 00	
195	-2.56357E 00	3.08720E 00	2.79536E-01	5.08345E-06	1.09771E 03	1.64105E-02	-2.11722E-02	4.20377E 00	
196	-2.94761E 00	2.74857E 00	2.79790E-01	5.08716E-06	1.09767E 03	1.75974E-02	-1.81900E-02	4.20322E 00	
197	-3.26959E 00	2.36444E 00	2.80044E-01	5.09089E-06	1.09762E 03	1.99995E-02	-1.52443E-02	4.20268E 00	
198	-3.53233E 00	1.95744E 00	2.80123E-01	5.09204E-06	1.09761E 03	2.20689E-02	-1.19925E-02	4.20251E 00	
199	-3.74860E 00	1.50191E 00	2.79787E-01	5.08712E-06	1.09767E 03	2.33266E-02	-8.33210E-03	4.20323E 00	
200	-3.90128E 00	1.01776E 00	2.79372E-01	5.08103E-06	1.09774E 03	2.47124E-02	-8.14711E-03	4.20412E 00	

MACH 4 NOZZLE (G=1.24)

ZE = 2.40000E 01

STEP NO. 78

NO.	X	Y	P	RHO	Q	THETA	PSI	M	RDY
201	-3.90521E 00	5.18680E-01	2.79269E-01	5.07953E-06	1.09776E 03	2.58137E-02	-1.95856E-03	4.20434E 01	
202	-4.01394E 00	6.13514E-03	2.78945E-01	5.37477E-06	1.09782E 03	2.72975E-02	7.05304E-04	4.20503E 00	
203	-3.99110E 00	-5.18968E-01	2.79319E-01	5.08026E-06	1.09775E 03	2.56874E-02	2.78967E-03	4.20423E 00	
204	-3.89769E 00	-1.02244E 00	2.79491E-01	5.08279E-06	1.09772E 03	2.45719E-02	5.30549E-03	4.20386E 00	
205	-3.74730E 00	-1.50431E 00	2.80236E-01	5.09371E-06	1.09759E 03	2.30470E-02	8.26729E-03	4.20227E 00	
206	-1.53577E 00	-1.95850E 00	2.80687E-01	5.10932E-06	1.09751E 03	2.18568E-02	1.14935E-02	4.20130E 00	
207	-3.27100E 00	-2.36563E 00	2.80676E-01	5.10016E-06	1.09751E 03	1.98244E-02	1.51338E-02	4.20133E 00	
208	-2.94910E 00	-2.75048E 00	2.80456E-01	5.09693E-06	1.09755E 03	1.74402E-02	1.80385E-02	4.20180E 00	
209	-2.56495E 00	-3.08879E 00	2.80203E-01	5.09322E-06	1.09759E 03	1.62946E-02	2.06672E-02	4.20234E 00	
210	-2.14830E 00	-3.39751E 00	2.80251E-01	5.09393E-06	1.09759E 03	1.45069E-02	2.21400E-02	4.20224E 00	
211	-1.70388E 00	-3.64558E 00	2.80390E-01	5.09506E-06	1.09756E 03	1.18683E-02	2.28560E-02	4.20194E 00	
212	-1.23364E 00	-3.82720E 00	2.80395E-01	5.09604E-06	1.09756E 03	8.78775E-03	2.40135E-02	4.20193E 00	
213	-7.45312E-01	-3.96250E 00	2.80717E-01	5.10076E-06	1.09750E 03	5.08756E-03	2.39875E-02	4.20124E 00	
214	-2.47285E-01	-4.04522E 00	2.81285E-01	5.10907E-06	1.09740E 03	1.60018E-03	2.40995E-02	4.20003E 00	
215	2.41859E-01	-4.02364E 00	2.80246E-01	5.09385E-06	1.09759E 03	-2.25026E-03	2.54520E-02	4.20225E 00	
216	7.44533E-01	-3.96337E 00	2.80259E-01	5.09404E-06	1.09759E 03	-4.83986E-03	2.48280E-02	4.20222E 00	
217	1.23889E 00	-3.81514E 00	2.79412E-01	5.08162E-06	1.09774E 03	-7.55354E-03	2.39246E-02	4.20403E 00	
218	1.71201E 00	-3.63981E 00	2.79519E-01	5.08319E-06	1.09772E 03	-1.02779E-02	2.44045E-02	4.20380E 00	
219	2.15531E 00	-3.39532E 00	2.79391E-01	5.08131E-06	1.09774E 03	-1.33319E-02	2.21906E-02	4.20408E 00	
220	2.56781E 00	-3.10058E 00	2.79287E-01	5.07979E-06	1.09776E 03	-1.62362E-02	1.98228E-02	4.20430E 00	
221	2.94444E 00	-2.76045E 00	2.79362E-01	5.08088E-06	1.09775E 03	-1.86092E-02	1.73721E-02	4.20414E 00	
222	3.26840E 00	-2.38059E 00	2.79323E-01	5.08034E-06	1.09775E 03	-2.07269E-02	1.43563E-02	4.20422E 00	
