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COMBUSTOR DESIGN CRITERIA VALIDATION
Volume III - User's Manual

H. C. Mongia, R. S. Reynolds
AiRESEARCH MANUFACTURING COMPANY OF ARIZONA
111 South 34th Street
Phoenix, Ariz. 85034

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APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report describes an effort undertaken to improve small gas turbine combustor design techniques. This analytical procedure is viewed as a significant step toward reducing the design and development time and the cost associated with future Army gas turbine combustors while simultaneously achieving a more durable and fuel-efficient design. The reader is referred to the report documentation page for a description of each of the three volumes of this report. It is considered worthy of widespread application with the turbine industry. Any critique or other response regarding its use should be addressed to this Laboratory.

Mr. Kent Smith of the Propulsion Technical Area, Aeronautical Technology Division, served as Project Engineer for this effort.

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This document, the User's Manual, is Volume III of the Combustor Design Criteria Validation Program. It contains general information, descriptions of analytical models, descriptions of associated computer codes, and illustrations of the various combustor models. Volume I of this report contains the results of the combustor element tests and analytical model validation which took place in Task I of the program. Volume II contains the results of Tasks II and III on the design, fabrication, and rig tests of two different reverse flow annular combustors (3 pps) designed to specific goals utilizing the analytical procedures.

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I. INTRODUCTION

GENERAL INFORMATION

The present program represents an extension and refinement of the previous effort with specific application to the design requirements of advanced, small, high-temperature-rise combustors for aircraft engines in the 2- to 5-pound-per-second (0.91- to 2.27-kilogram-per-second) flow range. This program was performed for the Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), Ft. Eustis, Virginia by the AiResearch Manufacturing Company of Arizona during the period July, 1975, to October, 1978. The program is documented in this three-volume final report.

OBJECTIVE

The primary objective of this program was to further develop and validate existing analytical combustor design procedures that can be used to significantly shorten the design and development cycle of small advanced gas turbine engine combustors. Descriptions of the combustor analytical models, element tests and model validations are presented in Volume I.

The basic approach of the program consisted of a concentrated analytical treatment of key combustion phenomena affecting combustor performance complemented by rig tests. The rig test culminated in a complete series of performance mapping to validate the empirical/analytical combustor design procedure in an environment matching an actual operating engine.

The program was initially comprised of four technical tasks:

Task I - Analytical-Model Refinement

Task II - Full-Scale Combustor Design, Fabrication, and Preliminary Tests

Task III - Combustor-Performance Mapping

Task IV - Limited Modification and Retest

The Task I technical effort is described in Volume I. A complete description of the Task II and Task III activities is presented in Volume II. The computer codes for combustor design that evolved from that effort are fully documented in Volume III of this report. The combustor performance goals were achieved in Tasks II and III; thus Task IV was cancelled.

The computer models are based upon the numerical solution of the governing aero/thermo equations applicable to turbo-propulsion combustor environment, and are, therefore, applicable for analyzing internal flow field of can, can-annular and annulus combustor geometries. Both the inline and reverse-flow combustor configurations can be analyzed.

The cost-effectiveness of the empirical/analytical design procedure was to be demonstrated by undertaking the design and development testing of two full-scale annular combustors based on the following engine/combustor configurations, parameters and goals:

1. Engine/Component Configurations.

- Annular-combustor configurations
- Centrifugal compressor (last stage)
- First-stage axial turbine
- Nonregenerative cycle

2. Parameters and Goals.

- Engine airflow, W_{a3}= 2.87 pounds per second (1.30 kg/s)
- Combustor inlet pressure (P_3) = 10 atmospheres
- Compressor efficiency = 78.4 percent (total-to-static)
- Combustor inlet temperature = 660°F (622°K)
- Combustion efficiency = 99.5 percent (100 percent power) = 98.0 percent (5 percent power)
- Combustor pressure loss $\frac{P_{T3}-P_{T4}}{P_{T3}}$ = 3 percent
- Combustor discharge temperature (T_{4avg}) = 2300°F (1533°K)
- Maximum pattern factor (PF) ≤ 0.23

where $$PF = \frac{T_{4\,max} - T_{4avg}}{T_{4avg} - T_3}$$

- Average radial temperature profile compatible with typical turbine blade requirements
- Maximum radial pattern factor (RPF) ≤ 0.075

where $$PF = \frac{T_{4\ avg\ rad\ max} - T_{4\ avg}}{T_{4\ avg} - T_3}$$

$T_{4\ avg\ rad\ max}$ = peak value of the circumferentially averaged radial temperature profile

- Good light-off/relight capability to 20,000 feet (6091 meters) altitude and ambient-temperature conditions per MIL-E-5007D Paragraph 3.2.5.1 (dated 15 October 1973)

- No visible carbon formation with hot fuel or at high-altitude conditions

- Multifuel capability, including JP-4 and JP-5

- Fuel contamination tolerance per MIL-E-8593A, Table X with filtration to 10 microns

- The combined CO and HC exhaust emissions will be sufficiently low to meet the previously noted combustion efficiency goals at 100- and 5-percent rated power. The NO_x LTO emissions level will be at or below the 1979 EPA NO_x standards. The maximum smoke number will be below the threshold of the exhaust plume visibility

- Acceptable component temperature levels and gradients to ensure long combustion system life and reliability

- Reasonable cost and weight

SUMMARY

A complete description of the following six combustor analytical models, associated computer codes, and users manuals are given in this report.

- Annulus-flow model

- Combustor-performance model

- Liner-cooling model
- Transition-liner mixing model
- Emissions model
- Fuel-insertion model

The annulus-flow model is used to compute airflow distribution around the combustor liner and pressure drop. The information provided by this model on jet velocities and efflux angles is used for specifying the boundary conditions of the internal-flow computer models.

A 3-D reacting recirculating-flow model is used for computing internal profiles of velocity components, chemical species, and temperature of a given combustor design. Effects of detail-design changes can be analytically predicted in regard to combustion efficiency, exhaust temperature quality, and lean blowout.

Two-dimensional parabolic programs are used for predicting liner-wall-temperature levels, mixing rate in the combustor transition liner of reverse-flow annular combustors, and gaseous emissions. A fuel-insertion model is used to compute mean droplet size and size distribution of pressure atomizers, including simplex, duplex, and air-assist pressure atomizers, and airblast nozzles. The model is also used to compute spray trajectory and evaporation rate of a given nozzle design in a specified flow field.

The use of these models is illustrated in Section IV by a worked-out illustration of a simple combustor.

II. DESCRIPTION OF ANALYTICAL MODELS

The six combustor analytical models are described in this section. The relevent computer codes are described in Section III. The use of these models is illustrated by an example in Section IV.

ANNULUS-FLOW MODEL

An annulus-flow model is used to compute pressure losses, annulus Mach number and associated air velocity, and airflow distribution around the combustor liner.

A one-dimensional analysis of the plenum annulus is conducted based upon the generalized one-dimensional continuous flow-analysis approach of Shapiro[1]. The analysis considers the effect of area change, wall friction, drag introduced by inserted obstacles such as fuel nozzles and service struts, heat transfer from the liner wall, and injection or extraction of air from the annulus. The analysis is valid for constant specific heat and molecular weight.

Following the approach of Shapiro for a small control volume around a point P located at a distance "X" from the compressor discharge, as shown in Figure 1, the following three working relations are obtained for Mach number M, stagnation pressure P_0, and static temperature T.

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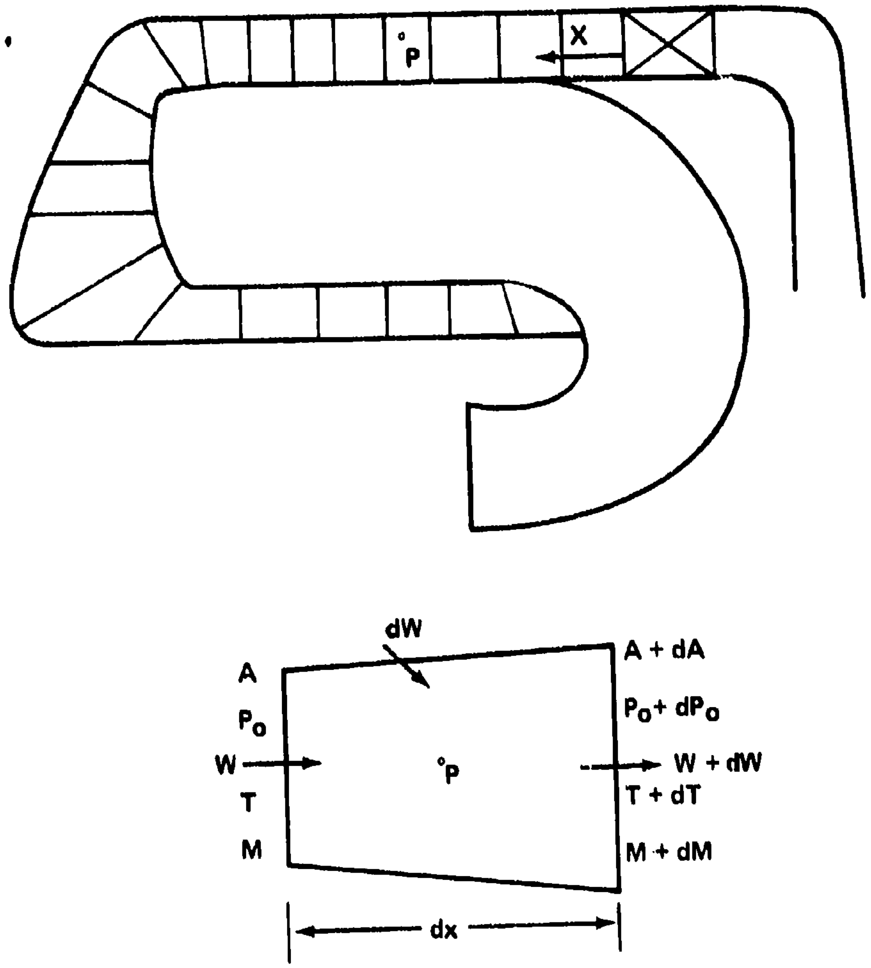
[1] Shapiro, Ascher H., "The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. I", Chapter 8, The Ronald Press Company, New York (1953).



Control volume around P

Figure 1. Control Volumes for Annulus-Flow Model.

$$\frac{dM^2}{M^2} = \frac{-2\left(1+\frac{\gamma-1}{2}M^2\right)}{1-M^2}\left[\frac{dA}{A} + \left(\frac{1+\gamma M^2}{2}\right)\frac{dT_o}{T_o} + \frac{\gamma M^2}{2}\left(4f\frac{dx}{D_H} + \frac{dF}{\frac{1}{2}\gamma p A M^2} - 2y\frac{dW}{W}\right) + \left(1+\gamma M^2\right)\frac{dW}{W}\right] \tag{1}$$

$$\frac{dp_o}{p_o} = \frac{-\gamma M^2}{2}\left[\frac{dT_o}{T_o} + 4f\frac{dx}{D_H} + \frac{dF}{\frac{1}{2}\gamma p A M^2} + 2(1-y)\frac{dW}{W}\right] \tag{2}$$

$$\frac{dT}{T} = \frac{M^2}{1-M^2}\left[(\gamma-1)\frac{dA}{A} + \left(\frac{1-\gamma M^2}{M^2}\right)\left(1+\frac{\gamma-1}{2}M^2\right)\frac{dT_o}{T_o} - \frac{\gamma}{2}(\gamma-1)M^2\left(4f\frac{dx}{D_H} + \frac{dF}{\frac{1}{2}\gamma p A M^2} - 2y\frac{dW}{W}\right) - (\gamma-1)\left(1+\gamma M^2\right)\frac{dW}{W}\right] \tag{3}$$

Where:

A = Flow area

D_H = Mean hydraulic diameter

f = Coefficient of skin friction

F = Drag force by inserted obstacles

T = Static gas temperature

W = Mass flow rate

y = Injected mass axial velocity/mainstream velocity

γ = Ratio of specific heats

The above set of equations is written for each of the control volumes, shown schematically in Figure 1, applicable to a reverse-flow combustor geometry. Appropriate expressions are used for skin friction coefficient and drag introduced by fuel nozzles and other obstacles in the flow path. The remaining unknown variable dW, which will be negative for the flow through various orifices, is calculated by using the following approach.

The orifice configurations used in a combustor liner can be broadly divided into two basic categories.

- Configurations such as swirlers, primary pipes, and venturi sections which are either difficult to handle analytically or their flow rates are less affected by approach conditions.

- Liner orifices, including flush port, plunged holes, and scooped ports are affected by approach conditions and are amenable to analytical approach for predicting flow rates, jet velocities, and efflux angles.

The first type of ports are handled by specifying discharge coefficients, whereas the liner orifices are handled by using a modified analytical approach described by Gurevice[2]. The Gurevice approach is based upon a 2-D potential flow solution of a problem shown schematically in Figure 2.

For an infinitely long slot of width b, the following three relations are obtained for the three unknowns, namely n, β and C_D.

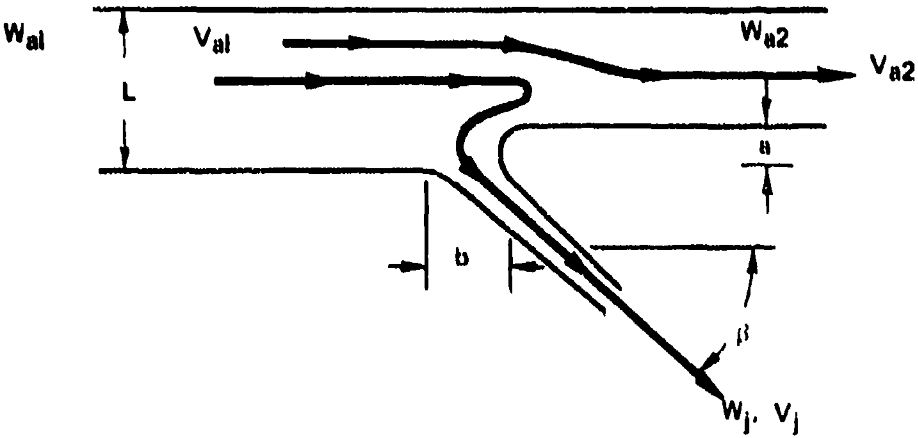
---

[2] Gurevich, M.I., "Theory of Jets in an Ideal Fluid", Pergamon Press, pp 52-59.

$$c = \cos\beta/(1-\tfrac{1}{2n}) \tag{4}$$

$$\begin{aligned}\frac{b}{L} = \frac{1}{\pi} \Bigg[& \frac{\pi\sin\beta}{n} - \frac{\cos\beta}{n} \ln\left(\frac{1+\cos\beta}{1-\cos\beta}\right) \\ & + \frac{\left(1-\frac{1}{2n}\right)^2 + \cos^2\beta}{\left(1-\frac{1}{2n}\right)\cos\beta} \ln\left|\frac{\left(1-\frac{1}{2n}\right)+\cos\beta}{\left(1-\frac{1}{2n}\right)-\cos\beta}\right| \\ & \frac{\left(1-\frac{1}{2n}\right)^2 + \left(1-\frac{1}{n}\right)^2\cos^2\beta}{\left(1-\frac{1}{2n}\right)\cos\beta} \ln\left|\frac{\left(1-\frac{1}{2n}\right)+\left(1-\frac{1}{n}\right)\cos\beta}{\left(1-\frac{1}{2n}\right)-\left(1-\frac{1}{n}\right)\cos\beta}\right| \Bigg] \frac{\cos\beta}{\left(1-\frac{1}{2n}\right)}\end{aligned} \tag{5}$$

$$C_D = \frac{L}{b}\left(\frac{2\cos\beta}{2n-1}\right) \tag{6}$$



Where:

a/L = annulus width change/upstream width

b/L = slot width/upstream annulus width

n = annulus upstream flow rate/slot flow rate, W_{al}/W_j

c = upstream annulus velocity/slot velocity, V_{al}/V_j

β = jet efflux angle

C_D = discharge coefficient

Figure 2. Liner Port Model Schematic.

These equations are applied to combustor liner orifices by maintaining area similarity through the following relationships:

$$b/_{L} = A_{H}/A_{ea}$$

where A_H = orifice area ($= \frac{\pi}{4} D^2$ for circular hole)

A_{ea} = effective annulus area with boundary-layer blockage effects

For a given application, the annulus upstream conditions and the static pressure inside the combustor must be specified. With the above equations, an orifice can be sized to pass a specified flow rate, or the flow through a specified orifice can be calculated. The procedure for each is outlined as follows.

For given values of annulus and orifice flow rates and velocities, c can be calculated and then the efflux angle can be found from Equation 4. For the special case where all annulus flow passes through the orifice, n = 1 and

$$\cos \beta = c/2$$

If the orifice flow is a negligible portion of the annulus flow, n approaches infinity,

$$\cos \beta = c$$

After the value of β is obtained, Equation 5 can be used to calculate b/L and A_H/A_{ea} from Equation 7; then from Equation 6, C_D can be calculated.

For the alternate problem, with the orifice specified, the above procedure is used in an iterative solution starting with an estimated flow rate (value of n). The iteration is continued until n converges to a small difference between iterations.

Such an approach has given good correlation with measure C_D[3] data of the circular orifices, as shown typically in Figure 3. For plunged orifices and the metering orifices of film-cooling geometries, the approach gave only qualitative agreement. However, by multiplying the computed C_D values by 1.48 and 1.4, and by assuming β equal to 80- and 0-degrees, respectively, for the plunged orifices and the cooling slot, the approach gave good agreement with the data, as shown in Figure 3.

With the above procedure for computing dW appearing in Equations 1, 2, and 3, it is now possible to write a set of equations for each of the control volumes around the combustor liner, as shown schematically in Figure 1. These equations are solved iteratively to compute isothermal combustor-pressure drop. To this can be added pressure drop due to heat addition which gives combustor total pressure drop.

3-D COMBUSTOR PERFORMANCE MODEL

A 3-D elliptic, reacting-flow model is used for calculating internal flow field of gas turbine combustors. The model solves governing equations for the following variables, as described in Paragraph 6 below:

- Axial, radial, and swirl velocity components
- Specific enthalpy and temperature
- Turbulence kinetic energy and dissipation rate

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[3] Hunter, S. C., K. M. Johansen, H. C. Mongia, and M. P. Wood, "Advanced, Small, High-Temperature-Rise Combustor Program, Volume II: Analytical Mode Derivation and Combustor-Element Rig Tests (Phases I and II)", AD778766 (1974).

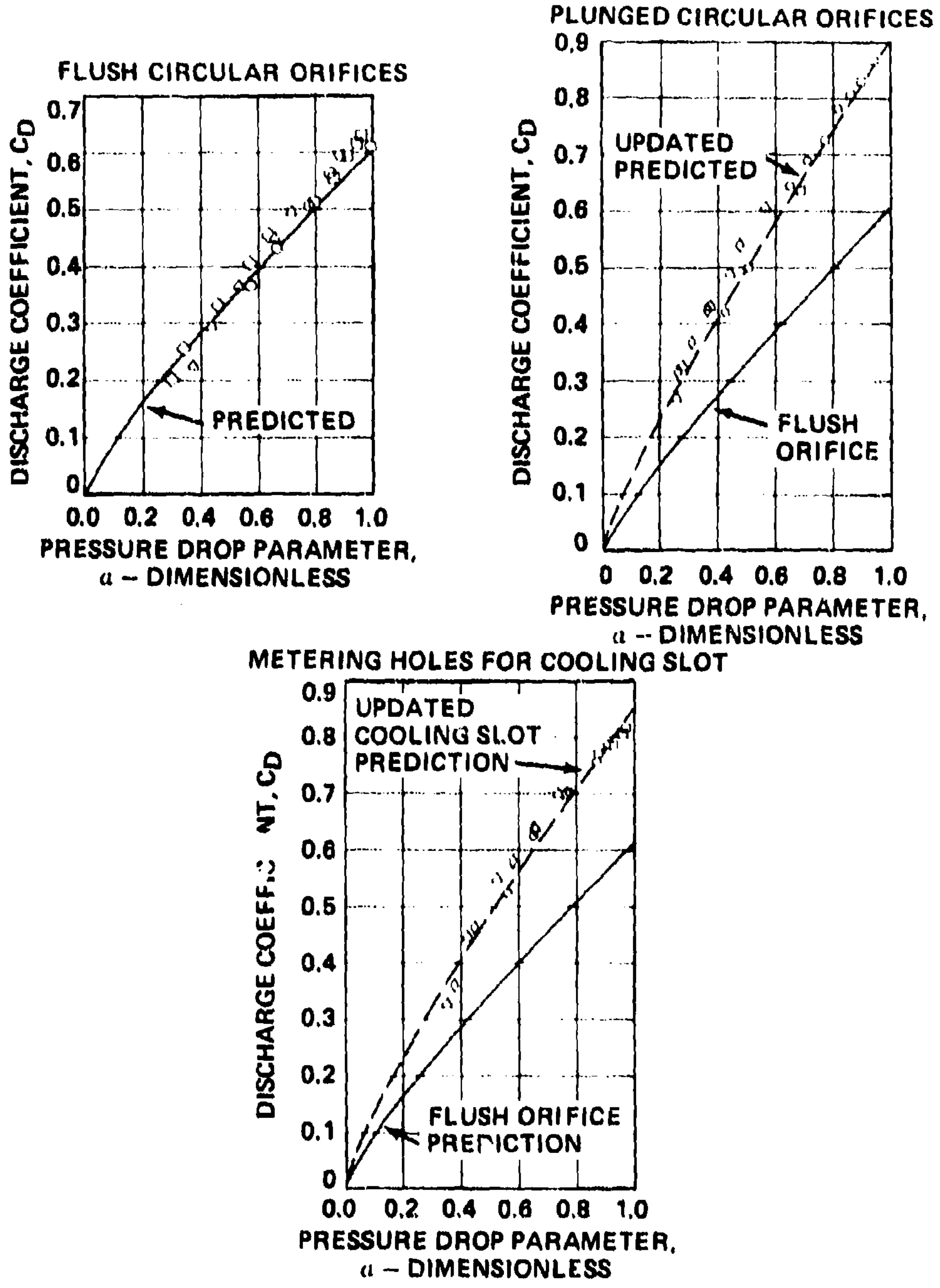

Figure 3. A Typical Comparison Between Prediction and Measured C_D.

- Unburned fuel, CO, and composite fuel fraction
- Radiation-flux vectors
- Spray combustion

Paragraphs 7 and 8 below give a brief description of the boundary conditions and the numerical scheme used for solving the set of nonlinear coupled partial differential equations.

1. Equations of Continuity, Momentum, and Enthalpy.

a. Continuity.

$$\text{div}\ (\rho\vec{V}) = \dot{m}'''_{\text{spray}} \tag{8}$$

b. x-Momentum.

$$\begin{aligned}\text{div}\ (\rho\vec{V}u - \mu_{\text{eff}}\ \text{grad}\ u) &= -\frac{\partial p}{\partial x} - \frac{2}{3}\frac{\partial}{\partial x}(\mu_{\text{eff}}\text{div}\ \vec{V}) \\ &+ \frac{\partial}{\partial x}(\mu_{\text{eff}}\frac{\partial u}{\partial x}) + \frac{1}{r}\frac{\partial}{\partial r}(\mu_{\text{eff}}\ r\frac{\partial v}{\partial x}) + \frac{1}{r}\frac{\partial}{\partial\theta}(\mu_{\text{eff}}\frac{\partial w}{\partial x}) \\ &+ S^u_{\text{spray}}\end{aligned} \tag{9}$$

c. y-Momentum.

$$\begin{aligned}\text{div}\ (\rho\vec{V}v - \mu_{\text{eff}}\ \text{grad}\ v) &= -\frac{\partial p}{\partial r} - \frac{2}{3}\frac{\partial}{\partial r}(\mu_{\text{eff}}\ \text{div}\ \vec{V}) \\ &+ \frac{\partial}{\partial x}(\mu_{\text{eff}}\frac{\partial u}{\partial r}) + \frac{1}{r}\frac{\partial}{\partial r}(\mu_{\text{eff}}\ r\frac{\partial v}{\partial r}) + \frac{1}{r}\frac{\partial}{\partial\theta}[\mu_{\text{eff}}(\frac{\partial w}{\partial r} - \frac{w}{r})] \\ &- 2\frac{\mu_e}{r}(\frac{1}{r}\frac{\partial w}{\partial\theta} + \frac{v}{r}) + \frac{\rho w^2}{r} + S^v_{\text{spray}}\end{aligned} \tag{10}$$

d. θ-Momentum.

$$\mathrm{div}\,(\rho\vec{V}w - \mu_{eff}\,\mathrm{grad}\,w) = -\frac{1}{r}\frac{\partial p}{\partial\theta} - \frac{2}{3}\,\frac{\partial}{r\partial\theta}\,(\mu_{eff}\,\mathrm{div}\,\vec{V})$$

$$+ \frac{\partial}{\partial x}\,(\frac{\mu_{eff}}{r}\,\frac{\partial u}{\partial\theta}) + \frac{1}{r}\,\frac{\partial}{\partial r}\,[\mu_{eff}\,r\,(\frac{1}{r}\,\frac{\partial v}{\partial\theta} - \frac{w}{r})]$$

$$+ \frac{1}{r}\,\frac{\partial}{\partial\theta}\,[\frac{\mu_{eff}}{r}\,(\frac{\partial w}{\partial\theta} + 2v)] - \frac{\rho vw}{r} + \frac{\mu_{eff}}{r}\,(\frac{\partial w}{\partial r} + \frac{\partial v}{r\partial\theta} - \frac{w}{r}) \qquad (11)$$

$$+ S^{w}_{spray}$$

e. Specific enthalpy.

$$\mathrm{div}\,(\rho\vec{V}\,h - \frac{\mu_{eff}}{P_{r_{eff}}}\,\mathrm{grad}\,h) = S_h \qquad (12)$$

where

S_h represents the sum of all the enthalpy source terms for radiation and spray evaporation

Definition of variables are:

$\vec{V}$ = Net gas velocity vector

u,v,w = Velocity components along x, radial and circumferential directions

x,y,θ = Axial, radial and circumferential coordinates

p = Static pressure

h = Static specific enthalpy

S^{u}_{spray}, S^{v}_{spray}, S^{w}_{spray} = Momentum transfer from spray to the gas phase u, v and w - momentum equations

$\dot{m}'''_{spray}$ = spray evaporation/combustion rate per unit volume

$$\operatorname{div}\,(\rho\vec{V}\phi) = \frac{1}{r}\left[\frac{\partial}{\partial x}(r\rho u\phi) + \frac{\partial}{\partial r}(r\rho v\phi) + \frac{\partial}{\partial \theta}(\rho w\phi)\right]$$

$$\operatorname{div}\,(\mu \operatorname{grad} \phi) = \frac{1}{r}\left[\frac{\partial}{\partial x}\left(r\mu\frac{\partial \phi}{\partial x}\right) + \frac{\partial}{\partial r}\left(r\mu\frac{\partial \phi}{\partial r}\right) + \frac{\partial}{\partial \theta}\left(\frac{\mu}{r}\frac{\partial \phi}{\partial \theta}\right)\right]$$

The effective viscosity μ_{eff} is given by $\mu_{eff} = \mu_{\ell} + \mu_t$

where μ_{ℓ} and μ_t are the molecular and turbulent viscosities of the fluid, respectively.

2. Turbulence Model.

The turbulent viscosity μ_t is calculated by using a two-equation turbulence model that solves governing equations for the turbulence kinetic energy (k) and the dissipation rate (ϵ). The governing equations for k and ϵ are:

$$\operatorname{div}\,(\rho\vec{V}k - \Gamma_{k,eff} \operatorname{grad} k) = G_k - \rho\varepsilon \qquad (13)$$

$$\operatorname{div}\,(\rho\vec{V}\varepsilon - \Gamma_{\varepsilon,eff} \operatorname{grad} \varepsilon) = (C_1 G_k - C_2\rho\varepsilon)\,\frac{\varepsilon}{k} \qquad (14)$$

where

$$\begin{aligned} G_k = \mu_t\Big[\, 2\,\Big\{ \left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial r}\right)^2 + \left(\frac{\partial w}{r\partial \theta} + \frac{v}{r}\right)^2 \Big\} \\ + \left(\frac{\partial w}{\partial x} + \frac{\partial u}{r\partial \theta}\right)^2 + \left(\frac{\partial u}{\partial r} + \frac{\partial v}{\partial x}\right)^2 + \left(\frac{\partial w}{\partial r} + \frac{\partial v}{r\partial \theta} - \frac{w}{r}\right)^2 \Big] \end{aligned} \qquad (15)$$

$$\begin{aligned} \Gamma_{k,eff} &= \mu_{eff}/\sigma_{k,eff} \\ \Gamma_{\varepsilon,eff} &= \mu_{eff}/\sigma_{\varepsilon,eff} \end{aligned} \qquad (16)$$

$$\mu_t = C_D\, \rho\, k^2/\varepsilon$$

C_D, C_1, and C_2 are constants. $\Gamma_{k,eff}$, $\Gamma_{\epsilon,eff}$, $\sigma_{k,eff}$ and $\sigma_{\epsilon,eff}$ are the effective exchange coefficients and Schmidt numbers for k and , respectively.

The k-ε turbulence model is moderate in complexity and is considered to be superior to other models having a similar degree of complexity. This model has been extensively used by many investigators and has proved to be adequate in a wide range of flow conditions. More advanced turbulence models, such as those based upon the Reynolds-stress modeling approach, are not yet fully developed to warrant their use in recirculating flow-field problems as encountered in gas-turbine combustors. In addition, such an approach will appreciably increase the computation effort.

Recommended values for the constants appearing in the above equations are

$$C_D = 0.09$$

$$C_1 = 1.44$$

$$C_2 = 1.92$$

$$\sigma_{k,eff} = 0.9$$

$\sigma_{\epsilon,eff}$ is calculated from

$$\sigma_{\epsilon,eff} = \frac{k^2}{(C_2-C_1)C_D^{1/2}}$$

where k is the vonKarman constant taken to be equal to 0.42.

3. Chemical Species Equations.

A two-step kinetic scheme is used as represented by Equations 18 and 19.

$$C_xH_y + (\frac{x}{2} + \frac{y}{4})(O_2 + n\ N_2) \rightarrow x\ CO + \frac{y}{2}\ H_2O + n(\frac{x}{2} + \frac{y}{4})N_2 \quad (18)$$

$$x\ CO + \frac{x}{2}\ (O_2 + n\ N_2) \rightarrow x\ CO_2 + n\ \frac{x}{2}\ N_2 \quad (19)$$

Stoichiometric oxygen-to-fuel and oxygen-to-CO ratios for the first and the second reactions are given by

$$i_1 = \frac{32\left(\frac{x}{2} + \frac{y}{4}\right)}{(12\,x + y)}$$

$$i_2 = 0.571$$

Combining Equations 18 and 19, one obtains overall stoichiometry equation as

$$C_xH_y + \left(x + \frac{y}{4}\right)(O_2 + n\,N_2) \rightarrow x\,CO_2 + \frac{y}{2}\,H_2O + n\left(x + \frac{y}{4}\right)N_2 \qquad (20)$$

The corresponding stoichiometric oxygen-to-fuel ratio is

$$i = \frac{32\left(x + \frac{y}{4}\right)}{(12\,x + y)}$$

Governing equations for fuel and CO mass fractions are:

$$\text{div}\,(\rho\vec{V}m_{fu} - \Gamma_{fu,eff}\,\text{grad}\,m_{fu}) = \dot{m}'''_{evap} - R_{fu} \qquad (21)$$

$$\text{div}\,(\rho\vec{V}m_{CO} - \Gamma_{CO,eff}\,\text{grad}\,m_{CO}) = -\,R_{CO} \qquad (22)$$

where R_{fu} and R_{CO} are rate of oxidation of fuel and CO in accordance with the combustion model explained in paragraph a. m'''_{evap}, is the rate of spray evaporation per unit volume computed in accordance with the spray combustion model description in Paragraph 5.

Equations similar to the above are required for O_2, CO_2, and H_2O. However, by using Shvab-Zeldovich approximation[4], one needs to solve only one more equation for composite fuel fraction, Φ_{fuox}

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[4] Williams, F. A., "Combustion Theory", Addison-Wesley Publishing Company, Inc. (1965).

$$\operatorname{div}\,(\rho\vec{V}\,\phi_{fuox} - \Gamma_{fuox}\,\phi_{fuox}) = \dot{m}'''_{evap} \tag{23}$$

where $\phi_{fuox} = \dfrac{\phi - \phi_A}{\phi_F - \phi_A}$

where $\phi = m_{fu} - \dfrac{m_{ox}}{i}$

ϕ_A and ϕ_F are the values of ϕ for air and fuel streams, respectively.

Knowing the amount of fuel burned ($FB = \phi_{fuox} - m_{fu}$), the concentrations of CO_2, O_2, and H_2O are given by

$$m_{CO_2} = 44\,\frac{x\ FB}{(12 + y)} - \frac{44}{28}\,m_{CO}$$

$$m_{ox} = i\ m_{fu} + i_2\ m_{CO} + 0.232 - (0.232 + i)\,\phi_{fuox}$$

$$m_{H_2O} = \frac{18\ y\ FB}{2\,(12 + y)}$$

Mass fraction of N_2 is given by

$$m_{N_2} = 1 - (m_{ox} + m_{fu} + m_{CO} + m_{CO_2} + m_{H_2O})$$

a. Calculation of Reaction Rates.

Equations are needed for oxidation rates of fuel and CO, i.e., R_{fu} and R_{CO}. The turbulent reactive flow is an area of intensive research, and a number of models have been proposed to predict burning rate of fuel in turbulent environments. A simple model is used in the present study as explained in the following paragraphs.

The rate of oxidation of fuel is determined by the minimum of the following three equations:

$$R_{fu,ch} = k_1 \rho^{1.5} m_{ox} m_{fu}^{\frac{1}{2}} e^{\left(-\frac{E_1}{R_T}\right)} \quad (24a)$$

$$R_{fu,turb} = C_{R_1} \rho m_{fu} \epsilon/k \quad (24b)$$

$$R_{fuox,turb} = C_{R_1} \rho \frac{m_{ox}}{i_1} \epsilon/k \quad (24c)$$

Here, Equation 24a is the rate of fuel oxidation as controlled by chemical kinetics. Generally, a bimolecular Arrhenous expression is assumed for this reaction. However, the Task I reacting-flow mapping data was best correlated by using Equation 24a in conjunction with Equations 24b and 24c.

Equation 24b is based upon the eddy-breakup model of Spalding[5] and expresses the rate of fuel oxidation as influenced by turbulence intensity and scale, and concentration of unburned fuel. This model is applicable to premixed flames. Since combustion in gas-turbine combustors is neither fully premixed nor entirely diffusion controlled, Equation 24c is postulated, similar to Equation 24, which determines the rate of fuel oxidation as controlled by the availability of the oxygen. The constant i_1 appears from stoichiometry of the chemical Equation 18. One could use i instead of i_1 without any loss of generality, because the empirical constant C_{R_1} will simply be different.

The rate of oxidation of CO is similarly the minimum of the following three equations:

$$R_{CO,ch} = k_2 \rho^2 m_{CO} m_{ox} e^{-\left(\frac{E_2}{R_T}\right)} \quad (25a)$$

$$R_{CO,turb} = C_{R_2} \rho m_{CO} \epsilon/k \quad (25b)$$

$$R_{CO_{ox,turb}} = C_{R_2} \rho \frac{m_{ox}}{i_2} \epsilon/k \quad (25c)$$

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[5] Spalding, D. B., "Mixing and Chemcial Reaction in Steady Confined Turbulent Flames", Thirteenth Symposium (International) on Combustion, The Combustion Institute, 1971.

4. Radiation Model.

A six-flux radiation model based upon the Schuster-Hamaker approximation[6,7] is used in the present program. It should be noted that, as pointed out by Siddall,[8] other flux model approximations such as Milne-Eddington and Schuster-Schwarzschild can be represented by the same form of flux equations with constants being different. Therefore, the user can modify the flux equations with relative ease.

The differential equations describing the variations of the fluxes along the six directions are:

$$\frac{d}{dx}(I_{x+}) = -(a+s)\,I_{x+} + aE + \frac{s}{6}\,I \tag{26}$$

$$\frac{d}{dx}(I_{x-}) = (a+s)\,I_{x-} - aE - \frac{s}{6}\,I \tag{27}$$

$$\frac{1}{r}\frac{d}{dr}(r\,I_{r+}) = -(a+s)\,I_{r+} + \frac{I_{r-}}{r} + a\,E + \frac{s}{6}\,I \tag{28}$$

$$\frac{1}{r}\frac{d}{dr}(r\,I_{r-}) = (a+s)\,I_{r-} + \frac{I_{r-}}{r} - a\,E - \frac{s}{6}\,I \tag{29}$$

$$\frac{1}{r}\frac{d}{d\theta}(I_{\theta+}) = -(a+s)\,I_{\theta+} + a\,E + \frac{s}{6}\,I \tag{30}$$

$$\frac{1}{r}\frac{d}{d\theta}(I_{\theta-}) = (a+s)\,I_{\theta-} - a\,E - \frac{s}{6}\,I \tag{31}$$

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[6] Hamaker, H. C., "Radiation and Heat Conduction in Light-Scattering Material", Philips Research Report, Vol. 2, pp 55-67, 1947.

[7] Patankar, S. V., and D. B. Spalding, "A Computer Model for Three-Dimensional Flow in Furnaces", Fourteenth Symposium (International) on Combustion, The Combustion Institute, 1973.

[8] Siddall, R. G., "Flux Methods for the Analysis of Radiant Heat Transfer", Paper presented at the Fourth Symposium on Flames and Industry, 1972.

where I_{x+}, I_{r+}, and $I_{\theta+}$ are the fluxes along the positive directions of axial, radial and circumferential directions, respectively; I_{x-}, I_{r-}, and $I_{\theta-}$ are the corresponding fluxes along the negative directions.

a = absorption coefficient defined as radiation absorbed per unit length

s = scattering coefficient defined as radiation scattered per unit length

E = black body emissive power = σT^4

where σ is the Stefan-Boltzman constant

$$I = I_{x+} + I_{x-} + I_{r+} + I_{r-} + I_{\theta+} + I_{\theta-}$$

With the composite-fluxes R^x, R^r and R^Z defined as:

$$R^x = \frac{1}{2} (I_{x+} + I_{x-})$$
$$R^r = \frac{1}{2} (I_{r+} + I_{r-})$$
$$R^Z = \frac{1}{2} (I_{\theta+} + I_{\theta-})$$

one can reduce the six first-order flux equations into the following three second-order equations:

$$\frac{d}{dx} \left(\frac{1}{a+s} \frac{dR^x}{dx}\right) = a \; (R^x - E) + \frac{S}{3} \; (2R^x - R^r - R^Z) \tag{32}$$

$$\frac{1}{r} \frac{d}{dr} \left(\frac{r}{a + s + \frac{1}{r}} \frac{dR^r}{dr}\right) = a \; (R^r - E) + \frac{S}{3} \; (2R^r - R^x - R^Z) \tag{33}$$

$$\frac{1}{r} \frac{d}{d\theta} \left(\frac{1}{a+s} \frac{dR^Z}{\gamma d\theta}\right) = a \; (R^Z - E) + \frac{S}{3} \; (2R^Z - R^x - R^r) \tag{34}$$

Once R^x, R^r, and R^Z are known, the net radiation fluxes in the axial, radial, and circumferential directions, Q^x, Q^r, and Q^Z respectively, are given by:

$$
\begin{aligned}
Q^x &= I_{x+} - I_{x-} \\
&= - \frac{2}{a+s} \frac{dR^x}{dx}
\end{aligned}
\qquad (35)
$$

$$
\begin{aligned}
Q^r &= I_{r+} - I_{r-} \\
&= - \frac{2}{a + s + \frac{1}{r}} \frac{dR^r}{dr}
\end{aligned}
\qquad (36)
$$

$$
\begin{aligned}
Q^Z &= I_{\theta+} - I_{\theta-} \\
&= \frac{2}{a+s} \frac{1}{r} \frac{dR^Z}{d\theta}
\end{aligned}
\qquad (37)
$$

The contribution of R^X, R^r, and R^Z to the source terms of specific enthalpy, Equation 12, is given by:

$$
(S_h)_{\text{radiation}} = 2a \, [(R^x - E) + (R^r - E) + (R^Z - E)] \qquad (38)
$$

Since information on the variations of a and s (with other quantities such as concentrations of CO, H_2O, CO and soot particles) is often scarce and unprecise, they have been assumed to be uniform. However, variable values of a and s can be incorporated in the program with minor modifications.

