Experimental Investigation of the Mixing and Combustion of an Underexpanded H₂ Jet in Supersonic Flow

By

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ABSTRACT

The interaction of an underexpanded hydrogen jet coaxially injected into supersonic flow is investigated experimentally. Experimental results are discussed and analyzed. Comparisons are made between the experimental results and theoretical predictions computed using an analytical technique. Changes to improve the theory are suggested.
ACKNOWLEDGEMENTS

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\( C_p \)  
non-dimensional specific heat, \( C_p^*/C_p^\infty \)

\( H \)  
non-dimensional total enthalpy, \( H^*/C_p^\infty T^\infty \)

\( h \)  
non-dimensional static enthalpy, \( h^*/C_p^\infty T^\infty \)

\( Le \)  
Lewis number

\( M \)  
Mach number

\( \mu_i \)  
molecular weight of \( i^{th} \) specie, \( \text{kg/kmol} \)

\( n \)  
coordinate normal to streamlines

\( P \)  
nondimensional pressure, \( p^*/(\rho^\infty q^\infty)^2 \)

\( Pr \)  
Prandtl number

\( P_{i2} \)  
pitot pressure, \( \text{N/m}^2 \)

\( q \)  
nondimensional velocity, \( q^*/q^\infty \)

\( Re \)  
freestream Reynolds number, \( \frac{\rho^\infty q^\infty r^\infty}{u^\infty} \)

\( r_j \)  
radius of jet at injector's exit (used as reference dimension), 0.3175 cm

\( s \)  
coordinate along streamlines

\( S_1, S_2, S_3 \)  
forcing functions defined in text

\( T \)  
nondimensional temperature, \( T^*/T^\infty \)

\( U_1, U_2 \)  
nondimensional velocities normal to the shock wave in Rankine-Hugoniot equations, \( U_1^*/q^\infty; U_2^*/q^\infty \)

\( V \)  
nondimensional velocity, \( V^*/q^\infty \)

\( V_{t_1}, V_{t_2} \)  
nondimensional tangential velocities in Rankine-Hugoniot equations, \( V_{t_1}^*/q^\infty; V_{t_2}^*/q^\infty \)

\( W \)  
molecular weight of mixture, \( \text{kg/kmol} \)
\[ \dot{\omega}_0 \]  
the production rate of oxygen at 1000 K and the local

\[ \dot{\omega}_1 \]  
nondimensional species production team, \( \dot{\omega}_1/\dot{\omega}_0 \)

\[ x/r_j \]  
nondimensional coordinate along nozzles' axis

\[ y/r_j \]  
nondimensional coordinate normal to nozzles' axis

\[ \omega_i \]  
mass fraction of \( i^{th} \) specie

\[ \gamma \]  
ratio of specific heats

\[ \Theta \]  
flow angle, radians

\[ \rho \]  
nondimensional density, \( \rho^* / \rho_\infty \)

\[ \mu \]  
nondimensional absolute viscosity, \( \mu^* / \mu_\infty \)

\[ \overline{\mu} \]  
Mach angle, radians

\[ \phi \]  
equivalence ratio; the ratio of the actual \( \dot{m}_{H_2} \) to that
required for stoichiometric reaction,

\[ \frac{\dot{m}_{H_2}}{0.029157 \dot{m}_{air}} \]

(The fictitious \( \phi \)'s for nitrogen test medium are computed
as if the test stream were air.)

Subscripts:

\[ CL \]  
centerline

\[ f \]  
frozen state

\[ i \]  
pertaining to specie \( i \)

\[ j \]  
jet

\[ t_0 \]  
test stream vessel stagnation condition

\[ \infty \]  
freestream nozzle exit conditions

Superscripts:

\[ * \]  
dimensional variable
SUMMARY

An experimental data base for the injection, mixing, and combustion of an underexpanded hydrogen jet in a supersonic test stream has been obtained. Experimental pitot pressure data have been compared with theoretical predictions.

The experimental tests were conducted with both air and nitrogen as test media which led to reacting and nonreacting flows, respectively. Tests were conducted in a free-jet and in a ducted mode. Theoretical values were computed using two different viscosity models and a wide range of Prandtl number (0.7 to 1.4) with a Lewis number of 1.

The comparison of the experimental and theoretical data indicates that the theory is inadequate for predicting the flow field resulting from the injection of an underexpanded (hydrogen) jet into supersonic flow. Suggestions are made for improving the theory.
CHAPTER 1

INTRODUCTION

The hydrogen fueled supersonic combustion ramjet (scramjet) engine is envisioned as the prime candidate to fill the propulsion requirements for future hypersonic aircraft. However, feasible scramjet engines face problems in several technological areas. (Status evaluations of the scramjet concept may be found in references 1, 2, 3, and 4.) Three such areas are of concern in this work. These are the injection, mixing, and combustion of hydrogen. Note that the last two are directly related to the first by the following sequence: injection controls mixing and mixing controls combustion. As a result, fuel injection holds an important position in the total scramjet problem. Thus, it is not surprising that numerous fuel injection schemes have been investigated in both cold and hot supersonic flows. Simplicity in flow field modeling has made parallel coaxial injection the scheme most widely investigated (references 5, 6, and 7 present investigations of this type).

These previous investigations of coaxial injection were limited to cases where injector exit pressure matched the test stream static pressure. These matched pressure cases were selected primarily because the theory available was designed to handle them.

On the other hand, recent theory (see references 8 and 9) is designed to handle the more complex underexpanded (jet pressure greater than the test stream static pressure) injection. The significance of such a theory becomes apparent when one notes that any practical scramjet engine
is likely to use hydrogen injection by an underexpanded jet.

In fact, all scramjet engines must be capable of operating with underexpanded injection, although this may not be the primary type of injection. However, a search of the literature indicated that there was very little information on an underexpanded hydrogen jet coaxially injected into supersonic flow. Particular information, such as data on the underexpansion (exit) shock wave's affect on the hydrogen mixing and combustion, is completely lacking. The present investigation was therefore undertaken to experimentally determine some of the fundamental characteristics of the mixing and combustion of an underexpanded hydrogen jet in supersonic flow. In addition, the theory of reference 8 was tested by comparing experimental data with theoretical data computed using the computer program (reference 9) based on the theory of reference 8.
CHAPTER II

APPARATUS AND INSTRUMENTATION

Facility and Test Conditions

The experimental portion of this work was conducted in the Langley 11-Inch Ceramic-Heated Tunnel. This facility, described in reference 10, has a bed of zirconia pebbles which is heated by the combustion products from a propane burner. The products from the burner are passed through the bed until the desired stagnation temperature is reached. The hot test gas is obtained by passing the test medium (air or nitrogen) through the heated pebbles. In this manner, test gas total temperatures up to 2530 K (maximum usage temperature of the zirconia pebbles) can be furnished with a maximum stagnation pressure of 4 MN/m$^2$.

For the purpose of the present tests, the facility was fitted with the Mach 2 test stream nozzle which is a scaled version of one given in reference 11. This axisymmetric nozzle was constructed of stainless-steel and cooled by about 6 kg/sec of water. The facility was operated in two modes, a free-jet mode and a ducted mode. In the ducted mode, the ducting around the supersonic flow formed a circular combustor. A schematic of the facility (in the ducted mode configuration) is given in figure 1. The free-jet mode configuration is obtained by removing the constant area duct which extends from plane A-A to plane B-B of figure 1. In each configuration, the exit plane of the Mach 2 hydrogen injector nozzle was 0.3175 cm downstream of the exit plane of the test stream nozzle. Tests were conducted with both air and nitrogen as test media.
Figure 1. - Schematic of the coaxial supersonic combustion apparatus.
and for all tests the total temperature of the test stream was 2167 K, with a nozzle exit (static) temperature of 1338 K. This temperature was high enough to give ignition without a pilot flame or ignitor. The stagnation pressure ranged from 0.759 to 0.858 MN/m$^2$, which gave rise to test gas flow rates of 1.23 to 1.39 kg/sec and nozzle exit (static) pressures of 0.099 to 0.112 MN/m$^2$.

A summary of the test conditions is presented in Table I.

**Hydrogen Injector**

The hydrogen injector, which was mounted coaxial with the main nozzle, is a 0.953 cm (3/8 in) stainless-steel tube with a 5° conical nozzle at the exit. This nozzle, with a 0.635 cm exit diameter and 0.488 cm throat diameter, gives a nominal exit Mach number of 2. The injector exit lip thickness is 0.159 cm.

This injector lip of finite thickness introduces the problem of wake effects in the base region of the injector. However, it is considered to be a good compromise between the ideal and technically practical nozzle. Ideally, for ease of analysis, the injector should have an infinitely thin lip, and parallel flow at its exit. Unfortunately, the contoured nozzle needed to fulfill these ideal conditions cannot be built and a compromise must be sought. If the requirement of parallel flow is dropped, the infinitely thin lip can be approached by at least two designs. One is the boattail conical type nozzle given in figure 2. This design produces two undesirable results. First, the boattail causes the test flow to expand to a lower pressure, and second, the expansion
<table>
<thead>
<tr>
<th>$\frac{X}{r_j}$</th>
<th>$P_{T_0}$ MN/m²</th>
<th>$P_{\infty}$ MN/m²</th>
<th>$\frac{P_1}{P_{\infty}}$</th>
<th>$\text{Re} \times 10^4$</th>
<th>$\dot{m}$ kg/sec</th>
<th>$\dot{m}_{H_2}$ kg/sec</th>
<th>Test Type</th>
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<tr>
<td>1.5</td>
<td>0.789</td>
<td>0.103</td>
<td>2.03</td>
<td>2.446</td>
<td>1.302</td>
<td>0.015</td>
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<td>19</td>
<td>0.794</td>
<td>0.103</td>
<td>2.031</td>
<td>2.460</td>
<td>1.307</td>
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<tr>
<td>30</td>
<td>0.802</td>
<td>0.104</td>
<td>2.189</td>
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<td>0.817</td>
<td>0.106</td>
<td>2.022</td>
<td>2.531</td>
<td>1.345</td>
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<td>2.657</td>
<td>1.388</td>
<td>0.016</td>
<td>N-D</td>
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</table>

A - Air  FJ - Free Jet  N - Nitrogen  D - Ducted  $\frac{X}{r_j}$ = Duct Length
Figure 2. Half cross section of a nozzle having a very thin lip and boattail.
turns the flow (near the injector) so that it is no longer parallel with the rest of the test stream. The other design is the one of figure 3, where the boattail has been eliminated. Unfortunately, this design suffers from the increased chance of separation of boundary layer on the injector. Such separation of boundary layer would be caused by interaction with the exit shock and the jet flow. If a nozzle of this design is cut off (see figure 3), the resulting nozzle has a finite lip thickness with a base region. Although the wake effects of this region cannot be computed close to the base, the probability of boundary layer separation is reduced. This result is obtained from the fact that the boundary layer can bleed into the wake and the compression effects of the divergent flow are eased. It was felt that the exit thickness (0.159 cm) of the injector chosen was sufficient to prevent separation but small enough to get a far field (several $r_j$'s) solution for the wake region. It is also pointed out that the experimental data of reference 12 indicates that the jet spreads better when injected from a blunt body of this type. Increased spreading (mixing) suggests better burning. This design was therefore adopted for the present investigations.

The cooling needed to protect the injector during each test is provided by the injectant (hydrogen). In the present tests, the hydrogen supplied at ambient temperature was heated to a total temperature of approximately 470 K as it cooled the injector before injection into the stream. With this total temperature, and stagnation pressures ranging from 1.59 to 1.94 MN/m$^2$, the injector supplied hydrogen mass flow rates of 0.015 to 0.018 kg/sec. The resulting equivalence ratio, based on
Figure 3. - Half cross section of a nozzle with no boattail but with a very thin lip. (Cutting the tip off this nozzle as indicated by the vertical line produces an injector of the type used in the present work.)
total flow in the test stream nozzle, varied from 0.381 to 0.467 and the exit (static) pressures ranged from 0.203 to 0.248 MN/m$^2$. The injector exit pressure was therefore about 2 times the test stream static pressure for each test, and the injected hydrogen was thus underexpanded.

Circular Combustor

In the ducted mode, constant area ducts of four different lengths (9.53, 12.70, 30.48, and 45.72 cm) were individually attached to the facility nozzle to form circular combustors. These combustors, constructed of stainless-steel, are uncooled (heat sink) and have numerous pressure orifices for measuring static pressure. The orifices are arranged in three rows (designated P, Q, and R in figure 4) that run axially along the duct with each row spaced 120° apart. A schematic of the 12.7 cm combustor, accompanied by a table summarizing the orifice locations for all four ducts, is given in figure 4.

Pitot Probes

The pitot probes used in the present tests were of two different designs. One design is a modified version of a probe developed by the Applied Physics Laboratory of Johns Hopkins University and reported in reference 13. It has an outside diameter of 0.635 cm and a tip half-angle of 30° (see figure 5 for details of probe tip). The other design is a slightly modified version of a probe described in reference 14. It has an outside tip of 0.914 cm and a tip half-angle of 20° (see figure 6 for details of probe).
**Figure 4.** Half section of 12.7 cm length duct (ken in the plane bisecting the pressure taps of Row P) with axial locations for all four ducts.
Figure 5. Cross section of the modified Johns Hopkins' probe.
Figure 6.- Half-section of the modified Eggers' probe.
Probes of both designs were water-cooled by a no return method. In this method, water is supplied through a single passage in the main body of the probe, sprayed against the rear of the probe tip, and then injected into the test stream at a location behind the pressure sensing region. Once in the test stream, the water is swept downstream over the probe body furnishing further cooling.

Pitot-pressure profiles were obtained with a single moving probe which was driven perpendicularly across the flow field at a rate of approximately 0.5 cm/sec by a dc motor. Comparisons of pitot pressures taken at the same points with the probe moving and stationary indicated that response of the pressure transducer was sufficient to give accurate measurements while moving. In addition, probes of either design gave the same results for identical test conditions.

Photographs and Shadowgraphs

Data obtained in the form of photographic records were of two types: black and white movies, and shadowgraphs. The movies were taken at a frame rate that varied from 20 to 64 frames/sec. They were used to check the pitot probe alignment and vibration. The shadowgraphs were taken at a constant frame rate of 24 frames/sec. They were used to define the flow quality and are quite valuable for analyzing the flow field.

Photographic records of both types were obtained on 16 mm black and white movie film with an ASA number of 400 (Lin number of 27). The total photographic records will not be included in this work. However, an example of the shadowgraphs are given in figure 7.
(a) Test stream and jet.

(b) Flow-up of wave structure.

Figure 7.- Shadowgraph of the test stream and jet in the free-jet mode with combustion.
Example of Pitot Test Data

Although the majority of the test data is to be presented in Chapter IV, the exit pitot surveys are introduced here to provide a feel for the experimental data. In figures 8 and 9, radial exit pitot pressure profiles for the free-jet reacting and nonreacting cases are given respectively. Both profiles have the same general shape, however their peak (centerline) values are not equal. The nonreacting peak value is less than the reacting, since it is taken at an axial location slightly downstream of the axial location of the reacting case. The solid line of both figures is a straight line connection of adjacent data points intended as a guide to the data trend.

Since both cases have the same shape, only one discussion will be offered. This discussion uses the letters common to both of these figures, and the flow schematic of figure 10. The pitot pressure varies radially in the following manner. The pressure decrease in going from points a to b is due partly to the radial travel across the conical jet flow field, and partly to an expansion fan from the injector lip. Both processes result in higher Mach numbers, and thus lower pitot pressures. The small peak at c is the result of the shock wave which terminates the expansion fan. The decrease in pressure from c to d is due to the shock wave indicated at c and the fact that d is in the base region of the injector. The shock indicated at c is a curved shock which extends from the injector lip at the exit to the centerline at a slightly downstream location. Thus, much of the region c to d is behind the curved shock, whose strength varies from a minimum near the
Figure 8. Pitot profile at exit of injector ($x/r_j = 1 \pm .5$) with air test medium.
Figure 9. - Pitot profile at exit of injector ($x/r_j = 1.5 \pm .5$) with nitrogen test medium.
Figure 10. - A schematic of the free-jet flow field with various prominent features at the survey location labeled.
injector lip to a maximum at the centerline. The strength variation in this region produces a radial pitot pressure profile which varies in the same direction (minimum to maximum), whereas the radial Mach number profile varies in the opposite direction. In idealized flow, d would be the location of a slip line separating the test stream and jet flow. In the present work, the radial region near d is probably a mixing boundary. Point e is the underexpansion or exit shock wave which extends from the injector’s outer lip to the test stream boundary, where it is reflected as an expansion fan. Therefore, the region d to e is similar but in opposite sense to the region c to d. The region from e to f is the test stream without any interaction. The dip from f to g is an indication of the free-jet test stream interacting with the ambient air.

It may be surmised from the above discussion that the flow field resulting from the underexpanded injection of hydrogen into supersonic flow is quite complex. As a consequence, the theoretical treatment by necessity must be rather sophisticated. The theory used for comparison in this work is that of reference 8, and is outlined in the next chapter.
CHAPTER III

THEORY

General Governing Equations

The basic governing equations are the well known "viscous-inviscid" equations used in higher order boundary layer and viscous flow field analysis with the finite rate chemistry terms included. These "viscous-inviscid" equations are supplemented by the Rankine-Hugoniot and Prandtl-Meyer relations to facilitate the computation of shock and expansion conditions respectively. The basic equations are given in Appendix A along with a limited discussion of how they are applied. The reader interested in a more thorough delineation of the equations and the numerical application may consult references 15, 16, and 17.

Viscosity Models

The program as published in reference 9 had a turbulent eddy viscosity model referred to as the "Ferri-Kleinste" model. This model, which was developed in references 18 and 19, has viscosity variation in the axial direction only. However, it was felt that Eggers' viscosity model (see reference 20), which varies both axially and radially, may be more accurate. Thus, it was decided that the program would be run with both models individually incorporated.

Ferri-Kleinstein Model

In this model, the turbulent eddy viscosity undergoes an axial variation from the jet exit to the end of the potential core. The length
of the potential core is defined as: the distance $x$ from the jet exit to the downstream location where the mass fraction of hydrogen on the centerline becomes less than 0.99. The viscosity is then assumed to be constant for all locations downstream of the potential core length $x$.

The viscosity is computed, for stream locations ($x/r_j$) less than $x$, with the nondimensional equation,

$$
\mu = K_1 \text{Re} \left( (\rho q)_{\text{max}} - (\rho q)_{\text{min}} \right) \left( \frac{x}{r_j} + K_3 \right)
$$

(1)

where, $K_1 = 7.5 \times 10^{-4}$ and $K_3 = 100$.

For stream locations equal to or greater than $x$

$$
\mu = K_1 \text{Re} \left( (\rho q)_{\text{max}} - (\rho q)_{\text{min}} \right) x + K_3
$$

(2)

and since $\mu$ is constant downstream of the length $x$, equation 2 is executed once. The resulting value of $\mu$ is stored for future downstream calculations.

**Eggers' Model**

There are two viscosity models generally referred to as Eggers' model, thus one must be careful to specify the model intended. The two models, which are similar in mathematical structure, are called $Z$-difference and kinematic $Z$-difference models by Eggers (reference 6). In the $Z$-difference model (see reference 20) the absolute viscosity varies axially only and is computed using the nondimensional equation,

$$
\mu = K_Z (\rho q)_{\text{CL}}
$$

(3)

In the kinematic $Z$-difference model, the kinematic viscosity varies axially and is computed using the nondimensional equation,
The absolute viscosity is obtained by multiplying the kinematic viscosity (of equation 4) by the local density which varies radially. Thus, the absolute viscosity varies both axially and radially, and is computed with the equation,

\[ \mu = \rho_{\text{local}} K Z (q)_{CL} \]  

(5)

In all three equations (3-5), the empirical constant \( K \) has a value of 0.01. The quantity \( Z \) is defined as the radial distance between the points where the local velocities are \( U_1 \) and \( U_2 \) as given by the equations,

\[ U_1 = U_a + 0.95 (U_{CL} - U_a) \]  

(6)

and,

\[ U_2 = U_a + 0.5 (U_{CL} - U_a) \]  

(7)

where \( U_a \) equal the stream velocity external to the jet.

It is the model computed by use of equation 5 that is referred to as the Eggers' model in this work.
CHAPTER IV

RESULTS AND DISCUSSION

The experimental data and theoretical predictions of the present study are presented in dimensionless form. All pressures are nondimensionalized by dividing by the test stream stagnation pressure \( P_t \). Similarly, dimensionless coordinates and lengths are obtained by division by the hydrogen jet radius \( r_j \) at the exit of the injector. It is also noted that all theoretical calculations were performed with a Lewis number of 1.

Free-jet Data

Radial pitot pressure surveys were taken at several axial stations for the free-jet mode and at the end of the ducts when operating in the ducted mode. The pitot pressure data (surveys) for each mode of operation can be subdivided into reacting and nonreacting cases. In the reacting cases, the test stream is air, and in the nonreacting cases the test stream is nitrogen.

The data for the free-jet reacting cases given in figure 11 are typical and will be discussed. The pitot surveys were made at axial locations \( x/r_j \) of 1, 19, 30, 40, 56, and 80. The data for the axial location \( x/r_j = 1 \) equal one were previously presented in figure 8, and will not be covered here. The prominent features, such as high jet centerline pressure bounded by jet mixing boundaries, present at the \( x/r_j = 1 \) location extend downstream. In fact, the high centerline pressure is present for the \( x/r_j = 19, 30, \) and 40 locations. However, the mixing
Figure 11.- Experimental and theoretical pitot profiles at various axial locations for the reacting free-jet mode (Perry-Kleinlein viscosity model).
Figure 11.— Continued.

(c) $x/r_j = 40$
region has engulfed the centerline at the $x/r_j = 56$ location and the centerline is not discernible. The regions of no interaction, previously discussed in the section on the pitot sample, have become tenuous at the $x/r_j = 56$ location. This demise of these regions is attributed to the fact that free-jet test mixing boundary spreads inward to meet the jet-test-stream mixing region which spreads outward.

Other details of the data are given in the following discussion, in which theoretical predictions are compared with the data.

The theoretical calculations at the free-jet test stream boundary were not expected to agree with the experimental data, since the program does not have the necessary theory for handling the test stream mixing boundary. The program takes a constant pressure boundary approach which is sufficient for mathematical consistence, but improper for actual boundary conditions. This approach does not affect the accuracy of the calculations performed for the region inside the test stream mixing boundary since this region is supersonic. Thus, the boundary disturbances cannot be transmitted to the internal region of interest, and the calculations should be in agreement with the experimental data. Unfortunately, an actual comparison of the theoretical calculations and the experimental data does not show such agreement. In figure 11, for example, there is a comparison of the experimental pitot pressure data to theoretical calculations performed with the Ferri-Kleinstein viscosity model. The test stream is air, and the theoretical data are for Prandtl numbers of 0.7 and 1.4. As expected, there is no agreement in the region of the test stream mixing boundary. For axial locations $x/r_j = 19$ and 30 where there is a
region of test stream not affected by the mixing boundary or jet interaction, the agreement is excellent. (At \( x/r_j = 19 \) these regions extend from \( y/r_j = -7.5 \) to \(-4\) and from \( y/r_j = 4 \) to \(9\).) This agreement indicates that the constant pressure boundary approach does not affect the accuracy of the program for the region internal to the test stream mixing boundary. However, the only other semblance of agreement is at the centerline region \( y/r_j = \pm 1 \) and that is not complete. For example, the centerline differences between the experimental and theoretical values \( Pr = 0.7 \) are given in Table 2.

Table 2

<table>
<thead>
<tr>
<th>( x/r_j )</th>
<th>( z ) difference @ ( \xi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>80</td>
<td>10</td>
</tr>
</tbody>
</table>

This erratic agreement on the centerline suggests that the analytical technique does not handle the wave structure internal to the jet (see figure 7).

Theoretical jet mixing (spreading) effects, as indicated by pitot pressure, are much too large at all the axial locations (this may be observed by comparing the theoretical and experimental widths of the region of interaction in figure 11).
In figure 12, the theoretical data computed using the Eggers' viscosity model (and Prandtl number of 0.7, 1.1, and 1.4) are compared to the same experimental data given in figure 11. As can be seen, the agreement with this viscosity model is about the same as that of the Ferri-Kleinstein model. Likewise, the discussion of figure 11 is in general true of figure 12.

The nonreacting free-jet case, resulting from the use of nitrogen as the test medium, is presented in figure 13. The theoretical results obtained with each of the viscosity models are so close together that only the theoretical results obtained with Eggers' model will be presented. In this figure, only the theoretical results obtained with a Prandtl number of 1 are offered since this gives the best agreement. At an axial location of $x/r_j = 19$ theoretical and experimental results have the same general shapes. The numerical agreement, however, is quite poor in the near centerline region $y/r_j = \pm 1.5$. In addition, the shape agreement is short lived and disappears by the time an axial location of 40 is reached. For all values of $x/r_j \geq 40$ the experimental data have a minimum at the centerline and the theoretical have a maximum. That is, the theoretical data exhibit a valley in the near centerline region. These results indicate that the theoretical near centerline Mach numbers are too low, thus producing pitot pressures which are too high. This contrary behavior of the theoretical predictions is probably due to improper handling of the jet wave structure.

The expected disagreement for the test stream mixing boundary is also present. Furthermore, the region of no test stream interaction (for
Figure 12.- Experimental and theoretical pitot profiles at various axial locations for the reacting free-jet (Eggers' viscosity model).
Figure 12. Continued.

(b) \( x/l_j = 30 \)
Figure 13: Nonreacting free-jet pitot profiles at various axial locations. (Theoretical curve represents both viscosity models, and a Prandtl number of 1.)
(b) \( x/r_j = 30 \)

Figure 13. - Continued.
Figure 13—Continued.

(c) $x/r_j = 40$
Nitrogen Test Gas

\[
\frac{p_{t_2}}{p_{t_0}}
\]

\[
\frac{y}{r_j}
\]

(d) \( x/r_j = 56 \)

Figure 13.- Continued.
example at $x/r_j = \pm 7.0$ to $\pm 2.0$ gives excellent agreement between the experimental and theoretical values of pitot pressures.

**Ducted Data (Circular Combustors)**

The experimental data for the ducted case are presented in figures 14, 15, and 16. Figure 14 presents the pitot surveys made at the exit of the four ducts using air test medium (reacting case). Figure 15 gives similar data for the nonreacting case (nitrogen test medium). Figure 16 gives the static pressures measured along the various ducts. The static pressure measurements and exit pitot profiles were made simultaneously for each duct. The same technique was used for both air and nitrogen test gas.

The program was unable to calculate the flow field for even the shortest (length = 30 $r_j$) duct, therefore a comparison between the experimental and theoretical data cannot be made. The inability of the program to compute the flow field for the ducted cases stemmed from the fact that the underexpansion shock wave, which reflects from the duct wall, is unable to traverse the region of test stream jet interaction. The flow angle computed for the jet and its interaction with the test stream are inconsistent with the shock wave and the rest of the flow field. The reflected shock is not suspect since it is fully compatible with the portion of the test stream which has not interacted with the jet.

**An Evaluation of the Analytical Tool**

The utility of the analytical tool as applied here appears quite limited with either of the two viscosity models employed. This is not
Figure 14.- Lateral pitot pressure distributions at the exits of the four ducts. (Test medium, Air)
Figure 15.- Lateral pitot pressure distributions at the exits of the four ducts. (Test medium, Nitrogen)
Figure 16.- Static pressures along the duct wall.
to imply that the inadequacy of the program is due to the viscosity models employed. In fact, the similar results obtained with the two different models indicate that the fault lies in handling the internal (jet) flow, and its interaction with the test stream. This hypothesis is further supported by the fact that the spreading as indicated by theoretical pitot pressure is excessive for the reacting case (see figures 11 and 12). Similarly, pitot pressure was consistently overpredicted by the program for the nonreacting case, particularly in the near centerline region which is highly dependent on the jet flow.