223	3.52088E 00	-1.96420E 00	2.78870E-01	5.07388E-06	1.09783E 03	-2.30127E-02	1.09923E-02	4.20519E 00	
224	3.74389E 00	-1.48824E 00	2.78513E-01	5.06844E-06	1.09790E 03	-2.34259E-02	9.18410E-03	4.20596E 00	
225	3.89911E 00	-1.00290E 00	2.78181E-01	5.06358E-06	1.09796E 03	-2.47679E-02	6.91311E-03	4.20668E 00	
226	3.99541E 00	-5.06569E-01	2.78310E-01	5.06545E-06	1.09793E 03	-2.54618E-02	3.71113E-03	4.20640E 00	
227	4.51574E 00	-3.27531E-03	2.91368E-01	5.25627E-06	1.09563E 03	-1.31312E-02	-6.61178E-05	4.17897E 00	
228	4.48792E 00	4.98631E-01	2.91430E-01	5.25716E-06	1.09562E 03	-1.31084E-02	-1.78845E-03	4.17885E 00	
229	4.40551E 00	9.69509E-01	2.91440E-01	5.25732E-06	1.09561E 03	-1.30100E-02	-3.41942E-03	4.17882E 00	
230	4.27150E 00	1.46968E 00	2.91797E-01	5.26251E-06	1.09555E 03	-1.25026E-02	-4.48567E-03	4.17809E 00	
231	4.07409E 00	1.92468E 00	2.91296E-01	5.25522E-06	1.09564E 03	-1.28719E-02	-5.78140E-03	4.17912E 00	
232	3.86229E 00	2.37699E 00	2.92860E-01	5.27796E-06	1.09537E 03	-1.01600E-02	-6.13075E-03	4.17592E 00	
233	3.56630E 00	2.78865E 00	2.92542E-01	5.27334E-06	1.09542E 03	-1.01551E-02	-7.36140E-03	4.17657E 00	
234	3.22717E 00	3.15986E 00	2.92625E-01	5.27454E-06	1.09541E 03	-9.85288E-03	-8.88971E-03	4.17640E 00	
235	2.85680E 00	3.49222E 00	2.92730E-01	5.27618E-06	1.09539E 03	-8.90536E-03	-9.91115E-03	4.17617E 00	
236	2.45807E 00	3.78437E 00	2.93311E-01	5.28016E-06	1.09534E 03	-7.56377E-03	-1.09266E-02	4.17561E 00	
237	2.03070E 00	4.03065E 00	2.93330E-01	5.28479E-06	1.09529E 03	-6.12232E-03	-1.20606E-02	4.17497E 00	
238	1.57798E 00	4.22132E 00	2.93223E-01	5.28324E-06	1.09531E 03	-4.55292E-03	-1.37006E-02	4.17518E 00	
239	1.11792E 00	4.36739E 00	2.93247E-01	5.28359E-06	1.09530E 03	-2.99803E-03	-1.38473E-02	4.17513E 00	
240	6.35944E-01	4.47488E 00	2.93460E-01	5.28568E-06	1.09528E 03	-7.77176E-04	-1.26541E-02	4.17470E 00	
241	1.31048E-01	4.53384E 00	2.93841E-01	5.29222E-06	1.09520E 03	-2.71609E-04	-1.16703E-02	4.17392E 00	
242	-3.79793E-01	4.50048E 00	2.93140E-01	5.28202E-06	1.09539E 03	7.90775E-04	-1.31671E-02	4.17535E 00	
243	-8.75543E-01	4.42646E 00	2.93231E-01	5.28336E-06	1.09530E 03	1.97989E-03	-1.30485E-02	4.17516E 00	
244	-1.35607E 00	4.30368E 00	2.93179E-01	5.28280E-06	1.09531E 03	3.27716E-03	-1.28535E-02	4.17527E 00	
245	-1.82017E 00	4.13166E 00	2.93378E-01	5.28549E-06	1.09528E 03	4.72764E-03	-1.24773E-02	4.17487E 00	
246	-2.26046E 00	3.90395E 00	2.93281E-01	5.28408E-06	1.09530E 03	6.58562E-03	-1.24913E-02	4.17507E 00	
247	-2.66709E 00	3.63462E 00	2.92062E-01	5.28090E-06	1.09533E 03	8.61640E-03	-1.18158E-02	4.17551E 00	
248	-3.07985E 00	3.32806E 00	2.92993E-01	5.27989E-06	1.09535E 03	9.97429E-03	-9.68444E-03	4.17556E 00	
249	-3.39711E 00	2.98290E 00	2.93048E-01	5.28069E-06	1.09534E 03	9.80889E-03	-7.72690E-03	4.17554E 00	
250	-3.71118E 00	2.58792E 00	2.93000E-01	5.27990E-06	1.09534E 03	1.03081E-02	-6.78368E-03	4.17564E 00	

