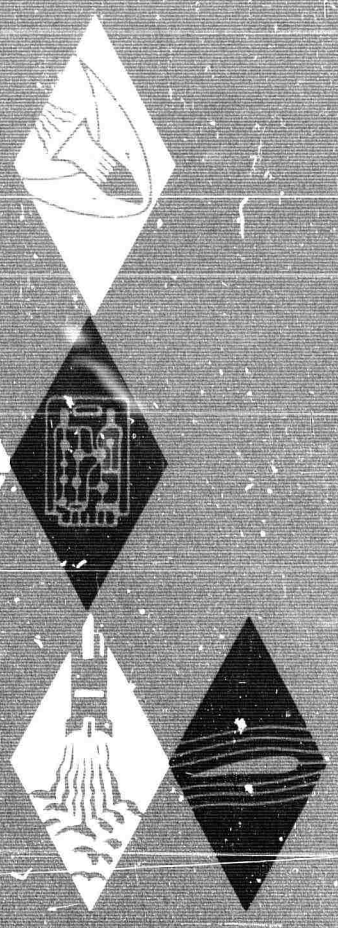


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TECHNICAL REPORT NO. 501

A FINITE DIFFERENCE METHOD SOLUTION
OF NON-SIMILAR, EQUILIBRIUM
AND NON-EQUILIBRIUM AIR,
BOUNDARY LAYER EQUATIONS
WITH LAMINAR AND TURBULENT
VISCOSITY MODELS

PART II: COMPUTER PROGRAM
AND SUPPLEMENT
(FINAL REPORT)

By H. E. Gould
L. S. Galowin

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February 2, 1965

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Prepared for
Advanced Research Projects Agency
Washington 25, D. C.

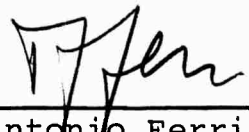
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SUMMARY

This report describes a program for the numerical solution by an explicit finite difference technique of the momentum, species conservation, and energy equations for an equilibrium or chemically reacting air boundary layer. Laminar and several turbulent viscosity models can be applied through the thickness of the boundary layer. Seven air species are included: O_2 , O , N_2 , N , NO , NO^+ and e^- .

Laminar and turbulent effects in any of the equations can be selectively controlled by input indicators. The various viscosity models can be applied to the entire thickness of the boundary layer or the boundary layer can be divided into two segments and different viscosity models applied to each segment. Provision has also been made for boundary layer swallowing of new inviscid streamlines. Properties along the inviscid streamline are computed to establish the varying streamwise outer edge conditions.

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I. INTRODUCTION

This program is written in FORTRAN II language for the IBM 7090-4. It solves the non-equilibrium and equilibrium air boundary layer conservation equations for momentum, energy and species mass fractions. These parabolic partial differential equations are solved in the domain defined by the body surface and the inviscid edge of the boundary layer. The technique of solution is an explicit finite difference method. The boundary conditions at the body are specified as input data but those at the inviscid outer edge are not known a priori and are therefore computed as the calculation progresses. Edge conditions are determined from the solution of ordinary differential equations

which yield the velocity and species along an approximate inviscid streamline from the shock to the body station of interest. Initial conditions to start the problem require the distributions of the dependent variables of velocity, total enthalpy, and species mass fractions.

A number of significant capabilities are provided by the program. The multicomponent air species considered are O_2 , O , N_2 , N , NO , NO^+ and e^- . Laminar and several turbulent viscosity representations may be optionally selected for the diffusional transport terms applied to any of the partial differential equations. The boundary layer thickness can be divided into two segments and different viscosity models applied to each of the segments. Various two-dimensional or axisymmetric body geometrical configurations are possible. Similarly, shock shapes consisting of conical and parabolic segments are acceptable. Input tolerances upon the slope at the outer edge of the enthalpy, velocity or species profiles govern the boundary layer swallowing which results from the growth of the viscous layer into the inviscid flow.

The program described herein is based upon the analysis reported in Part I. The engineering definitions and the preparation of input data for application of the program to given boundary

layer problems are discussed in the Part III manual.

Typical hypersonic reentry body configurations have been investigated. Computer time required for their solution ranges from 3/4 to 4 hours, depending on body length, altitude, free stream velocities and mode of computation.

II. BOUNDARY LAYER EQUATIONS

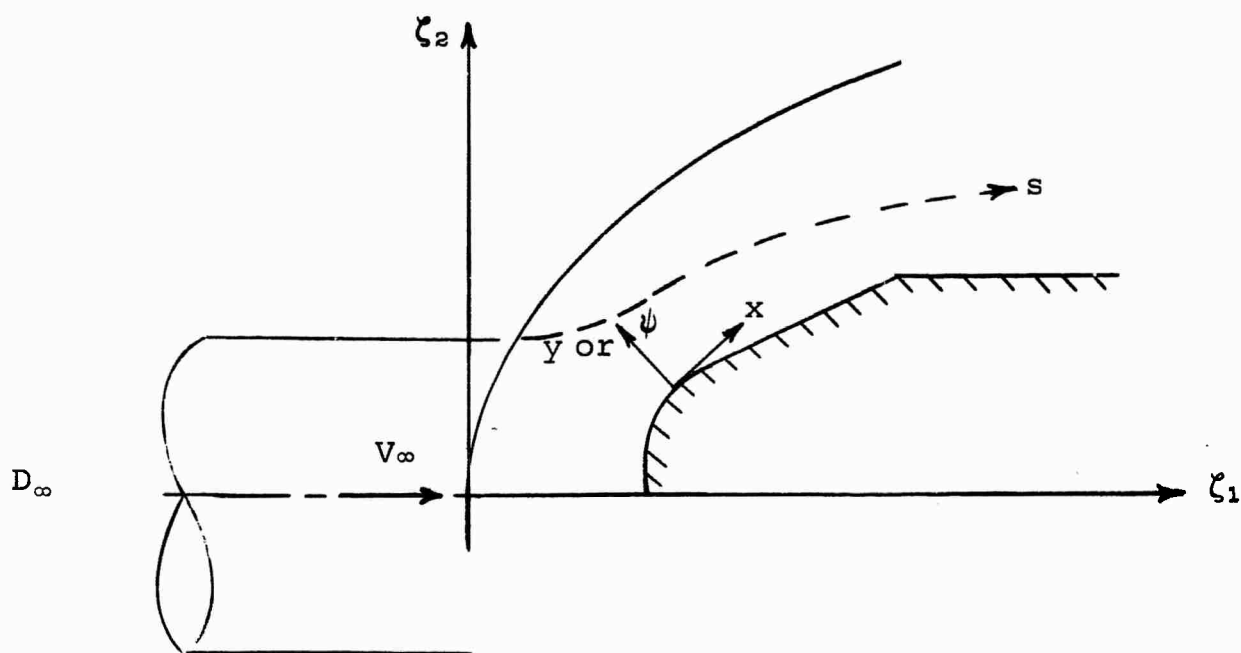
In this section the explicit finite difference method solution of the boundary layer conservation equations is described.

A. Coordinate Systems

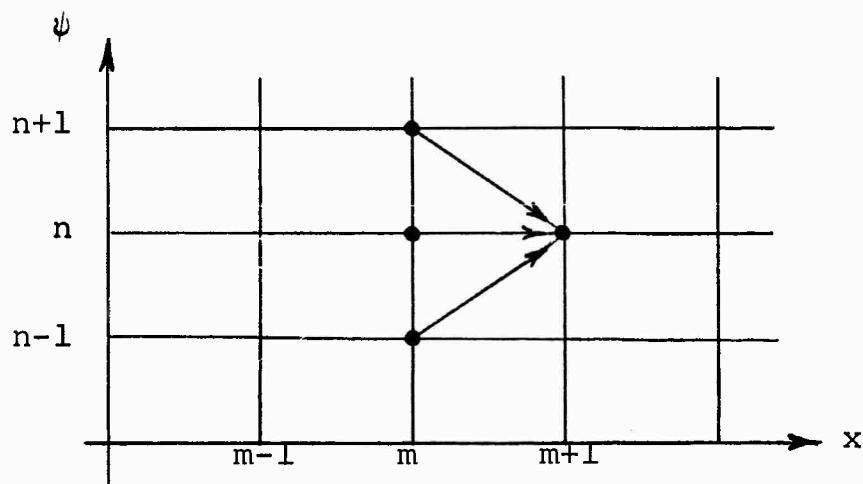
The program continuously calculates in four different coordinate systems. Thus for the permissible body and shock geometry configurations, the following systems shown in the sketch below are defined:

1. Overall - a basic reference system designated as ζ_1, ζ_2 . The units of these coordinates are feet.
2. Physical - an x-y system where x, in feet, is along the body and y, in feet, is normal to the body.
3. Body and von Mises stream function - an x- Ψ system in which the finite difference solutions will be solved, where x, in feet, is along the body and Ψ is the transformed normal coordinate and represents the stream function defined by $\Psi = \int_0^y \rho u r^\epsilon dy$. For $\epsilon = 1$, Ψ is in slugs/sec; for $\epsilon = 0$, Ψ is in slugs/ft-secs. The sketch below shows the grid in the x- Ψ plane with the paths of the numerical step indicated.

4. Inviscid streamline - a fourth system is a one-dimensional coordinate, s , along the (approximate inviscid) streamline. The origin of this coordinate system is the shock streamtube intersection point.



Coordinate Systems for a Blunt Body



Finite Difference Grid

B. Momentum Equation

1. Analytic form

$$\frac{\partial u}{\partial x} = - \frac{1}{\rho u} \frac{dp}{dx} + r^\epsilon \frac{\partial \tau}{\partial \Psi}$$

$$\tau = \mu \frac{\partial u}{\partial \Psi} \rho u r^\epsilon$$

2. Finite difference form

$$u_{m+1,n} = u_{m,n} - \frac{\Delta x}{\rho_{m,n} u_{m,n}} \left(\frac{dp}{dx} \right)_m + \frac{\Delta x}{\Delta \Psi} r_m^\epsilon \left(\tau_{m,n+1/2} - \tau_{m,n-1/2} \right)$$

Note: Near the wall a series solution has been assumed since $u \rightarrow 0$. The expressions used are:

$$u = a_1 \Psi^{1/2} + b_1 \Psi$$

$$c_i = c_{i_w} + a_{i_2} \Psi^{1/2} + b_{i_2} \Psi$$

$$H = H_w + a_3 \Psi^{1/2} + b_3 \Psi$$

$$\rho u = a_4 \Psi^{1/2} + b_4 \Psi$$

Using the variables evaluated at $\Delta \Psi$ and $2\Delta \Psi$, the a_n 's and b_n 's are determined. Thus from the series solution the values at $\frac{\Delta \Psi}{2}$ required in the

finite difference solution of the momentum, species and energy equations are then evaluated.

3. The difference in shear stress

$$\Delta\tau = \left[\frac{(\rho u r^\epsilon)_{m,n+1} + (\rho u r^\epsilon)_{m,n}}{2} \right] \left[\frac{A_1^L (\mu_{m,n+1}^L + \mu_{m,n}^L)}{2} + A_1^T \frac{T_{m,n+1/2}}{\mu_{m,n+1/2}} \right] \left[\frac{u_{m,n+1} - u_{m,n}}{\Delta\psi} \right]$$

$$- \left[\frac{(\rho u r^\epsilon)_{m,n} + (\rho u r^\epsilon)_{m,n-1}}{2} \right] \left[\frac{A_1^L (\mu_{m,n}^L + \mu_{m,n-1}^L)}{2} + A_1^T \frac{T_{m,n-1/2}}{\mu_{m,n-1/2}} \right] \left[\frac{u_{m,n} - u_{m,n-1}}{\Delta\psi} \right]$$

4. Viscosity models

a. Laminar $\mu_{m,n}^L = \frac{3.04566 \times 10^{-8} T_{m,n}^{1.5}}{110.333 + T_{m,n}}$

b. Turbulent $\frac{-T}{\mu} = B_1^T \mu^{T1} + B_2^T \mu^{T2} + B_3^T \mu^{T3} + B_4^T \mu^{T4}$
 $+ B_5^T \mu^{T5} + B_6^T \mu^{T6} + B_7^T \mu^{T7}$ where the B's are
input coefficients and the μ^{Ti} are defined as
follows:

i. Law of the wall - dimensional coordinate, y

$$\mu_{m,n+1/2}^{T1} = \left\{ y_{m,n} + \Delta\psi \left[\frac{.375}{(\rho_{ur}^{\epsilon})_{m,n}} + \frac{.125}{(\rho_{ur}^{\epsilon})_{m,n+1}} \right] \right\}^2 (FK)^2 \left\{ \frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right\}$$

$$\left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n+1} + (\rho_{ur}^{\epsilon})_{m,n}}{2} \right\} \left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\psi} \right|$$

$$\mu_{m,n-1/2}^{T1} = \left\{ y_{m,n} - \Delta\psi \left[\frac{.125}{(\rho_{ur}^{\epsilon})_{m,n-1}} + \frac{.375}{(\rho_{ur}^{\epsilon})_{m,n}} \right] \right\}^2 (FK)^2 \left\{ \frac{\rho_{m,n} + \rho_{m,n+1}}{2} \right\}$$

$$\left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n} + (\rho_{ur}^{\epsilon})_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\psi} \right|$$

ii. Law of the wake - dimensional coordinate, y_e .

$$\mu_{m,n+1/2}^{T2} = \left\{ \frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right\} \left\{ \frac{K_{m,n+1} + K_{m,n}}{2} \right\} (Y_e^u)_m$$

$$\mu_{m,n-1/2}^{T2} = \left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{K_{m,n} + K_{m,n-1}}{2} \right\} (Y_e^u)_m$$

where $K(N)$ is an input function of ψ

$$K(N) = a + b\psi + c\psi^2$$

iii. Laminar contribution

$$\mu_{m,n+1/2}^{T3} = 1/2 \{ \mu_{m,n}^L + \mu_{m,n+1}^L \}$$

$$\mu_{m,n-1/2}^{T3} = 1/2 \{ \mu_{m,n}^L + \mu_{m,n-1}^L \}$$

iv. Eddy viscosity fit - dimensional coordinate, y

$$\begin{aligned} \mu_{m,n+1/2}^{T4} = & \left\{ (Y_e)_m \left[.14 - .08 \left(1 - \frac{Y_{m,n} + \Delta\psi \left(\frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} + \frac{.125}{(\rho_{ur}^\epsilon)_{m,n+1}} \right)}{(Y_e)_m} \right)^2 \right. \right. \\ & \left. \left. - .06 \left(1 - \frac{Y_{m,n} + \Delta\psi \left(\frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} + \frac{.125}{(\rho_{ur}^\epsilon)_{m,n+1}} \right)}{(Y_e)_m} \right)^4 \right] \right\}^2 \\ & \left\{ \frac{\rho_{m,n} + \rho_{m,n+1}}{2} \right\} \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n+1} + (\rho_{ur}^\epsilon)_{m,n}}{2} \right\} \left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\psi} \right| \end{aligned}$$

$$\mu_{m,n-1/2}^{T4} = \left\{ (Y_e)_m \left[.14 - .08 \left(1 - \frac{Y_{m,n}^{-\Delta\Psi} \left(\frac{.125}{(\rho_{ur}^\epsilon)_{m,n-1}} + \frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} \right)}{(Y_e)_m} \right) \right]^2 - .06 \left(1 - \frac{Y_{m,n}^{-\Delta\Psi} \left(\frac{.125}{(\rho_{ur}^\epsilon)_{m,n-1}} + \frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} \right)}{(Y_e)_m} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n} + (\rho_{ur}^\epsilon)_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

v. Law of the wall - streamline coordinate, Ψ

$$\mu_{m,n+1/2}^{T5} = \left[\left(\Psi_n + \frac{\Delta\Psi}{2} \right) \left(\frac{FK}{\rho_e u_e r^\epsilon} \right)_m \right]^2 \left[\frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right] \left[\frac{(\rho_{ur}^\epsilon)_{m,n+1} + (\rho_{ur}^\epsilon)_{m,n}}{2} \right]$$

$$\left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi} \right|$$

$$\mu_{m,n-1/2}^{T5} = \left[\left(\Psi_n - \frac{\Delta\Psi}{2} \right) \left(\frac{FK}{\rho_e u_e r^\epsilon} \right)_m \right]^2 \left[\frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right] \left[\frac{(\rho_{ur}^\epsilon)_{m,n} + (\rho_{ur}^\epsilon)_{m,n-1}}{2} \right]$$

$$\left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

vi. Law of the wake - streamline coordinate, Ψ_e

$$\mu_{m,n+1/2}^{T6} = \left(\frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right) \left(\frac{K_{n+1} + K_n}{2} \right) \frac{\Psi_e}{(\rho_e r^\epsilon)_m}$$

$$\mu_{m,n-1/2}^{T6} = \left(\frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right) \left(\frac{K_n + K_{n-1}}{2} \right) \frac{\Psi_e}{(\rho_e r^\epsilon)_m}$$

vii. Eddy viscosity fit - streamline coordinate, Ψ

$$\mu_{m,n+1/2}^{T7} = \left\{ \frac{\Psi_e}{(\rho_e u_e r^\epsilon)_m} \left[.14 - .08 \left(1 - \frac{\Psi_n + \frac{\Delta\Psi}{2}}{\Psi_e} \right)^2 - .06 \left(1 - \frac{\Psi_n + \frac{\Delta\Psi}{2}}{\Psi_e} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right\} \left\{ \frac{(\rho u r^\epsilon)_{m,n+1} + (\rho u r^\epsilon)_{m,n}}{2} \right\} \left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi} \right|$$

$$\mu_{m,n-1/2}^{T7} = \left\{ \frac{\Psi_e}{(\rho_e u_e r^\epsilon)_m} \left[.14 - .08 \left(1 - \frac{\Psi_n - \frac{\Delta\Psi}{2}}{\Psi_e} \right)^2 - .06 \left(1 - \frac{\Psi_n - \frac{\Delta\Psi}{2}}{\Psi_e} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{(\rho u r^\epsilon)_{m,n} + (\rho u r^\epsilon)_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

5. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_u is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_u . If $\epsilon_u = 0$, the streamline test is not made. If ϵ_u is set as any positive number (used as the tolerance), the test

$$\left| \frac{u_{m+1}(L+1) - u_{m+1}(L-1)}{u_{m+1}(L+1)} \right| \leq \epsilon_u$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over. When the incremented expansion of the Ψ grid is called for then set $u_{m+1}(L-J) = \frac{u_m(L-J)}{u_m(L-1)} u_{m+1}(L+2)$, for $J = 2, 3, 4$, and $u_{m+1}(L-1) = u_{m+1}(L+2)$.

6. Boundary conditions

- a. Initial distributions - an input velocity profile vs. physical coordinates.
- b. Inner value at the wall - $u = 0$.
- c. Outer edge - velocity at the outer edge is obtained from the finite difference equation of "B" or the inviscid streamline solution of $u \frac{du}{ds} = - \frac{1}{\rho} \frac{dp}{ds}$ accordingly as the momentum, species

or enthalpy slope tests are satisfied or not (see Subsections II.B.5, II.C.5, II.D.5 for formulation of tests).

- d. Inviscid streamlines - two inviscid streamlines external to the boundary layer which represent the locally uniform (assumed) external flow are always computed.

C. Species Equation

1. Analytic form

$$\frac{\partial c_i}{\partial x} = \frac{\dot{w}_i A_2}{\rho u} + r^\epsilon \frac{\partial \phi}{\partial \Psi}, \quad i = 1, 2, \dots, 7$$

2. Finite difference form

$$(c_i)_{m+1,n} = (c_i)_{m,n} + \frac{\Delta x (\dot{w}_i)_{m,n} A_2}{(\rho u)_{m,n}} + \frac{\Delta x}{\Delta \Psi} r_{m,n}^\epsilon \left[\phi_{m,n+1/2} - \phi_{m,n-1/2} \right]$$

See Section II.B.2 for note regarding solution near the wall.

3. The species diffusion terms are given by:

$$\begin{aligned}
 \Delta \mathcal{G} = & \frac{1}{2} \left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n+1} + (\rho_{ur}^{\epsilon})_{m,n}}{2} \right\} \left\{ A_3^L \left[\left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n+1} + \left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n} \right] \right. \\
 & + A_3^L \mu_{m,n+1}^T \left[\left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n+1} + \left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n} \right] \left. \left\{ \frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta \Psi} \right\} \right. \\
 & - \frac{1}{2} \left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n} + (\rho_{ur}^{\epsilon})_{m,n-1}}{2} \right\} \left\{ A_3^L \left[\left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n} + \left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n-1} \right] \right. \\
 & + A_3^L \mu_{m,n-1}^T \left[\left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n} + \left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n-1} \right] \left. \left\{ \frac{(C_i)_{m,n} - (C_i)_{m,n-1}}{\Delta \Psi} \right\} \right.
 \end{aligned}$$

4. Chemistry production terms

a. Formulation

$$\dot{w}_i(\Psi, x) = \dot{w}_i(T, \rho, C_i), \quad i = 1, 2, \dots, 7$$

$$\dot{w}_{O_2} = \frac{\rho}{L} \left[-A + \frac{M_{O_2}}{M_{NO}} D \right]$$

$$\dot{w}_O = \frac{\rho}{L} \left[A + \frac{M_O}{M_{NO}} (C-D-E) - \frac{M_O}{M_{NO^+}} F \right]$$

$$\dot{w}_{N_2} = -\frac{\rho}{L} \left[B + \frac{M_{N_2}}{M_{NO}} E \right]$$

$$\dot{w}_N = \frac{\rho}{L} \left[B + \frac{M_N}{M_{NO}} (C+D+E) - \frac{M_N}{M_{NO^+}} F \right]$$

$$\dot{w}_{NO} = \frac{\rho}{L} \left[-C-D+E-K \right]$$

$$\dot{w}_{NO^+} = \frac{\rho}{L} \left[F+K \right]$$

$$\dot{w}_{e^-} = \frac{\rho}{L} \frac{M_e}{M_{NO^+}} \left[F+K \right]$$

where

$$A = \frac{2L}{M_O} \left[\sum_i \frac{C_i}{M_i} K_{ra}^i \right] \rho \left[\rho_{do} C_{O_2} e^{D_{O_2}/KT} - \rho C_O^2 \right] 9.6573302 \times 10^{25}$$

$$B = \frac{2L}{M_N} \left[\sum_i \frac{C_i}{M_i} K_{rb}^i \right] \rho \left[\rho_{dN} C_{N2} e^{-D_{N2}/KT} - \rho C_N^2 \right] 9.6573302 \times 10^{25}$$

$$C = \frac{LM_{NO}}{M_N M_O} \left[\sum_i \frac{C_i}{M_i} \right] K_{rc} \rho \left[\rho_{dNO} C_{NO} e^{-D_{NO}/KT} - \rho C_N C_O \right] 9.6573302 \times 10^{25}$$

$$D = \frac{LM_{NO}}{M_N M_{O2}} K_{rd} \rho \left[\sigma C_{NO} C_O e^{-\frac{D_{NO} - D_{O2}}{KT}} - C_{O2} C_N \right] 3.1076201 \times 10^{23}$$

$$E = \frac{LK_{re}}{M_N} \rho \left[\gamma C_{N2} C_O e^{-\frac{D_{N2} - D_{NO}}{KT}} - C_{NO} C_N \right] 3.1076201 \times 10^{23}$$

$$F = \frac{LK_{rf}}{M_e} \rho \left[\frac{1}{K} C_O C_N e^{-\frac{I_{NO} - D_{NO}}{KT}} - (C_{NO}^+) C_e \right] 3.1076201 \times 10^{23}$$

$$K = \frac{L}{M_e} \left[\sum_i \frac{C_i}{M_i} K_{rk}^i \right] \rho \left[\rho_{de} C_{NO} e^{-I_{NO}/KT} - \rho (C_{NO}^+) C_e \right] 9.6573302 \times 10^{25}$$

Set

$$ETT \ 228 = 5 + 3 e^{-228/T} + e^{-327/T}$$

$$ET \ 178 = 1 + e^{-178/T}$$

$$ET\ 2274 = 1 - e^{-2274/T}$$

$$ET\ 2740 = 1 - e^{-2740/T}$$

$$ET\ 3395 = 1 - e^{-3395/T}$$

$$ET\ 1130 = 3 + 2 e^{-11300/T}$$

Then

$$\sigma_{dO} = \frac{M_O}{2\eta h_p^3} (\pi m_O KT)^{3/2} \left(\frac{4.161}{T} \right) (ET\ 2274) \left(\frac{(ETT\ 228)^2}{ET\ 1130} \right) 3.87871 \times 10^{-11}$$

$$\sigma_{dN} = \frac{8M_N}{\eta h_p^3} (\pi m_N KT)^{3/2} \left(\frac{5.789}{T} \right) (ET\ 3395) 3.87871 \times 10^{-11}$$

$$\sigma_{dNO} = \frac{M_O}{\eta h_p^3} (2\pi m_O KT)^{3/2} \left(\frac{M_N}{M_{NO}} \right)^{5/2} \left(\frac{4.906}{T} \right) (ET\ 2740) \left(\frac{ETT\ 228}{ET\ 178} \right) 3.87871 \times 10^{-11}$$

$$\sigma = \left(\frac{M_{O2} M_N}{M_{NO} M_O} \right)^{5/2} \left(\frac{4.906}{4.161} \right) \left(\frac{ET\ 2740}{ET\ 2274} \right) \left(\frac{ET\ 1130}{ETT\ 228\ ET\ 178} \right)$$

$$\gamma = 16 \left(\frac{M_{NO} M_N}{M_{N2} M_O} \right)^{5/2} \left(\frac{5.789}{4.906} \right) \left(\frac{ET\ 3395}{ET\ 2740} \right) \left(\frac{ET\ 178}{ETT\ 228} \right)$$

$$\bar{K} = \left(\frac{(M_{NO^+}) \cdot M_e}{M_N M_O} \right)^{5/2} \left(\frac{T}{5.789} \right) \left(\frac{1}{ET \ 3395 \ ETT \ 228} \right)$$

$$\rho_{de} = \frac{M_e (2\pi m_e KT)^{3/2}}{\eta_p^3} (.4237) \left(\frac{ET \ 2740}{ET \ 3395} \right) \frac{2}{ET \ 178} 3.87871 \times 10^{-11}$$

b. Input $A_2 = 1$ for reacting system

= 0 for frozen system; bypass all $\dot{w}_i$

= - 1 for equilibrium system.

= 10 for reacting system with equilibrium at the wall

5. Equilibrium mass action laws

As indicated in II.C.4.b, an input of -1 for A_2 , activates the logic for obtaining the species from the following equilibrium relationships:

$$c_{m+1}(O_2) = \frac{908.19 \ T^{5/2} \left(\frac{5}{3} e^{-\frac{11391}{T}} + \frac{1}{3} e^{-\frac{18985}{T}} \right) \bar{A}^2 (2.773 \times 10^{-15})}{\rho \left(1 - e^{-\frac{2274}{T}} \right)}$$

$$c_{m+1}(O) = \frac{2237 T^{3/2} \left(1.6 e^{-\frac{228}{T}} + .2 e^{-\frac{326}{T}} \right) e^{-\frac{29501}{T}} \bar{A} (1.386 \times 10^{-9})}{\rho}$$

$$c_{m+1}(N_2) = \frac{178.39 T^{5/2} B^2 (2.428 \times 10^{-15})}{\rho \left(1 - e^{-\frac{3395}{T}} \right)}$$

$$c_{m+1}(N) = \frac{1462 T^{3/2} (3.5) \left(e^{-\frac{27698}{T}} + \frac{3}{2} e^{-\frac{41520}{T}} \right) e^{-\frac{56544}{T}} \bar{B} (1.214 \times 10^{-9})}{\rho}$$

$$c_{m+1}(NO) = \frac{934.14 T^{5/2} \left(1 - e^{-\frac{178}{T}} \right) e^{-\frac{11063}{T}} \bar{AB} (2.6 \times 10^{-15})}{\rho \left(1 - e^{-\frac{2740}{T}} \right)}$$

$$c_{m+1}(NO^+) = 233.9 \sqrt{\frac{.1597 \times 10^{-11} T e^{-\frac{32125}{T}} c_{m+1}(O) c_{m+1}(N)}{\left(1 - e^{-\frac{3395}{T}} \right) \left(1.6 e^{-\frac{228}{T}} + .2 e^{-\frac{326}{T}} \right)}}$$

$$c_{m+1}(e^-) = \frac{1}{(233.9)^2} c_{m+1}(NO^+)$$

$\bar{A}$ and $\bar{B}$ are obtained from an iteration procedure which is satisfied when two successive values of $\bar{B}$ agree to within $\frac{1}{1000}$ %.

The iteration procedure is initiated with $\bar{B} = 0$ and then the following calculations take place in the sequence shown:

$$BT = \frac{\left(2237 T^{3/2} B_4 e^{-\frac{29501}{T}} \right) \bar{B} \left(934.14 T^{5/2} E_4 e^{-\frac{11063}{T}} \right) 10^{-18}}{E_3}$$

$$AC = \frac{(908.19 T^{5/2}) B_1 \rho (1338.7 \times 10^{-12})}{E_1}$$

$$\bar{A} = \frac{\left(-BT \sqrt{(BT)^2 + AC} E_1 \right)}{(908.19 T^{5/2} E_1) (4 \times 10^{-12})}$$

$$BT = \frac{\left(1461.9 T^{3/2} E_5 e^{-\frac{56544}{T}} \right) \bar{A} \left(934.14 T^{5/2} E_4 e^{-\frac{11063}{T}} \right) 10^{-18}}{E_3}$$

$$AC = \frac{(178.39 T^{5/2}) \rho (5060.8 \times 10^{-12})}{E_2}$$

$$\bar{B} = \frac{\left(-BT + \sqrt{(BT)^2 + AC} \right) E_2}{(178.39 T^{5/2}) (4 \times 10^{-12})}$$

where

$$B_1 = \frac{5}{3} e^{-\frac{11390}{T}} + \frac{1}{3} e^{-\frac{18984}{T}}$$

$$B_4 = 1.6 e^{-\frac{228}{T}} + .2 e^{-\frac{326}{T}}$$

$$B_5 = 3.5 e^{-\frac{27698}{T}} + 1.5 e^{-\frac{41520}{T}}$$

$$E_1 = 1 - e^{-\frac{2274}{T}}$$

$$E_2 = 1 - e^{-\frac{3395}{T}}$$

$$E_3 = 1 - e^{-\frac{2740}{T}}$$

$$E_4 = 1 - e^{-\frac{178}{T}}$$

6. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_c is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_c . If $\epsilon_c = 0$, the streamline test is made. If ϵ_c is set as any positive number (used as the tolerance) the test

$$\left| \frac{c_{m+1,i}(L+1) - c_{m+1,i}(L-1)}{c_{m+1,i}(L+1)} \right| \leq \epsilon_c \quad i=1, \dots, 7$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over. When the incremented expansion of the Ψ grid is called for then set $c_{m+1}(L-J)$

$$= \frac{c_m(L-J)}{c_m(L-1)} c_{m+1}(L+2), \text{ for } J = 2, 3, 4 \text{ and}$$

$$c_{m+1}(L-1) = c_{m+1}(L+2).$$

7. Boundary conditions

- a. Initial - $c_i(y)$ profiles are input for all species except N_2 and e^- , which are computed from:

$$c_{e^-}(N) = \frac{M_{e^-}}{M_{NO^+}} c(NO^+)$$

$$c_{N_2}(N) = 1 - \sum c_i \quad i \neq N_2$$

- b. Wall - $c_{m+1}(I) = C_1(I) + C_2(I) \frac{x}{Rn} + C_3(I) \left(\frac{x}{Rn}\right)^2$
 $+ C_4(I) \left(\frac{x}{Rn}\right)^3 + C_5(I) \left(\frac{x}{Rn}\right)^4$ where the C_1 through C_5 are input for each specie except e^- .

- c. Outer edge - Species at the outer edge are obtained from the finite difference equation in Subsection II.C.2. or the inviscid solution of $u \frac{dc_i}{ds} = \frac{\dot{w}_i}{\rho}$ accordingly as the momentum, species or enthalpy slope tests are satisfied or not (see Subsections II.B.5, II.C.5., II.D.5. for formulation of tests).
- d. Along the two external inviscid streamlines the species are obtained from the inviscid equation.

D. Energy Equation

1. Analytic form

$$\frac{\partial H}{\partial x} = r^\epsilon \frac{\partial}{\partial \Psi} (\mathcal{E}^H + \mathcal{E}^C)$$

2. Finite difference form

$$\begin{aligned} H_{m+1,n} = H_{m,n} + r_m^\epsilon \frac{\Delta x}{\Delta \Psi} (\mathcal{E}_{m,n+1/2}^H - \mathcal{E}_{m,n-1/2}^H) \\ + r_m^\epsilon \frac{\Delta x}{\Delta \Psi} (\mathcal{E}_{m,n+1/2}^C - \mathcal{E}_{m,n-1/2}^C) \end{aligned}$$

See Section II.B.2. for note regarding solution near the wall.

3. The difference of enthalpy-kinetic energy terms $\mathcal{E}^H$ is given by:

$$\underline{N = 2}$$

$$UAVG1 = \frac{r^\epsilon}{\Delta\Psi} \left[\rho_{\frac{1}{2}} u_{\frac{1}{2}}^2 \left(\frac{du}{d\Psi} \right)_{\frac{1}{2}} + \rho_2 u_2^2 \frac{(u_2 + u_3)}{2} - u_{\frac{1}{2}} \right]$$

$$UAVG2 = \frac{r^\epsilon}{2\Delta\Psi} \left[(\rho_3 u_3^2 + \rho_2 u_2^2) (u_3 - u_2) + \rho_2 u_2^2 (u_2 + u_3 - 2u_{\frac{1}{2}}) \right]$$

$$SUMHL = 2 \sum_i h_{i\frac{1}{2}} \left(\frac{D_{ki}}{D_2^L} + \frac{D_{ki}}{D_1^L} \right) \left(\frac{dC_i}{d\Psi} \right)_{\frac{1}{2}}$$

$$SUMHT = 2 \sum_i h_{i\frac{1}{2}} \left(\frac{D_{ki}}{D_2^T} + \frac{D_{ki}}{D_1^T} \right) \left(\frac{dC_i}{d\Psi} \right)_{\frac{1}{2}}$$

$$RURN = 2(\rho u)_{\frac{1}{2}} r^\epsilon$$

$$\begin{aligned} PARTH2 = \frac{1}{4} (RURN) & \left[A_4^L \mu_{\frac{1}{2}}^L \left(\frac{1}{P_{r_2}^L} + \frac{1}{P_{r_1}^L} \right) + 2A_4^T \left(\frac{\mu_{3/2}^T}{P_{r_1}^T} \right) \right] \left(\frac{dH}{d\Psi} \right)_{\frac{1}{2}} \\ & + \left[A_4^L (\mu_2^L + \mu_{\frac{1}{2}}^L) \left(1 - \frac{1}{P_{r_2}^L} \right) \frac{A_4^T}{2} \mu_{3/2}^T \left(1 - \frac{1}{P_{r_2}^T} \right) \right] UAVG1 \end{aligned}$$

$$\begin{aligned} PARTC2 = \frac{1}{8} \left[2 - \frac{1}{L_{e_2}^L} - \frac{1}{L_{e_1}^L} \right] & \left[\frac{1}{S_{c_2}^L} + \frac{1}{S_{c_1}^L} \right] (RURN) \frac{A_5^L}{4} \mu_{\frac{1}{2}}^L (SUMHL) + \\ \frac{1}{8} \left[2 - \frac{1}{L_{e_2}^T} - \frac{1}{L_{e_1}^T} \right] & \left[\frac{1}{S_{c_2}^T} + \frac{1}{S_{c_1}^T} \right] (RURN) \frac{A_3^T}{4} \mu_{\frac{1}{2}}^T (SUMHT) \end{aligned}$$

$$\underline{N > 2}$$

$$UAVG1 = \frac{r^\epsilon}{2\Delta\Psi} \left[\rho_n u_n^2 (u_{n+1} - u_{n-1}) + (\rho_n u_n^2 + \rho_{n-1} u_{n-1}^2) (u_n - u_{n-1}) \right]$$

$$UAVG2 = \frac{r^\epsilon}{2\Delta\Psi} \left[\rho_n u_n^2 (u_{n+1} - u_{n-1}) + (\rho_{n+1} u_{n+1}^2 + \rho_n u_n^2) (u_{n+1} - u_n) \right]$$

$$SUMHL = \sum_i (h_{i_n} + h_{i_{n-1}}) \left(\frac{D_{ki}}{D_n^L} + \frac{D_{ki}}{D_{n-1}^L} \right) \left(\frac{dc_i}{d\Psi} \right)$$

$$SUMHT = \sum_i (h_{i_n} + h_{i_{n-1}}) \left(\frac{D_{ki}}{D_n^T} + \frac{D_{ki}}{D_{n-1}^T} \right) \left(\frac{dc_i}{d\Psi} \right)$$

$$RURN = r^\epsilon (\rho_n u_n + \rho_{n-1} u_{n-1})$$

$$PARTH2 = \frac{1}{4} (RURN) \left[A_4^L \left(\frac{\mu_n^L}{p_{r_n}^L} + \frac{\mu_{n-1}^L}{p_{r_{n-1}}^L} \right) + A_4^T \left(\frac{\mu_{n-1/2}^T}{p_{r_{n-1}}^T} \right) \right] \frac{dH}{d\Psi} +$$

$$\left[\frac{A_4^L}{4} (\mu_{n-1}^L) \left(1 - \frac{1}{p_{r_{n-1}}^L} \right) + 3\mu_n^L \left(1 - \frac{1}{p_{r_n}^L} \right) + A_4^T \mu_{n-1/2}^T \right]$$

$$\left(1 - \frac{1}{p_{r_n}^T} \right) \right] UAVG1$$

$$\text{PARTC2} = \frac{1}{16} \left(2 - \frac{1}{L_{e_n}^L} - \frac{1}{L_{e_{n-1}}^L} \right) \left(\frac{1}{S_{c_n}^L} + \frac{1}{S_{c_{n-1}}^L} \right) (\text{RURN})$$

$$\frac{A_8^L}{4} (\mu_n^L + \mu_{n-1}^L) (\text{SUMHL}) + \frac{1}{8} \left(2 - \frac{1}{L_{e_n}^T} - \frac{1}{L_{e_{n-1}}^T} \right)$$

$$\left(\frac{1}{S_{c_n}^T} + \frac{1}{S_{c_{n-1}}^T} \right) (\text{RURN}) \frac{A_8^T}{4} \mu_{n-1/2}^T (\text{SUMHT})$$

$$\Delta \rho^H = \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n+1} + (\rho_{ur}^\epsilon)_{m,n}}{2} \right\} \left\{ A_4^L \left[\frac{\left(\frac{\mu^L}{P_r^L} \right)_{m,n+1} + \left(\frac{\mu^L}{P_r^L} \right)_{m,n}}{2} \right] + 2A_4^T \left(\frac{\mu^T}{P_r^T} \right)_{m,n+1/2} \right\}$$

$$\left\{ \frac{H_{m,n+1} - H_{m,n}}{\Delta \Psi} \right\} + \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n} + (\rho_{ur}^\epsilon)_{m,n+1}}{2} \right\} \left\{ A_4^L \left[\frac{\mu_{n+1}^L \left(1 - \frac{1}{P_r^L} \right) + 3\mu_n^L \left(1 - \frac{1}{P_r^L} \right)}{2} \right] \right\}$$

$$+ A_4^L \left[\mu_{n+1/2}^T \left(1 - \frac{1}{P_r^T} \right) \right] \left\{ \text{UAVG2} - \text{PARTH2} \right\}$$

4. The energy transport due to species gradients $\mathcal{C}^c$ is given by:

$$\Delta \mathcal{C}^c = \frac{1}{16} \left[\left(1 - \frac{1}{L_e^L} \right)_{m,n+1} + \left(1 - \frac{1}{L_e^L} \right)_{m,n} \right] \left[\left(\frac{1}{S_c^L} \right)_{m,n+1} + \left(\frac{1}{S_c^L} \right)_{m,n} \right]$$

$$\left[(\rho_{ur} \epsilon)_{m,n+1} + (\rho_{ur} \epsilon)_{m,n} \right] \left[A_s^L (\mu_{m,n+1}^L + \mu_{m,n}^L) \right] \cdot \left[\frac{1}{4} \sum_i (h_{i,m,n+1} + h_{i,m,n}) \right]$$

$$\left[\left(\frac{D_{ki}^L}{D^L} \right)_{m,n+1} + \left(\frac{D_{ki}^L}{D^L} \right)_{m,n} \right] \left[\frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta \Psi} \right] + \frac{1}{8} \left[\left(1 - \frac{1}{L_e^T} \right)_{m,n+1} + \left(1 - \frac{1}{L_e^T} \right)_{m,n} \right]$$

$$\left[\left(\frac{1}{S_c^T} \right)_{m,n+1} + \left(\frac{1}{S_c^T} \right)_{m,n} \right] \left[(\rho_{ur} \epsilon)_{m,n+1} + (\rho_{ur} \epsilon)_{m,n} \right] \left[A_s^{T-T} \mu_{m,n+1/2}^T \right]$$

$$\frac{1}{4} \sum_i \left[(h_{i,m,n+1} + h_{i,m,n}) \right] \left[\left(\frac{D_{ki}^T}{D^T} \right)_{m,n+1} + \left(\frac{D_{ki}^T}{D^T} \right)_{m,n} \right] \left[\frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta \Psi} \right] - \text{PARTC2}$$

5. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_H is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_H . If $\epsilon_H = 0$, the streamline test is

not made. If ϵ_H is set to any positive number (the tolerance) the test

$$\left| \frac{H_{m+1}(L+1) - H_{m+1}(L-1)}{H_{m+1}(L+1)} \right| \leq \epsilon_H$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over.