Another failing of the program is that it did not detect the fact that the expansion fan is terminated by an intersecting shock front. A discussion of why there is an intersecting shock terminating the fan can be found in reference 21, and one may refer to the discussion of figures 7 and 8 for the location of the shock. The program has incorporated in it a subprogram which checks the entire flow field at one axial location before each downstream marching step is taken, to see if a pressure gradient exists. If a pressure gradient of sufficient strength is encountered, it inserts an embedded shock wave. Thus, it must be concluded that the computed jet flow did not produce the pressure gradient necessary for shock wave insertion.

It should be noted that all of the shortcomings of the analytical approach, detected by the present work, are associated with the divergent internal (conical jet) flow and its interaction with the test stream. Thus, there is the possibility that it can be successfully applied to the case of underexpanded jets whose flow divergence is small at the injector
It is felt that the analytical predictions can be improved by replacing the present method of handling the jet flow with a characteristic expansion network. This network, which would require considerable effort to implement, would be terminated by an intersecting shock front. The intersecting shock may require little additional effort since the subprogram previously mentioned may insert the required shock once the proper jet flow is computed by means of an expansion network. An improved program, which correctly handles the jet flow by an expansion network, would be very useful and probably effective in analyzing underexpanded jets.
CHAPTER V

CONCLUDING REMARKS

One of the major technological problems facing the scramjet engine concept is the ability to successfully predict the flow field resulting from the injection, mixing, and combustion of hydrogen fuel. Such predictions are necessary for good design of major components of the engine (i.e. fuel injectors, the combustor, and the exit nozzle). Of particular importance here is the ability to predict the flow field resulting from underexpanded injection of hydrogen. More fundamental, however, is the need for experimental data on an underexpanded \( \text{H}_2 \) jet in a supersonic flow.

The present work has accomplished the task of furnishing a small data base on the coaxial injection of an underexpanded \( \text{H}_2 \) jet into supersonic flow. The data obtained are for a Mach 2 test stream of air or nitrogen, and a Mach 2 hydrogen jet whose exit pressure is approximately twice the test stream static pressure. Since the air or nitrogen test stream has a static temperature of 1338 K, data with and without combustion is provided. In addition, the facility was operated in a free-jet mode and in a ducted mode furnishing data for four different duct lengths. The free-jet data consist of radial pitot profiles at various axial locations. The ducted data consist of radial pitot profiles at the duct ends and static pressures measured along the duct walls. In addition, the present work tested the utility of an analytical technique designed to predict the flow field resulting from the injection of

50
an underexpanded jet into supersonic flow. The theory is tested by comparing experimental data with theoretical predictions. The theoretical calculations, which cover a wide range of Prandtl number (0.7 to 1.4), were unable to correctly predict the experimental results.
REFERENCES


APPENDIX A

THEORY

General Governing Equations

The basic governing equations are the well known "viscous-inviscid" equations used in higher order boundary layer and viscous flow field analysis (see references 15, 16, and 17) with the finite rate chemistry terms included. These equations are evolved from the full Navier-Stokes equations by assuming that the transport effects depend only on gradients normal to the streamlines. (The normal momentum equations are kept in the inviscid form.)

These equations, written in nondimensional form for an intrinsic coordinate system (with \( s \) along the streamlines and \( n \) normal to the streamlines), are as follows for axisymmetric flow.

\[ \frac{\partial (\rho q)}{\partial s} + \rho q \frac{\partial \theta}{\partial n} + \frac{\rho q}{y} \sin \theta = 0 \]  
\[ (A1) \]

\[ \rho q \frac{\partial q}{\partial s} + \frac{j p}{s} = S_1 \]  
\[ (A2) \]

where,

\[ S_1 = \frac{1}{Re} \left[ \frac{\partial}{\partial n} \left( \frac{\mu}{\partial n} \right) + \frac{\mu \left( \cos \theta \right)}{y} \frac{\partial q}{\partial n} \right] \]

\[ \psi - \text{Momentum:} \]

\[ \rho q^2 \frac{\partial \theta}{\partial s} = \frac{\partial p}{\partial n} \quad \n \]  
\[ (A3) \]
Energy:

\[ \rho q \left( C_p \right) \frac{\partial T}{\partial s} - q \frac{\partial p}{\partial s} = S_2 - \Sigma W_1 h_1 \]  \hspace{1cm} \text{(A4)}

where,

\[ S_2 = \frac{1}{\text{Re} (Y_0 - 1)} M_{\infty}^2 \left[ \frac{\partial}{\partial n} \left( \frac{\mu C_p}{\text{Pr}} \frac{\partial T}{\partial n} \right) + \frac{\mu C_p}{y \text{Pr}} \frac{\partial T}{\partial n} \right] + \frac{\mu (Le)}{\text{Pr}} \frac{\partial T}{\partial n} \sum \frac{\partial x_i}{\partial n} + (Y_0 - 1) M_{\infty}^2 \mu \left( \frac{\partial q}{\partial n} \right)^2 \]

Species Conservation:

\[ \rho q \frac{\partial x_i}{\partial s} = S_{3i} + W_i \]  \hspace{1cm} \text{(A5)}

where,

\[ S_{3i} = \frac{1}{\text{Re}} \left[ \frac{\partial}{\partial n} \left( \frac{\text{Le} \mu}{\text{Pr}} \frac{\partial x_i}{\partial n} \right) + \frac{\mu \text{Le} \cos \theta}{y \text{Pr}} \frac{\partial x_i}{\partial n} \right] \]

State:

\[ p = \frac{W_0 \rho T}{\gamma_0 M_{\infty}^2 W} \]  \hspace{1cm} \text{(A6)}

where,

\[ w = \left[ \sum \frac{x_i}{m_i} \right]^{-1} \]

For supersonic flow fields, the above equations (A1 to A6) have a dual mathematical nature (see reference 15). That is, they exhibit features of both hyperbolic and parabolic systems. The analytical tool of reference 9, therefore, uses a numerical scheme employing a characteristic network in conjunction with a boundary layer type network to yield a coupled solution. This scheme is thoroughly discussed in reference 17,
and will not be fully covered here. However, the following description of the approach used by the scheme is offered.

Essentially, the approach finds a characteristic solution which feels the effects of diffusion and finite rate chemistry. This is done by treating the diffusive and chemistry terms as forcing functions in the "compatibility relation" along characteristics. Treating these terms as forcing functions results in the characteristic directions of the viscous system being exactly those of the inviscid system. Namely, the frozen Mach line (Cz)

\[
\frac{dy}{dx} = \tan (\theta \pm \bar{u}_f)
\]

(A7)

and thus the streamlines are defined by the equation

\[
\frac{dy}{dx} = \tan \theta
\]

(A8)

The compatibility relation can be shown to be (see reference 17 for an excellent derivation)

\[
\frac{\sin \bar{u}_f \cos \bar{u}_f}{\gamma_\infty P} dp + \left[ \frac{\sin \theta}{y} + \frac{S_1}{\rho q^2} \right] \left[ \frac{(\gamma_f - 1)}{\gamma_\infty P} S_2 + \frac{(\gamma_f - 1)}{\gamma_\infty P} \left( \frac{a_\infty}{3} - 1 \right) \frac{\rho^2}{\rho q} \right] W_i h_i - \frac{W}{\rho q} \left[ \frac{S_3}{m_i} + \frac{w_i}{m_i} \right] \frac{\sin \bar{u}_f}{\cos (\theta \pm \bar{u}_f)} dx = 0
\]

(A9)

The program of reference 9 is designed to analyze the mixing and combustion of an underexpanded \( H_2 \) jet; therefore, it is apparent that the equations previously presented are not sufficient. Since the jet is
underexpanded, it has an exit pressure greater than the test stream static pressure and must expand into the test stream. The expanded jet, however, is seen by the test stream as an obstruction and an exit shock wave is generated. In addition, embedded shocks caused by combustion compression are possible downstream. The equations required to perform the expansion and shock calculations are also incorporated into the program (reference 9).

The expansion was assumed to be isentropic, two dimensional, and inviscid in the limit of vanishing radial distance with respect to the injector lip. These assumptions allowed the use of the following isentropic relations (Prandtl-Meyer expansion) near the injector’s lip.

1. State $\frac{p}{\rho^\gamma} = \text{constant}$ (A15)

2. Energy $h + \frac{1}{2} \mathbf{v}^2 = \text{constant}$ (A11)

3. Momentum $\frac{\rho}{\rho} \frac{dp}{p} + \frac{1}{2} \frac{d(V^2)}{V} = 0$ (A12)

4. Compatibility $\frac{1}{\gamma} \frac{d(\&n\rho)}{n} + \frac{d\Theta}{\cos \mu \sin \mu} = 0$ (A13)

In the case of the shock wave, it was assumed that the chemistry was frozen across the shock and that it was two dimensional (the 2-D shock is an exact solution for the conical shock if there is no angle attack). Thus, the following Rankine-Hugoniot relations were incorporated into the program. They are:

1. Continuity $\rho_1 U_1 = \rho_2 U_2$ (A14)

2. Normal Momentum $p_1 + \rho_1 (U_1)^2 = p_2 + \rho_2 (U_2)^2$ (A15)

3. Tangential Momentum $V_{t_1} = V_{t_2}$ (A16)

4. Energy $H = h + (1/2)V^2 = \text{constant}$ (A17)

where, $h = \Sigma \alpha_i h_i(T)$
5. State \( p = \rho(p, T, \theta_i) \) \hspace{1cm} (A18)

Exit (Underexpansion) Shock

As previously stated, when the jet expands into the test stream an exit (underexpansion) shock wave is generated. The idealized flow resulting from such an interaction is depicted in figure A1.

Although it can easily be deduced that the pressures (\( p \)'s), and flow angles (\( \theta \)'s) are equal on either side of the slip line separating the regions 1 and 2 of this figure, it is not possible to calculate them by a direct method. Fortunately, the downstream conditions can be calculated by the iterative process that follows. A shock angle is chosen (an angle slightly larger than \( \sin^{-1}(1/M_{\infty}) \) is a good choice) and the downstream properties \( (p_1, T_1, \theta_1, \text{etc.}) \) are computed. The jet is then expanded from its exit pressure to the pressure \( p_2 = p_1 \). If the flow angle \( \theta_2 \) associated with this pressure does not equal the flow angle \( \theta_1 \) downstream of the shock wave, a new shock angle is selected and the above procedure is repeated until convergence is obtained. The stream properties \( (p, \theta) \) for which convergence is obtained are the properties existing across the slip line of figure A1.
Figure A1. - A schematic of the flow field resulting from the interaction of the test stream and the underexpanded jet.
APPENDIX B

MODIFIED COMPUTER PROGRAM

The original program of reference 9 has been streamlined and modified to the extent that it is not readily recognized as essentially the same program. Numerically, both old and new versions give the same mathematical results for the cases they are both able to handle. (The original program was not able to handle shock waves which ran from the outer boundary toward the centerline, and various other subtleties.) The version given here has the Ferri-Kleinstein viscosity model as did the original of reference 9.
BEGIN INPUTTING PARAMETERS
WRITE(6,480)
112 FORMAT(I5,5X,9.15)
480 FORMAT(1H1)
C     J=0 TWO DIMENSIONAL
C     J=1 AXISYMMETRIC
C     SPECIES 1 IS H
C     SPECIES 2 IS O
C     SPECIES 3 IS H2O
C     SPECIES 4 IS H2
C     SPECIES 5 IS O2
C     SPECIES 6 IS OH
C     SPECIES 7 IS H2
WMOLE(1)=1.009
WMOLE(2)=16.
WMOLE(3)=16.016
WMOLE(4)=2.016
WMOLE(5)=32.0
WMOLE(6)=17.008
WMOLE(7)=28.014
FAS=WMOLE(4)/16.
J23=0
X00=0.
IDG=0
DEL=0.
DO 8220 I=1,4
      BETAN(I)=0.
      BETB(I)=0.
      IS(I)=0
8220 CONTINUE
IFS=0
MSP=7
Q0=1.987
RO=RO0=3.087*32.2*2.205*1000.
EP=1.E-10
EPH=1.E-10
EPQ=1.E-10
EPT=1.E-10
ICHEN=1
M0=8
EXX=1.E-06
I13=0
KFIRST=-1
KKQ=10000
JCONV=8
INPTS=0
363 CONTINUE
CALL INDATA
C ********************************************************* MAKE INITIAL SHEAR
VISD=VISI(KBPI)
CFF=8.
CALL SHEAREL(CFF,VISW)

6789 CONTINUE
CALL EMRED
VIS=VISD=VISC=VISE=VISA=VIS(N1)
VISD=VISB=DOISA=VISB=8.
DO 7198 K=1,NPTS
DO 7199 J=1,NSP

7198 CONTINUE
IF(KOUNT.LT.KKKK) GO TO 407
IF(I311.EQ.1) GO TO 407
IF(KOUNT.EQ.KOUNT0) GO TO 407
IF(KCOUNT.LT.LLL) KOUNTGO TO 179
407 WRITE(6,408) KOUNT
408 FORMAT(7H1KOUNT=1S)
WRITE(6,526) K11
526 FORMAT(5H X = E13.5)
DO 9485 I313=1,4
IF(BET0(I313).EQ.0.) GO TO 9485
IF(I313.LT.1) 1WRITE(6,8484) I313,BET0(I313)
19484 FORMAT(5H X = E13.5)
DO 9485 I313=1,4
IF(BET0(I313).EQ.0.) GO TO 9485
19484 FORMAT(5H X = E13.5)
9485 CONTINUE
VIS=VIS*9.*VISINF
WRITE(6,7222) VISW
7222 FORMAT(5X,11HVISCOSITY =E13.5,15H (LB*SEC**21))
WRITE(6,5207)

5207 FORMAT(5X,3HPTT++,11X,1MY,11X,1MQ,11X,1MT,11X,1MP,11X,1MH,11X,1MB)
12HM11X3HHERO183X9HAMP9X5HPTOT)
DO 70 I=1,NPTS
P(I)=PIN
70 P(ITOT(1)*P(1)*PRES*I(GAMM(1)*I1.15*EM(1)**2))**2**(GAMM(1)/(GAMM(1)-1.))
4**2**(GAMM(1)/(GAMM(1)-1.)*I1.15*EM(1)**2))**2**(GAMM(1)-1.)*1.)/
0.15-GAMM(1))
WRITE(6,112) I1,Y(I1),T(1),P(I),TH(I),EM(I),RH0(I),GAM0(I),PITOT
1(I),I=1,NPTS)
DO 71 I=1,NPTS
71 P(I)=PIN
WRITE(6,150)
160 FORMAT(12X,6HALP(1),7X,6HALP(2),7X,
6HALP(3),7X,6HALP(4),7X,6HALP(5),7X,6HALP(6),7X,6HALP(7),9X,3HPHI
2.11X1HW)

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WRITE(6,112) (I, ALP(I) ) * PHI(I) + W(I) = 1, NPTS)
179 CONTINUE
   IF(KOUNT.GE.IKKKK) GO TO 1572
   IF(I.EQ.1) GO TO 1572
   ALPHA=1.0
   BETA=0
   CALL STEP(VIS)
   IF(I.EQ.1) GO TO 407
   IF(KOUNT.NE.KFIRST .OR.I13.NE.1) GC TO 300
   CALL PUNCH
   IF(J31.I.EQ.JSUBU .AND.JSUBU .LE.JSUBU)
   Y PRIII(Y I)
   THPRED(I) = TH(I)
301 CONTINUE
300 CONTINUE
   CALL CHEM(FAS)
8292 CONTINUE
   ICONT=0
   IEND=1
   L=2
807 IF(L.GE.JSUBU .AND.L.LE.JSUBU) GO TO 956
888 K=L
   KT=L-1
   IF(L.EQ.MAX) GOTO 612
   IF(L.EQ.JSUBU .AND.ICONT.EQ.1) GO TO 1622
   IF(BETB(1).EQ.0 .AND.BETB(2).EQ.0 .AND.BETB(3).EQ.0 .AND.BETB(4).EQ.0 .EQ.0)
   GO TO 777
   IF(BETB(1).GT.0 .OR.BETB(3).GT.0 .EQ.0)
   777 IF(K.EQ.IS(2) .OR.K.EQ.IS(4) ) GO TO 8236
   IF(K.EQ.IS(1) .EQ.182311 .EQ.775
    8231 IF(K .EQ.IS) .EQ.18234 .EQ.773
    776 IF(K .EQ.IS(1) .EQ.1) GO TO 11
    777 MMM=1
   K=IS(I)
   KT=K
   GO TO 8232
11 IF(K .EQ.IS(3) .EQ.1) GO TO 22
773 MMM=3
   K=IS(3)
   KT=K
   GO TO 8232
22 IF(K .EQ.IS (2) ) GO TO 33
   MMM=2
   GO TO 8232
33 IF(K .EQ.IS(4) ) GO TO 44
   MMM=4
   GO TO 8232
44 IF(K .EQ.IS(2) .EQ.1 .OR. K .EQ.IS(4) .EQ.1) 988888 .EQ.234
88888 K=K+1
L=K
K=L-1
GO TO 8234
8232 L=K
8230 IFS=1
 IPOI=1
ALSX=ALPHA
BEX=BETA
IF (BET11 .EQ. 0 AND. BET12 .EQ. 0 AND. BET13 .EQ. 0 AND. BET14 .EQ. 0) GO TO 772
IF (BET11 .GT. 0 OR. BET13 .GT. C) GO TO 772
KTSAX=KT
772 CALL CPOINT
THD=THN(K)
ALPHA=.5
BETA=.5
IF (BET11 .EQ. 0 AND. BET12 .EQ. 0 AND. BET13 .EQ. 0 AND. BET14 .EQ. 0) GO TO 2194
IF (BET11 .GT. 0 OR. BET13 .GT. C) GO TO 2194
K=KTSAX
215 CALL 'JPAINT'
L=K
IF (L .LT. 20) GO TO 2195
WRITE(6,4191)
WRITE(6,2196)
2196 FORMATTING ERROR IN CPOINT ITERATION FOR SHOCK IN CHAR.
STOP
2195 THD0=ABS(THD-THN(K))
THD=THN(K)
IF (BET11 .EQ. 0 AND. BET12 .EQ. 0 AND. BET13 .EQ. 0 AND. BET14 .EQ. 0) GO TO 771
IF (BET11 .GT. 0 OR. BET13 .GT. C) GO TO 771
KT=KTSAX
771 IF (ERTNO .GT. EXXX) GO TO 2194
ALPHA=ALSX
BETA=BEX
IF (K .EQ. IS1) MMH=2
IF (K .EQ. IS4) MMH=4
IFS=2
CALL HKCHCK(MMH)
IFS=0
K=K+1
L=L+1
GO TO 887
8234 CONTINUE
IPJ=1
ALSX=ALPHA
BEX=BETA
CALL CPoi NT
KT=L-1
THID=THN(K)
ALPHA=5
BETA=5
26C1 CALL CPoi NT
KT=L-1
IPOI=IPOI+1
IF(IPOI.LT.20)GO TO 26A2
WRITE(6,919)
9191 FORMAT(1X)
WRITE(6,2197) K
2197 FORMAT(53H ERROR IN STANDARD CPOi NT ITERATION IN CHAR AT POINT 12)
STOP
26C2 ERROR=ABS(THID-THN(K))
THID=THN(K)
IF(SELECT(.LT.EXX)) GO TO 26C1
ALPHA=ALSV
BETA=BEVS
C **************************** INCREASE COUNTERS DO NEXT C POINT
9C1 CONTINUE
K=K+1
IF(L.EQ.NPTS) GO TO 76F6
L=L+1
IF(TOTNTP.EQ.1) GO TO 8A8
GO TO 8A7
C NOZZLE WALL CALCULATION
612 CONTINUE
IPOI=1
ALSV=ALPHA
BEVS=BETA
CALL LPCI AT(NPTS+1)
K=NPTS
THID=THN(K)
IF(1) IPRESU.EQ.0) THID=PN(K)
ALPHA=5
BETA=5
26C7 CALL LPCI AT(NPTS+1)
K=NPTS
IPOI=IPOI+1
IF(IPOI.LT.20)GO TO 26A8
WRITE(6,919)
919A FORMAT(1X)
WRITE(6,2198) K
2198 FORMAT(53H ERROR IN NOZZLE WALL CALCULATION ITERATION IN CHAR)
STOP
26A8 ERROR=ABS(THID-THN(K))
IF(1) IPRESU.EQ.0) ERTHO=ABS(1.-THID/PN(K))
THID=THN(K)
IF(1) IPRESU.EQ.0) THID=PN(K)
IF(ERTHD.GT.EXXX) GO TO 2607
ALPHA=ALSY
BETA=BEV
C COMPLETE FIRST POINT
7676 CONTINUE
IF(JSUBL.EQ.1) GO TO 1800
CALL LPCINT(1,0.)
K=1
IPOI=1
ALSY=ALPHA
BEV=BETA
THDE=THN(K)
IF(IPRESS.EQ.0) THDE=PN(K)
ALPHA=5
BETA=5
2609 CALL LPCINT(1,0.)
K=1
IPOI=IPOI+1
IF(IPOI.LT.20) GO TO 2610
WRITE(6,9191)
WRITE(6,2199)
2199 FORMAT(39, ERROR IN FIRST POINT ITERATION IN CHAR)
STOP
2610 ERTHD=ABS(THDE-THN(K))
IF(IPRESS.EQ.0) ERTHD=ABS(1.-THDE/PN(K))
THDE=THN(K)
IF(IPRESS.EQ.0) THDE=PN(K)
IF(ERTHD.GT.EXXX) GO TO 2619
ALPHA=ALSY
BETA=BEV
C SUBSONIC PRESSURE ITERATION
1800 CONTINUE
IF(JSUB.EQ.0) GO TO 1622
IF(IICNT.EQ.1) GO TO 1622
IF(JSUB.NE.1.OR.KOUNT.NE.KFIRST) GO TO 1777
CALL PDPHTH(THS+JSUBU)
CALL PDPHTH(TH+JSUBU+1)
CALL PDPHTH(TM+JSUBU-1)
CALL THSS(TMSS)
AUP=Y(JSUBU)
BU=TAN(1TH(JSUBU))
IF(IREG1.NE.0.AND.JSUBU.EQ.JSUBU) GO TO 8375
CUP=THS/COS(TH(JSUBU))**3
DUP=(THS**3*TAN(TH(JSUBU))**3+THS)/COS(TH(JSUBU))**4
EUP=-4.095
GO TO 8376
8375 CONTINUE
CUP=0.
DUP=-1.

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EUP=0.

0376 CONTINUE
DO 391 JSUB=JSU8
381 CALL DPCTHR(OTSPIII,I)
1777 CONTINUE
CALL SSCHIG(TOS)
IF(ING.EQ.2) GO TO 1622
II=1
IPUNCH=1
GO TO 677
1622 CONTINUE
IF(ISUB.EQ.0) GO TO 359
IF(JCCNV.EQ.1) GO TO 355
IF(MNNT.EQ.KKQ-1) GO TO 361
IF(IPTSBN.EQ.0) NPTS=0
INPTS=1
REWIND 7
GO TO 369
360 NPTS=NPTS
INPTS=0
359 DC 357 I=1,NPTS
II=NPTS+II+1
IF(MNNT.IEQ.GT.EMST) GO TO 397
IF(ISUB.EQ.1) GO TO 355
ISUB=1
WRITE(6,354)
354 FORMAT(3H1) SUBSONIC REGION ENCOUNTERED)
EMST=EMSUB
EMSUB=1.15
API=0
IREGI=0
GO TO 359
355 K=II+1
IF(IREGIG.EQ.1) JSUB=0
GO TO 358
357 CONTINUE
IREGI=2
GO TO 361
358 CONTINUE
IF(JCCNV.EQ.0) GO TO 1417
JCCNV=0
DO 1416 I=1,NPTS
II=NPTS+II+1
IF(MNNT.GT.EMST) GO TO 1418
GO TO 1417
1418 CONTINUE
IREGI=2
II=0
EMSUB=EMST