MACH 4 NOZZLE (G=1.24)

ZE = 2.00000E 01

STEP NO. 76

NO.	X	Y	P	RHO	Q	THETA	PSI	M	BODY
251	-3.97710E 00	2.15395E 00	2.92827E-01	5.27748E-06	1.09537E 03	1.18806E-02	-5.92400E-03	4.17599E 00	
252	-4.18996E 00	1.69511E 00	2.92712E-01	5.27581E-06	1.09539E 03	1.16426E-02	-5.20449E-03	4.17623E 00	
253	-4.34927E 00	1.22017E 00	2.92573E-01	5.27378E-06	1.09542E 03	1.22537E-02	-4.23742E-03	4.17651E 00	
254	-4.45668E 00	7.33235E-01	2.92798E-01	5.27706E-06	1.09538E 03	1.28426E-02	-2.92104E-03	4.17605E 00	
255	-4.50435E 00	2.38035E-01	2.92800E-01	5.27709E-06	1.09538E 03	1.42871E-02	-1.19561E-03	4.17605E 00	
256	-4.50150E 00	-2.44419E-01	2.92618E-01	5.27444E-06	1.09541E 03	1.44612E-02	1.53440E-03	4.17642E 00	
257	-4.45331E 00	-7.34110E-01	2.92862E-01	5.27799E-06	1.09537E 03	1.32228E-02	3.32249E-03	4.17592E 00	
258	-4.34923E 00	1.22111E 00	2.92791E-01	5.27695E-06	1.09536E 03	1.22563E-02	4.50955E-03	4.17607E 00	
259	-4.19006E 00	-1.60559E 00	2.93123E-01	5.28178E-06	1.09532E 03	1.14032E-02	5.32224E-03	4.17539E 00	
260	-3.97804E 00	-2.15414E 00	2.93332E-01	5.28481E-06	1.09529E 03	1.09068E-02	6.00307E-03	4.17496E 00	
261	-3.71191E 00	-2.58829E 00	2.93576E-01	5.28836E-06	1.09524E 03	1.01941E-02	6.70468E-03	4.17446E 00	
262	-3.39758E 00	-2.96283E 00	2.93666E-01	5.28968E-06	1.09523E 03	9.79480E-03	7.66897E-03	4.17428E 00	
263	-3.04001E 00	-3.32958E 00	2.93658E-01	5.28966E-06	1.09522E 03	9.91250E-03	9.61209E-03	4.17430E 00	
264	-2.66698E 00	-3.63651E 00	2.93715E-01	5.29038E-06	1.09522E 03	8.58098E-03	1.14091E-02	4.17418E 00	
265	-2.26005E 00	-3.90675E 00	2.93897E-01	5.29303E-06	1.09519E 03	6.57630E-03	1.23680E-02	4.17381E 00	
266	-1.81940E 00	-4.13193E 00	2.93919E-01	5.29335E-06	1.09519E 03	4.75424E-03	1.24825E-02	4.17377E 00	
267	-1.35614E 00	-4.29992E 00	2.93993E-01	5.28862E-06	1.09524E 03	3.30661E-03	1.29538E-02	4.17443E 00	
268	-8.79377E-01	-4.42310E 00	2.93480E-01	5.28710E-06	1.09526E 03	2.00598E-03	1.26853E-02	4.17464E 00	
269	-3.81739E-01	-4.50984E 00	2.93795E-01	5.29155E-06	1.09521E 03	1.35277E-03	1.20586E-02	4.17402E 00	
270	1.33555E-01	-4.32555E 00	2.93682E-01	5.28991E-06	1.09523E 03	5.18248E-04	1.25573E-02	4.17425E 00	
271	6.31691E-01	-4.47729E 00	2.93480E-01	5.28697E-06	1.09526E 03	-7.00304E-04	1.29148E-02	4.17466E 00	
272	1.11586E 00	-4.37109E 00	2.93140E-01	5.28203E-06	1.09532E 03	-2.38897E-03	1.37484E-02	4.17535E 00	
273	1.57635E 00	-4.22247E 00	2.93024E-01	5.28035E-06	1.09536E 03	-4.58646E-03	1.35219E-02	4.17559E 00	
274	2.02837E 00	-4.03047E 00	2.92938E-01	5.27910E-06	1.09535E 03	-6.24937E-03	1.20576E-02	4.17576E 00	
275	2.45607E 00	-3.78435E 00	2.92653E-01	5.27495E-06	1.09540E 03	-7.72036E-03	1.08712E-02	4.17635E 00	