5. Spray Combustion.

It is very important to predict aerodynamic interaction between evaporating/burning sprays and flow field insofar as combustion efficiency, pattern factor, stability, liner-wall temperature levels and gradients, smoke and gaseous emissions formation are concerned. For example, the presence of smaller droplets influence flame stabilization as they provide the main source of heat in the recirculation zone. Larger droplets, however, escape the recirculation zone and are mainly responsible for the smoke formation. Measured data by McCreath and Chigier[9] showed that droplets with initial sizes less than 50 microns were evaporated in the recirculation zone. The smaller droplets were influenced greatly by the recirculation zone velocity field, whereas up to 70 percent of the bigger droplets in the 100-200 microns range escaped the recirculation zone. Their trajectory was not influenced by the flow-field velocity distribution. The flow-field influence on evaporation and trajectory of medium-size droplets, between 50 and 100 microns, was moderate.

Combustion characteristics of liquid droplets burning individually are significantly different from those burning collectively in a spray. For example, Beer and his associates[10] showed that the burning-rate constant of monosized droplet arrays was about half that of single droplets. There was also significant reduction[10,11] in drag coefficient, C_D, as compared to that of a

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[9] McCreath, C. G. and N. A. Chigier, "Liquid Spray Burning in the Wake of a Stabilizer Disc", Fourteenth Symposium (International) on Combustion, The Combustion Institute (1973).

[10] Nuruzzaman, A. S. M., A. B. Hedley, and J. M. Beer, "Combustion of Monosized Droplet Streams in Self-Supporting Flames", Thirteenth Symposium (International) on Combustion, The Combustion Institute (1971).

[11] Chigier, N. A., et. al, "Dynamics of Droplets in Burning and Isothermal Sprays", Combustion and Flame, V23 (1974).

nonreactive sphere On the other hand, Natarajan[12] showed that C_D of a burning droplet should be calculated for a nonreacting sphere at the mean properties and initial diameter.

The quasi-steady droplet combustion theory with spherical symmetry predicts the burning rate constant K to be independent of the surrounding gas pressure, where $K = -\frac{d}{dt} d_L^2$, and d_L is the liquid-droplet diameter. However, it has been found experimentally[13] that K increases with an increase in pressure. Raghunandan and Mukunda[14] critically evaluated the quasi-steady approximation, variable gas phase properties and incomplete combustion as related to predictions of burning-rate constant, the flame-to-diameter ratio and the flame temperature. The liquid-phase unsteadiness lasts for about 20-25 percent of the total burning time. It was shown by the authors that a good correlation with the burning rate data could be obtained by taking thermal conductivity and C_D as a function of concentration and temperature.

A majority of the reported work has been concerned with combustion of single component hydrocarbon fuels. Limited work has been reported, such as Reference 15, for combustion of multi-component fuel droplets; but, these approaches became quite complicated for predicting spray combustion of complex fuels like jet aviation fuels.

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[12] Natarajan, R., "Experimental Drag Coefficients for Evaporating and Burning Drops at Elevated Pressures", Combustion and Flame, V20 (1973).

[13] Rush, J. H., and H. Krier, "Burning of Fuel Droplets at Pressures Greater than Atmospheric", Combustion and Flame V22 (1974).

[14] Raghunandan, B. N., and H. S. Mukunda, "The Problem of Liquid Droplet Combustion - Reexamination", Combustion and Flame V30 (1977).

[15] Shyu, R. R., C. S. Chen, G. O. Gondie and M. M. Elwakil, "Multi-Component Heavy Fuel Drop Histories in a High Temperature Flow Field", Fuel, V51 (1972).

Figure 4 pictorially presents the approach that has been used for spray combustion in the present program. The spray cone is divided into a number of sections or rays. Each ray has a particular x, y, and z direction associated with it, depending on the orientation of the fuel nozzle in the combustor and the spray cone angle.

The initial conditions for each droplet are that they have a velocity as specified by the program user and a direction corresponding to the particular ray in question. The total fuel-flow rate is currently divided equally among the rays, although it would be easily possible to do otherwise. For each ray and for each droplet size group, of which five are assumed, the droplet trajectories are calculated from a force balance assuming the drag on the droplet is for that of a sphere. Heat transfer to the droplet is calculated using the coefficient given in Equation 39.

$$h = 2\,\frac{K}{D}\,(1+0.3\mathrm{Pr}^{\frac{1}{3}}\mathrm{Re}^{\frac{1}{2}})\,(\frac{J}{m^2\text{-}K}) \qquad (39)$$

where k is the thermal conductivity of fuel vapor, Re is Reynolds number based on relative velocity, and D is the droplet diameter. Until the droplet reaches the boiling temperature, no evaporation is assumed to occur; however, once reached, the evaporation rate is obtained from the burning rate constant k. Where:

$$k_o = \frac{d}{dt}(D^2)$$

$$k_o = \frac{8}{\rho_f}\,\frac{1}{CP_1}\,\ln(1+B)$$

$$B = \text{mass transfer No.} = \frac{1}{L_{vap}}\left[m_{ox_\infty}\,\frac{Hc}{i} + C_{P_1}\,(T_\infty - T_\beta)\right]$$

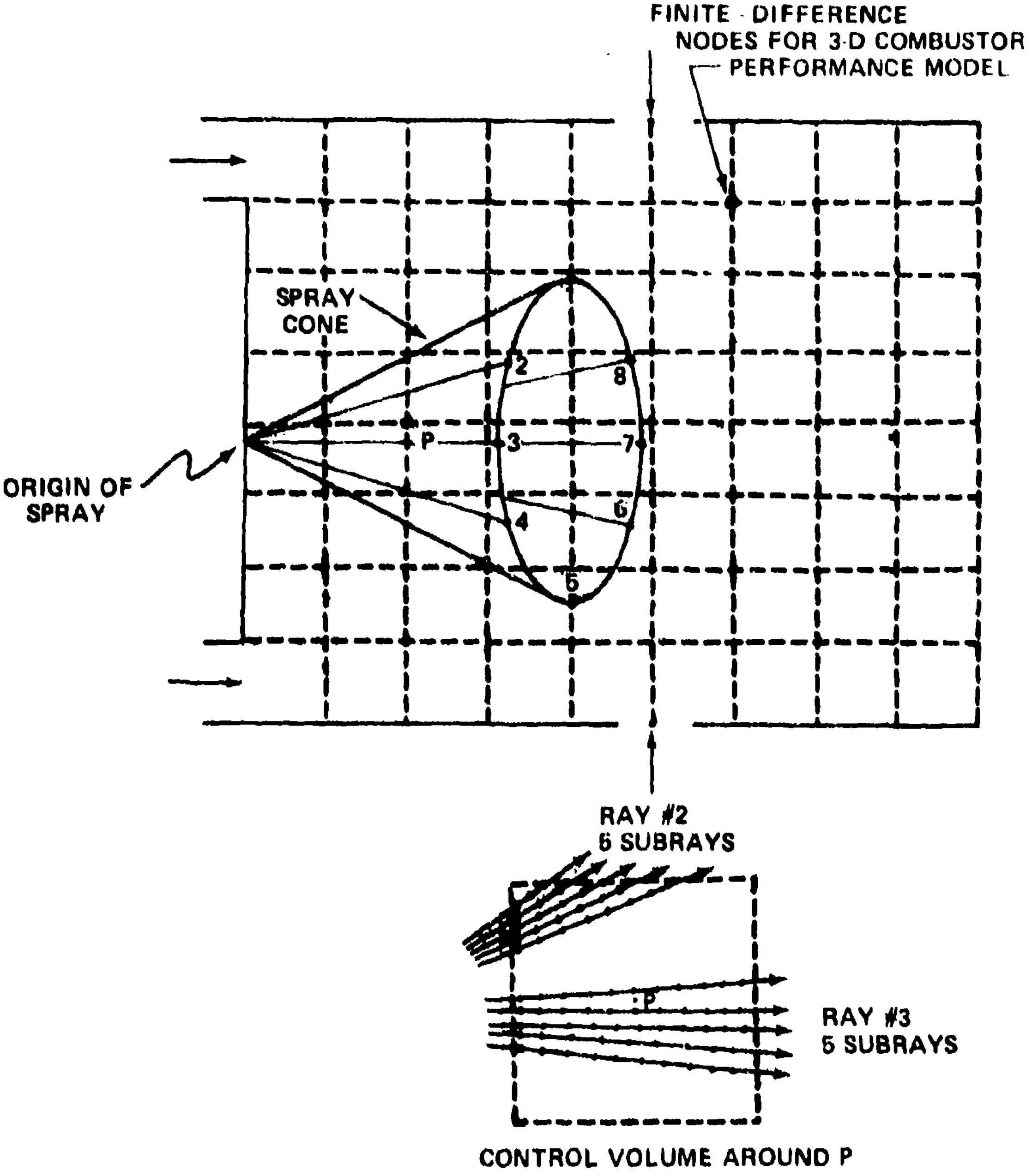

Figure 4. Schematic of Spray in Combustor Flow Field.

H_c = Heat of combustion

i = Stoichiometric O_2-fuel mass ratio

L_{vap} = Latent heat of vaporization

ρ_f = Liquid fuel density

λ_1 and (CP_1) the thermal conductivity and specific heat inside the flame zone, are assumed to be

$$\lambda_1 = 0.4\lambda_f + 0.6\ \lambda_{AIR}$$

$$CP_1 = CP_f$$

and are evaluated at the average of the boiling and flame temperatures. These calculations are performed explicitly, with care taken that the time step is sufficiently small, until at least 99 percent of the fuel has evaporated.

The above procedure requires knowledge of the fuel and air properties. The particular values used in the current program are listed below.

a. Droplet-Size Distribution.

Group	Vol. % of Spray	Size Ratio (D/SMD)
1	0-20	0.6
2	20-40	0.9
3	40-60	1.2
4	60-80	1.5
5	80-100	2.1

b. Liquid-Fuel Density (ρ_f).

$$\rho_f = 1000[PR_{60} + 0.208 - 0.00072\ T_f]\ \frac{KG}{m^3}$$

$$PR_{60} = \frac{1.076}{1 + \frac{1.076}{0.775} - 1\ (1 - 0.67F)} \text{ for JP4}$$

PR_{60} = Specific gravity of residue at 60°F

F = Fraction evaporated

T_f = Fuel temperature

c. Specific Heat of Liquid Fuel (CP_f).

$$CP_f = 840.5 + 4.1372\ T_f\ (J/KG - {}^\circ K)$$

d. Molecular Weight of Fuel Vapor.

Interpolated from table below,

F	MW(JP4)
0	93.26
0.1	114.60
0.3	126.61
0.5	138.16
0.7	150.59
0.9	173.21
1.0	204.76

e. Thermal Conductivity of Fuel Vapor (λ_f).

$$\lambda_f = 1.729\ (A+BT_f)\ (J/M-{}^\circ K-Sec)$$

where A and B are from the following list:

MW_{fuel}	A	B
50	-6.362E-3	53.5E-6
100	-6.358E-3	49.1E-6
150	-6.284E-3	46.6E-6
300	-6.010E-3	42.3E-6

f. Specific Heat of Fuel Vapor (CP_{f_v}).

$$CP_{f_v} = 4183.3\ (0.153 + 0.00081T_f)\ \left(\frac{J}{KG\text{-}°K}\right)$$

g. Latent Heat of Vaporization (L_{vap}).

$$L_{vap} = 30676.6\ (1092.88 - 1.8T_f)^{.39}\quad (J/KG)$$

h. Boiling Temperature of Fuel (T_B).

$$T_B = A\ \ell n\ P_v + B\ (°K)$$

where P_v is vapor pressure in pascals, A and B are from the following list:

% Evaporated	A	B
0	41.026	-114.000
10	30.857	41.574
30	27.348	96.534
50	23.997	146.567

The spray calculation procedure is briefly described in the following paragraph. Referring to Figure 4, the analysis is done for each of the rays selected and their subrays. Details are given for the control volume around a point P, where it is shown for two typical rays identified as Ray No. 2 and Ray No. 3. With each of these rays there might be five subrays, or less, depending upon the location of point P, initial droplet sizes, and the properties of the field through which the individual drops have traveled. Depending upon the direction of the ray and the finite-difference nodal volume, calculations for evaporation/burning are done for a number of subgrid points. The droplets are allowed to exchange mass, momentum, and energy with the surrounding gas phase. The net amount of mass, energy, and momentum received by the node P is the sum total of all droplets passing through the control volume of P.

6. Calculation of Gas Temperature.

With the specific enthalpy and chemical species known, the gas temperature is calculated as follows: The specific enthalpy h is the summation of the enthalpies of individual species, i.e.,

$$h = \sum_i m_i h_i$$

$$\sum_i m_i \, [h_{i,o} + \int_{T_o}^{T} C_{pi}(T) \, dT]$$

$$= \sum_i m_i \, [h_{i,o} + \int_{T_o}^{T^*} C_{pi}(T) dT + \int_{T^*}^{T} C_{pi}(T) dT]$$

Thus, giving

$$h = \sum_i m_i \, [h_i(T^*) + C_{pi}(T^*)(T-T^*)] \qquad (47)$$

where m_i, h_i, h_{io}, C_{p_i}, T^*, and T are species mass fraction, specific enthalpy, heat of formation at a reference temperature T_o, isobaric specific heat, gas temperature of the previous iteration, and the unknown gas temperature, respectively.

Therefore, from Equation 47 one obtains the following expression for the gas temperature T:

$$T = T^* + \left[\frac{h - \sum_i m_i \, h_i(T^*)}{\sum_i m_i \, C_{pi}(T^*)}\right] \qquad (48)$$

The variation of C_p as a function of temperature is taken as a fourth-order polynomial of temperature as given in Reference 16.

7. Finite-Difference Solution of the Equations.

The numerical solution of the nonlinear, coupled, partial differential equations can be obtained by using finite-difference methods. A numerical solution of the hydrodynamic equations can be obtained by two methods. The earlier approach employed for 2-D flows was the so-called streamline-vorticity method[3]. Here pressure is replaced from the momentum equations by differentiation. Stream function (ψ) and vorticity (ω) replace the velocity components and the pressure, thus requiring solution of only two instead of three variables: namely, u, v, and p. The equations were solved by a point-by-point successive-substitution procedure. Since ψ and ω are linked at the boundaries by way of the no-slip condition, the ω boundary specification could be done a number of ways leading to considerably different false diffusion levels as recently evaluated by de Vahl, Davis, and Mallinson[17]. In addition, problems were encountered in obtaining fully converging solutions with nonuniform grid spacing. Since 1973, AiResearch has used a pressure-velocity (primitive variable) solution approach, which has the following three advantages over the ψ - ω method:

- It permits computation of variable density flows where ρ depends upon pressure and temperature.

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[16] Gordon, S., and B. J. McBride, "Computer Program for Calculation of Complex Chemical Equilibrium Compositions, Rocket Performance, Incident and Reflected Shocks and Chapman-Jouguet Detonations", NASA SP-273 (1971).

[17] de Vahl, Davis, and G. D. Mallison, "An Evaluation of Upwind and Central Difference Approximations by a Study of Recirculating Flow", Computers and Fluids (1976).

- It allows unsteady flows to be calculated as easily as steady ones.

- It works for 3-D flows as well as 2-D flows, whereas the $\psi - \omega$ method cannot be easily extended.

Many primitive variable solution methods have been put forward by different researchers[18]. They vary enormously in complexity, ease of use, efficiency, and applicability. The 3-D combustor performance code is based on the well-tried SIMPLE (Semi-Implicit Method for Pressure-Linked Equations) algorithm of Patankar and Spalding as described in Reference 19. The features of the computer model include:

- Solution of sufficiently general single form differential equations

- Provision for use with different physical models

- Use of pressure and velocities as the main hydrodynamic variables

- Use of the pressure correction technique

- Provision of two coordinate (plane and axisymmetric) systems

- Use of nonuniformly spaced grids

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[18] Anon., "Proceedings of the Third AIAA Computational Fluid Dynamics Conference", Albuquerque, New Mexico, June 27-28, 1977.

[19] Patankar, S. V., "Numerical Prediction of Three-Dimensional Flows", in Studies in Convection: Theory, Measurement and Application, Volume 1, Edited by B. E. Launder, Academic Press, 1975.

- Use of staggered grid with attendant minimum truncation errors

- Derivation of finite-difference equations by integrating the differential equations over finite control volumes and thus ensuring mathematical compatibility between the finite difference and the original differential-equation formulations

- Efficient line-by-line tri-diagonal matrix solution of the difference equations

- Unconditional convergence for all Reynolds numbers

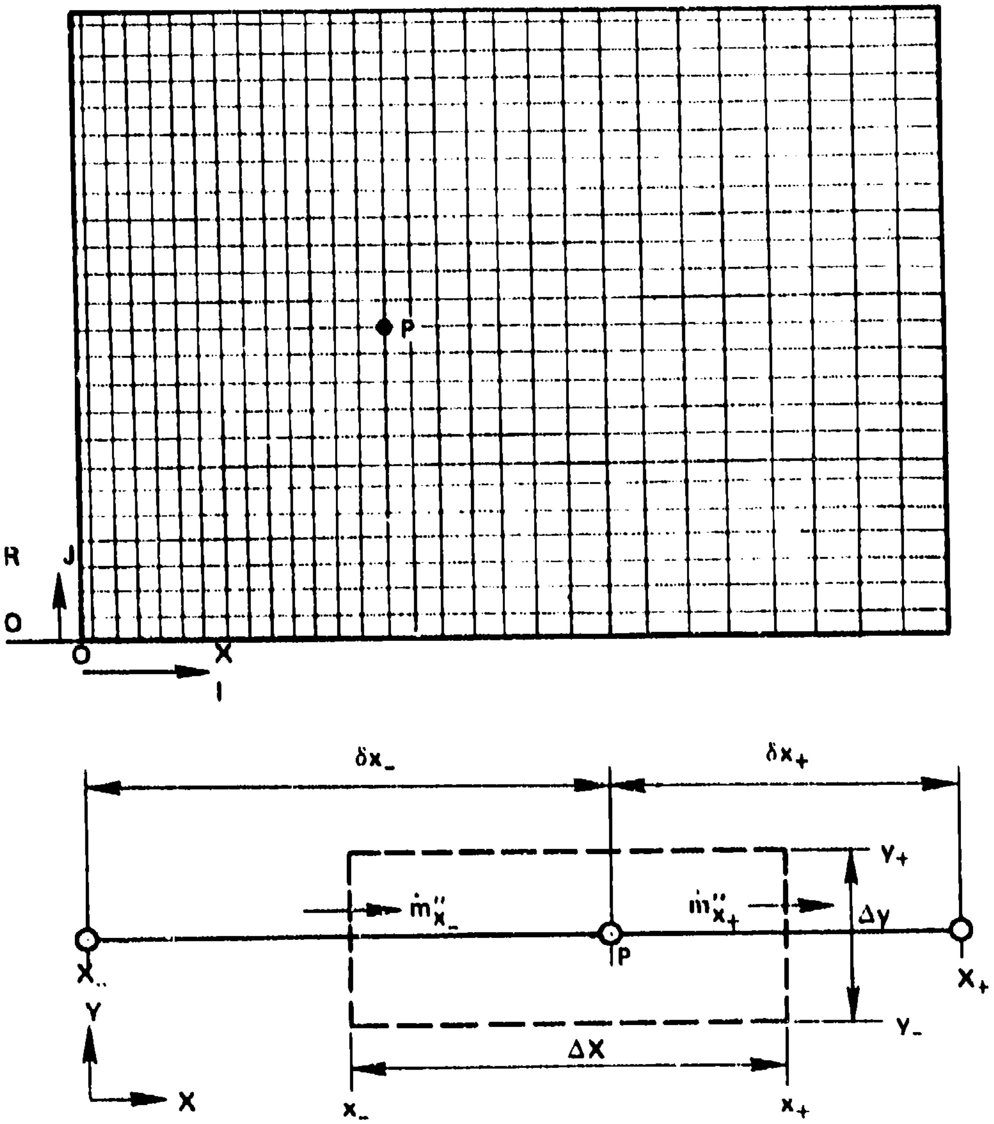
- Provision for under-relaxation

A typical grid node spacing is shown in Figure 5. Finite-difference equations for a node are obtained by integrating the differential equations over a control volume enclosing a grid node. For evaluating the convection and diffusion fluxes through a control volume face, a linear variation (in the direction normal to the face) of the flow properties is assumed. For other purposes, a step-wise variation with discontinuities at control-volume boundaries is assumed. Net rate of flow of ϕ into the control volume around a node P (Figure 5) by convection and diffusion in the x-direction is

$$
\begin{aligned}
&[T_{X-} + (1 - f_{X-})\, L_{X-}]\, \phi_{X-} + [T_{X+} - f_{X+}\, L_{X+}]\, \phi_{X+} \\
&- [T_{X-} - f_{X-}\, L_{X-} + T_{X+} + (1 - f_{X+})\, L_{X+}]\, \phi_{P}
\end{aligned}
$$

where

$$
\begin{aligned}
T_X &= \Gamma_{eff,\phi}\, A_X/\delta_X \\
L_X &= \dot{m}_X''/A_X \\
A_X &= 0.5\, (r_+ + r_-)\, \Delta Y
\end{aligned}
\qquad (49)
$$



$$f_{x_-} = \frac{\overline{X_- x_-}}{\overline{X_- P}} \qquad f_{x_+} = \frac{\overline{P x_+}}{\overline{P X_+}}$$

Figure 5. Typical Grid Spacing and Control Value Around a Point P.

Defining $\iiint S_{\phi} V = S_u + S_p \phi_p$, the one-dimensional transport equation for the variable ϕ becomes

$$[T_{X-} + (1 - f_{X-}) L_{X-} + T_{X+} - f_{X+} L_{X+} - S_p] \phi_p$$

$$= [T_{X-} + (1 - f_{X-}) L_{X-}] \phi_{X-} + [T_{X+} - f_{X+} L_{X+}] \phi_{X+} + S_u$$

The above equation was derived based on reasonable assumptions. However, the linear-profile assumption becomes unacceptable when $f_{X+} L_{X+}$ is large compared with T_{X+} because the weighting factor $(T_{X+} - f_{X+} L_{X+})$ then becomes negative, implying an unrealistic physical process through which raising the value of ϕ_{X+} could lower the value of ϕ_p. Therefore, it is assumed that if the convective flow rates (L) are large compared to the diffusion coefficients (T), the diffusion across the control-volume face is zero and the value of ϕ convection is equal to the value at the node on the upwind side of the face. With this assumption, the coefficient $T_{X+} - f_{X+} L_{X+}$ is replaced by $T^*_{X+} - f_{X+} L_{X+}$ where

$$T^*_{X+} = [T_{X+}, -(1 - f_{X+}) L_{X+}, f_{X+} L_{X+}] \tag{50}$$

Here $[a_1, a_2, a_3]$ stands for the largest of the three quantities a_1, a_2, and a_3.

The final finite-difference equation is reduced to

$$A_p \phi_p = A_{X+} \phi_{X+} + A_{X-} \phi_{X-} + A_{Y+} \phi_{Y+} + A_{Y-} \phi_{Y-} + A_{Z+} \phi_{Z+} + A_{Z-} \phi_{Z-} + S_U \tag{51}$$

The solution of the above equation is obtained by line-by-line relaxation using an efficient tri-diagonal matrix algorithm. By this method, for an x-y plane, a traverse along one direction, say the X-direction, is made with old values for the y-direction nodes. Using this solution as the best estimate, the y-direction is then traversed. The same procedure is repeated for other x-y planes.

8. Boundary Conditions.

The specification of the boundary conditions is done in a number of ways depending upon the problem. For the left inlet boundaries, velocity, density, and turbulence profiles are either experimentally known or estimated. The program can handle any specified profiles. For boundaries of the second kind, where gradients and not the values of the variables are specified, the program uses one of the following two approaches. In the first approach, the boundary value is guessed and continually updated so as to satisfy the given gradient condition. The second approach breaks the link through the boundary to all adjoining external control volumes by first arranging for the finite-difference coefficient connecting the boundary node to an internal node to be zero, and then inserting the correct flux at the boundary as a false source of diffusion and/or convection for that internal node.

At the symmetry plane, the convection and diffusion fluxes are zero. Therefore, the convection coefficient C_{y-} and the exchange coefficient (Γ_{eff}) are made zero at the axis of symmetry. For the exit plane, information about some of the variables is not available. However, since it is the process occurring in the calculation domain that decides values of the variables which the outgoing fluid will carry, there is no need for information at such boundaries. These boundaries are simply treated by making the boundary Γ_{eff} equal to zero. The cyclic boundary conditions are used for the circumferential direction.

The near-wall region is given a special treatment in the program. Since the expression for Γ_{eff} is accurate for turbulent flows only, a means is provided for the inclusion of the correct shear stresses and other fluxes at the wall. Therefore, the nodes next to the wall are assigned the following values as per an empirical wall law:

$$
\begin{aligned}
&y^+ \le 11.5 && \Gamma_{\phi,\mathrm{wall}} = \frac{\mu}{\sigma_\phi} \\
&y^+ > 11.5 && \Gamma_{\phi,\mathrm{wall}} = \frac{\mu}{\sigma_\phi} \; \frac{y^+}{\frac{1}{\kappa} \ln (9y^+) + P_\phi} \qquad (52)
\end{aligned}
$$

$$
y^+ = \rho \, k^{\frac{1}{2}} \, C_D^{\frac{1}{4}} \, \frac{\delta}{\mu}
$$

$$
P_\phi = 9.0 \left(\frac{\sigma}{\sigma_{\mathrm{eff}}} - 1 \right) \left(\frac{\sigma}{\sigma_{\mathrm{eff}}} \right)^{-\frac{1}{4}}
$$

Where δ is the normal distance of the wall from the first interior adjacent node. The kinetic energy of turbulence has small diffusion near the wall; hence, Γ_{wall} for k is set equal to zero. Instead of computing Γ_{wall} for ϵ, it is calculated for the near-wall node by assuming a linear variation of the length scale giving the following expression:

$$
\epsilon = C_D^{3/4} \, k^{3/2} / (\kappa \delta)
$$

LINER COOLING MODEL

In order to design a durable combustor with conventional materials, the liner-wall temperature levels and gradients must be controlled. Consequently, it is imperative to have a calculation procedure that can be universally used for predicting liner wall temperatures. The wall temperature at a point P in a combustor liner (shown schematically in Figure 6) is determined by energy balance on a control volume around P, i.e.,

$$
C_H + R_H = C_C + R_C
$$

where C and R denote the heat transfer rate by convection and radiation, respectively. The subscripts H and C correspond to the hot side and cold side of the liner, respectively.

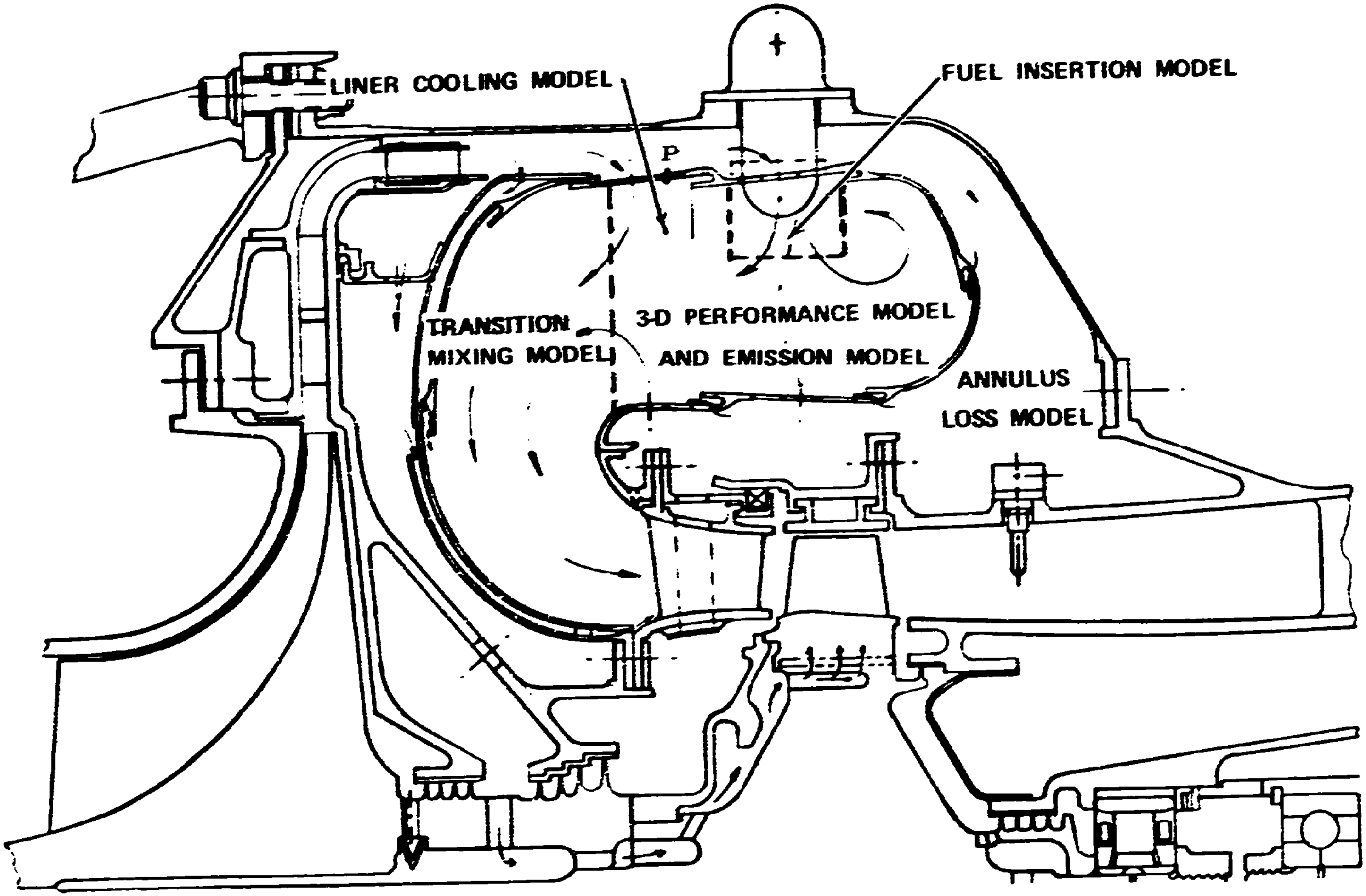


Figure 6. A Schematic of Reverse-Flow Annular Combustor and Application of Analytical Models.

A 2-D parabolic program is used to compute the hot-side convection and radiation heat transfer, the marching direction being x. The following expressions are used for calculating the cold-side heat-transfer rate.

$$C_C = 0.0268(C_P\ G)_{an}\ R_{ex}^{-0.2}\ (T_w - T_{an}) \tag{54}$$

$$R_C = \sigma \left[\frac{1}{\frac{1}{\varepsilon_\omega} + \frac{D_L}{D_P}\left(\frac{1}{\varepsilon_P} - 1\right)} \right] (T_w^4 - T_{an}^4) \tag{55}$$

where C_{Pan}, G_{an}, and T_{an} are annulus air specific heat, mass velocity, and temperature, respectively. The length Reynolds number is based upon x downstream from the cooling-slot metering orifices. ϵ_w and ϵ_p are the liner-wall and the plenum-wall emissitivites; D_L and D_P are the diameters of the liner and plenum, respectively. σ and T_w are the Stefan-Boltzman constant and the liner-wall temperature, respectively.

One major advantage of using algebraic expressions for the cold-side heat-transfer rates is that the appropriate expressions can be used for advanced cooling schemes that increase the heat-transfer rate from the cold side. Consequently, the cooling schemes, such as multiple impingement, extended-surface geometries, and chemically-etched surfaces, can be predicted by using the liner cooling model developed in this program.

Since a 2-D calculation procedure is used for calculating the hot-side heat-transfer rates, the model is strictly applicable to either uncooled liners or the liner walls protected by cooling films. The user will need to make approximations in predicting wall temperatures downstream from discrete radial jets such as the primary and secondary jets.

The 2-D parabolic program solves the governing equations for the following variables:

- Streamwise velocity and swirl velocity
- Turbulence kinetic energy and dissipation model of Jones and Launder[20].
- Specific enthalpy
- Unburned fuel, CO, and total fuel appropriate to the two-step kinetic scheme.
- Composite-radiation flux for the two-flux radiation model.
- Five-droplet trajectories

The governing equations, as reduced from the set of equations presented in paragraph B for parabolic flows, are transformed to the following generalized form of transport equations for the von Mises coordinate system[21].

$$\frac{\partial \phi_j}{\partial x} + (a + b\omega) \frac{d\phi_j}{d\omega} = \frac{\partial}{\partial \omega} \left(c \frac{\partial \phi_j}{\partial \omega}\right) + d_j \tag{56}$$

where

$$a = r_I \dot{m}''_I/(\Psi_E-\Psi_I) \tag{57}$$

$$b = (r_E\dot{m}''_E - r_I\dot{m}''_I)/(\Psi_E-\Psi_I) \tag{58}$$

$$C = \frac{r^2 \rho u \mu_{eff}}{(\Psi_E-\Psi_I)^2 \sigma_{j,eff}} \tag{59}$$

$$\omega = (\Psi-\Psi_I)/(\Psi_E-\Psi_I) \tag{60}$$

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[20] Jones, W. P., and B. E. Launder, "The Calculation of Low-Reynolds Number Phenomena with a Two-Equation Model of Turbulence", ASME Paper 72-HT-20, 1971.

[21] Patankar, S. V., and D. B. Spalding, "Heat and Mass Transfer in Boundary Layers", Intertext Books, London; 1970.

Here ϕ_j is a generalized variable, and d_j contains the source/sinks and the other terms in the governing equation that do not fit in the convection and diffusion terms presented in Equation 56. ψ, r, and $\dot{m}''$ denote streamline, radius, and entrainment rate across the boundaries $\psi = \psi_I$ and $\psi = \psi_E$. The subscripts I and E refer to the inner and outer (external) boundaries of the domain of interest.

The numerical scheme used is a variant of the efficient numerics of Patankar and Spalding as described in Reference 21. A brief description of how the model is used for predicting liner-wall temperatures is given in the following paragraphs.

Consider a typical combustor liner and its predicted isothermal lines for an x-y plane; e.g., in line with primary jets, such as shown in Figure 7. The 3-D combustor-performance model predicted a reverse flow region near the dome, as shown by broken lines. This particular combustor has three cooling slots on the OD liner wall and four cooling slots on the ID wall. The wall-cooling model is used for predicting both inner- and outer-liner wall temperature with initial conditions for the three stations shown, defined by the combustor-performance model. The number of x-y planes to be solved depends upon a particular combustion system. If the predicted combustor internal flow is highly three-dimensional, then one may have to solve as many planes as the number of θ-nodes used in the 3-D computation. However, as the flow field approaches a two-dimensional approximation, one need not analyze more than a few x-y planes to obtain an accurate wall-temperature prediction.

Since the present wall-cooling model is a two-dimensional model, it cannot analyze wall regions near primary, intermediate, and dilution orifices. Consequently, it is advisable to restart the model for each panel with initial conditions as given by the combustor-performance model. Care should be taken in analyzing

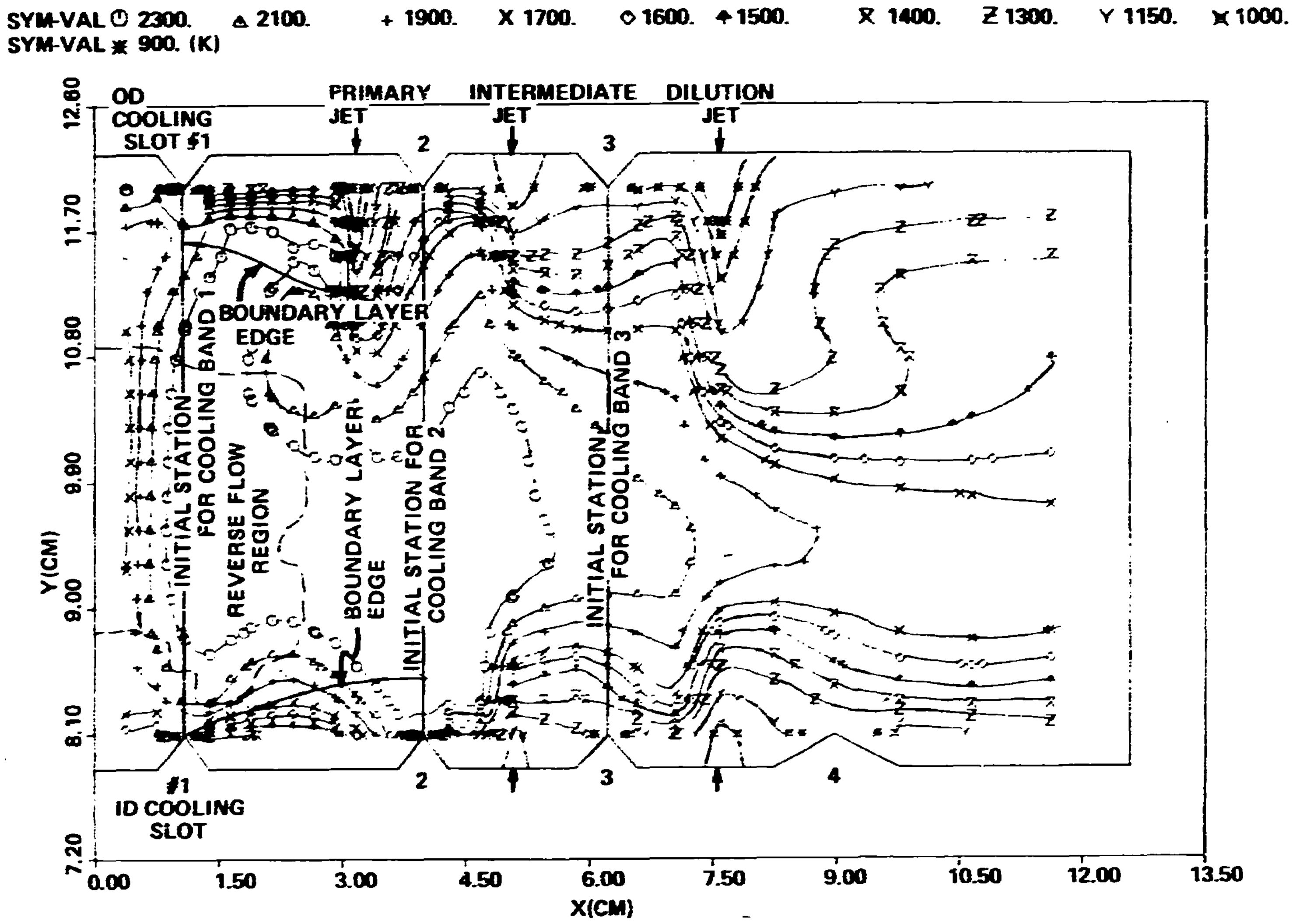

Figure 7. Typical Isothermal Plots of an Annular Combustor Along X-Y Plane In Line With Primary Jet.

the primary panel because of the presence of reverse-flow region. There are two possible approaches for analyzing this section. The first approach, the marching region lies between the liner walls and $u > 0$ with exchange rate specified for $u > 0$ line. In the second approach, one can define a boundary edge for which the edge conditions for dependent variables, including radiation flux, are defined based upon the combustor performance predictions. Then the wall-cooling model is run separately for the inner and outer primary panels.