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COMMON/AX/JSPLC,JSUW
COMMON/BF/ALP(7,55),EM-INF,XINF
COMMON/BC/XMASS(55)
COMMON/CJ/CP(7,55),CP1(7),CPX(55)
COMMON/CW/PMOLE(7)
COMMON/D8/BEET(4),IS14
COMMON/ED/CPR1,RC
COMMON/E/EM(55),GAM(55),P(55),TH(55),Y(55)
COMMON/EC/GAMINF,M1(7),RINF
COMMON/EG/DXY
COMMON/HL/ALPHA,BETA
COMMON/HM/ALPN(7,55),CPN(7,55),CPY(55),EMN(55),EMMN(55),MN(7,55),
  LN(55),QN(55),QMN(55),P(55),THN(55),TN(55),WN(55),XH(55)
COMMON/HP/PHN(55),PHN2(55),PHN(55),SPN(55),SPN(55),THN(55),TN(55),WN(55),XH(55)
COMMON/R/PJCH4,HSP(55)
COMMON/AR/RH(7,55),RH(7,55),RH(7,55),RH(55)
COMMON/CH/R(55)
COMMON/TL/RH(7,55),RH(7,55),RH(7,55),RH(7,55),RH(7,55),RH(7,55),
  RH(7,55),RH(7,55),RH(7,55)
DATA EPPRES/1.,E-4/
  TEMBC=0.
  ALPH=1.
  PET=1.
  PET=0.
  OEX=1.
DO 550 M=1,2
  IF(ISM(M,AE)=0) GO TO 500
  N=PMTS-2
  DO 1 =2,IM
  IF(II,GE,JSUR,ANC1.LT,JSUW) GO TO 1
  I=I+1
  I=I+1
  I=I+2
  T1I=I(I1)-Y(I1)
  T1I=I(I1)-Y(I1)
  T1I=I(I1)-Y(I1)
  IF(T1I,L1.E-04,CR,T1L1.LT,1.E-C4,OR,T1L2.LT,1.E-C4) GO TO 1
  D=Y(I11)-Y(I11)
  IF(D>1.02,E3,M) GO TO 200
  XP2=X(NI1,ALPH,AE,TH(I+1),XMU(I1)+0+0,0,0)
  XP1=X(NI1,ALPH,AE,TH(I1),XMU(I)+0+0,0,0)
  GO TO 201
270 CONTINUE
  XP2=X(NI2,ALPH,AE,TH(I+1),XMU(I1)+0+0,0,0)
  XP1=Y*X(NI1,ALPH,AE,TH(I1),XMU(I)+0+0,0,0)
201 DZLAM=XP1-XP2
    IF(DZLAM.IE.1.E-10) GO TO 1
    DT=DZ/CZLAM
    IF(DT) 1,1,7
    7 IF(GI.GT.10.*DELX) GO TO 1
    P15=P(I1)+P(I1)
    P25=P(I2)+P(I2)
    P35=P(I3)+P(I3)
    P45=P(I4)+P(I4)
    T1=P(I1)-P(I2)
    T2=P(I2)-P(I3)
    T3=P(I3)-P(I4)
    T4=P15-P25
    T5=P25-P35
    T6=P35-P45
    T7=P15-P(I1)-P25-P(I2)
    T8=P25-P(I2)-P35-P(I3)
    T9=P35-P(I3)-P45-P(I4)
    CALL SOLVE(T1 ,T2 ,T3 ,T4 ,T5 ,T6 ,T7 ,T8 ,T9 ,E)
    CALL SOLVE(T10,T11,T12,T14,T5 ,T6 ,T7 ,T8 ,T9 ,&)
    CALL SOLVE(T1 ,T2 ,T3 ,T4 ,T5 ,T6 ,T15,T16,T17,CD)
    CALL SOLVE(T1 ,T2 ,T3 ,T4 ,T5 ,T6 ,T15,T16,T17,DD)
    9=DD/E
    C=DD/E
    D=DD/E
    A=Y(I1)+P(I1)*(-B*P(I1)*(C0-D*P(I1)))
    TRE=1./3.
    CD=4./32.
    YST=1.*A*P*TR/E*2.*C1*CO/D**2
    IF(YST.LE.Y(I1),OR,YST.GF.Y(I+1)) GO TO 1
    YSTP=P*P*TR/0
    IF(YST.PGE.EPPEES) GO TO 1
    IS(M) =I+1
    IF(IS(M))=2.EQ.&)
    IS(M)=I
    XP5=XP1
    XP6=XP2
    GO TO 501
1 CONTINUE
    GO TO 550
501 ISM=ISM(M)
    BET(O)=ATAN(XP5)+ATAN(XP6))/2.
    WRITE(16,506)
506 FORMAT(13x,20X,19HEMBEDDED SHOCK TYPE I2#/I3X,2HIS ,5X,4HRETA )
    WRITE(16,506) IS(M),BET(O)
508 FORMAT(10X,IS5,E11.5)
    L=1
    IF(IS(M))=2.EQ.&)
    ISMM=ISM(L)
    ISP=ISM(L)
CALL THEPOD(ISM),DF1P)
DO 100 KJ=1,NSP
J=KJ
ALP (KI,ISM)=ALP (KI,ISM)+RAT*(ALP (KI,ISM)-ALP (KI,ISM))
DALP (KI,ISM)=DALP (KI,ISM)+RAT*(DALP (KI,ISM)-DALP (KI,ISM))
DDALP (KI,ISM)=DDALP (KI,ISM)+RAT*(DDALP (KI,ISM)-DDALP (KI,ISM))
H (J,ISM)=H (J,ISM)
CP (J,ISM)=CP (J,ISM)
WIISM (J,ISM)=ALP (J,ISM)/WTQDL (J)
CPX (ISM)=CPX (ISM)+ALP (J,ISM)*CP (J,ISM)
H (K,I,ISM)=H (K,I,ISM)
ALFN (K,I,ISM)=ALP (K,I,ISM)
100 CONTINUE
WIISM =1./WIISM
RISM =R(C'M (ISM))
GAM (ISM)=CPX (ISM)/CPX (ISM)+R (ISM)/GPIN
RHO (ISM)=RISM *W (ISM)*GW/TH (ISM)
RI =1./R (ISM)
EM (ISM)=G (ISM)*EMINF*SQR (GAR/GAM (ISM)*RI/T (ISM))
XMU (ISM)=ZMU (EM (ISM))
Q (N (ISP))=0 (ISM)
R (N (ISP))=1 (ISP)
T (N (ISP))=T (ISM)
P (N (ISP))=P (ISP)
W (N (ISP))=W (ISP)
TH (N (ISP))=TH (ISP)
RHO (N (ISM))=RHO (ISM)
GAM (N (ISP))=GAM (ISP)
IF (J,SUBL.GT.ISM)) JSUBL=JSUBL+1
IF (J,SUBL.GT.ISM)) JSUBL=JSUBL+1
DO 101 KJ=1,4
IF (IS (KK).GT.IS (M)) IS (KK)=IS (KK)+1
101 CONTINUE
IEMBED=1
CALL HSHOCK(K)
IEMBEDD=3
K(ISMM)=K(ISN)
Y(ISMM)=Y(ISN)
XMAX(ISMM)=XMAX(ISN)
W(ISMM)=W(ISMM)
P(ISMM)=P(ISMM)
G(ISMM)=G(ISMM)
T(ISMM)=T(ISMM)
D(ISMM)=D(ISMM)
TH(ISMM)=TH(ISMM)
EM(ISMM)=EM(ISMM)
RX(ISMM)=RX(ISMM)
CPX(ISMM)=CPX(ISMM)
GAM(ISMM)=GAM(ISMM)
XMU(ISMM)=XMU(ISMM)
NO 1313 XI=145P
P(<I,ISMM)=N(KL,ISMM)
CP(KL,ISMM)=CP N(KL,ISMM)
ALP(KL,ISMM)=ALPH(KL,ISMM)
1313 CONTINUE
MOD="",
RE=0,
XEP=0,
CALL SHEAL(12,...)
5CP CONTINUE
RETURN
END
SUBROUTINE SOLVE(A11,A12,A13,A21,A22,A23,A31,A32,A33,DEL)
DEL=A11*(A22*A33-A23*A32)-A12*(A21*A33-A31*A23)+A13*(A21*A32-A22*A
131)
RETURN
END
SUBROUTINE HSHOCK(K)
COMMON/A1,GAM,GEN
COMMON/BB,P(17,55),EMINF,WINF
COMMON/PP,P14,S2A,STAT
COMMON/PC/SAMP,PA,"d,RHCA,TIME,MB,XMUB,TA"
COMMON/CA/WOON(7,55),XN(55)
COMMON/CJ/CP(7,55),CP1(7),CPX(55)
COMMON/DE/BETA(4),IS1(4)
COMMON/EP/YN(55)
COMMON/EP/CPIN,RO
COMMON/EF/EN(55),GAM(55),P(55),TH(55),Y(55)
COMMON/EF/FIN,PRXLE
COMMON/EF/GAMINF,M1(7),RINF
COMMON/EF/DFI
COMMON/CF/CFI
COMMON/ML/ALPHA,BETA
COMMON/HN/ALPN(7,55),CPN(7,55),CPY(55),EMN(55),GAMN(55),HN(7,55),
ILS,PN(55),QN(55),RHON(55),RN(55),THN(55),TN(55),WN(55),XUN(55)
COMMON/HQ/BE(TAN(16),,M95E)
COMMON/HQ/JCHEM,NSP,T(55)
COMMON/HQ/AAH(7,55),Q(55),PHO(55),XHU(55)
COMMON/HQ/RHOP(2),40D(T(7,55),WOO(C(7,55),WP(2),XMUP(2)
COMMON/SQ/BO(N(55),DALPN(7,55),DNQ(55),DQUPM(55),DQUPN(55),DQUPR(7,55),
10TAU(55),TAU(55)
COMMON/SQ/I13,IREC,KS,KFIRST,KKQ,PSTAR
COMMON/TS/OVISA,CVISC,IFS,VMN,WINA,VISC
COMMON/TU/BQ(55),JALP(7,55),OBQ(55),DCPX(55),DOALP(7,55),DTAU(55),
1TAU(55)
COMMON/TU/ALPD(7,2),P1,BO(2),DAHIP(7,2),DALPD(7,2),DBPD(2),
10CPK(2),CPDAU(7,2),DPDAU(2),DTCHP(2),G,MP(2),PQ(2),
1TDAP(2),TIDP(2),TP(2),YP(2)
COMMON/VW/ICONT,(END,K,T,THBP,KBPN)
DIMENSION DUMM(7)
I=IS(K)
I=I+1
BET=1+ETB(1)
I11=1
XXX=1.
ICCC=1
L=1
IF(T(K)*K)*N.E.K) L=-1
M=IS(K) +L
IF(BET.NE.0.1 GO TO 210
TAU(M)=TAU(M)
BQ(M)=BQ(M)
DCPX(M)=DCPX(M)
D,AM=AM=AM
DBQ(M)=DBQ(M)
CPK(M)=CPK(M)
DO R211 J=1,NSP
DALPN(J,M)=DALPN(J,M)
DDALP(J,M)=DDALP(J,M)
. . .
M=1+M
CONTINUE
0211 CONTINUE
0210 CONTINUE
IF(BET.GT.0.1) BET=BETAN(K)
I=1
CA=1.
S=0.
VT=QN(I) *COS(BET-TN(I))
UT=QN(I) *CA*SIN(BET-TN(I))
UT=ABS(U1)
XMS=RHON(I) *U1
GN=GAMN(I)
GP1=(GN+1.)
GM1=GN-1.
RN1=1./RN(I)
XM1=U1**2*GM1**2*(GAR*GAMN(I)*RN1/TN(I))
OXM=1./XM1
IF(IT*EQ.1)UZ=U1*(GM1**2.1)*GP1*OXM
5 RH2P=XMS/L2
PZ=XMS*(U1-U2)+PN(I)
V2=VT**2
V1=V2*U1**2
V2=V2*U2**2
H6=0.
DO 1400 J=1,NSP
1400 H6=M1(I,J)*ALPN(J,J)+H6
H2=H6/(V1-V2)/2.*EIN
IIT1=1
I1=TN(I)
IF(I1.EQ.1)T2=T1*2.*GM1**2*(GM1**2.1)/(2.*GP1)**2.*OXM
8200 CALL THERMO(T2,M1,GP1)
H2P=0.
DO 92E1 J=1,NSP
92E1 H2P=H2P*ALPN(J,M)*H1(J)
ERR1=H2P-H2P1/HE
IF(ABS(ERR1).LT.1.E-8) GO TO 82E2
IIT1=IIT1+1
IF(IIT1.GT.15) GO TO 92E3
IF(IIT1.GT.2) GO TO 9204
ERR2=ERR1
T2=T2+T2*0.1
GO TO 82E2
92E3 WRITE(6,9191)
9191 FORMAT(151)
WRITE(6,8205)
8205 FORMAT(* ERROR IN TEMPERATURE LCOP IN HSHOCK*)
STOP
92E4 DUM=T22-ERR2*(T2-T22)/(ERR1-ERR2)
ERR2=ERR1
T2=T22
T2=DUM
GO TO 82E6
A202 CONTINUE
RH2=PZ*WN(J)*GW/T2
ER1=TW-ZH2P/RHON(I)
IF(ABS(ER).LT.1.E-8) GO TO 7
I1=IT+1
IF(IT.GT.15) GO TO 190
IF(I+2.0) 50 TO 6
F02=EP
U2=U2
U2=U2*99
GO TO 5
6 CONTINUE
IF(K/K*2.0) 50 TO 6
IF(K/K*2.0) 50 TO 6

7 CONTINUE
C8=DOT(SX)
SR=SIN(FT)
IF((K*2.0)*EQ.1) U2=-U2
Q2=-U2*CA
UV=VT*CA+CN2*SA
NV=VT*SA+DN2*CP
PPE2=ATAN(NV/UV)
Q2=SOMP(UV*UV+NV*NV)
IF((PPE2) 50 TO 535
YH=0.5*(TAN(BET1K) 1+TAN(BET1)) 50
DEL=1
IF(BET1 50 TO 577
DEL=1
S1A=0.
S2A=0.
S3AT=0.
GAMB=GAMP(1)
PB=PP(1)
Q8=QP(1)
ROD=RDCP(1)
WR=WR(1)
XMU=XMP(1)
Y8=YP(1)
A1=F1(M)
A2=F2(M,S1A,S2A,S3AT)
IF(JCHEQ.EQ.1) GO TO 7254
A3=0.
GO TO 7257
7254 TP1=(TP1+Y)/2.
      DTCHP=DTCHP(TP1)/2.
      DO 1552 J=1,NST
    1552 DUMM(J)=CAHP(J,1)/2.
      A3=F3(TP1,DTCHP,TP1,T2,TPP1,PHE2,DUMM,HP1,WM(N))
7257 CONTINUE
      OPT=-1.
      IF(K/2)**2.EQ.K) OPT=1.
      A4*(OPT,XP1,T2,HP1,WM(N))
      A2=(A2+A3)*A4
      PSH=PP1+OPT*(PHE2-THP1)-A2*DELK/A1
      ER3=(PSH-P2M)/P1M)
      IF(ABS(ER3).LT.1.E-3) GO TO 19
      IT1=IT1+1
      IF(IT1.GT.15) GO TO 11
      IT1=IT1+1
      IF(IT1.EQ.2) GO TO 1430
      IF(ER1.EQ.1) GO TO 14
      IF(ABS(ER1-ER3).LT.5.E-06) GO TO 1492
      IF(ABS(EP1).GT.ABS(ER1)) GO TO 1430
      IF(ICC.IG.EQ.1) GO TO 103
      XXX=-1.
      IT11=IT11-1
      IT11=IT11-1
1430 ER1=ER3
      BET1=BET
      BET=BET+0.01*(IT11-1)*BET*XXX
      GO TO 15
1492 BET2=(BET-BET1)*20.
      EP1=ER3
      BFT1=BET
      BET=BET+BET2
      GO TO 15
113 WRITE(6,9191)
      WRITE(6,220)
220 CHAIN(* ERROR IN SHOCK ANGLE IN *SHOCK*)
      STOP
14 DUM=BT1-ER1*(BET-ET1)/(ER3-ER1)
      ER1=ER3
      BET1=ER1
      BET=DUM
      IF(YM(N).LT.7*(TAN(BET1)+TAN(BET1)+0.7*(LX-IK))
      YM*:5)=.N(M)
      KS=IS(K)
      LS=KS
      KT=KS
      IF(K.EQ.2 OR K.EQ.4) KT=KT+1
      CALL CPINT.
GO TO 4

19 BETAN(k) = BE

YN(M) = 5*(TAN(BETAN(K))) + TAN(BETAN(K)))*DELX+Y(M)
TS = [5(K)]
YN(5) = YN(M)

3535 CONTINUE
FN(M) = R2H
GN(M) = G2
TH(M) = RHE2
NON = GM2
TN(M) = T2
RN(M) = RC/AN(M)
CP(m) = 3.
DO 1451 J = 1, VSP
HN(J,M) = H1(J)
CPN(J,M) = CP1(J)
1451 CPN(M) = CPXN(M) + ALPH(J,M)*CPN(J,M)
GAM(M) = (FXN(M)/(CPXN(M)-RN(M)/CPN))
NON = 1./NON(M)
CPN(M) = QA(M)*EPINF*SCRT(GAR/GAM(M)*DGM/YN(M))
IF(ELEM(M).LT.1.0G11) GO TO 1462
YNMN(M) = ZM*ELEM(M))

1462 CONTINUE
RETURN
END

SUBROUTINE SWITCH(J, K)
COMMON/BX/ALP(7,55), EMINF, XINF
COMMON/BE/XMSS(55)
COMMON/CJ/CPI(7,55), CP1(7), CPX(55)
COMMON/EP/EM(55), GAM(55), P(55), TH(55), Y(55)
COMMON/FC/W(55), X(55)
COMMON/GQ/JCHEM, NQP, T(55)
COMMON/DA/HA(7,55), Q(55), RH0(55), XMU(55)
COMMON/HR/7(55)
COMMON/5(7,55), TALP(7,55), DBQ(55), OCX(55), ODALP(7,55), ODA(55),
1TAU(55)

X (J) = Y (K)
Y (J) = Y (K)
O (J) = O (K)
P (J) = P (K)
T (J) = T (K)
W (J) = W (K)
R (J) = R (K)
E (J) = E (K)
'N (J) = 'N (K)
BQ (J) = BQ (K)
TAU (J) = TAU (K)
DBQ (J) = DBQ (K)
GAM (J) = GAM (K)
RH(J) = RH(M) (K)
XMU (J) = XMU (K)
CPX (J) = CPX (K)
CCPX (J) = CCPX (K)
DTAU (J) = DTAU (K)
XMASS (J) = XMASS (K)
DC 108 JJ = 1, NJO
H (JJ, J) = H (JJ, J)
CP (JJ, J) = CP (JJ, J)
ALP (JJ, J) = ALP (JJ, J)
DALP (JJ, J) = DALP (JJ, J)
CDALP (JJ, J) = CDALP (JJ, J)
IF B CONTINUE
RETURN
END
SUBROUTINE PM(KL, IFAN, K, OPT, KCP)
COMMON/ R(1:9, K, K)
COMMON/DF(1:5, K)
COMMON/ NF(1:5, K)
COMMON/ X(1:5)
COMMON/ y(1:5)
COMMON/ m(1:5)
COMMON/ J(1:5)
COMMON/ Q(1:5)
DO 1 LL = 1, LF
IF (LL .GT. KCP) GO TO 1
IF (J(J) .NE. J(J)) GO TO 2
N = LL - 1
H(J, J) = H(J, J)
DO 2 K = 1, KCP
P(N) = P(KK) * EXP (CP)
ALMR = R(PR) / GAM(KK)
RHO(N) = RH(C(I, K)) / EXP (ALMR)
G = 2. * GAM(KK) / GAM(KK) - 1.
CG = G * (P(K) / RHO(N) - P(KK) / RHO(KK))
Q(N) = CG(KK) / Q(KK) + QQ
Q(N) = SQRT (Q(N))
H(N) = H(N) - G * 2. * EIN
IIT = 1
1 CONTINUE
RETURN
END
T1=T(KK)
IF(IIGT.EQ.1) T2=T1*.99
8260 CALL THE: J(T2, M1, CP1)
H2P=0.
DO 4 J=1, NSP
ALPJ(J,N)=ALPJ(J, KK)
4 H2P=H2P+ALPJ(J,N)*M1(J)
ERPI=(H2-H2P)/M6
IF(ABS(ERPI).LT.1.E-08) GO TO 8202
IIT1=IIT1+1
IF(IIT1.GT.15) GO TO 8263
IIT1+1, GO TO 8204
ERR2=ERR1
T2=T2
T2=T2*.99
GO TO 8260
8203 WRITE(6,9191)
9191 FORMAT(1=I)
WRITE(6,8205)
8205 FORMAT(* ERROR IN TEMPERATURE LCCP IN PM*)
STOP
8204 DUM=T22-ERR2*(T2-T22)/(ERR1-ERR2)
ERR2=ERR1
T22=T2
T2=DUM
GO TO 8209
8209 CONTINUE
T(N)=T2
M(N)=0.
CPI(N)=0.
DO 5 J=1, NSP
CP(I,J,N)=CP1(J)
M(J,N)=M1(J)
CPX(N)=CPX(N)+ALP1(J,N)*CP1(J)
5 M(N)=M(N)+ALP1(J,N)/MTOLE(I)
W(N)=1./W(N)
R(N)=RO/W(N)
GAM(N)=CPX(N)/(CPX(N)-R(N)/CPI1)
ORIZ=1./R(N)
EM(N)=QINF*SQRT(GAM)*ORIZ/T(N))
XMU(N)=2*EM(N)
TH(N)=TH(KK)+OPT*ALMN*(COS(XMU*XX, SIN(XMU*XX, COS(XMU*NN)))*SIN(180, NN))*.5
M6=H2
1 CONTINUE
RETURN
END
SUBROUTINE CHEMFA
COMMON/BA/ALPJ, 551, *MINF, WINF
COMMON/CA/WDTN(7,55),XN(55)
COMMON/CB/BETB(4),IS(4)
COMMON/CP/YN(55)
COMMON/E1/EM(55),GAM(55),P(55),TH(55),T(55)
COMMON/PH/DALCH(I),NTCHEM
COMMON/CP/ALPB(17),PHI(55)
COMMON/PC/P(55),X(55)
COMMON/PD/CHM,NSP,T(55)
COMMON/QR/YN(55),Q(55),WNO(55),XMU(55)
COMMON/QS/RHOP(2),WDT(7,55),WDOT(7,55),MP(2),XMUP(2)
COMMON/VT/DACH(7,55),OTCH(55),OVISO,VISD
COMMON/VR/NPTS,RE,KP,XJ
COMMON/YZ/APRESU,CHMCFG,CPRESU,EHSUB,RTH,XS;R
IF(JCHEM.EQ.9) GO TO 9351

********** CHEMISTRY PACKAGE **********

DO 935 L=1,NPTS
DO 99 I=1,4
IF(IS(I).EQ.0) GO TO 99
ITEST=ITEST+1
IF(M/2).EQ.1 ITEST=ITEST+M
IF(L.EQ.1 ITEST=0.L.EQ.1 ITEST+1) GO TO 9398
99 CONTINUE
FAT=ABS(PHI(L))
IF(FAT.LT.1.E-5) GO TO 839A
X=3QFT1(YNL-L(1)**2+YNL-L(1)**2)**RTH
DO 9350 J=1,NSP
9350 ALPB(J)=ALPB(J)
CALL HCL5(TK(1),Q(K),WNO(1),ALPB,NSP)
9351 DACH(J,L)=DACH(J,L)
OTCH(L)=NTCHEM
GO TO 8355
9398 OTCH(L)=0.
DO 8399 J=1,NSP
WDOT(J,L)=0.
WDTN(J,L)=0.
8399 CONTINUE
839A WD=0.
8399 CONTINUE
8355 CONTINUE
GO TO 400C
A35I DC 6100 L=1,NPTS
OTCH(L)=0.
DO 8352 J=1,NSP
WDTN(J,L)=0.
8352 CONTINUE
6100 CONTINUE
400C CONTINUE
RETURN
END
SUBROUTINE SHFA4(I, ASHEAR)
COMMON/CJ/CP(7,55),CP1(7),CPX(55)
COMMON/CKWTMOCF(7)
COMMON/EP/E(55),GA4(55),PB55,TH(55),VY(55)
COMMON/OKJOLY
COMMON/PE/M(55),X(55)
COMMON/YG/JCHFMP+ASP+T(55)
COMMON/SA/H,T(55),AWT(55),XU(55)
COMMON/SS/AL1,AL2,AL3,AL4,AL5,B1,B2,B12,CH1,CH2,CH3,DD1,DD2,DT1,DT2,DV
AL1,DLV2,PA1,PA2,PA3,PA4,PA5,PB1,PB2,PB3,PB4,PB5,PL1,PL2,POR
COMMON/ST/I13,INCTK,FXRST,XXKQ,PSAPF
COMMON/TL/H0(7,55),OLP(7,55),OQP(55),OC(55),ODLPH(7,55),OTAU(55),
ITAU(55)
COMMON/VJ/DaC17,EB,OTCH(55),OVD(55),OVDL,VISG
COMMON/IV/NVTS,PX,VXR,YJ
DIMENSION S3I(7)
K=I
V1=V2=WISC
CV1=CV2=VISC
T12=TAU2(TK)
DT1=DT2=DTAU2(TK)
Y1=Y2=Y3(TK)
TH1=TH2=TH3(TK)
SIDE=S1(XJ,RE)
CH2=C
DO 10 J=1,NISP
10 CH2=CH2+DALP(J,K)*CP(J,K)
BO1=BO2=EO(K)
C1=C2=CPX(K)
DB1=DB2=DOO(K)
PX1=PX2=CPX(K)
CM1=CM2=CM2
S20=SC(JJ,RE)
SIDE=S3I(J)
DO 20 J=1,NISP
AL1=AL2=AL2
DEL1=DEL2=DALP(J,K)
DO1=DO2=DOO(JK)
SIDE=SIDE+S3I(J)
26 SIDE=SIDE+S3I(J)/WTMOCF(J)
PK=1*PK(K)
SH1=SH1*GAMM(K)*PK*YXK)**2
QK=1*QK(K)
SH2=SH2*GAMM(K)*L1*S20*GA*(PK*PK)*K
SH3=SH3*PK*PK*RO(K)*K
IF(JJ.GE.1) SH4=0
IF(JJ.EQ.0) GO TO 20
IF(IK+1+OR+Y1),GT,1+6) GO TO 20
SH4=SH4+Y2(2)

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GO TO 40
30  SH4=Sin(TH(K)) / Y(K)
40  CONTINUE
   OD=1. / DELX
   SM5=-DTCK(K) / T(K) / OD * COS(TH(K))
   DUM=0.
   OD SR J=1, NSP
50  DUM=DUM * GACH(J) / WIMOLE(J)
   SM6=-WEK(I) * DUM / DELX * COS(TH(K))
   SH=SH1 + SH2 + SH3 + SH4 + SH5 + SH6
   ASHEAR=-GAM(K) * PI(K) * EM(K) / 2 * SH
RETURN
END
SUBROUTINE PRESS(K, P, TH, TMN)
COMMON/AC/I900*PIN
COMMON/MY/APPRES,APPRESU
COMMON/MY/ABODS,EPRES,CPRESS
P=APPRES*X (BPRESS+CPRESS*X)
P=P*PIN
THN=TH
RETURN
 END
FUNCTION GVIS(I)
COMMON/RA/LP(7,55), HMIN, WMIN
COMMON/DP/BETB(I), IS(4)
COMMON/FR/XK1, XK2, XM1
COMMON/RH/(7,55), GM55, RM55, XMU55
COMMON/MY/PMTS, RE, X3P, XJ
DATA IVIS = 7
   ID=-1
   IF(I5(I4, I)=1, IODD=IS(4)+1
   IF(I5(I3, I)<1, IODD=IS(4)-1
DUM=0.
   RU=RM0*(ICCI=1: IODD)
   IDE=IODD+1
   DO 10 I=IDE, IDUM
   DUM=ABSF(I+I*I+I-I-1)-RU)
   IF(IDUM>LT.DUM1) GO TO 10
   DUM=DUM1
10  CONTINUE
   IF(ALF(4, I)=1, G1, 99) GO TO 30
   IF(ALF(4, I)=1, EJ, I=1, 99, ANC, XBP, LT, XPT0) GO TO 30
   IF(IVIS.EQ.0) XVIS=XX1*RE*XBP*DUM1*XX3
   IF(IVIS.EQ. 0)
   1MPITE(6, 9696) XBP, XVIS
9696 FORMAT(3H VISCOSITY MODEL SWITCHED AT X =E13.3, 14H VISCOSITY = ,
   1F13.5)
   IVIS=1
XVIS=XVIS1
GO TO 43
30 CONTINUE
XVIS=XK1*RF*XBP*UM1*XK3
43 CONTINUE
RETURN
END

SUBROUTINE COWL
COMMON/BA/ALP(7,55),EMINF,MINH
COMMON/CJ/CP(7,55),CP1(7),CPX(55)
COMMON/DB/BETA(4),LAM4
COMMON/DE/MM
COMMON/EF/EM(55),GM(55),P(55),TH(55),V(55)
COMMON/HJ/KOUNT,LZ,NPT
COMMON/RL/ALPHA,BETA
COMMON/RP/ALPHA(55),CPN(7,55),TPXN(55),EMN(55),GANM(55),MN(7,55),
ILS,PN(55),QN(55),RHON(5,5),RN(55),THN(55),TN(55),WN(55),XMUN(55)
COMMON/RP/ETAN(4),IEMB=0
COMMON/RC/M(55),X(55)
COMMON/RG/RC=*,NSP,T(55)
COMMON/RH/RAH(7,55),R(55),RHO(55),XMU(55)
COMMON/RH/R(55)
COMMON/RL/BO(55),DALP(7,55),OBX(55),OCPX(55),ODALP(7,55),DTAU(55),
ITAU(55)
COMMON/RW/NPTS,RE,XAP,YJ
ALPHA=1.
BETA=0.
NPTSSS=NFT
NPT=NPT-3
2002 WRITE(6,9191)
9191 FORMAT(1H1)
WRITE(6,2004)
2004 FORMAT(1H1,6F7.7) ERR? IN INPUT DATA - NO PRESSURE DIFFERENCE ACROSS
1 SPLITTER PLATE/23H SET INPUT - INTACT = 0
STOP
2003 OPT=1.
K=4
IS(K)=NPTSSS-1
L=IS(K)
M=L+MM
GO TO 2005
2005 CPT=-1.
K=3
IS(K)=NPT+MM
M=NPT
L=M+MP
2005 IFAN=MM-2
KOPT=CPT*1,5
N13=NPTSSS-2*K775
IF(K/K2.*2.EQ.K) N12=NPTSSS
DO JEC N12=N11,NPTS
K5=NPTS*K13-N12
J5=K5+1
CALL SWITCH(JF,K5)
300 CONTINUE
NPTS=NPTS+1
30 J31 I11=1+1
IF(I11.EQ.K) GO TO 3C1
IF(IS(I11).LT.N13) I11=IS(I11)+1
3C1 CONTINUE
LL=L+*KOPT
TAU(LL)=C
P(LLL)=P(L)
MK(L)=P(L)
2 N(L)=C (L)
T N(L)=T (L)
R N(L)=R (L)
PHON(L)=RK20(L)
GAMA(L)=GAM(L)
R0(LL)=C
GCPX(LLL)=C
DTCUP(LL)=C
GBC(LLL)=C
CPX(LL)=C
DC 2706 J=1,MSP
MNJ(L)=MNJ(L)
DALP(J,LL)=C
DDALP(J,LL)=C
2706 ALP(J,L)=ALP(J,L)
ITT=1
PETR=-T*KMLE-OPX*XMUL(LLL)*1.31
BET=BE(40K)
20.7 IEMBED=1
CALL +SNCCK(K)
IEMBED=C
KK=LL+*KCP
P (LLL)=P NLLL
O (LLL)=O NLLL
T (LLL)=T NLLL
W (LLL)=W NLLL
R (LLL)=R NLLL
TH (LLL)=TH NLLL
EM (LLL)=EM NLLL
XMUL(LLL)=XMUL NLLL
GAM(LL)=GAMN(LLL)
RH0(LL)=RH0 NLLL