276	2.85533E 00	-3.49272E 00	2.92354E-01	5.27061E-06	1.09546E 03	-9.07219E-03	9.82900E-03	4.17696E 00	
277	3.22615E 00	-3.16048E 00	2.92272E-01	5.26941E-06	1.09547E 03	-1.00166E-02	8.72070E-03	4.17712E 00	
278	3.56555E 00	-2.78941E 00	2.92216E-01	5.26860E-06	1.09548E 03	-1.02998E-02	7.18955E-03	4.17724E 00	
279	3.86160E 00	-2.37751E 00	2.92381E-01	5.27391E-06	1.09542E 03	-1.02807E-02	5.96727E-03	4.17649E 00	
280	4.07385E 00	-1.92509E 00	2.91999E-01	5.25235E-06	1.09567E 03	-1.27449E-02	5.62084E-03	4.17953E 00	
281	4.27152E 00	-1.46988E 00	2.91671E-01	5.26067E-06	1.09567E 03	-1.25543E-02	4.31322E-03	4.17835E 00	
282	4.40569E 00	-9.89533E-01	2.91371E-01	5.25632E-06	1.09563E 03	-1.30401E-02	3.25089E-03	4.17897E 00	
283	4.48803E 00	-4.98646E-01	2.91399E-01	5.25672E-06	1.09562E 03	-1.31215E-02	1.64480E-03	4.17891E 00	
284	4.97253E 00	-2.13480E-05	3.03216E-01	5.42797E-06	1.09360E 03	-3.52451E-04	-5.72648E-03	4.15519E 00	YES
285	4.94798E 00	4.94179E-01	3.03288E-01	5.42991E-06	1.09359E 03	-3.32952E-04	-2.18671E-04	4.18504E 00	YES
286	4.87441E 00	9.83409E-01	3.03378E-01	5.43030E-06	1.09357E 03	-2.84692E-04	-3.67523E-04	4.15487E 00	YES
287	4.75207E 00	1.46504E 00	3.03438E-01	5.43117E-06	1.09356E 03	-1.97009E-04	-5.51814E-04	4.15475E 00	YES
288	4.58281E 00	1.93021E 00	3.02890E-01	5.42326E-06	1.09366E 03	-1.27160E-05	-8.71943E-04	4.15583E 00	YES
289	4.37324E 00	2.36633E 00	3.04153E-01	5.44149E-06	1.09344E 03	1.96512E-04	-1.08778E-03	4.15335E 00	YES
290	4.10207E 00	2.81037E 00	3.04206E-01	5.44285E-06	1.09343E 03	-6.62768E-04	3.48650E-04	4.15324E 00	YES
291	3.79435E 00	3.21412E 00	3.04262E-01	5.44307E-06	1.09342E 03	-1.12585E-03	7.87177E-04	4.15314E 00	YES
292	3.45528E 00	3.57518E 00	3.04677E-01	5.44905E-06	1.09333E 03	-1.07621E-03	5.57202E-04	4.15232E 00	YES
293	3.08629E 00	3.89814E 00	3.04759E-01	5.45042E-06	1.09334E 03	-9.63690E-04	3.21459E-04	4.15216E 00	YES
294	2.68744E 00	4.18423E 00	3.04988E-01	5.45353E-06	1.09330E 03	-7.55923E-04	7.24824E-05	4.15171E 00	YES
295	2.25970E 00	4.43016E 00	3.05235E-01	5.45739E-06	1.09326E 03	-6.14970E-04	-7.78003E-05	4.15119E 00	YES
296	1.80948E 00	4.63205E 00	3.05282E-01	5.45778E-06	1.09325E 03	-1.54991E-04	-3.13014E-04	4.15114E 00	YES
297	1.34950E 00	4.78604E 00	3.05231E-01	5.45704E-06	1.09326E 03	9.01252E-04	-6.15671E-04	4.15124E 00	YES
298	8.71825E-01	4.85531E 00	3.05123E-01	5.45548E-06	1.09328E 03	1.20705E-03	-5.69218E-04	4.15145E 00	YES
299	3.69772E-01	4.95877E 00	3.05163E-01	5.45605E-06	1.09327E 03	4.36729E-04	-3.74649E-04	4.15137E 00	YES
300	-1.45519E-01	4.97057E 00	3.05224E-01	5.45694E-06	1.09326E 03	-8.25527E-04	-3.69400E-04	4.15129E 00	YES