In order to get more accurate wall temperature predictions, it is imperative to know the precise cooling slot exit conditions. In addition, one must accurately predict the effect of the splash-plate thickness on initial mixing between the cold-stream and main-combustion gases. The 3-D elliptic code can be used with minor modifications to predict the development of the jets exiting from the cooling-slot metering orifices. The effect of liner-pressure drop, orifice size and spacing, slot-lip length, and height on the slot-exit profiles can be analytically predicted. The 3-D elliptic code can also be used to predict the effect of the lip thickness on the initial mixing between hot and cold streams.

TRANSITION-LINER MIXING MODEL

The overall length of a gas turbine engine that employs a centrifugal compressor as the last stage of compression can be minimized by using a reverse-flow combustor. When the engine uses an axial turbine as its high-pressure turbine, a transition liner is needed between the combustor exit and the stator inlet. The transition-liner geometry, as shown in Figure 6, is quite complicated in that combustor exit flow, with mainly axial velocity component flowing from right to left, is bent through a 180-degree turn in order to flow into the turbine stator. The radii of curvature of both the inner- and outer-liner walls vary as a function of distance along the surface.

The flow in a practical transition liner is generally stream wise with little separation. Small regions of separated flows may exist along the ID transition liner surface. But, to insure structural durability of the liner, cooling air is generally injected in these separated areas so that the local liner-temperature levels and gradients are within allowable limits. As burner-exit temperatures increase along with reduction in burner length, cooling-film bands might be used for maintaining transition liner-wall temperature characteristics at an acceptable level.

A significant fraction of the mixing of hot streaks with the cooler combustor gases takes place within the transition liner. With the advent of volume-limited turbopropulsion engines, there would be need to predict performance of the transition liner in regard to exhaust-temperature quality. In addition, the transition-liner-wall temperatures must be determined so as to estimate the liner life. A 2-D transition mixing model was therefore developed for this purpose. The program was adopted from the wall-cooling model described in the Liner Cooling Model paragraph. It solves governing equations for streamwise velocity and swirl velocity, specific enthalpy, turbulence kinetic energy, and dissipation. The effect of curvature on radial pressure gradient is taken into account. However, the pressure elliptic effects due to streamline curvature have been neglected.

GASEOUS EMISSIONS MODEL

Both the combustor-performance model and the wall-cooling model use a simple kinetic scheme in that the combustion process is described by two reaction steps, as given by Equations 18 and 19. Such a scheme is manageable for complex computer codes like the combustor-performance model. In addition, the model predicts both unburned fuel and CO which accounts for most of the combustion inefficiency. Since the engineer is generally interested in estimating combustion efficiency of a given combustor design, the combustor performance model is adequate for the purpose. However, when there is a need for estimating the NO_x emissions, one should preferably use a detailed kinetic scheme so as to predict intermediate species (such as O, N, and OH) that are considered important for the NO production. A number of calculation procedures exist for estimating the NO_x levels; e.g., those described in References 22 and 23. The approach taken here is explained as follows.

The wall-cooling model was modified to incorporate the following 16-step kinetic scheme involving 11 chemical species.

$$C_XH_Y + \left(\frac{X}{2}+\frac{Y}{4}\right)(O_2 + 3.76\ N_2) \longrightarrow \left(XCO + \frac{Y}{2}\right)H_2O + \left(\frac{X}{2}+\frac{Y}{4}\right)(3.76\ N_2) \tag{61}$$

$$CO + OH \rightleftharpoons CO_2 + H \tag{62}$$

$$CO + O_2 \rightleftharpoons CO_2 + O \tag{63}$$

$$M + CO + O \rightleftharpoons CO_2 + M \tag{64}$$

$$CO + H_2O \rightleftharpoons CO_2 + H_2 \tag{65}$$

$$O_2 + H_2 \rightleftharpoons OH + OH \tag{66}$$

$$OH + H_2 \rightleftharpoons H_2O + H \tag{67}$$

$$O_2 + H \rightleftharpoons OH + O \tag{68}$$

$$O + H_2 \rightleftharpoons OH + H \tag{69}$$

$$O + H_2O \rightleftharpoons OH + OH \tag{70}$$

$$H + H + M \rightleftharpoons H_2 + M \tag{71}$$

$$O + O + M \rightleftharpoons O_2 + M \tag{72}$$

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[22] Sanborn, J. W., R. S. Reynolds, and H. C. Mongia, "A Quasi-Three-Dimensional Calculation Procedure for Predicting the Performance and Gaseous Emissions of Gas Turbine Combustors", AIAA Paper 76-642, 1976.

[23] Mosier, S. A., and R. Roberts, "Low-Power Turbopropulsion Combustor Exhaust Emissions, Volume 3, Analysis", Technical Report AFAPL-TR-73-36, 1974.

$$O + H + M \rightleftarrows OH + M \tag{73}$$

$$N + OH \rightleftarrows NO + H \tag{74}$$

$$N_2 + O \rightleftarrows NO + N \tag{75}$$

$$O_2 + N \rightleftarrows NO + O \tag{76}$$

A one-step global reaction is assumed for oxidation of fuel to CO as described by Equation 56. This reaction step is similar to the first reaction of the two-step kinetic scheme used in the combustor-performance model and the wall-cooling model. The reaction step is slightly different from that proposed by Edelmen[24] where his postulation produces H_2 instead of H_2O, assumed here. A set of four reactions are used to describe oxidation of CO. Eight steps are used for reactions involving H_2, O_2 and their dissociation products. Finally, three reaction steps are used for the NO production. Although the program uses the 16-step kinetic scheme, a more extensive kinetic scheme such as that used by Edelman can be incorporated with relative ease.

The fuel-oxidation reaction is controlled by both chemical kinetics and turbulence similar to the scheme used in the two-step kinetic scheme described in paragraph B3. The remaining 15 reaction steps are controlled by chemical kinetics, although the modified eddy-breakup model could be used for these reactions also.

The numerical scheme used in the emission model is slightly different from that used in the wall-cooling model in regard to the way the source term d_j of Equation 56 is calculated for the 11 chemical species. For each marching step

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[24] Edelman, R., J. Boccio, and G. Weilerstein, "The Role of Mixing and Kinetics in Combustion Generator NO_x", Paper presented at AICHE Symposium on Control of NO_x Emissions in Direct Combustion Power Sources, 1973.

size ΔX of the parabolic program, d_j for the chemical species is computed by using the following 1-D equation

$$\frac{\partial \phi_j}{\partial x} = d_j^* \tag{77}$$

which is obtained by neglecting the cross-stream convection and diffusion terms of Equation 56. Equation 77 is solved for each of the species by taking a number of steps for the distance ΔX. Typically, 50 steps are used for each ΔX. With the source terms for the species now estimated, Equation 56 is then integrated for each of the species over the distance ΔX. Such a modification results in approximately 70-percent reduction in computation time as compared to the numerical scheme used in the wall-cooling model.

FUEL-INSERTION MODEL

It may be recalled that a spray-combustion model is used in the combustor-performance code. This spray-combustion model includes heating, evaporation, and combustion of the spray, as well as the spray trajectories. The code also allows for the exchange of mass, momentum, and energy between the spray and the gas phase. Since a complete solution of the 3-D combustor-performance model takes a long computation time, on the order of three hours on the Cyber 174, an inexpensive calculation procedure was needed for initial selection of the fuel-nozzle characteristics. In addition, such a procedure would allow approximate evaluation of different nozzle designs in a flow field as computed by the combustor-performance model. A fuel-insertion model was therefore developed for this purpose.

Fuel-droplet evaporation rate and heat-transfer rate of the droplet are calculated according to the Priem-Heidmann model as described briefly in the following paragraphs. Vaporization of the droplet m_f, lbm/sec is given by

$$\dot{m}_f = A_s \; K \; P_{vap} \alpha \tag{78}$$

$$Nu_m = \frac{2 \; r_L K}{\rho_{vap} D} = 2 \; (1 + 0.3 \; S_c^{1/3} \; R_e^{1/2}) \tag{79}$$

$$\alpha = \frac{P_\infty}{P_{vap}} \ln \frac{P_\infty}{P_\infty - P_{vap}} \tag{80}$$

where A_s, K, Nu_m, P_{vap}, r_L, ρ_{vap}, D, S_c, R_e, and P_∞ are droplet-surface area, burning-rate constant, Nusselt number for mass transfer, fuel-vapor pressure, droplet radius, fuel-vapor density, diffusivity, Schmedt number, Reynolds number, and surrounding pressure, respectively.

Similarly, heat-transfer rate to the liquid surface q_v, Btu/sec is given by

$$q_v = A_s \; h \; (T_\infty - T_L) \; Z \tag{81}$$

$$Nu_H = \frac{2h r_L}{k} = 2 \; (1 + 0.3 \; P_r^{1/3} \; R_e^{1/2}) \tag{82}$$

$$Z = \frac{z}{e^{z} - 1} \tag{83}$$

$$z = m_f \; C_{p,vap}/h \; A_s$$

where h, Nu_H, k, P_r, and $C_{p,vap}$ are heat-transfer coefficient, Nusselt number for heat transfer, thermal conductivity, Prandtl number, and isobaric-heat capacity of fuel vapor, respectively.

As in the spray combustion model of the combustor performance code, the spray is divided into five discrete droplet sizes. The physical and chemical properties of the jet fuels are varied as a function of the fraction evaporated, as described previously in Paragraph B5.

The following expressions for the spray SMD are currently incorporated in the code. These can be easily changed by the user if desired.

1. Simplex Nozzle.

$$\mathrm{SMD} = \frac{225 * W_f^{0.205} \left(\frac{\mu}{1.5}\right)^{0.3}}{\Delta P_f^{0.354}} \qquad (85)$$

2. Simplex Nozzle with Air Assist.

$$\mathrm{SMD} = \frac{196 \sqrt{\frac{\sigma \cdot S}{\rho_a}} \, (\mu)^{0.095}}{0.438 \left(\frac{W_a}{W_f}\right)^{0.1} V_{aa} \left[0.5 + \left(\frac{V_f}{V_{aa}}\right)^2 - \frac{V_f}{V_{aa}}\right]^{1/2}} \qquad (86)$$

3. Duplex Nozzle.

$$\mathrm{SMD} = \frac{330 \, W_f^{0.205} \left(\frac{\mu}{1.5}\right)^{0.3}}{\left[\frac{\Delta P_p \, W_{fp} + \Delta P_s \, W_{fs}}{(W_{fp} + W_{fs})}\right]^{0.354}} \qquad (87)$$

4. Duplex Nozzle with Air Assist.

$$\mathrm{SMD} = \frac{196 \sqrt{\frac{\sigma \cdot S}{\rho_a}} \, (\mu)^{0.095}}{0.438 \left(\frac{W_a}{W_f}\right)^{0.1} V_{aa} \left[0.5 + \left(\frac{V_f}{V_{aa}}\right)^2 - \left(\frac{V_f}{V_{aa}}\right)\right]^{1/2}} \qquad (88)$$

5. Air-Blast Nozzle.

$$\mathrm{SMD} = 1.25 \left(\frac{\sigma\rho_f}{D_f}\right)^{1/2} \frac{\left(1+\frac{W_f}{Wa_n}\right)}{V_a \cdot \rho_a} + 0.73 \left(\frac{\nu_f^2}{\rho_a \sigma}\right)^{0.425} \frac{\left[1+\left(\frac{W_f}{Wa_n}\right)\right]^2}{D_f^{0.575}} \qquad (89)$$

where:

W_f = Fuel flow
μ = Fuel viscosity
ν = Fuel kinematic viscosity
ΔP_f = Fuel-pressure drop
σ = Fuel-surface tension
S = Fuel-sheet thickness
ρ_a = Air density
W_a = Air-assist airflow
V_{aa} = Air-assist air velocity
V_f = Fuel velocity
ΔP_p = Primary fuel-pressure drop
ΔP_s = Secondary fuel-pressure drop
W_{fp} = Primary fuel flow
W_{fs} = Secondary fuel flow
ρ_f = Fuel density
D_f = Filming diameter
Wa_n = Air-blast airflow rate

III. DESCRIPTION OF COMPUTER CODES

ANNULUS FLOW MODEL

The annulus-flow model calculates flow conditions around the combustor annulus by solving 1-D fluid-flow equations and provides information regarding annulus axial and tangential velocities, heat transfer from the liner wall, flow rates, jet velocities, jet angles and discharge coefficients of the various liner orifices, as well as the overall liner-pressure drop. Coding logic is provided so that the user may analyze can, and axial-flow and reverse-flow geometries. In addition, options allow the program to calculate the pressure drop for a given inlet flow rate or inlet flow for a given pressure drop. The program will also calculate either the flow through a specified orifice row or the orifice diameters required to pass a specified-flow rate. Finally, a plot, if desired, can be made giving the flow conditions around the combustor annulus and through the liner orifices.

The function of the MAIN program (a computer listing has been provided in Appendix B) is to call subroutine COMANN, which is the main controlling routine, and to perform file manipulations in the case of an axial-flow geometry. For this geometry, one item (usually not known) is the flow split between inner and outer panels. The user inputs essentially two separate cases, one for the OD panel and one for the ID. The program will then iterate on the flow split until the inner- and outer-panel pressure drops are equal. While calculations are being performed on one panel, information about the other is stored on scratch files.

Subroutine COMANN performs the iteration logic and calls the other subroutines as required. Iteration on pressure drop or flow rate is performed until the calculated flow through the liner orifices agrees to within 0.05 percent of the inlet flow. However, if a solution is not obtained in 20 iterations, the program will stop, as errors in the input or high annulus Mach numbers could make convergence difficult. Of particular importance is the variable RELAX, defined at card C0.31. This is a relaxation parameter used in the convergence logic and has considerable influence on the convergence rate. The simple function provided has worked moderately well for various combustor geometries; however, for complex designs or high annulus mach numbers it is anticipated that the value of RELAX will need to be reduced to obtain a solution.

The names of the remaining subroutines are descriptive of their functions. All data cards are read in subroutine INPUT and then are printed out in subroutine PINPUT. INLET calculates the inlet conditions to the combustor annulus while LENGTH and FLOW perform calculations of annulus flow conditions and orifice flow conditions, respectively. FLOW, in turn, calls JET and DCOEF which calculate the orifice jet velocity and discharge coefficient. Some attention to cards DC.34 to DC.57 in DCOEF is warranted. As there was only qualitative agreement between the measured and calculated discharge coefficients, a constant multiplier was applied to the calculated values. Line printer output is produced in PROUT while the plots are generated in PICTUR and BOXES.

3-D-COMBUSTOR-PERFORMANCE MODEL.

The 3-D performance model is a three-dimensional recirculating-flow program that is capable of analyzing a variety of combustor configurations, including can, can-annular, and annular. The deck solves for the three velocity components, U, V, and W, three species concentrations, including UHC and CO, turbulence qualities for the K-ϵ viscosity model, and three radiation fluxes. In addition, the use of primitive variables makes modifications to the boundary conditions easy, allowing the user to analyze complex inlet geometries. Also provided is a subroutine for calculating the trajectories and evaporation rates of a fuel-nozzle spray.

Program MAIN (a computer listing has been provided in Appendix C) is divided into two basic sections. Up to card MA.167, the routine is concerned with reading the input data and converting it to the program's internal units which are Systéme International (S.I.). The input sequence is covered in paragraph B of Section IV so only the units will be discussed. Cards MA.7 to MA.11 are used to define seven arrays which convert lengths associated with dimensions and lengths associated with velocity, energy, mass, temperature, pressure, and angles respectively. By proper specification in the data statements, the user may employ those input units that are most convenient. The output units are always S.I. From card MA.168 on, MAIN's function is to call the other various routines in their proper sequence.

Subroutine INITIAL performs some preliminary calculations (AL.10 to AL.155), prints the input data (AL.156 to AL.258), and defines the initial conditions and some of the boundary conditions on the various arrays (AL.259 on). In section AL.48 through AL.78, two arrays, JKIN and IKIN, are defined. They merely contain flags which indicate the locations of mass injection points. Cards AL.261 to AL.272 contain logic for the restart option. If Tape 8 from a previous run is saved and then made available for use during a subsequent run, the program will read the initial and boundary conditions from it.

Subroutine ALLMOD contains several entry points which perform miscellaneous calculations pertaining, usually, to the boundary nodes where modifications to the standard equation are in order. The cyclic nature of the boundary conditions in the θ or K direction is evident in FMOD as well as limits to the fuel and carbon monoxide mass fractions. VELMOD allows the inlet swirl velocity to be increased gradually over a number of iterations and assures that overall continuity is maintained at the exit plane. DENMOD makes alterations to the density at the boundaries to maintain the correct mass-flow rate. GAMOD specifies the wall viscosity values as calculated by the wall functions. SOMAS is used to initialize an array DIVG which is used later in the program. The largest entry point SOMOD contains logic for modifying the equation coefficients and source terms when cooling slots, walls, and droplet evaporation are present. Each variable has its own section and accounts for transfer with the walls and mass addition from the evaporating fuel. SOMODZ deals only with the Z-direction radiation equation and is in a section alone as the data storage is slightly different for this variable.

Subroutine AUX performs the auxilliary calculations for temperature, density, viscosity, and source terms. Entry DENS uses AU.11 to AU.56 to calculate temperature. Cards AU.52 to AU.56 limit the values calculated in order to account for disassociation and early iteration fluctuations. With known temperature, density is then determined from AU.57 to AU.108. VISCO obtains effective viscosity from turbulent kinetic energy and dissipation and calculates y+ for use by the wall function routine. SOURCE contains all calculations for source terms with the exception of the aforementioned modifications in SOMOD. Again each variable has its own section, with coding that is quite straightforward and requires no explanation.

Subroutine AUXRAD performs the same function as AUX except that it pertains only to the radiation equations.

SPRAY is used to determine the evaporation rate of the fuel-nozzle spray. A large section, from SP.106 to SP.269, deals with locating the droplet, determining free-stream conditions, and handling the situation where the droplet approaches a boundary. Next, various fuel- and free-stream properties are evaluated (to SP.292). The drag forces and time step are then determined and used to obtain new velocities and location. If the droplet is below the boiling temperature, no evaporation occurs (SP.340 to SP.347); but, when the boiling temperature is reached, evaporation rates are calculated, and the appropriate entries to the evaporation array (EVAP) are made. Information concerning momentum changes due to evaporation are also stored in their respective arrays and later (SP.382 to SP.425) on a scratch file for use when the three momentum equations are solved.

The coefficients for each variable are generated and the solution routine called in subroutine STRIDE. First, equations for U, V, and W are handled (ST.117 to ST.632), then the pressure perturbation (P') is obtained (SP.633 to ST.714) and used to correct the velocities (SP.716 to ST.753) so that mass errors are minimized. Then, the remaining variables are solved with the radiation equations having their own special section (ST.915 to ST.937).

STRAD is a subroutine used in the radiation model which performs the same function as STRIDE performed for the other variables.

SOLVE provides a solution to the equations generated in STRIDE. A full three-dimensional solution would be time consuming and would require enormous computer storage. Therefore, an approximate solution is obtained by "sweeping" through the field several times alternately solving along one direction, while holding the values in the other two fixed. The variable ICTDMA

(UV) at S0.36 is used to specify the number of such sweeps. As the program converges, and the variables assume their final values, the solution becomes more and more accurate.

LINER COOLING MODEL

This program is derived from the 2-D parabolic GENMIX program of S.V. Patankar and D.B. Spalding[21]. Modifications have included the addition of a two-equation viscosity model, two-step reaction scheme, two-flux radiation model, plus subroutines for calculating wall temperatures and liquid-fuel-evaporation rates.

The basic geometry for which this program has been geared is continuous inner and outer walls or continuous inner axis of symmetry and outer wall. Other situations may be analyzed provided the proper internal modifications are made to the code.

The MAIN program (a computer listing has been provided in Appendix D) handles several functions, including input, establishment of initial profiles, logic for boundary conditions, calling the additional routines in sequence, and output. The initial section of MAIN (through MA.369) deals with input and initial conditions. Input begins at MA.44 with the case title followed by control indices and grid parameters. More computer storage has been provided than is required for the six species involved in the two-step reaction-scheme, therefore, the extra arrays are zeroed. Various other variables are initialized prior to reading the name list at MA.187. The initial profiles are read from MA.212 to MA.222 and values are assigned to all the arrays from MA.292 to MA.269. The main marching loop (MA.272) begins with the calculation of pressure, temperature, and density (through MA.472). STRIDE(1) called at MA.497 calculates the

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[21] Patankar, S. V. and D. B. Spalding.

physical dimension of y from the transformed cross-stream variable ω. The forward step size is next determined along with checks for specified X-locations. The boundary conditions are established between MA.528 and MA.743, and in this deck can be either an inner wall or axis of symmetry and an outer wall. Sections dealing with others are bypassed. The wall temperatures of the inner and outer walls, if required, are determined by the two call statements MA.747 and MA.748, while STRAD (MA.750) is a subroutine used to calculate the radiation flux. Duct geometry and pressure gradient occupy the next section MA.755 to MA.857 and provides two methods for pressure gradient calculation which are selected by IDPDX. When the value is 01, the program uses a guess-correction method, whereas for a value of 02, the program immediately corrects the velocity and pressure fields if the duct area and flow area differ. Entrainment rates are calculated from MA.907 to MA.934 but are not used in any calculations by this code. DROP, a subroutine called at MA.937, calculates the evaporation rates of the liquid-fuel spray. This is followed by STRIDE(2), which performs some preliminary calculations needed prior to solving the equations. The remainder of MAIN is devoted to printout with the exception of STRIDE(3), called at MA.1195 which actually solves the finite difference equations.

Subroutine AUX has two parts; the first (through AU.37) calculates the effective viscosity from the two equation turbulence model, while the second computes the source terms for each equation.

As mentioned above, DROP calculates evaporation rates. Note that the input data for the fuel nozzle is read at AUS.15. With the location of a particular droplet established (AUS.42 to AUS.68), properties of the fuel and free stream are determined (AUS.76 to AUS.94). Some preliminaries are performed before iterative loop AUS.111 to AUS.151 is entered. Calculations are performed until the guessed value of the distance the droplet travels agrees with the calculated value. With this distance and the droplet velocity known, the time step and evaporation rate can be determined. The proper entries in the evaporation array EVAP are then made at AUS.173 and AUS.190.

STRAD performs all calculations relative to the two-flux radiation model. Modifications to the source terms due to the presence of a wall are made at GA.130 to GA.136. The central difference coefficients are then computed and solved using the standard tri-diagonal algorithm.

WTEMP uses an energy balance on the wall to determine the wall temperature. Cold-side convection, cold-side radiation, hot-side radiation, and hot-side convection are calculated in turn, and a Newton-Raphson iteration procedure is employed to solve the resulting heat-flux equation. The cold-side velocity and temperature are updated at each marching step, accounting for the heat transferred to the annulus.

STRIDE performs the bulk of the numerical calculations and has been documented in literature.

WF is used to evaluate the Couette-flow-equation solutions and to obtain wall shear stress and other transfer data.

PLOTS is a line printer plot routine.

TRANSITION LINER MIXING MODEL

This computer code is derived from the 2-D parabolic GENMIX program of S.V. Patankar and D.B. Spalding. The primary modifications include the ability to have a varying step size across the grid, since, for a given number of marching steps, the distance traveled along the outer-transition liner is considerably greater than along the inner. Other modifications include the addition of K-ϵ viscosity model.

A computer code that could handle all geometrical configurations would be greatly increased in size; therefore, this deck has been tailored to the geometry of a reverse-flow annular-combustor transition liner. Other configurations can be analyzed if the proper modifications are made to the computer code.

The MAIN program (a computer listing has been provided in Appendix E) handles several functions, including input, establishment of initial profiles, logic for boundary conditions, calling additional routines in sequence, and output. The initial section of MAIN, through card MA.255, contains input and data initialization coding. Note that the x and r values of the boundaries are read at cards MA.64 and MA.65, but that the value of Z, the actual marching direction, is computed at MA.74 and MA.77. ISOLVE and IPRNT perform the functions their names suggest, determining which variables are solved for and printed. Various constants are initialized in the next few cards. MA.157 is of some significance since it is here that the name list is read, and finally the various profiles are read in and defined. Starting at MA.256, the main marching loop begins with the calculation of pressure, temperature, and density (MA.293 to MA.315). STRIDE(1), called at MA.345, is a subroutine which extracts the physical cross-stream dimension from the transformed cross-stream variable, ω. The forward step size is calculated in the next section (MA.349 through MA.403), which was necessitated by having a smaller step size at the inner boundary than the outer, plus some checks for specified z-locations. Next, the boundary conditions are assigned (MA.406 to MA. 479), and since they are always walls in the transition liner, only those appropriate sections are entered. The actual duct area is determined in section MA.481 through MA.505, plus the area required by the flow. Should these two not agree, compensation in the pressure gradient for the next marching step will be made. The pressure gradient is calculated between MA.507 and MA.598. Two methods are provided and are selected by IDPDX. When the value is 01, the program uses a guess-correction method (MA.539 through MA.543), whereas for a value of 02, the program immediately corrects the velocity and pressure fields (MA.521 through MA.536). The pressure gradient across the grid due to radius-of-curvature effects is calculated at MA.579 and incorporated into the axial-pressure gradient at MA.595. Statement MA.645 calls AUXO(0), which calculates the effective viscosity from the K-ϵ model. Since there is no entrainment for the geometry employed, cards MA.646 through MA.670 are bypassed. STRIDE(2), called at MA.673, performs some preliminaries necessary prior to the equation solution. The rest of MAIN is devoted to outputs of various types with the exception being MA.902 where STRIDE(3) is called, solving the equations for that marching step.

Subroutine AUX performs two functions; it calculates effective viscosity (up to AU.37) and the source terms for the equations (AU.38 on). Subroutine STRIDE performs the bulk of the numerical calculations and has been heavily documented in literature. Subroutine WF is used to evaluate the Couette-layer-equation solutions near a wall, to extract shear stress and other transfer data needed in the solution of the equations, and finally PLOTS is a line printer plot routine.

EMISSIONS MODEL

The emission model is a 2-D parabolic program derived from the GENMIX deck of S.V. Patankar and D. B. Spalding. The principal modifications include the addition of a 16-step reaction scheme and the ability to handle cooling slots and radial injection orifices.

The MAIN program (a computer listing has been provided in Appendix F) is concerned with input, establishment of initial conditions, logic for boundary conditions calling other subroutines in sequence, and output. The coding is similar to that already described for the liner-cooling model; therefore, only those items unique to the emissions model will be discussed. Two additional input items are (1) extra specie-input profiles are required (MA.213 to MA.217), and (2) data describing the cooling slots and radial-injector orifices is read at MA.223 to MA.275. To accompany the additional input, there is also logic for the special boundaries, conditions associated with the cooling slots and radial injections MA.562 to MA.618 and MA.659 to MA.715, respectively. When the program reaches the edge of a slot lip, a free boundary is assumed until the flow rate of the slot has been entrained. A similar procedure is used for radial-injection orifices where the boundary is assumed to be a porous wall. All the other subroutines perform the same functions as described in the Liner-Cooling Model paragraph; however, an additional subroutine, AUXS, has been added which calculates the specie source terms and writes them on a scratch file. AUXS solves the same equations as STRIDE except that cross-stream convection and diffusion are omitted. The equations are solved many times using a step size considerably smaller than the main program. In this manner, an estimation of the change in the specie value for the larger main program marching step is obtained from which an average source term over the interval can be calculated. This is then used when the complete equations are solved in STRIDE(3). The first section of AUXS (up to AUS.68) performs data initialization followed by the calculation of forward and backward rate constants (AUS.70 to AUS.95). The main loop is entered next where first the source terms and then the derivatives are determined. Note that the rate expression for the global fuel reaction contains the effect of turbulence (AUS.125) and that the kinetic source term contains a number of variables each raised to a respective power (AUS.123 and AUS.124). These powers, EFU, ERO, etc., are read in through the name list in the MAIN program. A step size, such that the species values do not change excessively, is then selected using the variables TERM1 and TERM2, also part of the name list. Examination of AUS.223 shows that the maximum change allowed during the marching step is the larger of TERM2 and TERM1 times the upstream specie value. The Equations are then solved and the process is repeated until a distance equal to the main program step size, DX, has been traversed. ISMAX, which is also part of the name list in the MAIN program, is a limit on the maximum number of these steps. The average source term over the interval is then calculated and stored on a scratch file for later use.

FUEL INSERTION MODEL

The function of the fuel-insertion model is to determine the evaporation rates and trajectories of a fuel spray in a two-dimensional flow field. Information concerning the fuel nozzle and flow field are read in, and from these the program calculates the fuel SMD and the trajectories. If desired, a plot of the droplet paths can be made and the evaporation rates saved for use in other programs.

INJECT1 (a computer listing has been provided in Appendix G) is the main program and controls input, output, and the other subroutines. Up to INJ.67 several data statements initialize some fuel and air properties needed in the evaporation calculations. Input data is read to INJ.119 followed by some preliminary calculations. Additional input is read at INJ.187 to INJ.195 if a nonuniform flow field is specified. Calculations of SMD for the particular fuel nozzle type selected begin at INJ.206 continuing to INJ.310. The next section entered (INJ.311 through INJ.435) loops over the five droplet sizes, calculating, in turn, their trajectories. The remainder of INJECT1 provides output and plotting. Subroutine FEVAPC is used to save the evaporation rates for later use, if desired, while AIRPRP interpolates the 2-D nonuniform flow field to obtain the free-stream conditions. Subroutine EVAP performs the majority of the calculations, including the force balances on the droplets so that their trajectories and the evaporation rates can be calculated.

Each of the remaining routines provides some property of the fuel or air required by the calculations.

IV. ILLUSTRATIONS

ANNULUS FLOW MODEL

Figure 8 shows the annulus-loss model example geometry. It is a simple reverse-flow combustor with inner- and outer-panel cooling slots, plunged primary orifices and two dome inlets. For the purposes of analysis, the annulus was divided into elements denoted by the dashed lines. These divisions correspond to places at which mass was extracted or where the annulus was of irregular shape. The elements can be length-type for which skin-friction losses and heat transfer, etc., are calculated or flow-type for which mass extraction is calculated. Thus, the length element ② is the annulus section between the inlet ① and ②, and flow element $\boxed{3}$ is the OD cooling slot.

Inspection of the input sheets, Figures 9 through 11, shows that Card 1 contains the case title and specifies some control parameters. The annulus-inlet conditions are specified on Card 2 along with the total number of elements used and the inlet-element number. Card 3 is for internal liner flow only and is omitted, whereas Card 4 specifies various constants. It now remains to describe the plenum and liner shape and the various orifices. This is done on the second input sheet with explanations of the various items given in Figure 11. Since, for this case, the flow split between the various orifices was known and not the orifice size, the flow-element cards are of the fixed-flow ratio type (FF). Had the orifice size been known instead, the fixed diameter type (FD) should have been used. If the C_D of a particular orifice row is known, it may be specified as has been done for flow elements 8 and 10. Even though these are actually annular slots in the dome, the program will still calculate an orifice diameter, which is, of course, meaningless; however, the effective and geometric areas are also provided in the output from which the correct annular-slot height can easily

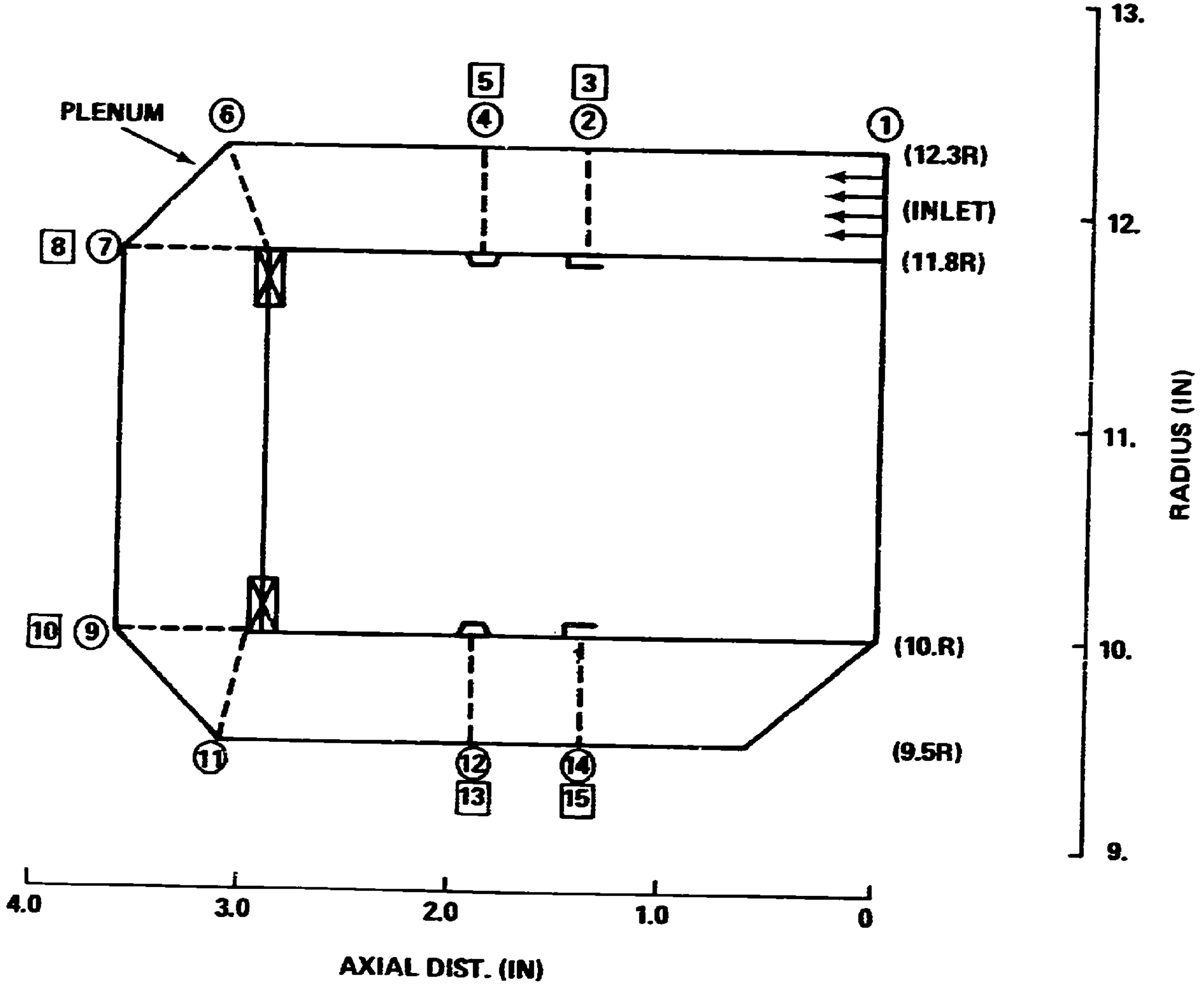

Figure 8. Annulus Loss Model Example Geometry.

	1 TITLE - MUST HAVE FOR EACH CASE	ITER 78	IPIC 79	IDBUG 80
1	ANNULUS LOSS MODEL EXAMPLE GEoMETRY	1	1	0

ANNULUS INLET FLOW CARD

	1		NEL 345	NELI 678		11 W1	21 PT1	31 TT1	41 BETA1	51 DP/P	61	71
2	I	/	015	001	/	1.6	14.7	1040.	20.	.03	—	—

DOME INLET FLOW CARD (REQUIRED FOR INTERNAL LINER FLOW ONLY)

	12		NELI 678		11 W	21 PT	31 TT	41 BETA	51	61	71
3	ID	/		/					—	—	—

CONSTANTS CARD

	1		11 FRIC	21 BLKF	31 TANS	41 CDB	51 SK	61 RG	71 IREAX
4	C	—	0.	.83	.1	1.1	1.4	53.3	0.0

1 Title - Run ident appears on printed output and plot

ITER = 1 some (or all) holes fixed, inlet flow fixed, iterate to get pressure drop.
ITER = 2 some (or all) holes fixed, pressure drop fixed iterate to get inlet flow (input W1 is first guess).

IPIC = 0 no plot
IPIC = 1 plot drawn

IDBUG = 0 output printed after converged solution
IDBUG = 1 output printed after each iteration | Use only to debugg non-convergence
IDBUG = 2 output printed after each element |

2 3 NEL = total number of element stations (card 2 only)
NELI = element ID no. (NELEM) at annulus or dome inlet 2 and 3
W_1 and W = air flow at inlet stations, lb/sec
PT_1 and PT = inlet total pressure, PSIA
TT_1 and TT = inlet total temperature, R
$Beta_1$, Beta = swirl angle at inlet
DP/P = total pressure drop, PSIA/PSIA (first guess if ITER = 1) card 2 only

4 FRIC = 0, smooth wall friction factor
FRIC -1, no wall friction
FRIC = roughness factor for rough walls
BLKF = annulus effective area factor (= .83 for fully developed turbine flow)
TANS = tangent of flow separation spread angle (.1 recommended)

Figure 9. Annulus Loss Model Input Sheet (Sheet 1 of 2)

CDB = drag coefficient of struts across annulus (1—1.2 RECM)
SK = ratio of air specific heats,
RG = air gas constant
IREAX = 0. for reverse flow annular or can combustors
IREAX = 1. for axial flow annular. First data set is for OD panel. Program expects a second set for ID panel

CASE TERMINATION

After last card of case:

o In Column 1, Column 2 blank - case repeated with changes, next card is title card followed by cards with changes from previous run.

oo In Columns 1 and 2, next card is EOF to quit or new title card followed by all cards for complete new case.

Figure 9. Annulus Loss Model Input Sheet (Sheet 2 of 2)

NELEM

L				XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	I			XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	C			XP	RP	XL	RL	CL	T RISE		
F	P			W/WL	N HOLES	NHTYP	CD		I SEP		
F	D			W/WL	N HOLES	NHTYP	CD	D HOLES	I SEP		
F	B			W/WL					I SEP		
F	I			WINJ/W	V JET	ANG I	ABETA		I SEP		

	1	2	345		11	21	31	41	51	61	71	76
1	L		001		0.	12.3	0.	11.8		1760.		
2	L		002		1.4	12.3	1.4	11.8		1960.		
3	F	F	003		.15	120.	3.0			1.0		
4	L		004		1.9	12.3	1.9	11.8		1960.		
5	F	F	005		.15	30.	2.0			1.0		
6	L		006		3.1	12.3	2.9	11.8		1960.		
7	L		007		3.6	11.8	2.9	11.8		1960.		
8	F	F	008		.20	1.0	5.0	.50		1.0		
9	L		009		3.6	1.0	2.9	10.		1960.		
10	F	F	010		.20	1.0	5.0	.50		1.0		
11	L		011		3.1	9.5	2.9	10.		1960.		
12	L		012		1.9	9.5	1.9	10.		1960.		
13	F	F	013		.15	30.	2.0			1.0		
14	L		014		1.4	9.5	1.4	10.		1960		
15	F	F	015		.15	120.	3.0			1.0		
16	●	●										
17												
18												
19												
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40												

Figure 10. Sample Work Sheet for Program 117.

NELEM

ALL NUMBERS MUST HAVE DECIMAL POINTS

1	2	3 4 5		11	21	31	41	51	61	71	76
L		0 0 1		XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	I	0 0 2		XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	C	0 0 3		SP	RP	XL	RL	CL	T RISE	--	--
F	F	0 0 4		W/W1	N HOLES	NHTYP	CD	--	I SEP	--	--
F	D	0 0 5		W/W1	N HOLES	NHTYP	CD	D HOLES	I SEP	--	--
F	B	0 1 0		W/W1	--	--	--	--	I SEP	--	--
F	I	0 2 0		W/INJ/W	V JET	ANGJ	ABETA	--	I SEP	--	--

ELEMENT SPECIFICATION

Flow passage is divided into length (L) and flow (F) elements, element numbers, NELEM, can be in arbitrary order, i.e., 10, 1, 3, 4, 16, 30. The cards are stacked in order from inlet to last F because numbers are arbitrary, a new element can be inserted without renumbering other cards.

L. LENGTH ELEMENTS All Dimensions in Inches

First L card is annulus inlet (CL = 0) - For both external and internal cases.