CPX(LL) = CPXN(LL)
P (KK) = F N(LL)
Q (KK) = Q N(LL)
T (KK) = T N(LL)
W (KK) = W N(LL)
R (KK) = R N(LL)
TH (KK) = TH N(LL)
EM (KK) = EM N(LL)
NWMU (KK) = NWMU N(LL)
GMN (KK) = GMN N(LL)
RHO (KK) = RHO N(LL)
CPX (KK) = CPXN (LL)
DO 2080 J = 1, NNP
H (J, LL) = H N(J, LL)
CP (J, LL) = CP N(J, LL)
ALP (J, LL) = ALPN (J, LL)
H (J, KK) = H N(J, LL)
CP (J, KK) = CP N(J, LL)
2080 ALP (J, K) = ALPN (J, LL)
X (LL) = X (LL)
X (KK) = X (LL)
TMS = T + (KK)
CALL PM (*, L, IFAN + K, CP + KOPT)
NNN = IFAN + 1 + M
IF ((K + 1) = 1 + EQ + K) NNN = M - IFAN + 1
TMPM = TH (NNN)
ERR = TMS - TMPM
IF (ABS (ERR1) LT 1.0E - 24) GO TO 15
ITT = ITT + 1
IF (ITT = 2) GO TO 12
IF (ITT = 2) GO TO 14
EPS = EPS + 1/BET
BET = 1.01 * BET
BET (K) = BET
GO TO 2080
100 WRITE (6, 203)
203 FORMAT (* ERROR IN BETA SHOCK IN CGNL*)
CALL EXIT
14 SUM = BET + ER1 * (BET - BET1) / (ER1 - ER1)
EPS1 = EPS
BET1 = BET
BET = SUM
BET (K) = BET
GO TO 2080
15 CONTINUE
WRIT = WRIT + 1
RETURN
END

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SUBROUTINE DPOINT(K,

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16 RAT=(YD-YF(1))/YP(2)-YP(1)

ALAMD=TAN(TMP(1))<RAT*(TAN(TMP(2))-TAN(TMP(1)))

YAT=YN(1)-NLAMD*DEL

ERR=ABS((YAT-YD)/YP(2)-YP(1))

IF(ERR.LT.1.E-05) GO TO 10

YO=YAT

IT=IT+1

IF(IT.LE.10) GO TO 16

WRITE(*,9191)

WRITE(*,9192)

202 FORMAT(* ERROR IN D POINT ITERATION*)

STOP

18 YKI=YO

P (K)=P (P(1)+RAT*(P(2)-P(1))

Q (K)=Q (P(1)+RAT*Q(2-Q(1))

T (K)=T (P(1)+RAT*(T(2)-T(1))

TH (K)=TH (P(1)+RAT*(TH (2)-TH (1))

BG (K)=BG (P(1)+RAT*(BG (2)-BG (1))

DCPX(K)=DCPX(K)+RAT*(DCPX(K)+DCPX(K))

DTAU(K)=DTAU(K)+RAT*(DTAU(K)+DTAU(K))

DTCM(K)=DTCM(K)+RAT*(DTCM(K)+DTCM(K))

CPX(K)=0

WRITE(C,0)

CALL THERMO(T(K),H1,CP1)

00 1 J=1,NP

H (J,K)=H 1(J)
CPI(j,k)=CPI(j,j)
ALP (j,k)=ALP P(j,1)+RAD(ALP P(j,2)-ALP P(j,1))
DAL (j,k)=DALP P(j,1)+RAD(DALP P(j,2)-DALP P(j,1))
DACH(j,k)=DACHP(j,1)+RAD(DACHP(j,2)-DACHP(j,1))
DODALP(j,k)=DODALPP(j,1)+RAD(DODALPP(j,2)-DODALPP(j,1))
CPXK(j)=CPX(j,k)+3LPL(j,k)*CPX(j,k)
1 WK(j)=W(j)+ALP P(j,k) WTK(j)
WK(j)=1./WK(j)
QHK(j,k)=P(j,k)*WK(j)*GHW(j,k)
RETURN
END

SPECIALIZE STEP VI$)
COMMON/AC/IROD,FIN
COMMON/AX/JSUBL,JSU3
COMMON/CA/HQFIN(7,55),XN(55)
COMMON/CO/BET(14),I(4)
COMMON/CP/YN(55)
COMMON/E/EF(55),GAM(55),P(55),TH(55),Y(55)
COMMON/EG/EIN,PR,YLE
COMMON/E/RAD,ROU,UIN,VI$INF
COMMON/GK/DELX
COMMON/HJ/KOUt,LL,NPT
COMMON/HY/ALPH(7,55),CP(7,55),CPXN(55),ENN(55),GAMN(55),HN(7,55),
L(55),ON(55),RN(55),THN(55),TN(55),WN(55),XMUN(55)
COMMON/OR/THB,YP,YPN
COMMON/F/CHN,NSP,T(55)
COMMON/GA/H(7,55),CH(55),XH(55),XM(55)
COMMON/S/I,IREG,KS,KFIRST,KKKO,PSTAR
COMMON/UV/II,IIER,IPRES,IPRESU,ISUB
COMMON/V,ICONT,IREG,H,K,T,HAPK,YWP
COMMON/V,IPRESU,SP,CPC(55)
COMMON/YAPRESU,APRESU
COMMON/Y7/APRESU,CHOMC,CPRESU,EMSUB,TM,XSTEP
DIMENSION DELL(55),XM(2),YM(2),TN(1)
DATA II/1/C
DATA IREG/1/7/
ISPA=0
NSAVE=2
XM(1)=0.
XM(2)=10000.
YM(1)=10000.
YM(2)=10000.
TN(1)=0.
TN(2)=0.
ISUB=0
JSUBL=NPT+1
JSU3=NPT+1
DO 910 I=1,NPT
IF(EMI(1) .GT. EMSUB) GO TO 910
JSUBL=1
ISUB=1
GO TO 806

910 CONTINUE
GO TO 806

806 CONTINUE
DO 902 I=1,NPTS
II=NPTS-I+1
IF(EMI(II) .GT. EMSUB) GO TO 922
JSUBU=II+1
GO TO 806

902 CONTINUE

801 CONTINUE
IF(ISUB .EQ. 0) GO TO 10
II=1
KFIRST=KCUNT

10 CONTINUE
JNUM=JSUBL-1
NP2=NPTS-1
DO 499 K=1,NP2
DEY=Y(K+1)-Y(K)
IF(DEY .LT. 1.E-09) GO TO 499
IF(K .GE. JNUM .AND. K .LE. JNUM) GO TO 498
EMI=XM1(1)+TH(K)+XMU(K),G,0.
EM2=XM2(1)+TH(K+1)+XMU(K+1),J,,0.
DELLX(K)=1/(EM1-EM2)
IF(BETB11 .EQ. 0 .AND. BET42 .EQ. 0 .AND. BET3 .EQ. 0 .AND. BET4 .EQ. 0) GO TO 499
AEQ .EQ. 0 .GO TO 499
IF(BETB1 .GT. 0 .OR. BET3 .GT. 1) GO TO 499
IF(K .EQ. (1) .OR. K .EQ. IS(3)) DELLX(K)=DELLX(K-1)
IF(K .EQ. IS(2) .OR. K .EQ. IS(4)) DELLX(K-1)=DELLX(K-2)
GO TO 499

498 DELLX(K)=1.E+06

499 CONTINUE
DELMX=DELLX(1)
DO 500 K=2,NP2
IF(DELMX .LT. DELMX) DELMX=DELLX(K)

500 CONTINUE
IF(BETB1 .EQ. 0 .AND. BET42 .EQ. 0 .AND. BET3 .EQ. 0 .AND. BET4 .EQ. 0) AEQ .EQ. 0 .GO TO 777
IF(BETB11 .GT. 0 .OR. BET3 .GT. 1) 777,777,776

777 DCHAR=DELMX
GO TO 775

776 DCHAR=2.*DELMX

777 IF(XLE .EQ. 0 .OR. VIS .EQ. 0) GO TO 50
VI=1./VIS
DELV=S*PR*RE*VI/XLE
GO TO 51

ORIGINAL PAGE IS OF POOR QUALITY
50  OELY=.3.
51  DO 502  K=1,NPTS
      OELY1=1.E11.
      IF(K.NE.1) OELY=Y(K)-Y(K-1)
      IF(K.NE.NPTS) OELYY=Y(K+1)-Y(K)
      IF(K.EQ.1) OELY=OELYY
      IF(K.EQ.NPTS) OELYY=OELY
      IF(OELYY.LT.0.E1) OELY=OELYY
      IF(OELYY.LT.1.E-80) GO TO 502
      OELY1=OELYRHO(K)*Q(K)*OELY**2*COS(TH(K))
502  OELY=OELY1
      OELYH=OELY(1)
      DO 504  K=2,NPTS
504  IF(OELYH(K).LT.OELYH(NPTS)) OELYH=OELYH(K)
      OELYH=OELYH/(1.+OCH1A1./OELYH)
      OELYH=OELYH/1.E10
      IF(ISPA.EQ.1) GO TO 4
      ISP=1
      CALL SPACE(ISPP)
      IF(II11.EQ.1) RETURN
      IF(ISPP.EQ.1) GO TO 10
      4 CONTINUE
      IF(JCHEM.EQ.0) GO TO 4275
      DO 505  I=1,NPTS
          DTST=C111*U1N**4.*E-7/RTH
          DTST=CHAMPC*DTST
      505  IF(OELYH.GT.DTST) OELYH=DTST
4275  CONTINUE
      IF(I111.EQ.1.OR.KOLNT.NE.KFIRST) GO TO 4545
      KKK=KOUNT+26
4545  CONTINUE
      IF(MN1JSLUB1.LT.1.001) KKK=KOUNT+1
      XWT=XBP+1.E1X
      RA=1./RAD
      IF(XWT.LT.XW(1)) GO TO 741
      IF(XWT.LE.XW(NSAVE)) GO TO 5209
      THBN=0.
      XBN=1X(NSAVE)
      XHPN=XWT
      XBPN=XWT
      XBPN=14+1X(NSAVE)
      XBPN=1X(NSAVE)
      II11=1
      GO TO 5210
5209  CALL TBL(XWT,THBN,XW,THW,NSAVE)
      GO TO 5204
5204  XHBN=THBN+DELX/COS(THBN)*R
      XELX=DELX/COS(THBN)*(COS(THBN)+COS(THBN))**2.
      XPBN=XWT
      XBPN=XPBN+(SIN(THBN)+SIN(THBN))**.5*DELX/COS(THBN)
      5210  CONTINUE
DO 5211 I=1,NPTS
  XN(I)=XBP
  YN(I)=Y(I)+TAN(TH(I))*DELX

5211 THN(I)=TH(I)
  IF(INDC.EQ.1) CALL RODY(XN(I),YN(I),THN(I),0)
  IF(IPREST.EQ.1) CALL PRES(XN(I),PN(I),TH(I),THN(I))
  IF(IPRESU.EQ.1) PNP(I)=PN(I)*(APRESU+XP(NPTS))**(BPRESU+CPRESU)
  XN(NPTS)=XWT
  IF(IPRESL.EQ.1) RETURN
  IF(YN(NPTS).EQ.YBP) GO TO 6211
  CALL BODY(XWT,YN(NPTS),TH(NPTS),1)
  XN(NPTS)=XWT
  RETURN

6211 XN(NPTS)=XBP
  YN(NPTS)=YAP
  THN(NPTS)=THBP
  RETURN
END

SUBROUTINE SSONIC(IDG)
COMMON/AC/IAC,FIN
COMMON/AK/JUSAL,JUSU
COMMON/RK/IXASS(55)
COMMON/CG/UX,UY,UXR,UYR,UXR,R,URY,URYR
COMMON/DP/YN(55)
COMMON/EK/EN(55),GN(55),P(55),TH(55),Y(55)
COMMON/GK/DELX
COMMON/HJ/JK,KLL,LNT
COMMON/HL/ALPHA,BETA
COMMON/HP/LPH(7,55),CPN(7,55),CPXN(55),EMN(55),GMN(55),MN(7,55)
COMMON/IL,PN(55),QN(55),RN(55),THN(55),TN(55),MN(55),XNUN55
COMMON/IR/AP1,A1,AP2
COMMON/ST/I3,IRQG,K,KSTOP,KSSP,PSTAP
COMMON/UV/I11,IERR,IPRESU,IPRESU,ISUB
COMMON/VW/ICONT,IXE,KT,THAP,XBP
COMMON/VX/NPTS,RE,XAP,XJ
DIMENSION EZ(2),ERE(2),SRTHT(2)
DATA LKIP/=0,LNE/=0,LIC0/=0,LICK/=0,L1JUMP/=0
DATA DTHQ/=0.0
IF(I13.NE.1.OR.KOUNT.NE.KFIRST) GO TO 1777
KKF=XEP
CALL QPCTH(THMSBOT,JUSAL)
ATH=1(JSUBL)
BTH=1(TH(JSUBL))
IF(IREGI.EQ.0)CTHM=THSQCT/COS(TH(JSUBL))**3
IF(IREGI.NE.0)CTHM=(CTHA+BTH*KDEL)
DTM=OHTQ
XMKF=XMASS(JSUBU)
1777 CONTINUE
K=JSUBU
DO=XBPW-XKF
OS=1./6.
DO=1./2.
YN(K)=AUP+DUP*EQ+CUP*QQ**2.*5+DUP*QQ**3*OS+EUP*QQ**4*OQ
THN(K)=ATAN(OUR+CUP+DUP*QQ**2.*5+EUP*QQ**3*OS)
DS=2.*COS(YP(K))\*COS(THN(K))
THG=THN(K)
YGH=YN(K)
IG001=I0CC
IG002=1
IPRES1=IPRESS
IPRESS=0
IPRE U1=IPRESU
IPRESU=0
ALSV=ALPHA
BESV=BETA
CALL LPPOINT(JSUBU,0.)
K=JSUBU
THN(K)=THG
YN(K)=YGH
ALPHA=5
BETA=5
CALL LPCINT(JSUBU,0.)
ALPHA=ALSV
BETA=BESV
K=JSUBU
THN(K)=THG
YN(K)=YGH
IG002=IG001
IPRESS=IPRES1
IPRESU=IPREU1
DS=2.*COS(THN(K))\*COS(THN(K))
PSA=(PN(K)-P(K))/DS
THSA=(CUP+CUP*QQ+EUP*QQ**2.*5)*COS(THN(K))\*OS
PNA=GA(K)*PN(K)*CHN(K)*2*THSA
PY=CCS(THN(K))*PNA+SIN(THN(K))*PSA
K=JSUBL
DO=XBPW-XKF
YN(K)=QTHB*QTHB*QQ+QTHB*QQ**2.*5+QTHB*QQ**3*OS
THN(K)=ATAN(QTHB*QTHB*QQ+QTHB*QQ**2.*5)
THS=QTHB*QQ**3*OS
DS=2.*COS(YP(K))*COS(THN(K))
PYB=API
ITEI=1
ITE=0
1790 AP2=(PY2-PYB)**.5/(YN(JSUBU)-YN(K))
AP2=PN(JSUBU)**.5*(PY2-PYB)*(YN(JSUBU)-YN(K))
API2=PYB
PN(K)=AP2
ICONT=1
IEND=0
K=K
L=K
K=K
PSTAR=PNIK
YGH=YNIK
TGH=TNNK
CALL CPCIAK
YNIK=YGH
TNNK=TGH
PNB=-GAMNK*PNI*K1*ENK2*TNSB
PVB=CGSTK*PNB
ET=PYE-PYB
IF(IAGET<.LT.1.0.E-06) GO TO 1789
IET=IET+1
IFIET.LT.20) GO TO 6532
WRITE(6,6533)
6533 FORMAT(* ET LOOP IN SSONIC*)
STOP
6532 CONTINUE
ETE=ETE1+ET
IFIET(LT,1) GO TO 358
ITET=2
PYB=PYB1
PPY=PPYB2
GO TO 1790
358 PYB=PYB1-ETE1*(PYB-PYB1)/(ETE2-ETE1)
PYB=PYB
ETER=ETER1+ETER2
PYB=PYB
GO TO 1790
1789 CONTINUE
ICON=1
IEND=0
JSUBL=JSUBL1+1
JSUBL1=JSUBL1+1
DO 1734 K=JSUBL1,JSUBL1
K=JSUBL1+1
THK=THK+DELX*YK
PK=APK*(YK-Y(THK))=(YK-YK1)**2
KIP=1
ME=1
KPK=K
L=K
K=K
PSTAR=PNIK
DS2=DLS/(COSTH(K)+COSTH(K))
YN(K)=Y(K)+\*0.5*(TAN(TM(K))+TAN(THN(K)))*DELX

YN(K)=YN(K) 
THG=THN(K) 
CALL CPCINT 
YN(K)=YN(G) 
THN(K)=THG 
YN(K)=YN(K)+\*0.5*(TAN(TM(K))+TAN(THN(K)))*DELX 
KP=KP+1 
TERM=(RM(K)*QN(K)*COS(TM(K))+RMON(K)*QN(K)*COS(THN(K)))/2. 
XMDUM=XMASS(K)+FEPH*(YN(K)**(1.0+XJ)-YN(K)**(1.0+XJ))/(1.0+XJ) 
QIJ=QIJ+1.0 
YN(K)=YN(K)**(CIJ+QIJ)*(XMASS(K)-XMASS(KP))/TERM**((1.0/QIJ) 

1734 CONTINUE 
IF (KCOUNT.NE.KKQ-1) RETURN 
XMDIF=WKF-XMASS(JSUBU) 
JK=JSUBU+1 
OC 347 I=JK+JSUBU 
347 XMASS(I)=XMASS(I)+XMDIF 
JSU1=JSUBU+1 
WRITE(4,1418) 
1418 FORMAT(1X,"CORRECTED INTERMEDIATE STREAMLINES/2X,STREAMLINE NO.
,10X,*7X,KK*12X,*Y*11X,*TM*) 
OC 356 KK=1,JSU1 
K=JSU1+KK 
KIP=1 
ME=1 
DTERM=0. 
QDYX=TAN(TM(K)) 
Q2YX2=CTPRI(K)/COS(TM(K))**3.5 
IF (.EQ.1.00000) GOTO 2 
CThQ*,5 
XDEL=XDPN-KKF 

6030 YSTAR=TPRI(K)+QDYX*XDEL+QDYX2*XDEL**2+DTERM*XDEL**3*OS 
TSTAR=ATAN(QDYX2+QDYX*XDEL+DTERM*XDEL**2,5) 
KP=KP+1 
TERM=(RMON(K)*QN(K)*COS(TM(K))+RMON(K)*QN(K)*COS(THSTAR))/2. 
XJ=1.0+XJ 
XMDUM=XMASS(KP)+TERM*(YSTAR*XJ-YN(KP)**(1+XJ))/(1+XJ) 
EZME=XMDUM-XMASS(K) 
IF (ABS(EZME)) .LT. 1.0E-106 1 
GO TO 6034 
KIP=KIP+1 
GO TO (6041,6042),ME 
6041 ME=2 
DTERM=DTERM 
DTERM=-.01/XDEL**2 
GO TO 6036 
6042 DTERM=DTERM1*(DTERM-DTERM1)/(EZ11-EZ11) 
DTERM=DTERM 
DTERM=DTERM 
EZ11=EZ12,
IF(KLF .LE. .20) GO TO 603C
WRITE(*,6081)
6081 FORMAT(* TOO MANY ITERATIONS FOR ONE POINT IN SSNONIC*)
STOP
6034 IF(K.EQ.1.1) GO TO 6036
YN(K)=ystar
THH(K)=THSTAR
XDEL1=XCEL/4.
DO 1417 I=1,4
XDE=XDEL1*FLOAT(I)
XPRNT=XKFXDE
WRITE(YPRT+YPI(K)+DYCXDE+D~DYX2+XDE**2+TERM*XDE**3*OS
THPRNT=ATAN(DYX2.2*D~DYX2+XDE+TERM*XDE**2*5)
WRITE(6,1419) K,XPRNT,YPRNT,THPRNT
1419 FORMAT(*15.5X,3E13.5)
1417 CONTINUE
GO TO 386
6036 ERTH=THSTAR-THN(JUSTAR)
JCONV=0.
II=2
ERTH(1)=ERTH
J=1
IF(JJUMP.EQ.1) GO TO 2501
IF(ABS(ERTHML(ME)).LT.0.01) GO TO 2501
LKIP=LKIP1
GO TO (2502,2503).LMEE
2502 LME=2
DTHB2=DTHB
DTHQ=DTHB-.05
GO TO 2504
IF(JJUMP.EQ.1) GO TO 2505
IF(ERETHL(1)*ERTHL(1)*LT.0.) GO TO 2505
IF(JJUMP.EQ.1.) GO TO 2506
LICK=1
RTHL=.5
IF(ABS(ERETHL(1)) .GE. ABS(ERETHL(2))) RTHL=PTHL
2506 IF(ABS(ERETHL(1)) .GE. ABS(ERETHL(1)) .AND. LKIP.GE.41) GO TO 2537
DTHB1=DTHB
DTHB2=DTHB
DTHQ=DTHB+RTHL
2509 ERTH=ERTHL(II)
ERTHL(II)=ERTHL(1)
IF(LKIP.LE.10) GO TO 2504
WRITE(6,2508)
2508 FORMAT(* TOO MANY ITERATIONS IN LOWER WALL LOOP IN SSNONIC*)
STOP
2507 PM=ERTHL(1)*DTHB**2-ERTHL(2)*DTHB**2+ERTHL(1)*DTHB**2-ERTHMX
1DTHB**2+ERTHMX*DTHB**2-ERTHL(1)*DTHB**2
PM=ERTHL(2)*DTHB2-ERTHL(1)*DTHB*ERTHMX*DTHB-ERTHL(2)*DTHB1
1*ERTHL(II)*DTHB1*ERTHMX*DTHB2
DTHQ=-PM8/(2.0*PMC)
LJUMP=1
GO TO 2564

2505 LICQ=1
DTHQ=DTHB2-ERTHL(1)/(DTHA-DTHB2)/ERTHL(2)-ERTHL(1))
DTHB1=DTHB2
DTHB2=DTHP
DTHQ=CTHQ
GO TO 25C9

25C1 JCONV=1
I13=8
LKIP=1
LMF=1
LICQ=C
LICK=C
LIJUMP=0
IREG1=1
DTHQ=0.

25C4 IF (JCONV.EQ.0) DTHB=DTHQ
386 CONTINUE
RETURN
END

SUBROUTINE BODY(X1,Y,TH,ID)
COMMON/AC,IF0D,PIN
COMMON/X0/X00
COMMON/YA,AP0D,AROD,CAOD,EB0D,FB0D,GB0D,IAVE,IPUNCH,J80D,KKKK
X=X1
IF (I0D.EQ.1) GO TO 4
IF (I80D.EQ.0) GO TO 1
X=X1-X00
Y=ABOD*X+(AROD+X)*CB0D
TH=TAN((EBOD+Z.*CROD*X)
GO TO 2
1 Y=0.
TH=0.
GO TO 2
4 Y=EB0D*X+(FB0D+X)*GB0D
TH=TAN((FB0D+Z.*GR0D*X)
2 RETURN
END

SUBROUTINE DPOTH(DTOS,I)
COMMON/AX,JSUBL,JSUBU
COMMON/EF,EM(55),GA4(55),P(55),TH(55),Y(55)
COMMON/R0/0P0D,AP1,AP2
CALL SMEAR(I,ASPEAR)
ASH=ASHEAR
PY=AP1+2.*AP2*(Y(I)+Y(JSUBL))
D2=Y(I+1)-Y(I)
D1=Y(I)-Y(I-1)
COMMON/VW/ICONT, IEND, KT, TH0PN, X0PN
COMMON/VW/NPTS, RE, XPN, XJ
DIMENSION ALPSS(7), AALPSS(7), DDALPS(7), HHSS(7), GPSS(7)
DIMENSION DUMCHP(7), DACHSP(7)
IF(IEND.EQ.1) GO TO 601
EN3=X3(X(1), BETA, TH(K), THN(L))
XN(L)=XRFN
IF(IFPS.EQ.1.AND.L.EQ.1) E3=TAN(BETB(MM))
IF(IFPS.EQ.2.AND.L.EQ.3) E3=0.5*(TAN(BETB(MM))+TAN(BET))
YN(L)=Y(K)+DELX*EM3
IF(IICNT.EQ.1) GO TO 601
KP=1
EM2=EM1(ALPHA, BETA, T(H(K+1)), XMU(K+1), THN(L), XMUN(L))
EM2L=EM1(ALPHA, BETA, T(H(K)), XMU(K), THN(L), XMUN(L))
351 EM2=0.5*(EM2L+EM2)
X(KP)=X0P
YP(KP)=YN(L)-DELX*EM2K
KIP2=0
IF(YP(KP).LT.1.0E13.5) WRITE(6,9191)
WRITE(6,4151) KP, L, KT, ALPHA, YP(KP), YN(L), THN(L), XMUN(L), PN(L)
WRITE(6,1111) Y(KT), (Y(K), DELX, EM2K, X0PN, TH(K), XMU(K), XMUN(K+1)),
1 DELT, TH0PN, DELY, Y(K+1)
WRITE(6,2000)
2060 FORMAT(' 9TH Y LOCATION OF CHARACTERISTIC ON ORIGINAL DATA LINE IS ')
404 TOUTSIL OF ROUNDING STREAMLINES IN CPPOINT
STOP
201 RATB=YP(KP)-Y(KT)/Y(KT+1)-Y(KT)
EM2=EM2L+RATB*(EM2-EM2L)
YB=YP(KP)
YP(KP)=YN(L)-DELX*EM2
IF(AABS(YB-YP(KP))/AABS(Y(KT+1)-Y(KT))) .LT.0.01 GO TO 2.2
KIP2=KIP2+1
IF(KIP2.LT.20) GO TO 201
WRITE(6,9191)
9191 FORMAT('1M11')
WRITE(6,2001)
201 FORMAT('156H UNABLE TO LOCATE Y LOCATION OF CHARACTERISTIC IN CPPOINT')
STOP
222 RATB=(YP(KP)-Y(KT))/Y(KT+1)-Y(KT)
QP(KP)=C(KT)+RATB*(C(KT+1)-C(KT))
PP(KP)=P(KT)+RATB*(P(KT+1)-P(KT))
TP(KP)=T(KT)+RATB*(T(KT+1)-T(KT))
THKP(Y(KP)+RATB*(TH(KT+1)-TH(KT))
TUP(KP)=T(AU(KT)+RATB*(T(AUT(KT+1)-TAU(KT)))
BQP(TP)=BQ(KT)+RATB*(BQ(KT+1)-BQ(KT))
DCP(KP)=DCP(KT)+RATB*(DCP(KT+1)-DCP(KT))
DTAU(KP)=DTAU(KT)+QAB*(DTAU(KT+1)-DTAU(KT))
DBQ(KP)=CMQ(KT)+RATB*(DBQ(KT+1)-DBQ(KT))
OTCHP(KP)=OTCH(KT)+RATB*(OTCH(KT+1)-OTCH(KT))
CPJ(KP)=0.0
WP(KP)=0.0
CME(KP)=0.0
CALL THERPO(TP(KP),HP,CPB)
DO 4020 J=1, NSP
  LPP(J,KP)=ALP(J,KT)+RATB*(ALP(J,KT+1)-ALP(J,KT))
  ALPP(J,KP)=DALP(J,KT)+RATB*(DALP(J,KT+1)-DALP(J,KT))
DDALPF(J,KP)=DOLPF(J,KT)+RATB*(DDALPF(J,KT+1)-DDALPF(J,KT))
CHC(KP)=CHC(KP)+ALPP(J,KP)*CPB(J)
CPX(KP)=CPX(KP)+ALPP(J,KP)*CPB(J)
WP(KP)=WP(KP)+ALPP(J,KP)/WMTOL(EJ)
DACH(J,KP)=DACH(J,KT)+RATB*(DACH(J,KT+1)-DACH(J,KT))
IF(KE,NE,2) GO TO 4020
WDOT(J)=WDOT(J)+RATB*(WDOT(J,KT+1)-WDOT(J,KT))
CONTINUE
4020 CONTINUE
WP(KP)=1.0/HP(KP)
PP(KP)=RC/HP(KP)
GMP(KP)=CPX(KP)/(CPX(KP)-PP(KP)/CPB)
RK=1.0/HP(KP)
HP(KP)=CP(KP)*EMINF*SQR(T/GMP(KP)*RK/TP(KP))
UMKP(KP)=2*UM(KP)
IF(KP, FC, 2) GO TO 581
KP=2
IF(IFS.LG, 0) KT=L
EM2P=XP2(ALPHA,BETA,TH(KT+1),XMU(KT+1),THNL(L),XMUN(L))
EM2L=XP2(ALPHA,BETA,TH(KT),XMU(KT),THNL(L),XMUN(L))
GO TO 351
C GET ALL THE PROPERTIES AT THE C POINT
CONTINUE
651 CONTINUE
IF(IFS.EQ, 0) GO TO 9600
V SS=V (K)
P SS=P (K)
Q SS=Q (K)
T SS=T (K)
TH SS=TH (K)
BO SS=BO (K)
W SS=W (K)
TAU SS=TAU (K)
QNO SS=QNO (K)
CP SS=CP (K)
DBQ SS=DBQ (K)
DTAUSS=DTAU(K)
DGK=SS=CPX(K)
OTCHS=OTCH(K)
DO 1555 JT=1, NSP
CPSS(JI)=CP(J,JI)
HSS(JI)=H(J,JI)
ALPSS(JI)=ALP(J,JI)
DALPSS(JI)=DALP(J,JI)
DACHSS(JI)=DACH(J,JI)