NACH 4 NOZZLE (G=1.24)

ZE = 2.40000E 01

STEP NO. 78

NO.	X	Y	Z	RHO	Q	THETA	PSI	M	BODY
301	-6.32573E-01	4.93241E 00	3.05269E-01	5.45758E-06	1.09326E 03	-8.48742E-04	-4.56292E-04	4.15117E 00	YES
302	-1.11277E 00	4.84822E 00	3.05167E-01	5.45900E-06	1.09324E 03	-9.03791E-04	-5.62772E-04	4.15097E 00	YES
303	-1.58310E 00	4.71434E 00	3.05222E-01	5.45691E-06	1.09326E 03	-8.57809E-04	-6.81248E-04	4.15126E 00	YES
304	-2.04200E 00	4.53442E 00	3.05259E-01	5.45744E-06	1.09326E 03	-7.14642E-04	-6.98895E-04	4.15118E 00	YES
305	-2.48387E 00	4.30803E 00	3.05199E-01	5.45652E-06	1.09327E 03	-2.98464E-04	-5.69335E-04	4.15131E 00	YES
306	-2.89476E 00	4.04243E 00	3.04883E-01	5.45272E-06	1.09332E 03	7.41958E-04	1.10421E-04	4.15192E 00	YES
307	-3.27734E 00	3.73863E 00	3.04997E-01	5.45367E-06	1.09330E 03	1.21809E-03	7.01400E-04	4.15170E 00	YES
308	-3.63365E 00	3.39418E 00	3.04772E-01	5.45042E-06	1.09334E 03	1.17344E-03	7.54268E-04	4.15214E 00	YES
309	-3.95812E 00	3.70988E 00	3.04763E-01	5.45028E-06	1.09334E 03	6.17461E-04	2.46134E-04	4.15215E 00	YES
310	-4.23996E 00	2.94783E 00	3.04764E-01	5.45030E-06	1.09334E 03	1.85128E-04	-3.50903E-04	4.15215E 00	YES
311	-4.47996E 00	2.15823E 00	3.04604E-01	5.44799E-06	1.09337E 03	3.75457E-05	-7.88134E-04	4.15246E 00	YES
312	-4.67374E 00	1.69916E 00	3.04491E-01	5.44636E-06	1.09339E 03	7.37672E-07	-9.88238E-04	4.15269E 00	YES
313	-4.81955E 00	1.22505E 00	3.04356E-01	5.44442E-06	1.09341E 03	5.92613E-05	-1.14378E-03	4.15295E 00	YES
314	-4.91780E 00	7.36834E-01	3.04478E-01	5.44818E-06	1.09339E 03	1.51867E-04	-1.27813E-03	4.15271E 00	YES
315	-4.96693E 00	2.39795E-01	3.04665E-01	5.44888E-06	1.09338E 03	2.93092E-04	-9.66645E-04	4.15235E 00	YES
316	-4.96645E 00	-2.49864E-01	3.04435E-01	5.44556E-06	1.09340E 03	3.22801E-04	3.34887E-04	4.15279E 00	YES
317	-4.91767E 00	-7.37968E-01	3.04600E-01	5.44793E-06	1.09337E 03	1.69576E-04	1.16412E-03	4.15247E 00	YES
318	-4.81937E 00	-1.22508E 00	3.04473E-01	5.44610E-06	1.09339E 03	9.65620E-06	1.33673E-03	4.15272E 00	YES
319	-4.67289E 00	-1.69980E 00	3.04775E-01	5.45047E-06	1.09334E 03	-1.09537E-04	1.29090E-03	4.15213E 00	YES
320	-4.47938E 00	-2.15951E 00	3.05030E-01	5.45414E-06	1.09330E 03	-5.76118E-05	8.98378E-04	4.15163E 00	YES
321	-4.23937E 00	-2.59918E 00	3.05314E-01	5.45823E-06	1.09325E 03	1.33941E-04	4.28673E-04	4.15108E 00	YES
322	-3.95717E 00	-3.01047E 00	3.05306E-01	5.45812E-06	1.09325E 03	6.00306E-04	-2.29220E-04	4.15109E 00	YES
323	-3.63285E 00	-3.39464E 00	3.05358E-01	5.45887E-06	1.09324E 03	1.16826E-03	-7.53246E-04	4.15099E 00	YES
324	-3.27701E 00	-3.73978E 00	3.05659E-01	5.46321E-06	1.09319E 03	1.34061E-03	-7.23631E-04	4.15040E 00	YES
325	-2.89273E 00	-4.04372E 00	3.05804E-01	5.46097E-06	1.09322E 03	8.02797E-04	-1.55513E-04	4.15070E 00	YES
326	-2.48179E 00	-4.30875E 00	3.05738E-01	5.46435E-06	1.09318E 03	-2.14848E-04	5.19614E-04	4.15085E 00	YES
327	-2.03981E 00	-4.53576E 00	3.05793E-01	5.46914E-06	1.09317E 03	-6.35124E-04	6.62035E-04	4.15014E 00	YES
328	-1.58174E 00	-4.71534E 00	3.05740E-01	5.46437E-06	1.09318E 03	-8.25739E-04	6.39102E-04	4.15025E 00	YES
329	-1.11575E 00	-4.84610E 00	3.05717E-01	5.46484E-06	1.09318E 03	-9.36661E-04	5.67348E-04	4.15029E 00	YES
330	-6.36084E-01	-4.93162E 00	3.05787E-01	5.46462E-06	1.09317E 03	-3.45609E-04	3.90457E-04	4.15021E 00	YES
331	-1.42147E-01	-4.97009E 00	3.08134E-01	5.45564E-06	1.09328E 03	3.43636E-04	3.35347E-04	4.15143E 00	YES
332	3.66029E-01	-4.95871E 00	3.05322E-01	5.45835E-06	1.09325E 03	8.56509E-04	4.09230E-04	4.15166E 00	YES
333	8.68845E-01	-4.89616E 00	3.04992E-01	5.45360E-06	1.09330E 03	1.33292E-03	5.85812E-04	4.15170E 00	YES
334	1.14977E 00	-4.78603E 00	3.04993E-01	5.45361E-06	1.09330E 03	8.95645E-04	6.11623E-04	4.15170E 00	YES
335	1.81054E 00	-4.63149E 00	3.05057E-01	5.45453E-06	1.09329E 03	-1.17678E-04	3.26286E-04	4.15158E 00	YES
336	2.25941E 00	-4.43010E 00	3.04874E-01	5.45189E-06	1.09332E 03	-6.13119E-04	7.71187E-05	4.15194E 00	YES
337	2.68655E 00	-4.18475E 00	3.04652E-01	5.44869E-06	1.09336E 03	-8.23262E-04	-1.14736E-04	4.15237E 00	YES
338	3.08550E 00	-3.89932E 00	3.04407E-01	5.44515E-06	1.09340E 03	-1.05856E-03	-3.91975E-04	4.15285E 00	YES
339	3.45442E 00	-3.57831E 00	3.04355E-01	5.44440E-06	1.09341E 03	-1.19741E-03	-6.69508E-04	4.15295E 00	YES
340	3.79389E 00	-3.21509E 00	3.03941E-01	5.43843E-06	1.09348E 03	-1.24832E-03	-9.29814E-04	4.15376E 00	YES
341	4.10187E 00	-2.81117E 00	3.03909E-01	5.43797E-06	1.09348E 03	-7.68471E-04	-5.02632E-04	4.15383E 00	YES
342	4.37311E 00	-2.36780E 00	3.03921E-01	5.43814E-06	1.09348E 03	1.17415E-04	9.51996E-04	4.15380E 00	YES
343	4.58270E 00	-1.93070E 00	3.02732E-01	5.42899E-06	1.09358E 03	-7.62851E-05	7.26741E-04	4.15414E 00	YES
344	4.75201E 00	-1.48527E 00	3.03329E-01	5.42960E-06	1.09358E 03	-2.49965E-04	3.89101E-04	4.15496E 00	YES
345	4.87430E 00	-9.83505E-01	3.03316E-01	5.42942E-06	1.09358E 03	-3.17399E-04	2.13965E-04	4.15499E 00	YES
346	4.94792E 00	-4.94316E-01	3.03261E-01	5.42861E-06	1.09359E 03	-3.46455E-04	8.45271E-05	4.15510E 00	YES