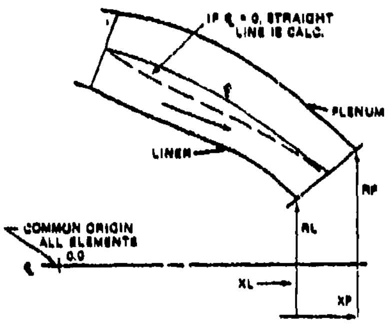
Internal and external flow cases must be run separately

For internal cases, 2nd card is dome inlet (LI) and LC cards are used with T RISE = ΔT due to combustion in this element (no L cards)

For external cases use only L Cards

XL, XP = X COORD to end of element L = Liner
RL, RP = Radius to end of element P = Plenum
(For internal flow XP, RP = OD, XL, RL = ID)
CL = Length of element (optional)
TLIN = Mean wall temp. over CL, °R
If = 0 then TLIN = TT1
$BLKI = \frac{\text{Frontal Area of Struts}}{\text{Annulus Area}}$
DBKI = Width of strut

LENGTH ELEMENT



F. ORIFICE FLOW ELEMENT

F Cards are inserted between L cards at points where flow is extracted. Flow conditions into F elem. are those from upstream L elem.

Types: FF - Fixed Flow Ratio, W/W1
FD - Fixed Orf. Diam. (W/W1 is First Guess)
FB - Bleed flow (not included in liner flow)
FI - Internal flow elem. (input to these elements is obtained from an external flow solution)

W/W1 - Orifice Flow/Inlet Flow
NHOLES - No. of Orifices
NHTYP - Hole Type (For CD)
1. Flush Hole, Thin Wall
2. Plunged Hole
3. Cooling Skirt
4. Flush Hole, Thick Wall
5. CD Input
6. Rectangular Hole

CD = DISCH Coefficient (NHTYP = 5 Only)
DHOLES = Hole Diam. (For FD Only)
I SEP = 1, Separation is Reattached
VJET = Jet Injection Velocity, FPS
ANGJ = Jet Injection Angle, Deg.
ABETA = Swirl Angle in Annulus Outside FI Elem.

FLOW ELEMENTS

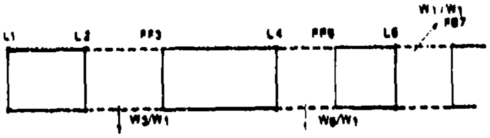


Figure 11. Program 117 Input Data Sheet
Input Format for Element Cards
Sheet 2.

be obtained. Other irregular shaped orifices, such as slotted-dilution holes, for example, can be handled in a similar manner. Card deck termination is specified by the double periods.

The output of the program is shown in Figures 12 through 14. Figure 12 is merely a printout of the input data. Figure 13 gives information of conditions in the annulus at the various stations the user has specified. Figure 14 has information regarding the orifices. Note that the program has calculated orifice-hole diameters and that the flow split is the same as was specified in the input. Overall output parameters such as pressure drop, corrected flow, etc., are also given. The numbers under the heading INPUT FOR SUB BOXES- are associated with the plot subroutine.

COMBUSTOR PERFORMANCE MODEL

The combustor geometry for the 3-D combustor-performance model example is shown in Figure 15. The reverse-flow annular liner has been divided into a grid network consisting of 30 nodes in the axial or X direction, 19 nodes in the radial or y direction, and 13 nodes in the tangential or θ directions. The decision of how large a θ segment to analyze is depending upon where radial planes of symmetry can be found, since the program assumes that there are cyclic boundary conditions in the θ direction. Therefore, any mass leaving the system along the K-13 plane is assumed to reenter the system through the $K = 1$ plane and vice versa. For this example, uniform grid spacing has been used, although this is obviously not required.

The completed input sheets for the case are shown in Figure 16. Additional input information can be found on the input sheet forms located in Appendix A. Cards 1 and 2 are titles used for printout and case identification. The grid size (30 by 19 by 13) has been entered on Card 3 along with indicators for axisymmetric geometry, K-ϵ viscosity model, kinetic and turbulence controlled

```
ANNULUS LOSS MODEL EXAMPLE GEOMETRY

      INPUT DATA -
        CALCULATION CONTROLS - SOME (OR ALL) HOLES FIXED SIZE, ITERATE TO FIND PRESSURE DROP (ITER = 1)
                               PICTURE WILL BE PLOTTED (IPIC = 1)
                               OUTPUT PRINTING OCCURS AFTER FINAL SOLUTION ONLY (IDBUG = 0)
        OVERALL PRESSURE DROP -  .0450
        ANNULUS EFFECTIVE AREA FACTOR -  .8300
        AIR RATIO OF SPECIFIC HEATS -   1.400
        AIR GAS CONSTANT - 53.300
        ANNULUS WALL ROUGHNESS FACTOR -  0.0000
        TANGENT OF SEPARATION SPREAD ANGLE -   .1000
        DRAG COEFFICIENT FOR INSERTED BLOCKAGE -   1.1000
        NUMBER OF POSITION ELEMENTS -  15

          DIMEN. AT DOWNSTREAM END OF ELEMENT
          ***********************************
            XO       RO         XI        RI        CL      WALL     INSERT   INSERT       HOLE      NUMBER  HOLE  DISCH ORIFICE
ELEM  ELEM  OUTER    OUTER      INNER     INNER   ELEMENT  TEMP,     AREA   DIAMETER     DIAM        OF    TYPE  COEFF FLOW /
 NO.  TYPE  LENGTH   RADIUS     LENGTH    RADIUS  LENGTH    R       FACTOR    IN.         IN.       HOLES              FLOW IN
*****************************************************************************************************************************


  1   L     0.000    12.300     0.000    11.800   -0.000  1960.0    1.000    1.000
  2   L     1.400    12.300     1.400    11.800   -0.000  1960.0    1.000    1.000
  3   FF                                                                              1.0000     120       3  *.0000    .1500
  4   L     1.900    12.300     1.900    11.800   -0.000  1960.0    1.000    1.000
  5   FF                                                                              1.0000      30       2  *.0000    .1500
  6   L     3.100    12.300     2.900    11.800   -0.000  1960.0    1.000    1.000
  7   L     3.600    11.800     2.900    11.800   -0.000  1958.0    1.000    1.000
  8   FF                                                                             -0.0000       1       5   .5000    .2000
  9   L     3.600    10.000     2.900    10.000   -0.000  1960.0    1.000    1.000
 10   FF                                                                             -0.0000       1       5   .5000    .2000
 11   L     3.100     9.500     2.900    10.000   -0.000  1960.0    1.000    1.000
 12   L     1.900     9.500     1.900    10.000   -0.000  1960.0    1.000    1.000
 13   FF                                                                              1.0000      30       2  *.0000    .1500
 14   L     1.400     9.500     1.400    10.000   -0.000  1960.0    1.000    1.000
 15   FF                                                                              1.0000     120       3  *.0000    .1500

START ITERATION NO.  1
SOLUTION CONVERGED, TOTAL JET FLOW=   1.6000 FLOW ERROR=  -.000000 FINAL PRESSURE DROP=   .045000
```

Figure 12. Annulus Loss Model Output.

```
ANNULUS LOSS MODEL EXAMPLE GEOMETRY

        OUTPUT RESULTS - PAGE 1

ELEM  ELEM  SWIRL   FLOW     MACH   FLOW    AXIAL   TANG    TOTAL   STATIC  TOTAL   STATIC  DENSITY  DYNAM  DYN HD
 NO   TYPE  ANGLE   RATE      NO    VEL     VEL     VEL     TEMP,   TEMP,   PRESS,  PRESS,           HEAD,  /PTOT
                    LB/S            FPS     FPS     FPS       R       R     PSIA    PSIA    LB/FT3   PSIA     --

  1    L    20.00   1.600   .1306  206.09  193.66   70.49  1040.0  1036.5   14.70   14.53    .0379    .174  .0118
  2    L    19.76   1.600   .1311  207.75  195.57   70.08  1049.6  1046.0   14.69   14.52    .0375    .175  .0119
  3    FF   22.89   1.360   .1136  180.08  165.88   70.08  1049.6  1046.9   14.69   14.56    .0376    .131  .0089
  4    L    22.76   1.360   .1137  180.56  166.46   69.90  1053.2  1050.5   14.69   14.56    .0374    .132  .0090
  5    FF   27.04   1.120   .0967  153.67  136.86   69.90  1053.2  1051.3   14.69   14.59    .0375    .096  .0065
  6    L    28.45   1.120   .0913  145.65  128.05   69.41  1061.7  1059.9   14.69   14.60    .0372    .085  .0058
  7    L    30.10   1.120   .0883  140.97  121.94   70.73  1064.2  1062.5   14.69   14.61    .0371    .080  .0054
  8    FF   44.52    .800   .0631  100.85   71.57   70.73  1064.2  1063.3   14.69   14.65    .0372    .041  .0028
  9    L    43.70    .800   .0740  118.85   85.90   82.14  1076.8  1075.6   14.68   14.63    .0367    .056  .0038
 10    FF   57.89    .480   .0603   96.94   51.49   82.14  1076.8  1076.0   14.68   14.65    .0368    .037  .0025
 11    L    50.55    .480   .0674  108.49   68.09   83.81  1080.2  1079.2   14.68   14.64    .0366    .047  .0032
 12    L    47.66    .480   .0689  111.47   75.04   82.44  1092.1  1091.0   14.68   14.63    .0362    .049  .0033
 13    FF   65.51    .240   .0559   90.56   37.49   82.44  1092.1  1091.4   14.68   14.65    .0363    .032  .0022
 14    L    64.98    .240   .0551   89.53   37.81   81.16  1101.4  1100.7   14.68   14.65    .0360    .031  .0021
 15    FF   89.69    .002   .0499   81.16     .38   81.16  1101.4  1100.8   14.68   14.65    .0360    .026  .0017
```

Figure 13. Annulus Loss Model Output.

```
ANNULUS LOSS MODEL EXAMPLE GEOMETRY

       OUTPUT RESULTS - PAGE 2

       /*********** ANNULUS GEOMETRIC PARAMETERS ******** / ******************* ORIFICE PARAMETERS *******************
ELEM ELEM MEAN   CHANNEL ANN    AN EFF WAKE   SEPAR  ATTCH    HOLE   DISCH   JET    ORIF    ORIF     ORIF     JET     ORIF
 NO. TYPE RADIUS  WIDTH  AREA    AREA  AREA   AREA   LENGTH   DIAN   COEFF   ANGLE  GEOM    EFF      CUMUL  VELOCITY  FLOW
           IN.     IN.   IN2     IN2   FACTOR FACTOR  IN.      IN.     -     DEG    AREA    AREA   EF AREA    FPS     /MIN

  1   L   12.050  .500   37.86   29.53 1.000  1.000   0.000
  2   L   12.050  .500   37.86   29.58 1.000  1.000   0.000
  3   FF  12.050  .500   37.86   28.94 1.000  1.000   0.000   .1877  .6847   0.00   3.321   2.273    2.273  405.44   .1500
  4   L   12.050  .500   37.86   28.97 1.000  1.000   0.000
  5   FF  12.050  .500   37.86   27.98 1.000  1.000   0.000   .3542  .7700  80.00   2.955   2.276    4.549  405.64   .1500
  6   L   12.050  .539   40.77   29.75 1.000  1.000    .343
  7   L   11.800  .700   51.90   30.81 1.000   .827   0.000
  8   FF  11.800  .700   51.90   30.70 1.000  1.000   0.000 2.7873  .5000  90.00   6.102   3.051    7.600  406.68   .2000
  9   L   10.000  .700   43.98   26.38 1.000  1.000   0.000
 10   FF  10.000  .700   43.98   19.39 1.000  1.000   0.000 2.7968  .5000  90.00   6.144   3.072   10.672  408.31   .2000
 11   L    9.750  .539   32.99   17.39 1.000  1.000   0.000
 12   L    9.750  .500   30.63   17.11 1.000  1.000   0.000
 13   FF   9.750  .500   30.63   10.52 1.000  1.000   0.000   .3375  .8665  80.00   2.684   2.325   12.997  410.18   .1500
 14   L    9.750  .500   30.63   10.74 1.000  1.000   0.000
 15   FF   9.750  .500   30.63     .12 1.000  1.000   0.000   .1716  .8413   0.00   2.776   2.336   15.333  411.58   .1500
                         OVERALL FLOW COEFFICIENT =     .6282
                         INLET CORRECTED FLOW, LB/S =   2.266
                         DISCHARGE PRESSURE, PSIA =    14.04
                         PRESSURE DROP / PT INLET   =   .0450
                         TOTAL GEOMETRIC AREA, IN2 =    23.981

INPUT FOR SUB BOXES -
  2.750  -1.850  -7.850    .500  -7.850  -1.500   0.000   0.000   0.000  -4.700   6.550   8.855  -8.225
-3.075 2.350  1    -2.050 2.350  2    -2.050 4.575  3    -1.025 2.350  4
-1.025 4.575  5      .000 2.350  6     1.025 2.350  7     1.025 4.575  8
 2.050 2.350  9     2.050 4.575 10     1.537-4.450 11      .512-4.450 12
  .512-6.225 13    -.513-4.450 14     -.513-5.225 15
```

Figure 14. Annulus Loss Model Output.

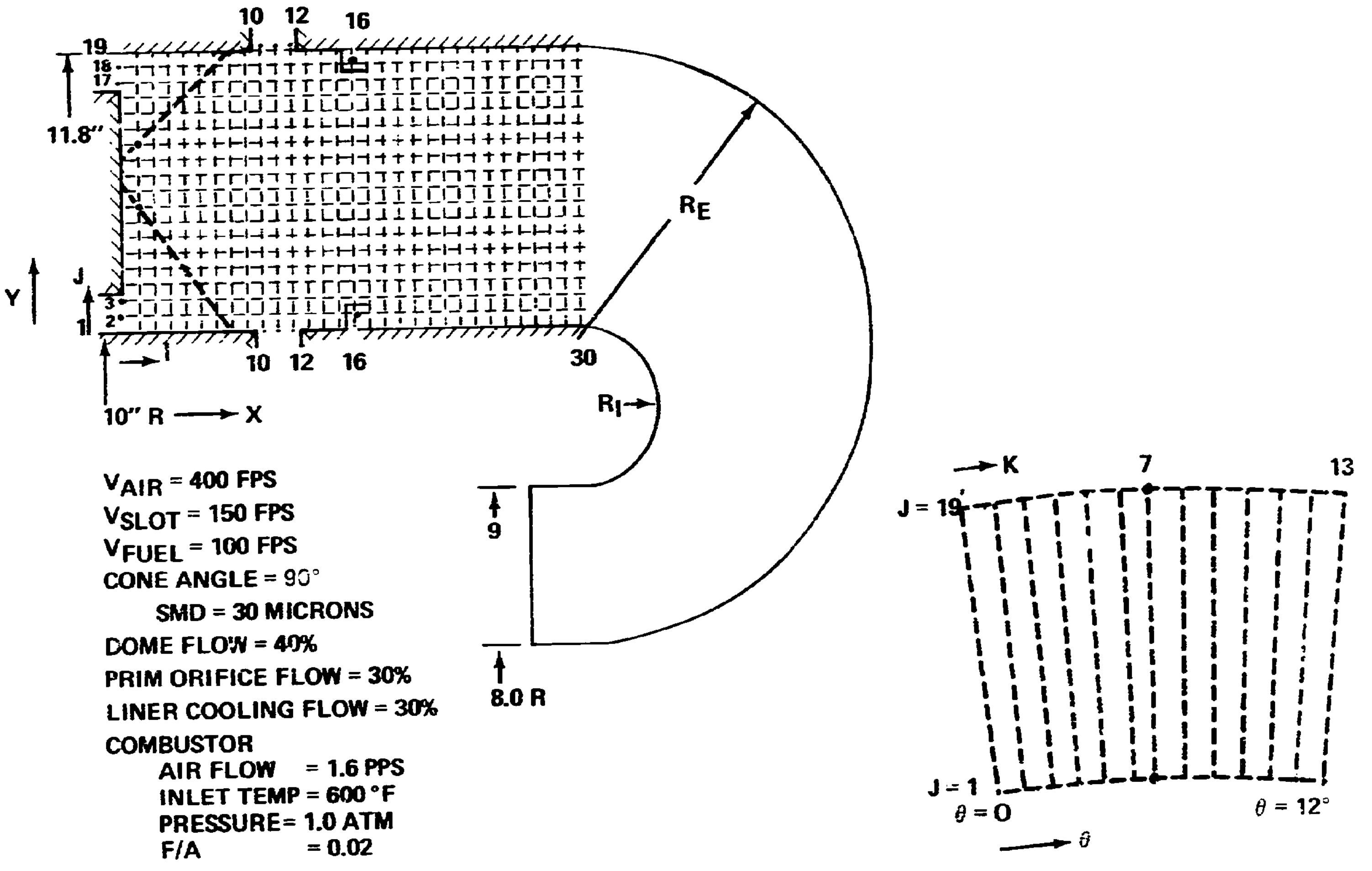


Figure 15. Combustor Geometry for 3-D Combustor-Performance Model.

22 VARIABLE TITLE CARDS (4A10) SAME ORDER AS IMPRINT

1								

CASE TITLE CARD (8A10)

2	3D PER	FORMANC	E MOD	EL EXA	MPLE CA	SE		

	LP1	MP1	LP1	IPLAX	MODEL	MODER	IPAR	ITRAD
3	30	19	13	02	02	02	02	02

	IU	MODEN	INTAPE	IDW	IRES			
4	02	02	00	01	00			

ISOLVE (8(I2, 8X))

	U	V	W	P'	KE	ε	Φ	MFU
5	01	01	01	01	01	01	01	01
	MCO	$\tilde{h}$	FX	FY	FZ			
	01	01	01	01	01			

ICTDMA (8(I2, 8X))

	U	V	W	P'	KE	ε	Φ	MFU
6	01	01	01	06	01	01	01	01
	MCO	$\tilde{h}$						
	01	01						

IMPRINT (8(I2, 8X))

	U	V	W	PRESS	KE	ℓm	Φ	MFU
7	06	06	06	06	06	06	06	06

Figure 16. 3-D Combustor Performance Model (1 of 6)

TEMP	$\tilde{h}$	Favg	Fx	Fy	Fz	MCO	MH2O
06			06	06	06	06	

MO2	MCO2	MN2	μEFF	DENSITY	EVAP		
			06	06	06		

RELAXATION PARAMETERS (8E10.4)

8

U	V	W	P'	KE	ε	Φ	MFU
.2	.2	.2	1.0	.5	.5	.8	.8

MCO	$\tilde{h}$	Fx	Fy	Fz	PRESS	DENSITY	VISCOS
.8	.8	1.	1.	1.	.5	.2	.1

LAMINAR PRANDTL NUMBERS (8E10.4)

9

U	V	W	P'	KE	ε	Φ	MFU
1.	1.	1.	1.	1.	.7	.7	.7

MCO	$\tilde{h}$						
.7	.7						

TURBULENT PRANDTL NUMBERS (8E10.4)

10

U	V	W	P'	KE	ε	Φ	MFU
1.	1.	1.	1.		.9	.9	.9

MCO	$\tilde{h}$						
.9	.9						

X-COORDINATES (1-LP1) (8E10.4)

11

0.	.1	.2	.3	.4	.5	.6	.7

.8	.9	1.0	1.1	1.2	1.3	1.4	1.5

Figure 16. 3-D Combustor Performance Model (2 of 6)

1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3
2.4	2.5	2.6	2.7	2.8	2.9		

RI Y-COORDINATES (2-MP1) (8E10.4)

12

10.	.1	.2	.3	.4	.5	.6	.7

.8	.9	1.0	1.1	1.2	1.3	1.4	1.5

1.6	1.7	1.8					

Z-COORDINATES (1-NP1) (8E10.4)

13

0.	1.	2.	3.	4.	5.	6.	7.

8.	9.	10.	11.	12.			

IWEI JWIO (2(I2,8X))

14

02	19						

IWLI VALUES (8(I2,8X)) (SKIP 15 AND 16 IF IWEI = 2)

15

Figure 16. 3-D Combustor Performance Model (3 of 6)

JWLO VALUES (8(I2, 8X))

16								

(8E10.4)

	PRESS	DEN	ABSOR	SCATR	AKFAC	ALFAC		
17	1.0	—	.1	.01	.003	.02		

(8E10.4)

	CX	HY	HFU	FUMCO				
18	1.0	19.28	-49317.	.00001				

(8E10.4)

	PREXP1	ARCON1	CR1	PREXP2	ARCON2	CR2		
19	3.3E+14	27000.	3.0	6.0E+8	12500.	4.0		

(8E10.4)

	C1	C2	CD	AMU	ERROR	TCYLW	TINLW	TLIP
20	1.43	1.92	.09	185E-5	.01	1960.	1960.	1560.

(2(I3, 7X), 6(I2, 8X)

	LASTEP	IJUMP	JSW1	JSW2	NUINJ	NVINJ		
21	150	999	02	03	02	06		

(8E10.4)

	USW	VSW	SWNO	AFSW	FSW	TSW		
22	400.	0.	0.	.02133	0.0	1060		

	NFNZ	ISPRAY	TFUEL					
23	01	9	540					

	XO	YO	ZO	ALFA	BETA	DELTA	THETA 1	THETA 2
24	.05	.9	6.0	9C	-90.	0.0	0.	360.

(SKIP 24 IF NFNZ = 00)

	RSP	WF	SMD	VFUEL				
	20.	.001067	30.	100				

Figure 16. 3-D Combustor Performance Model (4 of 6)

(SKIP CARDS 25 → 30 IF NUINJ = 00)

I - LOCATION OF COOLING SLOTS (8(I2, 8X))

25	17	17						

J - LOCATION OF COOLING SLOTS (8(I2, 8X))

26	02	18						

AXIAL SLOT VELOCITY (8E10.4)

27	150.	150.						

TANG. SLOT VELOCITY (8E10.4)

28	0.	0.						

SLOT FLOW RATE (8E10.4)

29	.008	.008						

SLOT TEMPERATURE (8E10.4)

30	1060.	1060.						

(SKIP CARDS 31 → 38 IF NVINJ = 00)

I - LOCATION OF RADIAL INJECTION (8(I2.8X))

31	10	11	12	10	11	12		

J - LOCATION OF RADIAL INJECTION (8(I2, 8X))

32	01	01	01	19	19	19		

K - LOCATION OF RADIAL INJECTION (8(I2, 8X))

33	07	07	07	07	07	07		

INJECTION VELOCITY (8E10.4)

34	400.	400.	400.	-400.	-400.	-400.		

Figure 16. 3-D Combustor Performance Model (5 of 6)

INJECTION TURBULENT KINETIC ENERGY (8E10.4)

35	480.	480.	480.	480.	480.	480.		

INJECTION TURBULENT LENGTH SCALE (8E10.4)

36	.0005	.0005	.0005	.0005	.0005	.0005		

INJECTION FLOW RATE (8E10.4)

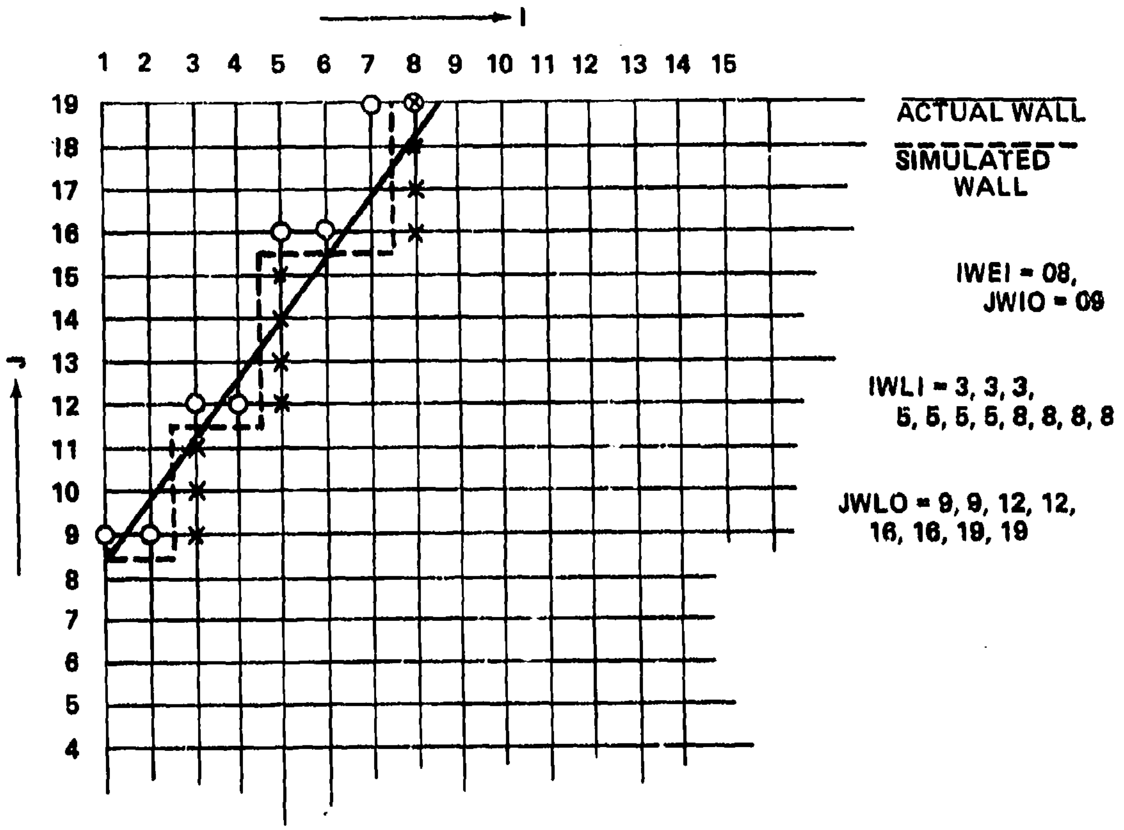
37	.002667	.002667	.002667	.002667	.002667	.002667		

INJECTION TEMPERATURE (8E10.4)

38	1060.	1060.	1060.	1060.	1060.	1060.		

Figure 16. 3-D Combustor Performance Model (6 of 6)

combustion, relative pressure, and radiation to be included, respectively. The use of relative pressure, rather than absolute pressure, merely means that the pressure field is referenced to one particular grid node by subtracting that pressure value from the entire field. On Card 4, the user-selected-input units have been specified. The particular units employed are combinations of convenient ones and are specified by data statements in the main program, at lines MA.9 to MA.11. The user should redefine the arrays for his own input units or use S.I. by specifying IU = 01. Specifying the perfect gas-density calculation, not printing the initial values, the inner boundary as a wall and that this is not a restart, complete the information on Card 4. In order to restart a case, Tape 8 must be saved from the previous run and be made available to the program. Card 5 indicates that all the variables are to be solved. P' is the pressure perturbation used in the solution algorithm, h is stagnation enthalpy, and F_x, F_y, and F_z are the three radiation fluxes. Card 6 shows that all the variables will receive one sweep of the solution routine per iteration except P', which will have six. The solution of the equations in early iterations is not exact, but this does not present a problem since the coefficients are changing from iteration to iteration anyway. However, it is beneficial to the convergence rate to obtain a more accurate solution to the P' equation. The variables to be printed are specified on Card 7. The 06 merely indicates that every 6th K-plane will be printed. The relaxation parameters specified on Card 8 have been used successfully on a wide range of problems and probably need not be altered. The Prandtl numbers and coordinates, Cards 9 through 13, are fairly self explanatory except that the first field, Card 12, is the radius of the inner boundary and that values of y(2) to y(MPL) are measured from that line. Cards 14 through 16 are used to specify an inclined wall at the inlet. Since there is none for this case, the values of IWEI and JWIO are set equal to 2 and MP1 (i.e., 19) respectively, and Cards 15 and 16 are omitted. Were there an inclined wall, Figure 17 gives the necessary information



THE ACTUAL WALL IS SIMULATED BY STAIRSTEPS ALONG THE MIDPOINTS BETWEEN NODES. JWIO IS THE J-NODE WHERE THE INCLINED WALL STARTS, i.e.,09, AND IWEI IS THE I-NODE WHERE THE INCLINED WALL ENDS, i.e.,08. IWLI IS THE 1ST I-NODE INSIDE THE SIMULATED WALL AT A PARTICULAR J-LOCATION. ELEVEN VALUES ARE REQUIRED SINCE THIS IS THE NUMBER OF J-NODES INCLUDED IN THE INCLINED WALL, J = 9 - 19, AND ARE MARKED BY ✳. JWLO IS THE 1ST J-NODE OUTSIDE THE SIMULATED WALL AT A PARTICULAR I-LOCATION. EIGHT VALUES ARE REQUIRED SINCE THIS IS THE NUMBER OF I-NODES INCLUDED IN THE INCLINED WALL, I = 1 - 8, AND ARE MARKED BY ⌖.

Figure 17. Information Necessary to Describe an Inclined Wall.

required to describe it. Cards 17 through 20 need no further explanation other than that given in input sheet forms. A total of 150 iteration steps, along with no intermediate printout, have been specified in the first two fields of Card 21. The basic program contains provisions for only one dome inlet, specified by JSW1 and JSW2; however, the example problem has two. The second inlet was handled by internal modifications to the program in the Subroutine ALLMOD, a process required on nearly every combustor analyzed, as a code which makes provisions for all possible configurations would be extremely complex and lengthy. Note that each primary orifice is simulated by three nodes, making the total of radial-injection points equal to six. Inlet conditions for the dome are provided on Card 22, while Cards 23 and 24 describe the fuel nozzle. A back angle (β) of zero would have the nozzle spraying in a purely tangential and in an increasing θ direction. Positive β would have the spray cone rotated toward the dome; therefore, a value of -90 degrees has the spray cone directed axially along the combustor as is required. Zero down angle (δ) was needed for this example. A positive value would, however, rotate the spray cone toward the inner wall. For geometries that have the entire spray cone in the calculation domain, such as this annular one, THETA1 and THETA2 never change from 0 and 360 degrees or their equivalent in whatever angular input units are selected. Cards 25 through 30 are used to describe the cooling slots, of which two were specified (NUINJ = 2 on Card 21). Note that even though the slots surround I-node 16, the I location is specified as one greater (or 17) due to internal conveniences in the program. Similarly, Cards 31 through 38 specify the radial injection points. Due to the sign convention on V-velocity (positive is in the positive y-direction), injection points on the outer wall have a negative V-velocity component, as shown on the last three fields of Card 34.

The output of the 3-D model is illustrated in Figure 18 (7 sheets). Sheet 1 is a printout of some input data, including fuel and air flow rates, injection velocities, and other important quantities. Note that the output units here are S.I. Sheets 2 and 3 show the u-velocities at $\theta = 6$ deg (in line with the primary holes) after 150 iterations. The total error in mass, i.e., the sum of the mass error in all the grid cells, was 1.5 percent of the total flow, which was deemed accurate enough for this example. The two dome inlets J = 2-3 and J = 17-18 can be seen at I = 2. The u-velocities are calculated for slightly different control volumes than the other variables. The U-velocity printed at I = 8, for example is actually the U-velocity that occurs at the cell boundary between I = 7 and I = 8. This displacement results in the inlet U-velocity being stored at I = 2 rather than I = 1. A small recirculation zone exists behind the dome and is terminated by the primary orifices at I = 10, 11, and 12. Small recirculation regions are also evident behind each jet at I = 14, while the presence of the two cooling slots can be seen at I = 16 and 17. Sheets 3 and 4 of Figure 18 show the fuel mass fractions for the same θ plane. The figure also shows the extremely rich regions just behind the dome at I = 2-4 near the fuel nozzle. By the time the exit plane is reached, some unburned fuel still remains. Temperature is shown in Sheets 5 and 6. The fuel-rich region behind the dome (seen in Figure 15) exists at a relatively low temperature as the amount of oxygen is very limited. Farther down the combustor where the primary jets have recirculated (I = 6,7) one sees temperatures closer to stoichiometric. The primary jets penetrate to the combustor centerline as evidenced by the temperature profile at I = 12. These jets produce a colder core with hot regions on either side that extend well past the cooling slots at I = 16. These slots provide a cool film that extends to the exit of the combustor. Sheets 6 and 7 show the evaporation rate of liquid fuel. One can clearly see the two sides of the spray cone and that some fuel is impinging on the wall at I = 9. Practically all the fuel has evaporated

```
                  3D PERFORMANCE MODEL EXAMPLE CASE
                  ------------------------------------------------------------------------

I.   PHYSICAL INPUT
     --------------
       1.FUEL-
                       HYDROGEN-CARBON RATIO ----------  1.9280E+00
                       MOLECULAR WEIGHT----------------  1.3928E+02  (KG/KGMOLE)
                       HEAT OF FORMATION---------------  -4.9317E+04 (CAL/GMOLE)
       2.AIR -         INLET-1 MASS FLOW RATE----------  0.0         (KG/S)

                       PRESSURE------------------------  1.0133E+05  (NEW/SQ.M)
                       INLET-1 MASS FLOW RATE----------  9.6753E-03  (KG/S)
                       INLET-1 AXIAL VELOCITY----------  1.2192E+02  (M/S)
II.  GEOMETRICAL INPUT INLET-1 SWIRL NUMBER------------  0.0
     -----------------
                       CHANNEL HEIGHT OF COMBUSTOR-----  9.1440E-02  (M)
                       LENGTH OF COMBUSTOR-------------  7.3660E-02  (M)
                       ANGULAR SECTOR------------------  2.0940E-01  (RAD-M)
III. AIR INJECTIONS    INLET-1 FLOW AREA---------------  7.3628E-04  (SQ.M)
     --------------
       1.FILM COOLING AIR-
                 SLOT NO    I     J    K      U-VELOCITY    V-VELOCITY    W-VELOCITY    MASS FLOW     FUEL FLOW
                                                (M/S)         (M/S)         (M/S)        (KG/S)        (KG/S)
                    1      17     2  ***      4.572E+01     2.545E-73     0.0           3.629E-03
                    2      17    18  ***      4.572E+01     2.545E-73     0.0           3.629E-03
       2.DILUTION AND SECONDARY AIR-
                 SLOT NO    I     J    K      U-VELOCITY    V-VELOCITY    W-VELOCITY    MASS FLOW     FUEL FLOW
                                                (M/S)         (M/S)         (M/S)        (KG/S)        (KG/S)
                    1      10     1    7      2.545E-73     1.219E+02     2.545E-73     1.210E-03
                    2      11     1    7      2.545E-73     1.219E+02     2.545E-73     1.210E-03
                    3      12     1    7      2.545E-73     1.219E+02     2.545E-73     1.210E-03
                    4      10    19    7      2.545E-73    -1.219E+02     2.545E-73     1.210E-03
                    5      11    19    7      2.545E-73    -1.219E+02     2.545E-73     1.210E-03
                    6      12    19    7      2.545E-73    -1.219E+02     2.545E-73     1.210E-03
       3.FUEL NOZZLES-
          XO         YO        ZO       ALFA       BETA      DELTA    THETA1    THETA2      NSL       WF        SMD       VFUEL
          (M)        (M)     (M-R)     (RAD)      (RAD)      (RAD)    (RAD)     (RAD)       -       (KG/S)   (MICRON)    (M/S)
       1.27E-03  2.29E-02  1.05E-01  1.57E+00  -1.57E+00  0.0       0.0       6.28E+00  2.00E+01  4.84E-04  3.00E+01  3.05E+01
IV.  AIR-FUEL BALANCE
     ----------------
                       TOTAL FUEL FLOW RATE------------  4.8399E-04  (KG/S)
                       TOTAL AIR FLOW RATE-------------  2.4191E-02  (KG/S)
                       FUEL TO AIR RATIO---------------  2.0007E-02
```

Figure 18. 3-D Performance Model Output (Sheet 1 of 7).

```
V.   SOME IMPORTANT QUANTITIES
     ------------------------
                         SPECIFIC HEAT-------------------      1.1578E+03  (J/KG-K)
                         ACTIVATION ENERGY (1ST) --------      2.7000E+04  (K)
                         PRE-EXPONENT (1ST) -------------      3.3000E+14
                         EDDY BREAKUP CONSTANT (1ST) ----      3.0000E+00
                         ACTIVATION ENERGY (2ND) --------      1.2500E+04  (K)
                         PRE-EXPONENT (2ND) -------------      6.0000E+08
                         EDDY BREAKUP CONSTANT (2ND) ----      4.0000E+00
                         TURB. CONSTANT (C1) ------------      1.4300E+00
                         TURB. CONSTANT (C2) ------------      1.5200E+00
                         TURB. CONSTANT (CD) ------------      9.0000E-02
                         ABSORPTION COEFFICIENT----------      1.0000E-01
                         SCATTERING COEFFICIENT----------      1.0000E-02
                                                                            U-VELOCITY(M/SEC)
                                        K =  7

  I =  2         3         4         5         6         7         8         9         10        11        12        13
 J
 19  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 18  1.22E+02  4.47E+01  5.22E+01  5.37E+01  5.28E+01  4.99E+01  4.39E+01  3.06E+01 -1.72E+00  3.34E+00  4.58E+00  1.42E+01
 17  1.22E+02  6.07E+01  6.45E+01  6.33E+01  5.94E+01  5.33E+01  4.36E+01  2.83E+01  6.22E+00  7.74E+00  5.40E+00  6.86E+00
 16  0.0      -3.89E+00  9.93E+00  2.31E+01  3.10E+01  3.47E+01  3.32E+01  2.61E+01  9.30E+00  1.01E+01  6.25E+00  5.42E+00
 15  0.0      -1.07E+00 -1.92E+00  5.53E+00  1.43E+01  2.04E+01  2.37E+01  2.29E+01  8.97E+00  1.08E+01  6.85E+00  5.75E+00
 14  0.0       2.04E+00 -4.27E-01 -3.40E-01  5.76E+00  1.16E+01  1.62E+01  1.88E+01  9.15E+00  9.63E+00  6.94E+00  7.11E+00
 13  0.0       4.41E+00  2.55E+00  1.28E+00  1.11E+00  4.46E+00  9.49E+00  1.50E+01  4.51E+00  5.10E+00  6.13E+00  1.39E+01
 12  0.0       4.62E+00  2.84E+00  5.40E-02 -3.74E+00 -3.22E+00  8.51E-01 -1.27E+00 -1.47E+01 -5.64E+00  5.22E+00  2.03E+01
 11  0.0       2.97E+00 -1.33E+00 -1.30E+01 -2.16E+01 -3.09E+01 -4.18E+01 -5.26E+01 -5.37E+01 -2.92E+01  2.54E+00  4.20E+01
 10  0.0      -1.07E+01 -2.39E+01 -3.32E+01 -4.37E+01 -5.60E+01 -6.62E+01 -7.29E+01 -6.68E+01 -3.20E+01  6.48E+00  4.50E+01
  9  0.0       1.27E+00 -2.89E+00 -9.87E+00 -1.16E+01 -1.14E+01 -1.26E+01 -1.94E+01 -2.46E+01 -6.55E+00  6.29E+00  2.15E+01
  8  0.0       4.05E+00  2.00E+00 -8.54E-01 -3.19E+00 -4.21E-01  4.64E+00  1.36E+01  2.49E+00  5.20E+00  6.13E+00  9.63E+00
  7  0.0       4.64E+00  2.74E+00  1.51E+00  2.01E+00  6.69E+00  1.22E+01  1.67E+01  1.06E+01  1.01E+01  6.53E+00  4.30E+00
  6  0.0       3.16E+00  8.20E-01  1.56E+00  7.40E+00  1.37E+01  1.90E+01  2.14E+01  1.07E+01  1.18E+01  6.59E+00  2.32E+00
  5  0.0       6.39E-01 -7.13E-01  6.07E+00  1.64E+01  2.28E+01  2.62E+01  2.46E+01  1.04E+01  1.19E+01  6.12E+00  1.90E+00
  4  0.0      -2.16E+00  1.26E+01  2.54E+01  3.30E+01  3.58E+01  3.50E+01  2.67E+01  9.35E+00  1.07E+01  5.40E+00  2.26E+00
  3  1.22E+02  6.04E+01  6.40E+01  6.29E+01  5.95E+01  5.35E+01  4.41E+01  2.69E+01  6.20E+00  7.64E+00  4.80E+00  5.14E+00
  2  1.22E+02  4.62E+01  5.17E+01  5.32E+01  5.25E+01  4.99E+01  4.42E+01  3.01E+01 -7.44E+00  2.13E+00  4.87E+00  1.86E+01
  1  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0

  I =  14        15        16        17        18        19        20        21        22        23        24        25
 J
 19  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 18 -1.17E+01 -2.10E-01  5.29E-33  4.57E+01  3.38E+01  3.53E+01  3.54E+01  3.52E+01  3.48E+01  3.43E+01  3.39E+01  3.35E+01
 17 -1.34E+00  3.28E+00  2.76E+01  2.61E+01  1.79E+01  1.69E+01  1.71E+01  1.75E+01  1.81E+01  1.87E+01  1.93E+01  2.00E+01
 16  5.59E-01  4.21E+00  2.35E+01  2.82E+01  2.79E+01  2.76E+01  2.75E+01  2.74E+01  2.73E+01  2.71E+01  2.68E+01  2.66E+01
 15  1.04E+00  3.49E+00  1.83E+01  2.55E+01  2.83E+01  2.94E+01  2.99E+01  3.00E+01  3.00E+01  2.99E+01  2.97E+01  2.96E+01
 14  3.03E+00  2.10E+00  1.43E+01  2.22E+01  2.66E+01  2.89E+01  3.01E+01  3.06E+01  3.08E+01  3.09E+01  3.08E+01  3.07E+01
 13  9.50E+00  4.32E+00  1.28E+01  2.03E+01  2.52E+01  2.81E+01  2.98E+01  3.07E+01  3.12E+01  3.14E+01  3.14E+01  3.14E+01
 12  2.43E+01  1.91E+01  1.83E+01  2.19E+01  2.57E+01  2.86E+01  3.06E+01  3.15E+01  3.22E+01  3.25E+01  3.25E+01  3.25E+01
 11  5.38E+01  5.16E+01  4.56E+01  4.06E+01  3.76E+01  3.60E+01  3.53E+01  3.50E+01  3.48E+01  3.46E+01  3.44E+01  3.43E+01
 10  5.92E+01  6.01E+01  5.70E+01  5.34E+01  5.06E+01  4.80E+01  4.61E+01  4.44E+01  4.28E+01  4.15E+01  4.02E+01  3.92E+01
  9  2.44E+01  1.91E+01  1.80E+01  2.13E+01  2.48E+01  2.79E+01  3.03E+01  3.20E+01  3.31E+01  3.38E+01  3.42E+01  3.43E+01
  8  4.92E+00 -2.59E+00  7.07E+00  1.55E+01  2.08E+01  2.44E+01  2.67E+01  2.81E+01  2.90E+01  2.95E+01  2.98E+01  2.99E+01
  7 -1.77E+00 -2.59E+00  8.06E+00  1.62E+01  2.13E+01  2.44E+01  2.62E+01  2.72E+01  2.77E+01  2.80E+01  2.81E+01  2.82E+01
  6 -1.77E+00  2.45E-01  1.16E+01  1.92E+01  2.33E+01  2.54E+01  2.65E+01  2.70E+01  2.72E+01  2.73E+01  2.72E+01  2.72E+01
  5 -1.44E+00  2.39E+00  1.64E+01  2.30E+01  2.56E+01  2.62E+01  2.64E+01  2.65E+01  2.64E+01  2.63E+01  2.62E+01  2.60E+01
  4 -1.76E+00  3.07E+00  2.21E+01  2.59E+01  2.54E+01  2.48E+01  2.44E+01  2.42E+01  2.40E+01  2.38E+01  2.36E+01  2.35E+01
  3 -3.78E+00  1.88E+00  2.71E+01  2.41E+01  1.67E+01  1.55E+01  1.56E+01  1.60E+01  1.65E+01  1.72E+01  1.79E+01  1.86E+01
  2 -1.62E+01 -2.19E+00  4.53E-33  4.57E+01  3.65E+01  3.74E+01  3.72E+01  3.68E+01  3.62E+01  3.57E+01  3.52E+01  3.47E+01
  1  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
```

Figure 18. 3-D Performance Model Output (Sheet 2 of 7).