1555
DGALPS(JI)=DGLP(J,JI)
CALL EPCIHI(JL)
KI=K

863E CONTINUE
CH2O=0.0
DO 4338 J=1, NSP
CH2O=CH2O+DALPI(J,JI)*CP(J,JI)

4338 CONTINUE
IF(ETA. EQ. 0.0) GOTO 4336
TAUN(LI)=TAU(JK)
BGN(LI)=GN(K)
DCPKXNL=L=DCP(K)
CTAU(LI)=GTAU(K)
DQNLXLI=EQ(K)
THNLXLI=THK(K)
CPXKXLI=CPY(K)
TNXLI=TN(K)+CTHY(K)
WNXLI=WK(K)
CH2C=CH2C
DO 4335 J=1, NSP
DALP(JLJL)=DALP(JLJL)
DDALPN(JLJL)=DDALP(JLJL)
HCJL=H(JLJL)
WOOTC(JLJL)=WOTH(JLJL)

4335 CONTINUE
4336 CONTINUE
IF(ETA. EQ. 0.0) GOTO 362
CH2C=0.
DC 332 J=1, NSP
HCJL=HC(JLJL)
WOOTC(JLJL)=WOTH(JLJL)
362 CONTINUE
V1=VISA
V2=VISC
DV1=DVISA
DV2=DVISC
TA1=TAU(J)
TA2=TAU(L)
DT1=DTAU(J)
DT2=DTAU(L)
EO1=EO1
EO2=EO2
V1=VY1
V2 = V(N(L))
VH = T(M(1))
TH = T(1/N(L))
C1 = GPX(K1)
C2 = GPX(K2)
D0 = DQQP(1)
D2 = DQQK(L)
P1 = DQQP(1)
P2 = DQQK(L)
C1 = CMG(1)
C2 = CMG(2)

IF(CONT.EQ.1) GO TO 4369
S1 = S1(J, RE)
S2 = S2(J, RE)

4369 V1 = VISD
D1 = VISO
T1 = TAU(K)
D2 = QTAU(K)
Q1 = QC(K)
F1 = F(K)
T1 = T1(K)
C1 = GPX(K)
D0 = DQQK(K)
P1 = DQQP(K)
C1 = CMG(K)
S1 = S1(J, RE)
S2 = S2(J, RE)

IF(CONT.EQ.1) GO TO 6427
IF(L.EQ.MTS) GO TO 6427

V1 = VISD
D1 = VISO
T1 = TAU(P(2)
D2 = QTAU(P(2)
Q1 = QC(P(2)
F1 = F(P(2)
T1 = TP(2)
C1 = GPX(P(2)
D0 = DQQP(2)
P1 = DQQP(2)
C1 = CMG(P(2)
S1 = S1(J, RE)
S2 = S2(J, RE)

6427 CONTINUE
S3A = 0.0
S3B = 0.0
S3C = 0.0
GO 4040 J = 1, NSP
AL2 = DALPM(J, L)
D0E = 00ALPM(J, L)
IF.ICCN1.EQ.1) GO TO 4311
V1=VISA
DV1=DVISA
AL1=DALPP(J+1)
DD1=DCLALPF(J+1)
901=800P(J)
TH1=THP(J)
Y1=YP(J)
S3A(J)=S3(XJ,PE)
S3AT=S3AT+3A(J)/WMOLE(J)
AL1=DALP(J+KT)
DD1=DCLALPF(J+KT)
V1=VISC
DV1=DVISC
9Q1=BC(KT)
TH1=TH(KT)
Y1=Y(KT)
S3DI(J)=S3(XJ,RE)
S3DT=S3DI(J)/WMOLE(J)
IF.(CCN1.EQ.1) GO TO 434C
IF.L.EQ.4NYS) GO TO 4049
V1=VISO
DV1=DVISO
AL1=DALPP(J+2)
DD1=DCLALPF(J+2)
9Q1=800P(2)
TH1=THP(2)
Y1=YP(2)
S3P(J)=S3(XJ,PE)
S3ET=S3ET+3B(J)/WMOLE(J)
CONTINUE
IF.ICCN1.EQ.1) GO TO 4329
GAB=2GMF(J)
PB=PP(J)
9B=QP(J)
RHOB=RHOF(J)
THB=THP(J)
W8=WNP(J)
XMUB=XMUP(J)
VR=FP(J)
A1=F1(L)
A2=F2(L,SH,SHA,S3AT)
IF.JCHEM.EQ.1) GO TO 7252
A3=0.
GO TO 7255
7252 DD 1712 J=J+NSP
1712 DUNCHP(J)=(DACHP(J+1)+DACH(J+K))/2.
OTCHP(J)=(OTCHP(J+1)+OTCH(J))2.
TP1=(T(L)+TP1)+CTCH(L)/2.
3 = F3(T1, DTCHP(1), TP(1), THN(L), THP(1), THN(L), OUMCHP, WP(1), WN(L))
7255 A4 = F4(BETA, XMUP(1), THP(1), XMUN(L), THN(L))
A2 = (A2 + A3) * A4
IF (L.EQ.0.0) GO TO 6429
GB = GBP (2)
P8 = PP(2)
Q8 = OP(2)
RHO8 = RGM(2)
THB = TP(2)
WB = WP (2)
XMUB = XMUP(2)
YB = YP(2)
91 = F1(L)
B2 = F2(L, S19, S20, S30)
IF (JCHEF .EQ. 1) GO TO 7253
93 x C
GO TO 7256
7253 GO 1713 J = 1, NSP
1713 OUMCHP(J) = OACH(J, 2) + OACH(J, K) / 2.
DTCHP(T) = DTCHP(T) + DTCH(T, K) / 2.
TP2 = TP(2) + DTCH(T, K) / 2.
93 = F3(TP2, DTCHP(T), TP(2), THN(L), THP(2), THN(L), OUMCHP, WP(2), WN(L))
7256 B4 = F4(BETA, XMUP(2), THP(2), XMUN(L), THN(L))
6429 CONTINUE
IF (IND .NE. 1) GO TO 630
THN(L) = THP(L)
PK(L) = PP(1) + (THP(1) - THN(NPTS) - A2 * (XP(NPTS) - XP(1))) / A1
GO TO 631
630 IF (ICNT .EQ. 0) THEN
1PNL = (A1 + PP(1) + OP(2)) + THP(2) - TP2
(PI + B2) * XMUP(1)
1PNL = PSTA
IF (ICNT .EQ. 0) THEN
1TNL = THP(1) - A1 * (PNL - PP(1)) - A2 * (XL - XP(1))
631 CONTINUE
DELS = 2. * (XMUN(L) - X(IN))/COS(TKN(THN) + COS(TKN(L))
TERM2 = RC(K) * C(K)
IF (BETA .GT. 0.1) THEN
TERM2 = TERM2 * RMON(L) * QNL(1) * 5
OT = 1. / TERM2
QNL(1) = (C * DELS + PN(L) + P(K) * OT * G(K)
IF (BETA .GE. 0.1) CPXNL(1) = CPX(K)
DTCHM = DTCHM + 1. * (QP(L) - XP(L)) / (C * (CPX(K) + CPXNL(1) * QNL(1) + QNL(1))
DTDFF = 2. * DELS * SIN(2. * TCKX(K) + CPXNL(1)) * OT
TN(L) = T(K) + DTCHM + DTDFF
CPXNL(1) = 0.0
WN(L) = 0.0
CALL THERMO(TNL, H1, CP1)

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DO 4050 J=1, NSP
DALDIF(J)=SSD(J)*DELS*OT
ALP(J,L)=ALP(J,K)+DALDIF(J)*DACH(J,L)
HM(J,L)=Ht(J)
CPNJ,J,L)=CPI(J)
WM(J,W(L)=ALPN(J,L)/WTMOLE(J)
CPXNL,J,L)=FNL(L)+ALPN(J,L)*CPN(J,L)
4050 CONTINUE
WN(L)=1./HM(L)
RN(L)=RN(W(L))/CPXNL(L)*(CPXNL(L)-RN(L)/CPN)
ORN=1./RA(L)
RMON(L)=FNL(L)*WN(L)*GEM/TN(L)
ENM(L)=Q(L)*ENINF*SQTIGAR*GAMN(L)*ORN/TN(L))
IF(EHM(L).LT.1.0001) GO TO 900
7360 XMNL(L)=2MUE(ENM(L))
900 CONTINUE
IF(FIFS.EQ.0) GO TO 1361
V (K)=V SS
P (K)=P SS
Q (K)=Q SS
T (K)=T SS
W (K)=W SS
TH (K)=TH SS
BO (K)=BO SS
TAU (K)=TAU SS
DBQ (K)=DBQ SS
CPX (K)=CPX SS
RMO (K)=RMO SS
DCPQ (K)=DCPQ SS
DTAU (K)=DTAU SS
DTHM (K)=DTHM SS
DO 1556 J=1, NSP
ALP(J,K)=ALPSS(J)
DALP(J,K)=DALPSS(J)
DACH(J,K)=DACHSS(J)
DALP(J,K)=DALPS(I)
CPNJ,J,K)=CPSS(J)
1556 HM(J,K)=HSS(J)
1361 CONTINUE
111 FORMAT(10X,9E12.5)
RETURN
END
SUBROUTINE SPACE(ISPP)
COMMON,=C/1MOD0,FIN
COMMON,=AL/SAREGEN
C- /W/X/SUBL./SUBU
COMMON/B/A/LP(7,55),ENM,WINF
COMMON/BD/XASS(5/5)

COMMON/CA/NQTHN(7,55),XNN(55)
COMMON/CJ/CPI(7,55),CP1(7),CPX(55)
COMMON/CK/WMOLE(7)
COMMON/DJ/BETR(4),ISR(4)
COMMON/DL/YN(55)
COMMON/ED/CPIN,PC
COMMON/EF/EM(55),GAM(55),R(55),TN(55),Y(55)
COMMON/EP/GAMINF,H1(7),RINF
COMMON/CK/DELX
COMMON/H1/ALP(7,55),CPN(7,55),CPX(55),EMN(55),BMW(55),HM(7,55),
R,L(55),CN(55),HRQ(55),RN(55),THN(55),TN(55),WN(55),XMUN(55)
COMMON/PC/W(55),X(55)
COMMON/PC/JCMEH,NST,TT(55)
COMMON/CA/H1(7,55),Q(55),RHO(55),XMU(55)
COMMON/RC/R(55)
COMMON/PC/AG,AP1,AP2
COMMON/SQ/BQN(55),DALP(7,55),DBN(55),DCPX(55),ODALP(7,55),
ODAUN(55),TAUN(55)
COMMON/S1/I3,IREG(1),KSTAR
COMMON/LB/R(55),CALP(7,55),DBQ(55),DCPX(55),ODALP(7,55),ODAUN(55),
IHAU(55)
COMMON/UV/I11,ICIT,IPRESS,IPRESU,ISUB
COMMON/WV/NPTS,RE,XBP,XJ
COMMON/WV/APRESS,APQEU
COMMON/XY/APR,APUS,DELTA,Y,EOOS,BOOS,INTACT,IPRS,IPUS,ITYP,
JBOOS,MMAX,RHET,XX2,XX4,YBOO,YTP
COMMON/YB/BDOS,IPRESS,CPRESS
COMMON/ZB/BDOS,BOOS,BOOS,E900,F900,GBO0,IAVE,IPUNCH,JO00,KKK
DIMENSION IS(4),XMAX(55)
XJ2=1.1-XJ
XJ1=1.1+XJ
DY=DELTA
DC=I=1.4
IF(ISI2,*EQ.0) GO TO 1
N=-1
IF(I/I2)*2,EQ.1)=N=1
IS=ISI2
IS=ABS(ISI2/M)-Y(ISI2*N))
IF(DYS-LT-2.0*DY) GO TO 2
C*********** ACC PT ON COMSTREAK SIDE OF SHOCK *****
ISM=SI(I1)-1
IF(I/I2)*2,EQ.1) ISM=IS(I1)+2
DO 3 K=ISM,NPTS
3 K=NPTS+ISM+K
J=K+1
CALL SWITCH(I,K)
3 CONTINUE
NPTS=NPTS+1
ISPP=1
IF(JSUBL.GT.IST(I)) JSUBL=JSUBL+1
IF(JSUBU.GT.IST(I)) JSUBU=JSUBU+1
DE J=1,4
IF(ISET(J).GT.IST(I)) ISET(J)=IST(J)+1
4 CONTINUE
IF((I/2).NE.1) IST(I)=IST(I)+1
L=ISTM+1
M=ISTM+1
K=ISTM
P=1.
P(K)=P (L)*RAT*(P ((M)-P (L))
TH(K)=TH(L)*RAT*(TH((M)-TH(L))
X(K)=X(L)*RAT*(X((M)-X(L))
Y(K)=Y(L)*RAT*(Y((M)-Y(L))
Q(K)=Q(L)*RAT*(Q((M)-Q(L))
T(K)=T(L)*RAT*(T((M)-T(L))
AG(K)=AG(L)*RAT*(AG((M)-AG(L))
TAU(K)=TAU(L)*RAT*(TAU((M)-TAU(L))
DBQ(K)=DBQ(L)*RAT*(DBQ((M)-DBQ(L))
DCPX(K)=DCPX(L)*RAT*(DCPX((M)-DCPX(L))
DTAU(K)=DTAU(L)*RAT*(DTAU((M)-DTAU(L))
YMASS(K)=YMASS(L)*RAT*(YMASS((M)-YMASS(L))
CPX(K)=0.
WK(I)=0.
CALL THERMO(IK)*H1,CPL
DO 5 J=1,HSP
ALP(J)=ALP(0)*RAT*(ALP(J,M)-ALP(J,L))
DALP(J)=DALP(0)*RAT*(DALP(J,M)-DALP(J,L))
DDALP(J)=DDALP(0)*RAT*(DDALP(J,M)-DDALP(J,L))
H(J,K)=H1(J)
CP(J,K)=CP(J)
WK(I)=ALP(J,K)*NTMPL(K)
CPX(K)=CFX(K)+ALP(J,K)*CP(J)
5 CONTINUE
W(K)=1.
R(K)=RO(W(K)
GAM(K)=CFX(K)/(CPX(K)-R(K)/CPIN)
OR=1./R(K)
RHO(K)=P(K)*W(K)*GEW/T(K)
EM(K)=GAM(K)*EMINF*SQRT(GAR/GAM(K)*OR/T(K))
XMU(K)=2*P(U2M)(EM(K))
2 CONTINUE
YSN=Y(ISET(I)+TAN(ABTBI(I)))*DELX1
IF((I/2).NE.1) GO TO 6
J=1
K=JM1
EMP=XM1(I+G,TH(K),XMU(K),0,0)
EMP=XM2(I+G,TH(J),XMU(J),0,0)
EMP1=XM1(I+G,TH(K),XMU(K),0,0)
EM1=XM1(I+9*TH(J),XMU(J)*5.5)
GO TO 7
6 J=IS(I)
   K=J-1
   EMP=XM1(I+9*IN(J),XMU(J)*5.5)
   EPL=XM1(I+9*TH(K),XMU(K)*5.5)
   EMPI=XM2(I+9*TH(J),XMU(J)*5.5)
   EM1=XM2(I+9*TH(K),XMU(K)*5.5)

7 EM3=XM3(I+9*TH(K),G(J))
   YCN=Y(K)*EM3*DELX
   YCT=YCN-CELX*(EMP1*EML1)*5
   YST=YCN-DELX*(EMP1*EML1)*5
   DYT=-N*(YCT-YST)
   IF(BETB(I),EQ.0.,AND.BETB(I),EQ.0.,AND.BETB(I),EQ.0.,AND.BETB(I),EQ.0.)
      AEG.O.)G TO 777
      IF(BETB(I),GT.0.,OR.BETB(I),GT.0.)777,77E
577 IF(DY/N,ABS(Y(J)),Y(J)),GT.11,775
775 IF(N*(YSN-YCN),GT.0.3),GO TO 1
   ISIMN=IS(I)-N
   IF(ISMN,EQ.NPTS,OR.ISMN,EQ.1),GO TO 1
C******* SUBTRACT PT FROM FREE STREAM SIDE OF SHOCK ****
775 L=K+1
   DO 8 K=L,NPTS
      J=K-1
      CALL SWITCH(I,J,K)
8 CONTINUE
   NPTS=NPTS-1
   ISPP=1
   IF(JSUBL.GT.IS(I)) JSUBL=JSUBL-1
   IF(JSUBU.GT.IS(I)) JSUBU=JSUBU-1
   GO TO 877
   J=1+4
   IF(ISJ.GT.IS(I)) ISJ=ISJ-1
9 CONTINUE
   IF(I/2,GT.2,FG),ISJ=ISJ-1
1 CONTINUE
   IF(ITYP.NE.1) GO TO 850
   IF(NPTS.LT,MMAK) GO TO 2121
   I111=1
   IPUNCH=1
   WRITE(6,9191)
9191 FORMAT(1P1)
   WRITE(6,851)
851 FORMAT(7H REQUESTED MAXIMUM NUMBER OF FLOW FIELD PTS. EXCEEDED. P
   IUNCH FILE OBTAINED/9TH RESUBMIT RUN WITH REDUCED NUMBER OF FLOW FI
   1E5D PTS. OR INCREASE INPUT FOR MAXIMUM NUMBER OF PTS.)
   RETURN
850 CONTINUE
   IF(I1.EQ.YNOT. OR ITYP.EQ.4) GO TO 2130
   IPRESS=1
   WRITE(6,850)
APRESU=P(IN)/PIN
2100 IF(Y(NPTS)=EQ,YTP.OR.IYTP.EQ.3) GO TO 2101
APRESU=1
APRESU=P(INPTS)/PIN
21C1 CONTINUE
IF(NPTS.LT.MMAX) GO TO 1000
ISC=0
DO 701 I=1,4
700 IF(IS(I).NE.0) ISC=ISC+1
IF(IYTP.EQ.2.OR.ISC.NE.0.OR.ISUB.NE.3) GO TO 701
YQ=YTP
IF(Y(NPTS).LE.Y(P-2.*DELTAY)YQ=Y(NPTS)+DELTAY
IK=1
IX=1
NP=NPTS
IF(NPTS/2+2.NE.NPTS) GO TO 702
800 J=NPTS+1
K=NPTS
CALL SWITCH(J,K)
V(J)=YQ
NPTS=NPTS+1
VYFUN=(Y(J))*(XJ2+Y(J)*XJ)-Y(K)*(XJ2+Y(K)*XJ)/XJ
RQAV=P(0)+Q(0)*COS(TH(K))
XMASE(J)=XMASE(K)+RQAV*VYFUN
TH(NPTS)=0.
APRESU=P(NPTS)/FIN
GO TO 1702,903,11X
7C2 J=1
DO 7C3 K=3,NP+2
J=J+1
CALL SWITCH(J,K)
7C3 CONTINUE
DELTAY=DELTAY*2.
IF(K.EQ.2) GO TO 774
NPTS=NPTS/2+1
GO TO 1000
771 IF(IYTP.EQ.3.OR.IS(I).EQ.0.OR.ISUB.NE.0.OR.ISC.NE.1) GO TO 303
IK=2
NP=IS(I)+1
IF((NP/2)+2.NE.NP) GO TO 702
IO=1
IF(Y(1).GE.YBOT+2.*DELTAY+1.E-03) GO TO 706
YT=YBOT
GO TO 707
7C6 YT=Y(1)-DELTAY
707 GO FOR KK=1,NPTS
K=NPTS+1-KK
J=K+1
CALL SWITCH(J,K)

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700 CONTINUE
NPTS=NPTS+1
DO 709 I=1,4
709 IF(IS(I).NE.0) IS(I)=IS(I)+1
IF(ISUB.EQ.0) GO TO 710
JSUBL=JSUEL+1
JSUB=JSUEL+1
710 Y11=YT
VFUN=V(Y21)*XJ2+Y11)*XJ1-Y11)*XJ1)/XJ1
RQAV=RHO(2)+Q(2)*COS(TH(2))
XMASS(1)=XMASS(2)-RQAV*VFUN
TH(1)=0.
APRSST=P11/PIN
GO TO (711,907),IQ
711 NPP=NPP+1
GO TO 702
704 ISN(3)=NF/2+2
IQ=IS(3)-ISN(3)
IS=IS(3)
IS(3)=ISN(3)
DO 705 K=IS, NPTS
J=K-ID
CALL SWITCH(J, K)
705 CONTINUE
NPTS=NPTS-ID
GO TO 1000
303 ICT=ISC
ICTP=KPTS
IF(IS(3).NE.0) ICTP=IS(3)-1
ILOT=1
IF(IS(4).NE.0) ILOT=IS(4)+1
DY=V(1ICTP)-Y(1ICT)
DELTA=CY/FLAT((MMAX-(NPTS-ITOP)-IS(4))/2-ICT)
ID=ILOT
ISN(1)=IS(1)
ISN(2)=IS(2)
ISN(3)=IS(3)
ISN(4)=IS(4)
JSUBLNK=JSUBL
JSUBN=JSLAU
IQF=IQ
IREG=1
IF(IS2).EQ.0) GO TO 501
I=IS(I2)
GO TO 502
501 IREG=2
IF(ISUB.EQ.0) GO TO 504
IF(JSUBL.EQ.1) GO TO 503
I=JSUBL
GO TO 502

503 CONTINUE
IB=JSUBU
IBB=IB

504 IREG=4
IF(IS(I).EQ.0) GO TO 505
IT=IS(I)=1
GO TO 502

505 IREG=5
IF(IS(I).EQ.0) GO TO 506
IT=IS(I)=1
GO TO 502

506 IT=NPTS
5C2 MP=(Y(IT)-Y(IB))/DELTAY
L=IB
JZ=1
DEL=(Y(IT)-Y(IB))/FLOAT(MP)

5932 CONTINUE
J=IBB
K=IB
X N(J)=X (K)
Y N(J)=Y (K)
Q N(J)=Q (K)
P N(J)=P (K)
T N(J)=T (K)
W N(J)=W (K)
R N(J)=R (K)
EM N(J)=EM (K)
TH N(J)=TH (K)
BQ N(J)=BQ (K)
TAU N(J)=TAU (K)
OBQ N(J)=OBQ (K)
GAM N(J)=GAM (K)
RHO N(J)=RHO (K)
XMU N(J)=XMU (K)
CPX N(J)=CPX (K)
DCPX N(J)=DCPX (K)
OITAUN(J)=OITAUN (K)
XMASS(J)=XMASS (K)
OO3108 JJ=1,NSP
H N(JJ,JK)=H (JJ,K)
CP N(JJ,JK)=CP (JJ,K)
ALP N(JJ,JK)=ALP (JJ,K)
DALPN(JJ,JK)=DALPN (JJ,JK)
DDALPM(JJ,JK)=DDALPM(JJ,JK)