NACH 4 NOZZLE (G=1.24)

BODY POINTS AT ZE = 2.40000E 01

STEP NO. 78

NO.	X	Y	P	RHO	Q	THETA	PSI	M
284	4.97253E 00	-0.13480E-05	3.03216E-01	5.42797E-06	1.09360E 03	-3.52451E-04	-5.72640E-05	4.15519E 00
285	4.94794E 00	4.94179E-01	3.03286E-01	5.42901E-06	1.09359E 03	-3.32952E-04	-2.10671E-04	4.15504E 00
286	4.87441E 00	9.83409E-01	3.03378E-01	5.43030E-06	1.09357E 03	-2.84692E-04	-3.67523E-04	4.15487E 00
287	4.75207E 00	1.46804E 00	3.03438E-01	5.43117E-06	1.09356E 03	-1.97009E-04	-5.41814E-04	4.15475E 00
288	4.58281E 00	1.93021E 00	3.02890E-01	5.42320E-06	1.09366E 03	-1.27100E-05	-8.71943E-04	4.15583E 00
289	4.37324E 00	2.36633E 00	3.04153E-01	5.44149E-06	1.09344E 03	1.96512E-04	-1.09778E-03	4.15335E 00
290	4.10297E 00	2.81037E 00	3.04206E-01	5.44225E-06	1.09343E 03	-6.62768E-04	3.48290E-04	4.15324E 00
291	3.79435E 00	3.21412E 00	3.04262E-01	5.44307E-06	1.09342E 03	-1.12585E-03	7.87177E-04	4.15314E 00
292	3.45528E 00	3.57518E 00	3.04677E-01	5.44905E-06	1.09335E 03	-1.07621E-03	5.57202E-04	4.15232E 00
293	3.08629E 00	3.89814E 00	3.04759E-01	5.45024E-06	1.09334E 03	-9.63690E-04	3.21459E-04	4.15216E 00
294	2.68746E 00	4.18423E 00	3.04928E-01	5.45353E-06	1.09330E 03	-7.55023E-04	7.24624E-05	4.15171E 00
295	2.25970E 00	4.43016E 00	3.05255E-01	5.45739E-06	1.09326E 03	-6.14970E-04	-7.70003E-05	4.15119E 00
296	1.80948E 00	4.63200E 00	3.05262E-01	5.45778E-06	1.09325E 03	-1.54991E-04	-3.13014E-04	4.15114E 00
297	1.34950E 00	4.76604E 00	3.05231E-01	5.45704E-06	1.09326E 03	9.01252E-04	-6.15671E-04	4.15124E 00
298	8.71025E-01	4.85531E 00	3.05123E-01	5.45548E-06	1.09328E 03	1.20705E-03	-5.69218E-04	4.15145E 00
299	3.69772E-01	4.95877E 00	3.05163E-01	5.45605E-06	1.09327E 03	4.36729E-04	-3.76649E-04	4.15137E 00
300	-1.45519E-01	4.97057E 00	3.05224E-01	5.45694E-06	1.09326E 03	-8.28327E-04	-3.69400E-04	4.15125E 00
301	-6.32573E-01	4.93241E 00	3.05269E-01	5.45758E-06	1.09325E 03	-6.48742E-04	-4.58292E-04	4.15117E 00
302	-1.11277E 00	4.84682E 00	3.05367E-01	5.45900E-06	1.09324E 03	-9.03791E-04	-6.62772E-04	4.15097E 00
303	-1.58310E 00	4.71434E 00	3.05222E-01	5.45691E-06	1.09326E 03	-6.57809E-04	-6.51248E-04	4.15126E 00
304	-2.04200E 00	4.53442E 00	3.05269E-01	5.45744E-06	1.09326E 03	-7.14642E-04	-6.98855E-04	4.15110E 00
305	-2.48387E 00	4.30803E 00	3.05195E-01	5.45652E-06	1.09327E 03	-2.99464E-04	-5.69335E-04	4.15131E 00
306	-2.89476E 00	4.04243E 00	3.04883E-01	5.45282E-06	1.09332E 03	7.41958E-04	1.10421E-04	4.15192E 00
307	-3.27734E 00	3.73863E 00	3.04907E-01	5.45367E-06	1.09330E 03	1.31809E-03	7.01400E-04	4.15170E 00
308	-3.63365E 00	3.39416E 00	3.04772E-01	5.45042E-06	1.09334E 03	1.17344E-03	7.54268E-04	4.15214E 00
309	-3.95812E 00	3.00968E 00	3.04762E-01	5.45028E-06	1.09334E 03	6.17451E-04	2.46134E-04	4.15215E 00