6. Boundary conditions

a. Initial - an input enthalpy profile vs. physical coordinates.

b. Wall - $H_{m+1} = HH_1 + HH_2 \left(\frac{x}{Rn} \right) + HH_3 \left(\frac{x}{Rn} \right)^2 + HH_4 \left(\frac{x}{Rn} \right)^3 + HH_5 \left(\frac{x}{Rn} \right)^4$ where the HH_1 through HH_5 are input.

c. Outer edge

Enthalpy at the outer edge is obtained from the finite difference equation in Subsection II.D.2. or set equal to the input free stream value accordingly as the momentum, species or enthalpy slope tests are satisfied or not (see Subsections II.B.5., II.C.5., II.D.5. for formulation of tests).

III. INVISCID FLOW EQUATIONS

A. Governing Equations for One-Dimensional Streamlines

1. Momentum

$$u_{\text{inv}} \frac{du_{\text{inv}}}{ds} = - \frac{1}{\rho_{\text{inv}}} \frac{dp}{ds}$$

2. Species

$$u_{\text{inv}} \frac{dc_{i\text{inv}}}{ds} = \frac{\dot{w}_i}{\rho_{\text{inv}}}$$

3. Total enthalpy (energy)

$$H = \text{constant}$$

$$= h_{\text{inv}} + \frac{u_{\text{inv}}^2}{2}$$

B. Tracing the Streamline from the Shock

Reference: NACA Report #1135 - "Equations, Tables and Charts for Compressible Flow 1953"

1. Intersection of streamline and shock, see sketch.

$$\frac{D_{\infty}}{2} = \left(\frac{m_{bL}}{\rho_{\infty} u_{\infty} \pi} \right)^{\frac{1}{2}}$$

where

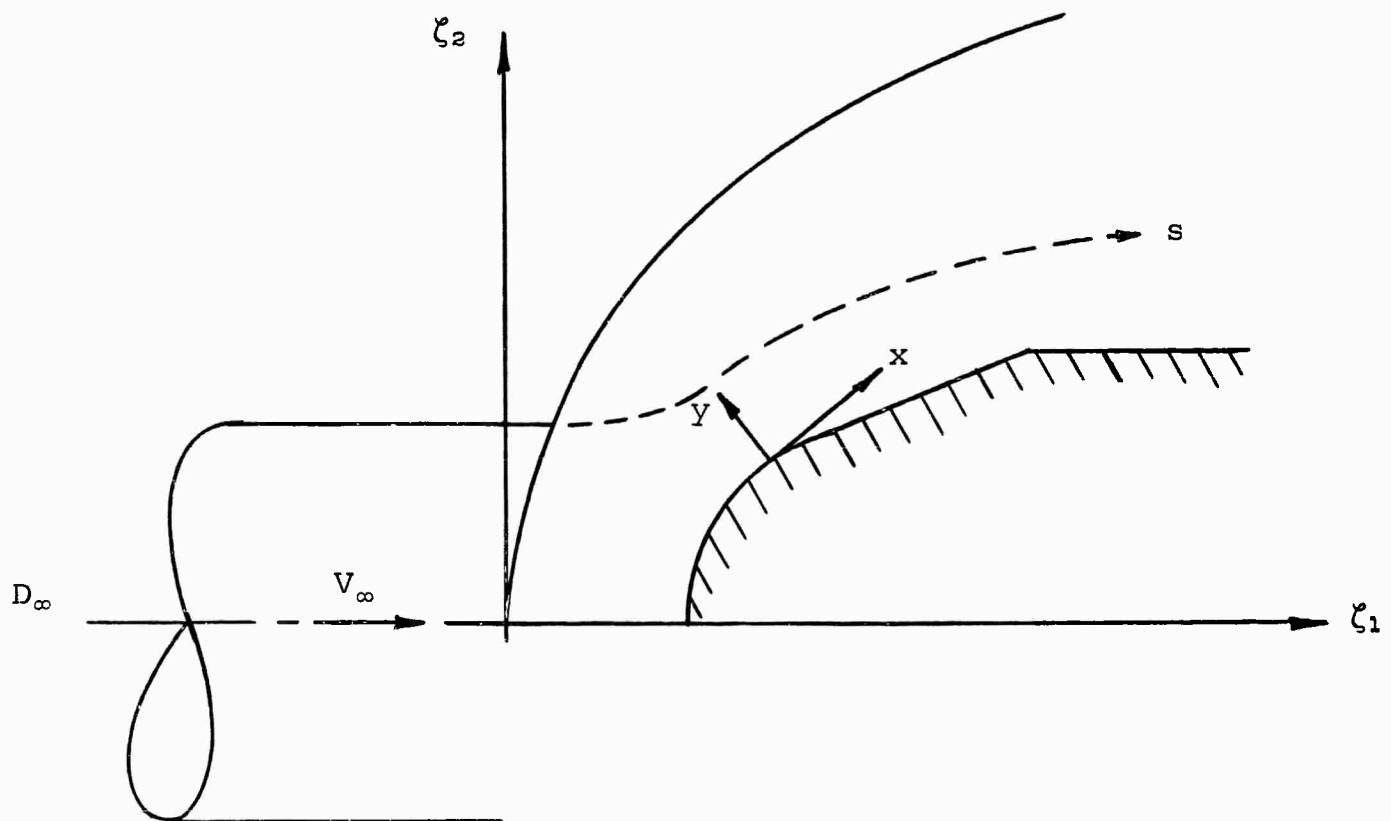
$$m_{bL} = \int_0^{\Psi_e} \epsilon \left[(2\pi) \epsilon_Y \cos \theta_t \frac{d\Psi}{r\epsilon} \right] + (2\pi) \epsilon \Psi_e$$

$\theta_t = 90 - \alpha$, for arc, ogive

= 0, cylinder, flat plate

= cone angle, cone

α = angle which the current point on the body and the coordinates of the center of the arc make with ζ_1 axis, measured in a clockwise direction from ζ_1 .



Coordinate Systems for a Blunt Body

2. Conditions downstream of the shock

a. Following will be input

$$\rho_{\infty}$$

$$\rho_{\text{stag}}$$

$$\left. \begin{array}{l} h_{\infty} \\ c_{p_{\infty}} \end{array} \right\} \text{ needed for } T_{\infty} = \frac{h_{\infty}}{c_{p_{\infty}}}$$

$$p_{\infty}$$

altitude

γ (specific heat ratio)

u_{LOLIM} - used for checking against calculated u in the one-dimensional streamline equation in order to keep $u > 0$.

b. Following will be program set from input

$$u_{\infty} = u(L)$$

$$c_{i_{\infty}} = c(L, I)$$

$$H_{\infty} = H(L)$$

c. The program calculates:

$$u_{\text{ds}} = 1 - \left[\frac{[4(M_1^2 \sin^2 \theta - 1)(\gamma M_1^2 \sin^2 \theta + 1)]}{[(\gamma + 1)^2 M_1^4 \sin^2 \theta]} \right]^{\frac{1}{2}} u_{\infty}$$

where

$$M_1 = \frac{u_\infty}{a_\infty} \text{ Mach \#}$$

$$a_\infty = \text{speed of sound} = 49.9 \sqrt{1.8 T_\infty}$$

$$T_\infty = \frac{h_\infty}{C_{p_\infty}} \text{ } ^\circ\text{K}$$

$$\theta = \angle \text{ shock wave makes with } \zeta_1$$

$$c_{ids} = c_{i_\infty}$$

$$p_{ds} = \left[\frac{2\gamma M_1^2 \sin^2 \theta - (\gamma - 1)}{\gamma + 1} \right] p_\infty$$

d. The program outputs:

(a) p_{ds}

(b) u_{ds}

(c) c_{ids}

3. Completion of streamline calculation

The program sets:

$$u_{m+1}(L) = u_{m+1}(L+1) = u_{m+1}(L+2)$$

$$c_{m+1}(L, I) = c_{m+1}(L+1, I) = c_{m+1}(L+2, I)$$

IV. INPUTS

Under this section the various input parameters are discussed from a programming viewpoint; see Manual, Part III, for input data preparation. In Subsection A through C, certain critical parameters are discussed, and in Subsection D the input definitions and card formats are specified. Also included in the latter sections of this report is a sample problem which illustrates the nature of the inputs.

A. Body Geometry

1. Classification

Bodies will be classified accordingly as the first geometrical region is:

- a. Blunted $\Delta s \neq 0$
 - (a) arc (hemispherical nose)
- b. Pointed $\Delta s = 0$
 - (a) cone
 - (b) ogive
 - (c) flat plate

where Δs = standoff distance from shock to stagnation point of body along centerline (see IV.B.3).

2. Subsequent geometric regions of the body

The following geometrical descriptions for body sections are available:

- | | | |
|---------------|---|--|
| a. arc | } | 2 dimensional or axisymmetric
depending upon input ϵ , (or EPSI in
the input list, Subsection IV.D) |
| b. cone | | |
| c. cylinder | | |
| d. ogive | | |
| e. flat plate | | |

3. Calculation of radius of the body and the ζ_1 , ζ_2 coordinates

a. For each region the program reads in

- | | | | |
|-----|---------------------------|---|----------------|
| (a) | INDP = pressure type | } | 1 = cosine |
| | indicator | | 2 = polynomial |
| | (see p.39, Section C) | | 3 = quotient |
| (b) | INDR = geometry indicator | } | 1 = arc |
| | | | 2 = cone |
| | | | 3 = cylinder |
| | | | 4 = ogive |
| | | | 5 = flat plate |
| (c) | INDLR = last subregion of | } | 1 = yes |
| | last region indicator | | 0 = no |

- (d) INDLSR = last subregion of any region indicator $\left\{ \begin{array}{l} 1 = \text{yes} \\ 2 = \text{no} \end{array} \right.$
- (e) OGIVE H $\left\{ \begin{array}{l} \text{coordinates of center of arc} \\ \text{with respect to } \zeta_1, \zeta_2 \text{ origin} \end{array} \right.$
OGIVE K
- (f) $p(J)$, $J = 1, 8$, pressure coefficients
- (g) $CC_i(K)$, $K = 1, 5$, C_{WALL} coefficients
- (h) R_n = nose or reference base radius
- (i) XL = cumulative upper $\frac{x}{R_n}$ limit of this subregion
- (j) CONEAN = cone angle/2 (vertex semi-angle)

B. Shock Geometry

1. Description of the Shock

The shock consists of up to 10 sections of the form:

a. $\zeta_2 = a_n \zeta_1 + b_n$ straight line

b. $\zeta_1 - a_n = b_n (\zeta_2 - c_n)^2$ parabola

Type 6 is a parabola whose coefficients a_n , b_n and c_n are specified as input. Type 7 is a parabola whose beginning and ending slopes and the ζ_1 projection of the end point of the geometrical shock region are specified as input.

The present version of the program permits parabolas to follow each other but they may not follow straight lines.

2. Shock input is specified by giving

- a. Curve type
- b. Slope and cumulative ζ_1 limit for a straight line
- c. Coefficients and cumulative ζ_1 limit for a parabola or
- d. Beginning and ending slopes and cumulative ζ_1 limit

3. Section 1 of the shock has optional provision (type 7) for internally computing and establishing the shock

$$\zeta_1 - a_n = b_n (\zeta_2 - c_n)^2$$

with

$$a_n = c_n = 0, \quad b_n = \frac{.5}{1 + \frac{\Delta s}{Rn}} \frac{1}{Rn}$$

where $\Delta s = \frac{2/3}{\frac{\rho_{stag}}{\rho_\infty} - 1} Rn$ (physical standoff distance). $\frac{\Delta s}{Rn}$ is the

dimensionless standoff distance.

4. The program has provision for specifying several shock shapes, e.g. conical, parabolic and normal. Moreover optional modes for specifying a particular shape are also possible, e.g.

parabolas can be specified by inputting the coefficients of the analytic expression or the beginning and ending slopes. The following indicates the formulae for obtaining the ζ coordinates and the balances of the shock coefficients for all permissible combinations of shock shapes.

a. Region 1 is a cone

i. $m, \zeta_1, b_1 = 0$ are input

ii. $\zeta_2 = m \zeta_1$

b. Region N-1 is a parabola

Region N is a parabola - Type 6

i. $a_{N-1}, b_{N-1}, c_{N-1}$ are available

a_N, b_N, c_N are input

ii. $\zeta_{1(N-1)} = a_{N-1} + b_{N-1} [\zeta_{2(N-1)} - c_{N-1}]^2$

$$\zeta_2 = \frac{b_{N-1} c_{N-1} - b_N c_N}{b_{N-1} - b_N}$$

c. Region N-1 is a parabola

Region N is a parabola - Type 7

i. $a_{N-1}, b_{N-1}, c_{N-1}$ are available

m_{N-1}, m_N, ζ_{1N} are input

$$\text{ii. } a_N = \frac{\zeta_1(N-1)m_{N-1}^2 - m_N^2 \zeta_1(N)}{m_{N-1}^2 - m_N^2}$$

$$c_N = \zeta_2(N-1) - \frac{2m_N^2(\zeta_1(N) - a_N)}{m_{N-1}}$$

$$b_N = \frac{1}{4m_N^2(\zeta_1(N) - a_N)}$$

$$\zeta_2(N-1) = \frac{1}{2b_{N-1} m_{N-1}} + c_{N-1}$$

$$\zeta_1(N-1) = a_{N-1} + b_{N-1}(\zeta_2(N-1) - c_{N-1})^2$$

d. Region N-1 is a parabola

Region N is a cone

i. a_{N-1} , b_{N-1} , c_{N-1} are available

m_N is input

$$\text{ii. } \zeta_2(N-1) = \frac{1}{2b_{N-1} a_N} + c_{N-1}$$

$$\zeta_1(N-1) = a_{N-1} + b_{N-1}[\zeta_2(N-1) - c_{N-1}]^2$$

$$b_N = \zeta_2(N-1) - a_N \zeta_1(N-1)$$

e. Region N-1 is a cone

Region N is a cone

i. a_{N-1} , b_{N-1} , $\zeta_1(N-1)$ are available

m_N is input

ii. $\zeta_2(N-1) = a_{N-1} \zeta_1(N-1) + b_{(N-1)}$

$$b_N = \zeta_2(N-1) - a_N \zeta_1(N-1)$$

C. Pressure Distribution

Associated with each body subregion is a distribution which is one of 3 possible types:

$$1. \quad p = p_1 \cos^2 \frac{x}{Rn} \quad (\text{Newtonian})$$

$$2. \quad p = p_2 + p_3 \frac{x}{Rn} + p_4 \left(\frac{x}{Rn} \right)^2 + p_5 \left(\frac{x}{Rn} \right)^3 + p_6 \left(\frac{x}{Rn} \right)^4$$

$$3. \quad p = \frac{p_7}{p_8 + \frac{x}{Rn}}$$

where p_1 through p_8 are inputs.

D. Input Definitions, Card Formats and Symbols

<u>SYMBOLS</u>	<u>DEFINITION</u>	<u>FORMAT</u>
*LP2	# Ψ pts + 2	I 10
NS	# species	
NPSI	print interval density in Ψ direction e.g. every point, every second point, etc.	
INDSTR	streamline starting point indicator	
FNDSSL	lower limit for step size control	E 10.3
FNDSSH	upper limit for step size control	
IALT	altitude - in kft	I 10
A ₁ ^L	laminar indicator for momentum equation	E 10.3
A ₁ ^T	turbulent indicator for momentum equation	
A ₂	chemistry indicator for equilibrium or non- equilibrium calculations (see p.18, Section b)	
A ₃ ^L	laminar indicator for species equation	
A ₃ ^T	turbulent indicator for species equation	
A ₄ ^L	laminar indicator for energy equation	
A ₄ ^T	turbulent indicator for energy equation	
A ₅ ^L	laminar indicator for energy equation	
A ₅ ^T	turbulent indicator for energy equation	
c(N,I)	species mass fraction profiles N = 1,2...LP2; I = 1,2,4,5,6	
*RESTAR	restart indicator; 1 = original run, 0 = continuation run	E 10.3

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
DELTA X	step size - x direction	E 10.3
EPSI	exponent for body radius	
EPSIU= ϵ_u	tolerance on velocity for a streamline call	
EPSIC= ϵ_c	tolerance on all species for a streamline call	
EPSIH= ϵ_H	tolerance on total enthalpy for streamline call	
EPSIT= ϵ_T	tolerance on temperature iteration	
FH(N)	total enthalpy profile, N = 1,2...LP2	
FK	factor in $\frac{-T_1}{\mu}$	
*CPE	free stream specific heat at constant pressure	E 10.3
FL	characteristic length to dimensionalize species production term	
FSHE	free stream static enthalpy	
GAMM	ratio of specific heat, Cp/Cr	
PE	free stream pressure	
RHOE	free stream density	
RHOSTG	stagnation density	
CE(I)	free stream species, I = 1,2...7	
R _N	nose radius	
UINF	free stream velocity	
ULOLIM	low limit for velocity in streamline	
XS	x starting value	

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
Z1S	ζ_1 coordinate starting value	E 10.3
Z2S	ζ_2 coordinate starting value	
Z1L	ζ_1 coordinate entire body	
u(N)	velocity profile, $N = 1, 2, \dots, LP2$	
*FA	coefficient for FKPSI in μ^{T2} FKPSI $\equiv$ K(N) (see p.8, Section ii)	E 10.3
FB		
FC		
TESTRA	test ratio for establishing turbulent viscosity model	
AB ₁ ^T	law of the wall - dimensional coordinate y law of the wake - dimensional coordinate, y_e laminar viscosity eddy viscosity fit dimensional coordinate y law of the wall - streamline coordinate, Ψ law of the wake - streamline coordinate, Ψ_e eddy viscosity fit streamline coordinate, Ψ law of the wall - dimensional coordinate, y	E 10.3
AB ₂ ^T		
AB ₃ ^T		
AB ₄ ^T		
AB ₅ ^T		
AB ₆ ^T		
AB ₇ ^T		
BB ₁ ^T		

Indicators and
coefficients for
invoking turbulent
viscosity model
components
(see p.7, Section 4,b)

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
BB ₂ ^T	law of the wake - dimensional coordinate, y_e	E 10.3
BB ₃ ^T	laminar viscosity	Indicators and coefficients for invoking turbulent viscosity model components (see p.7,Section 4,b)
BB ₄ ^T	eddy viscosity fit dimensional coordinate, y	
BB ₅ ^T	law of the wall - streamline coordinate, Ψ	
BB ₆ ^T	law of the wake - streamline coordinate, Ψ_e	
BB ₇ ^T	eddy viscosity fit streamline coordinate, Ψ	
FLELIN	Lewis laminar number	E 10.3
FLETIN	Lewis turbulent number	
PRALIN	Prandtl laminar number	
PRATIN	Prandtl turbulent number	
SCHLIN	Schmidt laminar number	
SCHTIN	Schmidt turbulent number	
Y(N)	physical coordinates for input profile normal to body	
*INDPRI	print interval x direction	I 10
NSR	# shock regions	
JINPUT	# times to bypass step size control halving	
THPER	% to be used to establish boundary layer thickness	E 10.3

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
*ASR(N)	coefficients for N^{th} shock region geometry, $N = 1, \text{NSR}$	E 10.3
BSR(N)		
CSR(N)		
Z1R(N)	ζ_1 boundary for N^{th} shock region, $N = 1, \text{NSR}$	
Z2R(N)	ζ_2 boundary for N^{th} shock region, $N = 1, \text{NSR}$	
INDTYP(N)	geometric type, $N = 1, \text{NSR}$	I 3
INDCOO(N)	end coordinate indicator, $N = 1, \text{NSR}$	I 3
INDLAS(N)	last shock region indicator, $N = 1, \text{NSR}$	I 4
Note: ASR(N)-INDLAS(N) are repeated for each shock region, $N = 1, \text{NSR}$		
*INDP	body subregion pressure type	I 10
INDR	body subregion geometric type	
INDLR	last region indicator	
INDLSR	last subregion indicator	
INDS5	spare	
INDS6	spare	
INDS7	spare	
OGIVEH	coordinates of center of body arcs or ogives	E 10.3
OGIVEK		
P(J)	coefficients for pressure formulas, $J = 1, 8$	
CC(K,I)	coefficients for species mass fractions at wall, $K = 1, 5; I = 1, \text{NS}-1$	

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
HH(J)	coefficients for total enthalpy at wall, J= 1,5	↓
R _N	body radius	
X _L	cumulative x limit for each subregion	
CONEAN	cone angle	

Note: INDP-CONEAN are repeated for each body subregion

* Indicates that this field is the first one on the input card, and subsequent fields until the next * are continuous through column 70 for as many cards as are necessary.

V. PROGRAM FEATURES

A. Step Size Control

The purpose of step size control is to allow the program to run as fast as possible within stability and truncation requirements.

1. Ψ direction

Whenever the number of Ψ intervals becomes twice the original input amount (as a result of swallowing) the program halves the number of points. This is of significance since the permissible stability control step size in the x direction varies with $(\Delta\Psi)^2$.

2. x direction

The program takes two single steps and compares the velocity, species and enthalpy with the results of a single step of double size. Depending on input limit tolerances, the step size is doubled, unchanged or halved. However, the step size is always subjected to the stability control for maximum size.

If a negative velocity, specie, enthalpy or temperature has been calculated, or depending on a sense switch being on, if a 5% out of monotonicity in u or H develops, the step size is halved up to seven times before the program stops. Provision has been made for overriding the halving for JINPUT times, so as

to allow zero species to fill in as a result of production and of diffusion in the Ψ direction. The above procedure for doubling, continuing and halving the step size which applies to the boundary layer also applies individually to u and c_i in the streamline calculations.

B. Stability Control

The expansion of the step size in the x direction which is described under "Step Size Control" is subsequently scrutinized to insure stability.

Δx is compared to $\frac{\overline{\Delta \Psi^2}}{2\sigma_n}$ and accordingly as it is less than (or equal to) or greater than, it is accepted or halved.

$$\sigma_u = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n A_1^L \mu_n^L + A_1 \left[\frac{\overline{\mu}_{n+1/2}^T + \overline{\mu}_{n-1/2}^T}{2} \right]$$

$$\sigma_H = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_4^L \frac{\mu_n^L}{P_{r_n}^L} + A_4^L \frac{\overline{\mu}_{n+1/2}^T + \overline{\mu}_{n-1/2}^T}{2} \frac{1}{P_{r_n}^T} \right]$$

$$\sigma_C = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_3^L \frac{\mu_n^L}{S_{c_n}^L} \frac{D_k^L}{D_n^L} + A_3^T \frac{\overline{\mu}_{n+1/2}^T + \overline{\mu}_{n-1/2}^T}{2} \frac{1}{S_{c_n}^T} \frac{D_k^T}{D_n^T} \right]$$

Δx must be $\leq$ the minimum of $\frac{\overline{\Delta \Psi^2}}{2\sigma_u T \ln}$, $\frac{\overline{\Delta \Psi^2}}{2\sigma_H T \ln}$, $\frac{\overline{\Delta \Psi^2}}{2\sigma_C T \ln}$ in order to insure stability.

C. Conversion from Physical to Streamline Coordinates

1. The various input profiles are given as functions of the physical coordinate Y , which may be unevenly spaced. The number of Ψ intervals equals the input number of Y intervals and is equal to $L - 1$.
2. The streamline coordinate $\Psi = \int_0^Y \rho u r^\epsilon dy$ is calculated and then equispaced over the thickness.
3. The corresponding Y 's are developed from $Y = \int_0^\Psi \frac{1}{\rho u r^\epsilon} d\Psi$ with $Y(0) = 0$.
4. A table lookup routine is used to linearly interpolate the dependent variables, u , C_i , H .
5. The calculated value of $Y_{\max}$ is compared with the input value of $Y_{\max}$ (see Input, Section IV.D). If the difference is greater than .1%, the following on line message is printed: "YCALC(L) = $Y(L)$ = "".

D. Continuation Procedure

At any time during the running of the program sense switch 4 can be depressed and an on-line punch of the continuation quantities will occur. This makes it possible to continue the program at a later date.

When the program is continued with on-line punched cards,

RESTAR must be set equal to zero.

E. Output Control

Based on the input quantity INDPRI, output at every n^{th} station is obtained and based on NPSI, output at every m^{th} Ψ level. There is also provision in the streamline calculation to obtain output whenever the step size doubles.

F. Streamline Control

An initial value or a complete body problem can be solved depending on whether we input a 0 or 1 for INDSTR. Thus there are two possible starting points for a streamline calculation:

1. The starting profile at the starting point on the body.
2. The starting profile at the point of intersection of the streamtube and the shock.

In addition, the first option can be additionally modified to constant edge conditions, i.e., $u_{m+1}(L+3) = u_e$,

$C_{i,m+1}(L+3) = C_{e,i}$, $H_{m+1}(L+3) = H_e$, by setting INDSTR = - 1.

G. Sense Switch Control

Is available for diagnostic and monitoring purposes and can be specifically determined by consulting the source language.

H. Additional Programming Logic

1. Momentum equation

- a. In order to step forward the required ρ is obtained as follows:

$$h(\Psi) = H(\Psi) - \frac{u^2(\Psi)}{2}$$

Using as our first approximation for T

$$T_i(\Psi) = \left[h - C_O \frac{D_{O2}}{2m_O} - C_N \frac{D_{N2}}{2m_N} - \frac{C_{NO}}{m_{NO}} \left(\frac{D_{N2} + D_{O2}}{2} - D_{NO} \right) \frac{C_{NO+}}{m_{NO+}} \right. \\ \left. \left(I_{NO} + \frac{D_{N2} + D_{O2}}{2} - D_{NO} \right) \right] / C_P$$

calculate

$$\Lambda_j = \left(\frac{T_j^V}{T} \right) / \left(e^{T_j^V / T} - 1 \right)$$

and solve for T_{i+1}

$$h = RT_{i+1} \left[\sum_j \frac{C_j}{M_j} \left(\Lambda_j + \frac{7}{2} \right) + \frac{5}{2} \sum_k \frac{C_k}{M_k} \right] + C_O \left(\frac{D_{O2}}{2m_O} \right) + C_N \left(\frac{D_{N2}}{2m_N} \right) \\ + \frac{C_{NO}}{m_{NO}} \left(\frac{D_{N2} + D_{O2}}{2} - D_{NO} \right) + \frac{C_{NO+}}{m_{NO+}} \left(I_{NO} + \frac{D_{N2} + D_{O2}}{2} - D_{NO} \right)$$

$$j = O_2, N_2, NO, NO^+$$

$$k = O, N, e$$

if $\left| \frac{T_{i+1} - T_i}{T_{i+1}} \right| < \epsilon_T$ we use T_{i+1} , otherwise continue the iteration cycle at Λ .

- b. $p(x)$ is chosen according to the indicator for the subregion and we compute

$$\rho = \frac{p}{RT \sum_i \frac{C_i}{M_i}}$$

- c. Because the nature of the u profile is not linear in the neighborhood of the wall, $u_{1/2}$ is obtained by assuming $u = a\Psi^{1/2} + b\Psi$ and determining a and b from u_2 and u_3 . The derivative at the $1/2$ point is obtained by differentiating u .
- d. If a velocity is negative or if both sense switch 5 is depressed and a 5% out of monotonicity occurs, then the step size is halved and the calculation repeated. If after halving seven times, the velocity is still negative, the program stops.

2. Species equation

If a species is negative, the step size is halved and the calculation repeated. If after halving the step size seven times, a species is still

negative, the program stops. $C_{1/2}$ is obtained by assuming $C = C_w + a\Psi^{1/2} + b\Psi$ and determine a and b from C_2 and C_3 . The derivative at the $1/2$ point is obtained by differentiating C .

3. Enthalpy equation

Halving of the step size will result when a negative enthalpy occurs.

If after seven halvings, this condition persists, the program will halt.

$H_{1/2}$ is obtained by assuming $H = H_w + a\Psi^{1/2} + b\Psi$ and determine a and b from H_2 and H_3 . The derivative at the $1/2$ point is obtained by differentiating H .

VI. PROGRAMMED STOPS AND PAUSES

<u>PROGRAM</u>	<u>STOP NO.</u>	<u>MEANING</u>
	Displayed in Address Field of Storage Register	
MAIN	17	$\epsilon < 0$
	77	Shock geometry is cone followed by parabola
	310	$A_i^{L,T} < 0$
	650	$K_s < 1$
	2575	$LP_2 \geq 99$
	2655	$L > 2$ (LORIG)
CEDGE(J)	60	$J < 1$
	71	$C_{w,i}$ or $\sum C_{w,i}$ is in error
RADBDY	550	$\epsilon < 0$
STEPSZ	603 (Pause)	Δx has been halved 7 times Additional 7 times can be obtained by depressing START
UCSTRE	21	$\frac{D_\infty}{2}$ is not in any shock region
UEDGE(J)	30	$J < 1$
	50	$J > 3$

VII. OPERATING PROCEDURE

A. Original Run

Standard 7094 Fortran operating procedure is employed with $RESTAR = 1.0E0$. Program language is FORTRAN II.

B. Continuation Run

Remove subregion parameter cards that were read in during previous run. Insert continuation cards after problem input and ahead of remaining subregion cards. Set $RESTAR = 0E0$.

There is present the option of modifying the original input or the continuation input by repunching the appropriate fields or cards. It should be noted that the continuation cards are necessarily in octal in order to preserve full significance.

APPENDIX 1

DIMENSIONS OF VARIABLES

APPENDIX 1DIMENSIONS OF VARIABLES

The units of the variables which appear in the equations are listed below. The conversion constants required for consistency are indicated.

A. Momentum Equation

1. The units for the quantities involved are

$$\rho = \frac{\text{lb sec}^2}{\text{ft}^4} \text{ or } \frac{\text{slugs}}{\text{ft}^3}$$

$$u = \text{ft/sec}$$

$$p = \text{lbs/ft}^2$$

$$\frac{dp}{ds} = \text{lbs/ft}^2, \text{ s is nondimensional}$$

$$\frac{dp}{dx} = \text{lbs/ft}^3, \text{ x is in feet}$$

$$\tau = \text{lbs/ft}^2$$

$$\mu = \frac{\text{lbs sec}}{\text{ft}^2}$$

$$\frac{d\tau}{dy} = \text{lbs/ft}^3$$

2. In order for ρ to have the units $\frac{\text{lbs sec}^2}{\text{ft}^4}$ R should be expressed in the following units:

$$\frac{\text{lb sec}^2}{\text{ft}^4} = \rho = \frac{P}{RT \sum C/M} = \frac{\text{lb/ft}^2}{R \cdot K \frac{\text{mole}}{\text{gm}}}$$

$$R = \frac{\text{gm ft}^2}{^\circ\text{K mole sec}^2}$$

$$= 8.31657 \times 10^3 \text{ joule (kilogram mole}^{-1}\text{) } ^\circ\text{K}^{-1}$$

$$= \frac{1}{1.356} \frac{\text{ft lbs}}{\text{joules}} 453.6 \frac{\text{gm}}{\text{lb}} 32.2 \text{ ft/sec}^2$$

$$= 8.95805 \times 10^7 \frac{\text{gm ft}^2}{^\circ\text{K (kilogram mole) sec}^2}$$

$$= 8.95805 \times 10^4 \frac{\text{gm ft}^2}{^\circ\text{K (gram mole) sec}^2}$$

3. In order for T to have the units $^\circ\text{K}$ the following adjustments must be made:

$$T = \frac{h - \frac{D_{O_2}}{m_O}}{C_P} = \frac{\frac{\text{ft}^2}{\text{sec}^2} - \left(\frac{\text{ev}}{\text{part}} \right) \frac{1}{\text{gm}}}{\frac{\text{ft}^2}{\text{sec}^2} \text{ K}} = ^\circ\text{K} - \frac{\text{ev sec}^2}{\text{part gm ft}^2} ^\circ\text{K}$$

Taking the second term

$$\frac{\text{ev sec}^2 \text{ } ^\circ\text{K}}{\text{part gm ft}^2} 453.6 \frac{\text{gm}}{\text{lb}} 32.2 \frac{\text{ft}}{\text{sec}^2} \frac{1}{1.356} \frac{\text{ft lb}}{\text{joule}} \frac{1 \text{ joules}}{6.24 \times 10^{18} \text{ ev}}$$

$$= 1726 \times 10^{-18} (^\circ\text{K})$$

Thus for all $\frac{D}{m}$ terms, this factor should be used, i.e.

$$\frac{D}{m} = 1726 \times 10^{-18} \left(\frac{D}{m} \right)$$

B. Species Equation

1. The units for the quantities involved are

$$\dot{w} = \frac{\text{lb sec}}{\text{ft}^4} \text{ which is derived from}$$

$$\dot{w} = \rho u \frac{dc_i}{dx}$$

2. ρ_{DO} should be of the same units as ρ for Eq. (7a),

p. 5 of GASL TR-246. Hence,

$$\rho_{DO} = \frac{\frac{\text{gm/mole}}{\frac{\text{particle}}{\text{mole}}}}{(\text{ft lbs sec})^3} \left(\frac{\text{gm}}{\text{part}} \frac{\text{ft lb}}{^\circ\text{K}} \text{ } ^\circ\text{K} \right)^{3/2}$$

$$= \frac{\frac{\text{gm}^{5/2}}{(\text{ft lbs})^{3/2} \text{ sec}^3 \text{ part}^{5/2}}}{\left(\frac{1}{453.6} \frac{\text{lb}}{\text{gm}} \right)^{5/2} \left(\frac{1}{32.2} \text{ sec}^2/\text{ft} \right)^{5/2}}$$

$$= 3.87871 \times 10^{-11} \frac{\text{lbs sec}^2}{\text{ft}^4} \bar{\rho}_{DO}$$

Similarly for ρ_{DN} , ρ_{DNO} , ρ_{DE}

3. $\sigma, \gamma, \bar{K}$ are dimensionless

4. A, B, C, K develop as follows (example for A shown below)

$$\frac{\text{ft}}{\text{gm/mole}} \left[\frac{1}{\frac{\text{gm}}{\text{mole}}} \frac{\text{cm}^6}{\text{part}^2 \text{sec}} \right] \left[\frac{\text{lb sec}^2}{\text{ft}^4} \right] \left[\frac{\text{lb sec}^2}{\text{ft}^4} \right]$$

$$A = \frac{\text{mole}^2 \text{cm}^6 \text{sec}^3 \text{lb}^2}{\text{ft}^7 \text{gm}^2 \text{part}^2} \left[453.6 \frac{\text{gm}}{\text{lb}} \right]^2 \left[\frac{1}{2.54} \frac{\text{in}}{\text{cm}} \frac{1}{12} \frac{\text{ft}}{\text{in}} \right]^6 \left[6.0251 \times 10^{23} \frac{\text{part}}{\text{mole}} \right]$$

$$= 4.9778 \times 10^{21} \frac{\text{mole sec}}{\text{part}} \bar{A}$$

5. D, E, F develop as follows (example for D shown below)

$$\frac{\text{ft}}{\frac{\text{gm}}{\text{mole}}} \frac{\text{cm}^3}{\text{part sec}} \frac{\text{lb sec}^2}{\text{ft}^4}$$

$$D = \frac{\text{mole cm}^3 \text{sec lb}}{\text{ft}^3 \text{gm part}} 453.6 \frac{\text{gm}}{\text{lb}} \left(\frac{1}{30.48} \frac{\text{ft}}{\text{cm}} \right)^3$$

$$= 1.6018 \times 10^{-2} \frac{\text{mole sec}}{\text{particle}} \bar{D}$$

6. Equation (9), p. 7 of GASL TR-246 would yield (neglecting $\frac{M_O}{\rho}$)

$\Sigma \dot{w}_i = \frac{\text{mole sec}}{\text{part}}$ but $\frac{\text{lb sec}}{\text{ft}^4}$ are required hence

$$\frac{\text{mole sec}}{\text{part}} \rho \frac{\text{lb sec}^2}{\text{ft}^4} 32.2 \text{ ft/sec}^2 6.0251 \frac{\text{part}}{\text{mole}} \times 10^{23} \frac{1}{\text{L}} \text{ ft}$$

$$\dot{w} = 1.94008 \times 10^{25} \frac{\rho}{\text{L}} \left[\right] \frac{\text{lb sec}}{\text{ft}^4} \bar{w}_i$$

7. In A, B, etc. $\frac{D_{O2}}{KT}$ should be dimensionless. This can be accomplished by setting

$$\begin{aligned} \frac{D_{O2}}{KT} &= \frac{\frac{\text{ev}}{\text{particle}}}{\frac{\text{ft lbs}}{\text{°K}}} \times 1.356 \frac{\text{joules}}{\text{ft lb}} 10^7 \frac{\text{erg}}{\text{joule}} \frac{1}{1.6021 \times 10^{-12}} \frac{\text{ev}}{\text{erg}} \\ &= .846389 \times 10^{19} \left(\frac{D_{O2}}{KT} \right) \end{aligned}$$

C. Energy Equation

1. The units for the quantities involved are:

$$H = -\frac{\text{ft}^2}{\text{sec}^2}$$

$$h_i = \frac{\text{ft}^2}{\text{sec}^2}$$

$$D_{Ki} = \frac{\text{ft}^2}{\text{sec}}$$

APPENDIX II

PROGRAM SOURCE LANGUAGE

CTMRBL

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LCRF1=L+I
NSM1=AS-1
REAC INPUT TAPE 5,5,RESTAR,DELTA,TAX,EPSI,EPSTU,EPSIC,EPSSIM,EPSSIT,
1(FH(IN),N=1,LP2),FK
DELXSI=CELTAX
5 FURPAT (TEIC,3)
REAC INPUT TAPE 5,5,CPE,F,L,F,SHE,GAMP,PE,RHCE,RHCSTG,(CE(I),I=1,NS)
1,MN,UINF,ULCLIP,XS,ZLSZ2S,ZIL,U(IN),N=1,LP2)
REAC INPUT TAPE 5,5,FA,Fb,FC,TESTRA,AB1T,AB2T,AB3T,AB4T,AB5T,AB6T,
1A87T,B0T,BE2T,BE3T,BE4T,BE5T,BE6T,BE7T,FLELIN,FLETIN,PRALLN,PRALIN,PRALIN,PRALIN,
2N,SCHLIR,SCHTIN,(V(N),N=1,LP2)
CALL C(EFFC(1))
5 LL 11 N=1,LF2
C(N,7)=FM(7)/FM(C)*C(R,C)
11 C(N,3)=1.-C(C(N,1))-C(N,2)-C(N,4)-C(N,5)-C(N,6)-C(N,N)-C(N,7)
UE=LL()
IF(IALSTR) 13,13,1c
13 LL 15 1=1,NS
15 CE(1)=(L,1)
1c FFE=FPL()
RS=225
IF(EFSI) 17,1e,15
17 STCF 17
1b RS=L.C
15 KS=C
20 REAC INFUT TAPE 5,25,INCPRI,HSH,JINPUT,IMPER,(ASK(N),BSR(N),CSR(N),
1,ZLR(N),Z2R(N),INCTYP(N),INCLCC(N),INDUCAS(N),N=1,NSR)
25 FORPAT(3)LC,EIO,3/(SEIO,3,213,14))
JF(INCTYF(1))-B132,22,2C
30 ASR(1)=C
CSR(1)=C
STATIS=(.66666*RMCE)/(RHGSTG-RHCE)*RN
BSR(1)=.5/(RN*STATIS)
32 N=2
63 IF(INCLCAS(N-1))/B5,65,5C
65 IF(INCTYP(N-1))-E1EE,7C,7C
KEGICA N-1 IS A CCNE
66 IF(INCTYF(N)-E175,7E,7E
REGION N-1 IS A PARABELLA
70 IF(INCTYF(N)-E1B1,64,67
CGNE CGNE
75 Z2R(N-1)=ASH(N-1)*Z1R(N-1)+BSR(N-1)
76 BSR(N)=Z2R(N-1)-ASR(N)*Z1R(N-1)
GC TC 55
CGNE FARABELLA
7E STCF 77
PARABELLA CGNE
81 Z2R(N-1)=.5/BSR(N-1)/ASH(N)+CSK(N-1)
IF(INCLCC(N-1))/E2,E2,7E
82 Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-(CSR(N-1)))**2
GC TC 76
PARABELLA FARABELLA 6
84 Z2R(N-1)=(BSR(N-1)*CSR(N-1)-BSR(N)*CSR(N))/(BSR(N-1)-BSR(N))
IF(INCLCC(N-1))/B5,E5,55
85 Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-(CSR(N-1)))**2
GC TC 55