U-VELOCITY (M/SEC)

```
  I =  26          27          28          29          30
J
19   0.0         0.0         0.0         0.0         0.0
18   3.32E+01    3.28E+01    3.26E+01    3.25E+01    3.26E+01
17   2.07E+01    2.13E+01    2.20E+01    2.27E+01    2.28E+01
16   2.64E+01    2.63E+01    2.62E+01    2.61E+01    2.63E+01
15   2.94E+01    2.92E+01    2.91E+01    2.91E+01    2.92E+01
14   3.06E+01    3.05E+01    3.05E+01    3.06E+01    3.07E+01
13   3.14E+01    3.14E+01    3.15E+01    3.16E+01    3.17E+01
12   3.25E+01    3.26E+01    3.27E+01    3.29E+01    3.30E+01
11   3.42E+01    3.41E+01    3.42E+01    3.45E+01    3.46E+01
10   3.82E+01    3.75E+01    3.70E+01    3.69E+01    3.70E+01
 9   3.43E+01    3.43E+01    3.42E+01    3.44E+01    3.45E+01
 8   3.00E+01    3.01E+01    3.02E+01    3.04E+01    3.06E+01
 7   2.82E+01    2.83E+01    2.84E+01    2.86E+01    2.87E+01
 6   2.71E+01    2.72E+01    2.72E+01    2.73E+01    2.74E+01
 5   2.59E+01    2.58E+01    2.58E+01    2.58E+01    2.59E+01
 4   2.35E+01    2.35E+01    2.35E+01    2.35E+01    2.36E+01
 3   1.94E+01    2.01E+01    2.08E+01    2.15E+01    2.16E+01
 2   3.43E+01    3.39E+01    3.35E+01    3.34E+01    3.35E+01
 1   0.0         0.0         0.0         0.0         0.0
```

FUEL MASS FRACTION

```
                                                     K =  7

  I =  1          2           3           4           5           6           7           8           9           10          11          12
J
19   0.0        0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
18   0.0        1.37E-02    1.46E-02    1.47E-02    1.44E-02    1.42E-02    1.41E-02    1.39E-02    1.55E-02    8.44E-04    4.89E-04    1.98E-03
17   0.0        5.10E-02    4.35E-02    3.58E-02    2.89E-02    2.21E-02    1.61E-02    1.55E-02    1.20E-02    1.20E-03    5.25E-04    1.93E-03
16   0.0        2.06E-01    1.31E-01    7.50E-02    5.29E-02    3.88E-02    3.64E-02    2.74E-02    1.24E-02    1.65E-03    5.99E-04    1.87E-03
15   0.0        2.28E-01    1.84E-01    9.98E-02    5.89E-02    5.68E-02    5.24E-02    3.66E-02    1.47E-02    2.22E-03    7.08E-04    1.81E-03
14   0.0        2.40E-01    2.45E-01    1.76E-01    1.04E-01    8.31E-02    6.04E-02    4.36E-02    2.06E-02    3.06E-03    8.47E-04    1.76E-03
13   0.0        2.48E-01    3.03E-01    3.25E-01    2.14E-01    1.08E-01    6.72E-02    4.81E-02    2.66E-02    3.66E-03    9.57E-04    1.72E-03
12   0.0        2.62E-01    3.75E-01    3.78E-01    2.22E-01    1.03E-01    6.40E-02    4.44E-02    1.36E-02    3.50E-03    9.58E-04    1.69E-03
11   0.0        3.03E-01    4.66E-01    2.63E-01    1.29E-01    5.16E-02    2.34E-02    1.17E-02    4.60E-03    2.73E-03    9.59E-04    1.66E-03
10   0.0        2.69E-01    2.55E-01    1.53E-01    7.29E-02    2.97E-02    1.35E-02    8.27E-03    5.48E-03    4.80E-03    1.83E-03    9.69E-04
 9   0.0        3.26E-01    4.95E-01    2.99E-01    1.84E-01    1.13E-01    7.96E-02    4.98E-02    2.36E-02    7.60E-03    1.93E-03    8.91E-04
 8   0.0        2.92E-01    4.24E-01    4.20E-01    2.43E-01    1.39E-01    1.01E-01    7.91E-02    5.42E-02    8.12E-03    1.93E-03    8.36E-04
 7   0.0        2.79E-01    3.58E-01    3.86E-01    2.30E-01    1.39E-01    9.92E-02    7.67E-02    4.39E-02    7.31E-03    1.72E-03    7.86E-04
 6   0.0        2.72E-01    3.13E-01    2.44E-01    1.52E-01    1.18E-01    9.00E-02    6.94E-02    3.88E-02    4.84E-03    1.38E-03    7.41E-04
 5   0.0        2.66E-01    2.62E-01    1.49E-01    9.99E-02    8.95E-02    7.90E-02    5.94E-02    2.70E-02    2.96E-03    1.12E-03    6.98E-04
 4   0.0        [illegible].50E-01    1.96E-01    1.23E-01    8.83E-02    6.64E-02    5.86E-02    4.50E-02    1.77E-02    1.73E-03    9.84E-04    6.66E-04
 3   0.0        7.0[illegible]E-02    6.26E-02    5.41E-02    4.56E-02    3.70E-02    2.83E-02    2.37E-02    1.46E-02    1.00E-03    9.32E-04    6.51E-04
 2   0.0        1.82E-0[illegible]    2.02E-02    2.02E-02    1.99E-02    1.97E-02    1.96E-02    1.95E-02    1.74E-02    5.91E-04    8.70E-04    6.42E-04
 1   0.0        0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
```

Figure 18. 3-D Performance Model Output (Sheet 3 of 7).

```
  I =  13        14        15        16        17        18        19        20        21        22        23        24
J
19  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  7.80E-03  8.52E-03  1.54E-02  4.72E-38  8.37E-04  9.74E-04  1.01E-03  1.02E-03  1.03E-03  1.02E-03  1.01E-03  1.00E-03
17  6.86E-03  4.18E-03  1.21E-02  9.33E-03  6.28E-03  3.86E-03  2.42E-03  1.59E-03  1.10E-03  7.98E-04  6.07E-04  4.80E-04
16  6.30E-03  2.78E-03  7.75E-03  6.00E-03  4.34E-03  3.10E-03  2.24E-03  1.64E-03  1.22E-03  9.24E-04  7.09E-04  5.51E-04
15  5.84E-03  2.05E-03  4.99E-03  4.07E-03  3.15E-03  2.41E-03  1.84E-03  1.42E-03  1.11E-03  8.70E-04  6.90E-04  5.53E-04
14  5.40E-03  1.70E-03  3.23E-03  2.78E-03  2.27E-03  1.82E-03  1.46E-03  1.17E-03  9.45E-04  7.65E-04  6.23E-04  5.10E-04
13  4.86E-03  2.07E-03  2.10E-03  1.67E-03  1.60E-03  1.35E-03  1.12E-03  9.35E-04  7.77E-04  6.46E-04  5.39E-04  4.51E-04
12  4.08E-03  3.01E-03  1.86E-03  1.38E-03  1.14E-03  9.64E-04  8.24E-04  7.04E-04  6.01E-04  5.13E-04  4.38E-04  3.74E-04
11  2.98E-03  3.00E-03  2.68E-03  2.30E-03  1.44E-03  9.74E-04  7.17E-04  5.63E-04  4.62E-04  3.89E-04  3.33E-04  2.87E-04
10  1.99E-03  2.13E-03  2.06E-03  1.96E-03  1.75E-03  1.41E-03  8.37E-04  5.25E-04  3.51E-04  2.50E-04  1.89E-04  1.50E-04
 9  2.89E-03  2.10E-03  1.16E-03  7.55E-04  5.65E-04  4.49E-04  3.66E-04  3.07E-04  2.59E-04  2.19E-04  1.87E-04  1.61E-04
 8  3.69E-03  1.15E-03  1.39E-03  1.18E-03  9.88E-04  8.22E-04  6.83E-04  5.88E-04  5.25E-04  4.74E-04  4.27E-04  3.92E-04
 7  4.20F-03  1.35E-03  2.22E-03  1.85E-03  1.51E-03  1.22E-03  9.93E-04  9.17E-04  9.10E-04  8.68E-04  7.97E-04  7.14E-04
 6  4.62E-03  1.80E-03  3.29E-03  2.69E-03  2.12E-03  1.66E-03  1.32E-03  1.55E-03  1.81E-03  1.69E-03  1.46E-03  1.23E-03
 5  4.96E-03  2.48E-03  4.81F-03  3.79E-03  2.87E-03  2.15E-03  1.68E-03  3.76E-03  4.99E-03  3.48E-03  2.50E-03  1.83E-03
 4  5.25F-03  3.50E-03  7.14E-03  5.37E-03  3.82E-03  2.68E-03  1.89E-03  1.36E-03  9.99E-04  7.47E-04  5.68E-04  4.50E-04
 3  5.51E-03  5.16E-03  1.08E-02  8.11E-03  5.32E-03  3.23E-03  1.99E-03  1.28E-03  8.61E-04  6.11E-04  4.53E-04  3.50E-04
 2  5.40E-03  8.63E-03  1.68E-02  5.24E-38  4.87E-04  5.74E-04  6.02E-04  6.15E-04  6.20E-04  6.19E-04  6.16E-04  6.10E-04
 1  0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0

  I =  25        26        27        28        29        30
J
19  0.0       0.0       0.0       0.0       0.0       0.0
18  9.86E-04  9.69E-04  9.51E-04  9.31E-04  8.92E-04  0.0
17  3.93E-04  3.31E-04  2.87E-04  2.55E-04  2.12E-04  0.0
16  4.34E-04  3.46E-04  2.80E-04  2.30E-04  1.78E-04  0.0
15  4.47E-04  3.64E-04  2.98E-04  2.46E-04  1.89E-04  0.0
14  4.19E-04  3.47E-04  2.89E-04  2.42E-04  1.89E-04  0.0
13  3.78E-04  3.18E-04  2.69E-04  2.28E-04  1.82E-04  0.0
12  3.20E-04  2.75E-04  2.36E-04  2.04E-04  1.66E-04  0.0
11  2.49E-04  2.17E-04  1.89E-04  1.66E-04  1.38E-04  0.0
10  1.23E-04  1.04E-04  8.97E-05  7.85E-05  6.65E-05  0.0
 9  1.40E-04  1.23E-04  1.09F-04  9.81E-05  8.64E-05  0.0
 8  3.41E-04  3.05E-04  2.73E-04  2.47E-04  2.15E-04  0.0
 7  6.30F-04  5.51E-04  4.79E-04  4.16E-04  3.39E-04  0.0
 6  1.02E-03  8.37E-04  6.88E-04  5.65E-04  4.27E-04  0.0
 5  1.37E-03  1.03E-03  7.87E-04  6.05E-04  4.23E-04  0.0
 4  3.66E-04  3.04E-04  2.54E-04  2.14E-04  1.67E-04  0.0
 3  2.80E-04  2.32E-04  1.98E-04  1.72F-04  1.38E-04  0.0
 2  6.02E-04  5.92E-04  5.82E-04  5.70E-04  5.45E-04  0.0
 1  0.0       0.0       0.0       0.0       0.0       0.0
```

FUEL MASS FRACTION

Figure 18. 3-D Performance Model Output (Sheet 4 of 7).

TEMPERATURE °K

```
                                                   K =   7

  I =    1          2          3          4          5          6          7          8          9          10         11         12
J
19   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   5.89E+02   5.89E+02   5.89E+02
18   5.89E+02   8.74E+02   9.32E+02   9.48E+02   9.51E+02   9.54E+02   9.58E+02   9.62E+02   9.38E+02   5.89E+02   5.89E+02   5.88E+02
17   5.89E+02   1.48E+03   1.78E+03   1.97E+03   2.03E+03   2.08E+03   1.99E+03   1.77E+03   1.41E+03   6.15E+02   5.90E+02   5.88E+02
16   1.09E+03   1.81E+03   2.08E+03   2.00E+03   2.04E+03   2.22E+03   2.25E+03   2.12E+03   1.83E+03   6.77E+02   5.96E+02   5.88E+02
15   1.09E+03   1.70E+03   1.91E+03   2.23E+03   2.00E+03   2.00E+03   2.05E+03   2.27E+03   2.15E+03   7.54E+02   6.07E+02   5.89E+02
14   1.09E+03   1.63E+03   1.60E+03   1.93E+03   2.22E+03   2.08E+03   2.00E+03   2.16E+03   2.31E+03   8.41E+02   6.21E+02   5.91E+02
13   1.09E+03   1.57E+03   1.39E+03   1.33E+03   1.75E+03   2.20E+03   2.00E+03   2.09E+03   2.37E+03   8.89E+02   6.31E+02   5.93E+02
12   1.09E+03   1.49E+03   1.20E+03   1.19E+03   1.69E+03   2.22E+03   2.00E+03   2.14E+03   1.97E+03   8.75E+02   6.31E+02   5.94E+02
11   1.09E+03   1.37E+03   9.96E+02   1.45E+03   2.05E+03   2.09E+03   2.12E+03   1.74E+03   1.28E+03   8.03E+02   6.31E+02   5.96E+02
10   1.09E+03   1.46E+03   1.48E+03   1.91E+03   2.00E+03   2.16E+03   1.90E+03   1.53E+03   1.20E+03   8.39E+02   6.55E+02   6.04E+02
 9   1.09E+03   1.31E+03   1.07E+03   1.36E+03   1.84E+03   2.16E+03   2.02E+03   2.12E+03   1.89E+03   9.67E+02   6.58E+02   6.01E+02
 8   1.09E+03   1.40E+03   1.09E+03   1.08E+03   1.54E+03   2.07E+03   2.22E+03   2.02E+03   2.02E+03   9.90E+02   6.58E+02   5.98E+02
 7   1.09E+03   1.44E+03   1.24E+03   1.16E+03   1.62E+03   2.07E+03   2.21E+03   2.30E+03   2.08E+03   9.56E+02   6.46E+02   5.95E+02
 6   1.09E+03   1.46E+03   1.35E+03   1.53E+03   2.00E+03   2.14E+03   2.22E+03   2.30E+03   2.24E+03   8.57E+02   6.25E+02   5.92E+02
 5   1.09E+03   1.48E+03   1.49E+03   2.00E+03   2.13E+03   2.20E+03   2.01E+03   2.01E+03   2.11E+03   7.62E+02   6.08E+02   5.90E+02
 4   1.09E+03   1.56E+03   1.75E+03   2.01E+03   2.12E+03   2.00E+03   2.02E+03   2.13E+03   1.80E+03   6.77E+02   5.96E+02   5.89E+02
 3   5.99E+02   1.42E+03   1.69E+03   1.89E+03   2.00E+03   2.02E+03   1.95E+03   1.80E+03   1.34E+03   6.15E+02   5.90E+02   5.89E+02
 2   5.89E+02   8.65E+02   9.17E+02   9.29E+02   9.32E+02   9.34E+02   9.37E+02   9.40E+02   8.59E+02   5.89E+02   5.88E+02   5.89E+02
 1   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   5.89E+02   5.89E+02   5.89E+02

  I =    13         14         15         16         17         18         19         20         21         22         23         24
J
19   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03
18   7.59E+02   9.47E+02   9.98E+02   5.89E+02   6.75E+02   7.04E+02   7.21E+02   7.37E+02   7.52E+02   7.67E+02   7.82E+02   7.98E+02
17   7.52E+02   1.07E+03   1.04E+03   1.10E+03   1.17E+03   1.25E+03   1.30E+03   1.33E+03   1.34E+03   1.34E+03   1.34E+03   1.34E+03
16   7.46E+02   1.12E+03   1.13E+03   1.18E+03   1.24E+03   1.29E+03   1.34E+03   1.38E+03   1.42E+03   1.44E+03   1.46E+03   1.47E+03
15   7.37E+02   1.15E+03   1.21E+03   1.25E+03   1.29E+03   1.34E+03   1.38E+03   1.41E+03   1.45E+03   1.48E+03   1.50E+03   1.51E+03
14   7.23E+02   1.14E+03   1.26E+03   1.30E+03   1.34E+03   1.37E+03   1.41E+03   1.44E+03   1.47E+03   1.49E+03   1.51E+03   1.53E+03
13   7.04E+02   1.04E+03   1.28E+03   1.34E+03   1.37E+03   1.40E+03   1.43E+03   1.46E+03   1.48E+03   1.50E+03   1.52E+03   1.53E+03
12   6.78E+02   8.75E+02   1.11E+03   1.26E+03   1.34E+03   1.39E+03   1.42E+03   1.45E+03   1.47E+03   1.49E+03   1.51E+03   1.52E+03
11   6.41E+02   7.25E+02   8.37E+02   9.55E+02   1.08E+03   1.18E+03   1.26E+03   1.32E+03   1.37E+03   1.41E+03   1.44E+03   1.47E+03
10   6.56E+02   7.24E+02   7.96E+02   8.69E+02   9.41E+02   1.01E+03   1.08E+03   1.15E+03   1.21E+03   1.26E+03   1.30E+03   1.34E+03
 9   7.12E+02   9.10E+02   1.12E+03   1.27E+03   1.36E+03   1.41E+03   1.45E+03   1.48E+03   1.49E+03   1.50E+03   1.50E+03   1.51E+03
 8   7.54E+02   1.14E+03   1.39E+03   1.44E+03   1.48E+03   1.51E+03   1.54E+03   1.56E+03   1.58E+03   1.59E+03   1.60E+03   1.61E+03
 7   7.81E+02   1.18E+03   1.35E+03   1.40E+03   1.45E+03   1.49E+03   1.52E+03   1.55E+03   1.58E+03   1.60E+03   1.62E+03   1.64E+03
 6   7.74E+02   1.15E+03   1.30E+03   1.36E+03   1.41E+03   1.46E+03   1.51E+03   1.55E+03   1.59E+03   1.62E+03   1.55E+03   1.67E+03
 5   7.65E+02   1.13E+03   1.26E+03   1.32E+03   1.38E+03   1.44E+03   1.49E+03   1.54E+03   1.59E+03   1.63E+03   1.66E+03   1.68E+03
 4   7.57E+02   1.11E+03   1.21E+03   1.27E+03   1.36E+03   1.41E+03   1.47E+03   1.52E+03   1.55E+03   1.57E+03   1.56E+03   1.59E+03
 3   7.50E+02   1.04E+03   1.16E+03   1.21E+03   1.29E+03   1.38E+03   1.43E+03   1.45E+03   1.45E+03   1.44E+03   1.43E+03   1.42E+03
 2   7.47E+02   9.78E+02   1.10E+03   5.89E+02   6.61E+02   6.87E+02   7.05E+02   7.21E+02   7.38E+02   7.54E+02   7.71E+02   7.88E+02
 1   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03   1.09E+03
```

Figure 18. 3-D Performance Model Output (Sheet 5 of 7).

```
 I =  25        26        27        28        29        30
J
19  1.09E+03  1.09E+03  1.09E+03  1.09E+03  1.09E+03  1.09E+03
18  8.13E+02  9.27E+02  8.41E+02  8.55E+02  8.79E+02  1.32E+03
17  1.34E+03  1.33E+03  1.33E+03  1.32E+03  1.31E+03  1.32E+03
16  1.48E+03  1.48E+03  1.48E+03  1.48E+03  1.47E+03  1.32E+03
15  1.52E+03  1.53E+03  1.53E+03  1.54E+03  1.53E+03  1.32E+03
14  1.54E+03  1.55E+03  1.55E+03  1.56E+03  1.56E+03  1.32E+03
13  1.54E+03  1.55E+03  1.56E+03  1.56E+03  1.57E+03  1.32E+03
12  1.53E+03  1.54E+03  1.55E+03  1.56E+03  1.56E+03  1.32E+03
11  1.48E+03  1.50E+03  1.51E+03  1.52E+03  1.53E+03  1.32E+03
10  1.37E+03  1.40E+03  1.43E+03  1.45E+03  1.47E+03  1.32E+03
 9  1.52E+03  1.52E+03  1.53E+03  1.53E+03  1.55E+03  1.32E+03
 8  1.62E+03  1.63E+03  1.64E+03  1.65E+03  1.66E+03  1.32E+03
 7  1.66E+03  1.67E+03  1.68E+03  1.69E+03  1.70E+03  1.32E+03
 6  1.69E+03  1.70E+03  1.71E+03  1.72E+03  1.72E+03  1.32E+03
 5  1.69E+03  1.69E+03  1.70E+03  1.70E+03  1.69E+03  1.32E+03
 4  1.59E+03  1.59E+03  1.59E+03  1.59E+03  1.57E+03  1.32E+03
 3  1.41E+03  1.40E+03  1.39E+03  1.38E+03  1.37E+03  1.32E+03
 2  8.05E+02  8.21E+02  8.37E+02  8.53E+02  8.79E+02  1.32E+03
 1  1.09E+03  1.09E+03  1.09E+03  1.09E+03  1.09E+03  1.09E+03
```

TEMPERATURE °K

```
                                                        K =  7

 I =  1          2          3          4          5          6          7          8          9          10         11         12
J
19  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
18  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        4.36E-07   1.02E-06   5.77E-07   2.48E-05
17  0.0        0.0        0.0        0.0        0.0        0.0        0.0        6.50E-07   3.95E-07   0.0        0.0        0.0
16  0.0        0.0        0.0        0.0        0.0        0.0        1.11E-06   5.59E-07   0.0        0.0        0.0        0.0
15  0.0        0.0        0.0        0.0        0.0        1.09E-06   4.32E-07   0.0        0.0        0.0        0.0        0.0
14  0.0        0.0        0.0        0.0        1.16E-06   9.09E-07   0.0        0.0        0.0        0.0        0.0        0.0
13  0.0        0.0        0.0        5.23E-06   2.65E-06   0.0        0.0        0.0        0.0        0.0        1.53E-08   0.0
12  0.0        0.0        2.57E-06   7.29E-06   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
11  0.0        4.70E-06   1.78E-05   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
10  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 9  0.0        4.55E-06   1.86E-05   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 8  0.0        0.0        2.46E-06   7.14E-06   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 7  0.0        0.0        0.0        5.17E-06   8.75E-07   0.0        0.0        0.0        0.0        0.0        0.0        0.0
 6  0.0        0.0        0.0        0.0        1.69E-06   9.16E-07   0.0        0.0        0.0        0.0        0.0        0.0
 5  0.0        0.0        0.0        0.0        0.0        1.12E-06   8.69E-07   0.0        0.0        0.0        0.0        0.0
 4  0.0        0.0        0.0        0.0        0.0        0.0        1.11E-06   5.82E-07   0.0        0.0        0.0        0.0
 3  0.0        0.0        0.0        0.0        0.0        0.0        0.0        6.05E-07   3.21E-07   0.0        5.94E-08   0.0
 2  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        6.70E-07   7.33E-07   1.06E-06   7.66E-07
 1  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
```

EVAPORATION RATE (KG/SEC)

Figure 18. 3-D Performance Model Output (Sheet 6 of 7).

```
  I =  13         14         15         16         17         18         19         20         21         22         23         24
 J
19  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
18  8.35E-07   2.38E-07   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
17  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
16  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
15  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
14  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
13  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
12  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
11  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
10  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 9  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 8  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 7  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 6  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 5  0.0        0.0        0.0        0.0        0.0        0.0        0.0        2.97E-07   2.67E-07   0.0        0.0        0.0
 4  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 3  1.92E-07   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 2  4.56E-07   2.06E-07   1.76E-06   0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
 1  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0

  I =  25         26         27         28         29         30
 J
19  0.0        0.0        0.0        0.0        0.0        0.0
18  0.0        0.0        0.0        0.0        0.0        0.0
17  0.0        0.0        0.0        0.0        0.0        0.0
16  0.0        0.0        0.0        0.0        0.0        0.0
15  0.0        0.0        0.0        0.0        0.0        0.0
14  0.0        0.0        0.0        0.0        0.0        0.0
13  0.0        0.0        0.0        0.0        0.0        0.0
12  0.0        0.0        0.0        0.0        0.0        0.0
11  0.0        0.0        0.0        0.0        0.0        0.0
10  0.0        0.0        0.0        0.0        0.0        0.0
 9  0.0        0.0        0.0        0.0        0.0        0.0
 8  0.0        0.0        0.0        0.0        0.0        0.0
 7  0.0        0.0        0.0        0.0        0.0        0.0
 6  0.0        0.0        0.0        0.0        0.0        0.0
 5  0.0        0.0        0.0        0.0        0.0        0.0
 4  0.0        0.0        0.0        0.0        0.0        0.0
 3  0.0        0.0        0.0        0.0        0.0        0.0
 2  0.0        0.0        0.0        0.0        0.0        0.0
 1  0.0        0.0        0.0        0.0        0.0        0.0
```

EVAPORATION RATE (KG/SEC)

Figure 18. 3-D Performance Model Output (Sheet 7 of 7).

by I = 15 with a few larger droplets persisting at I = 20, where they entered from neighboring K-planes.

LINER-COOLING MODEL.

The liner-cooling model was used to predict the wall temperatures downstream of the cooling slots in the combustor shown in Figure 15. Starting with the profiles at the exit of the slot, as predicted by the 3-D performance model, the program marched up to the beginning of the transition liner. At each marching step, the program performed a heat-flux balance at the wall and, thereby, obtained the wall temperature.

The input units, required by the liner-cooling model, are S.I., and since these are the output units of the 3-D performance model, data is easily transferred. Profiles for U-velocity, temperature, turbulent kinetic energy, turbulence length scale, fuel-mass fraction, total fuel, and CO are required along with information about the flow conditions in the inner and outer annuli. Since nearly all the liquid fuel has evaporated at the point where the marching process begins, no input for the droplet evaporation is needed.

The input data sheets (Figure 19, 3 sheets) begin with two cards devoted to case identification (additonal input information can be found in the input sheet forms located in Appendix A). Next, 40 cross stream grid cells are specified. It was unlikely that this would be sufficient to obtain a grid-independent solution; however, since this was merely an example case, the maximum dimension allowed in the existing deck was selected. Axisymmetric geometry, solve species equations, two-equation turbulence model, reacting species, wall temperature, and enthalpy calculation completed the specifications on Card 2. Card 3 indicates that the various profiles will be printed every 20 marching steps. On Card 4 one sees that the marching process will start at

CASE TITLE (12A6)

1	LINER C	OOLING	MODEL	EXAMPLE	CASE			

CASE TITLE (12A6)

	KPLANE	= 7						

(8(I2, 8X))

	N	KRAD	MASSTR	ISWRL	MODEL	INERT	IFLUX	ITEMP
2	40	01	01	00	02	02	01	01

(5(I5,5X))

	NSTAT	NPROF	NPLOT	ITEST	LASTEP			
3	99999	00020	99999		99999			

(8E10.4)

	XU	XULAST	FRA	XEND	XOUT	PRESS	POWER	
4	.03937	.073	.02	10.	10.	101325	2.0	

(I2)

	NBP							
5	02							

(8E10.4)

	X_1	RI_1	RE_1	X_2	RI_2	RE_2	X_3	RI_3
6	0.	.254	.29972	10.	.254	.29972		

(8E10.4)

	RE_3	X_4	RI_4	RE_4	X_5	RI_5	RE_5...	

(8E10.4)

	RA	RB	RD					
7	0.	.254	.29972					

Figure 19. Liner Cooling Model Input Sheet (1 of 3)

NAME LIST

8	$INPUT	KREAD	=1, PRE	XP1=3.3	E+14,	ARCON1=	27000,	$

CRI=3.0, CX=10, MY=19.28

	UA	UD					(8E10.4)	
9	0.	0.						

	F2A	F2D	TA	TD	T_{wall}		(8E10.4)	
10	0.	0.	589.	589.	589.			

	NIN						(I2)	
11	19							

	Y VALUES						(8E10.4)	
12								

	U VALUES						(8E10.4)	
13								

							(8E10.4)	
14								

	TEMPERATURE VALUES						(8E10.4)	
15								

	MFU VALUES						(8E10.4)	
16								

	PHI VALUES						(8E10.4)	
17								

Figure 19. Liner Cooling Model Input Sheet (2 of 3)

MCO VALUES (8E10.4)

18								

TURBULENT KINETIC ENERGY (8E10.4)

19								

TURBULENCE LENGTH SCALE (8E10.4)

20								

(8E10.4)

	VELA$_I$	VELA$_O$	TAN$_I$	TAN $_O$	PR$_I$	PR$_O$		
21	24.7	58.8	589.	589.	.2413	.3124		

(I2, 8X, 7E10.4)

	NFNZ	XDP	YDP	UF	VF	SMD	WF	TFUEL
22	00							

Figure 19. Liner Cooling Model Input Sheet (3 of 3)

0.03937 meter and proceed to 0.073 meter, using a step size of 0.02 times the grid height. In order to obtain the best estimation of the radiation flux, it is necessary to analyze the entire channel height, which means the inner and outer boundaries are walls. XEND and XOUT are, therefore, set to some large number. The variable POWER is used to distort the grid, since more nodes are required near the wall whose temperature is being predicted. This means, of course, that two runs must be made, one with the grid nodes concentrated near the outer wall (POWER <-1.0), and one with the nodes concentrated near the inner wall (POWER >1.0). If POWER equals 1.0 or -1.0, the resulting grid would be uniform in y.

Two straight walls require only two boundary point specifications, handled by Cards 5 and 6. The three radii specified on Card 7 are also easily understood. The name list is read next with the variables specified explained in the name list input sheet. The values on Cards 9 and 10 pertain to the free boundaries, which are not used on this program; however, entries are made for completeness. Cards 11 through 20 specify the initial profiles. The 19 points used correspond to the 19 radial nodes used by the 3-D performance model and are listed in Table 1. For this example the 3-D output was strictly used; however, it is usually the practice to combine the 3-D profiles with some additional information, if available, describing the profiles inside the slot lip. Card 21 lists data concerning the annulus flow conditions and dimensions while Card 22 is blank due to the absence of liquid fuel.

The output from the program is shown in Figure 20 (3 sheets). Sheet 1 begins with the titles, some control indices, and the values of omega for the transformed cross-stream variable. Information about the annuli is printed next along with the initial profiles. The printing of the variable arrays starts with the value at the inner boundary and continues outward.

TABLE 1. INITIAL PROFILES FOR LINER COOLING EXAMPLE.

Node	Y	U	KE	lm	ϕ	MFU	MCO	TEMP
19	0.04572	45.7	6.27	7.62E-5	0	0	0	589
18	0.04318	45.7	6.27	7.62E-5	0	0	0	589
17	0.04064	26.1	13.5	2.86E-4	0.0273	7.8E-3	0.0190	1135
16	0.03810	28.2	51.9	3.68E-4	0.0270	5.17E-3	0.0205	1210
15	0.03556	25.5	65.7	4.22E-4	0.0270	3.61E-3	0.0198	1270
14	0.03302	22.2	71.7	4.76E-4	0.0269	2.53E-3	0.0182	1320
13	0.03048	20.3	73.3	4.81E-4	0.0265	1.73E-3	0.0158	1355
12	0.02794	21.8	77.5	4.66E-4	0.0239	1.26E-3	0.0141	1300
11	0.02540	40.6	126	3.11E-4	0.0154	1.87E-3	0.00976	1018
10	0.02286	53.4	277	2.74E-4	0.0117	1.86E-3	0.00713	905
9	0.02032	21.0	123	4.72E-4	0.0233	6.6E-4	0.0120	1315
8	0.01778	15.3	83.3	5.17E-4	0.0283	1.08E-3	0.0129	1460
7	0.01524	16.2	76.8	4.87E-4	0.0288	1.68E-3	0.0166	1425
6	0.01270	19.2	71.5	4.52E-4	0.0291	2.41E-3	0.0195	1385
5	0.01016	23.0	65.5	4.15E-4	0.0294	3.33E-3	0.0215	1350
4	0.00762	25.9	52.3	3.62E-4	0.0298	4.60E-3	0.0228	1305
3	0.00508	24.1	12.9	2.87E-4	0.0302	6.72E-3	0.0227	1250
2	0.00254	45.7	6.27	7.62E-5	0	0	0	589
1	0.0000	45.7	6.27	7.62E-5	0	0	0	589

U-Values are for K = 7, I = 17 and the avg. of I = 16 and 17.   Other Values are for K = 7

```
XYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY
XYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY


LINER COOLING MODEL EXAMPLE CASE
NPLANE=7  I.D. WALL
MODER=  2 ICPDX=  1 MODEL=  2 MASSTR=  1 INEPT=  2 NRAD=  1 IFLUX=  1
 UA          UD          TA          TD          PA          RB          RD          XEND        XOUT        XJLAST
 0.          0.          5.890E+02   5.890E+02   0.          2.540E-01   2.997E-01   1.000E+01   1.000E+01   7.330E-02
 PRESS       PREXP1      ARCON1      CP1         VTA         VTO
 1.013E+05   3.300E+14   2.700E+04   3.000E+00-0.            -0.

OMEGA        0.          0.          1.486E-03   5.944E-03   1.338E-02   2.379E-02   3.719E-02   5.359E-02   7.300E-02   9.542E-02   1.209E-01
             1.469E-01   1.692E-01   1.866E-01   1.998E-01   2.107E-01   2.217E-01   2.336E-01   2.462E-01   2.590E-01   2.717E-01   2.842E-01
             2.961E-01   3.076E-01   3.186E-01   3.292E-01   3.450E-01   3.575E-01   3.772E-01   4.126E-01   4.739E-01   5.241E-01   5.604E-01
             5.845E-01   6.062E-01   6.293E-01   6.562E-01   6.880E-01   7.249E-01   7.688E-01   8.620E-01   1.000E+00   1.000E+00

  BOUNDRY         VELA         TAN        PRAD
  ********     ********     ********     ********
     I        2.470E+01    5.890E+02    2.413E-01
     E        5.200E+01    5.890E+02    3.124E-01

ISTEP=     3 IAX=10000 IEND=10000 IOUT=10000 KIN=  1 KEX=  1 DX=  1.372E-05 PSII=  0.          PSIE=  1.332E-01
RMI=  0.           RME=  0.           PEI=  1.332E-01 PRESSD=  0.          AFXD=  0.
XU=  3.937E-02 UFLUX=  4.660E+00 FLUX(J)= -3.181E+03   2.741E-04   3.355E-03   1.327E-03   2.534E-02   2.145E-03   0.          0.
                                          0.          0.          0.          0.          0.          8.110E+03   2.455E+04   1.998E-03
KIN= 1 TAUID=  2.649E-01 AJID(J)=  8.906E-03  0.          0.          0.          0.          0.          0.          0.
                                   0.          0.          0.          0.          0.          0.         -2.929E-02   0.
KEX= 1 TAUED=  1.543E-02 AJED(J)= -6.163E-04  0.          0.          0.          0.          0.          0.          0.
                                   0.          0.          0.          0.          0.          0.          1.390E-03   0.

R1,Y'S       2.540E-01   0.          2.858E-05   1.143E-04   2.572E-04   4.572E-04   7.144E-04   1.029E-03   1.400E-03   1.829E-03   2.315E-03
             2.857E-03   3.458E-03   4.115E-03   4.829E-03   5.601E-03   6.429E-03   7.315E-03   8.258E-03   9.258E-03   1.032E-02   1.143E-02
             1.260E-02   1.383E-02   1.512E-02   1.646E-02   1.786E-02   1.932E-02   2.083E-02   2.240E-02   2.403E-02   2.572E-02   2.746E-02
             2.926E-02   3.112E-02   3.303E-02   3.500E-02   3.703E-02   3.912E-02   4.126E-02   4.346E-02   4.572E-02   4.572E-02

U            0.          4.570E+01   4.570E+01   4.570E+01   4.570E+01   4.570E+01   4.570E+01   4.570E+01   4.570E+01   4.570E+01   4.570E+01
             4.300E+01   3.790E+01   3.231E+01   2.623E+01   2.447E+01   2.506E+01   2.569E+01   2.517E+01   2.403E+01   2.277E+01   2.110E+01
             1.935E+01   1.786E+01   1.635E+01   1.577E+01   1.548E+01   1.875E+01   2.752E+01   4.757E+01   4.750E+01   3.825E+01   2.535E+01
             2.102E+01   2.078E+01   2.222E+01   2.478E+01   2.707E+01   2.735E+01   3.090E+01   4.570E+01   4.570E+01   0.

FUEL         0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
             6.400E-04   2.428E-03   4.166E-03   6.056E-03   6.285E-03   5.594E-03   4.854E-03   4.291E-03   3.791E-03   3.274E-03   2.870E-03
             2.446E-03   2.085E-03   1.716E-03   1.392E-03   1.067E-03   8.759E-04   9.015E-04   1.644E-03   1.965E-03   1.794E-03   1.375E-03
             1.504E-03   1.931E-03   2.535E-03   3.374E-03   4.515E-03   6.225E-03   5.889E-03   0.          0.          0.

CO           0.          0.          0.          0.          0.          0.          0.          0.          0.          0.          0.
             2.838E-03   8.200E-03   1.407E-02   2.046E-02   2.272E-02   2.275E-02   2.279E-02   2.247E-02   2.195E-02   2.138E-02   2.056E-02
             1.958E-02   1.821E-02   1.674E-02   1.482E-02   1.287E-02   1.236E-02   1.102E-02   8.007E-03   8.343E-03   1.030E-02   1.328E-02
             1.498E-02   1.640E-02   1.821E-02   1.945E-02   2.021E-02   1.990E-02   1.434E-02   0.          0.          0.

OXYGEN       2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01   2.320E-01
             2.228E-01   2.053E-01   1.861E-01   1.653E-01   1.568E-01   1.550E-01   1.530E-01   1.514E-01   1.500E-01   1.485E-01   1.471E-01
             1.456E-01   1.442E-01   1.426E-01   1.413E-01   1.406E-01   1.499E-01   1.651E-01   1.920E-01   1.944E-01   1.641E-01   1.632E-01
             1.538E-01   1.512E-01   1.532E-01   1.565E-01   1.607E-01   1.659E-01   1.853E-01   2.320E-01   2.320E-01   2.320E-01

KE           0.          6.270E+00   6.270E+00   6.270E+00   6.270E+00   6.270E+00   6.270E+00   6.270E+00   6.270E+00   6.270E+00   6.270E+00
             7.099E+00   8.665E+00   1.038E+01   1.225E+01   2.098E+01   3.383E+01   4.757E+01   5.562E+01   6.051E+01   6.587E+01   6.850E+01
             7.127E+01   7.386E+01   7.654E+01   7.992E+01   9.454E+01   1.073E+02   1.540E+02   2.493E+02   2.074E+02   1.199E+02   8.665E+01
             7.532E+01   7.290E+01   7.167E+01   6.701E+01   5.770E+01   3.649E+01   1.173E+01   6.270E+00   6.270E+00   0.

LEN          0.          7.620E-05   7.620E-05   7.620E-05   7.620E-05   7.620E-05   7.620E-05   7.620E-05   7.620E-05   7.620E-05   7.620E-05
             1.026E-04   1.524E-04   2.065E-04   2.662E-04   3.074E-04   3.269E-04   3.530E-04   3.753E-04   3.962E-04   4.173E-04   4.335E-04
             4.596E-04   4.676E-04   4.853E-04   5.014E-04   5.156E-04   4.898E-04   4.322E-04   3.096E-04   2.911E-04   3.304E-04   4.367E-04
             4.738E-04   4.797E-04   4.757E-04   4.338E-04   3.907E-04   3.351E-04   2.346E-04   7.620E-05   7.620E-05   0.
```