310	-4.23990E 00	2.59783E 00	3.04764E-01	5.45030E-06	1.09334E 03	1.85128E-04	-3.50983E-04	4.15215E 00
311	-4.47996E 00	2.15523E 00	3.04604E-01	5.44799E-06	1.09337E 03	3.75457E-05	-7.09134E-04	4.15246E 00
312	-4.67374E 00	1.69916E 00	3.04491E-01	5.44635E-06	1.09339E 03	7.37672E-07	-9.88288E-04	4.15269E 00
313	-4.81958E 00	1.22503E 00	3.04350E-01	5.44442E-06	1.09341E 03	5.92613E-05	-1.14376E-03	4.15295E 00
314	-4.91780E 00	7.36839E-01	3.04478E-01	5.44618E-06	1.09339E 03	1.51867E-04	-1.27813E-03	4.15271E 00
315	-4.96693E 00	2.39795E-01	3.04665E-01	5.44888E-06	1.09336E 03	2.93092E-04	-9.66495E-04	4.15235E 00
316	-4.96645E 00	-2.49564E-01	3.04435E-01	5.44566E-06	1.09340E 03	3.22801E-04	3.34887E-04	4.15279E 00
317	-4.91767E 00	-7.37968E-01	3.04600E-01	5.44793E-06	1.09337E 03	1.69976E-04	1.15412E-03	4.15247E 00
318	-4.81937E 00	-1.22508E 00	3.04473E-01	5.44618E-06	1.09339E 03	9.65620E-06	1.33673E-03	4.15272E 00
319	-4.67289E 00	-1.69980E 00	3.04772E-01	5.45047E-06	1.09334E 03	-1.09537E-04	1.29090E-03	4.15213E 00
320	-4.47938E 00	-2.15981E 00	3.05030E-01	5.46414E-06	1.09330E 03	-5.76118E-05	8.98378E-04	4.15163E 00
321	-4.23937E 00	-2.59918E 00	3.05314E-01	5.45823E-06	1.09325E 03	1.33941E-04	4.28973E-04	4.15108E 00
322	-3.95717E 00	-3.01047E 00	3.05306E-01	5.45812E-06	1.09329E 03	6.09306E-04	-2.29220E-04	4.15109E 00
323	-3.63285E 00	-3.39464E 00	3.05358E-01	5.45867E-06	1.09324E 03	1.16826E-03	-7.63246E-04	4.15099E 00
324	-3.27701E 00	-3.73976E 00	3.05659E-01	5.46321E-06	1.09319E 03	1.34061E-03	-7.23631E-04	4.15040E 00
325	-2.89373E 00	-4.04372E 00	3.06804E-01	5.46097E-06	1.09322E 03	8.02797E-04	-1.55613E-04	4.15070E 00
326	-2.48179E 00	-4.30875E 00	3.05738E-01	5.46435E-06	1.09310E 03	-2.14848E-04	6.19614E-04	4.15025E 00
327	-2.03981E 00	-4.53574E 00	3.05793E-01	5.46514E-06	1.09317E 03	-6.35124E-04	6.62035E-04	4.15014E 00
328	-1.58174E 00	-4.71534E 00	3.05740E-01	5.46437E-06	1.09318E 03	-8.25739E-04	6.39102E-04	4.15025E 00
329	-1.11575E 00	-4.84618E 00	3.05717E-01	5.46404E-06	1.09318E 03	-9.36661E-04	5.67348E-04	4.15029E 00
330	-6.36048E-01	-4.93162E 00	3.05757E-01	5.46482E-06	1.09317E 03	-3.45600E-04	3.90657E-04	4.15021E 00
331	-1.42147E-01	-4.97009E 00	3.05134E-01	5.45564E-06	1.09320E 03	3.43636E-04	3.35347E-04	4.15143E 00
332	3.66020E-01	-4.95871E 00	3.05322E-01	5.45835E-06	1.09325E 03	8.56509E-04	4.69230E-04	4.15166E 00
333	8.68845E-01	-4.89616E 00	3.04992E-01	5.45360E-06	1.09330E 03	1.33292E-03	5.85812E-04	4.15170E 00
334	1.34977E 00	-4.78603E 00	3.04993E-01	5.45361E-06	1.09330E 03	8.95645E-04	6.11623E-04	4.15170E 00
335	1.81054E 00	-4.63149E 00	3.05057E-01	5.45493E-06	1.09329E 03	-1.17678E-04	3.26806E-04	4.15158E 00
336	2.25941E 00	-4.43016E 00	3.04874E-01	5.45169E-06	1.09332E 03	-6.13119E-04	7.71187E-05	4.15194E 00