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C      PARABOLA PARABOLA 7
87      SLCFEI=ASR(N)
        SLCFE2=RSK(N)
        Z2R(N-1)=.5/BSH(N-1)/SLCFEI*(SRIN-1)
        IF(J)INCLCCL(N-1)/6,8,85
88      Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-(SRIN-1))*2
89      ASR(N)=(Z1R(N-1)+SLCFEI**2-SLCFE2**2+Z1R(N))/(-SLCFEI**2-SLCFE2**2)
        CSK(N)=Z2R(N-1)-2-COS(CLE2**2+Z1R(N)-ASR(N))/SLCFEI
        ESR(N)=.25/SLCFEI**2+Z1R(N)-ZSR(N)
        GC TC 55
90      IF(INDTYP(N-1)-1)100,100,91
91      IF(INDTYP(N-1)-2)52,54,54
92      Z2R(N-1)=ASR(N-1)+Z1R(N-1)+ESR(N-1)
        CC TC 100
94      Z2R(N-1)=CSK(N-1)+SLCFEI*(Z1R(N-1)-ASR(N-1))/ESR(N-1)
        CC TC 100
95      N=N+1
        GC TC 63
100      IF(MESTART) 210,175,210
175      READ INPUT TAPE 5,2761,KS,INDFS(N),N=1,KS),L,L+2,(INDFS,INDP,INDR
1,INCLC,INCLSK
180      READ INPUT TAPE 5,2765,X,DELTA,X,IL (N),N=1,L+2).
        1000 (N,IL,N)=1,LP2,)=1,RS),IFM (N),R=1,LP2,(PSI(N),N=1,LP2),
        2DELTA*(Y(I),N=1,L+2),Z1,Z2,Z3,Z4,Z5,Z6,Z7,Z8,Z9,Z10,Z11,Z12,Z13,Z14,Z15,Z16,Z17,Z18,Z19,Z20,Z21,Z22,Z23,Z24,Z25,Z26,Z27,Z28,Z29,Z30,Z31,Z32,Z33,Z34,Z35,Z36,Z37,Z38,Z39,Z40,Z41,Z42,Z43,Z44,Z45,Z46,Z47,Z48,Z49,Z50,Z51,Z52,Z53,Z54,Z55,Z56,Z57,Z58,Z59,Z60,Z61,Z62,Z63,Z64,Z65,Z66,Z67,Z68,Z69,Z70,Z71,Z72,Z73,Z74,Z75,Z76,Z77,Z78,Z79,Z80,Z81,Z82,Z83,Z84,Z85,Z86,Z87,Z88,Z89,Z90,Z91,Z92,Z93,Z94,Z95,Z96,Z97,Z98,Z99,Z100,Z101,Z102,Z103,Z104,Z105,Z106,Z107,Z108,Z109,Z110,Z111,Z112,Z113,Z114,Z115,Z116,Z117,Z118,Z119,Z120,Z121,Z122,Z123,Z124,Z125,Z126,Z127,Z128,Z129,Z130,Z131,Z132,Z133,Z134,Z135,Z136,Z137,Z138,Z139,Z140,Z141,Z142,Z143,Z144,Z145,Z146,Z147,Z148,Z149,Z150,Z151,Z152,Z153,Z154,Z155,Z156,Z157,Z158,Z159,Z160,Z161,Z162,Z163,Z164,Z165,Z166,Z167,Z168,Z169,Z170,Z171,Z172,Z173,Z174,Z175,Z176,Z177,Z178,Z179,Z180,Z181,Z182,Z183,Z184,Z185,Z186,Z187,Z188,Z189,Z190,Z191,Z192,Z193,Z194,Z195,Z196,Z197,Z198,Z199,Z200,Z201,Z202,Z203,Z204,Z205,Z206,Z207,Z208,Z209,Z210,Z211,Z212,Z213,Z214,Z215,Z216,Z217,Z218,Z219,Z220,Z221,Z222,Z223,Z224,Z225,Z226,Z227,Z228,Z229,Z230,Z231,Z232,Z233,Z234,Z235,Z236,Z237,Z238,Z239,Z240,Z241,Z242,Z243,Z244,Z245,Z246,Z247,Z248,Z249,Z250,Z251,Z252,Z253,Z254,Z255,Z256,Z257,Z258,Z259,Z260,Z261,Z262,Z263,Z264,Z265,Z266,Z267,Z268,Z269,Z270,Z271,Z272,Z273,Z274,Z275,Z276,Z277,Z278,Z279,Z280,Z281,Z282,Z283,Z284,Z285,Z286,Z287,Z288,Z289,Z290,Z291,Z292,Z293,Z294,Z295,Z296,Z297,Z298,Z299,Z300,Z301,Z302,Z303,Z304,Z305,Z306,Z307,Z308,Z309,Z310,Z311,Z312,Z313,Z314,Z315,Z316,Z317,Z318,Z319,Z320,Z321,Z322,Z323,Z324,Z325,Z326,Z327,Z328,Z329,Z330,Z331,Z332,Z333,Z334,Z335,Z336,Z337,Z338,Z339,Z340,Z341,Z342,Z343,Z344,Z345,Z346,Z347,Z348,Z349,Z350,Z351,Z352,Z353,Z354,Z355,Z356,Z357,Z358,Z359,Z360,Z361,Z362,Z363,Z364,Z365,Z366,Z367,Z368,Z369,Z370,Z371,Z372,Z373,Z374,Z375,Z376,Z377,Z378,Z379,Z380,Z381,Z382,Z383,Z384,Z385,Z386,Z387,Z388,Z389,Z390,Z391,Z392,Z393,Z394,Z395,Z396,Z397,Z398,Z399,Z400,Z401,Z402,Z403,Z404,Z405,Z406,Z407,Z408,Z409,Z410,Z411,Z412,Z413,Z414,Z415,Z416,Z417,Z418,Z419,Z420,Z421,Z422,Z423,Z424,Z425,Z426,Z427,Z428,Z429,Z430,Z431,Z432,Z433,Z434,Z435,Z436,Z437,Z438,Z439,Z440,Z441,Z442,Z443,Z444,Z445,Z446,Z447,Z448,Z449,Z450,Z451,Z452,Z453,Z454,Z455,Z456,Z457,Z458,Z459,Z460,Z461,Z462,Z463,Z464,Z465,Z466,Z467,Z468,Z469,Z470,Z471,Z472,Z473,Z474,Z475,Z476,Z477,Z478,Z479,Z480,Z481,Z482,Z483,Z484,Z485,Z486,Z487,Z488,Z489,Z490,Z491,Z492,Z493,Z494,Z495,Z496,Z497,Z498,Z499,Z500,Z501,Z502,Z503,Z504,Z505,Z506,Z507,Z508,Z509,Z510,Z511,Z512,Z513,Z514,Z515,Z516,Z517,Z518,Z519,Z520,Z521,Z522,Z523,Z524,Z525,Z526,Z527,Z528,Z529,Z530,Z531,Z532,Z533,Z534,Z535,Z536,Z537,Z538,Z539,Z540,Z541,Z542,Z543,Z544,Z545,Z546,Z547,Z548,Z549,Z550,Z551,Z552,Z553,Z554,Z555,Z556,Z557,Z558,Z559,Z560,Z561,Z562,Z563,Z564,Z565,Z566,Z567,Z568,Z569,Z570,Z571,Z572,Z573,Z574,Z575,Z576,Z577,Z578,Z579,Z580,Z581,Z582,Z583,Z584,Z585,Z586,Z587,Z588,Z589,Z590,Z591,Z592,Z593,Z594,Z595,Z596,Z597,Z598,Z599,Z600,Z601,Z602,Z603,Z604,Z605,Z606,Z607,Z608,Z609,Z610,Z611,Z612,Z613,Z614,Z615,Z616,Z617,Z618,Z619,Z620,Z621,Z622,Z623,Z624,Z625,Z626,Z627,Z628,Z629,Z630,Z631,Z632,Z633,Z634,Z635,Z636,Z637,Z638,Z639,Z640,Z641,Z642,Z643,Z644,Z645,Z646,Z647,Z648,Z649,Z650,Z651,Z652,Z653,Z654,Z655,Z656,Z657,Z658,Z659,Z660,Z661,Z662,Z663,Z664,Z665,Z666,Z667,Z668,Z669,Z670,Z671,Z672,Z673,Z674,Z675,Z676,Z677,Z678,Z679,Z680,Z681,Z682,Z683,Z684,Z685,Z686,Z687,Z688,Z689,Z690,Z691,Z692,Z693,Z694,Z695,Z696,Z697,Z698,Z699,Z700,Z701,Z702,Z703,Z704,Z705,Z706,Z707,Z708,Z709,Z710,Z711,Z712,Z713,Z714,Z715,Z716,Z717,Z718,Z719,Z720,Z721,Z722,Z723,Z724,Z725,Z726,Z727,Z728,Z729,Z730,Z731,Z732,Z733,Z734,Z735,Z736,Z737,Z738,Z739,Z740,Z741,Z742,Z743,Z744,Z745,Z746,Z747,Z748,Z749,Z750,Z751,Z752,Z753,Z754,Z755,Z756,Z757,Z758,Z759,Z760,Z761,Z762,Z763,Z764,Z765,Z766,Z767,Z768,Z769,Z770,Z771,Z772,Z773,Z774,Z775,Z776,Z777,Z778,Z779,Z780,Z781,Z782,Z783,Z784,Z785,Z786,Z787,Z788,Z789,Z790,Z791,Z792,Z793,Z794,Z795,Z796,Z797,Z798,Z799,Z800,Z801,Z802,Z803,Z804,Z805,Z806,Z807,Z808,Z809,Z810,Z811,Z812,Z813,Z814,Z815,Z816,Z817,Z818,Z819,Z820,Z821,Z822,Z823,Z824,Z825,Z826,Z827,Z828,Z829,Z830,Z831,Z832,Z833,Z834,Z835,Z836,Z837,Z838,Z839,Z840,Z841,Z842,Z843,Z844,Z845,Z846,Z847,Z848,Z849,Z850,Z851,Z852,Z853,Z854,Z855,Z856,Z857,Z858,Z859,Z860,Z861,Z862,Z863,Z864,Z865,Z866,Z867,Z868,Z869,Z870,Z871,Z872,Z873,Z874,Z875,Z876,Z877,Z878,Z879,Z880,Z881,Z882,Z883,Z884,Z885,Z886,Z887,Z888,Z889,Z890,Z891,Z892,Z893,Z894,Z895,Z896,Z897,Z898,Z899,Z900,Z901,Z902,Z903,Z904,Z905,Z906,Z907,Z908,Z909,Z910,Z911,Z912,Z913,Z914,Z915,Z916,Z917,Z918,Z919,Z920,Z921,Z922,Z923,Z924,Z925,Z926,Z927,Z928,Z929,Z930,Z931,Z932,Z933,Z934,Z935,Z936,Z937,Z938,Z939,Z940,Z941,Z942,Z943,Z944,Z945,Z946,Z947,Z948,Z949,Z950,Z951,Z952,Z953,Z954,Z955,Z956,Z957,Z958,Z959,Z960,Z961,Z962,Z963,Z964,Z965,Z966,Z967,Z968,Z969,Z970,Z971,Z972,Z973,Z974,Z975,Z976,Z977,Z978,Z979,Z980,Z981,Z982,Z983,Z984,Z985,Z986,Z987,Z988,Z989,Z990,Z991,Z992,Z993,Z994,Z995,Z996,Z997,Z998,Z999,Z1000,Z1001,Z1002,Z1003,Z1004,Z1005,Z1006,Z1007,Z1008,Z1009,Z1010,Z1011,Z1012,Z1013,Z1014,Z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XLS(KS)=XL
600 CALL STACU(12)
601 IF (KS-1)E5C=66C,75C
602 STOP CSC
603 CALL PRTEMF (A,1,LF2,LF5)
604 IF (I2) 663,675,681
605 IF (I2-5,6) 675,675,662
606 CALL C66GE(5,1,1)
607 CC 6622 I=1,KS
608 ((I,1)=661,1)
609 GO TO 672
610 CALL C66U(5,1,662,
611 CC 664 A=1,LF2
612 CC 664 I=1,LF5
613 CC 664 J=1,LF5
614 CC 664 II=66(6,1)
615 IF (1,514) 667,667,675
616 CC 667 CC 668 J=1,KS
617 CC 668 J=1,KS
618 CC 668 J=1,KS
619 CALL C66F(62)
620 SDELIF=C66TAF*1.5
621 CALL STACU(5)
700 IDEL=1
800 CALL PRTEMF (A,1,LF2,LF5)
900 CALL PADBY
1000 CALL V15LAT
2000 CC 2425 A=2,1
IF (I-2) 2005,2005,2000
2005 TAP(12)=S*HMLC12*JAIL*FMUL12*0.17*FMULIN(21)*DUCPI2
GO TO 2010
2005 TAP(N)=.5*KS*FMUL(N)*L(P)*HML(N-1)*L(N-1)*JAIL*.5*(FMUL(N)+FMUL
(N-1))+A17*FMULIP(N)*L(N)-U(N-1))/DELTA P
2010 TAP(N)=.5*KS*(FMUL(N-1)*L(N-1)+HML(N)*L(N))*JAIL*.5*
(FMUL(N-1)+FMUL(N))+A17*FMULIP(N)*L(N-1)+L(N-1)/DELTA P
2250 LMIN)=U(N)-CELTAX*HF/H(C,N)/L(N)+CELTAX*RS*(TAP(N-1)-TAUM(N))/DEL
TA P
TAP(1)=FMUL(1)*KS*.5*JAL*JL12
CELT(1) IS UNALL
2300 CALL LELGE(1)
2350 CALL LELGE(3)
2400 IF (I2) 2500,2415,2410
2410 CALL MCGTRI(1,LF2)
2415 CC 2425 A=2,1
DO 2425 I=1,KS
IF (I-2) 2410,2410,2418
2416 IF (1,1) 2416,2416,24164
2416 IF (2,1) 2417,2418,2417
2416 IF (2SF(1),1)-L(2,1)/L(1,1)-.C512418,2417,2417
2417 LSUMF2=2.0*HML12*(A3L*FMUL12*(LKL(N-1)/SCL(N)+DKL(N-1,1))/SCL
(N-1))+A37*FMULIP(N)*L(KL(N-1)/SCL(N)+DKL(N-1,1))/SCL(N-1,1)+DUCPI
2417
GO TO 2415
2418 DSC62=(RML(N)+U(N)+HML(N-1)*U(N-1))*A3L*(FMUL(N)+DKL(N-1)/SCL(N)
+FMUL(N-1)+DKL(N-1,1)/SCL(N-1))+A37*FMULIP(N)*L(KL(N-1,1))/SCL(N-1,1)+DUCPI
2419 DSC6IP=.25*RS*(R+C(N-1)*U(N-1)+HML(N)+U(N-1)+A3L*(FMUL(N)+DKL
(N-1,1)/SCL(N-1)+FMUL(N-1)+DKL(N-1,1)+A37*FMULIP(N)+DKL(N-1,1)

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211/SCT(N+1)+UMDT(N,1)/SCT(N))+(C(N+1,1)-C(N,1))/DELTA-DSCR2)
IF(I2-5.8) 2424,2424,2420
2420 CM(N,1)=C(N,1)+DELTA*WCT(N,1)/RHC(N)/L(N)+DELTA*RS*DSCRIP/DELTA
IF
GL TC 2425
2424 CM(N,1)=C(N,1)+DELTA*WCT(N,1)+A2/RHC(N)/L(N)+DELTA*RS*DSCRIP/D
1ELTAF
2425 CONTINUE
CECLE(1) IS SMALL
IF(I2-5.8) 2430,2430,242E
242E CALL CELGELS,1,1)
GL TC 2431
2430 CALL CELGELS,1,1)
2431 CALL CELGELS,1,1)
2500 CALL FSLCT
IF(I2) 2501,2502,2502
2501 CALL CELGELS,1,1)
2502 IF(I2-5.8) 2508,2508,250E
2505 IF(I2-5.8) 2508,2508,250E
250E IF(I2-5.8) 2510,2510,251E
2510 IF(I2-5.8) 2510,2510,251E
251E IF(I2-5.8) 2510,2510,251E
2520 IF(I2-5.8) 2510,2510,251E
252E IF(I2-5.8) 2510,2510,251E
2525 IF(I2-5.8) 2510,2510,251E
2530 IF(I2-5.8) 2510,2510,251E
IF(I2-5.8) 2510,2510,251E
2540 CONTINUE
2560 GL TC 260E
2563 FHM(L+3)=FHE
PRINT 2565,L,UM(L-1),LM(L+1),(CM(L-1,1),I=1,5),(CM(L+1,1),I=1,5),
FHM(L-1),FHM(L+1)
2565 FORMAT(4F L=13,1P7E13.5/1P7E13.5)
CALL LCSTRE
L=L+1
LP2=LP2+1
UM(L-4)=UM(L-4)/UM(L-1)*(LP(LF2)
UM(L-3)=UM(L-3)/UM(L-1)*(LP(LF2)
UM(L-2)=UM(L-2)/UM(L-1)*(LP(LF2)
UM(L-1)=UM(LF2)
CM(L)=LP(LF2)
UM(L+1)=UM(LF2)
IF(EPSIC) 2567,256E,2567
2567 LC 2570 I=1,NS
CM(L-4)=(UM(L-4,1)/CM(L-1,1))*CM(LF2,1)
CM(L-3)=(UM(L-3,1)/CM(L-1,1))*CM(LF2,1)
CM(L-2)=(UM(L-2,1)/CM(L-1,1))*CM(LF2,1)
CM(L-1)=UM(LF2,1)
CM(L)=LP(LF2,1)
2570 CM(L+1,1)=CM(LF2,1)
GC TC 2573
2568 DL 2565 I=1,NS
CM(L,1)=CM(LF2,1)
2565 CM(L+1,1)=LP(LF2,1)
2573 CALL LCPAG(3)
IF(LP2-59) 2600,2575,2575

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2575 STCF 2575
2600 CC 2604 N=1,LP2
      L(N)=L(N)
      CC 2602 I=1,NS
2602 C(N,I)=CM(N,I)
2604 FH(N)=FF(N)
      LALL STALUT(S)
      X=X+DELTAX
      RS=RSP
      CC TC 2650
2606 CALL STEPS2
2610 IF (INCLSF-2) 700,800,2700
2650 IF (L+1-2*LCRPI) 2700,2600,2655
2655 STCF 2655
2660 CC 2670 N=2,LCRPI
      N2=2*N-1
      L(N)=L(N2)
      CC 2665 I=1,NS
      C(N,I)=C(N2,I)
      FH(N)=FH(N2)
      PSI(N)=PSI(N2)
2670 Y(N)=Y(N2)
      L=LCRPI
      LP2=L+2
      C(LF2)=C(LCRPI)
      CC 2675 I=1,NS
2675 C(LF2,I)=C(LCRPI,I)
      FH(LF2)=FH(LCRPI)
      DELTAP=2.0*DELTAF
      PSI(LF2)=PSI(LCRPI)+DELTAF
      CALL CCNPRG(3)
2680 PRINT 2685,JS
2685 FCMPAT(214 NC FSI PTS 1/2 JS=16)
2700 IF (INCLFSU) 2750,2750,3000
2750 IF (X-XL) 2755,2775,2900
2755 IF (SENSE SWITCH 4) 2760,700
2760 FUNCH 2761,KS,(INCLPS(N),N=1,KS),L,LP2,INCLFSU,INCL,INCLR,INCL
1R
2761 FCMPAT(1415)
2763 PUNCH 2765,X,DELTAX, (U(N),N=1,LP2),
      1 ((C(N,I),N=1,LP2),I=1,NS),(FH(N),N=1,LP2),(PSI(N),N=1,LP2),
      2 DELTAP,(Y(N),N=1,LP2),Z1,Z2,Z3,Z5,CGIVEH,CGIVEK,(P(J),J=1,8),
      3 ((C(N,I),K=1,5),I=1,NS),(H(J),J=1,5),RAXAL,CUNEAN,(PS(J,I),J=1,
      48),I=1,KS),(RAS(N),N=1,KS),(XLS(N),N=1,KS),ALPHA,XS,RS,RSM
      CC TC 3030
2765 FCMPAT(6012)
2775 DELTAX=DELTAX
2800 INCLFSU=1
      GC TC 700
2900 DELTAX=DELTAX
      DELTAX=DELTAX-(X-XL)
      X=X-DELTAX+DELTAX
      GC TC 2800
3000 IF (INCLSR) 3100,3100,3020
3020 IF (INCLR) 3100,3100,3030
3030 X=X-DELTAX

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CHMREI

CALL STACLT(9)
CALL EX17

17-517 201E

225-22

71133-X

15010915 777

[illegible]

3150 111.651 = C

5x173]=x7113]

(15 11)

12721174473 3005

0001 16K47Y(1F142)E14T(1A749)4 1005
1117447 774713304TE14T(1A749)4 1005
///SBA7 308105 1117447 SCIENCE LAB//

ECOE PLANET (14021) 770 111 LIFE-SCIENCE SOLUTION OF CHEMICALLY REAC

1005391A77 147731172 477 791111

112721 4113721-4113721 411374401 5005

(M.F.(1,1,C,C,C,C,C,C,C,C,C,C,C,C,C,C,C))

CHMRBL

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STORAGE NOT USED BY PROGRAM

LEC CCT
2117 64105

LEC CCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

ALL 32561 77461	LEC CCT	ALL 32560 77460	LEC CCT	A3L 32558 77457	DEC OCT	A3T 32557 77455	DEC OCT
A4L 32556 77454		A4T 32555 77453		A5L 32554 77452		AAU 23204 55244	
AB1T 32552 77450		AB2T 32551 77447		AB3T 32550 77446		AB5T 32548 77444	
AB6T 32547 77443		AB7T 32546 77442		AC12 32545 77441		ALPHA 32534 77426	
ASH 32533 77425		AL12 32523 77413		B1T 32522 77412		B3T 32402 77222	
B4T 32342 77126		B5T 32262 77032		B6T 32222 76736		B81T 32102 76546	
B82T 32101 76545		B83T 32100 76544		B84T 32099 76543		B86T 32097 76541	
B87T 32096 76540		B812 32095 76537		B812 32095 76537		BSR 32024 76430	
B012 32014 76410		C12 31413 75265		CC12 31353 75171		CE 30753 74041	
CM1 30143 72677		CM2 30133 72665		CM 30743 74027		CPE 29531 71533	
CP 29532 71534		C 32013 76415		CSR 28930 70402		CSUB 23314 55256	
DCDU12 28520 70370		DEL 28910 70356		DELTA 28909 70355		DELXOD 28907 70353	
DELXST 28906 70352		ENDF12 28905 70351		DIST 28904 70350		DKDT 28303 67217	
EN2012 27702 66066		EN2 27703 66067		ENL 27701 66065		DSCRIP 27699 66063	
LUOF12 27658 66062		EDR12 27697 66061		EF12 27636 65764		EPSI 27637 65765	
EPSIT 27634 65763		EF1 27633 65761		ETA 27632 65760		FB 27630 65756	
FC 27625 65755		F12 27626 65754		FELB 27627 65753		FH12 27565 65555	
FMALC 27564 65554		FPE 27504 65550		FPM2 27443 65463		FH 27625 65751	
FMS 27383 65387		F12 27323 65273		FKPSI 27321 65271		FLELIN 27260 65174	
FLE1T 27259 65173		FLEW 27258 65172		FLEW 27198 65076		FLNOP 27018 65612	
FLNC 27078 64706		FL2 26956 64516		FL 27261 65175		FMU12 26828 64314	
FMUL 26868 64410		FMLT1 26827 64313		FPUT1 26767 64217		FNDSSL 26706 64122	
FNOREW 23215 55257		FNLEF 23216 55260		F5M12 23210 55252		F5H12 26044 62674	
F5M1 26644 64024		F5HF 26034 62662		F5F 26705 64121		F5KRB 26022 62646	
F5KRC 26012 62654		F5KRD 26002 62622		F5KRE 26001 62621		FSKRR 25999 62617	
F5K 26032 62661		F5M1 25989 62605		F5PAC 25986 62602		FSMN 25988 62604	
F5MC 25966 62601		GAP 25964 62600		HE 25983 62577		IALT 25977 62571	
IDEL 25976 62570		INLCG 25975 62567		INDLAS 25965 62555		INDP 25955 62543	
INUPS 25553 62541		INDR 25503 62457		INDSTP 25902 62456		INDTYP 25900 62454	
IPRINT 23213 55255		JBYCTH 23211 55253		JAPLT 25890 62441		KS 25888 62440	
LP2 25686 62436		L 25687 62437		ACCUT 23212 55254		NSR 25883 62433	
NS 25684 62434		LCIVER 25682 62432		CGIVEK 25881 62431		NSRIN 25810 62332	
PRAL 25870 62416		PRATIN 25749 62225		PRAT 25809 62321		PRDS 25688 62130	
PRF 25687 62127		PSITOL 25165 61115		PASAVE 25686 62126		PSCALC 25285 61305	
PSI 25225 61211		REN 23217 55261		REX 23218 55262		RESTAR 25162 61112	
RETRET 23219 55263		RHC 25161 61111		RHCSTG 25039 60717		RHOCAL 25101 61015	
RMS 25041 60721		R 25163 61113		RSC 24966 60632		RN 25038 60716	
SCHLIN 24584 60630		SCHTIN 24583 60627		SCL 24582 60626		RS 24987 60633	
SIGMAC 24861 60435		SIGMAH 24801 60341		SIGMAU 24741 60245		SHANGL 24862 60436	
STRLL 23206 55246		T12 23205 55251		TALM 24620 60054		STRLL 23207 55247	
THETAT 24499 57663		THFER 24498 57662		TIN 24457 57661		TESTRA 24500 57664	
TITLE3 24472 57630		TM 24460 57614		T 24680 60150		TITLE2 24484 57644	
TVNO 24359 57517		TVD2 24397 57515		U12 24336 57420		TVNOP 24398 57516	
UINF 24274 57322		ULCLIP 24273 57321		UM1 24212 57224		UE 24275 57323	
U 24356 57514		US 24092 57034		WDT 24032 56740		UM 24272 57320	
XLS 23429 55605		XRN 23379 55523		X 23432 55610		XL 23430 55606	
Y12 23206 55250		YCALC 23316 55424		Y 23376 55520		XU12 23377 55521	
						YTH 23256 55330	

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YTHU 23245 55315 21R 23242 55312 21 23244 55314 21S 23232 55300
 ZZR 23230 55276 22 23231 55277 22S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

LOC	CCT	IFN	LCC	DEC	LOC	DEC	LOC
DELTA	2110 04104	15042	2110 04103	INDFSU	2114 04102	INDLR	2113 04101
INDS	2111 04073	INDSC	2110 04076	INDS7	2109 04075	1	2108 04074
LCRPI	2106 04072	N2	2105 04071	N	2104 04070	NSM1	2103 04067
SLOPE1	2101 04065	SLOPE2	2100 04064				

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

LOC	CCT	IFN	LCC	DEC	LOC	DEC	LOC
812	2045 04031	815	5 04024	81P	25 04022	81FK	500 04015
812JT	2045 04005	812MS	2761 04000	812MD	2765 03777	814S8	5000 03776
814SA	5002 03765	814SE	5003 03746				

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

LOC	CCT	DEC	LOC	DEC	LOC	DEC	LOC
11	2074 04032	21	1550 03706	31	2002 03722	41	32767 77777
C100	2065 04045	C101	2066 04046	C103	2067 04047	C105	2068 04050
C107	2069 04052	C108	2070 04053	C109	2071 04054	C110	2072 04055
C1106	2055 04057	C1107	2096 04060	C1109	2097 04061	C1200	2098 04062
C1245	1233 02321	C1246	1290 02412	C1345	1232 02320	D140M	353 00541
D1444	1225 02311	D1447	1461 02665	D1448	1472 02700	D1454	1507 02743
D1650	1667 03227	E10	342 00526	E10	363 00553	E112	460 00714
E117	456 00760	E119	522 01012	E11C	587 01113	E13D	993 01741
E150	1498 02732	E110F	368 00560	E113K	1067 02053	E114A	1289 02411
						E143P	1052 02034

LOCATIONS OF NAMES IN TRANSFER VECTOR

LOC	CCT	DEC	LOC	DEC	LOC	DEC	LOC
ATAN	10 00012	CELGE	12 00014	CUNPRG	7 00007	EXIT	23 00027
HSCLUT	10 00022	PRIERH	11 00013	RACBLY	14 00016	SHORT	8 00010
STEPSZ	21 00025	LCSTRE	20 00024	UEDGE	16 00020	VISLAT	15 00017
(F11)	5 00005	(FPT)	0 00000	(RTN)	3 00003	(SCH)	22 00026
(SLU)	6 00006	(SPH)	15 00023	(STH)	4 00004	(TSH)	1 00001

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

LOC	CCT	DEC	LOC	DEC	LOC	DEC	LOC
ATAN	10 00012	CELGE	12 00014	CUNPRG	7 00007	EXIT	23 00027
STEPSZ	21 00025	LCSTRE	20 00024	UEDGE	16 00020	VISLAT	15 00017
(F11)	5 00005	(FPT)	0 00000	(RTN)	3 00003	(SCH)	22 00026
(SLU)	6 00006	(SPH)	15 00023	(STH)	4 00004	(TSH)	1 00001

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LCC	LOC	EFN	IFN	LCC	LOC
1	21 00044	9	70 00500	11	72 00507	13	75 00530
16	77 00542	17	80 00551	18	81 00555	19	82 00562
30	90 00640	32	94 00670	63	95 00673	65	96 00676
70	58 00707	75	99 00715	76	100 00723	78	102 00731
82	105 00745	84	107 00761	85	109 00777	87	111 01013
89	116 01043	90	120 01114	91	121 01121	92	122 01125

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99	126 C1145	100	128 C1152	175	129 01156	180	175 01223	210	185 01451
300	186 C1455	305	187 01457	310	188 01462	315	189 01464	325	190 C1470
335	191 C1474	345	192 C1500	355	193 C1504	365	194 01510	375	195 01514
400	196 C1520	510	197 C1523	520	213 01622	521	214 01626	523	216 01645
526	216 01662	540	219 01664	545	221 01672	550	222 01704	600	225 01715
640	226 C1717	650	227 01723	660	228 C1725	661	230 01742	662	231 01747
662	233 C1762	663	235 C1767	664	238 C2010	667	240 02022	668	241 02026
675	242 C2035	680	243 C2040	700	245 C2054	800	246 02056	1700	247 02067
1900	248 C2071	2000	249 02073	2005	251 C2104	2009	253 02123	2010	254 02161
2250	251 C2217	2300	257 C2254	2350	258 02257	2400	259 02262	2410	260 02266
2415	261 C2275	2416	264 C2326	2418	265 C2332	24164	266 02335	2417	267 02347
2418	265 C2415	2419	270 C2465	2420	272 02545	2424	274 02564	2425	275 02601
2428	277 C2623	2430	275 C2630	2431	280 02634	2500	281 02640	2501	283 02644
2502	284 C2651	2503	285 02657	2508	286 C2663	2510	287 02666	2518	288 02676
2520	289 C2701	2528	290 C2711	2529	291 C2715	2530	292 02717	2540	294 02737
2560	295 C2742	2563	296 C2744	2567	316 03044	2570	322 03071	2568	324 03100
2565	328 C3107	2572	327 C3115	2575	329 03124	2600	330 03126	2602	333 03144
2604	334 C3151	2608	335 C3166	2610	340 03167	2650	341 03174	2655	342 03205
2660	343 C3207	2665	347 C3245	2670	350 03256	2675	355 03311	2680	360 03334
2700	362 C3344	2750	365 03347	2755	364 03353	2760	365 03355	2763	371 03407
2775	420 C3626	2800	421 C3630	2900	423 03633	3000	427 03647	3020	428 03653
3030	429 C3657	3100	432 C3665	3150	437 03701				

PAGE 1

SUBROUTINE CEDGE(J,NSTART,MEND)

SUBROUTINE CEDGE(J,NSTART,MEND)

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COMMON AIL,A11,A2,A3L,A3T,A4L,A4T,A5L,A5T,A6T,A6T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AC12,ALPHA,ASR,AU12,B1T,B2T,B3T,
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3B19T,B20T,B21T,B22T,B23T,B24T,B25T,B26T,B27T,B28T,B29T,B30T,
4B31T,B32T,B33T,B34T,B35T,B36T,B37T,B38T,B39T,B40T,B41T,B42T,
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229B1953T,B1954T,B1955T,B1956T,B1957T,B1958T,B1959T,B1960T,
230B1961T,B1962T,B1963T,B1964T,B1965T,B1966T,B1967T,B1968T,
231B1969T,B1970T,B1971T,B1972T,B1973T,B1974T,B1975T,B1976T,
232B1977T,B1978T,B1979T,B1980T,B1981T,B1982T,B1983T,B1984T,
233B1985T,B1986T,B1987T,B1988T,B1989T,B1990T,B1991T,B1992T,
234B1993T,B1994T,B1995T,B1996T,B1997T,B1998T,B1999T,B2000T,
235B2001T,B2002T,B2003T,B2004T,B2005T,B2006T,B2007T,B2008T,
236B2009T,B2010T,B2011T,B2012T,B2013T,B2014T,B2015T,B2016T,
237B2017T,B2018T,B2019T,B2020T,B2021T,B2022T,B2023T,B2024T,
238B2025T,B2026T,B2027T,B
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SUBROUTINE CEDGE(J,NSTART,MEND)
1XRN=0
55 CM(1,1)=CC(1,1)+CC(2,1)*XRN+CC(3,1)*XRN+2*CC(4,1)*XRN+3*CC(5,1)*
1XRN+4
CM(1,7)=FM(7)/FM(6)*CM(1,6)
DO 52 I=1,NS
IF(CM(1,1)) 70,60,60
60 IF(CM(1,1))-1.01 62,62,70
62 CONTINUE
63 DO 65 I=1,NS
SUMCW=SUMCW+CM(1,1)
65 IF(SUMCW-1.001) 67,78,70
67 IF(SUMCW-.999) 70,78,78
70 PRINT 72,(CM(1,1),I=1,NS),SUMCW
STOP 71
72 FORMAT(4E13.4,4E13.4)
78 RETURN
79 STOP 60
80 IF(J-3) 90,200,300
90 DO 100 I=1,NS
100 CM(L,1)=WDOT(L,I)*DELTA/RHO(L)/U(L)*C(L,I)
RETURN
200 DO 250 I=1,NS
250 CM(L+1,1)=WDOT(L+1,1)*DELTA/RHO(L+1)/U(L+1)*C(L+1,1)
300 DO 350 I=1,NS
350 CM(L+2,1)=WDOT(L+2,1)*DELTA/RHO(L+2)/U(L+2)*C(L+2,1)
RETURN
1000 DO 1150 I=NSTART,MEND
ROOTT(1)=SQRT(T(1))
81-1+.66667*EXP(-11390.772/T(1))+EXP(-18984.62/T(1))/3.
84-1+.6*EXP(-228./T(1))+.2*EXP(-326./T(1))
E4-1+.EXP(-178./T(1))
85-1+.25*EXP(-27698.424/T(1))+1.5*EXP(-41520.32/T(1))
E1-1.-EXP(-2274./T(1))
E2-1.-EXP(-3395./T(1))
E3-1.-EXP(-2740./T(1))
SF1=908.1869*ROOTT(1)*T(1)*T(1)*B1/E1
SF2=178.3938*ROOTT(1)*T(1)*T(1)/E2
SF3=934.13519*ROOTT(1)*T(1)*T(1)*E4*EXP(-11062.98/T(1))/E3
SF4=2237.1532*T(1)*ROOTT(1)*B4*EXP(-29501.28/T(1))
SF5=1461.9321*T(1)*ROOTT(1)*B5*EXP(-56544.12/T(1))
SF6=SQRT(SF4*SF5)
BBAR=0.0
DO 1130 M=1,20
BTERM=SF4*1.E-6+BBAR*SF3*1.E-12
AC=SF1*RHO(1)*1338.7286E-12
ABAR=(-BTERM+SQRT(BTERM*BTERM+AC))/(SF1*4.E-12)
BTERM=SF5*1.E-6+ABAR*SF3*1.E-12
AC=SF2*RHO(1)*5060.8386E-12
BBAR1=(-BTERM+SQRT(BTERM*BTERM+AC))/(4.E-12*SF2)
IF(ABS(BBAR1-BBAR)-.00001)1120,1130,1130
113) BBAR=BBAR1
PRINT 1300
130 FORMAT(4GH1ALPHA BAR AND BETA BAR DID NOT CONVERGE)
CALL EXIT
1120 BBAR=BBAR1
CM(1,1)=SF1*ABAR*ABAR*2.77278E-15/RHO(1)
CM(1,3)=SF2*BBAR*BBAR*2.428056E-15/RHO(1)

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SUBROUTINE CEDGE(J,NSTART,MEND)

```
CM(I,51)=SF3*ABAR*BAR*2.600418E-15/RHO(I)
CM(I,21)=SF4*ABAR*1.38639E-9/RHO(I)
CM(I,41)=SF5*BAR*1.214028E-9/RHO(I)
E12=EXP((-32125.131/T(I)))
Q=-.15966227E-11*Y(I)*E12/E2/B4
ENOP=SQRTF(Q)*SQRTF(CM(I,2))*SQRTF(CM(I,4))
CM(I,61)=ENOP*233.902493
CM(I,71)=ENOP/233.902493
1150 CONTINUE
      RETURN
END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

SUBROUTINE CEDGE(J,NSTART,NEND)

STORAGE NOT USED BY PROGRAM

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DEC OCT
725 01325

DEC OCT
23210 55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC OCT
ALL 32561 77461
A4L 32556 77454
AB21 32551 77447
AB7T 32546 77442
AUL2 32523 77413
B5T 32282 77032
B83T 32100 76544
B812 32095 76537
C12 31413 75265
CM2 30133 72665
C 32013 76415
DEL 28910 70356
CHUP12 28905 70351
DN2 27703 66067
EDENS 27697 66061
EPSIU 27633 65761
FEDA 27628 65754
FHE 27504 65560
FINO 27323 65271
FLEWL 27258 65172
FLO2 26958 64516
FMURIM 26827 64313
FMURLX 23216 55260
FSH 26705 64121
FSKRE 26001 62621
FSMNP 25986 62602
HE 25983 62577
INDLAS 25965 62555
INDSTP 25902 62456
JINPUT 25890 62442
NCOUNT 23212 55254
OGIVEH 25881 62431
PRAT 25809 62321
PRSAVE 25686 62126
PS 25685 62125
REX 23218 55262
RHODST 25039 60717
RSM 24985 60631
SCT 24922 60532
STADIS 24681 60151
TAPER 24498 57662
TM 24460 57614
TVJ2 24397 57515
ULOLIM 24273 57321
US 24092 57014
XRC 23379 55523
Y 23376 55520
Z1R 23242 55312
Z25 23220 55264

DEC OCT
A1T 32560 77460
A4T 32555 77453
AB3T 32550 77446
AC12 32545 77441
B1T 32522 77412
B6T 32222 76736
B84T 32099 76543
B812 32085 76525
CCALC 31353 75171
CM 30743 74027
CSR 28930 70402
DELTAP 28909 70355
DIST 28904 70350
DN2 27701 66065
EPSIC 27636 65764
ETA 27632 65760
FED8 27627 65753
FHM2 27443 65463
FKPSI 27321 65271
FLEWT 27198 65076
FL 27261 65175
FMUTIP 26767 64217
FSME 26645 64025
FSKRA 26032 62660
FSKRF 26000 62620
FSMNO 25987 62603
MH 25982 62576
INDPRI 25954 62542
INDSTR 25901 62455
JS 25889 62441
NPSI 25885 62435
PE 25872 62420
PRDIRA 25748 62224
P 25800 62430
QW 25164 61114
RH012 25140 60720
RN 25038 60716
RS 24987 60633
SHANGL 24862 60436
TAUM 24620 60054
TIM 24497 57661
T 24680 60150
U12 24336 57420
UM1 24212 57224
WDOT 24032 56740
X 23432 55610
YTHC 23255 55327
Z1 23244 55314

DEC OCT
A3L 32558 77456
AST 32553 77451
AB5T 32548 77444
ALPHA 32534 77426
B3T 32462 77316
B8T 32162 76642
B85T 32098 76542
BLOCK 32084 76524
CC 31403 75253
COMEAN 29533 71535
CS 29530 71532
DELTAX 28908 70354
DKOL 28903 70347
DO2 27700 66064
EPSIM 27635 65763
FAD 27631 65757
FEDC 27624 65752
FHM 27503 65557
FK 27322 65272
FLN2 27138 65002
FM 26898 64422
FNDSSM 26707 64123
FSH112 26044 62674
FSKRB 26022 62646
FSKRC 26012 62634
FSM 25999 62617
FSMN 25988 62604
IALT 25977 62571
INDP 25955 62543
INDTYP 25900 62454
KS 25888 62440
NSR 25883 62433
PRALIN 25810 62322
PROS 25688 62130
PSCALC 25285 61305
RESTAR 25162 61112
RHOCAL 25101 61015
RNS 25037 60715
SCHLIN 24984 60630
SIGMAC 24861 60435
TAUP 24560 57760
TITLE1 24496 57660
TVN2 24400 57520
UCALC 24335 57417
UM2 24152 57130
XI 23431 55607
XS 23378 55522
YIM 23256 55320
Z1S 23232 55300

DEC OCT
A3T 32557 77455
AB1T 32552 77450
AB6T 32547 77443
ASR 32533 77425
B4T 32342 77126
B82T 32101 76545
B87T 32096 76540
BUL2 32014 76416
CM1 30143 72677
CP 29532 71534
OCOP12 28920 70370
DELXST 28906 70352
UN2002 27702 66066
DUDP12 27698 66062
EPSIT 27634 65762
FC 27629 65755
FHCALC 27564 65654
FHS 27383 65367
FLELIN 27259 65173
FLNO 27078 64706
FMUL 26888 64314
FMUREM 23215 55257
FSMP 26034 62662
FSKRD 26002 62622
FSME 25989 62605
GAMM 25984 62600
INDCOO 25975 62567
INDR 25903 62457
JBYCTR 23211 55253
L 25887 62437
OGIVEH 25882 62432
PRATIN 25749 62225
PR 25871 62417
PSITCU 25165 61115
REM 23217 55261
RHO 25161 61111
RSC 24986 60632
SIGMAU 24741 60245
THETAT 24499 57663
TITLE3 24472 57630
TVNO 24399 57517
UINF 24274 57322
U 24396 57514
XLS 23429 55605
VCALC 23316 55424
Z1L 23243 55313
Z2 23231 55277

SUBROUTINE CEDGE(J,N,START,END)

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STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC	LOC	DEC	LOC	DEC	LOC
724	01324				

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	LOC	DEC	LOC	DEC	LOC
664	01230	AC	663	01227	
659	01223	BBAR	658	01222	
654	01216	E3	653	01215	
649	01211	Q	648	01210	
644	01204	SF5	643	01203	

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC
72	01161				
810K	1300	01156			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	LOC	DEC	LOC	DEC	LOC
626	01162	2)	561	01061	
634	01172	C100	635	01173	
639	01177	C1204	640	01200	
464	00720	E112	472	00730	

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	LOC	EXP	DEC	LOC	DEC	LOC
4	00004		3	00003		

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP	LOC	EXP	LOC	EXP	LOC
4	00004				

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC
40	17	00051	50	19	00060
63	26	00157	65	27	00164
79	38	00232	80	39	00234
250	45	00270	300	46	00302
112	77	00741	1150	88	01052

EFN	IFN	LOC	EFN	IFN	LOC
62	25	00154	78	36	00226
200	44	00262	1130	74	00724

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SUBROUTINE COMPRG(K)

SUBROUTINE COMPRG(K)