3108 CONTINUE
GO TO (2201,2904),JZ
2201 GO TO 500,MP
I=KK+IBB-1
YN(I+1)=YN(I)+DEL
602 IF(YN(I+1).GE.Y(L) .AND. YN(I+1).LT.Y(L+1)) GO TO 601
L=L+1
GO TO 602
601 PAT=YN(I+1)-Y(L)/(Y(L+1)-Y(L))
IF(1T.EQ.JSUB/GO TO 1280
PN(I+1)=PN(I)+R*T*(P(I+1)-P(I))
THN(I+1)=TH(I)+R*T*(TH(L+1)-TH(L))
GO TO 1201
1200 CONTINUE
YY=YN(I+1)
PN(I+1)=AP0+YY*AP1+YY*AP2
THN(I+1)=0.
1261 CONTINUE
M=L+1
K=1
X N(K)=X (L)+R*T*(X (M)-X (L))
Y N(K)=Y (L)+R*T*(Y (M)-Y (L))
Q N(K)=Q (L)+R*T*(Q (M)-Q (L))
T N(K)=T (L)+R*T*(T (M)-T (L))
B.Q N(K)=B.Q (L)+R*T*(B.Q (M)-B.Q (L))
TAU N(K)=TAU (L)+R*T*(TAU (M)-TAU (L))
DBQ N(K)=DBQ (L)+R*T*(DBQ (M)-DBQ (L))
DCPXN(K)=DCPX (L)+R*T*(DCPX (M)-DCPX (L))
DTAN(K)=DTAN (L)+R*T*(DTAN (M)-DTAN (L))
XNASS(K)=XNASS(L)+R*T*(XNASS(M)-XNASS(L))
CPXN(K)=0.
WN(K)=0.
CALL THERPO(TN(K),H1,CPI)
0055 J=1,NSP
ALP N(J,K)=ALP (J,L)+R*T*(ALP (J,M)-ALP (J,L))
DALPN(J,K)=DALP (J,L)+R*T*(DALP (J,M)-DALP (J,L))
DDALPN(J,K)=DDALP (J,L)+R*T*(DDALP (J,M)-DDALP (J,L))
WN(J,K)=WN(J)
CPN(J,K)=CPN(J,K)+CPN(J,K)/MT(HOLE(J))
CPN(K)=CPN(K)+ALPN(J,K)/MT(HOLE(J))
55 CONTINUE
WN(K)=WN(K)
RN(K)=RN(K)
GAMN(K)=CPN(K)/(CPN(K)-RN(K)/C/IN)
RK=1./RN(K)
RHON(K)=RN(K)*WN(K)/GEN/THN(K)
EMN(K)=QN(K)*EMINF*SQRTIGAR/GAMN(K)*RK/THN(K)
IF(EMN(K).GT.1.)
1M(N(K)=2*M(EMN(K))
600 CONTINUE
GO TO 1200,1603,604,605,606,610,IREG
2200 ISN(Z)=I+1
IE=IS(2)+1
IB=ISM(2)+1
GO TO 501
603 JSUBLX=I+1
IB=JSUBU
JSUBU=JSUBLN+JSUBU-JSURL
IBB=JSUBUN
6C4 CONTINUE
GO TO 504
6C5 ISM(1)=I+2
IB=ISM(1)
IBB=ISM(1)
GO TO 505
6C6 IF(IS(3).NE.0) ISM(3)=I+2
IF(IS(3).EQ.0) NPTS=I+1
NP=NPITS
IF(IS(3).EQ.0) GO TO 22C3
ID=IS(3)-ISN(3)
ISS=IS(3)
DO 2364 K=ISS,NPITS
J=K-ID
CALL SWITCH(I,J,K)
2344 CONTINUE
NPITS=NPITS-ID
NP=ISH(3)-1
IF(ISUE.EQ.0) GO TO 2903
JZ=2
JZIC=JSUEL-1
JZI=JSUBLN-1
29C4 JZI=JZI+1
JZIC=JZIC+1
IF(JZI.EQ.JSUBUN) GO TO 2903
IBB=JZI
IB=JZI
GO TO 5032
2903 CONTINUE
22C3 DO 22C4 I=1001,NP
J=I
K=I
X (J)=XN (K)
Y (J)=YN (K)
Q (J)=QN (K)
P (J)=P N(K)
T (J)=T N(K)
W (J)=W N(K)
R (J)=R N(K)
E (J)=EM N(K)
TH (J)=TH N(K)
8Q (J)=RQ N(K)
TAU (J)=TAU N(K)
DBQ (J)=DBQ 'K'
GAM (J)=GAM N(K)
RHO (J)=RHO N(K)
XMU (J)=XMU N(K)
CPX (J)=CPX N(K)
DCPX (J)=DCPX N(K)
OTAU (J)=OTAUN(K)
XMASS(J)=XMASS*4(K)
DO4100 JJ=1,NSF
H (JJ,J)=H '4(JJ,K)
CP (JJ,J)=CP N(JJ,K)
ALP (JJ,J)=ALP N(JJ,K)
DALP (JJ,J)=DALP N(JJ,K)
DDALP(JJ,J)=DDALP N(JJ,K)
4108 CONTINUE
2204 CONTINUE
DO 687 I=4,4
687 IS(I)=ISN(I)
JSUBL=JSUBLN
JSUBU=JSUBUN
1000 CONTINUE
IF(ITYP.EQ.3) GO TO 903
IF(Y(NPTS).LE.YTP) GO TO 903
YQ=YTP
IF(Y(NPTS).LE.YTP-1.*DELTAY) YQ=Y(NPTS)+DELTAY
L=2
N=PTS-1
M=1
IF(ABS(P-M)-P(L)) .LT.0.01) 900,900,830
900 IF(ABS(D-M)-Q(L)) .LT.0.01) 901,901,820
901 IF(ABS(T-M)-T(L)) .LT.0.001) 902,902,800
902 IF(ABS(ALP(5,M)-ALP(5,L)) .LT.0.001) 903,903,800
903 IF(Y(I),EYBOT) GO TO 967
IF(ITYP.EQ.4) GO TO 907
L=2
M=3
G=2
IF(Y(I).LE.EYBOT+DELTAY+L.E-03) 910 Y=VBLT
GO TO 910
910 IF(Y(I).LT.-DELTAY
910 IF(ABS(P-M)-P(L)) .LT.0.01) 904,904,767
904 IF(ABS(D-M)-Q(L)) .LT.0.001) 905,905,707
905 IF(ABS(T-M)-T(L)) .LT.0.001) 906,906,707
906 IF(ABS(ALP(4,M)-ALP(4,L)) .LT.0.001) 907,907,707
907 CONTINUE
IF(ITYP.EQ.4) GO TO 2102
907 IF(Y(I).LT.EYBOT) GO TO 2102
IBCD=IBCS
ABCD=ACCS
IPRSS=IPRS
APGRS=APRS

21C2 IF(ITYP.EQ.3) GO TO 2103
IF(Y(NPTS).NE.YIP) GO TO 2103
JBO=JBCS
EBO=EBCS
IPRSS=IPRS
APGRS=APRS

21C3 CONTINUE
IF(Y(1),EQL,YBO1.AND.,ITYP.EQ.3) ITYP=1
IF(Y(1),EQL,YBO1.AND.,ITYP.EQ.2) ITYP=2
IF(Y(NPTS),EQL,YIP.AND.,ITYP.EQ.4) ITYP=1
IF(Y(NPTS),EQL,YIP.AND.,ITYP.EQ.2) ITYP=3

2121 CONTINUE
IF(ISUB.EQ.1) RETURN
JSUBL=NPTS+1
JSUBL=NPTS+1
RETURN

END

SUBROUTINE RSET
COMMON/AL,GAR,GEN
COMMON/BK/ALP(7,55),EMNF,WINF
COMMON/BC/XMAS5(55)
COMMON/CI/C(17,55),CPX(55)
COMMON/DP/YN(55)
COMMON/EC/PN(55)
COMMON/EF/EM(55),GM(55),P(55),TH(55),Y(55)
COMMON/EP/GAMINF(17),WINF
COMMON/HF/ALPN(7,55),CPM(7,55),CPXM(55),EMM(55),GMN(55),HN(7,55)
COMMON/NF/PN(55),PN(55),QN(55),RN(55),THNN(55),THN(55),HN(55),XMN(55)
COMMON/OF/THBP,YBP,YAPN
COMMON/PC/X(55),X(55)
COMMON/FC/JOEY(55),X(55)
COMMON/DA/AT(17,55),RHO(55),XMU(55)
COMMON/RC/AT(55)
COMMON/ST/QT(55),DLPN(17,55),DNQ(55),DCPX(55),DDALP(17,55),
DITAUN(55),DAPN(55)
COMMON/ST/QT(55),DLPN(17,55),DNQ(55),DCPX(55),DDALP(17,55),DITAUN(55),
DITAUN(55)
COMMON/VW/CONT,INEO,KI,THBPN,XBPN
COMMON/VW/NPTS,RE,XBP,XJ
DO 5110 I=1,NPTS
TH(I)=TH(I)
X(I)=XBP
Y(I)=YN(I)
Q(I)=QK(I)
P(I)=PN(I)

DO 5110 I=1,NPTS
I[I]=TN[I]
RHO[I]=RHC[I]
EM[I]=EHC[I]
XMU[I]=XPMUN[I]
TAU[I]=TAUN[I]
40[I]=PCH[I]
CPXi[I]=CPX[I]
Dtau[I]=DTAUN[I]
DQ[I]=DQCM[I]
00489J=1, KSP
ALP[J][I]=ALP[N][J][I]
DALP[J][I]=DALP[N][J][I]
DDALP[J][I]=DDALP[N][J][I]
CP[J][I]=CP[C][J][I]
H[J][I]=H[N][J][I]
4098 CONTINUE
W[J]=WM[I]
F[J]=RN[I]
GAM[I]=GAM[I]
CPXI[I]=CPXI[N]
5110 CONTINUE
X[I]=X[I]+XJ
IF(Y[I]>=0.0) THEN
XMASST[I]=0.
DO 10 I=2,NPTS
YFUN=YY[I]*X[I]-Y[I-1]-X[I-1]*X[I]/XJ
RQAV=(RHI[I]*C[I]*COS(TH[I-1])+RHO[I-1]*C[I-1]*COS(TH[I-1]))/2.
XMASST[I]=XMASST[I]+RQAV*YFUN
10 CONTINUE
DO 110 I=1,NPTS
CPXI[I]=C
CALL THERMO(I,I+1,CP[I])
DO 120 I=1,NSP
CP[I][I]=CP[I][I]
H[I][I]=H[I][I]
110 CPXI[I]=CPXI[I]+ALP[I][I]*CP[I][I]
RHO[I]=GENW[I]*P[I]/T[I]
GAM[I]=CPXI[I]/ICPX[I]-R[I]/GPM
RI=1./R[I]
EM[I][I]=C[I]*EMIN*SQR(GBAR/GAM[I]*RI/T[I])
IF(EM[I][I]<1.0000) GO TO 8409
XMU[I][I]=2*MU[EM[I][I]]
8409 CONTINUE
XBP=XBN
YBP=Y(NPTS)
YBP=Y(NPTS)
IF(YBP,E=YN(NPTS)) RETURN
YBP=YBN
YBP=YBF
RETURN
END
SUBROUTINE SHEAR1(CFF, VISD)
COMMON/AC/I800*PIN
COMMON/BA/ALP(7,55), EMINF, WINF
COMMON/GJ/CPI(7,55), CPX(7,55)
COMMON/EF/EM(55), GA4(55), PI(55), THF(55), Y(55)
COMMON/PD/JCHEN.NSP,T(55)
COMMON/QW/N(7,55), Q(55), RHO(55), XMU(55)
COMMON/SC/BQX(55), DALPN(7,55), DOQX(55), DCNX(55), DDALPN(7,55),
1OTAUN(55), TAUN(55)
COMMON/WW/NPTS, RE, XCP, XJ
DIMENSION LOCS(4)
KKI=0
DO 190 K=1,8
100 LCSS(K)=0
LAST=NPTS
LAST1=NPTS+1
LAST2=NPTS-1
Y (LAST1)=2.*Y (LAST)-Y (LAST2)
0 (LAST1)=Q (LAST2)
T (LAST1)=T (LAST2)
CPX (LAST1)=CPX (LAST2)
PI(LAST1)=PI(LAST2)
TH (LAST1)=TH (LAST2)
TAU (LAST1)=0.
BO (LAST1)=0.
DCPX (LAST1)=0.
DO 6298 J=1,NSP
DALP (J,LAST1)=0.
6290 ALP(J,LAST1)=ALP(J,LAST2)
DO 629:2 K=2,LAST
DELY2=Y (K+1)-Y (K)
DELY1=Y (K)-Y (K-1)
IF (DELY2 LT 1.E-06 OR DELY1 LT 1.E-06) GO TO 1301
SUM=DELY1*DELY2
RATIO1=DELY1/DELY2
RATIO2=DELY2/DELY1
SU=1./SUM
RMR=RATIO1-RATIO2
TAU(K)=Q(K+1)*RATIO1-Q(K)*RMR-Q(K-1)*RATIO2*SU
0=1./DELY2
DTAU(K)=2.*Q(K+1)*DELY1*SU-Q(K)+Q(K-1)*DELY2*SU)/DELY1*00
BO(K)=T(K+1)*RATIO1-T(K)*RMR-T(K-1)*RATIO2*SU
BO(K)=2.*T(K+1)*DELY1*SU-T(K)+T(K-1)*DELY2*SU)/DELY1*00
DCPX(K)=CPX(K+1)*RATIO1-CPX(K)*RMR-CPX(K-1)*RATIO2*SU
DO 6291 J=1,NSP
DALF(J,K)=ALP(J,K)*RATIO1-ALP(J,K)*RMR-ALP(J,K-1)*RATIO2*SU
DO 6291 J=1,NSP
```
ODALP(J,J)=2.*(ALP(J,K+1))*DELY1*SU-ALP(J,K)+ALP(J,K-1)*DELY2*SU
1/DELY1*CD
6291 CONTINUE
GO TO 6292
1301 KK1=KK1+1
LOC8(KK1)=K
6292 CONTINUE
TAU (1) = 0.0
CY = Y(2)-Y(1)
IF(INCO.EQ.1) TAUU(1) = CYF*PE*RHO(1)*Q(1)**2.*5./VISO
Q(1) = 0.0
DCPX (1) = 0.
DTAU (1) = IQ (2) - C (1) + CY (2) - Y (1) ** 2
IF(INMOD.EQ.1) DTAU(1) = 4.*(Q(2) - C(1))/DY**2-2.*(TAU(1)+TAU(2))/DY*
ICTAU(2)
IPO (1) = IT (2) - T (1) + CY (2) - Y (1) ** 2
IF(INCO.EQ.1) DBQ(1) = 4.*(T(2) - T(1))/DY**2-2.*BQ(2)/DY+BQ(2)
D6293J=1, NSP
DALP (J, 1) = 0.0
ODALP (J, 1) = 2.*(ALP (J, 2)-ALP (J, 1))/DY (2)-
1.*Y (1) ** 2
IF(INCO.EQ.1) ODALP(J,1)=4.*(ALP(J,2)-ALP(J,1))/DY**2-2.*DALP(J,2
1)/DY+DALP(J,2)
6293 CONTINUE
DO 101 = 1, 8
IF(LOC8(I).EQ.0) GO TO 102
K = LOC8(I)
L=1
IF(M/2)=2.0, NSP, L = 1
YNK = Y (K+1)-(K+L)/YNK = R2 (K+L)
Q (K) = 2.*(T (K+1) - T (K+L))/YNK = TAU (K+L)
TAU (K+1) = 2.*IQ (K+1) /YNK = TAU (K+L)
DCPX (K+1) = 2.*(CPX (K+1) - CPX (K+L))/YNK = DCPX (K+L)
DTAU (K+1) = 2.*TAU (K+1) /YNK = DTAU (K+L)
DNA (K+1) = 2.*(BQ (K+1) - BQ (K+L))/YNK = DNA (K+L)
DO 103 = J+1, NSP
DALP (J,K)=2.*(ALP (J,K)-ALP (J,K+1))/YNK=DALP (J,K+1)
101 CONTINUE
102 CONTINUE
DC 7000 I=1, 1, LAST
TAU(I)=TAU(I)
BQN(I)=Q(I)
DCPXN(I)=DCPX(I)
DTAUN(I)=DTAU(I)
DQN(I)=DQ(I)
DO 7001 J=1, NSP
ODALP(N,J)=ODALP(J,1)
7001 ODALPN(J,1)=ODALP(J,1)
```
7000 CONTINUE
   NPTS=LAST
   RETURN
END

SUBROUTINE SHEAR2(CFF,WISD)
COMMON/AC/IOO0,PIN
COMMON/DP/VN(55)
COMMON/HY/ALPN(7,55),CPN(7,55),CPXY(55),EMN(55),EMM(35),HN17,55,1,
ILS,PW(55),QN(55),RHON(55),RN(55),THN(55),TN(55),HN(55),XHUN(55)
COMMON/PG/JCHEN,HSP,T(55)
COMMON/SQ/BN(55),DALPN(7,55),QDN(55),DCPYN(55),QDALLP(7,55),
1DTAUN(55),TAUN(55)
COMMON/NA/NPTS,AE,KXP,KXJ
DIMENSION LOC3(1)
KXJ=0
DO 100 K=1,8
100 LOC3(K)=G
LAST=NPTS
LAST1=NPTS+1
LAST2=NPTS-1
YN(LAST1)=2.*YN(LAST)-YN(LAST2)
QN(LAST1)=QN(LAST2)
TN(LAST1)=TN(LAST2)
CPN(LAST1)=CPN(LAST2)
PN(LAST1)=PN(LAST2)
THN(LAST1)=THN(LAST2)
TAUN(LAST1)=0.
QN(LAST)=0.
DCPYN(LAST)=0.
DO 3001 J=1,NSP
DALPN(J,LAST1)=G
3001 ALPN(J,LAST1)=ALPN(J,LAST2)
DO 6002 K=2,LAST
DELY2=YN(K+1)-YN(K)
DELY1=YN(K)-YN(K-1)
IF(DELY2.LE.-0.06.OR.DEY1.LE.-0.06) GO TO 1301
SUM=DELY1+DELY2
RATIO1=DELY1/DELY2
RATIO2=DELY2/DELY1
SUM=1./SUM
DD=1./DELY2
RMR=RATIO1-RATIO2
TAUN(K)=1.*QN(K)*RATIO1-SU QN(K)=1.*RATIO1-THN(K)*RMR-TN(K)*RATIO2*SU
DO 6001 J=1,NSP
DALPN(J,K)=ALPN(J,K)*RMR-AALPN(J,K)*RATIO2
END
1*SU
DDALPN(J,K)+1=2.*(ALPN(J,K)+1)*DELY1*SU-ALPN(J,K)+1)*DELY2
1*SU/DELY1=0
4081 CONTINUE
GO TO 6082
1311 KKI=KK1+1
LOCS(KKI)=K
6082 CONTINUE
FAUN(J)=0.0
DY=F.(2)-YN(1)
IF(IBCD(8,E,G,.)1=TAUN(1)=CFF*PE*RHON(1)*QN(1)**2.5/VISO
9QN(1)=0.0
OCPNX(1)=0.
DTAUN(1)=QN(1)*QN(1)*2.+(YN(2)-YN(1))**2
IFI(BOU(8,E,G,.)1=TAUN(1)=4.*(QN(2)-QN(1))/DY**2-2.*TAUN(2)
1/1/DY=CTAUN(2)
DOBQ(1)=QN(2)-QN(1)**2.+(YN(2)-YN(1))**2
IFI(BOU(8,E,G,.)1=DOBQ(1)=4.*(QN(2)-QN(1))/DY**2-2.*9QN(2)/DY+DOBQ(2)
00=082J=1,
NSP
DALPN(J); 1)=0.0
DDALPN(J, 1)=2.*(ALPN(J, 2)-ALPN(J, 1))/YN(2)-
YN(1))**2
IFI(IBCD(8,E,G,.)1=DDALPN(J,1)=4.*(ALPN(J,2)-ALPN(J,1))/DY**2-2.*DDALPN
1(J,2)/CY=DDALPN(J,2)
4082 CONTINUE
00 1311 N=1.0
IFI(LCCSM).EQ.0) GO TO 132
K=LOCSM(1)
L=1
IFI(K/2)+2.HT1. M-L=1
YNK=YN(K)@YN(K+1)
9QN(K)=2.*(YN(K)-YN(K+1))/YNK-BG.N(K+1)
TAUN(K)=2.*QN(K)**2/YNK-TAUN(K+1)
OCPNX(K)=2.*(CPNX(K)-CPNX(K+1))/YNK-OCPNX(K+1)
DTAUN(K)=2.*(TAUN(K)-TAUN(K+1))/YNK-OCPNX(K+1)
DOBQ(K)=2.*OBQ(K)+OBQ(K+1))/YNK-OCPNX(K+1)
00 132 J=1,NSP
DDALPN(J,K)+1=2.*(ALPN(J,K)+1)-ALPN(J,K+1))/YNK-DDALPN(J,K+1)
103 DDALPN(J,K)+1=2.*(ALPN(J,K)+1)-ALPN(J,K+1))/YNK-DDALPN(J,K+1)
101 CONTINUE
102 CONTINUE
NPTS=LAST
RETURN
END
SUBROUTINE LPINT(I,OPTP)
COMMON/AB/EPP,EPQ,EPT
COMMON/AC/IBOD,PIN
COMMON/AL/GRN,GEN
COMMON/AS/ALP(7,55),EMINF,WINF
COMMON/R8/S18,S26,S39T
COMMON/RC/GAM,PHGAM,PHQ,PHGAM,THGAM,TH9,THB,THW,TMUB,YF
COMMON/GAM/MTN(7,55),XN(55)
COMMON/CJ/CPR(7,55),CP1(71),CPX(55)
COMMON/KM/WMMOLE(7)
COMMON/QF/VN(55)
COMMON/EF/CPIN(40)
COMMON/EF/CPIN(55)
COMMON/EF/GAM(55),P(55),TM(55),Y(55)
COMMON/EF/EIN,PR,CRE
COMMON/EF/GAMINF,H1(7),PINF
COMMON/EF/DML
COMMON/EF/DELF
COMMON/ALPHA,BETA
COMMON/MA/ALPH1N(7,55),CPN(7,55),CPX(55),EMM(55),GAMN(55),MN(7,55),
ILS,PN(55),QN(55),PN(55),RN(55),TN(55),NN(55),XMUN(55)
COMMON/KH/CHC(2),CP9(7),CPX(2),DALCIF(71),DALPB(71),DALLPB(71),DELS,
AEMP(21),HR(7),HC(7),RP(21),SSA(7),SS(7),S3O(7),XDT8(71),XDP(12)
COMMON/CF/ALPB(71),PH1(55)
COMMON/PQ/MTN(55),X(55)
COMMON/PC/PR(55)
COMMON/PG/GAM(7,55),V(55),RH(55),PKM(55)
COMMON/CS/PHQ(21),WODT17,55,WGOCF(71),WP(2),XMUP(2)
COMMON/SG/BON(55),ALBON(7,55),PON(55),CPXN(55),DALLPB(7,55),
1D51(55),D51(55)
COMMON/SS/AL2,AL2,AL2,AL2,AL2,AL2,AL2,AL2,AL2,CH2,CH2,CH2,CH2,CH2,CH2,CH2,CH2,CH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
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PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
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PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
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PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
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PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
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PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,PH2,
CONTINUE

YB = (Y(K) + Y(I)) / 2.

CONTINUE

RATG = (VB - Y(I)) / (Y(K) - Y(I))

TH = TH(I) + RATG * (TH(K) - TH(I))

EXU = EXU(I) + RATG * (EXU(K) - EXU(I))

EM2 = XM2(ALPHA, BETA, THG, XMUB, THM(I), XMUN(I))

IF (OPTP.EQ.0) EP2 = EP1L + RATG * (E=10-Q-EM1)

YD = YB

IF (KIP4 .LT. 0) IF (KIP4 .LE. 20) GO TO 8372

WRITE (L, 9191)

CONTINUE

WRITE (L, 2222)

FCMATH15EP UNABLE TO LOCATE Y LOCATION OF CHARACTERISTIC IN LPPOINT 1

STOP

CONTINUE

RATG = (VB - Y(I)) / (Y(K) - Y(I))

TH = TH(I) + RATG * (TH(K) - TH(I))

NB = Q(I(I)) + RATG * (Q(K(I)) - Q(I(I))

PB = P(I(I)) + RATG * (P(K(I)) - P(I(I))

TT = T(I(I)) + RATG * (T(K(I)) - T(I(I))

TAU = TAU(I(I)) + RATG * (TAU(K(I)) - TAU(I(I))

DO = DO(I(I)) + RATG * (DO(K(I)) - DO(I(I))

DQ = DQ(I(I)) + RATG * (DQ(K(I)) - DQ(I(I))

DQP = DQP(K(I(I)) + RATG * (DQP(K(I(I)) - DQP(I(I))

DTAU = DTAU(I(I)) + RATG * (DTAU(K(I)) - DTAU(I(I))

DBQ = DBQ(I(I)) + RATG * (DBQ(K(I)) - DBQ(I(I))

DTCHP = DTCHP(I(I) + RATG * (DTCHP(K(I)) - DTCHP(I(I))

DTCHB = DTCHB(I(I) + DTCHB(K(I)) - DTCHB(I(I)) * 5

CPX = 0.

CM = 0.

CH2 = 0.

CALL THERMO(TT, HP, CPR)

DELQ = 0.1, NSP

ALPB1 = ALP(I(I), J(J)) + RATG * (ALP(J(J), K(K) - ALP(I(I), J(J))

DALPB = DALPB(I(I), J(J)) + RATG * (DALPB(K(K), J(J) - DALPB(I(I), J(J))

DALPB = DHALPB(I(I), J(J)) + RATG * (DHALPB(J(J), K(K) - DHALPB(I(I), J(J))

CH2 = CH2 + DALPB(I(I), J(J) + CPB(J(J)

CH2 = CH2 + DALPB(J(J), I(I) + CPB(J(J)

CPB = CPB + ALPB(I(I), J(J)

W = W + ALPB(I(I) / WTMLE(J)

WDTB(J(J) = WDTB(J(J) + RATG * (WDTB(J(J) - WDTB(J(J)

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DACHM=DACH(J,1)+RATG*(DACH(J,K)-DACH(J,1))
DACH(J)=(DACHM+DACH(J,1))*5
DACHP(J,1)=DACHM

4060 CONTINUE
W0=1./WB
R0=RO/NB
GAMB=CPXB/(CPXB-RO/CPIN)
OR=1./RB
RHOB=PB/RO*GEN/TT
ENB=QR*EPINF*SQRT(GAM/GENB*OR/TT)
XNUB=ZNU(ENB)
IF (DEL.EQ.0.) GO TO 8392
Y P(1)=Y 0
X P(1)=X 0
Q P(1)=Q 0
P P(1)=P 0
T P(1)=TT 0
W P(1)=W 0
A P(1)=A 0
TM P(1)=TM 0
EN P(1)=EN 0
GQ P(1)=GQ 0
RHO P(1)=RHO 0
XNU P(1)=XNU 0
CPX P(1)=CPX 0
GAM P(1)=GAM 0
TAU P(1)=TAU 0
OBQ P(1)=OBQ 0
OTAUP(1)=OTAUB
OCPXP1=CCPXB
GO 3939 J=1+NSP
ALP P(J,1)=ALP B(J)
DALP P(J,1)=DALP B(J)
3939 GDALP(J,1)=GDALP B(J)
8392 CONTINUE
IF (BETA-NE.0.) GOTO 4070
TAU0(I)=TAU(I)
BBN(I)=BB(I)
OCXP1(I)=OCXP(I)
OTAUP(I)=OTAUB
TM(I)=TM(I)+DCHM(I)
WX(I)=WX(I)
OBQN(I)=OBQ(I)
CPX1(I)=CPX(I)
CH0=CH0D
GO 4071 J=1, NSP
DALPN(J, L)=DALP(J, I)
ODALPN(J, L)=ODALP(J, I)
MG(J)=MG(J, I)