337	2.69695E 00	-4.18475E 00	3.04682E-01	5.44889E-06	1.09336E 03	-8.23262E-04	-1.14736E-04	4.15237E 00
338	3.08550E 00	-3.89932E 00	3.04407E-01	5.44515E-06	1.09340E 03	-1.05458E-03	-3.91975E-04	4.15265E 00
339	3.45482E 00	-3.57631E 00	3.04355E-01	5.44440E-06	1.09341E 03	-1.19741E-03	-8.69508E-04	4.15296E 00
340	3.79389E 00	-3.21509E 00	3.03941E-01	5.43843E-06	1.09346E 03	-1.24832E-03	-9.29814E-04	4.15376E 00
341	4.10187E 00	-2.81117E 00	3.03909E-01	5.43797E-06	1.09348E 03	-7.68471E-04	-5.02632E-04	4.15383E 00
342	4.37311E 00	-2.36708E 00	3.03921E-01	5.43814E-06	1.09348E 03	1.17419E-04	9.81998E-04	4.15380E 00
343	4.59270E 00	-1.92070E 00	3.02732E-01	5.42099E-06	1.09368E 03	-7.02881E-05	7.26741E-04	4.15614E 00
344	4.75201E 00	-1.46527E 00	3.03329E-01	5.42980E-06	1.09358E 03	-2.49965E-04	3.29181E-04	4.15496E 00
345	4.87438E 00	-9.83505E-01	3.03316E-01	5.42942E-06	1.09358E 03	-3.17399E-04	2.13969E-04	4.15499E 00
346	4.94792E 00	-4.94316E-01	3.03261E-01	5.42861E-06	1.09359E 03	-3.46455E-04	9.48871E-05	4.15510E 00

AEDC-TR-78-88

NOMENCLATURE

a	Speed of sound
h	Static enthalpy
L	Distance along bicharacteristic
$\bar{L}, \bar{M}, \bar{N}$	Bicharacteristic coordinate system
M	Mach number
n_1, n_2, n_3	Unit normal to body surface in z, x, y directions
p	Pressure
$\bar{q}$	Velocity
q	$ \bar{q} $
r^*	Throat radius of axisymmetric nozzle
R	Gas constant
T	Temperature
u	x component of velocity
v	y component of velocity
w	z component of velocity
x, y, z	Cartesian coordinate system

β	Mach angle
γ	Ratio of specific heats
δ	Parametric angle for bicharacteristic
θ, ψ	Flow angles defined in Fig. 1
ρ	Density

SUBSCRIPTS

i	$i = 1, 2, \dots$ refer to quantities at given points
ts	Stagnation conditions along streamline