```

COMMON AIL,AII,A2,A3L,A3T,A4L,A4T,A5L,A5T,A6T,A6T,A82T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AM12,ALPHA,ASR,AUI2,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,B9T,B0T,CC,CCALC,CE,CM,CW1,CM2,CONEAN,CP,CPE,CS,
3BLOCK,BSR,BUL2,C,C12,CC,CCALC,CE,CM,CW1,CM2,CONEAN,CP,CPE,CS,
4CSR,DCDP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5DKDT,DN2,DN2D02,DN2D02,DSCRIP,DUDP12,EDENS,EPSI,
6EPSIC,EPSIM,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
7FEBC,FM,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FIMO,FK,FKPSI,FL,FLELIN,FLELM,FLEWL,FLEWT,
1FLN2,FLNO,FLNOP,FLQ2,FM,FMUL,FMUL12,FMULT,FMULTIP,FNDSSM,
2FNDSSL,FMS,FMSHE,FSHI,FSM12,FSSH,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNP,FSMO,GAMM,HE,
4HH,IALT,IDEL,INDCOG,INDLAS,INDP,INDPRI,INDPS,INDR,
5INDSTP,INDSTR,INDTYP,INPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6OGIVEM,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMMON PRD,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RMO,
1RHOCAL,RHDE,RHOL2,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCI,SWANGL,SIGMAC,SIGMAH,SIGMAU,
3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITL1,TITL2,TITL3,TM,TN2,
5TVNO,TVNOP,TVO2,U,UI2,UCALC,UE,UINF,ULOLIM,UM,UMI,
6UM2,US,WGOT,X,XI,XL,XLS,XRN,XS,XUL2,Y,YCALC,YTH,YTHC,
7YTHU,ZI,ZIL,ZIR,ZIS,ZZ,ZZR,ZZS
COMMON RETHET,REX,REW,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
1,FSM12,I12,Y12,STRLL,STRUL,RHOL2,AAU,EMP,FSK15,
2FSM015,FSMN15,FSME5

```

```

DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
1B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CH(10),
3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMULT(60),
DIMENSION FMULTIP(60),FSH(60),FSH1(60,10),FSH12(10),FSKRA(10),
1FSKR8(10),FSKRC(10),FSKRK(10),HH(5),INDCOG(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITL1(12),TITL2(12),TITL3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UMI(60),UM2(60),US(60),
1UDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),ZIR(10),
2ZZR(10)

```

K=K

IF(K-9) 100,3000,3000

100 IF(K-2) 120,600,2200

C PROGRAM CONSTANTS FOR MOMENTUM EQUATION

120 CP=14000.

D02=5.1155

DN2=9.7592

DNO=6.5060

DN2D02=.5*(DN2+D02)-DNO

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SUBROUTINE CONPRG(K)

```

FINO=9.258
FM(1)=32.000
FM(2)=16.000
FM(3)=28.016
FM(4)=14.008
FM(5)=30.008
FM(6)=30.008
FM(7)=5.4862E-4
FSMO=2.6556E-23
FSMN=2.3249E-23
FSMNO=4.9805E-23
FSME=9.1056E-28
FSMNO=FSMNO-FSME
R=8.95805E4
TVN2=3395.0
TVNO=2740.0
TVNOP=3395.0
TV02=.274.0
    
```

PROGRAM CONSTANTS FOR SPECIES EQUATION

```

140 ETA=6.0251E23
FSMP=4.8247E-34
FSK=1.01794E-23
FSKRE=2.7E-11
EMP=ETA*FSHP
FSK15=FSK**1.5/FSHP
FSMN15=FSMNO**1.5/FSHP
FSMN15=FSMN**1.5/FSHP
FSME3=SQRT(FSME)/FSHP
    
```

SCHMIDT AND DIFFUSION COEF RATIOS FOR SPECIES EQS

```

DO 145 N=1,60
SCL(N)=SCHLIN
SCT(N)=SCHTIN
DKOL(N,1)=1.0
DKOL(N,2)=1.0
DKOL(N,3)=1.0
DKOL(N,4)=1.0
DKOL(N,5)=1.0
DKOL(N,6)=1.0
DKOL(N,7)=1.0
DKOT(N,1)=1.0
DKOT(N,2)=1.0
DKOT(N,3)=1.0
DKOT(N,4)=1.0
DKOT(N,5)=1.0
DKOT(N,6)=1.0
DKOT(N,7)=1.0
    
```

PRANDTL AND LEWIS NOS FOR ENERGY EQ

```

PRAL(N)=PRALIN
PRAT(N)=PRATIN
FLEW(N)=FLELIN
145 FLENT(N)=FLETIN
RETURN
END FN=L
    
```

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```

SUBROUTINE COMPRG(N)
  RHOCAL(1)=RHO(1)
  PSI(1)=0.0
  DO 700 N=2,L
    PSI(N)=PSI(N-1)+.5*(Y(N)-Y(N-1))*RS*(RHO(N)+U(N)+RHO(N-1)+U(N-1))
    DELTAP=(PSI(L)-PSI(1))/(FN-1.0)
    DO 800 N=1,LP2
      WRITE OUTPUT TAPE 4,750,N,PSI(N)
    750 FORMAT(5X13,3X1P13.5)
    FN=FN+1
    800 PSCALC(N)=(FN-1.0)*DELTAP
    910 J=2
    920 DO 1400 N=2,L
      950 IF(PSCALC(N)-PSI(J))1300,1200,1000
      1000 J=J+1
      IF(J-L)950,950,1010
    1010 J=J-1
    1200 UCALC(N)=U(J)
    DO 1250 I=1,NS
      CCALC(N,I)=C(J,I)
      FHCALC(N)=FH(J)
      RHOCAL(N)=RHO(J)
    GO TO 1400
    1300 PFACR=(PSCALC(N)-PSI(J-1))/(PSI(J)-PSI(J-1))
      UCALC(N)=U(J-1)+PFACR*(U(J)-U(J-1))
      DO 1310 I=1,NS
        CCALC(N,I)=C(J-1,I)+PFACR*(C(J,I)-C(J-1,I))
        FHCALC(N)=FH(J-1)+PFACR*(FH(J)-FH(J-1))
        RHOCAL(N)=RHO(J-1)+PFACR*(RHO(J)-RHO(J-1))
    1400 CONTINUE
      UCALC(L+1)=UCALC(L)
      UCALC(L+2)=UCALC(L)
      DO 1450 I=1,NS
        CCALC(L+1,I)=CCALC(L,I)
        CCALC(L+2,I)=CCALC(L,I)
        FHCALC(L+1)=FHCALC(L)
        FHCALC(L+2)=FHCALC(L)
        RHOCAL(L+1)=RHOCAL(L)
        RHOCAL(L+2)=RHOCAL(L)
      YCALC(1)=0.0
    1470 DEL12=SQRT(DELTAP)
      DELN12=.707107*DEL12
      AU12=(2.0*UCALC(2)-UCALC(3))/(.58579/DEL12)
      BU12=(UCALC(3)-1.41421*UCALC(2))/(.58579/DEL12)
      U12=AU12*DELN12+BU12*.5*DELTAP
      DU0P12=.5*AU12/DELN12+BU12
      AAU=(2.0*RHOAL(2)+UCALC(2)-RHOCAL(3)+UCALC(3))/DEL12+.58579
      ABU=(RHOCAL(3)+UCALC(3)-1.41421*RHOAL(2)+UCALC(2))/DEL12+.58579
      YCALC(2)=2.0/ABU/RS*LOGF(1.0+ABU/AAU*DEL12)
      PRINT 1510,RHOCAL(2),RHOCAL(3),RS,DELTAP,UCALC(2),UCALC(3),DU0P12
    1,AAU,ABU,YCALC(2),U12
    1510 FORMAT(3X1P6E13.5/8X1P5E13.5)
    1650 DO 1900 N=3,LP2
      1900 YCALC(N)=YCALC(N-1)+.5*(PSCALC(N)-PSCALC(N-1))/RS*(1.0/(RHOCAL(N)+
        UCALC(N))+1.0/(RHOCAL(N-1)+UCALC(N-1)))
        IF(ABS(YCALC(L)-Y(L))/Y(L))-.001) 1910,1910,1905
    1905 PRINT 1906, YCALC(L),Y(L)

```


SUBROUTINE CONPRG(K)

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STORAGE NOT USED BY PROGRAM

DEC OCT
800 11440

DEC OCT
23190 55236

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

A1L 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455	DELX00 28907 70353
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	A5T 32553 77451	AAU 23204 55244	DELX01 28908 70354
AE1T 32552 77450	AE1T 32551 77447	AB1T 32550 77446	AB1T 32549 77445	ABST 32548 77444	DELX02 28909 70355
AB6T 32547 77443	AB7T 32546 77442	AC12 32545 77441	AH12 32535 77427	ALPHA 32534 77426	DELX03 28910 70356
ASR 32533 77425	AU12 32523 77413	B1T 32522 77412	B2T 32462 77316	B3T 32402 77222	DELX04 28911 70357
B4T 32342 77126	B5T 32282 77032	R6T 32222 76736	B7T 32162 76642	B8T 32102 76546	DELX05 28912 70358
B8T 32101 76545	B8T 32100 76544	B8T 32099 76543	B8T 32098 76542	B8T 32097 76541	DELX06 28913 70359
B8T 32096 76540	BC12 32095 76537	BH12 32085 76525	BLOCK 32084 76524	B8T 32098 76542	DELX07 28914 70360
BUI2 32014 76416	C12 31413 75265	CCALC 31353 75171	CC 31403 75253	B8T 32099 76543	DELX08 28915 70361
CM1 30143 72677	CM2 30133 72665	CM 30743 74027	CCONEAN 29533 71533	B8T 32100 76544	DELX09 28916 70362
CP 29532 71534	C 32013 76415	CSR 28930 70472	CS 29530 71532	B8T 32101 76545	DELX10 28917 70363
DCCDP12 28920 70370	DEL 28910 70356	DELTA 28909 70355	DELX00 28907 70353	B8T 32102 76546	DELX11 28918 70364
DELX01 28906 70352	DHDP12 28905 70351	DIST 28904 70350	DELX01 28908 70354	B8T 32103 76547	DELX12 28919 70365
DN2002 27702 66066	DN2 27703 66067	DN2 27701 66065	DO2 27700 66064	B8T 32104 76548	DELX13 28920 70366
DUP12 27698 66062	EDENS 27697 66061	EMP 23203 55243	EPSIC 27636 65764	B8T 32105 76549	DELX14 28921 70367
EPSI 27637 65765	EPSIT 27634 65762	EPSTU 27633 65761	ETA 27632 65760	B8T 32106 76550	DELX15 28922 70368
FR 27630 65756	FC 27629 65755	FEDA 27628 65754	FEDB 27627 65753	B8T 32107 76551	DELX16 28923 70369
FH12 27565 65655	FHCALC 27564 65654	FHE 27504 65560	FHM2 27443 65463	B8T 32108 76552	DELX17 28924 70370
FH 27625 65751	FHS 27383 65367	FIND 27323 65273	FKPSI 27321 65271	B8T 32109 76553	DELX18 28925 70371
FLELIN 27260 65174	FLELIN 27259 65173	FLEWL 27258 65172	FLEWT 27198 65076	B8T 32110 76554	DELX19 28926 70372
FLN0P 27018 64612	FLND 27078 64706	FLO2 26958 64516	FL 27261 65175	B8T 32111 76555	DELX20 28927 70373
FMUL12 26828 64314	FMUL 26808 64410	FMUTIM 26827 64313	FMUTIP 26767 64213	B8T 32112 76556	DELX21 28928 70374
FFNUSS12 26706 64122	FNUREW 23215 55257	FNUREX 23216 55260	FSH12 23210 55252	B8T 32113 76557	DELX22 28929 70375
FSH12 26044 62674	FSHI 26644 64024	FSHP 26034 62662	FSM 26705 64121	B8T 32114 76558	DELX23 28930 70376
FSKRA 26032 62660	FSKRB 26022 62646	FSKRC 26012 62634	FSKRD 26002 62622	B8T 32115 76559	DELX24 28931 70377
FSKRF 26000 62620	FSKRK 25999 62617	FSK 26033 62661	FSME5 23199 55237	B8T 32116 76560	DELX25 28932 70378
FSM15 23200 55240	FSMOP 25986 62602	FSMND 25987 62603	FSMN 25988 62604	B8T 32117 76561	DELX26 28933 70379
FSMD 25985 62601	GAMM 25984 62600	HE 25983 62577	HH 25982 62576	B8T 32118 76562	DELX27 28934 70380
IDEL 25976 62570	IMDC00 25975 62567	INDLAS 25965 62555	INDPRI 25954 62542	B8T 32119 76563	DELX28 28935 70381
INDPS 25953 62541	INDR 25903 62457	INDSTP 25902 62456	INDSTR 25901 62455	B8T 32120 76564	DELX29 28936 70382
IPRINT 23213 55255	JBYCTR 23211 55253	JINPOT 25890 62442	JS 25889 62441	B8T 32121 76565	DELX30 28937 70383
LP2 25886 62436	L 25887 62437	MCOUNT 23212 55254	NPSI 25885 62435	B8T 32122 76566	DELX31 28938 70384
NS 25884 62434	OGIVEN 25882 62432	OGIVER 25881 62431	PE 25872 62420	B8T 32123 76567	DELX32 28939 70385
PRAL 25870 62416	PRATIN 25749 62325	PRAT 25809 62321	PROIRA 25748 62324	B8T 32124 76568	DELX33 28940 70386
PRP 25687 62127	PR 25871 62417	PRSAVE 25686 62126	P 25880 62430	B8T 32125 76569	DELX34 28941 70387
PSI 25225 61211	PSITCU 25165 61115	PS 25685 62125	QW 25164 61114	B8T 32126 76570	DELX35 28942 70388
RETHET 23219 55263	REW 23217 55261	REX 23218 55262	RHO12 25040 60720	B8T 32127 76571	DELX36 28943 70389
RMOE 25041 60721	RHO 25161 61111	RHOSTC 25039 60717	RMOU12 23203 55245	B8T 32128 76572	DELX37 28944 70390
RNS 25037 60715	R 25163 61113	RSC 24986 60632	RSM 24985 60631	B8T 32129 76573	DELX38 28945 70391
SCHLIN 24984 60630	SCHTIN 24983 60627	SCL 24982 60626	SCT 24922 60532	B8T 32130 76574	DELX39 28946 70392
SIGMAC 24861 60435	SIGMAH 24801 60341	SIGMAU 24741 60245	STADIS 24681 60151	B8T 32131 76575	DELX40 28947 70393
SIRUL 23206 55246	T12 23209 55251	TAUM 24620 60054	TAUP 24560 57760	B8T 32132 76576	DELX41 28948 70394
THETAT 24472 57663	THPLR 24498 57662	TIN 24497 57661	TITLE1 24496 57660	B8T 32133 76577	DELX42 28949 70395
TITLE3 24492 57630	TM 24460 57614	T 24680 60150	TVM2 24400 57520	B8T 32134 76578	DELX43 28950 70396
TVND 24399 57517	TV02 24397 57515	U12 24336 57420	UCALC 24335 57417	B8T 32135 76579	DELX44 28951 70397
UINF 24274 57322	U001 24273 57321	U01 24212 57224	UK2 24152 57130	B8T 32136 76580	DELX45 28952 70398
U 24396 57514	US 24092 57034	WDT 24032 56740	XI 23431 55607	B8T 32137 76581	DELX46 28953 70399
XLS 23429 55605	XRN 23379 55523	X 23432 55610	XS 23378 55522	B8T 32138 76582	DELX47 28954 70400
				B8T 32139 76583	DELX48 28955 70401
				B8T 32140 76584	DELX49 28956 70402
				B8T 32141 76585	DELX50 28957 70403
				B8T 32142 76586	DELX51 28958 70404
				B8T 32143 76587	DELX52 28959 70405
				B8T 32144 76588	DELX53 28960 70406
				B8T 32145 76589	DELX54 28961 70407
				B8T 32146 76590	DELX55 28962 70408
				B8T 32147 76591	DELX56 28963 70409
				B8T 32148 76592	DELX57 28964 70410
				B8T 32149 76593	DELX58 28965 70411
				B8T 32150 76594	DELX59 28966 70412
				B8T 32151 76595	DELX60 28967 70413
				B8T 32152 76596	DELX61 28968 70414
				B8T 32153 76597	DELX62 28969 70415
				B8T 32154 76598	DELX63 28970 70416
				B8T 32155 76599	DELX64 28971 70417
				B8T 32156 76600	DELX65 28972 70418
				B8T 32157 76601	DELX66 28973 70419
				B8T 32158 76602	DELX67 28974 70420
				B8T 32159 76603	DELX68 28975 70421
				B8T 32160 76604	DELX69 28976 70422
				B8T 32161 76605	DELX70 28977 70423
				B8T 32162 76606	DELX71 28978 70424
				B8T 32163 76607	DELX72 28979 70425
				B8T 32164 76608	DELX73 28980 70426
				B8T 32165 76609	DELX74 28981 70427
				B8T 32166 76610	DELX75 28982 70428
				B8T 32167 76611	DELX76 28983 70429
				B8T 32168 76612	DELX77 28984 70430
				B8T 32169 76613	DELX78 28985 70431
				B8T 32170 76614	DELX79 28986 70432
				B8T 32171 76615	DELX80 28987 70433
				B8T 32172 76616	DELX81 28988 70434
				B8T 32173 76617	DELX82 28989 70435
				B8T 32174 76618	DELX83 28990 70436
				B8T 32175 76619	DELX84 28991 70437
				B8T 32176 76620	DELX85 28992 70438
				B8T 32177 76621	DELX86 28993 70439
				B8T 32178 76622	DELX87 28994 70440
				B8T 32179 76623	DELX88 28995 70441
				B8T 32180 76624	DELX89 28996 70442
				B8T 32181 76625	DELX90 28997 70443
				B8T 32182 76626	DELX91 28998 70444
				B8T 32183 76627	DELX92 28999 70445
				B8T 32184 76628	DELX93 29000 70446
				B8T 32185 76629	DELX94 29001 70447
				B8T 32186 76630	DELX95 29002 70448
				B8T 32187 76631	DELX96 29003 70449
				B8T 32188 76632	DELX97 29004 70450
				B8T 32189 76633	DELX98 29005 70451
				B8T 32190 76634	DELX99 29006 70452
				B8T 32191 76635	DELX100 29007 70453
				B8T 32192 76636	DELX101 29008 70454
				B8T 32193 76637	DELX102 29009 70455
				B8T 32194 76638	DELX103 29010 70456
				B8T 32195 76639	DELX104 29011 70457
				B8T 32196 76640	DELX105 29012 70458
				B8T 32197 76641	DELX106 29013 70459
				B8T 32198 76642	DELX107 29014 70460
				B8T 32199 76643	DELX108 29015 70461
				B8T 32200 76644	DELX109 29016 70462
				B8T 32201 76645	DELX110 29017 70463
				B8T 32202 76646	DELX111 29018 70464
				B8T 32203 76647	DELX112 29019 70465
				B8T 32204 76648	DELX113 29020 70466
				B8T 32205 76649	DELX114 29021 70467
				B8T 32206 76650	DELX115 29022 70468
				B8T 32207 76651	DELX116 29023 70469
				B8T 32208 76652	DELX117 29024 70470
				B8T 32209 76653	DELX118 29025 70471
				B8T 32210 76654	DELX119 29026 70472
				B8T 32211 76655	DELX120 29027 70473
				B8T 32212 76656	DELX121 29028 70474
				B8T 32213 76657	DELX122 29029 70475
				B8T 32214 76658	DELX123 29030 70476
				B8T 32215 76659	DELX124 29031 70477
				B8T 32216 76660	DELX125 29032 70478
				B8T 32217 76661	DELX126 29033 70479
				B8T 32218 76662	DELX127 29034 70480
				B8T 32219 76663	DELX128 29

SUBROUTINE CONPRG(K)

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Y12 23208 55250 YCALC 23316 55424 Y 23376 55520 YTHC 23255 55327 YTH 23256 55330
YTHU 23245 55315 Z1L 23243 55313 Z1R 23242 55312 Z1 23244 55314 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC OCT
BRU 799 01437 DEL12 798 01436 DEC OCT
LP1MN 794 01432 LP2MN 793 01431 N 792 01430 FN 796 01434 DEC OCT
SUMDP 790 01426

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN LOC EFN LOC EFN LOC
8)NE 750 01405 8)IF6 1510 01402 8)IF1 1906 01376

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC OCT
1) 774 01406 2) 715 01313 3) 721 01321 6) 754 01362 DEC OCT
C1G2 782 01416 C1G3 783 01417 C1G4 784 01420 C1G5 785 01421 C1G1 761 01415
C1200 787 01423 C1202 788 01424 C1203 789 01425 C1210 649 01211 C1101 786 01422
D140A 257 00401 D140H 312 00470 D140J 341 00525 D141M 710 01306 D121L 692 01264
D160J 340 00524 D161M 709 01305 E15 162 00242 E1A 259 00403 D160A 256 00400
E1G 296 00450 E117 610 01142 E11H 680 01250 E11J 607 01257 E1B 266 00412
E1318 616 01150 E119 620 01154

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC OCT LOG DEC OCT LOG DEC OCT
EXP13 0 00000 LOG 4 00004 DEC OCT
(STM) 2 00002 SORT 1 00001 (FIL) 3 00003 DEC OCT
(SPH) 5 00005

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP13 LOG SORT (FIL) (SPH) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND DCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	LOC	
100	15	00033	120	16	00037	140	39	00123	600	71	00243
700	75	00257	800	81	00334	910	82	00344	950	84	00404
1000	85	00413	1010	87	00424	1200	88	00431	1300	94	00451
1310	97	00471	1400	100	00526	1450	105	00550	1450	122	00724
1900	123	00727	1905	125	00771	1910	127	01000	2200	135	01036
2300	139	01064	2310	147	01103	2500	154	01121	3001	158	01135
3005	159	01143	3009	160	01151	3101	162	01155	3111	167	01210
3115	168	01212	3119	170	01215	3201	172	01233	3211	175	01263
3215	176	01265	3301	177	01307						

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SUBROUTINE HS0LUT

SUBROUTINE HS0LUT

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COMMON AIL,AIT,A2,A3L,A3T,A4L,A4T,A5L,A5T,ABIT,AB2T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,B82T,B83T,B84T,B85T,B86T,B87T,B88T,B89T,
3BL0CK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONAN,CP,CPE,CS,
4CSR,DCOP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5OKDT,ON2,ON2002,ONG,002,OSCRIP,OU0P12,EDENS,EPSI,
6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,F8,FC,FEDA,FE08,
7FE0C,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FINQ,FK,FKPSI,FL,FLELIN,FLEIM,FLEWL,FLEWT,
1FLN2,FLN0,FLN0P,FL02,FM,FMUL,FMUL12,FMUTIM,FMUTIP,FNDSSH,
2FN0SSL,FSH,FSHE,FSHI,FSH12,FSHP,FSK,FSKRA,FSKR8,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMN0,FSMN0P,FSM0,GAMM,HE,
4HH,IALT,IOEL,INDC00,INOLAS,INDP,INOPRI,INDPS,INDR,
5INOSTP,INOSTR,(NOTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6GIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMMON PROS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RH0,
1RH0CAL,RH0E,RH012,RH0STG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCT,SHANGL,SIGMAH,SIGMAU,
3STA0IS,I,TAUM,TAUP,TESTRA,THETAT,THPER,T(N,
4TITLE1,TITLE2,TITLE3,TM,TVN2,
5TVN0,TVN0P,TV02,U,U12,UCALC,UE,UINF,USOLIM,UM,UM1,
6UM2,US,WOOT,X,X(XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
1,FSH12,I12,Y12,STRLL,STRUL,RH0U12,AAU

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DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),B8T(60),B82T(60),B83T(60),B84T(60),B85T(60),
2CC(15,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSK(10),DCOP12(10),OKDL(60,10),DKDT(60,10),
4EDENS(60),FHI(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPS(60),FLEWL(60),FLEWT(60),FLN2(60),FLN0(60),
6FLN0P(60),FL02(60),FM(10),FMUL(60),FMUTIM(60)
DIMENSION FMUTIP(60),FSH(60),FSHI(60,10),FSH12(10),FSKRA(10),
1FSKR8(10),FSKRC(10),FSKRK(10),HH(5),INOC00(10),
2INOLAS(10),INOPS(50),IND(10),P(8),PROIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSI(60),RH0(60),
4RH0CAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(50),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
1WD0T(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

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2500 FHM(1)=HH(1)+XRN*(HH(2)+XRN*(HH(3)+XRN*(HH(4)+HH(5)+XRN)))
2505 D0 2550 N=2,L
SUMHL=0.0
SUMHT=0.0
SUMHPL=0.0
SUMHPT=0.0
IF(N-2) 2508,2508,2520
2508 UAVGI=RS*(RH012*U12+U12*DU0P12+RH0(2)*U(2)+U(2)*(U(2)+U(3))+.5-U12
1)/OELTAP)
UAVG2=.5*RS/OELTAP*((RH0(3)+U(3)+U(3)+RH0(2)+U(2)+U(2))*(U(3)-U(2)

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SUBROUTINE HSOLUT

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STORAGE NOT USED BY PROGRAM

OEC OCT
809 01451
OEC OCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

ALL 32561 77461	A3L 32558 77456	OEC OCT	A3T 32557 77455
A4L 32556 77454	A5T 32553 77451	OEC OCT	AAU 23204 55244
AB1T 32552 77450	AB4T 32549 77445	OEC OCT	AB5T 32548 77444
AB6T 32547 77443	AB12 32545 77441	OEC OCT	ALPHA 32534 77426
ASR 32533 77425	AU12 32523 77413	OEC OCT	B3T 32402 77222
B4T 32342 77126	B5T 32282 77032	OEC OCT	B81T 32102 76546
B82T 32101 76545	B83T 32100 76544	OEC OCT	B86T 32097 76541
B87T 32096 76540	BC12 32095 76537	OEC OCT	B8R 32024 76430
BUI2 32014 76416	C12 31413 75265	OEC OCT	CE 30753 74041
CM1 30143 72677	CM2 30133 72665	OEC OCT	CPE 29531 71533
CP 29532 71534	C 32013 76415	OEC OCT	CSUB 23214 55256
OCOP12 28920 70370	OEL 28910 70356	OEC OCT	DELX0D 28907 70353
DELXST 28906 70352	OHOP12 28905 70351	OEC OCT	DKDT 28303 67217
ON2D02 27702 66066	ON2 27703 66067	OEC OCT	DSCRIP 27699 66063
OUOP12 27698 66062	EDENS 27697 66061	OEC OCT	EPSI 27637 65765
EPSIT 27634 65762	EP5IU 27633 65761	OEC OCT	FH12 27565 65655
FC 27629 65755	FEA 27628 65754	OEC OCT	FH 27625 65751
FHCALC 27564 65654	FHE 27504 65560	OEC OCT	FLELIN 27260 65174
FHS 27383 65367	FIN0 27323 65273	OEC OCT	FLN0P 27018 64612
FLETIN 27259 65173	FLEWL 27258 65172	OEC OCT	FMDL12 26828 64314
FLN0 27078 64706	FL02 26958 64516	OEC OCT	FNDSSL 26706 64122
FMUL 26818 64410	FMUTIM 26827 64313	OEC OCT	FSHI12 26044 62674
FNUREW 23215 55257	FNUREX 23216 55260	OEC OCT	FSKRB 26022 62646
FSHI 26641 64024	FSHP 26034 62662	OEC OCT	FSKRN 25999 62617
FSKRC 26012 62634	FSKRO 26002 62622	OEC OCT	FSMN 25988 62604
FSK 26033 62661	FSME 25989 62605	OEC OCT	IALT 25977 62571
FSM0 25985 62601	GAMM 25984 62600	OEC OCT	INDTP 25955 62543
IOEL 25976 62570	INOC00 25975 62567	OEC OCT	INDTYP 25900 62454
INOPS 25953 62541	INOR 25903 62457	OEC OCT	KS 25888 62440
IPRINT 23213 55255	JBYCTR 23211 55253	OEC OCT	NSR 25883 62433
LP2 25886 62436	L 25887 62437	OEC OCT	PRALIN 25810 62322
NS 25884 62434	OGIVEH 25882 62432	OEC OCT	PROS 25683 62130
PRAL 25870 62416	PRATIN 25749 62225	OEC OCT	RH0CAL 25101 61015
PRP 25687 62127	PR 25871 62417	OEC OCT	RN 25038 60716
PS1 25225 61211	PSITCU 25165 61115	OEC OCT	RS 24987 60633
RETHET 23219 55263	REW 23217 55261	OEC OCT	SHANGL 24862 60436
RH0E 25041 60721	RH0 25161 61111	OEC OCT	STRLL 23207 55247
RNS 25037 60715	R 25163 61113	OEC OCT	TESTRA 24500 57664
SCHLIN 24984 60630	SCHTIN 24983 60627	OEC OCT	TITLE2 24484 57644
SIGMAC 24861 60435	SIGMAH 24801 60341	OEC OCT	TNNOP 24398 57516
STRUL 23206 55246	T12 23209 55251	OEC OCT	UE 24275 57323
THETAT 24499 57663	THPER 24498 57662	OEC OCT	UM 24272 57320
TITLE3 24472 57630	TM 24460 57614	OEC OCT	XL 23430 55606
TNN0 24399 57517	TV02 24397 57515	OEC OCT	XU12 23377 55521
UINF 24274 57322	UL0LIM 24273 57321	OEC OCT	YTH 23256 55330
U 24396 57514	US 24092 57034	OEC OCT	
XL5 23429 55605	XRN 23379 55523	OEC OCT	
Y12 23208 55250	YCALC 23316 55424	OEC OCT	
	Y 23376 55520	OEC OCT	
	YTHC 23255 55327	OEC OCT	

SUBROUTINE HS0LUT

YTHU 23245 55215 Z1L 23243 55313 Z1R 23242 55312 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
ESCRC	808 01450	ESCRH	807 01447	N	806 01446	PARTC2	805 01445
RURNP	803 01443	RURN	802 01442	SUMHL	801 01441	SUMHPL	800 01440
SUMHT	798 01436	UAVG1	797 01435	UAVG2	796 01434	SUMHPT	799 01437

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
1)	774 01406	2)	756 01364	3)	759 01367	6)	768 01400
C1100	793 01431	C1200	794 01432	C1201	795 01433	D120A	537 01031
E12	70 00106						

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCIAL LOCATIONS

EFN	IFN	LQC	EFN	IFN	LQC	EFN	IFN	LQC
2500	10 00013		2505	11 00033		2510	20 00211	
2520	27 00450		2525	31 00563		2526	33 00617	
2534	37 01051		2540	39 01105		2550	41 01317	
						2570	46 01354	
						2580	34 00721	
						2590	35 01031	
						2600	47 01356	

SUBROUTINE PRTERH (X,NSTART,NEND,K)

SUBROUTINE PRTERH (X,NSTART,NEND,KS)

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7700 IF (NEND-NSTART) 800,750,800
7750 IF (INDSTR) 760,760,950
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760 XRM=(X-DELXOD)/RNS(KS)
GO TO 909

SUBROUTINE PRTERH IX,NSTART,NEND,KS)

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800 XRM=(X-DELTAX)/RNS(KS)
900 IF (INOPSIKS)-2) 910, 920, 930
910 PR=PS(1,KS)*(COSFI XRM)1#2
    PRP=-PS(1,KS)/RNS(KS)*SINF(2.0*XRM)
    PRSAVE=PR
    GO TO 1000
920 PR=PS(2,KS)+PS(3,KS)*XRM+PS(4,KS)*XRM**2+PS(5,KS)*XRM**3+PS(6,KS)*
    1XRM**4
    PRP=RNS(KS)*(PS(3,KS)+2.0*PS(4,KS)*XRM+3.0*PS(5,KS)*XRM**2+4.0*PS(
    16,KS)*XRM**3)
    PRSAVE=PR
    GO TO 1000
930 PR=PS(7,KS)/(PS(8,KS)+XRM)
    PRP=-PS(7,KS)*RNS(KS)/(X+PS(8,KS)*RNS(KS))**2
    PRSAVE=PR
    GO TO 1000
950 PR=PRDS+X/DIST*IPRSAVE-PRDS)
    PRP=(PRSAVE-PRDS)/DIST
1000 IF (NEND-NSTART) 1005, 1090, 1005
1005 NEND=NEND+1
    DELT12=.5*DELTAP
    SDEL12=SORTF(DELT12)
    SDELT12=.58579*SORTF(DELTAP)
    DELTP=.58579*DELTAP
    AH12=12.0*FH(2)-FH(1)-FH(3))/SDELT12
    BH12=(FH(3)+.414*FH(1)-1.414*FH(2))/DELT12
    FH(NEND)=FH(1)+AH12*SDEL12+BH12*DELT12
    FH12=FFH(NEND)
    DHOP12=.5*AH12/SDEL12+BH12
    AU12=(2.0*U(2)-U(3))/SDELT12
    BU12=(U(3)-1.41421*U(2))/DELT12
    U(NEND)=AU12*SDEL12+BU12*DELT12
    U12=U(NEND)
    QUDP12=.5*AU12/SDEL12+BU12
    GO 1030 I=1,NS
AC12(1)=(2.0*C(2,1)-C(1,1)-C(3,1))/SDELT12
BC12(1)=(C(3,1)+.414*C(1,1)-1.414*C(2,1))/DELT12
IF (C(3,1)+C(2,1)) 1010, 1015, 1010
1010 IF (C(2,1)+C(1,1)) 1020, 1015, 1020
1015 C(NEND,1)=0
    GO TO 1025
1020 C(NEND,1)=C(1,1)+AC12(1)*SDEL12+BC12(1)*DELT12
    IF (C(NEND,1)) 1022, 1025, 1025
1022 C(NEND,1)=.5*(C(1,1)+C(2,1))
    CDDP12(1)=(C(2,1)-C(1,1))/DELTAP
    GO TO 1030
1025 QDDP12(1)=.5*AC12(1)/SDEL12+BC12(1)
1030 C12(1)=C(NEND,1)
1090 GO 1100 N=NSTART,NEND
1100 FSH(N)=FH(N)-.5*U(N)**2
    IF (A2) 1150, 1110, 1115
1115 IF (A2-9.9) 1110, 1110, 1150
1150 PLOG=.43429448*LOGF(PR/2117.)
    C8=230.6335/110.-PLOG+.183042*(PLOG+.3.)