Figure 20. Liner Cooling Model Output (Sheet 1 of 3).

```
PHI      0.         0.         0.         0.         0.         0.         0.         0.         0.         0.         0.
         3.775E-03  1.091E-02  1.872E-02  2.722E-02  3.012E-02  2.999E-02  2.985E-02  2.970E-02  2.954E-02  2.938E-02  2.925E-02
         2.911E-02  2.897E-02  2.881E-02  2.856E-02  2.914E-02  2.577E-02  2.097E-02  1.379E-02  1.341E-02  1.646E-02  2.230E-02
         2.525E-02  2.660E-02  2.590E-02  2.698E-02  2.700E-02  2.712E-02  2.061E-02  0.         0.         0.

TEMP     5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02  5.890E+02
         6.716E+02  8.279E+02  9.988E+02  1.155E+03  1.261E+03  1.279E+03  1.298E+03  1.316E+03  1.334E+03  1.352E+03  1.367E+03
         1.384E+03  1.403E+03  1.423E+03  1.442E+03  1.455E+03  1.372E+03  1.232E+03  9.788E+02  9.571E+02  1.053E+03  1.247E+03
         1.329E+03  1.346E+03  1.320E+03  1.281E+03  1.235E+03  1.180E+03  1.001E+03  5.890E+02  5.890E+02  5.890E+02

RAD      6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03  6.824E+03
         1.154E+04  2.662E+04  5.643E+04  1.117E+05  1.435E+05  1.519E+05  1.611E+05  1.702E+05  1.796E+05  1.695E+05  1.983E+05
         2.078E+05  2.196E+05  2.325E+05  2.450E+05  2.544E+05  2.011E+05  1.308E+05  5.204E+04  4.758E+04  6.976E+04  1.370E+05
         1.767E+05  1.862E+05  1.720E+05  1.526E+05  1.320E+05  1.099E+05  5.698E+04  6.824E+03  6.824E+03  6.824E+03

AMU(I)   3.063E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05  5.958E-05
         7.342E-05  9.615E-05  1.183E-04  1.398E-04  2.041E-04  2.968E-04  3.989E-04  4.680E-04  5.714E-04  5.754E-04  6.099E-04
         6.454E-04  6.804E-04  7.156E-04  7.533E-04  7.988E-04  9.635E-04  1.168E-03  1.415E-03  1.212E-03  9.912E-04  8.162E-04
         7.572E-04  7.394E-04  7.437E-04  6.611E-04  5.536E-04  3.819E-04  1.448E-04  5.958E-05  5.958E-05  3.063E-05


TEMP     9.051E+02  6.616E+02  7.593E+02  5.552E+02  4.944E+02  5.912E+02  5.692E+02  5.890E+02  5.893E+02  5.894E+02  6.002E+02
         6.881E+02  8.453E+02  1.039E+03  1.322E+03  1.493E+03  1.559E+03  1.569E+03  1.577E+03  1.593E+03  1.580E+03  1.591E+03
         1.592E+03  1.589E+03  1.575E+03  1.541E+03  1.481E+03  1.388E+03  1.256E+03  1.068E+03  1.009E+03  1.099E+03  1.288E+03
         1.418E+03  1.484E+03  1.496E+03  1.462E+03  1.444E+03  1.345E+03  1.017E+03  5.954E+02  5.273E+02  9.539E+02

RAD      6.824E+03  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05
         1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05
         1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05
         1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  1.595E+05  6.824E+03

AMU(I)   4.029E-05  4.228E-05  4.601E-05  4.218E-05  3.719E-05  4.389E-05  5.549E-05  5.766E-05  5.492E-05  5.604E-05  5.960E-05
         7.876E-05  1.146E-04  1.449E-04  1.429E-04  1.688E-04  2.261E-04  2.644E-04  3.413E-04  3.325E-04  4.331E-04  4.794E-04
         5.196E-04  5.655E-04  6.276E-04  7.160E-04  3.239E-04  3.347E-04  1.178E-03  1.709E-03  1.095E-03  9.554E-04  8.249E-04
         6.916E-04  6.238E-04  5.847E-04  5.146E-04  4.193E-04  2.863E-04  1.626E-04  5.998E-05  2.373E-04  4.135E-05
```

Figure 20. Liner Cooling Model Output (Sheet 2 of 3).

```
ISTEP=   80 IAX=10000 IEND=10000 IOUT=10000 KIN= 1 KEX= 1 DX=  9.138E-04 PSII=  0.          PSIE=  1.332E-01
RMI=  0.          RME=  0.          PEI=  1.332E-01 PRESSD= -2.088E-04 AEXD= -6.909E-04
XU=  7.068E-02 UFLUX=  4.877E+00 FLUX(J)= -2.402E+03  9.087E-05  5.380E-03  4.109E-04  2.418E-02  7.376E-03  0.         0.
                                          0.         0.         0.         0.         0.         2.934E+00  3.125E+03  1.998E-03
KIN= 1 TAUID=  1.146E-02 AJID(J)= -1.119E-02  0.         0.         0.         0.         0.         0.         0.
                                  0.          0.         0.         0.         0.         0.        -5.557E-01  0.
KEX= 1 TAUED=  9.954E-03 AJED(J)=  9.575E-03  0.         0.         0.         0.         0.         0.         0.
                                  0.          0.         0.         0.         0.         0.         7.202E-04  0.

P1.Y*S     2.540E-01  5.447E-05  1.741E-04  3.965E-04  6.430E-04  8.990E-04  1.157E-03  1.468E-03  1.834E-03  2.256E-03  2.750E-03
           3.323E-03  3.959E-03  4.642E-03  5.357E-03  6.111E-03  6.959E-03  7.939E-03  8.987E-03  1.007E-02  1.119E-02  1.231E-02
           1.341E-02  1.447E-02  1.545E-02  1.632E-02  1.712E-02  1.795E-02  1.905E-02  2.084E-02  2.297E-02  2.496E-02  2.654E-02
           2.806E-02  2.955E-02  3.127E-02  3.327E-02  3.550E-02  3.784E-02  4.006E-02  4.228E-02  4.487E-02  4.569E-02

U          0.         5.792E+00  1.854E+01  2.718E+01  3.617E+01  4.366E+01  4.603E+01  4.644E+01  4.649E+01  4.641E+01  4.579E+01
           4.295E+01  3.971E+01  3.468E+01  3.142E+01  2.952E+01  2.875E+01  2.836E+01  2.784E+01  2.708E+01  2.611E+01  2.511E+01
           2.437E+01  2.423E+01  2.498E+01  2.651E+01  2.853E+01  3.107E+01  3.487E+01  4.035E+01  4.321E+01  3.880E+01  3.305E+01
           2.917E+01  2.700E+01  2.674E+01  2.792E+01  2.950E+01  3.057E+01  3.329E+01  4.604E+01  4.279E+01  0.

FUEL       5.830E-10  5.242E-10  6.418E-10  1.094E-09  3.056E-09  1.544E-08  1.017E-07  7.031E-07  5.143E-06  3.677E-05  2.671E-04
           1.157E-03  2.121E-03  1.972E-03  7.433E-04  3.571E-04  2.701E-04  1.580E-04  1.224E-04  9.790E-05  7.666E-05  6.310E-05
           5.069E-05  4.217E-05  4.024E-05  4.833E-05  6.971E-05  1.152E-04  2.390E-04  8.015E-04  1.237E-03  7.746E-04  2.534E-04
           1.101E-04  7.157E-05  7.828E-05  1.092E-04  1.854E-04  5.583E-04  4.773E-03  1.855E-04  5.216E-06  9.585E-05

CO         1.963E-09  1.762E-09  2.164E-09  3.696E-09  1.033E-08  5.220E-08  3.440E-07  2.380E-06  1.743E-05  1.316E-04  9.145E-04
           4.046E-03  7.949E-03  9.076E-03  5.015E-03  2.659E-03  1.697E-03  1.237E-03  9.710E-04  7.815E-04  6.303E-04  5.098E-04
           4.264E-04  4.007E-04  4.733E-04  6.936E-04  1.120E-03  1.945E-03  3.529E-03  6.212E-03  7.399E-03  6.720E-03  3.693E-03
           1.556E-03  8.903E-04  8.402E-04  1.143E-03  1.856E-03  3.687E-03  1.192E-02  4.593E-04  1.534E-05  2.373E-04

OXYGEN     2.320E-02  2.320E-01  2.320E-01  2.320E-01  2.320E-01  2.320E-01  2.320E-01  2.320E-01  2.319E-01  2.316E-01  2.290E-01
           2.180E-01  2.002E-01  1.777E-01  1.516E-01  1.350E-01  1.283E-01  1.261E-01  1.255E-01  1.254E-01  1.261E-01  1.270E-01
           1.287E-01  1.317E-01  1.361E-01  1.414E-01  1.469E-01  1.532E-01  1.618E-01  1.755E-01  1.919E-01  1.737E-01  1.600E-01
           1.496E-01  1.418E-01  1.372E-01  1.356E-01  1.361E-01  1.415E-01  1.619E-01  2.303E-01  2.319E-01  2.311E-01

KE         0.         1.435E+01  4.064E+01  3.529E+01  1.531E+01  3.726E+00  2.076E+00  2.021E+00  2.043E+00  2.086E+00  2.460E+00
           4.627E+00  8.419E+00  1.011E+01  9.900E+00  1.046E+01  1.249E+01  1.506E+01  1.743E+01  1.934E+01  2.079E+01  2.154E+01
           2.346E+01  2.677E+01  3.313E+01  4.186E+01  5.088E+01  5.937E+01  6.641E+01  6.266E+01  5.291E+01  5.221E+01  4.625E+01
           3.592E+01  2.749E+01  2.369E+01  2.229E+01  1.924E+01  1.390E+01  8.318E+00  2.437E+00  3.993E+00  0.

LEN        0.         1.551E-05  7.285E-05  9.132E-05  7.673E-05  5.650E-05  8.362E-05  1.182E-04  1.250E-04  1.265E-04  1.367E-04
           1.848E-04  2.549E-04  3.135E-04  3.730E-04  4.472E-04  5.197E-04  5.737E-04  6.192E-04  6.671E-04  7.045E-04  7.483E-04
           7.884E-04  8.021E-04  7.802E-04  7.489E-04  7.230E-04  6.992E-04  6.676E-04  6.113E-04  5.799E-04  6.013E-04  6.562E-04
           7.099E-04  7.593E-04  7.594E-04  7.062E-04  6.294E-04  5.259E-04  3.653E-04  1.375E-04  5.919E-04  0.

PHI        2.623E-09  2.358E-09  2.397E-09  4.924E-09  1.375E-08  6.951E-08  4.582E-07  3.171E-06  2.326E-05  1.762E-04  1.231E-03
           5.565E-03  1.197E-02  1.320E-02  2.352E-02  2.715E-02  2.884E-02  2.945E-02  2.955E-02  2.947E-02  2.930E-02  2.902E-02
           2.852E-02  2.768E-02  2.648E-02  2.506E-02  2.364E-02  2.208E-02  2.008E-02  1.727E-02  1.610E-02  1.781E-02  2.061E-02
           2.302E-02  2.501E-02  2.627E-02  2.680E-02  2.693E-02  2.599E-02  2.014E-02  7.075E-04  2.314E-05  3.653E-04

TEMP       3.580E+02  9.278E+02  8.172E+02  7.431E+02  6.696E+02  6.105E+02  5.925E+02  5.895E+02  5.896E+02  5.930E+02  6.171E+02
           7.181E+02  8.861E+02  1.107E+03  1.373E+03  1.525E+03  1.592E+03  1.618E+03  1.574E+03  1.574E+03  1.620E+03  1.613E+03
           1.598E+03  1.571E+03  1.532E+03  1.485E+03  1.433E+03  1.374E+03  1.289E+03  1.150E+03  1.084E+03  1.168E+03  1.307E+03
           1.410E+03  1.481E+03  1.522E+03  1.555E+03  1.527E+03  1.471E+03  1.048E+03  6.061E+02  5.266E+02  9.830E+02

RAD        6.824E+03  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05
           1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05
           1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05
           1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  1.682E+05  6.824E+03

AMU(I)     4.145E-05  4.374E-05  1.010E-04  1.332E-04  8.007E-05  4.258E-05  4.450E-05  5.419E-05  5.664E-05  5.740E-05  6.366E-05
           9.836E-05  1.530E-04  1.639E-04  1.528E-04  1.706E-04  2.128E-04  2.636E-04  3.162E-04  3.581E-04  4.190E-04  4.722E-04
           5.344E-04  6.092E-04  6.985E-04  8.040E-04  9.127E-04  1.071E-03  1.125E-03  1.133E-03  1.035E-03  9.729E-04  8.631E-04
           7.327E-04  6.280E-04  5.524E-04  4.751E-04  3.750E-04  2.548E-04  1.906E-04  6.431E-05  2.790E-04  4.199E-05

ISTEP=   83 IAX=10000 IEND=10000 IOUT=10000 KIN= 1 KEX= 1 DX=  0.          PSII=  0.          PSIE=  1.332E-01
RMI=  0.          RME=  0.          PEI=  1.332E-01 PRESSD= -2.117E-04 AEXD= -7.709E-04
XU=  7.300E-02 UFLUX=  4.875E+00 FLUX(J)= -2.340E+03  9.758E-05  5.419E-03  3.925E-04  2.416E-02  2.390E-03  0.         0.
                                          0.         0.         0.         0.         0.         2.885E+00  2.926E+03  1.998E-03
KIN= 1 TAUID=  1.146E-02 AJID(J)= -1.114E-02  0.         0.         0.         0.         0.         0.         0.
                                  0.          0.         0.         0.         0.         0.        -7.243E-01  0.
KEX= 1 TAUED=  9.654E-03 AJED(J)=  9.610E-03  0.         0.         0.         0.         0.         0.
                                  0.          0.         0.         0.
```

Figure 20. Liner Cooling Model Output (Sheet 3 of 3).

Since y is always referenced from the inner boundary, y(1) is always zero, so the radius of the inner boundary is printed in its place. It can also be seen that the y values are more closely spaced near the inner boundary, since this was the wall temperature that was calculated during this run. Sheets 2 and 3 of Figure 20 show a printout after 80 marching steps as indicated by ISTEP. The program has traversed to an X-location (XU) of 0.0706 meter, which is very near the end of the combustor. At this position the inner-wall temperature is 958°K. The other profiles are also printed with KE being the turbulent kinetic energy, LEN the turbulence length scale, PHI the total fuel, RAD the radiation-composite flux, and AMU(I) the effective viscosity. It should be noted that the boundary values of the radiation-composite flux are never used and are therefore left at their initial values.

TRANSITION MIXING MODEL

The 3-D performance model was used to predict the flow field up to the end of the combustor liner (Figure 15), but it is not capable of handling the geometric configuration of the transition liner. For that, the transition-mixing model (TMM) is used. Using initial profiles as predicted by the 3-D program, the TMM marches through the transition liner, thereby predicting the temperature distribution at what would be the turbine-stator inlet.

An enlarged drawing of the transition liner is shown in Figure 21. The inlet and exit planes are marked along with several intermediate ones. The location of these is a matter of user choice, but should be enough to simulate the actual liner-wall geometry. The radius of curvature is constant. In this case it is 0.5 inch for the inner wall and 1.9 inches for the outer wall. The input sheets are shown in Figure 22 (3 sheets). (Additional input information can be found in the input sheet forms located in Appendix A.) Card 1 is allocated to case identification. Card 2 shows that 40 cross-stream intervals are selected along with axisymmetric geometry, K-ε viscosity model, and

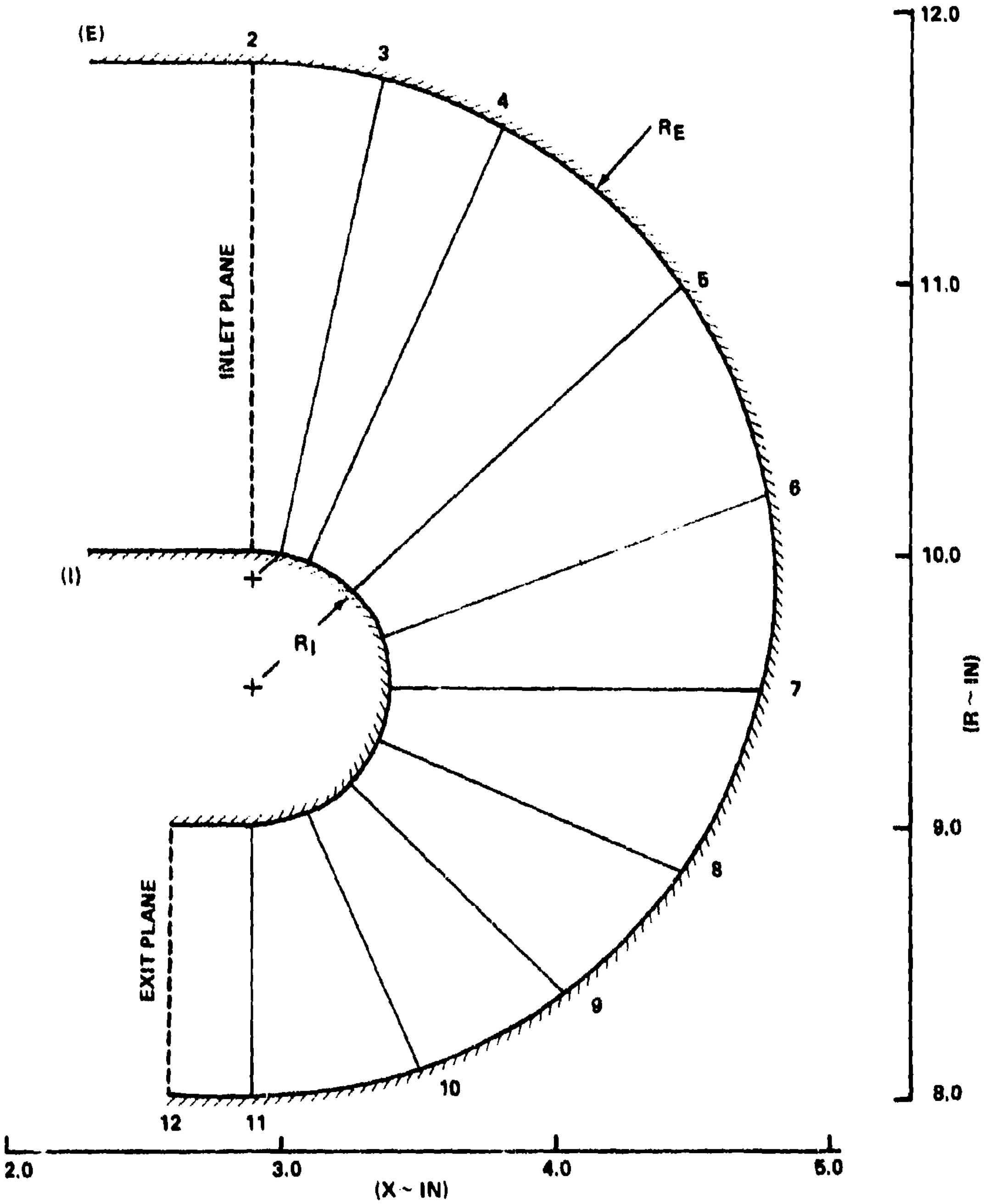


Figure 21. Transition Mixing Example Geometry.

CASE TITLE CARD (12A6)

1	TRANSI	TION M	IXING	MODEL	EXAMPL	E		

CASE TITLE CARD (12A6)

KPLANE	= 7						

(8(I2, 8X))

	N	KRAD	MASSTR	ISWRL	MODEL	INERT	IFLUX	ITEMP
2	40	01	00	00	02	01	00	01

(5(I5, 5X))

	NSTAT	NPROF	NPLOT	ITEST	LASTEP			
3	99999	00020	99999		99999			

(8E10.4)

	ZUI	ZUE	ZULAST	FRA	ZEND	ZOUT	PRESS	POWER
4	.07366	.07366	.2316	.02	10.	10.	101325	1.0

(8(I2, 8X))

	NBP	ICURV	NRCVI	NRCVE				
5	12	01	06	06				

(8E10.4)

	RI_1	XI_1	RI_2	XI_2	RI_3	XI_3	RI_4	XI_4...
6								

(8E10.4)

RE_1	XE_1	RE_2	XE_2	RE_3	XE_3	RE_4	XE_4...

(8E10.4)

	ZI_1	$RCVI_1$	ZI_2	$RCVI_2$	ZI_3	$RCVI_3$	ZI_4	$RCVI_4$...
7								

Figure 22. Transition Mixing Model Input Sheet (1 of 3)

(8E10.4)

	ZE_1	$RCVE_1$	ZE_2	$RCVE_2$	ZE_3	$RCVE_3$	ZE_4	$RCVE_4$...

(8E10.4)

	RA	RB	RD					
8	0.	.254	.29972					

NAMELIST

9	$INPUT	KREAD	= 1					$

(8E10.4)

	UA	UD						
10	0	0						

(8E10.4)

	F2A	F2D	TA	TD	T_{wall}			
11	0	0						

(I2)

	NIN							
12	19							

Y VALUES (8E10.4)

13								

U VALUES (8E10.4)

14								

15								

TEMPERATURE VALUES (8E10.4)

16								

Figure 22. Transition Mixing Model Input Sheet (2 of 3)

17								
18								
19								

TURBULENT KINETIC ENERGY (8E10.4)

20								

TURBULENCE LENGTH SCALE (8E10.4)

21								

Figure 22. Transition Mixing Model Input Sheet (3 of 3)

nonisothermal flow. Card 3 will allow a printout of the variable profiles at every 20 marching steps. The initial and final values of Z and the marching direction are placed on Card 4 along with the control on step size. Since the boundaries are always walls, ZOUT and ZEND are set to a large number while POWER equal to 1.0 forces the initial grid to be uniform in y. POWER >1.0 will distribute more nodes near the inner wall while 0 < POWER <1.0 will distort the grid toward the outer wall. Next, the number of boundary points and number of radius-of-curvature points are specified separated by a flag to indicate that radius-of-curvature effects are to be included. Card set 6 and 7 reads the actual boundary and curvature values which are listed in Table 2. The values listed are in inches and had to be converted to meters since the TMM requires S.I. units. The initial and final values of radius-of-curvature were just chosen to be a large (1000m) number. Cards 8 and 9 are quite obvious with the name-list variables listed with the input forms. Cards 10 and 11 deal with "free" boundaries, which are not used for this program, so the values listed are only for completeness. Card 12 indicates that 19 points on the input initial profile were used and correspond to the 19 radial nodes employed by the 3-D program. The various profiles are read on Cards 13 to 21 and are listed in Table 3. These profiles are merely the exit plane profiles for $\theta = 6$ degrees (in line with the primary orifices) as obtained from the 3-D output.

The output of the TMMs is illustrated in Figure 23 (4 sheets). It begins with a list of control indices and important quantities followed by ω, the transformed cross-stream variable. The specified boundary values of X and R for the inner and outer wall along with the value of Z, the distance along the wall, are listed next. Following these are the values of radius-of-curvature and the initial profiles. Printing of the variable arrays starts with the value at the inner boundary and continues outward. Since y is always referenced from the inner boundary,

TABLE 2. TRANSITION MIXING MODEL GEOMETRY INPUT.

Point	XI	RI	XE	RE
1	0.0	10.0	0.0	11.8
2	2.9	10.0	2.9	11.8
3	3.01	9.99	3.37	11.73
4	3.10	9.96	3.80	11.56
5	3.26	9.85	4.45	10.98
6	3.37	9.68	4.76	10.20
7	3.40	9.50	4.75	9.50
8	3.37	9.30	4.45	8.79
9	3.26	9.14	4.02	8.38
10	3.10	9.04	3.51	8.10
11	2.90	9.00	2.90	8.00
12	2.60	9.00	2.60	8.00

Point	ZI	RCVI	ZE	RCVE
1	0.0	39370.0	0.0	39370.0
2	2.9	39370.0	2.9	39370.0
3	3.01	0.5	3.37	1.9
4	4.27	0.5	8.19	1.9
5	4.47	39370.0	8.81	39370.0
6	4.77	39370.0	9.11	39370.0

TABLE 3. INITIAL PROFILES (SI UNITS) FOR TRANSITION MIXING EXAMPLE

Node	r	u	KE	lm	Temp.
19	0.04572	32.6	15.6	5.86E-4	879
18	0.04318	32.6	15.6	5.86E-4	879
17	0.04064	22.8	18.0	6.03E-4	1310
16	0.03810	26.3	27.0	6.16E-4	1470
15	0.03556	29.2	30.3	6.50E-4	1530
14	0.03302	30.7	30.6	6.64E-4	1560
13	0.03048	31.7	29.6	6.65E-4	1570
12	0.02794	33.0	28.7	6.59E-4	1560
11	0.02540	34.6	29.9	6.42E-4	1530
10	0.02286	37.0	61.8	4.65E-4	1470
9	0.02032	34.5	42.9	6.24E-4	1550
8	0.01778	30.6	27.0	6.58E-4	1660
7	0.01524	28.7	26.4	6.57E-4	1700
6	0.01270	27.4	27.8	6.59E-4	1720
5	0.01016	25.9	28.3	6.49E-4	1690
4	0.00762	23.6	25.3	6.21E-4	1570
3	0.00508	21.6	20.4	6.10E-4	1370
2	0.00254	33.5	16.4	5.88E-4	879
1	0.00000	33.5	16.4	5.88E-4	879

K = 7

```
XYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY
XYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY


 TRANSITION MIXING MODEL EXAMPLE
  KPLANE=7
MODER=  2 IOPDX=  1 MODE=  2 MASSFX=  0 INERT=  1 KRAD=  1 IFLUX=  0
 UA          UO          TA          TO          RA          RR          ZEND        ZOUT        ZOLAST      PRESS
 0.          0.          4.796E+02   5.740E+02   0.          2.540E-01   1.000E+01   1.000E+01   2.314E-01   1.013E+05
 PREXP1      ARCON1      CR1         PR-R22      ARCON2      CR2         ETA         WID
 5.000E+15   2.350E+34   5.000E+00   5.400E+05   1.250E+04   4.000E+00-0.           -0.

OMEGA       0.          0.          4.307E-02   9.032E-02   1.153E-01   1.403E-01   1.557E-01   1.737E-01   1.916E-01   2.080E-01   2.247E-01
            2.415E-01   2.583E-01   2.757E-01   2.956E-01   3.140E-01   3.337E-01   3.546E-01   3.771E-01   4.017E-01   4.280E-01   4.560E-01
            4.852E-01   5.111E-01   5.371E-01   5.623E-01   5.675E-01   6.112E-01   6.350E-01   6.586E-01   6.820E-01   7.052E-01   7.281E-01
            7.537E-01   7.777E-01   7.944E-01   8.159E-01   8.386E-01   8.594E-01   9.085E-01   9.542E-01   1.000E+00   1.000E+00

                    INTERNAL BOUNDARY                                      EXTERNAL BOUNDARY
                    -----------------                                      -----------------

  I          X            R           Z                          I          X            R           Z
  1    0.           .2540E+00   0.                               1    0.           .2997E+00   0.
  2     .7365E-01   .2540E+00    .7365E-01                       2     .7366E-01   .2997E+00    .7366E-01
  3     .7645E-01   .2537E+00    .7647E-01                       3     .9566E-01   .2979E+00    .8573E-01
  4     .7374E-01   .2530E+00    .7586E-01                       4     .9652E-01   .2936E+00    .9749E-01
  5     .9280E-01   .2532E+00    .8379E-01                       5     .1130E+00   .2788E+00    .1196E+00
  6     .9592E-01   .2459E+00    .8897E-01                       6     .1209E+00   .2551E+00    .1409E+00
  7     .9634E-01   .2413E+00    .9359E-01                       7     .1256E+00   .2413E+00    .1597E+00
  8     .9550E-01   .2362E+00    .9974E-01                       8     .1130E+00   .2233E+00    .1793E+00
  9     .9230E-01   .2322E+00    .1036E+00                       9     .1071E+00   .2129E+00    .1934E+00
 10     .7874E-01   .2296E+00    .1064E+00                      10     .8915E-01   .2057E+00    .2081E+00
 11     .7355E-01   .2285E+00    .1136E+00                      11     .7366E-01   .2037E+00    .2239E+00
 12     .4000E-01   .2256E+00    .1473E+00                      12     .4000E-01   .2032E+00    .2575E+00

                    INTERNAL BOUNDARY                                      EXTERNAL BOUNDARY
                    -----------------                                      -----------------

  I             Z                       RCVI                     I             Z                       RCVE
  1    0.                             .1000E+04                  1    0.                             .1000E+04
  2     .7365E-01                     .1000E+04                  2     .7366E-01                     .1000E+04
  3     .7647E-01                     .1270E-01                  3     .8573E-01                     .4826E-01
  4     .1094E+00                     .1270E-01                  4     .2081E+00                     .4826E-01
  5     .1136E+00                     .1000E+04                  5     .2230E+00                     .1000E+04
  6     .1212E+00                     .1000E+04                  6     .2315E+00                     .1000E+04

ISTEP=     0 IAA=10000 IEND=10000 IOUT=10000 KIN= 1 KEX= 1 DZI=  2.125E-05 DZE=  9.143E-05 PSII=  0.          PSIE=  9.726E-02
RMI=  0.          RME=  0.          RFI=  9.726E-02 PRESSD=  0.          AFXD=  0.
XI=  7.367E-02 XE=  7.367E-02 RI=  2.540E-01 RE=  2.997E-01 RCVI=  9.964E+02 RCVE=  9.991E+02 CSALFA=  1.000E+00
ZUI=  7.367E-02 ZUE=  7.367E-02 UFLUX= 2.967E+00 FLUX(J)= 5.976E+04 0.          0.          0.          0.          2.639E+00 2.179E+03
KIN= 1 TAUID=  1.678E-02 AJID(J)=  0.          0.          0.          0.          0.          0.          -5.867E-03
KEX= 1 TAUED=  1.454E-02 AJED(J)=  0.          0.          0.          0.          0.          0.           5.450E-03

R1,Y'S      2.540E-01   4.930E-16   1.143E-03   2.286E-03   3.429E-03   4.571E-03   5.714E-03   6.857E-03   8.000E-03   9.143E-03   1.029E-02
            1.143E-02   1.257E-02   1.371E-02   1.486E-02   1.600E-02   1.714E-02   1.829E-02   1.943E-02   2.057E-02   2.171E-02   2.286E-02
            2.400E-02   2.514E-02   2.629E-02   2.743E-02   2.857E-02   2.971E-02   3.086E-02   3.200E-02   3.314E-02   3.429E-02   3.543E-02
            3.657E-02   3.771E-02   3.886E-02   4.000E-02   4.114E-02   4.229E-02   4.343E-02   4.457E-02   4.571E-02   4.571E-02

U           0.          3.350E+01   3.350E+01   3.350E+01   2.934E+01   2.399E+01   2.210E+01   2.300E+01   2.394E+01   2.498E+01   2.597E+01
            2.655E+01   2.732E+01   2.792E+01   2.850E+01   2.927E+01   3.012E+01   3.139E+01   3.313E+01   3.475E+01   3.587E+01   3.700E+01
            3.572E+01   3.484E+01   3.434E+01   3.332E+01   3.266E+01   3.209E+01   3.155E+01   3.110E+01   3.063E+01   2.995E+01   2.929E+01
            2.604E+01   2.674E+01   2.525E+01   2.368E+01   2.476E+01   2.917E+01   3.260E+01   3.260E+01   3.260E+01   0.

KE          0.          1.540E+01   1.540E+01   1.540E+01   1.786E+01   1.950E+01   2.162E+01   2.383E+01   2.575E+01   2.710E+01   2.828E+01
            2.635E+01   2.783E+01   2.724E+01   2.561E+01   2.658E+01   2.665E+01   3.018E+01   3.733E+01   4.479E+01   5.329E+01   6.190E+01
            4.745E+01   3.307E+01   2.948E+01   2.594E+01   2.892E+01   2.933E+01   2.975E+01   3.020E+01   3.059E+01   3.045E+01   3.032E+01
            2.433E+01   2.753E+01   2.430E+01   2.025E+01   1.752E+01   1.644E+01   1.560E+01   1.550E+01   1.560E+01   0.
```

Figure 23. Transition Mixing Model Output (Sheet 1 of 4).