WDOTC(J,I)*WDOIN(J,I)
4071 CONTINUE
4070 CONTINUE
IF(ETA*EC<5.6) GO TO 4072
CM2C=0.0
DO 4073 J=1,NSP
MC(J)=MN(J,I)
WDOTC(J,I)*WDOIN(J,I)
4073 CM2C=CM2C+DALPN(J,I)*CPN(J,I)
4072 CONTINUE
V1=VISB
V2=VISC
DV1=VVISB
DV2=VVISC
TA1=TAUR
TA2=TAUR(I)
DT1=DATUR
DT2=DATUR(I)
Q01=QGB
Q02=QCN(I)
Y1=V0
Y2=YN(I)
T1=1+8
T2=THN(I)
S1=SL4(XJ,RE)
C1=CPXB
C2=CPNX(I)
Q1=QGB
Q2=QCN(I)
P1=CPXK
P2=CPNXK(I)
CM1=CM2
CM2=CM2C
IF(DEL*EC<3.6)1,2
1 S2B=24(XJ,RE)
V1=VISD
DV1=VVISD
TA1=TAUD(I)
DT1=DATUR(I)
Q01=Q0(I)
Y1=Y(I)
T1=TM(I)
S1=SL4(XJ,RE)
GO TO 56
2 S2B=24(XJ,RE)
56 IF(DEL*EC<3.4)3,4
3 V1=VISD
DV1=VVISD
C1=CPXK(I)
BO=BC(I)
DO=EQ(I)
TA=TAU(I)
TM=TH(I)
Y1=Y(I)
PK=DCP(I)
CH=CH2
S2=S2(XJ,RE)
S3T=0.
S30T=0.
DO4975J=1, NSP
AL1=DALP(J)
AL2=DALPM(J,L)
DO1=DDLPM(J)
DO2=DDLPM(J,L)
V1=VIS9
DV1=DVIS9
BO=BG
TH1=ThB
Y1=V9
S3B(J)=S3(XJ,RE)
IF(DEL.EQ.0.15.8
V1=VIS9
DV1=DVIS9
AL1=DALP(J)
DO1=DDLPM(J)
BO=BC(I)
TH1=TH(I)
Y1=Y(I)
S30(J)=S3(XJ,RE)
S30T=S30T+S30(J)/WMOLE(J)
S3BT=S3BT+S3B(J)/WMOLE(J)
4075 CONTINUE
IF(IDEL.EQ.0.) RETURN
B1=F1(I)
UH=XJ
I15=0
YY=YN(1)
IF(XAX.XLT.1.E-06.AND.XJX.EQ.0.) I15=1
XX=J
IF(I15.EQ.1) XJ=O
 IF(JCHM.EQ.1) GO TO 7254
B3=0.
GO TO 7257
7254 TP1=TT(I)+DTCH(I)+TT)/2.
B3=F3(TP1,DTCH,TT,TH(I),THB,TMN(I),DACHB,WB,WN(I))
7257 OPTT=1,
    IF(OPTT.NE.0.) OPTT=-1.
    B6=F6(BETA,-OPTT,XMUB,THB,XMUN(I),THN(I))
    B2=(B2+B3)*B4
    IF(OPTT.NE.0. AND. IPRES U.EQ.0.) GO TO 7444
    IF(OPTT.NE.0. AND. IPRES U.EQ.1.) GO TO 7482
    IF(IABCD.EQ.1) GO TO 7444
    IF(IPRESS.EQ.1) GO TO 7482
    AX=6.
    IF(I15.EQ.0) GO TO 100
    AX=KJ*SIN(XMUB)*SIN(THB-XMUB)
    IF(BETA.GT.0.0)AX=(AX+KJ*SIN(XMUN(I)))
    1/SIN(THN(I)-XMUN(I))=5
    AX=1.-AX
100 CONTINUE
    PN(I)=PB-(THB*AX+B2*(XN(I)-X0))/B1
    GO TO 7445
7482 CONTINUE
    KPRESS=KPRESS+1
    IF(KPRESS.LT.6) GO TO 3232
    IERR=7482
    WRITE(6,3131) IERR,I,THN(I),PN(I),YN(I),THB,PB,YB
3131 FORMAT(215,5F13.5)
    STOP
3232 THDUM=THN(I)
    KIP=6
    THN(I)=THB+OPTT*B1*(PN(I)-PB)+OPTT*B2*(XN(I)-X0)
    IF(ABS(THN(I)-THDUM).LT.1.E-64) GO TO 8372
    VN(I)=V(I)+.5*(TAN(THN(I))**TAN(THN(I)))**DELX
    GO TO 7445
7444 PN(I)=PB+OPTT*(THN(I)-THB)/B1-B2*(XN(I)-X0)
7445 CONTINUE
    IF(ABS(KPL(I)-P(I)).LT.LE.EPP) PN(I)=P(I)
    DELS=2.*(XN(I)-X(I))/COS(THN(I))**COS(THN(I))
    TERM2=AMQ(I)**Q(I)**I
    IF(BETA.GT.0.0)TERM2 = (TERM2+AMQ(I))
1*QN(I)**.5
    QT=1./TERM2
    QN(I)=(SIC**DELS-PN(I)+P(I))*QT*Q(I)
    IF(IBAB(QN(I)-Q(I)).LT.LE.EPQ) QN(I)=Q(I)
    IF(BETA.EQ.0.0)CPXN(I)=CPX(I)
    DTCHM=DTCHM+(PN(I)-P(I))*QN(I)*Q(I)/(CPX(I)+CPXN(I))**EIN*QT
    DTDIFF=SC*DELS*Q(I)**2./(CPX(I)+CPXN(I))**QT
    TN(I)=TN(I)+DTCHM+DTDIFF
    IF(ABB(TN(L)-T(L)).LT.LE.EPT) TN(L)=T(L)
    CPXN(I)=0.0
    W(NI)=0.0
    CALL THERMO(TN(I),NI,CP1)
    D04080J=1. HSP
DAMDF(I,J)=S30(J)*DELS/TERM2
ALPN(J,J)=ALPN(J,J)
  +DAMDF(J)+DACH(J,I)
HN(J,J)=M(J)
CPN(J,I)=CP1(J)

WN(I)=WN(I)+ALPH(J,I)/MTMOLE(J)
CPN(I,I)=CPN(I,I)+ALPN(J,I)*CPW(J,I)

CONTINUE
WN(I)=1./WN(I)
RN(I)=RC/WN(I)
GANN(I)=CPMN(I)/(CPN(I)-PMN(I)/CPN)
OR=1./RN(I)
RNH(I)=RN(I)*YN(I)*GEN/THN(I)
ENN(I)=QN(I)*EMINF*SQRT(GAR/GANN(I))*OR/THN(I)
XWUN(I)=ZM(I)*ENN(I)

RETURN

END
FUNCTION CERY(X1,X2,X3)
COMMON/QR,DEL1,DEL2,RAT1,RAT2,PR,SM
DERY=(X1*RAT1-X2*(RAT1-RAT2)-X3*RAT2)/SM
RETURN

END
SUBROUTINE THSSS(THSS)
COMMON/AXJSUBL,JSU
COMMON/EF,E(55),GAM(55),P(55),TH(55),Y(55)
COMMON/C,DEL1,DEL2,RAT1,RAT2,PR,SM
COMMON/R,GS,PS,THS,THSL,THSU
JSUBP=JSUEU+1
JSUBM=JSU-R-1
CALL SHEAR(JSUBP,ASH1)
CALL SHEAR(JSUBU,ASH2)
CALL SHEAR(JSUBM,ASH3)

EM=0.
DEL2=JJSUBP-JJSUBU
DEL1=JJSUBU-JJSUBM
SM=DEL2+DEL1
RAT1=DEL1/DEL2
RAT2=DEL2/DEL1
AY=DERY(ASH1,ASH2,ASH3)
R=JTH(JSUBU)
TERM1=AY*GAM
EM=DERY(EM,JSUBP,EM,JSUBU,EM,JSUBM)
TANT=TH(JSUBU)
ENNN=EM/GAM=EM/TANT
GPM1=GAM(JSUBU)*P(JSUBU)*EM(JSUBU)**2
TERM2=TERM1/GAM(JSUBP)*P(JSUBP)*EM(JSUBP)**2*GPM1*GAM(JSUBM)*P(JSUBM)

1=EM(JSUBM)**2
GPM=1*GAM/GPM2*ENNN
THN=DERY(TM1,JSUBP,TH(JSUBU,TH(JSUBM))
THNN=THY/COSTH=THS*TANTH
TERM3=GPM*COSTH*COTH*(EM(JSUBU)**2-1.)*THS
THSY=DERY(THS,THS,THSL)
TERM5=GPM*SIN(TH(JSUBU))*THSY
THYP=DERY(TH(JSUBU)+1.)*TH(JSUBP)+TH(JSUBU)
THYL=DERY(TH(JSUBU)+1.)*H(JSUBH)+TH(JSUBH+1)
THNNP=THYP*COSTH-THSU*TANTH
THNNL=THYL/COSTH-THSL*TANTH
THNF=DERY(THNNP,THNN,THNNL)
TERM6=GPM*COSTH*THY
D=GPM*(EM(JSUBU)**2*COSTH*COTH-1.)
XNUM=TERM1+TERM2+TERM3+TERM4+TERM5+TERM6
THSS=XNUM/D
RETURN
END
FUNCTION ZMU(EM)
ZMU=ATAK(1.0/SORT(EM,EM-1.0))
RETURN
END
SUBROUTINE THERMC(TI,H,C8)
COMMON/ED/CPIN,RO
COMMON/MK/RCO2,AR20,WFUEL
COMMON/TIN/TIN
DIMENSION WTHOLE(9)
DIMENSION H(J,CP17)
DIMENSION Q(J,AP(9))
WTHOLE(1)=1.000
WTHOLE(2)=16.0
WTHOLE(3)=16.016
WTHOLE(4)=2.016
WTHOLE(5)=32.0
WTHOLE(6)=17.000
WTHOLE(7)=28.014
WTHOLE(8)=44.061
WTHOLE(9)=WFUEL
T=T*TIN
C1=RO/CP11
C2=C1/TI
NO 10 J=1,9
M=C2/WTHOLE(J)
H2=C1/WTHOLE(J)
CALL COEFF(J,T,A,B,C,D,E,F,G)
Q(J)=T*(A+B*T+C/F+D*E*F+G)*H
Q(J)=C1/J*H1
AP(J)=AR*IC+J+(B+E*T))
AP(J)=AP(J)*1
10 CONTINUE
M11=Q11

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H(2)=Q(12)
N(3)=RHE0 *(3)+RC02*Q(10)
N(4)=Q(4)
N(5)=Q(15)
N(6)=Q(16)
N(7)=Q(17)
CBI(2)=AP(1)
CBI(3)=AP(2)
CB(3)=RH20*AP(3)+RC02*AP(4)
CB(4)=AP(4)
CB(5)=AP(5)
CB(6)=AP(6)
CB(7)=AP(7)
RETURN
END
SUBROUTINE T0L(T,TENPY,X,Y,N)
DIMENSION X(1),Y(1)
DO 10 J5=1,N
IF (X=X(J5)) 8,9,10
8 J6=J5-1
TENPY=V(J6)+{(Y(J5)-Y(J6))*((X-X(J6))/(X(J5)-X(J6)))}
GO TO 11
9 TENPY=Y(J5)
GO TO 11
10 CONTINUE
11 RETURN
END
FUNCTION XM1(ALPHA,BETA,TA,XA,TC,XC)
XM1=ALPHA*TAN(TA+XA)
IF (BETA.GT.0.0) XM1=XM1+BETA*TAN(1C+XC)
RETURN
END
FUNCTION XM2(AL,BETA,TA,XA,TC,XC)
XM2=AL*TAN(TA-XA)
IF (B.GT.0.0) XM2=XM2+B*TAN(1C-XC)
RETURN
END
FUNCTION XM3(AL,B,T,T0,TC)
XM3=A*TANT0)
IF (B.GT.0.0) XM3=XM3+B*TANTC)
RETURN
END
SUBROUTINE NQUS(T1,P1,U1,RHO1,ALPHA,DX,L)
COMMON/AC/IB00,PIN
COMMON/O/DOT
COMMON/CP/D0T(T1,99),XH(99)
COMMON/RE/RAD,R00,VIN,VSINF
COMMON/Hi/DALCH1P,0
COMMON/PC/ALPHN(T1),IF:AL,LPRES
COMMON/QS/RHOP(2),MOOT(7,55),NHOLE(7),ALPHA(7)
COMMON/IN/TIN
DIMENSION ASAVE(7),NHOLE(7),ALPHA(7)
NHOLE(1)=1.000
NHOLE(2)=16.
NHOLE(3)=19.016
NHOLE(4)=2.016
NHOLE(5)=32.0
NHOLE(6)=17.008
NHOLE(7)=26.014
TXX=TI
UXX=U1
TERM=RHO1*U1
TI=TI*TIN*.001
P1=P1/FH*PRES/2116.
U1=U1*U1
DELTAT=4.4E-7
DELTAX=U1*DELTAT
JER=INT(DX/DELTAX)
IF (JER.EQ.0) JER=1
DELX=DX/FLOAT(JER)
SAVE=TI
DO 201 J=1,7
201 ASAVE(J)=ALPHA(J)
DT=DELX/U1
P=P1
OP=2116./09517.
RHO=RHO*P/DT**1
DO 10 JERRY=1,JER
P=P1
DUM=0.C
DO 96 J=1,7
96 DUM=DUM*ASAVE(J)/NHOLE(J)
RHO=RHO/DUM
IF (ICCHEN.EQ.0)
1WRITE(6,250) TI,P,RHO,ASAVE,DT,TN,ALPHN
250 FORMAT(/'FOCUS FROM MOCUS*1E-11.3/17X.1E-11.3/')
CALL FOCUS(TI,P,RHO,ASAVE,DT,TN)
IF (ICCHEN.EQ.0)
1WRITE(6,250) TI,P,RHO,ASAVE,DT,TN,ALPHN
1WRITE(6,232)
232 FORMAT(/)
IF(JERRY.EQ.1) GO TO 100
DO 110 J=1,7
110 MOOT(J,L)=TERM*(ALPHN(J)-ASAVE(J))/DELX
100 CONTINUE
IF(JERRY.EQ.JER)GO TO 10
131

```
Ti=TN
DO 20 J=1,7
20 ASAVE(J)=ALPHN(J)
10 CONTINUE
OTCMEP=Ti-TSAVE)*1600.*TIN
DO 40 J=1,7
DALCM(J)=ALPHN(J)+ALPHA(J)
40 WOTNM(J,L)=TERM*(ALPHN(J)-ASAVE(J))/DELX
Ti=TXX
P1=PXK
U1=UXK
RETURN
END
```