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C9=2.1965+.31961*(PLDG+4.1)**2
E4=(C9-C8)/(C8+C9-C9-79.4)

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SUBROUTINE PRIERH (X,NSTART,NEND,K5)

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F2=79.4*(1.+E4)*(C8-79.4)
E1=(79.4-E2)*E4
E3=-E1+E4
C5=-2.1965+1.4643/(EXP(-2.*PLOG)+1.)
C6=-.00065+.012096/(PLOG+.6)
C7=-94.2-1.6*PLOG*(1.-.5*PLOG)
C8=5224./(33.842-PLOG)-1.7609*(PLOG+.68.5)
C9=12.813+.46218*(PLOG+.1)**2
K4=(C9-C8)/(C8+CK8-CK9-79.4)
CK2=79.4*(1.+CK4)*(CK8-79.4)
CK1=(79.4-CK2)*CK4
CK3=-CK1*CK4
CK5=-1.83+1.098/(EXP(-2.*(PLOG-.75))+1.)
CK6=.00038+.000953/(PLOG+.4.5)
CK7=-84.6-.8*PLOG*(1.-.5*PLOG)
IF(A2-9.8) 1155,1155,1110
1155 DO 1160 I=NSTART,NEND
      HRAR(I)=FSH(I)/25037.807
      D1=HBAR(I)/H465.
      D2=EXP(HBAR(I)/1693.-10.)
      D3=HBAR(I)/33.86
      F1=F1+F2*D1+F3/(E4+D1)+C5*EXP(-C6*(D3+C7)**2)+(5.4913-.56743*(PLOG+1.75)**2)*D2
      F2=CK1+CK2*D1+CK3/(CK4+D1)+CK5*EXP(-CK6*(D3+CK7)**2)+(9.2217-.276
      139*(PLOG+.5)**2)*D2
      T(I)=273.16+F1
      TM(I)=T(I)
1160 RH0(I)=PR*1.1799716F-6/F2
      GO TO 1200
1110 DO 1120 N=NSTART,NFND
      TNUM(N)=FSH(N)-1726.0F-18*(.5*C(N,2)*D02/FSM0+.5*C(N,4)*DN2/FSMN+C
      1(N,5)*DN2D02/FSMN+C(N,6)*(F1N0-DN2D02)/FSMN0P)
1120 T(N)=TNUM(N)/CP
1200 DO 1250 N=NSTART,NEND
      FL02(N)=TV02/T(N)/(EXP(TV02/T(N))-1.0)
      FLN2(N)=TVN2/T(N)/(EXP(TVN2/T(N))-1.0)
      FLN0(N)=TVN0/T(N)/(EXP(TVN0/T(N))-1.0)
      FLN0P(N)=TVN0P/T(N)/(EXP(TVN0P/T(N))-1.0)
      IF(A2) 1500,1300,1300
1300 DO 1350 N=NSTART,NFND
      TM(N)=TNUM(N)/(R*(C(N,1)/FM(1)*(FL02(N)+3.5)+C(N,3)/FM(3)*(FLN2(N)
      1+3.5)+C(N,5)/FM(5)*(FLN0(N)+3.5)+C(N,6)/FM(6)*(FLN0P(N)+3.5)+2.5*(
      2C(N,2)/FM(2)+C(N,4)/FM(4)+C(N,7)/FM(7)))
1400 DO 1450 N=NSTART,NFND
      IF(ABS(F(TM(N)-T(N))/TM(N))-EPS1T)1450,1450,1470
1450 CONTINUE
      GO TO 1500
1470 DO 1480 N=NSTART,NEND
1480 T(N)=TM(N)
      GO TO 1200
1500 DO 1520 N=NSTART,NEND
      SUMCM=0.0
      T(N)=TM(N)
      DO 1510 I=1,NS

```

1510 SUMCM=SUMCM+C(N,1)/FM(1)
RTM=RTM(N)

PAGE 4

SUBROUTINE PRTRH (X,NSTART,NEND,KS)

```

1517 IF(A2) 1519,1517,1517
1519 RHO(N)=PR/(RTM*SUNCM)
      FSH1(N,1)=RTM*(3.5+FL02(N))/FM(1)
      FSH1(N,2)=RTM*2.5/FM(2)+DN2*.5/FM(2)
      FSH1(N,3)=RTM*(3.5+FLN2(N))/FM(3)
      FSH1(N,4)=RTM*2.5/FM(4)+DN2*.5/FM(4)
      FSH1(N,5)=(RTM*(3.5+FLN0(N))+DN2002)/FM(5)
      FSH1(N,6)=(RTM*(3.5+FLNOP(N))+F1N0+DN2002)/FM(6)
1520 FSH1(N,7)=RTM*2.5/FM(7)
      FSH12=FSH(NEND)
      RHO12=RHO(NEND)
      T12=T(NEND)
      FMUL2=3.04566E-8*TM(NEND)**1.5/(110.333+TM(NEND))
      DO 1600 I=1,NS
1600 FSH112(I)=FSH1(NEND,I)
      NEND=NEND-1
1700 IF(A2-9.9) 2000,2000,1700
      HBAR(1)=FSH(1)/25037.807
      D1=HBAR(1)/8465.
      D2=EXPF(HBAR(1))/1693.-10.)
      D3=HBAR(1)/33.86
      F1=E1+E2*D1+F3/(F4+D1)+C5*EXPF(-C6*(D3+C7)**2)+(5.4913-.56743*(PL0
1701 1G+1.75)**2)*D2
      F2=CK1+CK2*D1+CK3/(CK4+D1)+CK5*EXPF(-CK6*(D3+CK7)**2)+(9.2217-.276
1702 T(1)=273.16#F1
      TM(1)=T(1)
      RHO(1)=PR*1.1799714E-6/F2
      FL02(1)=TV02/T(1)/(EXPF(TV02/T(1))-1.0)
      FLN2(1)=TVN2/T(1)/(EXPF(TVN2/T(1))-1.0)
      FLN0(1)=TVN0/T(1)/(EXPF(TVN0/T(1))-1.0)
      FLNOP(1)=TVNOP/T(1)/(EXPF(TVNOP/T(1))-1.0)
      RTM=R*TM(1)
      FSH1(1,1)=RTM*(3.5+FL02(1))/FM(1)
      FSH1(1,2)=RTM*2.5/FM(2)+DN2*.5/FM(2)
      FSH1(1,3)=RTM*(3.5+FLN2(1))/FM(3)
      FSH1(1,4)=RTM*2.5/FM(4)+DN2*.5/FM(4)
      FSH1(1,5)=(RTM*(3.5+FLN0(1))+DN2002)/FM(5)
      FSH1(1,6)=(RTM*(3.5+FLNOP(1))+F1N0+DN2002)/FM(6)
      FSH1(1,7)=RTM*2.5/FM(7)
2000 RETURN
END(1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0)

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SUBROUTINE PRTERH (X,NSTART,NEND,KS)

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STORAGE NOT USED BY PROGRAM

DEC OCT
1463 02667

DEC OCT
23207 55247

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

AIL 32561 77461
A4L 32556 77454
A4T 32551 77447
A8T 32546 77442
AUI2 32523 77413
B5T 32282 77032
B8T 32100 76544
B8T 32095 76537
C12 31413 75265
C42 30133 72665
C 32013 76425
DPL 28910 70356
DHOPI2 28905 70351
DN2 27703 66067
EDENS 27697 66051
FPSIU 27633 65761
FFDA 27628 65754
FHE 27504 65560
FINO 27323 65273
FLEWL 27258 65172
FL72 26958 64516
FMUTLP 26827 64313
FNURFX 23216 55260
FSHP 26034 62662
FSKRQ 26002 62622
FSMF 25989 62605
GAMM 25984 62600
INDCJO 25975 62567
INDR 25903 62457
JBYCTR 23211 55253
NCONUT 23212 55254
OGIVFK 25981 62431
PRAT 25909 62321
PRSAVE 25686 62126
PS 25685 62125
RDX 23218 55262
RHDSIG 25039 60717
RSM 24985 60631
SCI 24922 60532
STADIS 24681 60151
THFIAT 24499 57653
TITLE3 24472 57630
TVNO 24399 57517
UINF 24274 57322
U 24396 57514

A1T 32560 77460
A4T 32555 77453
A8T 32550 77446
AC12 32545 77441
B1T 32522 77412
B6T 32222 76736
B8T 32099 76543
BH12 32085 76525
CCALC 31353 75171
CM 30743 74027
CSR 28930 70402
DELTA 28909 70355
DIST 28904 70350
DNO 27701 66065
EPSIC 27636 65764
FTA 27632 65760
FEDB 27627 65753
FHM2 27443 65463
FKPSI 27321 65271
FLEWT 27198 65076
FL 27161 65175
FMUTLP 26767 64217
FSH12 23210 55252
FSH 26705 64121
FSKRE 26001 62621
FSMNDP 25986 62602
HE 25983 62577
INDLAS 25965 62555
INDSTP 25902 62456
JINPUT 25890 62442
NPSI 25885 62435
PE 25872 62420
PRDIRA 25748 62224
P 25880 62430
QW 25164 61114
RH012 25040 60720
RN 25038 60716
RS 24987 60633
SHANGL 24862 60436
T12 23209 55251
THPER 24498 57662
TM 24460 57614
TV02 24397 57515
ULOLIM 24273 57321
US 24092 57034

A3L 32558 77456
A5L 32554 77451
A8T 32548 77444
ALPHA 32514 77426
B2T 32462 77316
B7T 32162 76642
B8T 32098 76542
BLOCK 32084 76524
CC 31403 75253
CONCAN 29533 71535
CS 29530 71532
DELTA 28908 70354
DKDL 28903 70347
D02 27700 66064
EPSIH 27635 65763
FA 27631 65757
FEDC 27626 65752
FHM 27503 65557
FK 27322 65272
FLN2 27138 65002
FM 26898 64422
FNDSH 26707 64123
FSHF 26645 64025
FSKPA 26032 62660
FSKRF 26000 62620
FSMNO 25987 62603
HH 25982 62576
INDPRI 25954 62542
INDSTR 25901 62455
JS 25889 62441
NSR 25883 62433
PRALIN 25810 62322
PRDS 25688 62130
PSCALC 25285 61305
RESTAP 25162 61112
RHOCAL 25101 61015
RNS 25037 60715
SCHLIN 24984 60630
SIGMAC 24861 60435
TAUM 24620 60054
TIN 24497 57661
T 24680 60150
U12 24336 57420
UM1 24212 57224
WDOT 24032 55740

A3T 32557 77455
A8T 32552 77450
A8T 32547 77443
ASR 32533 77425
B4T 32342 77126
B4T 32101 76545
B8T 32096 76540
BU12 32014 76416
CM1 30143 72677
CP 29532 71534
OCOP12 28920 70370
DELXST 28906 70352
DN2902 27702 66066
DUP012 27698 66062
EPSIT 27634 65762
FC 27629 65755
FHCALC 27564 65554
FHS 27383 65367
FLFTIN 27259 65173
FLN 27078 64706
FMUL 26888 64410
FNURFW 23215 55257
FSHI 26644 64724
FSKRC 26012 62634
FSK 26033 62641
FSMN 25985 62601
IDEL 25976 62570
INDPS 25353 62541
IPRINT 23213 55255
L 25887 62437
OGIVEH 25982 62432
PRATIN 25749 62225
PR 25871 62417
PSITCU 25165 61115
REW 23217 55261
RHQ 25161 61111
RSC 24986 60632
SCL 24982 60624
SIGMAU 24741 60245
TESTRA 24500 57664
TITLE2 24484 57664
TVNJP 24398 57516
UF 24275 57323
UM 24214 57320
XL 23430 55606

XLS 23429 55605
YCALC 23316 55424
Z1L 23243 55313
72 23231 55277

XRN 23379 55523
Y 23376 55520
Z1R 23242 55312
Z2S 23220 55264

XS 23378 55522
YTHC 23255 55327
Z1 23244 55314

XJ12 23377 55511
YTH 23256 55330
Z1S 23232 55300

Y12 23208 55250
YTHJ 23245 55315
Z2R 23230 55276

SUBROUTINE PRTERH (X,NSTART,NEND,KS)

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STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
HRAR	1462 02666	TNUM	1402 02572				

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

C5	DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
CK1	1342	02476	C6	1341 02475	C1	1340 02474	C8	1339 02473
CK6	1337	02471	CK2	1336 02470	CK3	1335 02467	CK4	1334 02466
CK7	1332	02464	CK7	1331 02463	CK9	1330 02462	CK9	1329 02461
D2	1327	02457	D3	1326 02456	DFL112	1325 02455	OFLTP	1324 02454
E2	1322	02452	E3	1321 02451	E4	1320 02450	F1	1319 02447
N	1317	02445	PLOG	1316 02444	RTM	1315 02443	SDEL12	1314 02442
SUMCM	1312	02440	XR4	1311 02437			SOELTP	1313 02441

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

1)	DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
CJG2	1293	02415	2)	1223 02307	3)	1230 02316	6)	1287 02407
CJ102	1304	02430	CJG2	1305 02431	CJG3	1306 02432	CJ100	1307 02433
E1F	1309	02435	CJ103	1310 02436	DJ408	321 00501	DJ508	320 00500
	365	00555	FJ1K	1005 01755				

LOCATIONS OF NAMES IN TRANSFER VECTOR

CJS	DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
SOET	0	00000	EXP	4 00004	EXP(3	5 00005	LOG	3 00003
	2	00002						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS	EXP	EXP(3	LOG	SIN	SORT
100	11	00113	16	00136	750
900	21	00157	22	00163	920
1000	36	00346	1005	37 00351	1010
1022	61	00560	1025	64 00573	1030
1115	69	00627	1150	70 00634	1155
1120	103	01337	1200	104 01345	1250
1400	112	01522	1450	114 01541	1470
1510	123	01575	1517	126 01616	1519
1700	142	01756	2000	163 02272	

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND ACTUAL LOCATIONS

FFN	IFN	LJC	FFN	IFN	LJC	FFN	IFN	LJC	FFN	IFN	LJC
100	11	00113	700	16	00136	750	17	00143	760	18	00146
900	21	00157	910	22	00163	920	26	00212	930	30	00307
1000	36	00346	1005	37	00351	1010	56	00524	1015	57	00534
1022	61	00560	1025	64	00573	1030	65	00600	1090	66	00606
1115	69	00627	1150	70	00634	1155	90	01122	1160	99	01271
1120	103	01337	1200	104	01345	1250	108	01414	1300	110	01436
1400	112	01522	1450	114	01541	1470	116	01544	1480	117	01547
1510	123	01575	1517	126	01616	1519	127	01624	1520	133	01702
1700	142	01756	2000	163	02272						

SUBROUTINE RADBDY

```

21=(X-XS)*COSF(CONEAN)+Z1S
GO TO 230
220 Z2=(X-XLS(KS-1))*SINF(CONEAN)+Z2S
Z1=(X-XLS(KS-1))*CCSF(CONEAN)+Z1S
230 RSM=Z2
GO TO 330
300 Z2=Z2S
RSM=Z2
IF(KS-2)310,320,320
310 Z1=Z1S*(X-XS)
GO TO 330
320 Z1=X-XLS(KS-1)+Z1S
330 IF(EPSI) 550,700,800
400 GO TO 100
500 GO TO 300
550 STOP 550
700 RSM=1.0
800 RETURN
END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)

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SUBROUTINE RADBDY

STORAGE NOT USED BY PROGRAM

DEC OCT
193 003C1
23210 55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

AIL 32561 77461	DEC OCT	AIL 32560 77460	DEC OCT	A3L 32558 77456	DEC OCT	A3T 32557 77455	DEC OCT
A4L 32556 77454		A4T 32555 77453		A5L 32554 77452		AB1T 32552 77450	
AB2T 32551 77447		AB3T 32550 77446		AB4T 32549 77445		AB6T 32547 77443	
AB7T 32546 77442		AC12 32545 77441		AM12 32543 77440		ASR 32533 77425	
AU12 32523 77413		B1T 32522 77412		B2T 32462 77316		84T 32342 77126	
AS1 32282 77032		B6T 32222 76736		87T 32162 76642		882T 32101 76545	
AB3T 32100 76544		BB4T 32099 76543		885T 32098 76542		887T 32096 76540	
HC12 32095 76537		BH12 32085 76525		BLOCK 32084 76524		BUI2 32014 76416	
C12 31413 75265		CCALC 31353 75171		CC 31403 75253		CM1 30143 72677	
CM2 30133 72665		CM 30743 74027		COMEAN 29533 71535		CP 29532 71534	
C 32013 76415		CSP 28930 70402		CS 29530 71532		DCDP12 28920 70370	
DEL 28910 70356		DELIAP 28909 70355		DELTAX 28908 70354		DELXST 28906 70352	
DHDP12 28905 70351		DIST 28904 70350		DKDL 28903 70347		DN2002 27702 66066	
DN2 27703 66067		DMQ 27701 66065		DU2 27700 66064		DUDP12 27698 66062	
EDENS 27697 66061		EPSIC 27636 65764		EPSIM 27635 65763		EPSIT 27634 65762	
FPSIU 27633 65761		ETA 27632 65760		FA 27631 65757		FC 27629 65755	
FEDA 27628 65754		FEDR 27627 65753		FEDC 27626 65752		FHCALC 27564 65654	
FHE 27504 65560		FHM2 27443 65463		FHM 27503 65557		FHS 27383 65367	
FIND 27323 65273		FKPSI 27321 65271		FK 27322 65272		FLETIN 27259 65173	
FLEWL 27258 65172		FLEWT 27198 65076		FLN2 27138 65002		FLMO 27078 64706	
FLO2 26958 64516		FL 27261 65175		FM 26898 64422		FMUL 26868 64410	
FMUTIM 26827 64313		FMUTIP 26767 64217		FNDSSH 26707 64123		FNUREW 23215 55257	
FNUREX 23216 55260		FSHE 26645 64025		FSH12 26044 62674		FSDP 26034 62662	
FSH 26705 64121		FSKRA 26032 62660		FSKRB 26022 62646		FSKRD 26002 62622	
FSKRI 26001 62621		FSKRF 26000 62620		FSKRC 26012 62634		FSME 25989 62605	
FSMNOP 25986 62602		FSMNO 25987 62603		FSMN 25988 62604		GAMM 25984 62600	
HE 25983 62577		HH 25982 62576		IALT 25977 62571		INDC00 25975 62567	
INDLAS 25965 62555		INDPRI 25954 62542		INDP 25955 62543		INDR 25903 62457	
INDSTP 25902 62456		INDSTR 25901 62455		INDTYP 25900 62454		JBYCTR 23211 55253	
JINPUT 25890 62442		JS 25889 62441		KS 25888 62440		L 25887 62437	
OGIVEK 25881 62431		NPSI 25885 62435		NSR 25883 62433		OGIVEM 25882 62432	
PRAT 25809 62321		PE 25872 62420		PRALIN 25870 62416		PRATIN 25749 62225	
PRSAVE 25686 62126		PROIRA 25748 62224		PRDS 25688 62130		PR 25871 62417	
P 25880 62430		P 25880 62430		PSCALC 25285 61305		PSITCU 25165 61115	
QW 25164 61114		QW 25164 61114		RESTAR 25162 61112		REW 23217 55261	
RHO12 25040 60720		RH 25038 60716		RHOCAL 25101 61015		RHO 25161 61111	
RHO2 25039 60717		RS 24987 60633		RNS 25037 60715		RSC 24986 60632	
RSM 24985 60631		RS 24987 60633		SCMLIN 24984 60630		SCL 24982 60626	
SCT 24922 60532		SHANGL 24862 60436		SHMAC 24861 60435		SIGMAU 24741 60245	
STADIS 24681 60151		TAUM 24620 60054		TAUP 24560 57760		THETAT 24499 57663	
THPR 24498 57662		TIN 24497 57661		TITLE2 24496 57660		TITLE3 24472 57630	
TM 24460 57614		T 24680 60150		TIN2 24400 57520		TVNO 24399 57517	
TV02 24397 57515		U12 24336 57420		UCALC 24335 57417		UINF 24274 57322	
ULOLIM 24273 57321		UM1 24212 57224		UM2 24152 57130		U 24396 57514	
US 24092 57034		W00T 24032 56740		XI 23431 55607		XLS 23429 55605	
XRN 23379 55523		X 23432 56740		Y 23378 55522		YCALC 23316 55424	
Y 23376 55520		YTHC 23255 55327		YTH 23256 55330		Z1L 23243 55313	
Z1R 23242 55312		Z1 23244 55314		Z1S 23232 55300		Z2 23231 55277	
Z2S 23220 55264							

SUBROUTINE RA080Y

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LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1) 188 00274	2) 180 00264	3) 181 00265	6) 182 00266	C1G0 191 00277	OEC OCT		
C1G1 192 00300	E11 18 00022	E12 24 00030	E15 88 00130	E1E 166 00246			
E1H 174 00256	E1109 142 00216						

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT
COS 1 00001	SIN 0 00000				

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS SIN

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100 11 00024	120 12 00032	110 12 00032	130 15 00070	170 17 00125	190 19 00132	200 130	270 27 00220	300 30 00230
210 20 00136	220 23 00145	230 25 00213	240 25 00213	250 27 00220	260 30 00230	270 300	280 35 00250	290 36 00251
320 32 00235	330 33 00241	340 34 00245	350 34 00245	360 35 00250	370 36 00251	380 300	390 35 00250	400 36 00251
700 37 00253								

PAGE 1

SUBROUTINE STAOUT(KK)

SUBROUTINE STAOUT(KK)

C

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COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AB12,ALPHA,ASR,AU12,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BB8T,BB9T,
3B10T,B11T,B12T,B13T,B14T,B15T,B16T,B17T,B18T,B19T,B20T,B21T,
4B22T,B23T,B24T,B25T,B26T,B27T,B28T,B29T,B30T,B31T,B32T,B33T,
5B34T,B35T,B36T,B37T,B38T,B39T,B40T,B41T,B42T,B43T,B44T,B45T,
6B46T,B47T,B48T,B49T,B50T,B51T,B52T,B53T,B54T,B55T,B56T,B57T,
7B58T,B59T,B60T,B61T,B62T,B63T,B64T,B65T,B66T,B67T,B68T,B69T,
8B70T,B71T,B72T,B73T,B74T,B75T,B76T,B77T,B78T,B79T,B80T,B81T,
9B82T,B83T,B84T,B85T,B86T,B87T,B88T,B89T,B90T,B91T,B92T,B93T,
10B94T,B95T,B96T,B97T,B98T,B99T,B100T,B101T,B102T,B103T,B104T,
11B105T,B106T,B107T,B108T,B109T,B110T,B111T,B112T,B113T,B114T,
12B115T,B116T,B117T,B118T,B119T,B120T,B121T,B122T,B123T,B124T,
13B125T,B126T,B127T,B128T,B129T,B130T,B131T,B132T,B133T,B134T,
14B135T,B136T,B137T,B138T,B139T,B140T,B141T,B142T,B143T,B144T,
15B145T,B146T,B147T,B148T,B149T,B150T,B151T,B152T,B153T,B154T,
16B155T,B156T,B157T,B158T,B159T,B160T,B161T,B162T,B163T,B164T,
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18B175T,B176T,B177T,B178T,B179T,B180T,B181T,B182T,B183T,B184T,
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2065T,2066T,2067T,2068T,2069T,2070T,2071T,2072T,2073T,2074T,
2075T,2076T,2077T,2078T,2079T,2080T,2081T,2082T,2083T,2084T,
2085T,2086T,2087T,2088T,2089T,2090T,2091T,2092T,2093T,2094T,
2095T,2096T,2097T,2098T,2099T,2100T,2101T,2102T,2103T,2104T,
2105T,2106T,2107T,2108T,2109T,2110T,2111T,2112T,2113T,21
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SUBROUTINE STAOUT(KK)

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5020 FORMAT(15H  STAG DENSITY 6X3HNSR/14H (SLUGS/CU FT)/1PE13.5,110)
5025 FORMAT(/18H SHOCK REGION NO 12/6X4HTYPE10X6HSHANGLSX13HSTANDOFF
1 DIST19X9HGEOM COEF30X6HLIMITS/20X5H(RAD)10X4H(FT)12X3HASR12X3HBSR
212X3HCSR9X8HZ1R (FT)7X8HZ2R (FT))
5030 FORMAT(4X8HSTRAIGHT3X1PE13.5,1P6E15.5)
5035 FORMAT(4X7HCONICAL4X1PE13.5,1P6E15.5)
5038 FORMAT(5X6HNORMAL4X1PE13.5,1P6E15.5)
5040 FORMAT(3X12HPARABOLIC 1PE13.5,1P6E15.5)
5045 FORMAT(/34H PROBLEM PARAMETERS AND INDICATORS//13H PROBLEM TYPE/
1)
5050 FORMAT(5X15HINITIAL PROFILE15X24HCONSTANT EDGE CONDITIONS15X22HINI
TIAL PROFILES INPUT)
5055 FORMAT(5X15HINITIAL PROFILE15X15HSTREAMLINE CALC15X22HINITIAL PROF
ILES INPUT)
5060 FORMAT(5X14HSHOCK CROSSING16X15HSTREAMLINE CALC15X22HINITIAL PROFI
LES INPUT)
5065 FORMAT(/15H NO GRID PTS 15H NO SPECIES 15H NOSE RADIUS 15H
1 OVERALL ZETA 6X4HNPS110X6HJINPUT9X6HRESTAR/35X4H(FT)12X4H(FT)/1A,
2116,1P115.5,1PE15.5,111,114,1PE20.5)
5070 FORMAT(/6X2HXSI3X3HZISI2X3HZ2SI11X6HDELTAX/5X4H(FT)12X4H(FT)11X4H(F
IT)11X4H(FT)/1PE13.5,1P3E15.5)
5075 FORMAT(/6X3HAIL12X3HAIL12X2HA213X3HA3L12X3HA3T12X3HA4L12X3HA4T/1PE
113.5,1P6E15.5//6X3HA5L12X3HA5T11X20HSTEP SIZE TOLERANCEF57X12HSTAB.
2 FACTOR/1PE13.5,1P4E15.5)
5080 FORMAT(/4X7HU LOLIM4X418HTHICKNESS CRITERIA/4X8H(FT/SEC)10X1HU12X5
1HC(02)11X4HC(0)10X5HC(N2)11X4HC(N)10X5HC(N0)12X1HH/1PE13.5,1P7E15.
25)
5085 FORMAT(/4X4HEPSI5X6HEPSI U6X10HEPSI C(02)2X9HEPSI C(0)3X10HEPSI C(
1N2)2X9HEPSI C(N)3X10HEPSI C(N0)4X6HEPSI H7X6HEPSI T/1P8E12.5,1PE13
2.5)
5090 FORMAT(/11X8HLEWIS NO21X10HPRANDTL NO20X10HSCMIDT NO/4X,7HLAMINAR
17X9HTURBULENT7X7HLAMINAR7X9HTURBULENT7X7HLAMINAR7X9HTURBULENT/1PE1
23.5,1P5E15.5)
5095 FORMAT(/30H DIFFUSION COEF RATIOS LAMINAR/)
5100 FORMAT(6X2H0214X1H013X2HN214X1HN13X2HN013X3HNO+12X2HE-/1PE13.5,1P6
1E15.5)
5105 FORMAT(/32H DIFFUSION COEF RATIOS TURBULENT/)
5110 FORMAT(/4X6HTESTRA10X4HAB111X4HAB2T11X4HAB3T11X4HAB4T11X4HAB5T11X
14HAB6T11X4HAB7T/1PE13.5,1P7E15.5//20X4HBB1T11X4HBB2T11X4HBB3T11X4H
26B4T11X4HBB5T11X4HBB6T11X4HBB7T/1PE28.5,1P6E15.5//6X2HFK13X2HFA13X
32HFB13X2HFC13X4HFEDA11X4HFEDB11X4HFEDC/1PE13.5,1P6E15.5)
5115 FORMAT(/37H SUBREGION VALUES AND WALL PARAMETERS)
5120 FORMAT(/11H PRES TYPE37X9HPRES COEF/18,1PE17.5,1P7E13.5//3X9HGE0
1M SUBR6X6HOGIVEH9X6HOGIVEK10X2HRN13X2HXL11X6HCONEAN6X12HPRINTOUT I
2NT/21X4H(FT)11X4H(FT)10X4H(FT)11X4H(FT)10X5H(RAD)/19,1PE19.5,1P4E1
35.5,111)
5125 FORMAT(/11H CWALL COEF//6X2H0214X1H013X2HN214X1HN13X2HN013X3HNO+1
12X2HE-9X11HH WALL COEF/(1PE13.5,1P7E15.5))
5130 FORMAT(18H1 INITIAL PROFILES//6X14Y10X5HC(02)8X4HC(0)9X5HC(N2)8X4H
1C(N)9X5HC(N0)8X6HC(N0+)7X5HC(E-)10X1HH12X1HU/4X4H(FT)97X10H(FT/SEC
2)5Q4X8H(FT/SEC))
5135 FORMAT(1P10E13.5)
5140 FORMAT(15H1STATION VALUES3X15,4I10//)
5145 FORMAT(7X1HX11X7HDELTA XB6HZETA 19X8HRAID BODY4X12HRL MASS FLOW3X1
14HSTREAMTUBE RAD3X9H WALL PRES7X7HRETHETA/5X4H(FT)11X4H(FT)11X4H(FT
2)12X4H(FT)7X11H(LB SEC/FT)7X4H(FT)18X10H(LB/SQ FT)/1P4E15.7,1PE13.5

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SUBROUTINE STAOUT(KK)

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6020 CONTINUE
      WRITE OUTPUT TAPE 6,5045
      IF (INDSTR) 6025,6030,6035
6025 WRITE OUTPUT TAPE 6,5050
      GO TO 6040
6030 WRITE OUTPUT TAPE 6,5055
      GO TO 6040
6035 WRITE OUTPUT TAPE 6,5060
6040 WRITE OUTPUT TAPE 6,5065,L,NS,RN,Z1L,NPSI,JINPUT,RESTAR
      WRITE OUTPUT TAPE 6,5070,XS,Z1S,Z2S,DELTA
      WRITE OUTPUT TAPE 6,5075,A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,FNDSSL
1,FNDSSH,TIN
      WRITE OUTPUT TAPE 6,5080,ULOLIM,THPER,THPER,THPER,THPER,THPER,THPE
IR,THPER
      WRITE OUTPUT TAPE 6,5085,EPSI,EPSIU,EPSIC,EPSIC,EPSIC,EPSIC,EPSIC,
1EPSIH,EPSIT
      WRITE OUTPUT TAPE 6,5090,FLELIN,FLELIN,FLELIN,PRALIN,PRALIN,SCHLIN,SCHTIN
      WRITE OUTPUT TAPE 6,5095
      WRITE OUTPUT TAPE 6,5100,DKDL(1,I),I=1,NS)
      WRITE OUTPUT TAPE 6,5105
      WRITE OUTPUT TAPE 6,5110,DKDT(1,I),I=1,NS)
      WRITE OUTPUT TAPE 6,5110,TESTRA,AB1T,AB2T,AB3T,AB4T,AB5T,AB6T,AB7T
1,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,FK,FA,FB,FC,FEDA,FEDR,FEDC
      RETURN
C SUBREGION VALUES
6041 WRITE OUTPUT TAPE 6,5115
      WRITE OUTPUT TAPE 6,5120,INDP,(P(I),I=1,8),INDR,OGIVEH,OGIVEK,RN,X
1L,CONEAN,INDPRI
      WRITE OUTPUT TAPE 6,5125,((CC(J,I),I=1,NS),HH(J),J=1,5)
      WRITE OUTPUT TAPE 6,5130
      DO 6045 N=1,LP2
6045 WRITE OUTPUT TAPE 6,5135,Y(N),(C(N,I),I=1,NS),FH(N),U(N)
      RETURN
C STATION VALUES
C
6046 IF (KK-9) 60465,6048,6048
60465 IPRINT=IPRINT+1
6047 IF (IPRINT-INDPRI) 6170,6048,6048
6048 WRITE OUTPUT TAPE 6,5140,JS,IDEL,KK,IPRINT,INDPRI
      IF (EPSI) 6055,6050,6055
6050 FMBL=PSI(L)
      DIN2=PSI(L)/(RHOE*UINF)
      GO TO 6080
6055 AREA=0.0
      DO 6075 I=1,L
      IF (I-1) 6060,6065,6060
6060 IF (I-L) 6070,6065,6070
6065 AREA=AREA+(RS+Y(I)*COSF(THETAT))*0.5
      GO TO 6075
6070 AREA=AREA+(RS+Y(I)*COSF(THETAT))
6075 CONTINUE
      CONSTA=6.2831852/RS
      FMBL=AREA*CONSTA*DELTA
      UIN2=50RTF(FMBL/(3.1415926*RHOE*UINF))
6080 AREA1=0.0

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SUBROUTINE STAOUT(KK)
  DO 6100 I=2,L
    IF(I-2) 6085,6090,6085
    6085 IF(I-L) 6095,6090,6095
    6090 AREA1=AREA1+(U(L)-U(I))*5
    GO TO 6100
    6095 AREA1=AREA1+(U(L)-U(I))
    6100 CONTINUE
    DO 303 N=1,LP2
      BLOCK(N)=U(N)
    303 CALL CONPRG(9)
      YTHU=YTH
    DO 313 N=1,LP2
      BLOCK(N)=FH(N)
    313 CALL CONPRG(9)
      YTHH=YTH
    DO 323 I=1,NS
      DO 323 N=1,LP2
        BLOCK(N)=C(N,I)
      CALL CONPRG(9)
    323 YTHC(I)=YTH
      THETA=AREA1/RS*DELTAP/(RHO(L)*U(L)**2)
      RETHET=(RHO(L)*U(L)*THETA)/FMUL(L)
      REX=(RHO(L)*U(L)*X)/FMUL(L)
      REW=(RHO(L)*U(L)*X)/FMUL(L)
      IF(FH(1)-FH(2)) 440,400,440
    400 DHDP12=0
    GO TO 440
    440 DO 540 I=1,NS
      IF(C(1,I)-C(2,I)) 540,500,540
    500 DCOPI2(I)=0
    GO TO 540
    540 CONTINUE
    GARB=0
    DO 560 I=1,NS
      GARB=GARB+FSH(1,I)*DKDL(1,I)*5* AAU*AC12(I)
      FNUREW=X*RS/SQRTF(REW)*(.5*AAU*AH12+FLEWL(1)*GARB)/(FH
1(L)-FH(1))
      FNUREX=FNUREW*SQRTF(REW/REX)
      DESTAR=Y(L)-(PSI(L)/RHO(L)/U(L)/RS)
      CSUB=TAUM(1)/(.5*RHO(L)*U(L)**2)
      WRITE OUTPUT TAPE 6,5145,X,DELTAX,Z1,RSM,FMBL,DIN2,PRSAVE,RETHET
      WRITE OUTPUT TAPE 6,5150,YTHU,YTHH,(YTHC(1),I=1,NS)
      WRITE OUTPUT TAPE 6,5155,REX,REW,DESTAR,THETA,FNUREX,FNUREW,CSUB
      WRITE OUTPUT TAPE 6,5160
    DO 6108 N=1,LP2
      CSUM=0.0
    DO 6106 I=1,NS
      CSUM=CSUM+C(N,I)
    6106 WRITE OUTPUT TAPE 6,5161,N,(C(N,I),I=1,NS),CSUM
    6108 IF(EPSI) 6120,6110,6120
    6110 WRITE OUTPUT TAPE 6,5165
    DO 6115 N=1,LP2
      WRITE OUTPUT TAPE 6,5166,N,PSI(N),Y(N),U(N),T(N),FSH(N),FH(N),RHO(
1,N)
    GO TO 6130
  
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SUBROUTINE STAOUT(KK)
6120 WRITE OUTPUT TAPE 6,5170
DO 6125 N=1,LP2
6125 WRITE OUTPUT TAPE 6,5171,N,PSI(N),Y(N),U(N),T(N),FSH(N),FH(N),RHO(
IN)
6130 WRITE OUTPUT TAPE 6,5175
DO 6135 N=1,LP2
EDENS(N)=5.664696E26*(N.7)*RHO(N)
6135 WRITE OUTPUT TAPE 6,5176,N,EDENS(N),FMUL(N),FMUT1P(N),TAUM(N)
EDEN12=5.664696E26*C12(7)*RHO12
WRITE OUTPUT TAPE 6,6136,U12,FH12,RHO12,T12,Y12,FSH12,TAUM(2),EDEN
12,(C12(1),I=1,NS)
6136 FORMAT(1H03X5HU 1/210X6HFH 1/29X7HRHO 1/28X5HT 1/210X5HY 1/210X8HS
IM H 1/26X8HTAUM 1/27X8HEDEN 1/2/1H 1P8E15.5/9H0C(I) 1/2/1H 1P7E15.
25)
IF (KK-9) 6138,6139,6139
6138 IPRINT=0
6139 IF (SENSE SWITCH 3) 6140,6150
6140 WRITE OUTPUT TAPE 6,5180
DO 6145 N=1,LP2
6145 WRITE OUTPUT TAPE 6,5185,N,(WDOT(N,I),I=1,NS)
6150 IF (SENSE SWITCH 5) 6155,6170
6155 WRITE OUTPUT TAPE 6,5190
WRITE OUTPUT TAPE 6,5195
DO 6165 N=1,LP2
DO 6160 I=1,NS
C MODIFY DSCRIP FOR SUBSCRIPT VARIABLE WHEN CHANGED IN MP
6160 PRDIRA(I)=WDOT(N,I)*DELTAP/RHO(N)/U(N)/RS/DSCRIP
6165 WRITE OUTPUT TAPE 6,5200,N,(PRDIRA(I),I=1,NS)
6170 RETURN
END(1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0)

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	DLC	CCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
A1L	32561	77461	A1T	32560	77460	A2	32559	77457	A3L	32558	77456	A3T	32557	77455
A4L	32556	77454	A4T	32555	77453	A5L	32554	77452	A5T	32553	77451	A6U	32548	55244
AB1T	32552	77450	AB2T	32551	77447	AB3T	32550	77446	AB4T	32549	77445	ARST	32548	77444
AB6T	32547	77443	AB7T	32546	77442	AC12	32545	77441	AH12	32535	77427	ALPHA	32534	77426
ASK	32533	77423	AU12	32523	77413	B1T	32522	77412	B2T	32462	77316	R3T	32402	77222
A4T	32342	77120	B5T	32282	77032	B6T	32222	76736	B7T	32162	76642	B8T	32102	76546
BB2T	32101	76545	BB3T	32100	76544	BB4T	32099	76543	BB5T	32098	76542	BB6T	32097	76541
BB7T	32096	76540	BC12	32095	76537	BH12	32085	76525	BLOCK	32084	76524	BSR	32024	76430
BU12	32014	76410	C12	31413	75265	CCALC	31353	75171	CC	31403	75253	CE	30753	74041
CM1	30143	72677	CM2	30133	72665	CM	30743	74027	COMAN	29533	71533	CPE	29531	71533
CP	29532	71534	C	32013	76415	CSR	28930	70402	CS	29530	71532	CSUP	23214	55256
DCUP12	28920	70370	DEL	28910	70356	DELTAP	28909	70355	DELTAX	28908	70354	DELXOD	28907	70353
DELXST	28906	70352	DHUP12	28905	70351	DIST	28904	70350	DKDL	28903	70347	DKOT	28903	67217
DN2D02	27702	66060	DN2	27703	66067	DNO	27701	66065	D02	27700	66064	DSCRIP	27349	66063
DUOP12	27698	66062	EDENS	27697	66061	EPSC1	27632	65764	EPSIH	27635	65763	EPSI	27637	65765
EPSIT	27634	65762	EPSIU	27633	65761	ETA	27632	65760	FA	27631	65757	FB	27630	65756
FC	27629	65755	FEDA	27628	65754	FEDR	27627	65753	FEDC	27626	65752	FH12	27565	65655
FHCALC	27564	65654	FHE	27504	65560	FHM2	27443	65463	FHM	27503	65557	FH	27625	65751
FHS	27383	65367	FINO	27323	65273	FKPS1	27321	65271	FK	27322	65272	FLELIN	27260	65174
FLELIN	27259	65173	FLEWL	27258	65172	FLEWT	27198	65076	FLN2	27138	65002	FLNOP	27018	64612
FLNO	27078	64706	FLO2	26958	64516	FL	27261	65175	FM	26898	64422	FMUL12	26328	64314
FMUL	26888	64410	FMUTIP	26827	64313	FMUTIP2	26767	64217	FNDSSH	26707	64123	FNDSSL	26706	64122
FMUREW	23215	65257	FIGUREX	23216	55260	FSH12	23210	55252	FSHE	26645	64025	FSHI12	26044	62674
FSH12	26644	64024	F5HP	26034	62662	FSH	26705	64121	FSKRA	26032	62660	FSKRR	26022	62646
FSKRC	26012	62634	FSKRU	26002	62622	FSKRE	26001	62621	FSKRF	26000	62620	FSKRK	25999	62617
FSK	26033	62631	FSML	25989	62605	FSMNOP	25986	62602	FSMNO	25987	62603	FSMN	25988	62604
FSMO	25985	62601	GAM	25984	62600	HE	25983	62577	HH	25982	62576	IALT	25977	62571
IDEL	25976	62570	IUDCOC	25975	62567	INDLAS	25965	62555	INDPRI	25954	62542	INDP	25955	62543
INDPS	25953	62541	IINDR	25903	62457	IINDSTP	25902	62456	INDSTR	25901	62455	INDTRY	25900	62454
IPRINT	23213	55255	JBYCTR	23211	55253	JINOUT	25890	62442	JS	25889	62441	KS	25888	62440
LP2	25886	62436	L	25887	62437	NCOUNT	23212	55254	NPSI	25885	62435	NSR	25883	62433
NS	25884	62434	OGIVLH	25882	62432	OGIVEK	25881	62431	PE	25872	62420	PRALIN	25810	62322
PRAL	25870	62416	PRATIN	25749	62225	PRAT	25809	62321	PRDIRA	25748	62224	PRDS	25688	62130
PRP	25687	62127	PR	25871	62417	PRSAVE	25686	62126	P	25880	62430	PSCALC	25285	61305
PS1	25225	61211	PSITCU	25165	61115	PS	25685	62125	OW	25164	61114	RESTAR	25162	61112
METHET	23219	55263	REK	23217	55261	REX	23218	55262	RH012	23205	60720	RHOCAL	25101	61015
RH0E	25041	60621	RHO	25161	61111	RH0STG	25039	60717	RH0U12	25043	55245	RN	25038	60716
RNS	25037	60715	R	25163	61113	RSC	24036	60632	RSM	24985	60631	RS	24987	60633
SCHLIN	24984	60630	SCHTIN	24983	60627	SCL	24382	60626	SCT	24922	60532	SHANGL	24862	60436
SIGMAC	24661	60435	SIGMAH	24801	60341	SIGMAU	24741	60245	STADIS	24681	60151	STRLL	23207	55247
STRUL	23206	55246	T12	23209	55251	TAUM	24620	60054	TAUP	24560	57760	TESTRA	24500	57664
THETAT	24459	57663	THPER	24498	57662	TIN	24497	57661	TITLE1	24496	57660	TITLE2	24484	57644
TITLE3	24472	57630	TN	24460	57614	T	24680	60150	TVN2	24000	57520	TVPNO	24398	57516
TVNO	24399	57517	TV02	24397	57515	U12	24336	57420	UCALC	24335	57417	U5	24275	57323
UI0F	24274	57322	ULOLIM	24273	57321	UM1	24212	57224	UM2	24152	57130	UM	24272	57320
U	24396	57514	US	24092	57034	WDOT	24032	56740	X1	23431	55607	XL	23430	55606
XL5	23429	55605	XRN	23379	55523	X	23432	55610	XS	23378	55522	XU12	23377	55521
Y12	23208	55250	YCALC	23316	55424	Y	23376	55520	YTHC	23255	55327	YTH	23256	55330

SUBROUTINE STAOUT(KK)

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YTHU 23245 55315 Z1L 23243 55313 Z1R 23242 55312 Z1 23244 55314 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
AREA1	2086 04046	AREA	2085 04045	CONSTA	2084 04044	CSUM	2083 04043
DIN2	2081 04041	EDEN12	2080 04040	FMBL	2079 04037	GARB	2078 04036
N	2076 04034	THETA	2075 04033	TINF	2074 04032	YTHH	2073 04031

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
8)458	5000 04015	8)45D	5005 04003	8)45I	5010 03742	8)45N	5015 03723
8)4T1	5025 03704	8)4T6	5030 03651	8)4TB	5035 03643	8)4TE	5038 03635
8)4TL	5045 03622	8)4TQ	5050 03607	8)4TV	5055 03571	8)4U4	5060 03555
8)4UE	5070 03506	8)4UJ	5075 03467	8)4UO	5080 03435	8)4UT	5085 03407
8)4V7	5095 03331	8)4VC	5100 03322	8)4VH	5105 03307	8)4VM	5110 03300
8)500	5120 03216	8)505	5125 03154	8)50A	5130 03133	8)50F	5135 03103
8)50P	5145 03073	8)50U	5150 03031	8)513	5155 02764	8)518	5160 02734
8)51D	5165 02713	8)51E	5166 02657	8)51I	5170 02653	8)51J	5171 02620
8)51O	5176 02570	8)51S	5180 02564	8)521	5185 02510	8)526	5190 02504
8)526	5200 02463	8)5V0	6136 02457			8)528	5195 02475

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1)	2062 04016	2)	1287 02407	3)	1294 02416	6)	1300 02424
C)62	2068 04024	C)63	2069 04025	C)102	2070 04026	C)200	2071 04027
E)7	147 00223	E)D	235 00353	E)F	250 00372	E)10	606 01136

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
ATAN	2 00002	CONPRG	5 00005	COS	3 00003	SORT	4 00004
(5TH)	0 00000					(FIL)	1 00001

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN CONPRG COS SORT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
5800	59 00035	6000	75 00162	6001	77 00174	6003	80 00225
6010	84 00260	6015	87 00307	6020	90 00337	6025	93 00354
6035	97 00373	6040	98 00401	6041	126 00763	6045	143 01104
27697	152 01143	6047	153 01146	6048	154 01153	6050	157 01201
6060	163 01224	6065	164 01231	6070	166 01246	6075	167 01260
6085	174 01322	6090	175 01327	6095	177 01336	6100	178 01342
313	185 01407	323	192 01440	400	198 01515	440	200 01523
540	204 01542	560	207 01556	6106	226 02002	6108	227 02010
6115	236 02053	6120	239 02103	6125	241 02114	6130	243 02143
6138	256 02250	6139	257 02252	6140	258 02254	6145	260 02276
6155	267 02317	6160	271 02344	6165	272 02361	6170	278 02403

SUBROUTINE STEPSZ

SUBCLYTINE STEPSZ

CG-MCN AIL,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
11AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
21AB3T,AB5T,AB7T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BB12,BH12,
33BLDCK,BSR,BU12,C,C12,C2,CCALC,CE,CM,CM1,CM2,CDNEAN,CP,CPE,CS,
44CSR,DCCP12,DEL,DELTAP,DELXALC,DELXOD,DELXST,DHDPI2,DIST,DKDL,
55DKCT,DN2,DN2002,DNO,DC2,GSCRIP,DUDPI2,EDENS,EPSI,
66EPSIC,EPSIH,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
77FECG,FF,HH12,FHCALC,FHE,FHM,FHM2,FHS
COMPCN FIND,FK,FKPSI,FL,FLELIN,FLELIN,FLEWL,FLEWT,
11FLN2,FLNC,FLNCP,FLQ2,FM,FMUL,FMU12,FMUTIM,FMUTIP,FNDSSH,
22FNCSL,FSH,FSNE,FSH1,FSH12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
33FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNC,FSMD,GAMM,HE,
44HH,IALT,IUEL,INDCCO,INDLAS,INDP,INDPRI,INDPS,INDR,
55INDSTP,INDSTR,INDTYP,INJPUT,JS,KS,L,LP2,NPSI,NS,NSR,
66GIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMCN PROS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RHD,
11RHDCAL,RHDE,RHCL12,RHDSGT,RN,RNS,RS,RSC,RSN,SCHLIN,SCHTIN,
22SCL,SCT,SPANGL,SIGMAC,SIGMAH,SIGMAU,
33STACLS,I,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
44TITLE1,TITLE2,TITLE3,TM,TM2,
55TVNC,TVNDP,TVD2,U,U12,U4CALC,UE,UINF,ULDLIN,UM,UMI,
66UM2-US,WDDT,X,X1,XL,XLS,XPN,XS,XU12,Y,YCALC,YTH,YTHC,
77YTHU,Z1,ZIL,ZIR,ZIS,Z2,Z2R,Z2S

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DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),B8C12(10),BLOC(60),BSR(10),C(60,10),C12(10),
2,CCC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3,CCM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
4,FDENS(60),FHE(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5,FKPS1(60),FLEW(60),FLEWT(5),FLN2(60),FLND(60),
6,FLNCP(60),FL02(60),FM(10),FMUL(60),FMUTIM(60),
DIMENSION FMTU1P(60),FSH(60),FSH1(60,10),FSH12(10),FSKRA(10),
1,FSKR3(10),FSKRC(10),FSKRP(10),MH(5),INOCDO(10),
2,INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
3,PRAI(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
4,RHDCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5,SIGPAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6,TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60),
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
1,WDT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),ZIR(10),
2,ZIR2(10)

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PAGE 2

SUBROUTINE STEPSZ