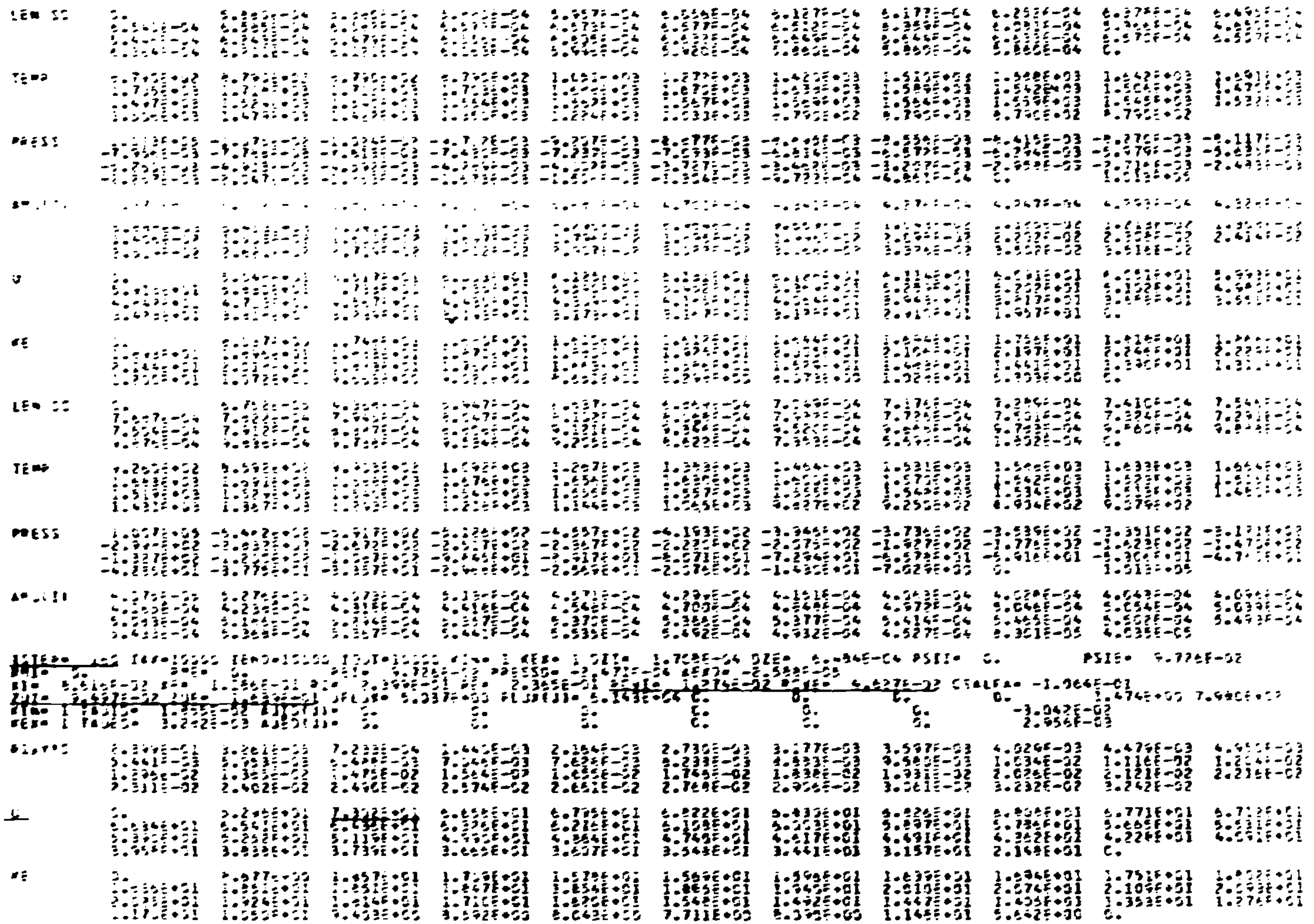


Figure 23. Transition Mixing Model Output (Sheet 2 of 4).

```
LEN SC     0.         6.254E-05  3.450E-04  5.533E-04  6.420E-04  6.912E-04  7.133E-04  7.270E-04  7.386E-04  7.511E-04  7.654E-04
           7.837E-04  7.959E-04  8.099E-04  8.210E-04  8.264E-04  8.230E-04  8.104E-04  7.919E-04  7.725E-04  7.589E-04  7.599E-04
           7.793E-04  8.175E-04  8.526E-04  9.052E-04  9.396E-04  9.658E-04  9.559E-04  1.002E-03  1.014E-03  1.021E-03  1.024E-03
           1.022E-03  1.018E-03  1.008E-03  9.694E-04  9.541E-04  8.539E-04  7.324E-04  5.700E-04  1.634E-04  0.

TEMP       9.451E+02  9.686E+02  1.025E+03  1.123E+03  1.283E+03  1.386E+03  1.463E+03  1.526E+03  1.581E+03  1.625E+03  1.657E+03
           1.675E+03  1.696E+03  1.691E+03  1.669E+03  1.650E+03  1.626E+03  1.598E+03  1.570E+03  1.544E+03  1.526E+03  1.513E+03
           1.522E+03  1.530E+03  1.540E+03  1.546E+03  1.553E+03  1.554E+03  1.551E+03  1.543E+03  1.527E+03  1.503E+03  1.465E+03
           1.415E+03  1.353E+03  1.295E+03  1.216E+03  1.146E+03  1.063E+03  9.865E+02  9.239E+02  8.936E+02  9.114E+02

PRESS      1.006E+05 -7.555E+02 -6.449E+02 -5.981E+02 -5.350E+02 -4.940E+02 -4.653E+02 -4.415E+02 -4.192E+02 -3.976E+02 -3.767E+02
          -3.557E+02 -3.373E+02 -3.155E+02 -3.005E+02 -2.828E+02 -2.656E+02 -2.494E+02 -2.316E+02 -2.132E+02 -1.952E+02 -1.774E+02
          -1.606E+02 -1.456E+02 -1.322E+02 -1.201E+02 -1.090E+02 -9.862E+01 -8.945E+01 -8.078E+01 -7.272E+01 -6.525E+01 -5.836E+01
          -5.295E+01 -4.531E+01 -4.106E+01 -3.617E+01 -3.117E+01 -2.561E+01 -1.736E+01 -8.285E+00  0.         1.013E+05

AMU(I)     4.124E-05  5.216E-05  2.962E-04  4.544E-04  4.322E-04  4.233E-04  4.135E-04  4.057E-04  4.021E-04  4.038E-04  4.100E-04
           4.143E-04  4.290E-04  4.347E-04  4.515E-04  4.642E-04  4.769E-04  4.934E-04  4.977E-04  5.037E-04  5.059E-04  5.073E-04
           5.131E-04  5.237E-04  5.355E-04  5.444E-04  5.492E-04  5.519E-04  5.552E-04  5.602E-04  5.663E-04  5.708E-04  5.714E-04
           5.674E-04  5.611E-04  5.559E-04  5.535E-04  5.514E-04  5.376E-04  4.823E-04  4.829E-04  7.840E-05  4.043E-05

ISTEP=  180 IAX=10000 IEND=10000 IOUT=10000 KIN= 1 KEX= 1 DZI=  1.604E-04 DZE=  5.090E-04 PSII=  0.          PSIE=  9.726E-02
RMI=  0.          RME=  0.          PEI=  9.726E-02 PRESSD= -6.711E-04 AEXD=  1.152E-04
XI=  9.567E-02 XE=  1.137E-01 RI=  2.367E-01 RE=  2.250E-01 RCVI=  1.281E-02 RCVE=  4.603E-02 CSALFA= -3.852E-01
ZUI=  9.826E-02 ZUE=  1.764E-01 UFLUX= 5.566E+06 FLUX(J)= 6.161E+04 0.          0.          0.          0.         1.482E+00 8.309E+02
KIN= 1 TAUID=  1.745E-02 AJID(J)=  0.          0.          0.          0.          0.          0.         -3.767E-02
KEX= 1 TAUED=  3.138E-03 AJED(J)=  0.          0.          0.          0.          0.          0.          3.807E-03

RI,Y'S     2.357E-01  9.474E-05  7.535E-04  1.427E-03  2.116E-03  2.646E-03  3.060E-03  3.449E-03  3.847E-03  4.261E-03  4.694E-03
           5.145E-03  5.617E-03  6.104E-03  6.621E-03  7.158E-03  7.721E-03  8.317E-03  8.964E-03  9.672E-03  1.044E-02  1.126E-02
           1.212E-02  1.295E-02  1.379E-02  1.462E-02  1.546E-02  1.630E-02  1.715E-02  1.801E-02  1.889E-02  1.976E-02  2.063E-02
           2.149E-02  2.233E-02  2.313E-02  2.391E-02  2.472E-02  2.573E-02  2.704E-02  2.854E-02  3.021E-02  3.045E-02

ISTEP=  245 IAX=10000 IEND=10000 IOUT=10000 KIN= 1 KEX= 1 DZI=  2.45[illegible] DZE=  2.460E-04 PSII=  0.          PSIE=  9.7[illegible]
RMI=  0.          RME=  0.          PEI=  9.726E-02 PRESSD= -4.997E-03 AEXD=  2.595E-04
XI=  6.639E-02 XE=  6.639E-02 RI=  2.286E-01 RE=  2.032E-01 RCVI=  1.000E+03 RCVE=  1.000E+03 CSALFA= -1.000E+00
ZUI=  1.212E-01 ZUE=  2.316E-01 UFLUX= 6.840E+00 FLUX(J)= 6.222E+04 0.          0.          0.          0.         1.766E+00 1.4[illegible]E+02
KIN= 1 TAUID=  6.256E-03 AJID(J)=  0.          0.          0.          0.          0.          0.         -3.132E-02
KEX= 1 TAUED=  5.042E-03 AJED(J)=  0.          0.          0.          0.          0.          0.          1.869E-02

RI,Y'S     2.286E-01  1.142E-04  9.755E-04  1.855E-03  2.719E-03  3.336E-03  3.930E-03  4.225E-03  4.652E-03  5.096E-03  5.530E-03
           5.997E-03  6.456E-03  6.939E-03  7.435E-03  7.947E-03  8.479E-03  9.037E-03  9.636E-03  1.028E-02  1.098E-02  1.171E-02
           1.245E-02  1.315E-02  1.384E-02  1.451E-02  1.516E-02  1.581E-02  1.644E-02  1.707E-02  1.769E-02  1.829E-02  1.898E-02
           1.945E-02  2.000E-02  2.053E-02  2.104E-02  2.159E-02  2.226E-02  2.316E-02  2.417E-02  2.577E-02  2.541E-02

U          0.         4.340E+01  6.641E+01  6.405E+01  6.933E+01  7.097E+01  7.185E+01  7.269E+01  7.349E+01  7.421E+01  7.490E+01
           7.525E+01  7.555E+01  7.573E+01  7.580E+01  7.591E+01  7.575E+01  7.566E+01  7.554E+01  7.542E+01  7.531E+01  7.525E+01
           7.524E+01  7.526E+01  7.527E+01  7.524E+01  7.515E+01  7.493E+01  7.470E+01  7.429E+01  7.372E+01  7.302E+01  7.219E+01
           7.126E+01  7.028E+01  6.976E+01  6.920E+01  6.795E+01  6.531E+01  6.272E+01  5.852E+01  4.426E+01  0.

KE         0.         4.395E+01  2.455E+01  1.755E+01  1.763E+01  1.560E+01  1.524E+01  1.535E+01  1.552E+01  1.577E+01  1.611E+01
           1.654E+01  1.701E+01  1.747E+01  1.756E+01  1.815E+01  1.833E+01  1.841E+01  1.837E+01  1.822E+01  1.795E+01  1.755E+01
           1.737E+01  1.557E+01  1.539E+01  1.565E+01  1.536E+01  1.515E+01  1.505E+01  1.534E+01  1.517E+01  1.528E+01  1.538E+01
           1.544E+01  1.549E+01  1.559E+01  1.590E+01  1.624E+01  1.730E+01  2.047E+01  2.977E+01  1.182E+01  0.

LEN SC     0.         1.580E-04  1.772E-04  3.347E-04  4.767E-04  5.932E-04  6.730E-04  7.283E-04  7.623E-04  7.857E-04  8.055E-04
           8.273E-04  8.491E-04  8.680E-04  8.826E-04  8.922E-04  8.959E-04  8.944E-04  8.872E-04  8.932E-04  8.809E-04  8.974E-04
           9.055E-04  9.335E-04  9.531E-04  1.006E-03  1.042E-03  1.074E-03  1.100E-03  1.119E-03  1.133E-03  1.143E-03  1.150E-03
           1.153E-03  1.146E-03  1.120E-03  1.066E-03  9.763E-04  8.243E-04  6.132E-04  4.554E-04  1.013E-04  0.

TEMP       1.034E+03  1.054E+03  1.101E+03  1.265E+03  1.371E+03  1.434E+03  1.479E+03  1.515E+03  1.556E+03  1.585E+03  1.611E+03
           1.523E+03  1.537E+03  1.573E+03  1.634E+03  1.623E+03  1.609E+03  1.592E+03  1.574E+03  1.559E+03  1.544E+03  1.537E+03
           1.534E+03  1.535E+03  1.537E+03  1.537E+03  1.534E+03  1.527E+03  1.514E+03  1.493E+03  1.455E+03  1.431E+03  1.390E+03
           1.346E+03  1.306E+03  1.254E+03  1.208E+03  1.160E+03  1.099E+03  1.025E+03  9.645E+02  9.221E+02  9.443E+02

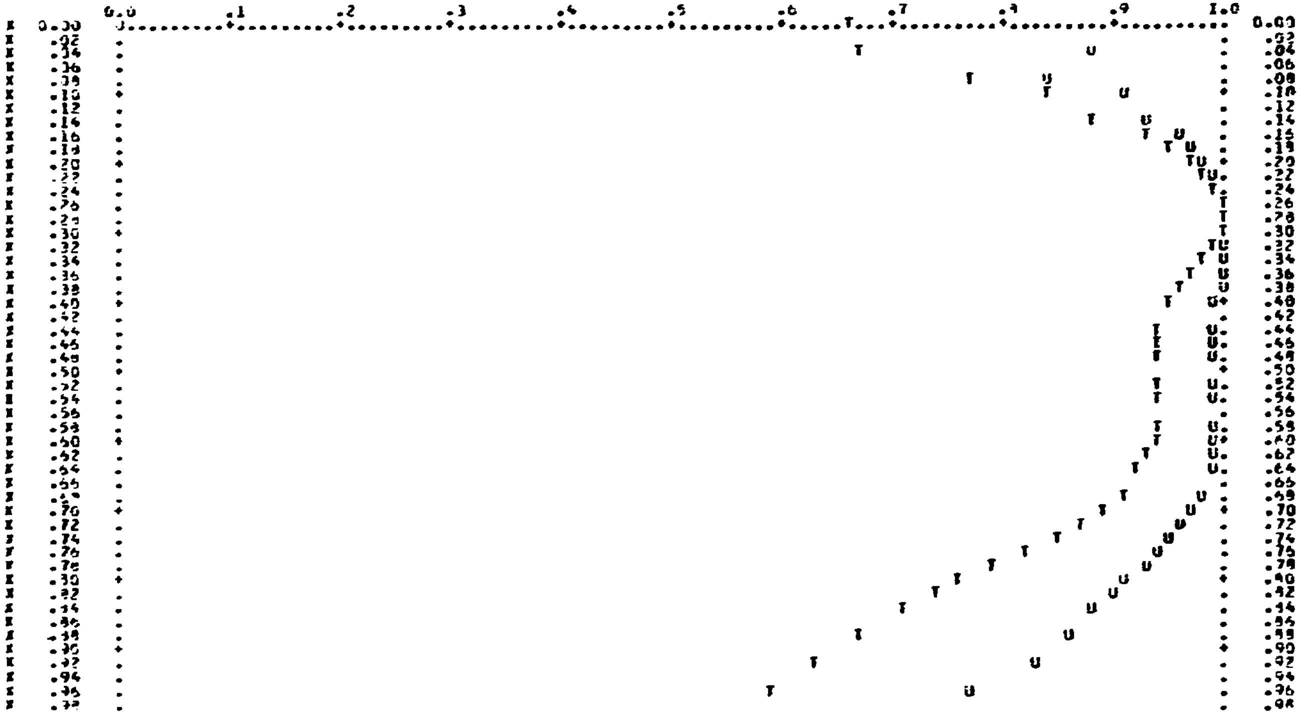
PRESS      1.038E+05 -3.173E-02 -3.134E-02 -2.979E-02 -2.833E-02 -2.808E-02 -2.751E-02 -2.705E-02 -2.648E-02 -2.595E-02 -2.541E-02
          -2.435E-02 -2.428E-02 -2.370E-02 -2.309E-02 -2.264E-02 -2.160E-02 -2.110E-02 -2.035E-02 -1.953E-02 -1.865E-02 -1.771E-02
          -1.675E-02 -1.584E-02 -1.446E-02 -1.409E-02 -1.325E-02 -1.242E-02 -1.150E-02 -1.090E-02 -1.000E-02 -9.220E-03 -8.450E-03
          -7.730E-03 -6.975E-03 -6.274E-03 -5.585E-03 -4.861E-03 -3.940E-03 -2.721E-03 -1.357E-03  0.         1.008E+05

AMU(I)     4.439E-05  1.312E-04  1.427E-04  2.672E-04  2.846E-04  3.234E-04  3.672E-04  3.929E-04  4.056E-04  4.130E-04  4.247E-04
           4.375E-04  4.588E-04  4.777E-04  4.996E-04  5.165E-04  5.294E-04  5.376E-04  5.415E-04  5.422E-04  5.417E-04  5.479E-04
           5.435E-04  5.530E-04  5.740E-04  5.926E-04  6.137E-04  6.369E-04  6.627E-04  6.903E-04  7.275E-04  7.593E-04  7.499E-04
           8.414E-04  8.774E-04  9.333E-04  9.982E-04  8.660E-04  7.852E-04  5.629E-04  6.277E-04  7.054E-05  4.115E-05
```

Figure 23. Transition Mixing Model Output (Sheet 3 of 4).

```
PLOT AT ZUE=  2.314E-01, ISTEP=  249

X-AXIS IS Y(I)        ,MAXIMUM VALUE = 2.541E-02
Y-AXES ARE         VELOCITY    TEMP
SYMBOL                 U          T
MAXIMUM VALUES   7.591E+01   1.539E+03
```



```
TERMINATED WITH ISTEP=  249 LASTEP=99999 ZUE=  2.314E-01 ZULAST=  2.314E-01 IFIN=  1
```

Figure 23. Transition Mixing Model Output (Sheet 4 of 4).

Y(1) is always zero; therefore, the radius of the inner boundary is printed instead. Note that the pressure variation across the grid (PRESS) is essentially zero due to the large values of radius-of-curvature (RCVI, RCVE) specified at the inlet plane. Sheets 2 and 3 of Figure 23 show the printout after 160 marching steps. Along the outer boundary, the program has marched to 0.1639 meter (ZUE), but the inner boundary is only to 0.09497 meter (ZUI). At this point, there exists a considerable radial pressure gradient with the inner wall at 744 N/m^2 lower pressure than the outer. In addition, the velocity profile is distorted so that the maximum is very near the inner wall. Sheets 3 and 4 of Figure 23 show the output at the exit plane. The radial-pressure gradient disappears as the radius-of-curvature effects are no longer present. A plot of velocity and temperature is also made. The top line of the plot corresponds to the inner boundary while the bottom line is the outer. However, it must be remembered that the inner boundary here is located at what would be the stator-blade tip and the outer at what would be the blade root.

EMISSION MODEL

The calculation domain that would be used by the emission model to predict the emission output of the example combustor is illustrated in Figure 24. Starting with the initial profiles near the dome, the program marches using the recirculation zone as the inner boundary. The mass and specie concentrations in the recirculation zone can be estimated or calculated by several methods, and this provides an entrainment rate and boundary conditions. Once the centerline of the combustor is reached, the inner boundary switches to an axis of symmetry. Cooling slots and radial-injection points can be handled without stopping the marching process. To input the information necessary to perform the above calculation would be quite lengthy and illustrates nothing about the emission program. Usually, the boundary along

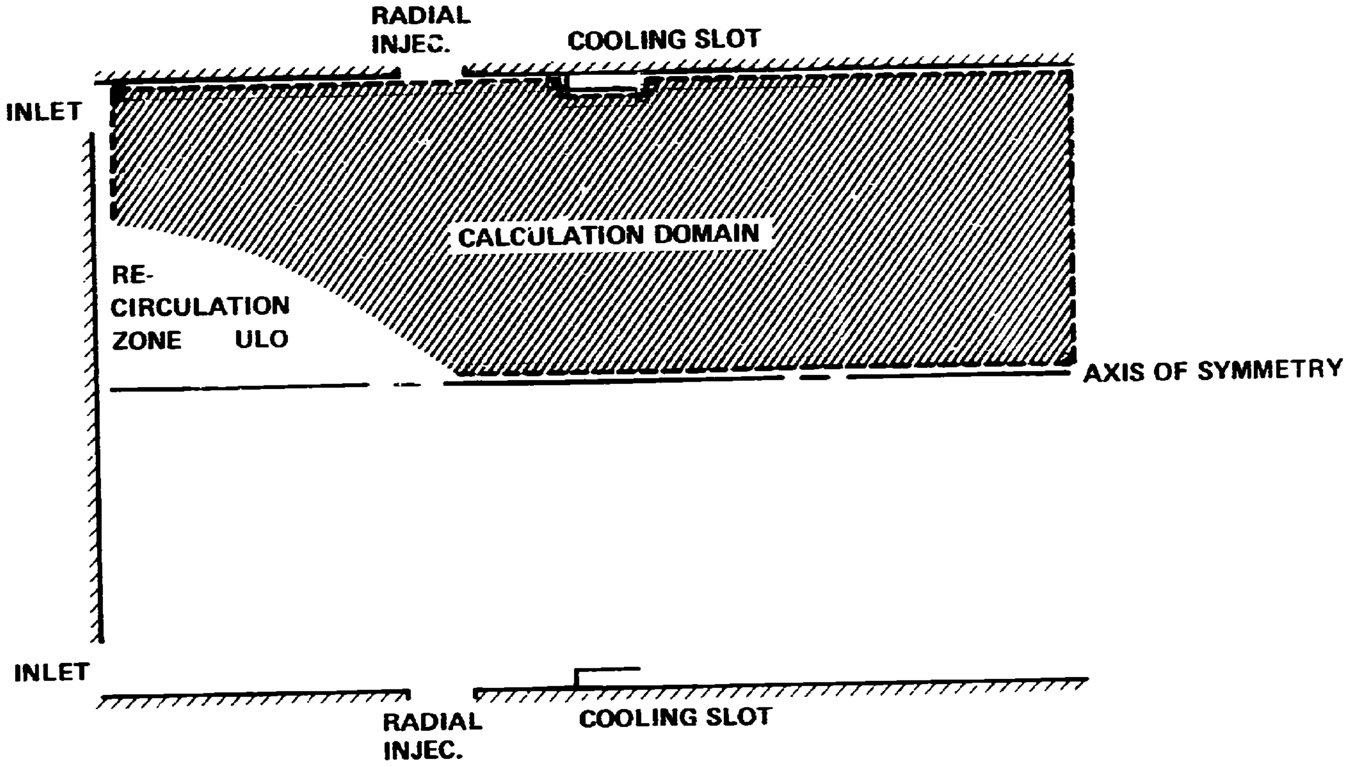


Figure 24. Calculation Domain for Predicting Emission Output of Example Combustor.

the recirculation zone must be handled in a manner that requires internal modifications to the program similar to the Cards MA.528 through MA.743 that are unique to each case analyzed. Therefore, for the example case (Figure 25) the program is started at the downstream edge of the cooling-slot lip and marched to the exit of the liner.

As illustrated in Figure 25, card set 1 is available for case identification. Card 2 specifies 30 cross-stream intervals, axisymmetric geometry, species, two-equation turbulence model, reaction and nonisothermal conditions, while Card 3 produces a profile printout at every 40 marching steps. The initial and final x locations are read on Card 4 and have units of meters, since all the units of the emission model are S.I. The step size was chosen to be small as is necessary with the 16-step kinetic scheme. Since the boundaries are always walls, XOUT AND XEND are set to a large number. A value of POWER equal to 1.0 provides an initial grid that is uniform in y. POWER >1.0 places more nodes near the inner boundary while POWER <-1.0 places more nodes near the outer boundary. Since both walls are straight, only two boundary points are needed, Cards 5 and 6. Cards 7 and 8 define the initial grid, inner and outer radii, and the name-list quantities. Cards 9 and 10 deal with quantities at free boundaries, which are not used, so the data is included only for completeness. The initial profiles are the same as those used in the wall-cooling model example. Nineteen points are used and correspond to the 19 radial nodes used in the 3-D performance model. Three additional profiles, listed in Table 4, are needed for the 16-step-reaction scheme. Since for this case there are no cooling slots or radial injections, the remaining Cards, 24 through 51, are omitted.

CASE TITLE CARD (12A6)

1	EMISSIO	N MOD	EL EXA	MPLE				

CASE TITLE CARD (12A6)

KPLANE	= 7						

(8(I2, 8X))

	N	KRAD	MASSTR	ISWRL	MODEL	INERT	IFLUX	ITEMP
2	30	01	01	00	02	02	00	01

	NSTAT	NPROF	NPLOT	ITEST	LASTEP	(5(I5, 5X))		
3	99999	00040	99999		99999			

	XU	XULAST	FRA	XEND	XOUT	PRESS	POWER	(8E10.4)
4	.03937	.073	.01	10.	10.	101325	1.0	

	NBP							(I2)
5	02							

	X_1	RI_1	RE_1	X_2	RI_2	RE_2	X_3	RI_3
6	0	.254	.29972	10.	.254	.29972		

RE_3	X_4	RI_4	RE_4	X_5	RI_5	RE ...	(8E10.4)

	RA	RB	RD					(8E10.4)
7	0	.254	.29972					

Figure 25. Emissions Model Input Sheet (1 of 4)

NAMELIST

8	$INPUT	KREAD=	1, PREXD	1 = 2.8E	+16, ARG	ON1 = 54	000.	$

CR1=3.0, CX=10, MY=19.28, ERO=1.5, EFU=.5, EO2=1.0
EH2O=0.

	UA	UD	VTA	VTD				(8E10.4)
9	0	0	0	0				

	F2A	F2D	TA	TD	T_{wall}			(8E10.4)
10	0	0	589.	589.	589.			

	NIN	NUI	NUE	NVI	NVE			(5(I2, 8X))
11	19	00	00	00	00			

	Y VALUES							(8E10.4)
12								

	U VALUES							(8E10.4)
13								

	Vθ VALUES							(8E10.4)
14								

	TEMPERATURE VALUES							(8E10.4)
15								

	MFU VALUES							(8E10.4)
16								

	MCO_2 VALUES							(8E10.4)
17								

Figure 25. Emissions Model Input Sheet (2 of 4)

MCO VALUES (8E10.4)

18

MOX VALUES (8E10.4)

19

MH_2O VALUES (8E10.4)

20

MH_2 VALUES (8E10.4)

21

TURBULENT KINETIC ENERGY (8E10.4)

22

TURBULENCE LENGTH SCALE (8E10.4)

23

SKIP FOLLOWING CARD SET IF NUI = 0

X - LOC. OF INTERNAL COOLING SLOTS (8E10.4)

24

LIP LENGTH OF INTERNAL COOLING SLOTS (8E10.4)

25

U - VELOCITY OF INTERNAL COOLING SLOTS (8E10.4)

26

VT - VELOCITY OF INTERNAL COOLING SLOTS (8E10.4)

27

Figure 25. Emissions Model Input Sheet (3 of 4)

TEMPERATURE OF INTERNAL COOLING SLOTS (8E10.4)

FLOW RATE OF INTERNAL COOLING SLOTS (8E10.4)

29

SLOT HEIGHT OF INTERNAL COOLING SLOTS (8E10.4)

30

SLOT TO METERING AREA RATIO FOR INT SLOTS (8E10.4)

31

SKIP FOLLOWING CARD SET IF NUE = 0

X-LOC OF EXTERNAL COOLING SLOTS (8E10.4)

32

LIP LENGTH OF EXTERNAL COOLING SLOTS (8E10.4)

33

U - VELOCITY OF EXTERNAL COOLING SLOTS (8E10.4)

34

V_T - VELOCITY OF EXTERNAL COOLING SLOTS (8E10.4)

35

Figure 25. Emissions Model Input Sheet (4 of 4)

TABLE 4. ADDITIONAL PROFILES FOR EMISSION MODEL.

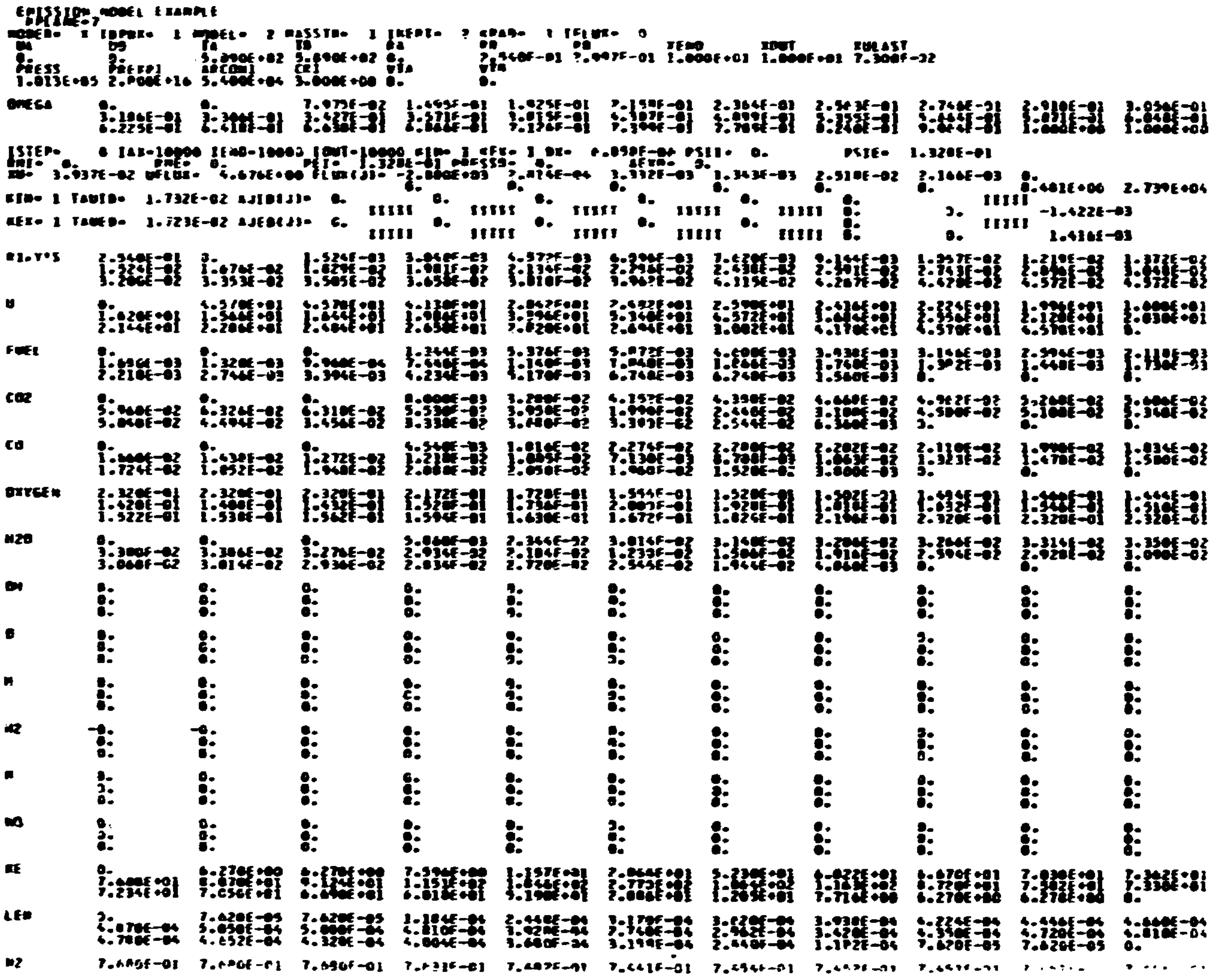
Node	M_{CO_2}	M_{OX}	M_{H_2O}
19	0	0.232	0
18	0	0.232	0
17	0.0318	0.170	0.0243
16	0.0368	0.163	0.0272
15	0.0311	0.157	0.0291
14	0.0484	0.153	0.0304
13	0.0534	0.151	0.0309
12	0.0494	0.157	0.0282
11	0.0274	0.188	0.0169
10	0.0199	0.200	0.0123
9	0.0527	0.156	0.0282
8	0.0657	0.140	0.0339
7	0.0596	0.142	0.0338
6	0.0537	0.146	0.0333
5	0.0486	0.149	0.0325
4	0.0438	0.152	0.0314
3	0.0400	0.158	0.0293
2	0	0.232	0
1	0	0.232	0

The output of the emission model is shown in Figures 26 and 27. The initial printout consists of some control parameters, the value omega (the transformed cross-stream variable), and the initial profiles. The printing of the variable arrays starts with the value at the inner boundary and continues outward. Since y is always referenced from the inner boundary, y(1) is always zero; therefore, the radius of the inner boundary is printed instead. Figure 27 shows the profiles at the exit of the combustor, XU = 0.073 meter. The profiles of NO show small values (much less, however, than one would expect as the principal area of NO formation) occur upstream of where the emission model is started.

FUEL-INSERTION MODEL

The fuel-insertion model could have been used to predict the droplet trajectories of the nozzle in the 3-D performance model example case, Figure 28; however, since that program contains its own spray model, a simple illustrative example was selected instead. A two-dimensional grid 5.0 X 1.5 inches, with the spray originating in the lower left-hand corner and processing a nonuniform flow field, was analyzed.

Card 1 (Figure 28, Sheet 1) allows for case identification. Card 2 specifies the atomizer type, in this case an airblast nozzle with a 10 flow no. and 90-degree cone angle. The other fields are left blank as they pertain to dual orifice and/or simplex nozzles. Cards 3 and 4 are omitted as they are used to input the ΔP versus fuel-flow curve for the secondaries of a dual-orifice nozzle. Card 5 specifies some dimensions of the airblast nozzle, the filming diameter, and exit-flow area along with the airflow rate and temperature. The fuel type, flow rate, and temperature are given on Card 6, plus the flag to specify a nonuniform 2-D field. Other quantities on Card 6 are required only for other



```
EMISSION MODEL EXAMPLE
MODER=  1 IDPBK=  1 MODEL=  2 MASSTR=  1 IKEPT=  ? KPAR=  1 IFLUX=  0
 UA          DS          TA          TB          PA          PB          PB          ZEND        ZOUT        ZULAST
 0.          0.          5.890E+02   5.890E+02   0.          7.560E-01   7.997E-01   1.000E+01   1.000E+01   7.300E-32
 PRESS       PREF        ARCON       CE          VIA         VIA
 1.013E+05   2.P00E+16   5.400E+04   3.000E+00   0.          0.

OMEGA        0.          0.          7.975E-02   1.495E-01   1.925E-01   2.159E-01   2.364E-01   2.543E-01   2.748E-01   2.910E-01   3.056E-01

KIN= 1 TAUID=  1.732E-02 AJID(J)=  0.
KEX= 1 TAUED=  1.723E-02 AJED(J)=  0.
```

Figure 26. Emission Model Output.

```
ISTEP=   120 IAX=10000 IEND=10000 IOUT=10000 KIN= 1 KEX= 1 NX=  0.      PSII=  0.        PSIE=  1.379E-01
RPI=  0.          RME=  0.          PCI=  1.329E-01 PRESSR= -2.929E-06 AFXD= -4.868E-06
XU=  7.300E-02 UFLUX=  4.855E+00 FLUX(J)= -2.080F+03  2.400E-05  4.493E-03  1.201E-04  2.314E-02  2.456E-03  9.650E-05
                                            1.377E-04  2.907E-04  5.445E-06  1.313E-13  1.092E-08  0.         2.910E+00  2.667E+03
KIN= 1 TAUIB=  1.334E-02 AJIDIJ)=  0.         0.         0.         0.         0.         0.         0.
                                   0.         0.         0.         0.         0.         0.         0.         -1.856E-03
KEX= 1 TAUEG=  1.328E-02 AJEDIJ)=  0.         0.         0.         0.         0.         0.         0.
                                   0.         0.         0.         0.         0.         0.         0.          1.849E-03

RI,Y'S      2.540E-01  1.756E-04  1.773E-03  3.354E-03  5.075E-03  6.479E-03  8.311E-03  9.971E-03  1.155E-02  1.302E-02  1.434E-02
            1.545E-02  1.639E-02  1.724E-02  1.813E-02  1.942E-02  2.151E-02  2.373E-02  2.554E-02  2.709E-02  2.829E-02  2.946E-02
            3.074E-02  3.219E-02  3.374E-02  3.540E-02  3.715E-02  3.891E-02  4.067E-02  4.239E-02  4.397E-02  4.552E-02  4.570E-02

U           0.         3.764E+01  4.629E+01  4.139E+01  3.234E+01  2.931E+01  2.829E+01  2.713E+01  2.572E+01  2.462E+01  2.459E+01
            2.581E+01  2.778E+01  3.015E+01  3.300E+01  3.738E+01  4.334E+01  4.359E+01  3.664E+01  3.350E+01  3.018E+01  2.792E+01
            2.645E+01  2.702E+01  2.800E+01  2.923E+01  3.019E+01  3.099E+01  3.349E+01  4.701E+01  4.421E+01  3.764E+01  0.

FUEL        3.325E-05  1.234E-05  5.415E-05  1.209E-07  4.979E-05  9.414E-06  4.679E-06  2.437E-06  1.597E-06  1.044E-06  8.859E-07
            5.003E-07  4.668E-07  5.491E-07  7.540E-07  1.333E-04  3.119E-06  3.193E-06  1.663E-06  9.342E-07  8.706E-07  1.048E-06
            1.464E-04  2.050E-04  2.818E-04  4.027E-04  6.991E-06  1.934E-05  5.541E-05  1.416E-03  4.355E-05  1.449E-05  3.902E-05

CO2         4.206E-04  1.468E-04  6.944E-04  1.899E-02  7.563E-02  9.991E-02  9.329E-02  9.325E-02  9.252E-02  9.125E-02  8.851E-02
            8.457E-02  8.021E-02  7.575E-02  7.087E-02  4.374E-02  5.392E-02  5.314E-02  8.023E-02  6.911E-02  7.396E-02  7.837E-02
            8.113E-02  8.197E-02  8.159E-02  8.193E-02  4.965E-02  8.249E-02  6.721E-02  1.944E-02  5.716E-04  1.200E-04  3.462E-04

CO          1.913E-05  8.329E-06  2.993E-05  4.999E-04  1.320E-03  2.574E-03  2.756E-03  2.684E-03  2.521E-03  2.297E-03  1.992E-03
            1.648E-03  1.356E-03  1.111E-03  8.974E-04  6.940E-04  3.904E-04  3.792E-04  5.374E-04  8.406E-04  1.098E-03  1.356E-03
            1.594E-03  1.756E-03  1.895E-03  1.995E-03  2.073E-03  1.461E-03  9.258E-04  4.799E-04  2.641E-05  7.281E-06  1.765E-05

OXYGEN      2.315E-01  2.318E-01  2.312E-01  2.109E-01  1.635E-01  1.253E-01  1.228E-01  1.216E-01  1.218E-01  1.239E-01  1.271E-01
            1.321E-01  1.373E-01  1.427E-01  1.485E-01  1.571E-01  1.679E-01  1.687E-01  1.609E-01  1.516E-01  1.443E-01  1.306E-01
            1.341E-01  1.313E-01  1.295E-01  1.274E-01  1.301E-01  1.734E-01  1.507E-01  2.143E-01  2.314E-01  2.319E-01  2.316E-01

H2O         1.192E-04  4.637E-05  1.940E-04  6.271E-03  2.951E-02  3.541E-02  3.639E-02  3.672E-02  3.591E-02  3.214E-02  3.392E-02
            3.234E-02  3.064E-02  2.895E-02  2.710E-02  2.665E-02  2.955E-02  2.831E-02  2.325E-02  2.634E-02  2.863E-02  3.052E-02
            3.201E-02  3.302E-02  3.348E-02  3.374E-02  3.350E-02  1.775E-02  7.700E-02  6.894E-03  1.552E-04  3.251E-05  9.435E-05

OH          9.578E-07  3.727E-07  1.543E-06  5.212E-05  1.093E-03  1.227E-03  1.033E-03  1.014E-03  1.724E-03  1.635E-03  1.486E-03
            1.314E-03  1.149E-03  9.996E-04  8.596E-04  6.579E-04  4.333E-04  4.229E-04  5.909E-04  8.139E-04  9.999E-04  1.167E-03
            1.300E-03  1.418E-03  1.497E-03  1.535E-03  1.518E-03  1.409E-03  8.403E-04  3.451E-05  1.876E-06  2.375E-07  6.570E-07

O           3.033E-06  9.376E-07  5.979E-06  1.961E-04  1.760E-03  2.953E-03  2.061E-03  2.008E-03  1.993E-03  1.306E-03  1.710E-03
            1.617E-03  1.346E-03  1.484E-03  1.464E-03  1.361E-03  1.212E-03  1.215E-03  1.347E-03  1.493E-03  1.562E-03  1.627E-03
            1.656E-03  1.767E-03  1.890E-03  1.954E-03  1.942E-03  1.914E-03  1.640E-03  1.324E-04  3.508E-06  6.385E-07  2.072E-06

H           2.070E-07  5.043E-08  3.651E-07  1.606E-05  3.720E-05  4.361E-05  4.430E-05  4.193E-05  3.961E-05  3.625E-05  3.360E-05
            3.096E-05  2.922E-05  2.779E-05  2.694E-05  2.568E-05  2.524E-05  2.568E-05  2.700E-05  2.900E-05  2.960E-05  3.095E-05
            3.302E-05  3.464E-05  3.790E-05  4.055E-05  4.071E-05  4.032E-05  3.552E-05  1.269E-05  7.447E-07  3.145E-08  1.381E-07

H2          5.639E-06  2.199E-06  9.079E-06  1.229E-04  4.054E-05  4.001E-05  6.300E-05  6.138E-05  5.753E-05  5.320E-05  4.775E-05
            4.181E-05  3.689E-05  3.268E-05  2.980E-05  2.394E-05  1.889E-05  1.077E-05  2.293E-05  2.891E-05  3.354E-05  3.817E-05
            4.271E-05  4.648E-05  5.071E-05  5.325E-05  5.776E-05  4.979E-05  3.414E-05  1.490E-04  8.733E-06  2.031E-06  5.382E-06

N           2.357E-19  5.092E-21  4.048E-19  2.932E-16  4.384E-13  4.504E-12  4.616E-12  6.606E-12  5.978E-12  4.268E-12  3.293E-12
            1.843E-12  9.416E-13  4.603E-13  2.005E-13  5.040E-14  5.192E-15  4.262E-15  2.511E-14  1.316E-13  3.942E-13  8.850E-13
            1.576E-12  2.194E-12  2.479E-12  2.604E-12  7.546E-12  1.431E-12  1.097E-13  7.634E-17  1.067E-19  5.762E-21  5.600E-20

NO          8.996E-12  1.672E-12  1.632E-11  1.644E-09  5.006E-09  3.355E-07  4.920E-07  5.181E-07  5.019E-07  4.673E-07  3.488E-07
            2.438E-07  1.837E-07  1.067E-07  4.379E-08  2.677E-08  5.304E-09  1.265E-09  6.300E-09  2.973E-09  4.401E-08  7.917E-08
            1.203E-07  1.528E-07  1.843E-07  1.622E-07  1.490E-07  9.826E-08  1.040E-09  2.620E-10  2.731E-12  2.606E-13  1.496E-12

KF          0.         4.759E+00  2.295E+00  4.020E+03  9.479E+03  1.140E+01  1.546E+02  1.040E+03  2.033E+01  2.222E+01  2.067E+01
            3.512E+01  4.503E+01  5.425E+01  6.150E+01  4.637E+01  5.944E+01  5.091E+01  5.144E+01  4.587E+01  3.724E+01  2.953E+01
            2.453E+01  2.247E+01  2.132E+01  1.645E+01  1.627E+01  1.155E+01  8.163E+00  3.911E+00  7.774E+03  4.781E+00  0.

LEN         0.         2.869E-04  1.496E-04  2.009E-04  3.979E-04  5.398E-04  5.979E-04  6.677E-04  7.300E-04  7.856E-04  8.019E-04
            7.745E-04  7.452E-04  7.226E-04  7.002E-04  4.434E-04  5.045E-04  5.798E-04  6.187E-04  6.659E-04  7.893E-04  7.497E-04
            7.735E-04  7.564E-04  7.131E-04  6.560E-04  5.011E-04  5.019E-04  3.776E-04  1.996E-04  1.495E-04  2.853E-04  0.

N2          7.679E-01  7.679E-01  7.679E-01  7.610E-01  7.648E-01  7.615E-01  7.409E-01  7.423E-01  7.435E-01  7.440E-01  7.452E-01
            7.464E-01  7.477E-01  7.470E-01  7.563E-01  7.579E-01  7.545E-01  7.557E-01  7.531E-01  7.507E-01  7.494E-01  7.403E-01
            7.481E-01  7.485E-01  7.501E-01  7.593E-01  7.459E-01  7.647E-01  7.515E-01  7.629E-01  7.676E-01  7.580E-01  7.679E-01

TEMP        5.944E+02  5.910E+02  5.962E+02  7.920E+02  1.419E+03  1.575E+03  1.590E+03  1.590E+03  1.593E+03  1.580E+03  1.552E+03
            1.513E+03  1.470E+03  1.425E+03  1.375E+03  1.302E+03  1.107E+03  1.190E+03  1.269E+03  1.351E+03  1.413E+03  1.463E+03
            1.500E+03  1.522E+03  1.527E+03  1.531E+03  1.590E+03  1.499E+03  1.239E+03  7.554E+02  5.949E+02  5.907E+02  5.936E+02

AMU(I)      3.084E-05  2.175E-04  6.795E-05  9.047E-05  1.399E-04  1.909E-04  2.853E-04  3.663E-04  4.675E-04  5.194E-04  6.150E-04
            7.279E-04  8.456E-04  9.513E-04  1.042E-03  1.097E-03  9.745E-04  8.933E-04  9.973E-04  9.337E-04  7.421E-04  6.553E-04
            5.842E-04  5.250E-04  4.676E-04  3.957E-04  3.095E-04  2.119E-04  1.431E-04  9.280E-05  4.802E-05  2.165E-04  3.081E-05
PLOT AT XU=  7.300E-02, ISTEP=  120

X-AXIS IS Y(I)          ,MAXIMUM VALUE = 4.570E-02
Y-AXES ARE          VELOCITY    FUEL        CO          OXYGEN      TEMP
SYMBOL                 U          1           3            4          T
MAXIMUM VALUES       4.621E+01   1.416E-03   2.756E-03   2.315E-01   1.590E+03
```

Figure 27. Emission Model Output.