SURROUNIWE COEFF(I,T,A ,B ,C ,D ,E ,F ,G )
IF(T<1000)1E*10.20
10 GO TO (15,16,13,11,12,17,14,18,19)*I
11 A = 2.7468849E 03
9 = 4.1932116E+03
C = -8.6119332E+06
D = 9.5122662E+09
E = -3.3693421E-12
F = -1.6725372E 02
G = -1.4117850E 00
GO TO 40
12 A = 3.7189946E 00
B = -2.3167288E-03
C = 8.5837353E-06
D = -8.2998715E-09
E = 2.7082100E-12
F = -1.0576766E 03
G = 3.9806744E 00
GO TO 40
13 A = 4.1956016E 00
B = -1.7244334E-03
C = 5.6982316E-06
D = 4.5938844E-09
E = 1.4233655E-12
F = -3.0288779E 04
G = -1.6616246E-01
GO TO 40
14 A = 3.6916148E 00
B = -1.3325525E-03
C = 2.6503179E-06
D = 9.7688341E-10
E = -9.9772234E-14
F = 1.0628336E 03
G = 2.2074900E 00
GO TO 40
15 A = 2.5000000E 00
```

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8 = 0.0
C = 0.0
D = 0.0
E = 0.0
F = 2.5470497E+04
G = -4.6801096E-01
go to 40

16 A = 3.0218896E+00
B = -2.1737249E-03
C = 3.7542203E-06
D = -2.9947208E-09
E = 9.0777547E-13
F = 2.9137190E-04
G = 2.6466076E+00
.go to 40

17 A = 3.4234706E+00
B = -1.1187229E-03
C = 1.2466819E-06
D = 2.105896E-10
E = -5.2466591E-14
F = 3.5852787E-03
G = 5.9253029E-01
.go to 40

18 A=2.1701
B=1.0378E-02
C=-1.87339E-05
D=6.34592E-09
E=1.48807E-12
F=-0.43526E+04
G=10.6644
.go to 40

19 A=2.49125
B=7.643625E-03
C=7.97754E-06
D=-1.29576E-09
E=5.03078E-12
F=-5.421.6E
G=E
.go to 40

20 go to (25,26,23,21,22,27,24,28,29,21,1)

21 A = 3.0438697E+00
B = 6.1187110E-04
C = 7.3993951E-09
D = -2.0331907E-11
E = 2.4593791E-15
F = -8.5491002E-02
G = -1.6481339E+00
.go to 40

22 A = 3.5976129E+00
23 A = 2.670753E 00
B = 3.971719E 03
C = -0.935157E 07
D = 1.179085E 10
E = -6.197356E 15
F = -2.998899E 04
G = 6.903039E 09
GO TO 40

24 A = 2.05457E 11
B = 1.597631E 03
C = -6.236225E 07
D = 1.131584E 10
E = 7.690709E 15
F = 6.901745E 02
G = 6.390287E 00
GO TO 40

25 A = 2.500000E 00
B = 0.0
C = 0.0
D = 0.0
E = 0.0
F = -2.547049E 04
G = 4.508109E 01
GO TO 40

26 A = 2.537256E 00
B = -1.942219E 05
C = 6.801792E 09
D = 5.963362E 12
E = -5.574360E 16
F = 2.923300E 04
G = 4.996794E 00
GO TO 40

27 A = 2.889554E 00
B = 9.383506E 04
C = -2.187990E 07
D = 1.982785E 11
E = 3.845294E 16
F = 3.801179E 03
G = 5.559701E 00
GO TO 40

28 A = 4.41293
B = 3.19229E 03
GO TO 40

29 A=3.1591
B=1.62274E-02
C=-1.6743E-14
D=4.6944E+04
E=-7.2876

GO TO 40

40 RETURN

END

FUNCTION S2I{XJ, FE}

COMMON/EG/EIN,PR,XLE
COMMON/SS/AL1,AL2,BQ1,BQ2,C1,C2,CH1,CH2,D01,D02,D01,D02,DT1,DT2,DV

C=1.2978E-06
D=2.41747E-13
E=-1.6743E-14
F=4.6944E+04
G=-7.2876

GO TO 40

TERM1=V1*QQ1*PR+V2*C2*PR
TERM2=V1*QQ1*PR+V2*C2*PR
TERM3=V1*QQ1*PR+V2*C2*PR
TERM4=V1*QQ1*PR+V2*C2*PR
TERM5=V1*QQ1*PR+V2*C2*PR

RETURN

END

FUNCTION S3{XJ, FE}

COMMON/EG/EIN,PR,XLE
COMMON/SS/AL1,AL2,BQ1,BQ2,C1,C2,CH1,CH2,D01,D02,D01,D02,DT1,DT2,DV

C=1.2978E-06
D=2.41747E-13
E=-1.6743E-14
F=4.6944E+04
G=-7.2876

GO TO 40

TERM1=V1*QQ1*PR+V2*C2*PR
TERM2=V1*QQ1*PR+V2*C2*PR
TERM3=V1*QQ1*PR+V2*C2*PR

RETURN

END
TERM3 = COS(TH1) * V1 * AL1 / Y1 + COS(TH2) * V2 * AL2 / Y2
GO TO 2
20 CONTINUE
TERM3 = TERM1
2 S3 = (TERM + TERM2 + TERM3) * XLE * RPR / RE * 0.5
RETURN
END
FUNCTION F1(N)
COMMON/Q0/GAM0, PB, Q0, RHO0, TH0, W8, XM0, Y8
COMMON/HL/ALPHA, BETA
COMMON/HN/ALPH0,55, CPH1,55, CPX1,55, EMM1,55, GANN1,55, HN1,55, ILN1,55, QM1,55, RNM1,55, RN1,55, THN1,55, TN1,55, WN1,55, XM01,55
RNP = 1 / PN(N)
IF (BETA.GT.0.) F1 = F1(SIN(XMUN1) / GAM0) / RNP
RETURN
END
FUNCTION F2(N, S11, S21, S31)
COMMON/Q0/GAM0, PB, Q0, RHO0, TH0, W8, XM0, Y8
COMMON/QP/YN(55)
COMMON/HL/ALPHA, BETA
COMMON/HN/ALPH0,55, CPH1,55, CPX1,55, EMM1,55, GANN1,55, HN1,55, ILN1,55, QM1,55, RNM1,55, RN1,55, THN1,55, TN1,55, WN1,55, XM01,55
COMMON/WW/PPTS, RE, XBP, XJ
IF (XJ.EQ.0.0) TERM1 = 0.0
IF (XJ.NE.0.) TERM1 = SIN(TH1) / Y8
IF (XJ.NE.0.0) ANO = BETA.GT.0.) TERM1 = 5.*(TERM1*SIN(TH(N)) / YN(N))
QS = 1 / Q8**2
TERM2 = S11 / RHO0 * QS
SQ = 1 / QN(M)**2
IF (BETA.GT.0.) TERM1 = 5.*(TERM2 * S11 / RHO0)**S8
P1 = S11 / Q8
TERM3 = S21 * (GAM0 - 1.1) / GAM0 * P1 / Q8
P2 = 1 / QN(M)
IF (BETA.GT.0.) TERM1 = 5.*(TERM2 * S21 * (GAM0 - 1.1) / GAM0 * P2 / QN(M))
Q0 = 1 / QN(M)
IF (BETA.GT.0.) TERM1 = 5.*(TERM4 + S31 * WN(M) / RHO0(M) * Q0)
F2 = (TERM1 + TERM2 - TERM3 - TERM4)
RETURN
END
FUNCTION F4(N, OPT, XM01, TH1, XM02, TH2)
F4 = SIN(XM01) / COS(TH1 + OPT * XM01)
IF (B.GT.0.) F4 = F4(SIN(XM02) / COS(TH2 + OPT * XM02))
RETURN
END
SUBROUTINE HERMAN(YN, DT, A, Y, CI, OB, CC, SCALE)
DIMENSION P(10,10), SVAL(10), Q(10), A(10,10), Y(7), YN(7), CI(4), FINK(4)

14 TIM1=DT/2.0
TIM2=DT
T0=TIM1+T1
T1=DT*T2=TIM1+T1+T2
T2=(DT*T2=TIM1+T1+T2)*T1/2.0
T3=T0*T3=TIM1+T1+T2
T4=T0*T4=TIM1+T1+T2
K=1
DO 19 I=1,4
DO 10 J=1,4
P(K+1,J)=A(I,J)*T3
10 P(K+1,J)=A(I,J)*T1
19 K=K+2
K=1
DO 20 I=1,4
DO 11 J=1,4
P(K+1,J)=A(I,J)*T4
11 P(K+1,J)=A(I,J)*T2
20 K=K+2
J=1
DO 12 I=1,8,2
S=1./SCALE
P(I,J)=P(I,J)*TIM1*S
P(I,J)=P(I,J)*TIM1*S
K=1
DO 14 I=1,4
DO 16 J=1,4
Q(I)=Y(I)
FINK(2)=Y(2)
FINK(3)=Y(3)
FINK(4)=Y(4)
K=1
DO 15 I=1,4
DO 16 J=1,4
14 Q(K)=C(K)+A(I,J)*FINK(J)*(TIM2-TIM1)
Q(K+1)=Q(K)
15 K=K+2
DO 15 I=1,4
J=J+1
Q(J-1)=Q(J-1)*CI(I)*(TIM2-TIM1)
16 Q(J)=Q(J)*CI(I)*(TIM2-TIM1)
DO 202 I=1,8

ORIGINAL PAGE IS
OF POOR QUALITY.
Q(I)=Q(I)/1.0E-5
DO 20 J=1,M

202 PJ(I,J)=P(I,J)/1.0E-5
CALL CLEM(SMALB,P,Q)
CALL SCLY(SMALB,OT,CC,BB,Y,YN)
RETURN
END

SUBROUTINE CLEM(M,X,0,D)
DIMENSION AT(10,10),X(10)
DIMENSION B(10,10),O(10)
M1=M+1
DO 12 I=1,M
12 X(I)=0.0
DO 20 I=1,M

200 AT(I,1)=C(I)
DO 201 I=1,M
C0 201 J=1,M

201 AT(I,J)=0.0
DO 32 N=1,M
0=AT(h,N)
IT=0
DO 9 I=1,M
IF(ABS(AT(I,N))>ABS(0)) 9,9,9
9 Q=AT(I,N)
IT=I
9 CONTINUE
IF(IT=N)7,7
7 DO 31 J=1,N1
TEMP=AT(N,J)
AT(N,J)=AT(IT,J)
71 AT(IT,J)=TEMP
7 DO 10 I=1,M
10 AT(N,I)=AT(N,I)/C
IF(M-N)50,50+10
10 N1=N+1
DO 30 I=1,N
Q=AT(I,N)
30 J=1,M
30 AT(I,J)=AT(I,J)-AT(N,J)*Q
32 CONTINUE
90 X(N)=AT(M+1,N)
DO 65 N=2,M
NR=N+1
Q=AT(NR,N+1)
DO 60 I=1,NR
60 Q=Q+AT(NR,NR)
65 X(NR)=Q/AT(NR,NR)
RETURN
END
SUBROUTINE SOL1(SMAL8, OT, GC, BB, Y, YN)

DIMENSION SMAL8(10), Y(7) ,YN(7)
TIME=DT
YNX=TIME*#2
YN(1)=YN(1)+SMAL8(11)*TIME+SMAL8(5)*TNX
YN(2)=YN(2)+SMAL8(21)*TIME+SMAL8(6)*TNX
YN(3)=YN(3)+SMAL8(31)*TIME+SMAL8(7)*TNX
YN(4)=YN(4)+SMAL8(41)*TIME+SMAL8(8)*TNX
YN(5)=YN(5)+SMAL8(51)*TIME+SMAL8(9)*TNX
YN(6)=YN(6)+SMAL8(61)*TIME+SMAL8(10)*TNX
YN(7)=YN(7)+SMAL8(71)*TIME+SMAL8(11)*TNX
RETURN
END

FUNCTION S1(XJ, RE)

COMMON/SS/AL1, AL2, AQL, GQ2, C1, C2, CM1, CM2, DB1, DB2, DQ1, DQ2, DT1, DT2, DV
A1, Q1, P1, X1, TA1, OA2, TH1, TH2, V1, V2, Y1, Y2
TERM1=V1*DT1*V2*DT2
TERM2=DV*TA1*QV2*TA2
IF(XJ .NE. 0) GO TO 10
TERM3=0
GO TO 2

10 Y1=V1*Y2
IF(Y1.LE.1.E-10) GO TO 20
TERM3=COS(TH1)*V1*TA1/V1+COS(TH2)*V2*TA2/V2
GO TO 2

20 CONTINUE
TERM3=TERM1
2 S1=(TERM1+TERM2+TERM3)/RE*0.5
RETURN
END

SUBROUTINE PUNCH

COMMON/AC/I00DS, FIN
COMMON/BA/ALP(7, 55), EMINF, MINF
COMMON/D0/BRM(4), IS(4)
COMMON/EG/EM(55), GAM(55), P(55), TH(55), Y(55)
COMMON/EK/EIN, P, X, XE
COMMON/FN/XK1, XK3, XPO
COMMON/HJ/KQNT, LL, NPT
COMMON/HJ/KPO/ALPHA(7), IFUEL, PRES
COMMON/PO/JCHEM, NSP, T(55)
COMMON/TH/TIN
COMMON/TV/NPTS, RE, XBP, YJ
COMMON/VX/APRS, APUS, DELTAY, I00DS, I00DS, INTACT, IPRS, IPUS, IYP, 100DS, MH, RHEAT, XK1, XK3, YBOT, YTP
COMMON/VX/A00DS, BPRESS, CPRESS
COMMON/TV/BPRESU, CHEMFC, CMRES, EMSUB, RTH, XSTEP
COMMON/TV/A00DS, B000, G000, E000, F000, G000, IAVE, 1PUNCH, JB00, KKKK
REWIN 7

100 FORMAT(11E15)
101 FORMAT(10E10.3)
200 FORMAT(5x,5x,F10.3)
102 FORMAT(7E10.3,F10.3)
103 FORMAT(5F10.5)
104 FORMAT(7E11.4)
   WRITE(7,100) KKKK,LL
   WRITE(7,200) IPUNCH,KSTEP
   INTACT=0
   ISMCK=0
   DO 1111 I=1,4
1111 IF(IS(I)) .NE. 0 ISMCK=1
   WRITE(7,100) ICHEN,INATE
   WRITE(7,102) ICHEN,INATE
   EMUSA,ETH,DELTAY,YBOT,YTP,CHENF,X8P
   RQ=RE/RTH
   WRITE(7,101) RQ,PP,XLE,EMINF,TIN,WINF,PRES
   WRITE(7,101) RQ,PP,XLE,EMINF,TIN,WINF,PRES
   WRITE(7,200) XBODS,A80DS,B080,B080,EX0D
   WRITE(7,200) XBODS,A80DS,B080,B080,EX0D
   WRITE(7,201) IPAS,APRS,BPRESS,CRESS
   WRITE(7,200) IPUS,APUS,BPRESS,CRESS
   IF(ISMCK.EQ.0) GO TO 5
   WRITE(7,100) (IS(I),I=1,4)
   WRITE(7,101) (BE(I),I=1,4)
5 CONTINUE
   70 10 I=1,NPTS
   A =P(I)/PIN
   ALP7 =ALP(I)+ALP(4,I)*A.*RHEAT
   ALP4 =ALP(4,I)*RHEAT
   WRITE(7,103) (A(I),A(I),T(I)
   WRITE(7,104) (ALP(I),ALP(I),ALP(I),ALP(I),ALP(I),ALP(I)
17
10 CONTINUE
REWIN 7
END
SUBROUTINE INDATA
COMMON/AC/IMOD,PIN
COMMON/AL/GAR,GEW
COMMON/B5/ALP(5,5),EMINF,WINF
COMMON/CK/XMASS(55)
COMMON/CJ/CP(7,55),CP1(7),CPX(55)
COMMON/CM/XMOLE(7)
COMMON/DG/BET(4),ISI4)
COMMON/ED/CPIN,RO
COMMON/EF/EM(55),GAN(55),P(55),TH(55),Y(55)
COMMON/EG/EIN,PR,XLE
COMMON/EP/GAMINF,H1(7),RINF
COMMON/FL/KK1,KK3,XPOT
COMMON/GR/RAD,RO,WINF
COMMON/GF/DEL,T,ELISA,KOUNTO,ISA
COMMON/HJ/KOUNT,LL,NPT
COMMON/HR/RCO2,RH2O,WFUEL
COMMON/HR/THBP,YPB,YBP
COMMON/HR/X(55),X(55)
COMMON/HP/ALPHN(7),IFUEL,PRES
COMMON/PC/JCHEM,NSP,T(55)
COMMON/PA/H(7.55),Q(55),RHO(55),X(55)
COMMON/PC/R(55)
COMMON/TM/TIN
COMMON/U1/I11,IERR,IPRESS,IPRESU,ISUB
COMMON/W/NTS,RE,XBP,XJ
COMMON/X3/APRESS,APRESU
COMMON/XY/AnAp,Aus,delTay,EBODS,IBODS,INTACT,IPRS,IPUS,ITYP,
1JBOOS,MAX,REHEAT,XK2,XK4,Y80T,YP
COMMON/Y1/A00S,OPRESS,CPRESS
COMMON/YZ/OPRESS,CHEMF,C0RESS,EMSUE,RTH,XSTEP
COMMON/ZY/A00S,BBOO,EBOD,EBODS,EBOD,EBODS,EBOD,F30C,GR00,IAVE,IPUNCH,JBOOD,KKKK
II=5
ISUB=0
XR=0
YPB=10000
THBP=0
RA=0
IFUEL=1
WFUEL=2.016
100 FORMAT(16E15.9)
111 FORMAT(16E10.0)
214 FORMAT(7E11.4)
210 FORMAT(5S,5X,7E10.0)
READ(IIN,100) KKKK,LL
READ(IIN,200) IPUNCH,XSTEP
READ(IIN,100) NPTS,NPT,ITYP,ISHOCK,NMAX,KCOUNT
READ(IIN,180) JCHEM,IAVE,
INTACT
IF(KCOUNT.LT.1) KOUNT=0
KOUNT=KOUNT
WRITE(6,111) KKKK,LL
111 FORMAT(8HKKKKK =IS,5X,4HLL =IS/)
WRITE(6,112) IPUNCH,XSTEP
112 FORMAT(9H IPUNCH =I2,5X,7IXSTEP =E10.3/)
WRITE(6,113) NPTS,NPT,ITYP,ISHOCK,NMAX
113 FORMAT(7H NPTS =I2,5X,5NHPT =I2,5X,6HITYP =I2,5X,8HSHOCK =I2,5X,6
1HMMAX =I2,/)
WRITE(6,114) JCHEM,IAVE,
INTACT
114 FORMAT(8H JCHEM =I2,5X,6HIAVE =I2,5X,
10INTACT =I2/,
IF(ITYP.EQ.2,.AND.,ITYP.NE.4) GO TO 12
IF(INTACT.EQ.0.AND.,ISHOCK.EQ.0) GO TO 12
WRITE(6,9191)
9191 FORMAT(13)
WRITE(6,102)
102 FORMAT(INH TYPE 2 OR TYPE 4 FLOWS MAY NOT START WITH SHOCKS OR HAVE SHOCKS COMING OFF SPLITTER PLATES/RECHECK INPUTS AND SUBMIT WITH PROPER TYPE)
STOP
12 CONTINUE
104 READ(IIN+101) XJ, ESMUB, RTH, DELTAY, YBOD, YTP, CHEMFC, XBP
READ(IIN+101) RE, PR, XLE, EMINF, TIN, WINF, PRES
READ(IIN+200) IBOQ, ABOQ, ABOQ, GBOD
READ(IIN+200) JBOQ, EBOQ, FBOQ, GBOQ
READ(IIN+200) IPRES, APRES, BPRESS, CPRESS
READ(IIN+200) IPRES, APRES, BPRESU, CPRESU
IF(XBP.LT.0.) XBP=0.
J=J+5
WRITE(6,115) XJ, ESMUB, RTH, DELTAY, YBOD, YTP, CHEMFC
115 FORMAT(XJ =E10.3,2X,7HEMSUB =E10.3,2X,5HRTN =E10.3,2X,6HDELTAY
1=E10.3,2X,6MYBOD =E10.3,2X,9HYP =E10.3,2X,8HCHENF =E10.3,2/
WRITE(6,116) RE, PR, XLE, EMINF, TIN, WINF, PRES
116 FORMAT(RE =E10.3,2X,4HPR =E10.3,2X,5HXTN =E10.3,2X,6HINF =E10
1.3,2X,5HIM =E10.3,2X,6HINF =E10.3,2X,6HPRES =E10.3,3/
WRITE(6,117) XOPT, XX1, XX2, XX3, XX4
117 FORMAT(XOPT =E10.3,2X,5XX1 =E10.3,2X,5XX2 =E10.3,2X,5XX3 =E10
1.3,2X,5XHXX4 =E10.3,2/
WRITE(6,118) JBOQ, EBOQ, FBOQ, GBOQ
118 FORMAT(JBOQ =E12.2X,6HABOD =E10.3,2X,6HBOQ =E10.3,2X,6HBOQ =E1
10.3,3/
WRITE(6,119) JBOQ, EBOQ, FBOQ, GBOQ
119 FORMAT(JBOQ =E12.2X,6HBOQ =E10.3,2X,6HBOQ =E10.3,2X,6HBOQ =E1
10.3,3/
WRITE(6,120) IPRES, APRES, BPRESU, CPRESU
120 FORMAT(IPRES =E12.2X,3HBPRES =E10.3,2X,8HBPRES =E10.3,2X,8HCP
1RESU =E10.3/
WRITE(6,121) IPRESU, APRESU, BPRESU, CPRESU
121 FORMAT(IPRESU =E12.2X,8HBPRESU =E10.3,2X,8HBPRESU =E10.3,2X,8HCP
RESU =E10.3/
411 ABOQ=ABOQ
ABOQ=ABOQ
IPRES=IPRES
APRES=APRES
JBOQ=JBOQ
EBOQ=EBOQ
IPRES=IPRES
APRES=APRES
IF(ISMUSH,EQ.0) GO TO 5
READ(IIN+101) (ISI1,I=1,4)
READ(IIN+101) (BET0(I),I=1,4)
WRITE(6,128) (ISI1,I=1,4)
128 Format(6H1S(1)=i3.2X,7HIS(2)=i3.2X,7HIS(3)=i3.2X,7HIS(4)=13/)
   WRITE(6,129) (BET(i),I=1,4)
129 Format(4H1T10H!BET(1)=E10.3,2X,9H!BET(2)=E10.3,2X,9H!BET(3)=E10.3, 
   12X,9H!BET(4)=E10.3/
5 Continue
   DO 10 I=1,NPS
   READ(101) Y(I),P(I),TH(I),EM(I),T(I)
   READ(104) (ALP(j),J=1,NSP)
10 Continue
   IF(ITYP.EQ.1)GO TO 4201
   IBOD=0
   IF(ITYP.EQ.2) IBOD=JBOJS
   IF(ITYP.EQ.4) IBOD=IBODS
4201 RHEAT=1.
   RHO=1.
   RCO2=0.
4204 WMOLE(4)=Wfuel
   RE=RE*RTM
   ERR=0.
   CALL COEFF(5,TIN,Z,0Z,DZ,DZ,HZ,FZ,GZ)
   CPM=1Z+Z*TM+Z*TM**2+2Z*TM**3+HZ*TM**4+4)*RO/WMOLE(5)
   CALL COEFF(7,TIN,Z,0Z,DZ,DZ,HZ,FZ,GZ)
   CPPI=1Z+Z*TM+Z*TM**2+2Z*TM**3+HZ*TM**4+4)*RO/WMOLE(7)
   CPM+=-3Z+CPM*768*CPPI
   RINF=RO/INF
   GMINF=1./1.-RINF/CPM
   RINF=RCD/MINF
   UIN=FAINF*SQRT(GAINF*INF*TM)
   RF=1./RINF
   RHOINF=PRES*RF/TIN
   WISINF=RHCINF*UINF/RF
   GAINF=GMINF*INF
   GMINF=EMINF**2/MINF
   EIN= (GAP.NF-1.) * EMINF**2
   EMS=1./EMINF**2
   FIN=1./GAINF*EMS
   WRITE(6,6090)

6090 Format(///4X,1HPRogram V I S - C H A R //60X,7HW ITH 
1//4X,3Hm B E O D E O S U B S O N I C F L O W / S / 53X,21HS K O 
1C K W A V E S / / 33X,63HAND F INITE RATE H Z - A I 
1R C H E M I S T R Y )
   IF(JCHEM.EQ.0.) WRITE(6,5610)
   IF(JCHEM.EQ.0.) WRITE(6,5611)
   IF(JCHEM.EQ.0.) WRITE(6,5612)
   IF(JCHEM.EQ.1.) WRITE(6,5613)
5610 Format(///10X,3HTYPE OF FLOW IS TWO DIMENSIONAL)
5611 Format(///10X,28HTYPE OF FLOW IS AXISYMMETRIC)
5612 Format(10X,19HSTRUCT IS FROZEN)

ORIGINAL PAGE IS OF POOR QUALITY
5613 FORMAT (14X,24HCHEMISTRY IS FINITE RATE)
WRITE(16,5680) RTH

5680 FORMAT
110X,80JET OR NOZZLE RADIUS RTH = E13.5,4H FT.
WRITE(6,5681) EMINF,UX,UX,UX,PRES,RHOMINF,GAMMINF,WINF,RE,PP,XLE

5681 FORMAT (/10X,20HREFERENCE CONDITIONS/20X,20H---------------------------
110X,10HMAC NO. (EMINF) = E13.5/10X16VELOCITY UIN = E13.5,
17HFT/SEC/10X19TEMPERATURE (TIN) = E13.5/10X17HP
17HRESSURE (PRES) = E13.5/10X18DENSIT (RHOMINF) = E13.5,
11HSLUGS/FT**3/10X3
1HPOZEN SPECIFIC HEAT RATIO (GAMMINF) = E13.5/16X,25NMOLECULAR WEIGHT
1HWINF = E13.5/10X,22HREYNOLDS NUMBER (RE) = E13.5/10X21HPOZEN
1HNUMBER (PP) = E13.5/10X,20HMLEAN NUMBER (XLE) = E13.5
WRITE (6,5682)

5682 FORMAT (/10X,15HOUTPUT Headings/20X,15H--------------------------
110X, 9HM - X/RTH/10X, 9HM - Y/RTH/10X,15HM - VELOCITY/UIN/10X,
119HM - TEMPERATURE/UIN/10X17HM - PRESSURE/PRES/10X3ENTH - FLOW D
1EFLECTION (RADIANs) /10X16HMEN - MAC NO.1/10X20HPHO - DENSITY/
1RHOMINF/10X,19HMGN - SPECIFIC HEAT
1/10X,33HMMASS - NON-DIMENSIONAL MASS FLOW
1/10X,23HPHI - EQULBEANCE RATIO/10X,
120HM - MOLECULAR WEIGHT/10X14HMMASS FRACTIONS/15X18HALP(I) - M/15X
110MHALP(1) - 0/15X,12MHALP(3) - M/20/15X,11MHALP(4) - M/2/15X,11MHALP(5)
1 - 02/15X,11MHALP(6) - OM/15X,11MHALP(7) - N2
413 DO 1774 I=1,NPTS
X(I) = X0P
P(I) = P(I)*PIN
ALP(I) = RHEAT*ALP(4, I)
ALP(7, I) = (1.0 - RHEAT)*ALP(4, I) + ALP(7, I)
DO 760 J = 1, NPH
760 ALP(4, J) = ALP(4, J) + ALP(J) - 1.0
ALP(7, I) = ALP(7, I) + ALP(2, I) + ALP(3, I) + ALP(4, I) + ALP(5, I) + ALP(6, I)
1 CONTINUE
DO 883 I = 1, NPTS
CALL THERMO(T(I), H1, CP1)
CPX(I) = 0.0
W(I) = 0.0
DO 1776 J = 1, NSP
CP(J, I) = CPJ(J)
W(I) = W(I) + CPX(I) + ALP(J) - CPJ(J) - CPX(I) + ALP(J) - CPJ(J)
1776 W(I) = W(I) + ALP(J, I) + XHOLE(j)
W(I) = 1.0 - W(I)
RHOM(I) = GEM*(PIN/P(I))**2/1(I)
II = RN**2/II
GAMM(I) = CPX(I) + ALP(J, I) - R(I)/CPIN
OM(I) = EMINF
OR(I) = 1.0
QII=EM(I)\*X/M/SORT(GAMGAH(I)*OR/T(I))
   IF(EM(I).LT.1.)
   XNU(I)=ATAN(1./SORT(EM(I)**2-1.))
8683 CONTINUE
   IF(NINTACT.EQ.1) CALL COMNL
   XJ1=1.+XJ
   XMSS1(I)=0.
   DO 1785 I=2,NPTS
      IF(J.EQ.1) GO TO 1785
      XJ2=1.+XJ
      YFUN=CY(I)**P(I)-XJ*(Y(I)**P(I)+XJ)-Y(I-1)**P(I-1)-XJ*(Y(I-1)**P(I-1))/XJ1
      RQAV=(RHO(I)**P(I)**COS(TH(I)**2)+RHO(I-1)**P(I-1)**COS(TH(I-1)**2))/2.
      XMSS(I)=XMSS(I)-1.+RQAV\*YFUN
1785 CONTINUE
   DELY=YP-B(Y(I))/FLOAT(NPTS-1)
   RETURN
END
FUNCTION F3(TP1,OTC,T1,TH1,THC,DA,MC)
COMMON/CK/MNOLM(7)
COMMON/OR/DELX
COMMON/SL/ALPHA1
DIMENSION DA(7)
NMP=7
A=ALPHA1
B=beta
TERM1=OTC/((A-B)**TP1+B**T1+1))
TERM2=0.
DO 10 J=1,NMP
   TERM2=TERM2+DA(J)/M!NOE(J)
10 CONTINUE
   TERM5=A**M1+0*MC
   TERM2=TERM2**TERM5
   TERM3=A**COS(TH1)+B**COS(THC)
   F3=-TERM1*TERM2*TERM3/DELX
RETURN
END
SUBROUTINE POCUS(I,PRISSI,RHOI,ALPHI,DT,TH)
COMMON/PO/ALPHA1(7),IFUEL,PRES
DIMENSION ALPHI(7),AD(11,10),CI(10),Y(7),YN(7),ALPHA1(7)
DIMENSION T(7),T1(7),D(7),E(7),G(7),Z(7)
T(1)=6.0
T(2)=6.0
T(3)=0.5
T(4)=0.5
T(5)=0.5
T(6)=0.5
T(7)=0.5
T1(1)=6.0
T1(2)=6.0
T1(3) = 3.8299
T1(4) = 4.0960
T1(5) = 2.9282
T1(6) = 3.4392
T1(7) = 2.6888
θ(1) = 39.7055
θ(2) = 2.5674
θ(3) = 3.4962
θ(4) = 27.4123
θ(5) = 1.7771
θ(6) = 3.3496
θ(7) = 2.2043
C(1) = 0.0
C(2) = 0.0
C(3) = 5.4866
C(4) = 1.5999
C(5) = 1.9999
C(6) = 1.6299
C(7) = 1.9311
D(1) = 0.0
D(2) = 0.0
D(3) = -31.7450
D(4) = -34.5288
D(5) = -1.0584
D(6) = 1.3139
D(7) = 1.4976
E(1) = 7.0
E(2) = 4.0
E(3) = 6.3657
E(4) = 30.9104
E(5) = 2.9422
E(6) = 4.3679
E(7) = 2.6593
G(1) = 404.5564
G(2) = 29.1774
G(3) = -28.9824
G(4) = -8.688
G(5) = -5.22
G(6) = 3.4213
G(7) = -5.5961
Z(1) = 0.63
Z(2) = 1.0
Z(3) = 1.13
Z(4) = 1.26
7 = 2.0
Z(6) = 1.063
Z(7) = 0.75
PRESS = PRESSI
KASE = IFUEL
IF(KASE.EQ.2) PRESSI=PRESSI*.35
IF(KASE.EQ.3) PRESSI=2*PRESSI
RHOI=RHOI*PRESSI/FS5555
KTEST=0
EL0=1.0
DLT=0.0
EPS=.001
TIME0=1.3825E-9*EL0
DT=DT/TIME0
P0=PRESSI*1.01325E6
RHO0=P0*1.924465E-12
RHO1=RHOI*.5154/RHO0
PRESSI=1.6
T=TI
HI=0.0
00 65 I=1,7
IF(T-T(I)) 62,61,61
61 HI=10(I)+E(I)*T*ALPH(I)*HI
GO TO 65
62 IF(T-T(I)) 63,63,64
63 HI=10(I)+E(I)*T*ALPH(I)*HI
GO TO 65
64 HI=10(I)+E(I)*T+C(I)*(T-T8(I))*2*ALPH(I)*HI
65 CONTINUE
92 CONTINUE
JJJ = 25
JJ=0
T = TI
ISAVE=1
KOUNT=0
RHO=RHOI
DELT=DLT
GAMMA=DT*DELT+1.
PRESS=PRESSI
HI=HI
SUMY=0.
00 11 I=1,7
ALPHA(I)=ALPH(I)
Y(I)=RHO*ALPHA(I)/Z(I)
YN(I)=0.0
11 SUMY=SUMY+(I)
DUM1=6.6703E-7*RHO3*EL0
DUM2=DUM1*RHO0/16.
IF(ALPHA(3).GT.1.E-10)GO TO 6
IF(ALPHA(6).GT.1.E-10) GO TO 6
IF(ALPHA(5).GT.1.E-10) GO TO 30
IF(ALPHA(2).GT.1.E-10) GO TO 30
FS=(1.85*17*EXP(-25./T))*(DUM1*EXP(-25./T)/T)
RS=1.1E16*DUM1*RS//16.
\begin{verbatim}
B11=-FS*.5+2.05*V(1)*SUNY
CC1=BB*V(1)**2*SUNY
C1=FS*CC*SUNY+CG1
A11=DELTA+G11
DUM=C1/A11
YN(1)=DUM*V(1)+DUM1*EXP(A11*OT)
IF(YN(1)<L.T.0.0) YN(1)=0.0
YN(1)=CC-YN(1)*.5
GO TO 99
99 IF(ALPHA41.CT.1.E-10) GO TO 6
IF(ALPHA41.GT.1.E-10) GO TO 6
F8=(1.85E16*EXP(-30.3/T11)*DUM1*EXP(-30.3/T1)/T)
B0=6.6E14*DUM1*RHO0/16.
B11=IF9+.5+2.05*V(1)*SUNY
CC1=BB*V(1)**2*V(1)*SUNY
BB=CSSA*V(2)+V(1)**.5
C1=FS*BB*SUNY+CG1
A11=DELTA+G11
DUM=C1/A11
YN(1)=DUM*V(1)+DUM1*EXP(A11*OT)
YN(2)=B0-VN(1)*.5
IF(YN(2)<L.T.0.0) YN(2)=0.0
YN(5)=B0-VN(2)*.5
GO TO 99
6 CONTINUE
KOUNT=1
IF(KASE.EQ.2) T=1./{(1.1067/T-.0497)}
IF(KASE.EQ.3) T=1./{(1.706/T+.2381)}
F1=3.014*EXP(-.811/T)*DUM1
F2=3.014*EXP(-.85/T)*DUM1
F3=3.014*EXP(-3.02/T)*DUM1
F4=F3
B1=2.85E13*EXP(-.66/T)*DUM1
B2=1.3214*EXP(-2.49/T)*DUM1
B3=1.35E15*EXP(-10.95/T)*DUM1
B4=3.12E14*EXP(-12.91/T)*DUM1
T=TSAVE
ITSAVE=T
IF(KASE.EQ.2) T=1.241+.05524*T
F6=9.65E10*EXP(-62.2/T)/T*DUM1
F7=8.801E16*EXP(-52.5/T)*T*DUM1
B6=1.E17*DUM2
B7=1.E16*DUM2
T=TSAVE
F5=1.85E17*EXP(-54.7/T)*T*DUM1
F8=5.801E16*EXP(-66.6/T)*T*DUM1
B5=1.E16*DUM2
B6=6.E14*DUM2
\end{verbatim}
DUM1 = (Y(2) + Y(6) + Y(3)) * 0.5
DUM2 = (Y(1) + Y(6) + Y(3)) * 0.5
DUM3 = (Y(1) + 0.5) * Y(6) + Y(3)
DUM4 = F1*Y(1) + DUM1 + B1*Y(2) * Y(6)
DUM5 = F2*Y(2) + DUM2 + B2*Y(1) * Y(6)
DUM6 = F3*Y(6) + DUM2 + B3*Y(1) * Y(3)
DUM7 = F4*Y(5) + Y(6) * B4*Y(2) * Y(1)
DUM8 = (F2 + 0.5 + B7*SUNY1) * Y(2) + B2*Y(6)
DUM9 = (F1 + 0.5 - B7*SUNY1) * Y(1) + B1*Y(6)
DUM10 = (F2 + 0.5 - B1*Y(2) + (B2 - F1 + 0.5) * Y(1)
DUM11 = (F1 + 0.5 - B3)*Y(1) + F3*Y(6)
DUM12 = F1*DUM1 - B3*Y(3) - F3*0.5*Y(16)
DUM13 = (F6*SUMY + F1*Y(11)) * 0.5
DUM14 = B6*Y(11)*SUMY - F3*DUM3
DUM15 = 2.0*F1*Y(6)
DUM16 = SUMY*Y(11)
DUM17 = B6*SUMY + Y(6)
B12 = DUM9 - F2*DUM2
B21 = DUM8 - F1*DUM1
B19 = (F6 - F5) * SUMY - F2*Y(2) + DUM11
B29 = (F2 + 0.4) * Y(2) - DUM13
B91 = DUM12 + B21 - CUM6 + DUM17
B27 = SUMY*F7 + F8 + F2.1 + DUM10 + DUM15
B79 = F6*SUMY - DUM12 + T2 * B4 + F2*Y(12)
B77 = (DUM14 + SUMY + F7 + F1.5 + B2) * Y(1) + (B1 + F2 + 0.5) * Y(2) + 2.0*DUM15
B92 = 0.4*Y(13)
B22 = SUMY*(2.0 + B8*Y(2) + B7*Y(11) + B1*Y(6) + F2*DUM2 - DUM13 + B92
B11 = DUM12 - F5*SUMY + 0.5 - (F2 + 0.5 + B7*SUNY) + Y(2) - B2*Y(6) - DUM17 - 2.0*B5*DUM1

16
B7 = DUM14 + DUM15
B94 = DUM11 + (F1 + 0.5) * Y(1) + F6*SUMY + B4*Y(2)
B71 = (DUM12 + DUM17)
B72 = 0.0 + B4*Y(13) - DUM9 - F2*DUM2
B71 = SUMY*(F7 + F5*2.1) - DUM10 - DUM14 + 2.0 + F3*DUM3
CC1 = DUM5 + DUM4 + DUM6 + B6*Y(6) + B5*Y(11) + B7*Y(2) + DUM16
CC2 = DUM4 + DUM5 + DUM4 + B7*Y(11) + B6*Y(2) + SUMY*Y(2)
CC7 = DUM4 + DUM5 + DUM6 + 2.0 + DUM7 + (B6*Y(6) - B7*Y(2)) + DUM16
CC9 = DUM6 + DUM7 + B6*Y(6) + DUM16

14
BB = GAMMA*(Y(5) + Y(2) + Y(6) + Y(3)) * 0.5
CC = GAMMA*(Y(4) + Y(3) + Y(1) + Y(6)) * 0.5
AD1(1) = 0.1 + DELTA - F1*BB
AD1(2) = $0.12 + F2*CC
AD1(3) = $0.17 + F3*CC
AD1(4) = $0.19
AD1(2, 1) = 0.21 + F1*BB
AD1(2, 2) = 0.22 + DELTA - F2*CC
AD1(2, 3) = 0.27
AD1(2, 4) = 0.29
AD1(3, 1) = $0.71 + F1*BB
AD{3, 2} = $872 + F2^\circ \text{CC}$
AD{3, 3} = $87^\circ \text{DELTA} - F3^\circ \text{CC}$
AD{3, 4} = $F9$
AD{4, 1} = $91$
AD{4, 2} = $92$
AD{4, 3} = $897 + F3^\circ \text{CC}$
AD{4, 4} = $899 + \text{DELTA}$
C{11} = $CC1 + F5^\circ \text{SUPY} + \text{CC}$
C{12} = $CC2 + F8^\circ \text{SUPY} + 88$
C{13} = $CC7$
C{14} = $CC9$
SCALE = 0.1$
DO 50 J = 1, 4$
DO 50 I = 1, 4$
50 SCALE = \text{AMAX1} (\text{SCALE}, \text{ABS}(\text{AD}(I, J)))$
DO 51 I = 1, 4
DO 52 J = 1, 4
51 C{II} = $\text{C}(I) / \text{SCALE}$
CALL \text{MMSAMANVH} (\text{DT}, \text{AO}, \text{Y}, \text{CI}, \text{88}, \text{CC}, \text{SCALE})$
99 00 90 J = 1, 6$
IF (\text{YN}(J) \geq 0.8) \text{GO TO} 90$
\text{DT} = \text{DT} / 10.$
K\text{TEST} = K\text{TEST} + 1$
IF (\text{K\text{TEST}} = 3) 92, 27, 27$
90 \text{CONTINUE}
DUM = 0.0$
DO 1 J = 1, 6$
1 DUM = DUM + YN(J) * Z(J)$
RHON = DUM / (1 - ALPHA(7))$
YN(7) = RHON * ALPHA(7) / Z(7)$
SUMYN = 0.0$
DO 2 J = 1, 7$
2 SUMYN = SUMYN + YN(J)$
TT = PRESS / SUMYN$
DO 4 J = 1, 6
4 ALPHA(J) = YN(J) * Z(J) / RHON$
AH = 0.0$
BH = 0.0$
CH = 0.0$
DO 505 I = 1, 7$
IF (TT < T{11}) 502, 501, 501
501 BH = AH - E(I) * ALPHA(I) * 0.5$
CH = CH + D(I) * ALPHA(I)$
GO TO 505
502 IF (TT < T{21}) 503, 503, 504
503 BH = BH - G(I) * ALPHA(I) * 0.5$
CH = CH * G(I) * ALPHA(I)$
GO TO 505
504 AH=AH+C(I)*ALPHA(I)
    BH=BH+ALPHA(I)*(C(I)*T8(I)-D(I)*.5)
    CH=CH+ALPHA(I)*(G(I)+C(I)*T8(I)**2)
      CONTINUE
    CH=CH-M
      IF(AH) 507,506,507
506 T=CH/BH/2.
      GO TO 508
507 T=IBN+SORT (BH*BH-AH*CH)/AH
      CONTINUE
      IF(JJJ)31,31,22
31 ERR1=IT-T
      IF(ABS(IT/T-1.0).LE.EPS) GO TO 27
      GAM1=GAMMA
      GAMMA=.98*GAMMA
130 GAM2=GAMMA
      DELTA=1(GAMMA-1.1)/DT
      JJ=JJ+1
      IF (JJ-JJJ) 84,84,12
94 IF (KOUNT.EQ.1) GO TO 14
      T=TSAVE
      GO TO 6
22 ERR2=IT-T
      IF(ABS(IT/T-1.0).LE.EPS) GO TO 27
      GAMMA=GAM1-ERR1*(GAM2-GAM1)/(ERR2-ERR1)
      GAM1=GAM2
      ERR1=ERR2
      GO TO 130
12 WRITE(6,13)
13 FORMAT(M0,23H JJ IS GREATER THAN JJJ)
27 TN=T
    DO 28 J=1,7
28 ALPH(J)=ALPHA(J)
    DT=DT*TWEB
    PRESS=P95SS
    RETURN
END