```

IF(SENSE SWITCH 2)106.108
106 CALL STACUT(3)
108 CC 114 N=1.0LP2
    IF(UM(N)) 116.111.111
111 CC 112 I=1.0NS
    IF(CM(N,I)) 118.112.112
112 CC CONTINUE
    IF(FPM(N)) 118.113.113
113 IF(T(N))118.114.114
114 CC CONTINUE
    IF(SENSE SWITCH 5) 1142.1162
1142 CC 116 N=1.0L
    IF((UM(N+1)-UM(N))/UM(N+1)+.05) 118.116.116
116 CC CONTINUE
1162 IF(X+3.1*DELTAX-XL) 120.130.130
118 PRINT 119.N.X.DELTAX
119 FORMAT(3X23+STEP SIZE CRITERIA N=13.5H X=1PE13.5.10H DELTAX=
11PE13.5)
    ACCUN7=ACCUN7+1
    IF(NCCUN7-7) 515.600.600
120 RS=RSM
125 IDEI=IDEL+1
    X=X+DELTAX
    INCSTP=2
    RETURN
130 X=X+DELTAX
    RS=RSM
    INCSTP=3
    RETURN
200 IF (SENSE SWITCH 2) 202.206
202 CC 205 N=1.0LP2
    L(N)=UM(N)
    FH(N)=FPM(N)
    CC 205 I=1.0NS
    C(N,I)=CM(N,I)
205 CALL STACUT(3)
206 CC 210 N=1.0LP2
    U(N)=LS(N)
    UM2(N)=UM(N)
    FH(N)=FPM(N)
    FHP2(N)=FHP(N)
    CC 210 I=1.0NS
    C(N,I)=CS(N,I)
210 CM2(N,I)=CM(N,I)
    RS=RSSS
    RSW=RSM
    DELTAX=2.0*DELTAX
    X=X+DELTAX
    CC 1C 125
300 CC 320 N=1.0LP2
    IF(ABSF((UM2(N)-UM(N))/UM2(N))-FNDSSL) 310.310.400
310 IF(ABSF((FHP2(N)-FHP(N))/FHP2(N))-FNCSSL) 320.320.400
320 CC CONTINUE
    IF(I42) 341.325.325
325 CC 340 I=1.0NS
    CC 340 N=1.0LP2

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PAGE 3

SUBROUTINE STEPSZ

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330 IF(ABS((CM2(N,I)-CM(N,I))/CM2(N,I))-FNDSSL) 340.340.400
340 CONTINUE
341 INCSS=1
342 IF(SENSE SWITCH 6) 343.346
343 PRINT 345.CELTAX.X
345 FORMAT(20H DELTAX INCREASED TO1PE15.8.7H X=1PE15.8)
346 CO 350 N=1.LP2
      U(N)=UP(N)
      FM(N)=FM(N)
      CO 350 I=1.NS
350 C(N,I)=CM(N,I)
352 CC 360 N=2.L
      IF(INCSS=1) 360.365.365
360 RSMRS=RS*RHQ(N)*UP1(N)*RS
      GC TC 370
365 RSMRS=RS*RHQ(N)*U(N)*RS
370 SIGNAL(N)=RSMRS*(A1L*FMUL(N)+A1T*(FMUT1P(N)+FMUT1M(N))*5)
      SIGMAH(N)=RSMRS*(A4L*FMUL(N)/PRAL(N)+A4T*(FMUT1P(N)+FMUT1M(N))*5/
      1PRAT(N))
      IF(A2) 3708.3705.3705
3705 SIGMAC(N)=RSMRS*(A3L*FMUL(N)*DKOL(N,1)/SCL(N)+A3T*.5*(FMUT1P(N)+FM
      1UT1P(N))*CKOT(N,1)/SCT(N))
3708 IF (SENSE SWITCH 2) 371.373
371 WRITE OUTPUT TAPE 6.372.N.SIGMAU(N).SIGMAC(N).SIGMAH(N)
372 FCRAI(5X13.1P3E13.5)
373 IF(SIGMAU(N)) 374.375.374
374 IF(DELTAX-DELTAP**2/2.0/SIGMAU(N)/1.00001) 375.375.485
375 IF(A2) 377.3755.3755
3755 IF(SIGMAC(N)) 376.377.376
376 IF(DELTAX-DELTAP**2/2.0/SIGMAC(N)/1.00001) 377.377.485
377 IF(SIGMAH(N)) 378.380.378
378 IF(DELTAX-DELTAP**2/2.0/SIGMAH(N)/1.00001) 380.380.485
380 CONTINUE
      JS=JS+1
385 CALL STAQUT(3)
390 NCCLN7=C
      JBYCTR=JBYCTR+2
      GC TC 130
400 CO 420 N=1.LP2
      IF(ABS((UP2(N)-UP(N))/UP2(N))-FNDSSH) 410.410.470
410 IF(ABS((FHM2(N)-FHM(N))/FHM2(N))-FNDSSH) 420.420.470
420 CCNTINLE
      IF(-2) 445.425.425
425 CC 440 I=1.NS
      CO 440 N=1.LP2
430 IF(ABS((CM2(N,I)-CM(N,I))/CM2(N,I))-FNDSSH) 440.440.470
440 CCNTINLE
445 INCSS=-1
      CELTAX=.5*CELTAX
      CC 460 N=1.LP2
      U(N)=UP2(N)
      FM(N)=FHM2(N)
      CO 460 I=1.NS
      C(N,I)=CM2(N,I)
      RSM=RSM5
      GC TC 352

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SUBROUTINE STEPSZ

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470 IF(JBYCTR-JINPUT)445,445,500
485 IF(SENSE SWITCH 6)486,500
486 PRINT 450
490 FORMAT(5X22+STARILITY REQD HALVING)
500 IF(SENSE SWITCH 6)501,506
501 PRINT 505,DELTA,X
505 FORMAT(20H DELTA DEC TC 1/4 IPE15.8.7H X=IPE15.8.7H
506 ACCLN7=NCCLN7+1
IF(NCCLN7-7)507,600,600
507 DO 510 A=1,LP2
U(N)=U(N)
FH(N)=FH(N)
DO 510 I=1,NS
C(N,I)=CM(N,I)
CALL STACUT(3)
515 DO 520 A=1,LP2
U(N)=US(N)
FH(N)=FS(N)
DO 520 I=1,NS
C(N,I)=CS(N,I)
520 RS=RSS
X=X+.75*DELTA
DELTA=.25*DELTA
INDSTP=1
RETURN
600 PRINT 602
602 FORMAT(2X22+DELTA X HALVED 7 TIMES)
PAUSE 603
GC TC 515
ENC(1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0)

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SUBROUTINE STEPSZ

DEC OCT
801 01441

STORAGE NOT USED BY PROGRAM

DEC OCT
23210 55252

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STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

A1L 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	A5T 32553 77451	A6T 32552 77450
A8T 32551 77447	A8T 32550 77446	A8T 32549 77445	A8T 32548 77444	A8T 32547 77443
A8T 32546 77442	AC12 32545 77441	AH12 32535 77427	ALPHA 32534 77426	ASR 32533 77425
AU12 32523 77413	B1T 32522 77412	B2T 32462 77316	B3T 32402 77222	B4T 32342 77126
B5T 32282 77032	B6T 32222 76736	B7T 32162 76642	B8T 32102 76546	B8T 32101 76545
B3T 32100 76544	B8T 32099 76543	B8T 32098 76542	B8T 32097 76541	B8T 32096 76540
B8T 32095 76537	BH12 32085 76525	BLOCK 32084 76524	BSR 32024 76430	BUI2 32014 76416
C12 31413 75265	CCALC 31353 75171	CC 31403 75253	CE 30753 74041	CM1 30143 72677
CM2 30133 72665	CM 30743 74027	CONAN 29533 71535	CPE 29531 71533	CP 29532 71534
C 32013 76415	CSR 28930 70402	CS 29530 71532	CSUB 23214 55256	DCDP12 28920 70370
DEL 28910 70356	DEL TAP 28909 70355	DEL TAX 28908 70354	DELXOD 28907 70353	DELXST 28906 70352
DN2 27703 66067	DIST 28904 70350	OKOL 28903 70347	DKOT 28303 67217	DN2D02 27702 66066
EDENS 27697 66061	DNO 27701 66065	DO2 27700 66064	DSCRIP 27699 66063	DUDP12 27698 66062
EPSIU 27633 65761	EPSIC 27636 65764	EPSIH 27635 65763	EPSI 27637 65765	EPSIT 27634 65762
FED8 27628 65754	ETA 27632 65760	FEDC 27626 65752	F8 27630 65756	FC 27629 65755
FHE 27504 65560	FHM2 27443 65463	FHM 27503 65557	FH12 27565 65655	FHCALC 27564 65654
FINO 27323 65273	FKPS1 27321 65271	FK 27322 65272	FH12 27565 65655	FHS 27383 65367
FLEWL 27258 65172	FLEMT 27198 65076	FLN2 27138 65002	FLELIN 27260 65174	FLETIN 27259 65173
FLU2 26558 64516	FL 27261 65175	FM 26898 64422	FLN2 27138 65002	FLND 27078 64706
FMUTIM 26827 64313	FMUTIP 26767 64217	FNDSSH 26707 64123	FNDSSL 26706 64122	FMUL 26808 64410
FNUREX 23216 55260	FSHE 26645 64025	FSH12 26044 62674	FSH1 26644 64024	FNUREW 23215 55257
FSH 26705 64121	FSKRA 26032 62660	FSKR8 26022 62646	FSKRD 26012 62634	F3HP 26034 62662
FSKRE 26001 62621	FSKRF 26000 62620	FSKR8 26022 62646	FSME 25989 62605	FSKRD 26002 62662
FSMNOP 25986 62602	FSMNO 25987 62603	FSMN 25988 62604	GAMM 25984 62600	GAMM 25984 62600
HE 25983 62577	HH 25982 62576	IALT 25977 62571	INDCOO 25975 62567	INDCOO 25975 62567
INCLAS 25565 62555	INDPRI 25954 62542	INDP 25955 62543	INDR 25903 62457	INDR 25903 62457
INDSTP 25502 62456	INDSTR 25901 62455	INDTYP 25900 62454	JBYCTR 23211 55253	JBYCTR 23211 55253
JINPOT 25890 62442	JS 25889 62441	NS 25888 62440	LP2 25886 62436	L 25887 62437
UGIVEK 25881 62431	NPS1 25885 62435	NSR 25883 62433	NS 25884 62434	OGIVEH 25882 62432
PRAT 25809 62321	PE 25872 62420	PRALIN 25810 62322	PRAL 25870 62416	PRATIN 25749 62225
PRSAVE 25686 62126	PRDIRA 25748 62224	PRDS 25688 62130	PRP 25687 62127	PR 25871 62417
PS 25685 62125	P 25880 62430	PSCALC 25285 61305	PSI 25225 61211	PSITCU 25165 61115
REX 23218 55262	RHO12 25040 60720	RHOCAL 25101 61015	RHOE 25041 60721	REW 23217 55261
RHOS1G 25039 60717	RN 25038 60716	RNS 25037 60715	R 25143 61113	RHO 25161 61111
RSM 24985 60631	RS 24987 60633	SCHLIN 24984 60630	SCHTIN 24983 60627	RSC 24986 60632
SCT 24522 60532	SHANGL 24862 60436	SIGMAC 24861 60435	SIGMAH 24801 60341	SCL 24982 60626
STADIS 24681 60151	TAUM 24620 60054	TAUP 24560 57760	TESTRA 24500 57664	SIGMAU 24741 50245
THPER 24458 57662	TIN 24497 57661	TITLE1 24496 57660	TITLE2 24484 57644	THETAT 24499 57653
TM 24460 57614	T 24680 60150	TVN2 24400 57520	TWNOP 24398 57516	TITLE3 24472 57630
TVO2 24397 57515	U12 24336 57420	UCALC 24335 57417	UE 24275 57323	TWNO 24399 57517
ULOLIM 24273 57321	UM1 24212 57224	UM2 24152 57607	UM 24272 57320	UINF 24274 57322
US 24092 57034	WOT 24032 56740	XI 23431 55607	XL 23430 55606	U 24396 57514
XRN 23375 55523	X 23452 55610	XS 23378 55522	XUI2 23377 55521	XLS 23429 55605

SUBROUTINE STEPSZ

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

INDSS	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
800	800	01440	I	799	01437	N	797	01435
RMS	795	01433	RSS	794	01432			
								796 01434

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
81A	345 01401	81B	372 01370	81FA	490 01365	81FP	505 01360
81C	602 01347						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
782	01416	21	719 01317	31	726 01326	61	733 01335
787	01423	C1101	788 01424	C1200	789 01425	C1201	790 01426
792	01430	C1204	793 01431	O1132	611 01143	O1131	711 01307
132	00204	D143D	664 01230	O1600	131 00203	D1700	130 00202
66	00102	E1E	85 00125	E1M	117 00165	E110	272 00420
304	00460	E12P	563 01063	E13D	666 01232	E11H	790 00442

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
0	00000	(FIL)	2 00002	(SPH)	1 00001	(STH)	3 00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

(FIL)	(SPH)	(STH)
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
50	16	00015	100	17	00021	105	25	00051
111	31	00107	112	33	00122	113	35	00136
116	40	00171	1162	41	00173	118	42	00205
130	52	00250	200	57	00263	202	58	00265
210	71	00345	300	77	00370	310	79	00407
330	84	00447	340	85	00467	341	86	00476
350	94	00531	352	95	00541	360	97	00554
3705	103	00635	3708	104	00660	371	105	00662
375	109	00714	3755	110	00720	376	111	00722
380	114	00754	385	116	00765	390	117	00767
420	123	01031	425	125	01040	430	127	01052
460	135	01130	470	138	01144	485	139	01151
501	142	01160	506	144	01167	507	146	01176
520	156	01255	600	163	01310			
						510	150	01216
						515		
						378		
						410		
						445		
						500		
						141		
						152		
						108		
						1142		
						125		
						206		
						325		
						346		
						370		
						374		
						108		
						113		
						122		
						129		
						141		
						152		
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SUBROUTINE UCSTHE

SUBROUTINE UCSTRE

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COMMON AIL,A11,A2,A3,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
11AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AM12,ALPHA,ASR,AU12,B01T,B2T,B3T,
21AB4T,B5T,B6T,B7T,B8T,B9T,BB0T,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,BB8T,BB9T,
31BBLOCK,B5R,BU12,C,C12,C2,C3,C4,C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C32,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C65,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81,C82,C83,C84,C85,C86,C87,C88,C89,C90,C91,C92,C93,C94,C95,C96,C97,C98,C99,C100,C101,C102,C103,C104,C105,C106,C107,C108,C109,C110,C111,C112,C113,C114,C115,C116,C117,C118,C119,C120,C121,C122,C123,C124,C125,C126,C127,C128,C129,C130,C131,C132,C133,C134,C135,C136,C137,C138,C139,C140,C141,C142,C143,C144,C145,C146,C147,C148,C149,C150,C151,C152,C153,C154,C155,C156,C157,C158,C159,C160,C161,C162,C163,C164,C165,C166,C167,C168,C169,C170,C171,C172,C173,C174,C175,C176,C177,C178,C179,C180,C181,C182,C183,C184,C185,C186,C187,C188,C189,C190,C191,C192,C193,C194,C195,C196,C197,C198,C199,C200,C201,C202,C203,C204,C205,C206,C207,C208,C209,C210,C211,C212,C213,C214,C215,C216,C217,C218,C219,C220,C221,C222,C223,C224,C225,C226,C227,C228,C229,C230,C231,C232,C233,C234,C235,C236,C237,C238,C239,C240,C241,C242,C243,C244,C245,C246,C247,C248,C249,C250,C251,C252,C253,C254,C255,C256,C257,C258,C259,C260,C261,C262,C263,C264,C265,C266,C267,C268,C269,C270,C271,C272,C273,C274,C275,C276,C277,C278,C279,C280,C281,C282,C283,C284,C285,C286,C287,C288,C289,C290,C291,C292,C293,C294,C295,C296,C297,C298,C299,C300,C301,C302,C303,C304,C305,C306,C307,C308,C309,C310,C311,C312,C313,C314,C315,C316,C317,C318,C319,C320,C321,C322,C323,C324,C325,C326,C327,C328,C329,C330,C331,C332,C333,C334,C335,C336,C337,C338,C339,C340,C341,C342,C343,C344,C345,C346,C347,C348,C349,C350,C351,C352,C353,C354,C355,C356,C357,C358,C359,C360,C361,C362,C363,C364,C365,C366,C367,C368,C369,C370,C371,C372,C373,C374,C375,C376,C377,C378,C379,C380,C381,C382,C383,C384,C385,C386,C387,C388,C389,C390,C391,C392,C393,C394,C395,C396,C397,C398,C399,C400,C401,C402,C403,C404,C405,C406,C407,C408,C409,C410,C411,C412,C413,C414,C415,C416,C417,C418,C419,C420,C421,C422,C423,C424,C425,C426,C427,C428,C429,C430,C431,C432,C433,C434,C435,C436,C437,C438,C439,C440,C441,C442,C443,C444,C445,C446,C447,C448,C449,C450,C451,C452,C453,C454,C455,C456,C457,C458,C459,C460,C461,C462,C463,C464,C465,C466,C467,C468,C469,C470,C471,C472,C473,C474,C475,C476,C477,C478,C479,C480,C481,C482,C483,C484,C485,C486,C487,C488,C489,C490,C491,C492,C493,C494,C495,C496,C497,C498,C499,C500,C501,C502,C503,C504,C505,C506,C507,C508,C509,C510,C511,C512,C513,C514,C515,C516,C517,C518,C519,C520,C521,C522,C523,C524,C525,C526,C527,C528,C529,C530,C531,C532,C533,C534,C535,C536,C537,C538,C539,C540,C541,C542,C543,C544,C545,C546,C547,C548,C549,C550,C551,C552,C553,C554,C555,C556,C557,C558,C559,C560,C561,C562,C563,C564,C565,C566,C567,C568,C569,C570,C571,C572,C573,C574,C575,C576,C577,C578,C579,C580,C581,C582,C583,C584,C585,C586,C587,C588,C589,C590,C591,C592,C593,C594,C595,C596,C597,C598,C599,C600,C601,C602,C603,C604,C605,C606,C607,C608,C609,C610,C611,C612,C613,C614,C615,C616,C617,C618,C619,C620,C621,C622,C623,C624,C625,C626,C627,C628,C629,C630,C631,C632,C633,C634,C635,C636,C637,C638,C639,C640,C641,C642,C643,C644,C645,C646,C647,C648,C649,C650,C651,C652,C653,C654,C655,C656,C657,C658,C659,C660,C661,C662,C663,C664,C665,C666,C667,C668,C669,C670,C671,C672,C673,C674,C675,C676,C677,C678,C679,C680,C681,C682,C683,C684,C685,C686,C687,C688,C689,C690,C691,C692,C693,C694,C695,C696,C697,C698,C699,C700,C701,C702,C703,C704,C705,C706,C707,C708,C709,C710,C711,C712,C713,C714,C715,C716,C717,C718,C719,C720,C721,C722,C723,C724,C725,C726,C727,C728,C729,C730,C731,C732,C733,C734,C735,C736,C737,C738,C739,C740,C741,C742,C743,C744,C745,C746,C747,C748,C749,C750,C751,C752,C753,C754,C755,C756,C757,C758,C759,C760,C761,C762,C763,C764,C765,C766,C767,C768,C769,C770,C771,C772,C773,C774,C775,C776,C777,C778,C779,C780,C781,C782,C783,C784,C785,C786,C787,C788,C789,C790,C791,C792,C793,C794,C795,C796,C797,C798,C799,C800,C801,C802,C803,C804,C805,C806,C807,C808,C809,C810,C811,C812,C813,C814,C815,C816,C817,C818,C819,C820,C821,C822,C823,C824,C825,C826,C827,C828,C829,C830,C831,C832,C833,C834,C835,C836,C837,C838,C839,C840,C841,C842,C843,C844,C845,C846,C847,C848,C849,C850,C851,C852,C853,C854,C855,C856,C857,C858,C859,C860,C861,C862,C863,C864,C865,C866,C867,C868,C869,C870,C871,C872,C873,C874,C875,C876,C877,C878,C879,C880,C881,C882,C883,C884,C885,C886,C887,C888,C889,C890,C891,C892,C893,C894,C895,C896,C897,C898,C899,C900,C901,C902,C903,C904,C905,C906,C907,C908,C909,C910,C911,C912,C913,C914,C915,C916,C917,C918,C919,C920,C921,C922,C923,C924,C925,C926,C927,C928,C929,C930,C931,C932,C933,C934,C935,C936,C937,C938,C939,C940,C941,C942,C943,C944,C945,C946,C947,C948,C949,C950,C951,C952,C953,C954,C955,C956,C957,C958,C959,C960,C961,C962,C963,C964,C965,C966,C967,C968,C969,C970,C971,C972,C973,C974,C975,C976,C977,C978,C979,C980,C981,C982,C983,C984,C985,C986,C987,C988,C989,C990,C991,C992,C993,C994,C995,C996,C997,C998,C999,C1000,C1001,C1002,C1003,C1004,C1005,C1006,C1007,C1008
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DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),B8C12(10),BLOC(60),BSR(10),C(60),C10(10),C12(10),
2,CC15(10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3,CC15(10),C3(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
4,MEDEMS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5,FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
6,FLNUP(60),FLO2(60),FMU(10),FMUL(60),FMUTIM(60)
DIMENS(UN FPUTIP(60),FSH(60),FSMI(60,10),FSMI12(10),FSKRA(10),
7,FSKR8(10),FSKRC(10),FSKRP(10),SH(5),INDCOO(10),
8,INDKAS(10),INDPS(50),INDTP(10),F(8),PROIRA(60),
9,BPRAL(60),PRAT(60),PSI8(50),PSCALC(60),PSI(60),RHO(60),
10,RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
11,SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
12,TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
13,WDUT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),ZIR(10),
14,ZZR(10)

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1 IF(INOSTR) 5000.50,2
2 GO TO (3,4,5,3,5),INOR
3 THETAT=1.5707963-(ALPHA+XRN)
4 GO TO 7
5 THETAT=CONAN
6 GO TO 7
7 THETAT=0.0
8 IF(EPSI) 0,9,10
9 TWOPI=1.0
10 RS1PE=RS

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GO TO 12
10 TWOPI=6.2831853
   RSIME=1.0
12 FMBL=0.0
   DO 15 N=2,4
15 FMBL=FMBL+2.0*Y(N)
   FMBL=(FMBL+Y(1)-Y(4))*TWOPI*COSE(THETAT)*DELTAP/RS+TWOPI*RSIME*PSI
   I(LL)
   DIN2=SQRT(FMBL/RHDE/UINF/3.1415926)
   IF(DIN2-RS) 19,19,16
16 PRINT 17,DIN2,RS,FMBL,THETAT
17 FORMAT(7H DIN2=1PE13.5,4HRS =1PE13.5,1P2E13.5)
   DIN2=.9*RS
19 DO 20 N=1,10
   IF(DIN2-ZZK(N))25,25,20
20 CONTINUE
   STOP 21
25 IF(INDTYP(1)-1)29,26,29
26 ZIA=0.0
   THETA=1.5707963
   GO TO 40
29 IF(INDTYP(N)-6)30,35,35
30 ZIA=(DIN2-BSR(N))/ASR(N)
   THETA=ATANF(ASR(N))
   GO TO 40
35 ZIA=ASR(N)+BSR(N)*(DIN2-CSR(N))*2
   THETA=ATANF(.5/BSR(N)/(DIN2-CSR(N)))
40 DIST=SQRT(ZIA-21)*2+(DIN2-22)*2
   FMI=UINF/49.9/SQRTF(1.8*FSHE/CPE)
   PROS=PE*(2.0*GAMM*(FMI*SINF(THETA))*2-GAMM+1.0)/(GAMM+1.0)
   UDS=SQRTF(1.0-(4.0*(FMI*2*(SINF(THETA))*2-1.0)*(GAMM*(FMI*SINF
   1(THETA))*2+1.0))/(GAMM+1.0)*2*FMI*2*(SINF(THETA))*2))*UINF
   SCOMP=(21-ZIA)/DIST
   UESTAR=UDS
42 WRITE OUTPUT TAPE 6,42,THETA,PROS,ZIA,DIN2,UDS
   IN DIN2=1PE13.5,6H UDS=1PE13.5)
   GO TO 52
50 UESTAR=UE
52 NCOUNT=0
55 WRITE OUTPUT TAPE 6,55
   FORMAT(6X3HXD10X4HZ10010X1HUI1X4HC(N)8X5HC(M)8X6HC(MD)8X5HC(E-))
   110X1MT11X3HRNO10X2HNE/,)
   K=1
   IF(INDSTR) 5555,56,58
56 X00=X5+DELXST
   GO TO 60
58 X00=DELXST
   Z100=Z1A+SCOMP*DELXST
60 U(L+3)=UESTAR
   DO 65 I=1,NS
65 C(L+3,I)=CE(I)
   FMI(L+3)=FMI
   PSI(L+3)=PSI(L+2)+DELTAP
70 INDF00=-1
   DELX00=DELXST

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100 CALL PRTERH(X00,L+3,L+3,K)
   IF(A2) IC05,I005,I003
1003 CALL WOOTRT(L+3,L+3)
1005 US(L+3)=U(L+3)
   UM1(L+3)=U(L+3)-PRP/RHO(L+3)*DELX00/U(L+3)
   U(L+3)=UM1(L+3)
   DO 1020 I=1,NS
     CS(L+3,I)=C(L+3,I)
     CM1(I) =C(L+3,I)+DELX00*WOOT(L+3,I)/U(L+3)/RHO(L+3)
1020 C(L+3,I)=CM1(I)
     X00=X00+DELX00
     IF(INOSTR)5555,1022,1021
1021 Z100=Z100+SCOMP*DELX00
1022 CALL PRTERH(X00,L+3,L+3,K)
   IF(A2) 1025,1025,1023
1023 CALL WOOTRT(L+3,L+3)
1025 UM2(L+3)=U(L+3)-PRP/RHO(L+3)*DELX00/U(L+3)
   U(L+3)=US(L+3)
   DO 2030 I=1,NS
     CM2(L+3,I)=C(L+3,I)+DELX00*WOOT(L+3,I)/U(L+3)/RHO(L+3)
2030 C(L+3,I)=CS(L+3,I)
     DELX00=2.0*DELX00
     CALL PRTERH(X00,L+3,L+3,K)
   IF(A2) 2035,2035,2033
2033 CALL WOOTRT(L+3,L+3)
2035 UM(L+3)=U(L+3)-PRP/RHO(L+3)*DELX00/U(L+3)
   DO 2040 I=1,NS
     CM(L+3,I)=C(L+3,I)+DELX00*WOOT(L+3,I)/U(L+3)/RHO(L+3)
2040 IF(ABSF(UM2(L+3)-UM(L+3))/UM2(L+3))-FNDSSL)2050,2050,2070
2050 IF(A2) 2065,2052,2052
2052 DO 2060 I=1,NS
     IF(ABSF(CM2(L+3,I)-CM(L+3,I))/CM2(L+3,I))-FNDSSL)2060,2060,2070
2060 CONTINUE
2065 IND22=C
     GO TO 2110
2073 IF(ABSF(UM2(L+3)-UM(L+3))/UM2(L+3))-FNDSSH)2080,2080,2100
2080 IF(A2) 2095,2082,2082
2082 DO 2090 I=1,NS
     IF(ABSF(CM2(L+3,I)-CM(L+3,I))/CM2(L+3,I))-FNDSSH)2090,2090,2100
2090 CONTINUE
2095 IND22=1
     GO TO 2110
2103 X00=X00-.75*DELX00
     IND22=-1
     IF(INOSTR) 5555,2105,2103
2103 Z100=Z100-.75*DELX00*SCOMP
2105 DELX00=.25*DELX00
     GO TO 100
2110 IF(INOSTR)5555,2120,2115
2115 IF(Z100+SCOMP*DELX00-Z11)2150,2130,2130
2120 IF(X00+DELX00-X) 2145,2130,2130
2130 UM(L+3)=UM1(L+3)
   DO 2140 I=1,NS
     CM(L+3,I)=CM1(I)
     X00=X00-.5*DELX00
     IF(INOSTR) 5555,2143,2141

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2141 2100-2100-.5*DELX00*SCOMP
2143 DELX00=0.5*DELX00
GO TO 2500
2145 IF(X00-DELX00-XLS(K)) 2150,2130,2130
2150 IF(IND22) 2500,2500,2170
2170 UM(L+3)=UM2(L+3)
DO 2180 I=1,NS
2180 CM(L+3,I)=CM2(L+3,I)
DELX00=0.5*DELX00
2500 IF(UM(L+3)-ULOLIM) 2505,2510,2510
2505 UM(L+3)=ULOLIM
2510 IF(IND22) 3060,2000,3060
2600 FNE=RHD(L+3)*CM(L+3,7)*5.664696E26
WRITE OUTPUT TAPE 6,3005,X00,2100,UM(L+3),(CM(L+3,I),I=4,NS),T(L+3
),RHD(L+3),FNE
3005 FORMAT (1H,1P10E13.5)
3060 IF(INDSTR) 5555,3109,3460
3109 IF(K-KS) 3120,3110,3110
3110 IF(ABSF(X00-XI)-.01*DELX00) 3500,3500,3115
3115 IF(X00-X) 3120,3500,3610
3120 XC=X00+DELX00
3123 U(L+3)=UM(L+3)
DO 3125 I=1,NS
3125 C(L+3,I)=CM(L+3,I)
IF(INDSTR) 5555,3140,3130
3130 2100-2100+DELX00*SCOMP
GO TO 100
3140 IF(INDFOO) 3150,3450,3400
3150 IF(ABSF(X00-XLS(K))-0.01*DELX00) 3200,3200,3155
3155 IF(X00-XLS(K)) 100,3200,3300
3200 INDFOO=0
GO TO 100
3300 DELX00=DELX00-(X00-XLS(K))
X00=XLS(K)
INDFOO=1
GO TO 100
3400 X00=X00-DELX00*DELXST
3450 K=K+1
GO TO 70
3460 IF(ABSF(2100-211)-.01*DELX00*SCOMP) 3500,3500,3470
3470 IF(2100-211) 3120,3500,3620
3500 IF(A2) 3510,3520,3520
3510 CALL CEUGE(9,L+3,L+3)
3520 RETURN
3610 DELX00=DELX00-(X00-X)
X00=X
GO TO 4000
3620 DELX00=DELX00-(2100-211)/SCOMP
X00=X00-(2100-211)/SCOMP
2100=211
4000 CALL PRTERH(X00,L+3,L+3,K)
IF(A2) 4030,4035,4033
4030 CALL WOOTR(L+3,L+3)
4035 UM(L+3)=U(L+3)-PRP/RHD(L+3)*DELX00/U(L+3)
DO 4040 I=1,NS
4040 CM(L+3,I)=C(L+3,I)+DELX00*WOOT(L+3,I)/U(L+3)/RHD(L+3)

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4500 IF(UM(L+3)-ULOLIM)4505,4510,4510
4505 UM(L+3)=ULOLIM
4510 FNE=RHO(L+3)*CM(L+3,7)*5.664696E26
      WRITE OUTPUT TAPE 6,3005,X00,Z100,UM(L+3),(CM(L+3,1),I=4,NS),T(L+3
      1),RHO(L+3),FNE
      GO TO 3500
5000 UM(L+3)=UE
      DO 5010,I=1,NS
5010 CM(L+3,I)=CE(I)
      FM(L+3)=FME
      PSI(L+3)=PSI(L+2)+DELTAP
      RETURN
5555 STOP 5555
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)

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21R 23242 55312 21 23244 55314 21S 23232 55300 22R 23230 55276 22 23231 55277
 22S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
DIM2	1130 02152	FM1	1129 02151	FM8L	1126 02150	FNE	1127 02147	INO22	1126 02146
INDFOD	1125 02145	I	1124 02144	K	1123 02143	N	1122 02142	RSIME	1121 02141
SCOMP	1120 02140	THETA	1119 02137	TWOPT	1118 02136	UDS	1117 02135	UESVAR	1116 02134
XOD	1115 02133	Z1A	1114 02132	Z10C	1113 02131				

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
811A	17 02102	811A	42 02073	811N	55 02053	812IT	3005 02035

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
I1	1091 02103	21	1022 01776	31	1030 02006	61	1045 02025
C1G0	1103 02117	C1G5	1104 02120	C1G5	1105 02121	C1100	1106 02122
C1201	1108 02124	C1201	1109 02125	C1202	1110 02126	C1203	1111 02127
D1110	615 01147	D121T	611 01143	D122A	696 01270	D131T	610 01142
D1430	946 01662	D161M	575 01077	D163D	945 01661	E13	39 00047
E16	50 00062	E1C	121 00171	E1E	129 00210	E1G	136 00210
E1L	157 00235	E1D	323 00503	E1R	344 00530	E111	385 00601
E117	450 00702	E11R	503 00767	E11G	549 01045	E111	563 01063
E11G	602 01132	E123	649 01211	E127	676 01244	E12F	719 01317
E12L	766 01376	E136	874 01552	E139	894 01576	E12A	495 01267
E113M	1019 01773	E123M	1019 01773	E133M	1019 01773	E1535	870 01546

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
ATAN	4 00004	CEGE	9 00011	COS	0 00000	OE	7 00007
SQRT	1 00001	WOOTRT	8 00010	(FIL)	3 00003	PRTRM	2 00002

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN	CEGE	COS	PRTRM	SIN	SQRT	WOOTRT	(FIL)	(SPH)	(STH)
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EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
2	15 00014	3	16 00041	4	18 00050	5	20 00054	7	21 00056		
9	22 00063	10	25 00070	12	27 00074	15	29 00101	16	33 00152		
19	36 00172	20	38 00211	25	40 00216	26	41 00224	29	44 00231		
30	45 00236	35	48 00250	40	50 00277	50	59 00504	52	60 00506		
56	64 00524	58	66 00531	60	68 00537	65	70 00545	70	73 00557		
102	75 00563	1003	77 00602	1005	78 00610	1020	84 00642	1021	87 00656		
1022	88 00664	1023	90 00703	1025	91 00711	1020	95 00741	1021	99 00770		
2035	100 01000	2040	102 01016	2050	104 01041	2052	105 01046	2060	107 01070		
2065	108 01073	2070	110 01101	2080	111 01111	2082	112 01115	2090	114 01137		
2095	115 01144	2100	117 01150	2103	120 01163	2105	121 01172	2110	123 01176		
2115	124 01202	2120	125 01212	2130	126 01220	2140	128 01226	2141	131 01245		

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

SUBROUTINE UCSTRE

2143	132	01254
2500	140	01313
3109	151	01377
3125	157	01435
3200	164	01476
3470	174	01541
3620	182	01577
4500	191	1676
5555	208	01774

2145
2505
3110
3130
3300
3500
4000
4505

2150
2510
3115
3140
3400
3510
4033
4510

135 01271
142 01322
153 01416
161 01453
170 01513
176 01553
187 01635
193 01704

2170
2600
3120
3150
3450
3520
4035
5000

2180
3060
3123
3155
3460
3610
4040
5010

PAGE 1

SUBROUTINE UEDGE(J)

SUBROUTINE UEDGE(J)

```

COMMON AIL,A11,A2,A3L,A3T,A4L,A4T,A5L,A5T,A6T,A6T,AB2T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,ALPHA,ASR,AU12,B1T,B2T,E3T,
2B4T,B5T,B6T,B7T,B8T,8B2T,8B3T,8B4T,8B5T,8B6T,8B7T,8C12,8H12,
3BLDCK,BSR,BU12,C,C12,CC,CALC,CE,CM,CM1,CM2,COMEAN,CP,CPE,CS,
4CSR,DCOP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5OKD1,DN2,DN2DQ2,DNC,DD2,DSCRIP,DUOP12,EDENS,EPSI,
6EPSIC,EPSIH,EPSIU,ETA,FA,FB,FC,FEDA,FEDE,
7FEDC,FI,FI12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FMD,FK,FKPSI,FL,FLELIN,FLEML,FLEWT,
1FLN2,FLNO,FLNOP,FLC2,FM,FML,FML12,FMLTIP,FNDSSM,
2FNUSSL,FSH,FSHE,FSH1,FSH12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMH,FSMND,FSMNDP,FSMD,GAMM,HE,
4HH,IALT,IDEL,INDCOC,INDLAS,INOP,INDPRI,INDPS,INDR,
5INDSTP,INDSTR,INDTYP,JINPUY,JS,KS,L,LP2,NPSI,NS,NSR,
6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIM,PROIRA
COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RHD,
1RHOCAL,RHDE,RHOL2,RHOSIG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIM,
2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
3SYADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TM,TVN2,
5TVND,TVNOP,TVD2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
6UM2,US,WDD1,X,XI,XL,XLS,XRM,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REW,FNUREX,FNUREN,CSUB,I,PRINT,NCDUNT,JBYCTR

DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),B8T(60),BLDCK(60),BSR(10),C(60,10),C12(10),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSR(10),DCOP12(10),DKOL(60,10),DKOT(60,10),
4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEML(60),FLENT(60),FLN2(60),FLND(60),
6FLNOP(60),FLD2(60),FM(10),FML(60),FMLTIP(60),
7DIMENSION FMUTIP(60),FSH(60),FSH1(60,10),FSH12(10),FSKRA(10),
1FSKRB(10),FSKRC(10),FSKRK(10),HM(5),INDCOC(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PROIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHD(60),
4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60),
7DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
1WDD1(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

```

UEDGE(1) IS UHALL

```

J=J
1F(J-1)3C,20,40
2U UM(1)=0.0
RETURN
3 STOP 30
4 1F(J-3)100,200,50
5 STOP 50
10 UM(L)=U(L)-PRP/RHD(L)*DELTA/U(L)
RETURN

```

PAGE 2

SUBROUTINE UEDGE(J)

```
200 UM(L+1)=U(L+1)-PRP/RHO(L+1)*DELTA X/U(L+1)
   UM(L+2)=U(L+2)-PRP/RHO(L+2)*DELTA X/U(L+2)
   RETURN
   END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)
```

SUBROUTINE UEDGE(IJ)

PAGE 3

STORAGE NOT USED BY PROGRAM

DEC OCT
80 00120

DEC OCT
23210 55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

A1L 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	A5T 32553 77451	A61T 32552 77450
A6T 32551 77447	A6T 32550 77446	A6T 32549 77445	A6T 32548 77444	A6T 32547 77443
A6T 32546 77442	AC12 32545 77441	AM12 32544 77440	ALPHA 32534 77426	ASR 32533 77425
AU12 32523 77413	A1T 32522 77412	B2T 32462 77316	B3T 32402 77222	B4T 32342 77126
B5T 32282 77032	B6T 32222 76736	B7T 32162 76642	B8T 32102 76546	B8T 32101 76545
B8T 32100 76544	B8T 32099 76543	B8T 32098 76542	B8T 32097 76541	B8T 32096 76540
BC12 32095 76537	BH12 32085 76525	BLOCK 32084 76524	BSR 32024 76430	BUI2 32014 76416
C12 31413 75265	CCALC 31353 75171	CC 31403 75253	CE 30753 74041	CM1 30143 72677
CM2 30133 72665	CM 30743 74027	COMEN 29533 71535	CPE 29531 71533	CP 29532 71534
C 32013 76415	CSR 28930 70402	CS 29530 71532	CSUB 23214 55256	DCDP12 28920 70370
DEL 28910 70356	DELTA 28909 70355	DELTA 28908 70354	DELX00 28907 70353	DELXST 28906 70352
OHDP12 28905 70351	OIST 28904 70350	OKOL 28903 70347	OKOT 28303 67217	DN2002 27702 66066
DN2 27703 66067	DN0 27701 66065	DO2 27700 66064	OSCRIP 27699 66063	DUOP12 27698 66062
EDENS 27697 66061	EPSIC 27636 65764	EPSIM 27635 65763	EPSI 27637 65765	EPSIT 27634 65762
EPSIU 27633 65761	ETA 27632 65760	FA 27631 65757	F8 27630 65756	FC 27629 65755
FEDA 27628 65754	FEDR 27627 65753	FEDC 27626 65752	FH12 27565 65655	FHCALC 27564 65654
FHE 27504 65560	FHM2 27443 65463	FHM 27503 65557	FH 27625 65751	FHS 27383 65367
FINO 27323 65273	FKPSI 27321 65271	FK 27322 65272	FLELIN 27260 65174	FLETIN 27259 65173
FLEWL 27258 65172	FLEWT 27198 65076	FLN2 27138 65002	FLMOP 27018 64612	FLNO 27078 64706
FLO2 26958 64516	FL 27261 65175	FM 26898 64422	FMUL12 26828 64314	FMUL 26888 64410
FMUTIN 26827 64313	FMUTIP 26767 64217	FNOSSH 26707 64123	FNDSSL 26706 64122	FMUREN 23215 55257
FNUREX 23216 55260	FSME 26645 64025	FSH12 26044 62674	FSH1 26644 64024	FSMP 26034 62662
FSH 26705 64121	FSKRA 26032 62660	FSKRB 26022 62646	FSKRC 26012 62634	FSKRD 26002 62622
FSKRE 26001 62621	FSKRF 26000 62620	FSKRR 25999 62617	FSK 26033 62661	FSME 25989 62605
FSMOP 25986 62602	FSMNO 25987 62603	FSMN 25988 62604	FSMO 25985 62601	GAMM 25984 62600
HE 25983 62577	HH 25982 62576	IALT 25977 62571	IDEL 25976 62570	IMDCOD 25975 62567
INDLAS 25965 62555	INOPRI 25954 62542	INDP 25955 62543	INDPS 25953 62541	INDR 25903 62457
INOSTP 25902 62456	INOSTR 25901 62455	INDUTP 25900 62454	IPRINT 23213 55255	JBYCTR 23211 55253
JINPUT 25890 62442	JS 25889 62441	KS 25888 62440	LP2 25886 62436	L 25887 62437
NCOUNT 23212 55254	NPSI 25895 62435	NSR 25883 62433	NS 25884 62434	OGIVEH 25882 62432
OGIVEK 25881 62431	PE 25872 62420	PRALIN 25810 62322	PRAL 25870 62416	PRATIN 25749 62225
PRAT 25809 62321	PADIRA 25748 62224	PROS 25688 62130	PAP 25687 62127	PR 25871 62417
PRSAVE 25686 62126	P 25880 62430	PSCALC 25285 61305	PSI 25225 61211	PSITCU 25165 61115
PS 25685 62125	QM 25164 61114	RESTAR 25162 61112	RETHET 23219 55263	REN 23217 55261
REX 23218 55262	RHO12 25040 60720	RHOALC 25101 61015	RHOE 25041 60721	RHO 23161 61111
RHOSTG 25039 60717	RN 25038 60716	RNS 25037 60715	R 25163 61113	RSC 24986 60632
RS 24985 60631	RS 24986 60633	SCHLIN 24984 60630	SCHTIN 24983 60627	SCL 24982 60626
SCI 24922 60532	SHANGL 24862 60436	SIGMAC 24861 60435	SIGMAH 24801 60341	SIGMAU 24741 60245
STADIS 24681 60151	TAUM 24620 60054	TAUP 24560 57760	TESTRA 24500 57664	THETAT 24499 57663
THPER 24498 57662	TIN 24497 57661	TITLE1 24496 57660	TITLE2 24484 57644	TITLE3 24472 57630
TH 24460 57614	T 24680 60150	TVM2 24400 57520	TVPNP 24398 57516	TVNO 24399 57517
TV02 24397 57515	U12 24336 57420	UM2 24152 57130	UE 24275 57323	UINF 24274 57322
ULOLIM 24273 57321	UM1 24212 57224	X1 23431 55607	UM 24272 57320	U 24396 57514
US 24092 57034	WDOT 24032 56740	X 23432 55610	XL 23430 55606	XLS 23429 55605
XRH 23379 55523	YTHC 23255 55327	YTH 23256 55310	XU12 23377 55521	YCALC 23316 55424
Y 23376 55520	Z1 23242 55312	Z1S 23244 55314	Z1L 23243 55313	Z1L 23243 55313
Z2S 23220 55264			Z2 23231 55277	Z2 23231 55277

SUBROUTINE UEDGE(J)

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1)	78 00116	2)	69 00105	3)	71 00107	4)	72 00110

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
20	12	00026	30	15	00034	40	16	00036
200	21	00061				50	17	00043
						100	18	00045

SUBROUTINE VISLAT

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DIMENSION AC12(10), ASR(10), BIT(60), B2T(60), B3T(60), B4T(60), B5T(60),
1, B6T(60), B7T(60), B8T(10), BLCK(50), BSRI(50), C(60,10), C12(10),
2CC15,10), CCALC(60,10), CE(10), CM(60,10), CM1(10),
3CM2(60,10), CS(60,10), CSR(10), DCDP12(10), DKDL(60,10), DKDT(60,10),
4EDENS(60), FHI(60), FHCALC(60), FHM(60), FHM2(60), FHS(60),
5FHP3(60), FLEWL(60), FLENT(60), FLN2(60), FLND(60),
6FLNTP(60), FLOW(60), FMT(10), FMULT(60), FMUTIM(60)
DIMENSION FRUTLP(60), FSH(60), FSH1(60,10), FSH12(10), FSKRA(10),
1FSKRB(10), FSKRC(10), FSKRK(10), MH(50), INDC00(10),
2INOLAS(10), INOPS(50), INDTP(10), P(8), PRDIRA(60),
3PRAL(60), PRAT(60), PS(B,50), PSCALC(60), PSI(60), RMD(60),
4RHOCAL(60), RNS(50), SCL(60), SCT(60), SIGMAC(60),
5SIGMAH(60), SIGMAU(60), T(60), TAUM(60), TAUP(60),
6TITL1(12), TITL2(12), TITL3(12), TM(60), UI(60)
DIMENSION UCALC(60), UM(60), UMI(60), UM2(60), US(60),
1WDT(60,10), XLS(50), Y(60), YCALC(60), YTHC(10), Z1R(10),
2Z2R(10)

```

00 100 N=1,LP2
 100 FMUL(N)=3.04566E-8*TM(N)+1.5/(110.333+TM(N))
 REVER=RMQ(L)*U(L)*NS
 00 600 N=2,LP2

```

DEL12=SQR12(DELTA)
AAU=(2.0+RH0(2)*U(2)-RH0(3)*U(3))/DEL12/.58579
BBU=(RH0(1)*U(3)-1.414*RH0(2)*U(2))/DELTA/.58579
Y12=(2.0)*BBU/RS*LOGF(1.0+BBU/AAU*DEL12)
Y12=2.0*BBU/RS*LOGF(1.0+BBU/AAU*SQR12(.5*DELTA))

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```

RHO12=AAUDEL12+.7071+BBU+.5*DELTA
RURNM=RHO(1)*U12+RS
RURN1=RHO(2)*U12+RS
RURN=RHO(2)*U(2)+RS
RURNP=RHO(3)*U(3)+RS
Y2K2P=Y(2)*DELTA*(-.375/RURN+.125+RURNP)
Y2K2M=Y(2)-DELTA*(-.125/RURNM+.375/RURN1)
P2K2P=PSI(2)+.5*DELTA
P2K2M=PSI(2)-.5*DELTA
FMUT1M(2)= RHO12*U12+RS+RHO12 *ABS(F(OUOP12)
GO TO 270
269 Y(N)=Y(N-1)+.5*DELTA/RS*(1.0/(RHO(N)*U(N))+1.0/(RHO(N-1)*U(N-1)))
RURNM=RHO(N-1)*U(N-1)+RS
RURN=RHO(N)*U(N)+RS
RURNP=RHO(N+1)*U(N+1)+RS
Y2K2P=Y(N)*DELTA*(-.375/RURN+.125+RURNP)
Y2K2M=Y(N)-DELTA*(-.125/RURNM+.375/RURN)
P2K2P=PSI(N)+.5*DELTA
P2K2M=PSI(N)-.5*DELTA
FMUT1M(N)= (RHO(N)+RHO(N-1))* (RURN+RURNM)*ABS(F(U(N)-U(N-1)))/
1DELTA+.25
270 FMUT1P(N)=(RHO(N+1)+RHO(N))* (RURNP+RURN)*ABS(F(U(N+1)-U(N)))/DELTA+
1.25
1*2 FLTP=(Y(L))*(.14-.08*(1.0-Y2K2P/Y(L)))*2-.06*(1.0-Y2K2P/Y(L))*4)**
1*2 FLTM=(Y(L))*(.14-.08*(1.0-Y2K2M/Y(L)))*2-.06*(1.0-Y2K2M/Y(L))*4)**
1*2 PLTP=(PSI(L)/REUER+.14-.08*(1.0-P2K2P/PSI(L)))*2-.06*(1.0-P2K2P/P
1SI(L))*4)**2
PLTM=(PSI(L)/REUER+.14-.08*(1.0-P2K2M/PSI(L)))*2-.06*(1.0-P2K2M/P
1SI(L))*4)**2
FMUT2P=-.25*(RHO(N+1)+RHO(N))* (FKPSI(N+1)+FKPSI(N))*Y(L)*U(L)
FMUT2M=-.25*(RHO(N)+RHO(N-1))* (FKPSI(N)+FKPSI(N-1))*Y(L)*U(L)
FMUT16P=FMUT2P/Y(L)*PSI(L)/REUER
FMUT16M=FMUT2M/Y(L)*PSI(L)/REUER
FMUT1P(N)=BIT(N+1)* (Y2K2P+PK)*2+FMUT1P(N)+B2T(N+1)*FMUT2P+B3T(N+1)
1)*.5*(FMUL(N)+FMUL(N+1))*B4T(N+1)*FLTP+FMUT1P(N)
2+B5T(N+1)* (P2K2P+FK/REUER)*2+FMUT1P(N)+B6T(N+1)*FMUT6P+B7T(N+1)*
3PLTP+FMUT1P(N)
600 FMUT1M(N)=BIT(N)* (Y2K2M+PK)*2+FMUT1M(N)+B2T(N)*FMUT2M+B3T(N)*.5*(
1FMUL(N)+FMUL(N-1))*B4T(N)*FLTM+FMUT1M(N)
2+B5T(N)* (P2K2M+FK/REUER)*2+FMUT1M(N)+B6T(N)*FMUT6M+B7T(N)*PLTM
3FMUT1M(N)
IF(SENSE SWITCH 2)*650,700
650 WRITE OUTPUT TAPE 6,655,AU12,XU12
655 FORMAT(10X$HAU12=1PE13.5,5HXU12=1PE13.5)
700 RETURN
END(1,1,C,0,0,0,0,1,0,0,0,0,0,0,0)

```

SUBROUTINE VISLAT

DEC OCT
633 01171

DEC OCT
ALL 32561 77461
A4L 32556 77454
AB1T 32552 77450
AB6T 32547 77443
ASR 32533 77425
B4T 32342 77126
887T 32101 76545
887T 32096 76540
8012 32014 76416
CM1 30143 72677
CP 29532 71534
DCDP12 28920 70370
DELXST 28906 70352
DN2D02 27702 66066
DUOP12 27698 66062
EPSIT 27634 65762
FC 27629 65755
FHCLC 27564 65654
FHS 27383 65367
FLETIN 27259 65173
FLNO 27078 64706
FMUL 26888 64410
FNUREW 23215 55257
FSH1 26644 64024
FSKRD 26012 62634
FSK 26033 62661
FSMU 25985 62601
IDEL 25976 62570
INDPS 25953 62541
IPRINT 23213 55255
LP2 25886 62436
NS 25884 62434
PRAL 25870 62416
PRP 25687 62127
PSI 25225 61211
RETHET 23219 55263
RHOE 25041 60721
RNS 25037 60715
SCHLIN 24984 60630
SIGMAC 24861 60435
STRUL 23205 55246
THETAT 24499 57663
TITLE3 24472 57650
TVNO 24399 57517
UINF 24274 57322
U 24396 57514
XLS 23429 55605
Y12 23208 55250

STORAGE NOT USED BY PROGRAM

DEC OCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC OCT
A1T 32560 77460
A4T 32555 77453
AB2T 32551 77447
AB7T 32546 77442
AU12 32523 77413
B5T 32282 77032
883T 32100 76544
8C12 32095 76537
C12 31413 75265
CM2 30133 72665
C 32013 76415
DEL 28910 70356
DHDP12 28905 70351
DN2 27703 66067
EDEM5 27697 66061
EPSIU 27633 65761
FEDA 27628 65754
FME 27504 65560
FINO 27323 65273
FLEWL 27258 65172
FLO2 26958 64516
FMUTIM 26827 64313
FNUREX 23216 55260
FSMP 26034 62662
FSKRD 26002 62622
FSME 25989 62605
GAMH 25984 62600
INDCOO 25975 62567
INDR 25903 62457
JBYCTR 23211 55253
L 25887 62437
OGIVEN 25882 62432
PRATIN 25749 62225
PR 25071 62417
PSITCU 25165 61115
REN 23217 55261
RHO 25161 61111
R 25163 61113
SCKTIM 24983 60627
SIGMAH 24801 60341
THPER 24498 57662
T12 23209 55251
TM 24460 57614
TV02 24397 57515
ULOLIM 24273 57321
US 24092 57034
XRM 23379 55523
YCAL 23316 55424

DEC OCT
A2 32559 77457
A5L 32554 77452
AB3T 32550 77446
AC12 32545 77441
81T 32522 77412
85T 32222 76736
884T 32099 76543
BM12 32085 76525
CCALC 31353 75171
CM 30743 74027
CSR 28930 70402
DELTA 28909 70355
DIST 28904 70350
DN2 27701 66065
EPSIC 27636 65764
ETA 27632 65760
FEOR 27627 65753
FHM2 27443 65463
FKPSI 27321 65271
FLENT 27198 65076
FL 27261 65175
FMUTIP 26767 64217
FSH12 23210 55252
FSH 26705 64121
FSKRD 26001 62621
FSMNO 25986 62602
HC 25983 62577
INDLAS 25965 62553
JIMPUT 25890 62442
NCOUNT 23212 55254
UGIVEK 25881 62431
PRAT 25809 62321
PRSAVE 25686 62126
PS 25685 62125
REX 23218 55262
RHO2TG 25039 60717
RSC 24966 60632
SCI 24502 60626
SIGMAU 24741 60245
TAUM 24620 60054
TIN 24497 57661
T 24680 60150
U12 24336 57420
UM1 24212 57224
WDOT 24032 56740
X 23432 55610
Y 23376 55520

DEC OCT
A3L 32558 77456
A5T 32553 77451
AB4T 32549 77445
AH12 32535 77427
82T 32462 77316
87T 32162 76642
885T 32098 76542
BLOCK 32084 75524
CC 31403 75253
CONEAN 29533 71535
CS 29530 71532
DELTA 28908 70354
DKDL 28903 70347
DO2 27700 66064
EPSIM 27635 65763
FA 27631 65757
FEDC 27626 65752
FHM 27503 65557
FK 27322 65272
FLN2 27138 65002
FM 26898 64422
FNDSM 26707 64123
FSHE 26645 64025
FSKRA 26032 62660
FSKRD 26000 62620
FSMNO 25987 62603
HM 25982 62576
INDPRI 25954 62542
INDSTR 25901 62455
JS 25889 62441
NPSI 25885 62435
PE 25872 62420
PROIRA 25748 62224
P 25880 62430
QM 25164 61114
RHO12 25040 60720
RHO12 23205 55245
RSM 24985 60631
SCT 24922 60532
STADIS 24681 60151
TAUP 24560 57760
TITLE1 24496 57660
TVN2 24400 57520
UCALC 24335 57417
UM2 24152 57130
XI 23431 55607
X 23378 55522
YTHC 23255 55327

DEC OCT
A33 32557 77455
AAU 32304 55244
AB5T 32548 77444
ALPHA 32534 77426
83T 32402 77222
881T 32102 76546
886T 32097 76541
8SR 32024 76430
CE 30753 74041
CPE 29531 71533
CSUB 23214 55256
DELXOD 28907 70353
DKDT 28303 67217
OSCRIP 27699 66063
EPSI 27637 65765
FB 27630 65756
FH12 27565 65655
FH 27625 65751
FLELIN 27260 65174
FLNOP 27018 64612
FMUL12 26828 64314
FNDSL 26706 64122
FSH112 26044 62674
FSKRB 26022 62648
FSKRD 25999 62617
FSM 25988 62604
IAT 25977 62571
INDP 25925 62543
INDTYP 25900 62454
KS 25888 62440
NSK 25883 62433
PRALIN 25810 62322
PRDS 25688 62130
PSCALC 25285 61305
RESTAR 25162 61112
RHOCAL 25101 61015
RN 25038 60716
RS 24987 60633
SHANGL 24862 60436
STRL 23207 55247
FESTRA 24500 57664
TITLE2 24484 57644
TVNOP 24398 57516
UE 24275 57323
UM 24272 57320
XL 23430 55606
XUI2 23377 55521
YTH 23256 55330

SUBROUTINE VISLAT

PAGE 4

YTHU 23245 55315 Z1L 23243 55313 Z1R 23242 55312 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
BRU	632 01170	DEL12	631 01167	FLTM	630 01166	FLTP	629 01165	FMT2M	628 01164
FMT2P	627 01163	FMT6M	626 01162	FMT6P	625 01161	N	624 01160	P2K2M	623 01157
P2K2P	622 01156	PLTM	621 01155	PLTP	620 01154	REUR	619 01153	RURN1	618 01152
RURNM	617 01151	RURNP	616 01150	RURN	615 01147	Y2K2M	614 01146	Y2K2P	613 01145

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC
8)KF	655 01131				

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT
1)	602 01132	2)	571 01073	3)	575 01077
E18	554 01052			6)	590 01116
				C)GI	612 01144

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT
EXP(3	0 00000	LOG	2 00002	SQRT	1 00001
				(FIL)	4 00004
				(ISTH)	3 00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3	LOG	SQRT	(FIL)	(ISTH)
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	
100	12 00022	160	16 00055	180	22 00157	269	32 00261	270	41 00406
600	51 00761	650	53 01053	700	55 01067				

V9 M1 1-18-61

PAGE 1

SUBROUTINE WDDTRT(NSTART,NEND)

SUBROUTINE WDDTRT(NSTART,NEND)

```

COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,A81T,A82T,
1AB3T,A84T,A85T,A86T,A87T,AC12,AH12,ALPHA,ASR,AUIP,81T,82T,83T,
284T,85T,86T,87T,88T,883T,884T,885T,886T,887T,888T,889T,890T,
3BLOC,BSR,BUI2,C,C12,CC,CCALC,CE,CM,CM2,CDNEAN,CP,CPE,CS,
4CSR,DCDP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5DKDT,DN2,DND2,DND2,DND2,DND2,DND2,DND2,DND2,DND2,DND2,
6EPSIC,EPST,EPST,EPST,ETA,FA,F8,FC,FEDA,FED8,
7FEDC,FA,FB,FC,FD,FE,FF,FG,HH,HH2,FHS
COMMON FINO,FK,FKPSI,FL,FLELIN,FLELIN,FLEWL,FLEWT,
1FLN2,FLND,FLNDP,FLC2,FM,FMUL,FMUL12,FMUTIM,FMUTIP,FNDSSH,
2FNDSSL,FSH,FSHE,FSHI,FSH12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNP,FSMD,GAMM,HE,
4HH,IALT,IDEL,INDC,INCLAS,INDP,INOPRI,INDPS,INDR,
5INDSTP,INDSTR,INCTYP,INPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6DGIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMMON PROS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RHO,
1RHDCAL,RHDE,RHDI2,RHDSIG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TP,TVN2,
5TVND,TVNDP,TVD2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REX,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
1,FSH12,Y12,Y12,STRLL,STRUL,RHOU12,AAU,EHP,FSK15,
2FSMD15,FSMN15,FSME5

```

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DIMENSION AC12(10),ASR(10),81T(60),82T(60),83T(60),84T(60),85T(60),
1,86T(60),87T(60),88T(60),883T(60),884T(60),885T(60),886T(60),887T(60),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKOL(60,10),DKCT(60,10),
4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLND(60),
6FLNDP(60),FLD2(60),FM(10),FMUL(60),FMUTIM(60),
DIMENSION FMUTIP(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
1FSKR(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHD(60),
4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(50),UM1(60),UM2(60),US(60),
1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

```

10 NSTART=NSTART

NEND=NEND

DD 300 N=NSTART,NEND

ETT228=5.0+3.0*EXP(-228.0/T(N))+EXP(-327.0/T(N))

ETT178=1.0+EXP(-178.0/T(N))

ETT2274=1.0-EXP(-2274.0/T(N))

ETT2740=1.0-EXP(-2740.0/T(N))

ETT3395=1.0-EXP(-3395.0/T(N))

ETT1130=3.0+2.0*EXP(-1130.0/T(N))

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SUBROUTINE WOORT (NSTART, NENO)

```

      RH000=FM(2)*11.584906/T(N)*ET2274*ETT228**2/ET1130*FSM015
      1*FSK15*3.87871E-11*T(N)**1.5/EHP
      RH00N=FM(4)*257.8804/T(N)*ET3395*FSMN15*FSK15
      1*3.87871E-11*T(N)**1.5/EHP
      RH00NO=FM(2)*77.267586*(FM(4)/FM(5))**2.5/T(N)*ET2740*ETT2
      128/ET178*FSM015*FSK15*3.87871E-11*T(N)**1.5/EHP
      RHODE=FM(7)*13.346219*ET2740/ET3395/ET178*FSMES
      1*FSK15*3.87871E-11*T(N)**1.5/EHP*FSME
      SIGMA=(FM(1)*FM(4)/FM(5)/FM(2))**2.5*.1790*ET2740/ET2274*ET1130/E
      1TT228/ET178
      GAMMA=(FM(5)*FM(4)/FM(3)/FM(2))**2.5*18.88*ET3395/ET2740*ET178/ET
      1228
      FKBAR=( FM(6)*FM(7) /FM(4)/FM(2))**2.5*T(N)/5.789/ET3395/ETT228
      TT2=1.0/SQRT(T(N))
      T32=TT2*TT2*TT2
      FSKRA(1)=2.2E-7*T32
      FSKRA(2)=6.2E-7*T32
      FSKRA(3)=1.7E-11*TT2
      FSKRA(4)=8.3E-12*TT2
      FSKRA(5)=FSKRA(4)
      FSKRA(6)=FSKRA(4)
      FSKRA(7)=FSKRA(4)
      FSKRB(1)=3.0E-11*TT2
      FSKRB(2)=FSKRB(1)
      FSKRB(3)=7.6E-11*TT2
      FSKRB(4)=6.5E-6*T32
      FSKRB(5)=FSKRB(1)
      FSKRB(6)=FSKRB(1)
      FSKRB(7)=FSKRB(1)
      FSKRC(1)=2.8E-7*T32
      FSKRC(2)=FSKRC(1)
      FSKRC(3)=FSKRC(1)
      FSKRC(4)=FSKRC(1)
      FSKRC(5)=5.5E-6*T32
      FSKRC(6)=FSKRC(1)
      FSKRC(7)=FSKRC(1)
      FSKRO=2.2E-14*TM(N)*EXP(-3560./TM(N))
      FSKRF=3.0E-3*T32
      FSKRK(1)=FSKRA(1)
      FSKRK(2)=FSKRA(1)
      FSKRK(3)=FSKRA(1)
      FSKRK(4)=FSKRA(1)
      FSKRK(5)=FSKRA(1)
      FSKRK(6)=FSKRA(1)
      FSKRK(7)=FSKRA(1)
      FSKT=FSK*T(N)*.846389E19
      EMD02=EXP(-002/FSKT)
      EMD0N2=EXP(-DN2/FSKT)
      EMD0NO=EXP(-ONO/FSKT)
      EMDINO=EXP(-FINO/FSKT)
      SUMCM=0.0
      SUMCMA=0.0
      SUMCMB=0.0
      SUMCMC=0.0
      SUMCMK=0.0
      00 150 1=1.NS

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SUBROUTINE WDDTRT(NSTART,NEND)

```

SUMCM=SUMCM+C(N,1)/FM(1)
SUMCPA=SUMCPA+C(N,1)/FM(1)+FSKRB(1)
SUMCMB=SUMCMB+C(N,1)/FM(1)+FSKR8(1)
SUMCMC=SUMCMC+C(N,1)/FM(1)+FSKRC(1)
SUMCMK=SUMCMK+C(N,1)/FM(1)+FSKRK(1)
150 A=2.0*FL/FM(2)*C(N,1)+1.94008E25*EMD2-RHD(N)
1.1.94008E25*(N,2)*C(N,2)+4.9778
8.2.0*FL/FM(4)*SUMCMB+RHD(N)*(RHDON+C(N,3)*1.94008E25*EMN2-RHD(N)
1.1.94008E25*(N,4)*C(N,4)+4.9778
G=FL*FM(5)/FM(4)/FM(2)+SUMCMC+RHD(N)*(RHDND+C(N,5)*1.94008E25*EMD
1ND-RHD(N)+1.94008E25*(N,4)*C(N,2)+4.9778
0=FL*FM(5)/FM(4)/FM(1)+FSKRDRHD(N)*(SIGMA+C(N,5)*C(N,2)*1.94008E2
15*EMOND/EMD2-C(N,1)+1.94008E25*(N,4)*1.6018E-2
E=FL*FSKRE/FM(4)*RHD(N)*(GAMMA+C(N,3)*1.94008E25*(N,2)*EMDN2/EPON
1D-C(N,5)+1.94008E25*(N,4)*1.6018E-2
F=FL*FSKRF/FM(7)*RHD(N)*(FK8AR+C(N,2)*1.94008E25*(N,4)*EMIND/EMDN
1D-C(N,6)+1.94008E25*(N,7)*1.6018E-2
TK=FL/FM(7)*SUMCMK+RHD(N)*(RHDDE+C(N,5)*1.94008E25*EMIND-RHD(N)*C(N
1,N,6)+1.94008E25*(N,7)+4.9778
WDDT(N,2)=(A+FM(2)/FM(5))*(G-D-E)-FM(2)/FM(6)*F)*RHD(N)/FL
WDDT(N,4)=(B+FM(4)/FM(5))*(G+D+E)-FM(4)/FM(6)*F)*RHD(N)/FL
WDDT(N,1)=(A+FM(1)/FM(5))*O)*RHD(N)/FL
WDDT(N,3)=(B+FM(3)/FM(5))*E)*RHD(N)/FL
WDDT(N,5)=(G+O+E-TK)*RHD(N)/FL
WDDT(N,6)=(F+TK)*RHD(N)/FL
IF(SENSE SWITCH 3)250,300
250 WRITE OUTPUT TAPE 6,255,A,8,G,D,E,F,TK,SUMCM,SUMCPA,SUMCM8,SUMCMC,
1SUMCMK,EMD22,EMON2,EMDND,EMINO,FSKRA(1),FSKR8(1),FSKRC(1),FSKRE,FS
2KRF,FSKRB(1),RHDOD,RHDON,RHDND,RHDE,SIGMA,GAMMA,FKBAR,ETA,E,T228
3,E1178,E1227,E12740,E13395,E1130,T(N),TM(N),T2,T32,FSKT
255 FORMAT(1H 7E10.3)
300 WDDT(N,7)=(F+TK)*RHD(N)/FL*FM(7)/FM(6)
RETURN
END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)

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SUBROUTINE WDDTRT(NSTART,NEND)

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STORAGE NOT USED BY PROGRAM

DEC OCT
858 01532
23198 55236

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
A1L 32561	77461	A1T 32560	77460	A2 32559	77457	A3L 32558	77456	A3T 32557	77455
A4L 32556	77454	A4T 32555	77453	A5L 32554	77452	A5T 32553	77451	AAU 23204	55244
AB1T 32552	77450	AB2T 32551	77447	AB3T 32550	77446	AB4T 32549	77445	AB5T 32548	77444
AB6T 32547	77443	AB7T 32546	77442	AC12 32545	77441	AM12 32535	77427	ALPHA 32534	77426
ASR 32533	77425	AU12 32523	77413	B1T 32522	77412	B2T 32462	77316	B3T 32402	77222
B4T 32342	77126	B5T 32282	77032	B6T 32222	76736	B7T 32162	76642	B81T 32102	76546
B82T 32101	76545	B83T 32100	76544	B84T 32099	76543	B85T 32098	76542	B86T 32097	76541
B87T 32096	76540	BC12 32095	76537	BH12 32085	76525	BLDCK 32084	76524	BSR 32024	76430
BUI2 32014	76416	C12 31413	75265	CCALC 31353	75171	CC 31403	75253	CE 30753	74041
CM1 30143	72677	CM2 30133	72665	CM 30743	74027	CONEAN 29533	71535	CPE 29531	71533
CP 29532	71534	C 32013	76415	CSR 28930	70402	CS 29530	71532	CSUB 23214	55256
DCDPI2 28920	70370	DEL 28910	70356	DELTA 28909	70355	DELTA 28908	70354	DELXDD 28907	70353
OELXSY 28906	70352	DMDPI2 28905	70351	CIST 28904	70350	DKOL 28903	70347	DKDT 28303	67217
DM2D02 27702	66066	DNA2 27703	66067	DND 27701	66065	DO2 27700	66064	DSCRIP 27699	66063
ODUP12 27698	66062	EDAS 27697	66061	EHP 23203	55243	EPSIC 27636	65764	EPSIM 27635	65763
EPSI 27637	65765	EPSIT 27634	65762	EPSIU 27633	65761	ETA 27632	65760	FA 27631	65757
FB 27630	65756	FC 27629	65755	FEDA 27628	65754	FEDB 27627	65753	FEDC 27626	65752
FH12 27565	65655	FHCALC 27564	65654	FHE 27504	65560	FHM2 27443	65463	FHM 27503	65557
FH 27625	65751	FHS 27383	65367	FIND 27323	65273	FKPSI 27321	65271	FK 27322	65272
FLELIN 27260	65174	FLELIN 27259	65173	FLEWL 27258	65172	FLEWT 27198	65076	FLN2 27138	65002
FLNOP 27018	64612	FLNO 27078	64706	FLD2 26958	64516	FL 27261	65175	FM 26898	64422
FMUL12 26828	64314	FMUL 26888	64410	FMUTIM 26827	64313	FMT1P 26767	64217	FNDSSH 26707	64123
FNDSSL 26706	64122	FNUREW 23215	55257	FNUREX 23216	55260	FSH12 23210	55252	FSHE 26645	64025
FSH12 26044	62674	FSH1 26644	64024	FSHP 26034	62662	FSK15 23202	55242	FSK15 23202	55242
FSKRA 26032	62660	FSKRA 26022	62646	FSKRC 26012	62634	FSKRD 26002	62622	FSKRE 26001	62621
FSKRF 26000	62620	FSKRA 25999	62617	FSK 26033	62661	FSMES 23199	55237	FSME 25989	62605
FSMN15 23200	55240	FSMNCP 25986	62602	FSMNO 25987	62603	FSMN 25988	62604	FSMD15 23201	55241
FSMO 25985	62601	GAM 25984	62600	HE 25983	62577	HH 25982	62576	IALT 25977	62571
IDEL 25976	62570	INDCCD 25975	62567	INDLAS 25965	62555	INDPRI 25954	62542	INDP 25955	62543
INDPS 25953	62541	INCR 25903	62457	INDSTP 25902	62456	INDSTR 25901	62455	INDTYP 25900	62454
IPRINT 23213	55255	JBYCTR 23211	55253	JINPUT 25890	62442	JS 25869	62441	KS 25888	62440
LP2 25886	62436	L 25887	62437	NCOUNT 23212	55254	NPSI 25885	62435	NSR 25883	62433
NS 25884	62434	CGIVEH 25882	62432	DGIVEK 25881	62431	PE 25872	62420	PRALIN 25810	62322
PRAL 25870	62416	PRATIN 25749	62225	PRAT 25809	62321	PRDIRA 25748	62224	PRDS 25688	62130
PRP 25687	62127	PR 25871	62417	PRSAVE 25686	62126	P 25880	62430	PSCALC 25285	61305
PSI 25225	61211	PSITCU 25165	61115	PS 25685	62125	Q 25164	61114	RESTAR 25162	61112
RETHET 23219	55263	REN 23217	55261	REX 23218	55262	RH012 25040	60720	RHOCAL 25101	61015
RHOE 25041	60721	RND 25161	61111	RMCSTG 25039	60717	RMDU12 23205	55245	RN 25038	60716
RNS 25037	60715	R 25163	61113	RSC 24986	60632	RSM 24985	60631	RS 24987	60633
SCHLIN 24984	60630	SCHTIN 24983	60627	SCL 24982	60626	SCT 24922	60532	SHANGL 24862	60436
SIGMAC 24861	60435	SIGMAH 24801	60341	SIGMAU 24741	60245	STADIS 24681	60151	STRL 23207	55247
STRUL 23206	55246	T12 23209	55251	TAUM 24620	60054	TALP 24560	57760	TESTRA 24500	57664
THETAT 24499	57663	THPR 24498	57662	TIN 24497	57661	TITLE1 24496	57660	TITLE2 24484	57644
TITLE3 24472	57630	TM 24460	57614	T 24680	60150	TVN2 24400	57520	TVNDP 24398	57516
TVNO 24399	57517	TVC2 24397	57515	U12 24345	57420	UCALC 24335	57417	UE 24275	57323
UINF 24274	57322	U12 24273	57321	UM1 24212	57224	UM2 24152	57130	UM 24272	57320
U 24396	57514	US 24092	57034	WDCI 24032	56740	XI 23431	55607	XL 23430	55606
XLS 23429	55605	XRN 23379	55523	X 23432	55610	XS 23378	55522	XU12 23377	55521

SUBROUTINE WOOTR(INSTART,NENO)

Y12 23208 55250	YCALC 23316 55424	Y 23376 55520	YTHC 23255 55327	YTH 23256 55330
YTHU 23245 55315	Z1L 23243 55313	Z1R 23242 55312	Z1 23244 55314	Z1S 23232 55300
Z2R 23230 55276	Z2 23231 55277	Z2S 23220 55264		

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	OEC	OCT	OEC	OCT	OEC	OCT	DEC	OCT	DEC	OCT	
A	857	01522	8	856	01530	0	855	01527	EMCN2	854	01526
EM002	852	01524	EMINO	851	01523	E	850	01522	ET1130	849	01521
ET2274	847	01517	ET2740	846	01516	ET3395	845	01515	ET1228	844	01514
F	842	01512	FSKT	841	01511	GAMMA	840	01510	G	839	01507
RHOONO	837	01505	RHOEN	836	01504	RHODO	835	01503	SIGMA	834	01502
SUMCMB	832	01500	SUMCMC	831	01477	SUMCMK	830	01476	SUMCPA	833	01501
TK	827	01473	TT2	826	01472				T32	828	01474
									SUMCM	829	01475
									EMONO	853	01525
									ET178	848	01520
									FK8AR	843	01513
									RHODE	838	01505
									SUMCPA	833	01501

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
817V	255	01463						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	OEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	
1)	820	01464	2)	770	01402	3)	774	01406	
						6)	812	01454	
							CIG0	825	01471

LOCATIONS OF NAMES IN TRANSFER VECTOR

	OEC	OCT	EXP(3	OEC	OCT	SQRT	DEC	OCT	(FIL)	DEC	OCT	(STH)	
EXP	0	00000		1	00001		2	00002		4	00004		
												3	00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP(3 SORT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

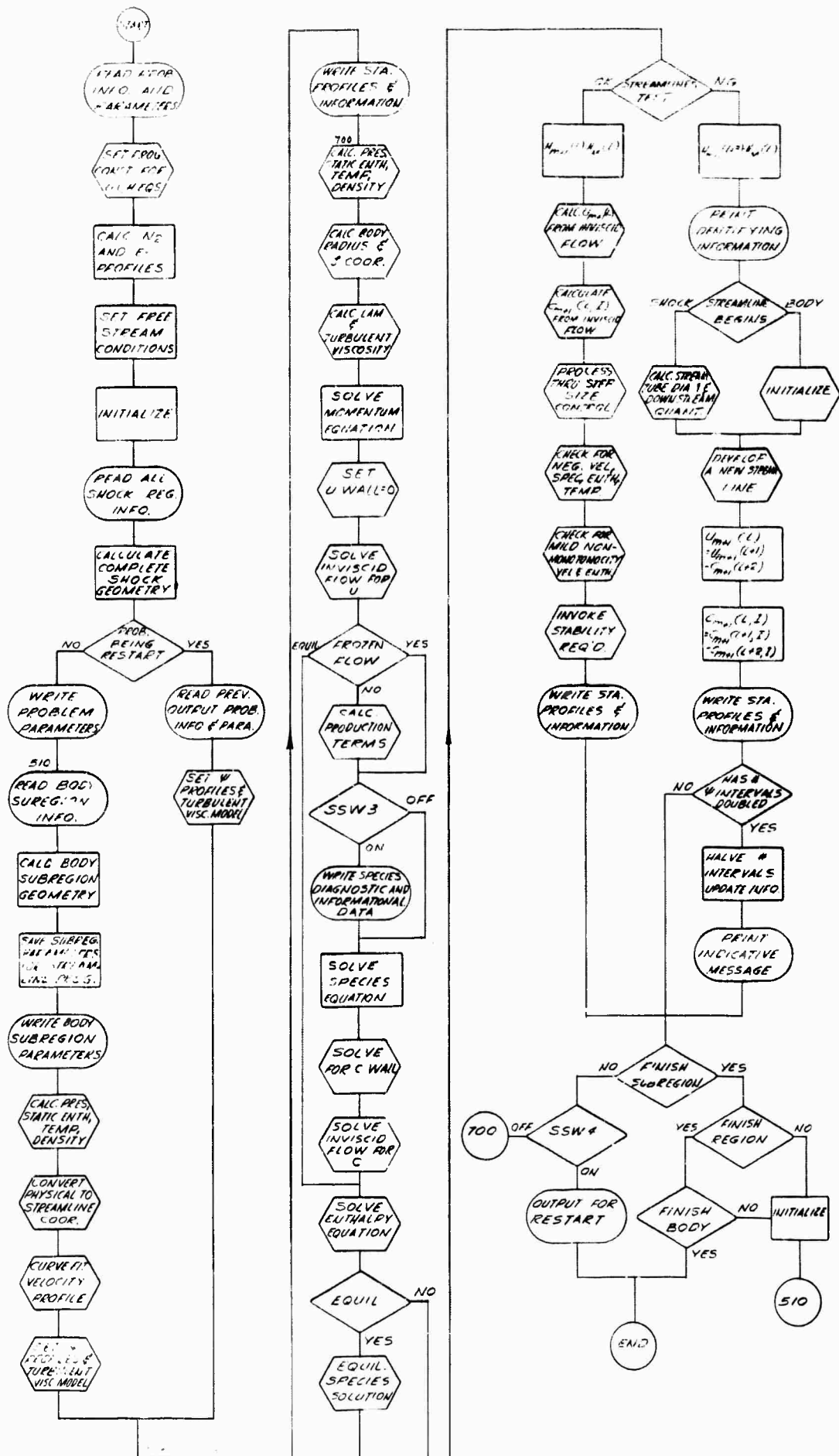
	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	
10	11	00030	150	74	00645	250	89	01230	91	01362

APPENDIX III

FLOW DIAGRAM

CHIEF CAVITY REACTING FLOW LAYER

OVERALL PROGRAM LOGIC



APPENDIX 4

SAMPLE INPUT

TITLE CARD
FIRING RANGE BLUNTED CONE

TITLE CARD
NON UNITY FLOW PARAMETERS

TITLE CARD
LAMINAR CHEMISTRY RUN

LP2	NS	NPSI	INDSTR	FNDSSL	FNDSSH	IALT
20	7	1	1	.5E-2	.75E-1	150
AIL	AIT	A2	A3L	A3T	A4L	A4T
1.0F0	0.0E0	1.0E0	1.0E0	0.0E0	1.0E0	0.0E0
ASL	AST	C(1,1)	C(2,1)	C(3,1)	C(4,1)	C(5,1)
1.0F0	0.0E0	.22741E0	.22170E0	.21183E0	.17982E0	.14297E0
C(6,1)	C(7,1)	C(8,1)	C(9,1)	C(10,1)	C(11,1)	C(12,1)
.11150E0	.85382E-1	.62616E-1	.43567E-1	.29410E-1	.20097E-1	.16908E-1
C(13,1)	C(14,1)	C(15,1)	C(16,1)	C(17,1)	C(18,1)	C(19,1)
.14904E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1
C(20,1)	C(1,2)	C(2,2)	C(3,2)	C(4,2)	C(5,2)	C(6,2)
.14469E-1	.67227E-3	.33476E-2	.10007E-1	.36819E-1	.71043E-1	.10170E0
C(7,2)	C(8,2)	C(9,2)	C(10,2)	C(11,2)	C(12,2)	C(13,2)
.12798E0	.15152E0	.17185E0	.18753E0	.19831E0	.20215E0	.20462E0
C(14,2)	C(15,2)	C(16,2)	C(17,2)	C(18,2)	C(19,2)	C(20,2)
.20516E0	.20516E0	.20516E0	.20516E0	.20516E0	.20516E0	.20516E0
C(1,4)	C(2,4)	C(3,4)	C(4,4)	C(5,4)	C(6,4)	C(7,4)
.14702E-8	.30977E-7	.25366E-6	.34105E-5	.14424E-4	.35360E-4	.69228E-4
C(8,4)	C(9,4)	C(10,4)	C(11,4)	C(12,4)	C(13,4)	C(14,4)
.12614E-3	.22343E-3	.37977E-3	.60274E-3	.73494E-3	.84654E-3	.87483E-3
C(15,4)	C(16,4)	C(17,4)	C(18,4)	C(19,4)	C(20,4)	C(1,5)
.87483E-3	.87483E-3	.87483E-3	.87483E-3	.87483E-3	.87483E-3	.73356E-2
C(2,5)	C(3,5)	C(4,5)	C(5,5)	C(6,5)	C(7,5)	C(8,5)
.13023E-1	.19050E-1	.28800E-1	.33728E-1	.35239E-1	.34955E-1	.33489E-1
C(9,5)	C(10,5)	C(11,5)	C(12,5)	C(13,5)	C(14,5)	C(15,5)
.31103E-1	.28245E-1	.25478E-1	.24262E-1	.23396E-1	.23195E-1	.23195E-1
C(16,5)	C(17,5)	C(18,5)	C(19,5)	C(20,5)	C(1,6)	C(2,6)
.23195E-1	.23195E-1	.23195E-1	.23195E-1	.23195E-1	.36175E-11	.93313E-10
C(3,6)	C(4,6)	C(5,6)	C(6,6)	C(7,6)	C(8,6)	C(9,6)
.87854E-9	.13790E-7	.61681E-7	.15267E-6	.29524E-6	.52305E-6	.88771E-6
C(10,6)	C(11,6)	C(12,6)	C(13,6)	C(14,6)	C(15,6)	C(16,6)
.14312E-5	.21502E-5	.25554E-5	.28882E-5	.29714E-5	.29714E-5	.29714E-5

C(17,6)	C(18,6)	C(19,6)	C(20,6)			
.29714E-5	.29714E-5	.29714E-5	.29714E-5			
RESTAR	DELTAX	EPSI	EPSIU	EPSIC	EPSIH	EPSIT
1.0E0	1.0E-9	1.0E0	0.5E-3	0.0E0	1.0E-4	1.0E-2
H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)
.26496E8	.31276E8	.36058E8	.45620E8	.55182E8	.64744E8	.74306E8
H(8)	H(9)	H(10)	H(11)	H(12)	H(13)	H(14)
.83868E8	.93428E8	1.02985E8	1.12551E8	1.17333E8	1.21160E8	1.22112E8
H(15)	H(16)	H(17)	H(18)	H(19)	H(20)	FK
1.22113E8	1.22114E8	1.22115E8	1.22116E8	1.22116E8	1.22116E8	.4E0
CPE	FL	FSHE	GAMM	PE	RHOE	RHOSTG
.432F0	1.0E0	1.20096E2	1.4E0	3.0597E0	3.5642E-6	4.1379E-5
CE(1)	CE(2)	CE(3)	CE(4)	CE(5)	CE(6)	CE(7)
.232F0	0.0E0	.768E0	0.0E0	0.0E0	0.0E0	0.0E0
RN	UINF	ULOLIM	XS	ZIS	ZZS	ZIL
.05E0	15.2E3	100.0E0	.0519E0	.02806E0	.041305E0	1.5E0
U(1)	U(2)	U(3)	U(4)	U(5)	U(6)	U(7)
0.0F0	.42518E3	.85037E3	.17007E4	.25511E4	.34014E4	.42518E4
U(8)	U(9)	U(10)	U(11)	U(12)	U(13)	U(14)
.51022F4	.59525E4	.68029E4	.76533E4	.80785E4	.84186E4	.85037E4
U(15)	U(16)	U(17)	U(18)	U(19)	U(20)	
.85037E4	.85037E4	.85037E4	.85037E4	.85037E4	.85037E4	
FA	FB	FC	TESTRA	AB4T	AB2T	AB3T
0.4F0	0.0E0	0.0E0	2.0E-1	0.0E0	0.0E0	0.0E0
AB4T	AB5T	AB6T	AB7T	BB1T	BB2T	BB3T
0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0
BB4T	BB5T	BB6T	BB7T	FLELIN	FLETIN	PRALIN
0.0E0	0.0E0	0.0E0	0.0E0	1.4E0	1.4E0	.7E0
PRATIN	SCHLIN	SCHTIN	Y(1)	Y(2)	Y(3)	Y(4)
.7F0	.5E0	.5E0	0.0E0	.62716E-4	.11128E-3	.24304E-3
Y(5)	Y(6)	Y(7)	Y(8)	Y(9)	Y(10)	Y(11)
.39216E-3	.55812E-3	.74335E-3	.95388E-3	.12015E-2	.15123E-2	.19643E-2
Y(12)	Y(13)	Y(14)	Y(15)	Y(16)	Y(17)	Y(18)
.23168E-2	.24369E-2	.25270E-2	.26171E-2	.27072E-2	.27973E-2	.28874E-2
Y(19)	Y(20)					
.29775E-2	.30673E-2					
INDPRI	NSR	JINPUT	THPER			
5	4	20	.99E0			

ASR(1)	BSR(1)	CSR(1)	ZIR(1)	Z2R(1)	TYP	COO	LAS	IND	IND	IND
0.0E0	5.3775E0	0.0E0	1.036E-3	1.3880E-2	6	1	0	IND	IND	IND
ASR(2)	BSR(2)	CSR(2)	ZIR(2)	Z2R(2)	TYP	COO	LAS			
.60962E-3	13.067	.81680E-2	.042663E0	.064899E0	6	1	0			
ASR(3)	BSR(3)	CSR(3)	ZIR(3)	Z2R(3)	TYP	COO	LAS	IND	IND	IND
9.6118E-3	1.6625E1	.020312E0	.390380E0	.168759E0	6	1	0			
ASR(4)	BSR(4)	CSR(4)	ZIR(4)	Z2R(4)	TYP	COO	LAS	IND	IND	IND
.2026F0	.0896068E0	0E0	1.5E0	1.50E0	2	1	1			
INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7				
2	1	0	0	0	0	0				
OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)				
.0534E0	0.0E0	0.0E0	593.330E0	-410.15E0	0.0E0	0.0E0				
P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)				
0.0F0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0				
CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)				
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0				
CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)				
0.0E0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0				
CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)				
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0				
CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2				
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0				
HH3	HH4	HH5	RN	XL	CONEAN					
0.0F0	0.0E0	0.0E0	.05E0	.06175E0	0.0E0					
INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7				
2	1	0	1	0	0	0				
OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)				
.0534E0	0.0E0	0.0E0	213.56E0	-102.64E0	0.0E0	0.0E0				
P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)				
0.0E0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0				
CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)				
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0				
CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)				
0.0F0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0				
CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)				
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0				

CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL .0717E0	CONEAN 0E0	
INDP 2	INDR 2	INDLR 0	INDLSR 0	INDSS 0	INDS6 0	INDS7 0
OGIVEH 0.0E0	OGIVEK 0.0E0	P(1) 0.0E0	P(2) 213.56E0	P(3) -102.64E0	P(4) 0E0	P(5) 0E0
P(6) 0E0	P(7) 0E0	P(8) 0E0	CC(1,1) .22741E0	CC(2,1) 0.0E0	CC(3,1) 0.0E0	CC(4,1) 0.0E0
CC(5,1) 0.0E0	CC(1,2) .67227E-3	CC(2,2) 0.0E0	CC(3,2) 0.0E0	CC(4,2) 0.0E0	CC(5,2) 0.0E0	CC(1,3) .76457E0
CC(2,3) 0.0E0	CC(3,3) 0.0E0	CC(4,3) 0.0E0	CC(5,3) 0.0E0	CC(1,4) .14702E-8	CC(2,4) 0.0E0	CC(3,4) 0.0E0
CC(4,4) 0.0E0	CC(5,4) 0.0E0	CC(1,5) .73356E-2	CC(2,5) 0.0E0	CC(3,5) 0.0E0	CC(4,5) 0.0E0	CC(5,5) 0.0E0

CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL .0864E0	CONEAN .13671E0	
INDP 2	INDR 2	INDLR 0	INDLSR 0	INDSS 0	INDS6 0	INDS7 0
OGIVEH 0.0E0	OGIVEK 0.0E0	P(1) 0.0E0	P(2) 43.840E0	P(3) -4.4213E0	P(4) 0.0E0	P(5) 0.0E0
P(6) 0.0E0	P(7) 0.0E0	P(8) 0.0E0	CC(1,1) .22741E0	CC(2,1) 0.0E0	CC(3,1) 0.0E0	CC(4,1) 0.0E0
CC(5,1) 0.0E0	CC(1,2) .67227E-3	CC(2,2) 0.0E0	CC(3,2) 0.0E0	CC(4,2) 0.0E0	CC(5,2) 0.0E0	CC(1,3) .76457E0
CC(2,3) 0.0E0	CC(3,3) 0.0E0	CC(4,3) 0.0E0	CC(5,3) 0.0E0	CC(1,4) .14702E-8	CC(2,4) 0.0E0	CC(3,4) 0.0E0
CC(4,4) 0.0E0	CC(5,4) 0.0E0	CC(1,5) .73356E-2	CC(2,5) 0.0E0	CC(3,5) 0.0E0	CC(4,5) 0.0E0	CC(5,5) 0.0E0
CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL .2877E0	CONEAN .136718E0	

INOP 2	INDR 2	INDLR 1	INDLSR 1	INDS5 0	INDS6 0	INDS7 0
OGIVEH 0.0E0	OGIVEK 0.0E0	P(1) 0.0E0	P(2) 19.228E0	P(3) -.13784E0	P(4) 0.0E0	P(5) 0.0E0
P(6) 0.0E0	P(7) 0.0E0	P(8) 0.0E0	CC(1,1) .22741E0	CC(2,1) 0.0E0	CC(3,1) 0.0E0	CC(4,1) 0.0E0
CC(5,1) 0.0E0	CC(1,2) .67227E-3	CC(2,2) 0.0E0	CC(3,2) 0.0E0	CC(4,2) 0.0E0	CC(5,2) 0.0E0	CC(1,3) .76457E0
CC(2,3) 0.0E0	CC(3,3) 0.0E0	CC(4,3) 0.0E0	CC(5,3) 0.0E0	CC(1,4) .14702E-8	CC(2,4) 0.0E0	CC(3,4) 0.0E0
CC(4,4) 0.0E0	CC(5,4) 0.0E0	CC(1,5) .73356E-2	CC(2,5) 0.0E0	CC(3,5) 0.0E0	CC(4,5) 0.0E0	CC(5,5) 0.0E0
CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL 1.5415E0	CONEAN .136718E0	

Appendix V

Total No. of Pages - 10

APPENDIX V

SAMPLE OUTPUT

GENERAL APPLIED SCIENCE LABS

FINITE DIFFERENCE SOLUTION OF CHEMICALLY REACTING AIR BOUNDARY LAYERS

FIRING RANGE BLUNTED CONE

NON UNITY FLOW PARAMETERS

LAMINAR CHEMISTRY RUN

FLIGHT CONDITIONS AND FREE STREAM PROPERTIES

ALT (K FT)	CP (FT/SEC) SQ/K	STAT ENTH (FT/SEC) SQ	GAMMA	PRESS (LB/SC FT)	DENSITY (SLUGS/CU FT)	TEMP (DEG K)	VEL (FT/SEC)
150	4.3200E-01	1.2009E 02	1.4000E 00	3.05970E 00	3.56420E-06	2.78000E 02	1.52000E 04
C(O2)	C(O)	C(N2)	C(N)	C(NO)	C(NO+)	C(E-)	
2.32000E-01	0.	7.68000E-01	0.	0.	0.	0.	

SHOCK CONDITIONS

STAG DENSITY
(SLUGS/CU FT)
4.13790E-05

NSR

4

SHOCK REGION NO 1

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)
PARABOLIC	0.	0.	0.	5.37750E 00	0.	1.03600E-03 1.38801E-02

SHOCK REGION NO 2

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)
PARABOLIC	0.	0.	6.09620E-04	1.30670E 01	8.16800E-03	4.26630E-02 6.49117E-02

SHOCK REGION NO 3

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)
PARABOLIC	0.	0.	9.61180E-03	1.66250E 01	2.03120E-02	3.90300E-01 1.68758E-01

SHOCK REGION NO 4

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)

STATION VALUES											
	0	0	9	0	5						
X (FT)	DELTA X (FT)	ZETA 1 (FT)	RAO BCOY (FT)	BL MASS FLOW (LB SEC/FT)	STREAMTUBE RAO (FT)	WALL PRES (LB/SQ FT)	RETHETA				
5.1900001E-03	1.0000000E-09	0.	0.	5.93238E-05	1.86697E-02	1.67594E C2	0.				
DELTA U (FT)	DELTA V (FT)	DELTA C (02) (FT)	DELTA C (01) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (N0) (FT)	DELTA C (E-) (FT)				
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03				
REX	REX	DELTA STAK (FT)	THETA (FT)	NU/SCRT (REX)	NU/SCRT (REW)	C SUB F					
0.	C.	7.61037E-04	4.66866E-04	-0.	-0.	0.					
K	C (02)	C (01)	C (N2)	C (N1)	C (N0)	C (N0+)	C (E-)	CSUB			
1	2.27410E-01	6.72270E-04	7.64582E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	10.00000E-01			
2	1.29755E-01	8.39162E-02	7.51943E-01	2.32153E-05	3.43625E-02	9.98883E-08	1.82620E-12	10.00000E-01			
3	9.12410E-02	1.22085E-01	7.51594E-01	6.16305E-05	3.50187E-02	2.63258E-07	4.81300E-12	10.00000E-01			
4	6.82956E-02	1.45544E-01	7.52087E-01	1.11692E-04	3.38612E-02	4.65216E-07	8.50529E-12	10.00000E-01			
5	5.30915E-02	1.61685E-01	7.52752E-01	1.74785E-04	3.22960E-02	7.05380E-07	1.28961E-11	10.00000E-01			
6	4.16140E-02	1.74013E-01	7.53418E-01	2.44988E-04	3.07087E-02	9.62888E-07	1.76003E-11	10.00000E-01			
7	3.45613E-02	1.81824E-01	7.54005E-01	3.22882E-04	2.92849E-02	1.23344E-06	2.25503E-11	10.00000E-01			
8	2.86205E-02	1.88444E-01	7.54525E-01	3.98673E-04	2.80104E-02	1.49215E-06	2.72803E-11	10.00000E-01			
9	2.56918E-02	1.91834E-01	7.54863E-01	4.68790E-04	2.71403E-02	1.71826E-06	3.14140E-11	10.00000E-01			
10	2.27632E-02	1.95224E-01	7.55202E-01	5.38907E-04	2.62702E-02	1.94436E-06	3.55477E-11	10.00000E-01			
11	1.99882E-02	1.98441E-01	7.55525E-01	6.07251E-04	2.54365E-02	2.16403E-06	3.95637E-11	10.00000E-01			
12	1.87739E-02	1.99903E-01	7.55689E-01	6.57589E-04	2.49735E-02	2.31832E-06	4.23845E-11	10.00000E-01			
13	1.75596E-02	2.01365E-01	7.55854E-01	7.07927E-04	2.45105E-02	2.47260E-06	4.52053E-11	10.00000E-01			
14	1.59034E-02	2.03388E-01	7.56087E-01	7.90885E-04	2.38279E-02	2.72223E-06	4.97691E-11	10.00000E-01			
15	1.45718E-02	2.05032E-01	7.56282E-01	8.68145E-04	2.32425E-02	2.95174E-06	5.39651E-11	10.00000E-01			
16	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01			
17	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01			
18	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01			
19	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01			
20	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01			

K	PSI (LB SEC/FT)	Y (FT)	U (FT/SEC)	T (DEG K)	SMALL H (FT/SEC)	H (FT/SEC)	RHO (SLUGS/CU FT)
1	0.	0.	0.	2.13739E 03	2.64960E 07	2.64960E 07	2.52367E-05
2	5.32981E-07	4.94177E-04	2.90815E 03	2.43659E 03	3.11856E 07	5.91972E 07	1.62111E-05
3	1.06596E-06	7.37640E-04	4.06103E 03	2.66925E 03	3.56964E 07	7.21610E 07	1.49018E-05
4	1.59894E-06	9.37584E-04	4.88631E 03	2.92658E 03	4.41738E 07	8.14405E 07	1.41470E-05
5	2.13192E-06	1.11638E-03	5.52735E 03	3.04724E 03	5.19279E 07	8.86480E 07	1.36572E-05
6	2.66490E-06	1.28189E-03	6.06982E 03	3.16703E 03	5.89592E 07	9.47464E 07	1.32801E-05
7	3.19788E-06	1.43829E-03	6.49346E 03	3.29234E 03	6.52671E 07	9.95075E 07	1.30119E-05
8	3.73086E-06	1.58811E-03	6.87499E 03	3.40126E 03	7.08518E 07	1.03796E 08	1.27749E-05
9	4.26385E-06	1.73313E-03	7.14242E 03	3.49876E 03	7.57119E 07	1.06804E 08	1.26225E-05
10	4.79683E-06	1.87452E-03	7.40984E 03	3.60118E 03	7.98453E 07	1.09812E 08	1.24701E-05
11	5.32981E-06	2.01261E-03	7.66781E 03	3.71113E 03	8.32645E 07	1.12714E 08	1.23241E-05
12	5.86279E-06	2.14819E-03	7.82971E 03	3.76492E 03	8.47019E 07	1.14535E 08	1.22429E-05
13	6.39577E-06	2.28188E-03	7.99162E 03	3.80586E 03	8.57236E 07	1.16356E 08	1.21618E-05
14	6.92875E-06	2.41322E-03	8.24899E 03	3.81533E 03	8.59555E 07	1.19251E 08	1.20410E-05
15	7.46173E-06	2.54188E-03	8.48359E 03	3.81540E 03	8.59565E 07	1.21887E 08	1.19375E-05
16	7.99471E-06	2.66919E-03	8.50370E 03	3.81547E 03	8.59575E 07	1.22113E 08	1.19290E-05
17	8.52769E-06	2.79639E-03	8.50370E 03	3.81555E 03	8.59585E 07	1.22115E 08	1.19287E-05
18	9.06067E-06	2.92360E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
19	9.59365E-06	3.05081E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
20	1.01266E-05	3.17802E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05

K	ELECTRON DENS PART/CC	MU L (LB SEC/SQFT)	MU T (LB SEC/SQFT)	TAUM (LB/SQFT)	SM H 1/2 2.64960E 07	TAUM 1/2 0.	EDEN 1/2 9.45480E 05
1	9.45480E 05	0.	0.	0.			
2	1.67702E 10	0.	0.	0.			
3	4.06286E 10	0.	0.	0.			
4	6.81601E 10	0.	0.	0.			
5	9.97687E 10	0.	0.	0.			
6	1.32403E 11	0.	0.	0.			
7	1.66215E 11	0.	0.	0.			
8	1.97416E 11	0.	0.	0.			
9	2.24618E 11	0.	0.	0.			
10	2.51106E 11	0.	0.	0.			
11	2.76203E 11	0.	0.	0.			
12	2.93947E 11	0.	0.	0.			
13	3.11431E 11	0.	0.	0.			
14	3.39468E 11	0.	0.	0.			
15	3.64925E 11	0.	0.	0.			
16	3.67093E 11	0.	0.	0.			
17	3.67084E 11	0.	0.	0.			
18	3.67074E 11	0.	0.	0.			
19	3.67074E 11	0.	0.	0.			
20	3.67074E 11	0.	0.	0.			
U 1/2	FH 1/2	RHO 1/2	T 1/2	V 1/2	SM H 1/2	TAUM 1/2	EDEN 1/2
2.07465E 03	2.64960E 07	2.52367E-C5	2.13739E 03	0.	2.64960E 07	0.	9.45480E 05
C(1) 1/2							
2.27410E-C1	6.72270E-C4	7.64582E-C1	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	

STATION VALUES											
	5	3	3	5	5						
DELTA X (FT)	DELTA X (FT)	ZETA 1 (FT)	RAD BODY (FT)	BL MASS FLOW (LB SEC/FT)	STREAMTUBE RAD (FT)	WALL PRES (LB/SQ FT)	REI METE				
5.1900058E-02	3.2000000E-08	2.7253924E-02	4.2619041E-02	5.91032E-05	1.86475E-02	1.67594E-02	2.51014E-01				
DELTA U (FT)	DELTA U (FT)	DELTA C (O2)	DELTA C (O)	DELTA C (N2)	DELTA C (N)	DELTA C (INC)	DELTA C (E-)				
2.43340E-03	2.42097E-03	2.83787E-03	2.32559E-03	2.83787E-03	2.46460E-03	2.83787E-03	2.46247E-03				
DELTA V (FT)	DELTA V (FT)	DELTA STAR (FT)	THEYA (FT)	NU/SCRT (REX)	NU/SCRT (REW)	C SUB F					
2.87921E-03	8.31842E-03	7.41979E-04	4.52473E-04	7.96174E-01	4.68407E-01	2.13448E-02					
	C (O2)	C (O)	C (N2)	C (N)	C (NO)	C (NO+)	C (E-)				
1	6.27410E-01	6.72270E-04	7.64570E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17				
2	1.29756E-01	6.39162E-01	7.51943E-01	2.32167E-05	3.43619E-02	9.98940E-08	1.82631E-12				
3	1.12417E-02	1.22084E-01	7.51594E-01	6.16322E-05	3.50186E-02	2.63226E-07	4.81311E-12				
4	6.83961E-02	1.45543E-01	7.52087E-01	1.11694E-04	3.38611E-02	4.65222E-07	8.50540E-12				
5	5.30918E-02	1.61685E-01	7.52752E-01	1.74786E-04	3.22960E-02	7.05384E-07	1.28961E-11				
6	4.16144E-02	1.74013E-01	7.53418E-01	2.45000E-04	3.07087E-02	9.62691E-07	1.75004E-11				
7	3.45614E-02	1.81824E-01	7.54005E-01	3.22883E-04	2.92850E-02	1.23344E-06	2.25503E-11				
8	2.86208E-02	1.88444E-01	7.54525E-01	3.98673E-04	2.80105E-02	1.49215E-06	2.72802E-11				
9	2.56918E-02	1.91834E-01	7.54863E-01	4.68790E-04	2.71403E-02	1.71826E-06	3.14140E-11				
10	2.27632E-02	1.95224E-01	7.55202E-01	5.38907E-04	2.62702E-02	1.94436E-06	3.55477E-11				
11	1.99884E-02	1.98441E-01	7.55525E-01	6.07249E-04	2.54366E-02	2.16402E-06	3.55636E-11				
12	1.87739E-02	1.99903E-01	7.55689E-01	6.57589E-04	2.49735E-02	2.31832E-06	4.43845E-11				
13	1.75596E-02	2.01365E-01	7.55854E-01	7.07932E-04	2.45104E-02	2.47262E-06	4.52055E-11				
14	1.59034E-02	2.03388E-01	7.56087E-01	7.90885E-04	2.38279E-02	2.72232E-06	4.97691E-11				
15	1.45720E-02	2.05032E-01	7.56282E-01	8.68136E-04	2.32426E-02	2.95171E-06	5.39645E-11				
16	1.44690E-02	2.05160E-01	7.56298E-01	8.74829E-04	2.31950E-02	2.97140E-06	5.43244E-11				
17	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11				
18	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11				
19	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11				
20	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11				

K	PSI (LB SEC/FT)	Y (FT)	U (FT/SEC)	T (DEC MI)	SMALL H (FT/SEC) SQ	H (FT/SEC) SQ	RWD (SLUGS/CU FT)
1	0.	0.	0.	2.13742E 03	2.64960E 07	2.64960E C7	2.52367E-05
2	5.32981E-07	4.60655E-04	2.90815E 03	3.10402E 03	5.49665E 07	5.91971E C7	1.61649E-05
3	1.06596E-06	7.17187E-04	4.06103E 03	3.26682E 03	6.39150E 07	7.21609E C7	1.48736E-05
4	1.59894E-06	9.11330E-04	4.86630E 03	3.37858E 03	6.95025E 07	8.14404E C7	1.41207E-05
5	2.13132E-06	1.08497E-03	5.52735E 03	3.45653E 03	7.33722E 07	8.86479E C7	1.36262E-05
6	2.66490E-06	1.24565E-03	6.06961E 03	3.51598E 03	7.63251E 07	9.47464E C7	1.32663E-05
7	3.19788E-06	1.39745E-03	6.49346E 03	3.56992E 03	7.84249E 07	9.95075E C7	1.29860E-05
8	3.73066E-06	1.54285E-03	6.87499E 03	3.61251E 03	8.01632E 07	1.03796E C8	1.27666E-05
9	4.26365E-06	1.68358E-03	7.14242E 03	3.65128E 03	8.12971E 07	1.06804E C8	1.25973E-05
10	4.79663E-06	1.82086E-03	7.40944E 03	3.68494E 03	8.23595E 07	1.09812E C8	1.24491E-05
11	5.32981E-06	1.95482E-03	7.66760E 03	3.71318E 03	8.33165E 07	1.12714E C8	1.23232E-05
12	5.86279E-06	2.08625E-03	7.92571E 03	3.73501E 03	8.38828E 07	1.14535E C8	1.22370E-05
13	6.39577E-06	2.21587E-03	8.18382E 03	3.75498E 03	8.44229E 07	1.16356E C8	1.21578E-05
14	6.92875E-06	2.34320E-03	8.44191E 03	3.78647E 03	8.52285E 07	1.19251E C8	1.20373E-05
15	7.46173E-06	2.46792E-03	8.69581E 03	3.81314E 03	8.59014E 07	1.21087E C8	1.19373E-05
16	7.99471E-06	2.59130E-03	8.95370E 03	3.81542E 03	8.59567E 07	1.22113E C8	1.19290E-05
17	8.52769E-06	2.71458E-03	9.21152E 03	3.81552E 03	8.59581E 07	1.22115E C8	1.19287E-05
18	9.06067E-06	2.83787E-03	9.46937E 03	3.81562E 03	8.59595E 07	1.22116E C8	1.19284E-05
19	9.59365E-06	2.96116E-03	9.72722E 03	3.81562E 03	8.59595E 07	1.22116E C8	1.19284E-05
20	1.01266E-05	3.08444E-03	9.98507E 03	3.81562E 03	8.59595E 07	1.22116E C8	1.19284E-05

K	ELECTRON DENS PART/CC	MU L (LB SEC/SQFT)	MU T (LB SEC/SQFT)	TAUM (LB/SQFT)	SV H 1/2	TAUM 1/2	EDEN 1/2
1	5.45480E 05	1.33896E-06	0.	9.20574E 00			
2	1.67234E 10	1.63861E-06	0.	9.09546E 00			
3	4.05525E 10	1.68446E-06	0.	8.22637E 00			
4	6.80345E 10	1.71432E-06	0.	7.25588E 00			
5	9.95435E 10	1.73522E-06	0.	6.37958E 00			
6	1.32266E 11	1.75100E-06	0.	5.89173E 00			
7	1.65613E 11	1.76519E-06	0.	4.90899E 00			
8	1.97278E 11	1.77632E-06	0.	4.64848E 00			
9	2.24170E 11	1.78636E-06	0.	3.36544E 00			
10	2.50483E 11	1.79508E-06	0.	3.48491E 00			
11	2.76183E 11	1.80234E-06	0.	3.46430E 00			
12	2.99604E 11	1.80794E-06	0.	2.22375E 00			
13	3.11321E 11	1.81304E-06	0.	2.26162E 00			
14	3.29203E 11	1.82106E-06	0.	3.67329E 00			
15	3.45510E 11	1.82763E-06	0.	3.43215E 00			
16	3.67692E 11	1.82840E-06	0.	2.98029E-01			
17	3.67003E 11	1.82843E-06	0.	1.08626E-05			
18	3.67073E 11	1.82845E-06	0.	1.81041E-06			
19	3.67073E 11	1.82845E-06	0.	0.			
20	3.67073E 11	1.82845E-06	0.	0.			
U 1/2	FM 1/2	RHO 1/2	Y 1/2	Y 1/2	SV H 1/2	TAUM 1/2	EDEN 1/2
2.07405E 03	4.98306E 07	1.76318E-05	2.90841E 03	3.29699E-04	4.76785E 07	9.09546E 00	5.02542E 09
C(1) 1/2							
1.57656E-01	5.82456E-02	7.53913E-01	6.23856E-06	3.01770E-02	2.75210E-08	5.03152E-13	

"STREAMLINE OUTPUT"

SHOCK ANGLE= XDO	1.24687E 00 #100	PRDS= U	6.12958E 02 C(N)	2.12017E -03 C(M)	DIN2= C(MO+)	1.88198E -02 C(E-)	UDS= C(E-)	4.81725E 03 Y	RHO	ME
2.32831E-19	2.12017E-03	4.81725E 03	7.37997E-20	0.	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.49246E-19	2.12017E-03	4.81725E 03	1.10700E-19	6.97570E-35	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.07454E-19	2.12017E-03	4.81725E 03	1.29149E-19	6.97570E-35	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.65661E-19	2.12017E-03	4.81725E 03	1.47599E-19	6.97570E-35	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.28057E-18	2.12017E-03	4.81725E 03	4.05898E-19	1.83112E-33	0.	0.	0.	8.23679E 03	2.39659E-05	0.
2.44472E-18	2.12017E-03	4.81725E 03	7.74897E-19	7.20241E-33	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.77303E-18	2.12017E-03	4.81725E 03	1.51289E-18	7.99008E-32	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.03610E-17	2.12017E-03	4.81725E 03	3.28409E-18	1.32903E-31	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.96742E-17	2.12017E-03	4.81725E 03	6.23607E-18	4.79457E-31	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.83006E-17	2.12017E-03	4.81725E 03	2.63096E-17	8.54337E-30	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.30041E-17	2.12017E-03	4.81725E 03	4.99255E-17	3.07451E-29	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.57110E-16	2.12017E-03	4.81725E 03	9.71574E-17	1.62931E-28	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.06522E-16	2.12017E-03	4.81725E 03	2.10514E-16	5.46088E-28	0.	0.	0.	8.23679E 03	2.39659E-05	0.
6.64149E-16	2.12017E-03	4.81725E 03	3.99441E-16	1.96808E-27	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.26020E-15	2.12017E-03	4.81725E 03	7.77296E-16	7.44350E-27	0.	0.	0.	8.23679E 03	2.39659E-05	0.
2.45229E-15	2.12017E-03	4.81725E 03	1.68415E-15	3.50088E-26	0.	0.	0.	8.23679E 03	2.39659E-05	0.
5.31331E-15	2.12017E-03	4.81725E 03	3.19557E-15	1.25940E-25	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.00817E-14	2.12017E-03	4.81725E 03	6.21842E-15	4.76390E-25	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.96184E-14	2.12017E-03	4.81725E 03	2.40581E-14	8.06148E-24	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.25066E-14	2.12017E-03	4.81725E 03	2.53647E-14	3.04891E-23	0.	0.	0.	8.23679E 03	2.39659E-05	0.
8.06531E-14	2.12017E-03	4.81725E 03	4.97475E-14	1.43398E-22	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.56948E-13	2.12017E-03	4.81725E 03	2.07786E-13	5.15931E-21	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.40053E-13	2.12017E-03	4.81725E 03	3.97981E-13	9.17747E-21	0.	0.	0.	8.23679E 03	2.39659E-05	0.
6.45229E-13	2.12017E-03	4.81725E 03	8.62294E-13	1.03320E-19	6.23059E-33	0.	0.	8.23679E 03	2.39659E-05	0.
1.25558E-12	2.12017E-03	4.81725E 03	2.87432E-12	4.01703E-19	3.82647E-33	0.	0.	8.23679E 03	2.39659E-05	0.
2.72042E-12	2.12017E-03	4.81725E 03	5.66020E-12	1.58226E-18	2.58111E-32	0.	0.	8.23679E 03	2.39659E-05	0.
9.06808E-12	2.12017E-03	4.81725E 03	1.13230E-11	6.28101E-18	2.17999E-31	0.	0.	8.23679E 03	2.39659E-05	0.
1.78571E-11	2.12017E-03	4.81725E 03	2.23756E-11	1.13744E-16	1.78365E-30	0.	0.	8.23679E 03	2.39659E-05	0.
3.54353E-11	2.12017E-03	4.81725E 03	9.41900E-11	3.77335E-16	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
7.05915E-11	2.12017E-03	4.81725E 03	4.46628E-11	1.13744E-16	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
1.40904E-10	2.12017E-03	4.81725E 03	1.73434E-10	3.77335E-16	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
5.47154E-10	2.12017E-03	4.81725E 03	3.51732E-10	1.55145E-15	9.75812E-24	0.	0.	8.23679E 03	2.39659E-05	0.
1.10965E-09	2.12017E-03	4.81725E 03	7.08330E-10	6.29237E-15	1.78365E-30	0.	0.	8.23679E 03	2.39659E-05	0.
2.34655E-09	2.12017E-03	4.81725E 03	1.42153E-09	2.53449E-14	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
4.48465E-09	2.12017E-03	4.81725E 03	2.84793E-09	1.01733E-13	6.34415E-24	0.	0.	8.23679E 03	2.39659E-05	0.
8.98465E-09	2.12017E-03	4.81725E 03	5.70075E-09	4.07640E-12	9.30325E-28	0.	0.	8.23679E 03	2.39659E-05	0.
1.79846E-08	2.12017E-03	4.81725E 03	1.4065E-08	1.63198E-12	7.45237E-27	0.	0.	8.23679E 03	2.39659E-05	0.
3.59846E-08	2.12017E-03	4.81725E 03	2.28181E-08	6.43078E-12	5.96583E-26	0.	0.	8.23679E 03	2.39659E-05	0.
7.19846E-08	2.12017E-03	4.81725E 03	4.56424E-08	1.04286E-11	3.82008E-24	0.	0.	8.23679E 03	2.39659E-05	0.
1.43985E-07	2.12017E-03	4.81725E 03	9.12944E-08	1.04525E-10	3.82008E-24	0.	0.	8.23679E 03	2.39659E-05	0.
2.79855E-07	2.12017E-03	4.81725E 03	1.82613E-07	4.18114E-10	3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
5.75985E-07	2.12017E-03	4.81725E 03	3.65305E-07	1.67243E-09	2.44529E-22	0.	0.	8.23679E 03	2.39659E-05	0.
1.15198E-06	2.12017E-03	4.81725E 03	7.30912E-07	6.68925E-08	1.95642E-21	0.	0.	8.23679E 03	2.39659E-05	0.
2.30398E-06	2.12017E-03	4.81725E 03	1.46302E-06	2.75261E-08	1.56537E-20	0.	0.	8.23679E 03	2.39659E-05	0.
4.60798E-06	2.12017E-03	4.81725E 03	2.93076E-06	1.06974E-07	1.25266E-19	0.	0.	8.23679E 03	2.39659E-05	0.
9.21598E-06	2.12017E-03	4.81725E 03	5.88018E-06	4.27597E-07	8.02910E-18	0.	0.	8.23679E 03	2.39659E-05	0.
1.84320E-05	2.12017E-03	4.81725E 03	1.18334E-05	1.70797E-06	6.43348E-17	0.	0.	8.23679E 03	2.39659E-05	0.
3.68640E-05	2.12017E-03	4.81725E 03	2.13934E-05	6.81193E-06	3.51894E-17	0.	0.	8.23679E 03	2.39659E-05	0.
7.37280E-05	2.12017E-03	4.81725E 03	4.82541E-05	2.70816E-05	5.15630E-16	0.	0.	8.23679E 03	2.39659E-05	0.
1.47456E-04	2.12017E-03	4.81725E 03	4.89197E-05	2.70816E-05	4.12125E-15	0.	0.	8.23679E 03	2.39659E-05	0.
2.94912E-04	2.12017E-03	4.81725E 03	1.01278E-04	1.06893E-04	2.73462E-14	0.	0.	8.23679E 03	2.39659E-05	0.
5.57036E-04	2.12017E-03	4.81725E 03	1.99472E-04	3.71113E-04	2.38946E-13	0.	0.	8.23679E 03	2.39659E-05	0.
1.08134E-03	2.12017E-03	4.81725E 03	4.01841E-04	1.31493E-03	1.88688E-13	0.	0.	8.23679E 03	2.39659E-05	0.
1.99885E-03	2.12017E-03	4.81725E 03	7.38032E-04	3.98423E-03	1.02682E-12	0.	0.	8.23679E 03	2.39659E-05	0.
3.30957E-03	2.12017E-03	4.81725E 03	1.14503E-03	9.12567E-03	3.63574E-12	0.	0.	8.23679E 03	2.39659E-05	0.
5.40672E-03	2.12017E-03	4.81725E 03	1.63219E-03	1.84331E-02	1.06534E-11	0.	0.	8.23679E 03	2.39659E-05	0.
8.55245E-03	2.12017E-03	4.81725E 03	2.09343E-03	3.15757E-02	2.44435E-11	0.	0.	8.23679E 03	2.39659E-05	0.