	1 TITLE	80
	FUEL INSERTION MODEL EXAMPLE	

	* ATOM TYPE	** AIR ASSIST	PRIM FLOW NO. (JP4) PPH/$\sqrt{PSI}$	SEC. FLOW NO. (JP4)	CONE ANGLE DEG	AIR ASSIST SHROUD EFF AREA IN^2	PRIM ORIFICE DIA, IN	SEC ORIFICE DIA, IN	
	1 →	6 →	11	21	31	41	51	61	71 80
2	3	1	10.		90.				

*ATOMIZER TYPE: 00001 = SIMPLEX
00002 = DUAL ORF
00003 = AIR BLAST

**AIR ASSIST: 00001 = NO ASSIST
00002 = WITH ASSIST

*FOR ATOM TYPE = 00002 (DUAL ORIF) ONLY (LEAVE OUT FOR OTHERS)
INPUT SECONDARY FLOW SCHEDULE

W_S = SECONDARY FUEL FLOW, LB/HR

$\Delta P_S = \Delta P_{SEC.\ ORIF} + \Delta P_{FLOW\ DIVIDER\ VALVE'}$ P/D

	CRACK POINT FLOW W_{S1}	W_{S2}	W_{S3}	W_{S4}	W_{S5}	
	1	11	21	31	41	51
3						

	CRACK PRESSURE ΔP_1	ΔP_2	ΔP_3	ΔP_4	ΔP_5	
	1	11	21	31	41	51
4						

*FOR ATOM TYPE = 00003 (AIRBLAST) ONLY (LEAVE OUT FOR OTHERS)

	FILMING DIA IN.	NOZZLE AIRFLOW LB/SEC	FLOW AREA IN^2	AIR TEMP °R	
	1	11	21	31	
5	0.5	.05	.2	1060.	

Figure 28. Fuel Insertion Model Input (1 of 3)

	*** FUEL TYPE 1 →	**** AIR FLOW OPTION 6 →	FUEL TEMP °R 11	FUEL FLOW LB/HR 21	FUEL ΔP PSI 31	AIR ASSIST ΔP PSI 41	AIR ASSIST TEMP °R 51	61	71
6	2	2	520.	60.					

***FUEL TYPE
00002=JP5
00004=JP4

****AIR FLOW OPTION
00001=UNIFORM GAS STREAM
00002=2-D FIELD OPTION

	T_{GAS}, °R 1	V_{GAS}, 11 FPS	P_{GAS}, 21 PSIA	X_{MAX}, 31 IN.	Y_{MAX}, 4 °R	51		
7	.2	.2	14.7	5.0	1.5			
	↑ X_{NOZ} ℄ IN.	↑ Y_{NOZ} ℄ IN.	↑ P_{GAS} PSIA	↑ X_{MAX} IN.	↑ Y_{MAX} IN.			

← UNIFORM STREAM OPTION (upper labels)

← Z-D FIELD OPTION (lower labels)

CARDS 8 THROUGH 13 SKIPPED IF AIR FLOW OPTION = 00001

IN = NO. OF X-DIR POINTS IN 2-D FIELD
JN = NO. OF Y- DIR POINTS

	IN	JN	(2(I2, 8X))					
8	03	03						

X VALUES (8E10.4) X - LOCATIONS OF GRID POINTS (FT)

9	0.	.2083	.4167					

Y VALUES (8E10.4) Y - LOCATIONS OF GRID POINTS (FT)

10	0.	.0625	.125					

U VALUES (8E10.4) READ ALONG + X LINES STARTING WITH SMALLEST Y VALUE (FT/SEC)

11	30.	75.	100.					
	35.	80.	110.					

40.	85.	115.					

Figure 28. Fuel Insertion Model Input (2 of 3)

V VALUES (8E10.4) READ ALONG + X LINES STARTING WITH SMALLEST Y VALUE (FT/SEC)

12

0.	0.	0.					

0. 0. 0.

0.	0.	0.					

T VALUES (8E10.4) READ ALONG + X LINES STARTING WITH SMALLEST Y VALUE (DEG. R)

13

1060	1060	1060					

1060 1060 1060

1060	1060	1060					

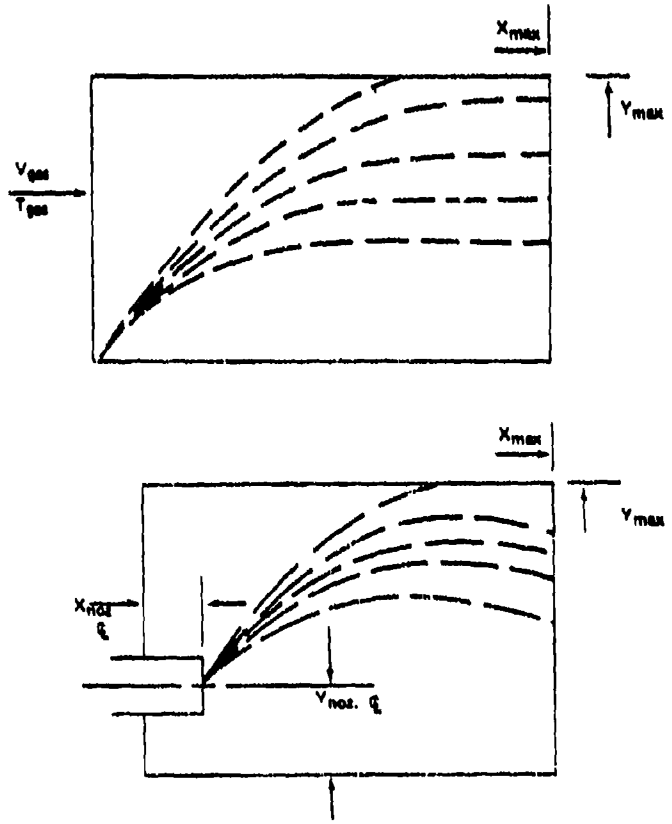


Figure 28. Fuel Insertion Model Input (3 of 3)

nozzle types. The values of Card 7 can have two meanings, depending on the type of flow field. In this case, they give the X and y location of the origin of the spray, the pressure, and limits of the two-dimensional grid. Cards 8 through 13 are required in this example, and it can be seen that only a 3 X 3 grid was used which requires 9 values of U, V, and temperature.

The program output is illustrated in Figures 29 and 30. The first items printed are some of the input quantities, along with the specific gravity and viscosity of the specified fuel. The fuel ΔP and velocity are given next, along with the calculated value of SMD. For each of the five droplets, the locations are then given at the point that selected fractions of the fuel that had evaporated. In this case, droplets 1 and 2 evaporated within the specified boundaries. Figure 30 shows the trajectory output for each of the five droplets. The output consists of a pair of lines, the first giving the X and Y location of the droplet and the second giving the diameter, temperature, velocity, and fraction evaporated.

```
 FUEL INSERTION MODEL EXAMPLE

AIRBLAST ATOMIZER, CONE ANGLE =    90.0
WITHOUT AIR ASSIST
FILM DIA, NOZZLE AIRFLOW, FLOW AREA,T3S,     .5000     .0500     .7009 1060.0000
 NFUEL IGPT TFUEL PPH DELP DELPSH TSM =     2    2 520.00000  60.00000  -0.00000  -0.00000  -0.00000
ARBITRARY FLOW OPTION, X START, Y START, P GAS, X MAX, Y MAX =     .20000     .20000 147.00000    5.00000    1.50000

SG=   .8260E+00 (DMLS)     VISC FUEL=   .2492E+01 CENTISTOKES


DELTA P (1)=      30.00      PPH (1)=      60.00
DELTA P (2)=       0.0C      PPH (2)=       0.00
DELTA P (V)=       0.00        VFUEL=      74.39
SMD=       41.20

AIR/FUEL MASS RATIO=        3.000 EFF. AIR VELOCITY=

DROPLET  1 E= .10      X1, X2=   .43062   .36682 IN

DROPLET  1 E= .20      X1, X2=   .52314   .40377 IN

DROPLET  1 E= .30      X1, X2=   .50326   .42652 IN

DROPLET  1 E= .40      X1, X2=   .68542   .44966 IN

DROPLET  1 E= .50      X1, X2=   .77486   .45777 IN

DROPLET  1 E= .60      X1, X2=   .87766   .47021 IN

DROPLET  1 E= .70      X1, X2=  1.00161   .48158 IN

DROPLET  1 E= .80      X1, X2=  1.16126   .49217 IN

DROPLET  1 E= .90      X1, X2=  1.38888   .50199 IN

DROPLET  1 E= .95      X1, X2=  1.56262   .50668 IN
DROPLET  1 HAS EVAPORATED

DROPLET  2 E= .10      X1, X2=   .65474   .49756 IN

DROPLET  2 E= .20      X1, X2=   .84873   .56477 IN

DROPLET  2 E= .30      X1, X2=  1.01970   .66716 IN

DROPLET  2 E= .40      X1, X2=  1.19730   .63969 IN

DROPLET  2 E= .50      X1, X2=  1.39640   .66632 IN

DROPLET  2 E= .60      X1, X2=  1.63604   .68880 IN

DROPLET  2 E= .70      X1, X2=  1.94389   .70746 IN

DROPLET  2 E= .80      X1, X2=  2.36680   .72219 IN

DROPLET  2 E= .90      X1, X2=  3.02991   .73325 IN

DROPLET  2 E= .95      X1, X2=  3.56925   .73771 IN
DROPLET  2 HAS EVAPURATED

DROPLET  3 E= .10      X1, X2=   .88633   .61133 IN
```

Figure 29. Fuel Insertion Model Output.

```
0 -  20 / VOLUME          20 -  40 / VOLUME         40 -  60 / VOLUME         60 -  80 / VOLUME         80 - 100 / VOLUME

     25.667                    38.397                    49.614                    59.737                    78.277 MICRONS

  X          Y              X          Y              X          Y              X          Y              X          Y
D    TF   VF  E*100 /     D    TF   VF  E*100 /     D    TF   VF  E*100 /     D    TF   VF  F*100 /     D    TF   VF  E*100 /


 .20        .20            .20        .20            .21        .20            .20        .20            .20        .20
26.  520.  74.   0. /     38.  520.  74.   0. /     49.  520.  74.   0. /     60.  520.  74.   0. /     78.  520.  74.   0. /
 .24        .23            .24        .23            .24        .23            .31        .30            .31        .30
26.  576.  62.   0. /     39.  547.  64.   0. /     49.  539.  66.   0. /     60.  561.  57.   0. /     79.  547.  59.   0. /
 .27        .27            .27        .27            .27        .27            .39        .36            .39        .37
26.  617.  54.   1. /     39.  573.  57.   0. /     49.  557.  60.   0. /     60.  597.  51.   0. /     79.  564.  54.   0. /
 .31        .30            .31        .30            .31        .30            .47        .42            .47        .43
26.  659.  48.   2. /     39.  599.  52.   0. /     49.  574.  55.   0. /     61.  612.  47.   1. /     79.  582.  50.   0. /
 .36        .33            .35        .33            .35        .33            .55        .47            .55        .48
26.  697.  45.   4. /     39.  623.  49.   1. /     49.  593.  51.   0. /     61.  635.  45.   1. /     79.  598.  47.   0. /
 .40        .35            .39        .36            .39        .36            .64        .52            .63        .54
26.  729.  42.   7. /     39.  646.  47.   1. /     49.  610.  49.   1. /     61.  656.  44.   2. /     79.  614.  46.   1. /
 .44        .37            .43        .39            .43        .39            .73        .57            .72        .58
26.  756.  40.  11. /     39.  667.  45.   2. /     49.  627.  47.   1. /     61.  676.  44.   3. /     79.  629.  45.   1. /
 .49        .39            .48        .41            .47        .42            .82        .61            .81        .63
25.  779.  40.  16. /     39.  687.  44.   3. /     49.  643.  45.   1. /     61.  694.  44.   4. /     80.  643.  45.   1. /
 .54        .41            .52        .44            .52        .44            .92        .65            .90        .67
25.  797.  40.  22. /     39.  705.  43.   5. /     49.  657.  44.   2. /     61.  710.  44.   5. /     80.  657.  45.   2. /
 .58        .42            .57        .46            .56        .47           1.01        .68            .99        .71
24.  811.  40.  28. /     39.  721.  42.   6. /     49.  671.  44.   2. /     60.  724.  45.   7. /     80.  669.  46.   2. /
 .63        .43            .61        .48            .60        .49           1.10        .71           1.09        .75
24.  822.  41.  34. /     39.  736.  42.   8. /     49.  684.  43.   3. /     60.  737.  46.   8. /     80.  681.  46.   3. /
 .68        .44            .66        .50            .65        .51           1.20        .74           1.18        .78
23.  831.  42.  40. /     39.  750.  42.  10. /     49.  697.  43.   4. /     60.  749.  48.  10. /     80.  691.  47.   4. /
 .73        .45            .70        .52            .69        .53           1.30        .77           1.28        .81
22.  838.  43.  45. /     38.  762.  42.  12. /     49.  708.  43.   5. /     60.  760.  49.  12. /     80.  701.  49.   4. /
 .78        .46            .75        .53            .74        .55           1.39        .79           1.37        .84
21.  844.  44.  51. /     38.  773.  42.  15. /     49.  719.  43.   6. /     59.  770.  50.  14. /     79.  710.  50.   5. /
 .83        .46            .80        .55            .79        .57           1.49        .81           1.47        .87
21.  849.  45.  56. /     38.  783.  43.  17. /     49.  729.  43.   7. /     59.  778.  52.  16. /     79.  719.  51.   6. /
 .88        .47            .85        .56            .83        .59           1.59        .83           1.56        .89
20.  853.  46.  60. /     37.  792.  44.  20. /     49.  739.  43.   9. /     59.  786.  54.  18. /     79.  727.  53.   7. /
 .93        .48            .89        .58            .88        .61           1.69        .85           1.66        .91
19.  857.  47.  65. /     37.  800.  44.  23. /     49.  748.  44.  10. /     58.  793.  55.  20. /     79.  734.  54.   8. /
 .98        .48            .94        .59            .93        .63           1.79        .87           1.76        .94
18.  860.  47.  68. /     37.  806.  45.  26. /     49.  756.  44.  11. /     58.  799.  57.  23. /     79.  741.  56.   9. /
1.03        .48            .99        .60            .97        .64           1.88        .89           1.86        .96
18.  864.  48.  72. /     36.  812.  46.  28. /     48.  764.  45.  13. /     57.  805.  58.  25. /     79.  748.  57.  10. /
1.08        .49           1.04        .61           1.02        .66           1.98        .90           1.96        .97
17.  867.  49.  75. /     36.  818.  47.  31. /     48.  771.  45.  14. /     56.  810.  60.  27. /     78.  754.  59.  11. /
1.13        .49           1.09        .62           1.07        .67           2.08        .91           2.05        .99
16.  870.  50.  78. /     35.  823.  48.  34. /     48.  778.  46.  16. /     56.  815.  62.  30. /     78.  760.  60.  12. /
1.18        .49           1.14        .63           1.12        .68           2.18        .93           2.15       1.01
16.  873.  51.  81. /     35.  827.  49.  37. /     48.  784.  47.  17. /     55.  819.  63.  32. /     78.  765.  62.  13. /
1.23        .50           1.19        .64           1.17        .70           2.28        .94           2.25       1.02
15.  875.  52.  83. /     34.  831.  50.  40. /     47.  790.  47.  19. /     55.  823.  65.  34. /     78.  770.  63.  14. /
1.28        .50           1.24        .65           1.22        .71           2.38        .95           2.35       1.04
14.  878.  53.  86. /     34.  834.  51.  42. /     47.  795.  48.  21. /     54.  826.  67.  36. /     77.  775.  65.  15. /
```

Figure 30. Fuel Insertion Model Output.

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APPENDIX A
INPUT SHEETS

ANNULUS LOSS MODEL INPUT SHEET

	TITLE - MUST HAVE FOR EACH CASE	ITER	IPIC	IDBUG
	1	78	79	80
1				

ANNULUS INLET FLOW CARD

		NEL	NELI	W1	PT1	TT1	BETA1	DP/P		
	1	345	678	11	21	31	41	51	61	71
2	H								—	—

DOME INLET FLOW CARD (REQUIRED FOR INTERNAL LINER FLOW ONLY)

		NELI	W	PT	TT	BETA			
	12	678	11	21	31	41	51	61	71
3	ID						—	—	—

CONSTANTS CARD

			FRIC	BLKF	TANS	CDB	SK	RG	IREAX
	1		11	21	31	41	51	61	71
4	C	—							

1 Title - Run ident appears on printed output and plot

ITER = 1 some (or all) holes fixed, inlet flow fixed, iterate to get pressure drop.
ITER = 2 some (or all) holes fixed, pressure drop fixed iterate to get inlet flow (input W1 is first guess).

IPIC = 0 no plot
IPIC = 1 plot drawn

IDBUG = 0 output printed after converged solution
IDBUG = 1 output printed after each iteration | Use only to debugg
IDBUG = 2 output printed after each element | non-convergence

2 3 NEL = total number of element stations (card 2 only)
NELI = element ID no. (NELEM) at annulus or dome inlet 2 and 3
W_1 and W = air flow at inlet stations, lb/sec
PT_1 and PT = inlet total pressure, PSIA
TT_1 and TT = inlet total temperature, R
$Beta_1$, Beta = swirl angle at inlet
DP/P = total pressure drop, PSIA/PSIA (first guess if ITER = 1) card 2 only

4 FRIC = 0, smooth wall friction factor
FRIC -1, no wall friction
FRIC = roughness factor for rough walls
BLKF = annulus effective area factor (≈ .83 for fully developed turbine flow)
TANS = tangent of flow separation spread angle (.1 recommended)

CDB = drag coefficient of struts across annulus (1 → 1.2 RECM)
SK = ratio of air specific heats,
RG = air gas constant
IREAX = 0. for reverse flow annular or can combustors
IREAX = 1. for axial flow annular. First data set is for OD panel. Program expects a second set for ID panel

CASE TERMINATION

After last card of case:

o In Column 1, Column 2 blank - case repeated with changes, next card is title card followed by cards with changes from previous run.

oo In Columns 1 and 2, next card is EOF to quit or new title card followed by all cards for complete new case.

		NELEM									
L				XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	I			XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	C			XP	RP	XL	RL	CL	T RISE		
F	F			W/W1	N HOLES	NHTYP	CD		I SEP		
F	D			W/W2	N HOLES	NHTYP	CD	D HOLES	I SEP		
F	B			W/W1					I SEP		
F	I			WINJ/W	V JET	ANG 1	ABETA		I SEP		

	1	2	345		11	21	31	41	51	61	71	76
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
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36												
37												
38												
39												
40												

PROGRAM 117 INPUT DATA SHEET

INPUT FORMAT FOR ELEMENT CARDS - SHEET 2

NELEM

ALL NUMBERS MUST HAVE
DECIMAL POINTS

1	2	3 4 5		11	21	31	41	51	61	71	76
L		0 0 1		XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	I	0 0 2		XP	RP	XL	RL	CL	T LINER	BLK I	DBK I
L	C	0 0 3		SP	RP	XL	RL	CL	T RISE	--	--
F	F	0 0 4		W/W1	N HOLES	NHTYP	CD	--	I SEP	--	--
F	D	0 0 5		W/W1	N HOLES	NHTYP	CD	D HOLES	I SEP	--	--
F	B	0 1 0		W/W1	--	--	--	--	I SEP	--	--
F	I	0 2 0		W/INJ/W	V JET	ANGJ	ABETA	--	I SEP	--	--

ELEMENT SPECIFICATION

Flow passage is divided into length (L) and flow (F) elements, element numbers, NELEM, can be in arbitrary order, i.e., 10, 1, 3, 4, 16, 30. The cards are stacked in order from inlet to last F because numbers are arbitrary, a new element can be inserted without renumbering other cards.

L. LENGTH ELEMENTS

All Dimensions in Inches

First L card is annulus inlet (CL = 0) - For both external and internal cases.

Internal and external flow cases must be run separately

For internal cases, 2nd card is dome inlet (LI) and LC cards are used with T RISE = ΔT due to combustion in this element (no L cards)

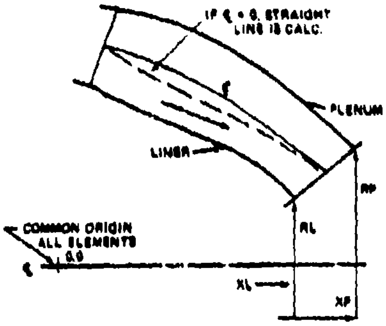
For external cases use only L Cards

XL, XP = X COORD to end of element   L = Liner
RL, RP = Radius to end of element   P = Plenum
(For internal flow XP, RP = OD, XL, RL = ID)
CL = Length of element (optional)
TLIN = Mean wall temp. over CL, °R
If = 0 then TLIN = TT1

$$\text{BLKI} = \frac{\text{Frontal Area of Struts}}{\text{Annulus Area}}$$

DBKI = Width of strut

LENGTH ELEMENT



F. ORIFICE FLOW ELEMENT

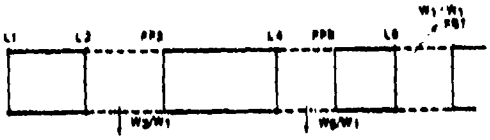
F Cards are inserted between L cards at points where flow is extracted. Flow conditions into F elem. are those from upstream L elem.

Types: FF = Fixed Flow Ratio, W/W1
FD = Fixed Orf. Diam. (W/W1 is First Guess)
FB = Bleed flow (not included in liner flow)
FI = Internal flow elem. (input to these elements is obtained from an external flow solution)

W/W1 = Orifice Flow/Inlet Flow
NHOLES = No. of Orifices
NHTYP = Hole Type (For CD)
1. Flush Hole, Thin Wall
2. Plunged Hole
3. Cooling Skirt
4. Flush Hole, Thick Wall
5. CD Input
6. Rectangular Hole

CD = DISCH Coefficient (NHTYP = 5 Only)
DHOLES = Hole Diam. (For FD Only)
I SEP = 1, Separation is Reattached
VJET = Jet Injection Velocity, FPS
ANGJ = Jet Injection Angle, Deg.
ABETA = Swirl Angle in Annulus Outside FI Elem.

FLOW ELEMENTS



3D COMBUSTOR PERFORMANCE MODEL

22 VARIABLE TITLE CARDS (4A10) SAME ORDER AS IMPRINT

1								

CASE TITLE CARD (8A10)

2								

	LP1	MP1	LP1	IPLAX	MODEL	MODER	IPAR	ITRAD
3								

	IU	MODEN	INTAPE	IDW	IRES			
4								

<u>ISOLVE</u> (8(I2, 8X))

	U	V	W	P'	KE	ϵ	Φ	MFU
5								

	MCO	$\tilde{h}$	FX	FY	FZ			

ICTDMA (8(I2, 8X))

	U	V	W	P'	KE	ϵ	Φ	MFU
6								

	MCO	$\tilde{h}$						

IMPRINT (8(I2, 8X))

	U	V	W	PRESS	KE	f_m	Φ	MFU
7								

TEMP	$\tilde{h}$	Favg	Fx	Fy	Fz	MCO	MH20

MO2	MCO2	MN2	μEFF	DENSITY	EVAP		

RELAXATION PARAMETERS (8E10.4)

8

U	V	W	P'	KE	ϵ	Φ	MFU

MCO	$\tilde{h}$	Fx	Fy	Fz	PRESS	DENSITY	VISCOS

LAMINAR PRANDTL NUMBERS (8E10.4)

9

U	V	W	P'	KE	ϵ	Φ	MFU

MCO	$\tilde{h}$						

TURBULENT PRANDTL NUMBERS (8E10.4)

10

U	V	W	P'	KE	ϵ	Φ	MFU

MCO	$\tilde{h}$						

X-COORDINATES (1-LP1) (8E10.4)

11

RI Y-COORDINATES (2-MP1) (8E10.4)

12

Z-COORDINATES (1-NP1) (8E10.4)

13

IWEI JWIO (2(I2,8X))

14

IWLI VALUES (8(I2,8X)) (SKIP 15 AND 16 IF IWEI = 2)

15

JWLO VALUES (8(I2, 8X))

16								

(8E10.4)

	PRESS	DEN	ABSOR	SCATR	AKFAC	ALFAC		
17								

(8E10.4)

	CX	HY	HFU	FUMCO				
18								

(8E10.4)

	PREXP1	ARCON1	CR1	PREXP2	ARCON2	CR2		
19								

(8E10.4)

	C1	C2	CD	AMU	ERROR	TCYLW	TINLW	TLIP
20								

(2(I3, 7X), 6(I2, 8X)

	LASTEP	IJUMP	JSW1	JSW2	NUINJ	NVINJ		
21								

(8E10.4)

	USW	VSW	SWNO	AFSW	FSW	TSW		
22								

	NFNZ	ISPRAY	TFUEL					
23								

	XO	YO	ZO	ALFA	BETA	DELTA	THETA 1	THETA 2
24								

(SKIP 24 IF NFNZ = 00)

RSP	WF	SMD	VFUEL				

(SKIP CARDS 25 → 30 IF NUINJ = 00)

I - LOCATION OF COOLING SLOTS (8(I2, 8X))

25								

J - LOCATION OF COOLING SLOTS (8(I2, 8X))

26								

AXIAL SLOT VELOCITY (8E10.4)

27								

TANG. SLOT VELOCITY (8E10.4)

28								

SLOT FLOW RATE (8E10.4)

29								

SLOT TEMPERATURE (8E10.4)

30								

(SKIP CARDS 31 → 38 IF NVINJ = 00)

I - LOCATION OF RADIAL INJECTION (8(I2.8X))

31								

J - LOCATION OF RADIAL INJECTION (8(I2, 8X))

32								

K - LOCATION OF RADIAL INJECTION (8(I2, 8X))

33								

INJECTION VELOCITY (8E10.4)

34								

INJECTION TURBULENT KINETIC ENERGY (8E10.4)

35								

INJECTION TURBULENT LENGTH SCALE (8E10.4)

36								

INJECTION FLOW RATE (8E10.4)

37								

INJECTION TEMPERATURE (8E10.4)

38								

3D COMBUSTOR PERFORMANCE MODEL
INPUT SHEET DESCRIPTION

Card Set	Description
1	Each card is a heading for a particular three-dimensional array that is printed out. These never change.
2	Case title card
3	LPI - Number of grid nodes in axial (x) dir. MPI - Number of grid nodes in radial (y) dir. NPI - Number of grid nodes in tang. (z) dir. IPLAX - 01 For plane geometry - 02 For axisymmetric geometry MODEL - 01 For laminar viscosity - 02 For K-E viscosity model MODER - 01 For kinetic controlled combustion - 02 For kinetic and turbulence controlled combustion IPAR - 01 For absolute pressure - 02 For relative pressure ITRAD - 01 No radiation - 02 With radiation
4	IU - 01 Input units are international system (i.e., meters, kilograms, degrees kelvin, newtons, joules, radians, seconds or combinations thereof) - 02 User selected input units MODEN - 01 Density is fixed at the value of "Den" on Card 17 - 02 Density calculated from perfect gas law INTAPE - 00 Initial conditions not printed - 08 Initial conditions printed IDW - 00 Inner boundary is axis of symmetry - 01 Inner boundary is wall IRES - 00 This is a new case - 01 This is a restart of previous case
5	An 01 in proper field indicates that this particular variable will be solved for; an 00 indicates that it will not be.
6	Indicates the number of "sweeps" made in the solve routine for each variable.

7 An 01 indicates that this variable will be printed, an 00 indicates that it will not be.

8 Relaxation parameters for each variable.

9 Laminar Prandtl numbers for each variable.

10 Turbulent Prandtl numbers for each variable.

11 X-coordinates (LPI values)

12 RI - Radius of inner boundary
Y-coordinates as measured from inner boundary (MP1-1) values. Since Y(1) is always 00, RI is read in its place.

13 Z - coordinates (NPI values)

14 IWEI - I-node at which inclined wall ends
JWIO - J-node at which inclined wall starts

15 IWLI - Starting I-nodes of the calculation domain when inclined wall is present

16 JWLO - Ending J-nodes of the calculation domain when inclined wall is present

17 PRESS - System pressure
DEN - The value of density if option MODEN = 01 is selected
ABSOR - Absorption coefficient in radiation model
SCATR - Scattering coefficient in radiation model
AKFAC - Internally defined turbulent kinetic energies are AKFAC times the appropriate velocity squared
ALFAC - Internally defined turbulent length scales are ALFAC times the appropriate distance

18 CX - Carbon atoms in fuel molecule
HY - Hydrogen atoms in fuel molecule
HFU - Heat of formation of fuel
FUMCO - Initial value assigned to M_{CO}

19 PREXPI - Preexponent of 1st reaction
ARCONI - Activation energy divided by gas constant of 1st reaction (E/R)
CR1 - Constant in turbulence controlled reaction rate for 1st reaction
PREXP2 - Preexponent of 2nd reaction

ARCON2 - Activation energy divided by gas constant of 2nd reaction (E/R)
CR2 - Constant in turbulence controlled reaction rate for 2nd reaction

20 C1 - Turbulence model constant
C2 - Turbulence model constant
CD - Turbulence model constant
AMU - The value of the viscosity if option model = 01 is specified. Also the laminar viscosity used in the "wall functions"
ERROR - Program will terminate if total error in mass becomes less than this value
TCYLW - Temperature of cylindrical portion of combustor wall
TINLW - Temperature of inclined wall portion of combustor and of dome.
TLIP - Temperature of cooling slot lip.

21 LASTEP - Maximum number of iterations
IJUMP - Number of iterations between array printout
JSW1 - J-node at start of dome inlet
JSW2 - J-node at end of dome inlet
NUINJ - Number of axial injection points (cooling slots)
NUINJ - Number of radial injection points

22 USW - Axial velocity of dome inlet
VSW - Radial velocity of dome inlet
SWNO - Ratio of tangential to axial velocity at dome inlet
AFSW - Flow rate of fuel and air through dome inlet
FSW - Flow rate of fuel through dome inlet
TSW - Temperature at dome inlet

23 NFNZ - 00 No liquid fuel nozzle
- 01 Liquid fuel nozzle present
ISPRAY - Droplet evaporation routine is called every ISPRAY iterations
TFUEL - Initial temperature of liquid fuel

24 XO - X-location of origin of fuel nozzle spray
YO - Y-location of origin of fuel nozzle spray
ZO - Z-location of origin of fuel nozzle spray
ALFA - Nozzle cone angle
BETA - Nozzle back angle
DELTA - Nozzle down angle
THETA1 - Initial spray cone segment angle
THETA2 - Final spray cone segment angle

RSP - Number of spray cone rays
WF - Fuel flow rate
SMD - Sauter mean diameter
VFUEL - Initial fuel droplet velocity

25 I node location of cooling slots

26 J node location of cooling slots

27 Cooling slot axial velocity

28 Cooling slot tangential velocity

29 Cooling slot mass flow rate

30 Cooling slot temperature

31 I node location of radial injection

32 J node location of radial injection

33 K node location of radial injection

34 Radial injection velocity

35 Radial injection turbulent kinetic energy

36 Radial injection turbulence length scale

37 Radial injection mass flow rate

38 Radial Injection temperature

LINER COOLING MODEL INPUT SHEET

CASE TITLE (12A6)

1								

CASE TITLE (12A6)

(8 (I2, 8X)

	N	KRAD	MASSTR	ISWRL	MODEL	INERT	IFLUX	ITEMP
2								

(5 (I5.5X)

	NSTAT	NPROF	NPLOT	ITEST	LASTEP			
3								

(8E10.4)

	XU	XULAST	FRA	XEND	XOUT	PRESS	POWER	
4								

(I2)

	NBP							
5								

(8E10.4)

	X_1	RI_1	RE_1	X_2	RI_2	RE_2	X_3	RI_3
6								

(8E10.4)

RE_3	X_4	RI_4	RE_4	X_5	RI_5	RE_5...	

(8E10.4)

	RA	RB	RD					
7								

	NAME LIST							
8	$INPUT							$

	UA	UD					(8E10.4)	
9								

	F2A	F2D	TA	TD	T_{wall}		(8E10.4)	
10								

	NIN						(I2)	
11								

	Y VALUES						(8E10.4)	
12								

	U VALUES						(8E10.4)	
13								

							(8E10.4)	
14								

	TEMPERATURE VALUES						(8E10.4)	
15								

	MFU VALUES						(8E10.4)	
16								

	PHI VALUES						(8E10.4)	
17								

MCO VALUES (8E10.4)

18								

TURBULENT KINETIC ENERGY (8E10.4)

19								

TURBULENCE LENGTH SCALE (8E10.4)

20								

(8E10.4)

	$VELA_I$	$VELA_O$	TAN_I	TAN_O	PR_I	PR_O		
21								

(I2, 8X, 7E10.4)

	NFNZ	XDP	YDP	UF	VF	SMD	WF	TFUEL
22								

LINER COOLING MODEL
INPUT SHEET DESCRIPTION

Card Set		Description
1	Case title cards	
2	N	- Number of cross stream intervals
	KRAD	- 00 For plane geometry 01 For axisymmetric geometry
	MASSTR	- 00 Species equations not solved 01 Species equations solved
	ISWRL	- 00 Always
	MODEL	- 01 Laminar viscosity 02 Two-equation K-E viscosity model
	INERT	- 01 Species are inert 02 Species will react
	IFLUX	- 00 Wall adiabatic 01 Wall temperature calculated
	ITEMP	- 00 Isothermal 01 Enthalpy solved
3	NSTAT	- Number of steps between printout of output variables
	NPROF	- Number of steps between printout of output variables and profiles
	NPLOT	- Number of steps between line-printer plots
	ITEST	- 00 No extra printout 01 Extra printout
	LASTEP	- Maximum number of marching steps
4	XU	- Initial X-location
	XULAST	- Final X-location
	FRA	- Fraction of grid height to be used as step size
	XEND	- X-location of end of inner wall
	XOUT	- X-location of end of outer wall
	PRESS	- Pressure
	POWER	- Control for node spacing
5	NBP	- Number of boundary pairs
6	X_i	- X-Location at which boundary is specified
	RI_i	- Inner boundary radius
	RE_i	- Outer boundary radius
7	RA	- Radius of axis of symmetry
	RB	- Inner boundary radius at initial X-location
	RD	- Outer boundary radius at initial X-location

8 Namelist, see page 158 for variables

9 UA - Axial velocity at "free" inner boundary
UD - Axial velocity at "free" outer boundary

10 F2A - Fuel mass fraction at "free" inner boundary
F2D - Fuel mass fraction at "free" outer boundary
TA - Temperature at "free" inner boundary
TD - Temperature at "free" outer boundary
TWALL - Wall temperature

11 NIN - Number of points on input initial profile

12 Y-values of input initial profile (NIN values)

13 U-values of input initial profile

14 Blank card(s)

15 Temperature values of input initial profile

16 MFU values of input initial profile

17 Total fuel values of input initial profile

18 M_{CO} values of input initial profile

19 KE values of input initial profile
(Read only if KREAD = 1)

20 ℓm Values of input initial profile
(Read only if KREAD = 1)

21 $VELA_I$ - Inner annulus velocity
$VELA_O$ - Outer annulus velocity
TAN_I - Inner annulus temperature
TAN_O - Outer annulus temperature
PR_I - Radius of inner plenum
PR_O - Radius of outer plenum

22 NFNZ - 00 No fuel nozzle
01 Fuel nozzle present
XDP - X-location of fuel nozzle
YDP - Y-location of fuel nozzle
UF - Axial velocity of fuel droplets
VF - Radial velocity of fuel droplets
SMD - Sauter mean diameter
WF - Fuel mass flow rate
TFUEL - Fuel temperature

LINER COOLING MODEL
NAMELIST INPUT

VBL	Value	Description
IUTRAP	2	Test for negative U's, see STRIDE(2)
ULIM	0.05	Entrainment control
PEILIM	0.01	Max. fractional mass flow change per step
AFAC	0.2	Relaxation on duct area deviation
AEXDLM	0.02	Max. duct area fractional deviation per step
NOVEL	2	01-U not solved for, 02-solve for U
ARCON1	28500	Activation energy divided by gas constant for fuel reaction
PREXP1	5E + 15	Preexponent for fuel reaction
CR1	6.0	Eddy breakup constant for fuel reaction
ARCON2	12500	Activation energy divided by gas constant for CO reaction
PREXP2	6E + 8	Preexponent for CO reaction
CR2	4.0	Eddy breakup constant for CO reaction
CP	1048	Specific heat
IPDDX	1	01 - Std genmix pressure grad. calculation 02 - "Grid filling duct" version
C1	1.42	Turb. Constant
C2	1.92	Turb. Constant
CD	0.09	Turb. Constant
C2VT	0.36	Turb. Constant
AKFAC	0.03	Factor for internally generated kinetic energy profiles, KE = AKFAC*U^2
ALFAC	0.02	Factor for internally generated length scale profiles, ℓm = ALFAC*ΔY
PREF	--	Turbulent Prandtl numbers
CX	1.0	Molecular carbon value of fuel
HY	4.0	Molecular hydrogen value of fuel
HFU	-49317	Heat of formation of fuel
MODER	2	1 - Kinetic only, 02 - Kinetic + Diffusion
ITHIN	1	Thins output profiles by printing every ITHIN value
KREAD	0	0 - K & E profiles generated internally 1 - K & ℓm read in
URAT	0.83	Cooling slot velocity shape factor
ABSOR	0.1	Absorption coefficient in radiation model
EMISW	0.8	Emissivity of liner wall

TRANSITION MIXING MODEL INPUT SHEET

CASE TITLE CARD (12A6)

1								

CASE TITLE CARD (12A6)

(8(I2, 8X))

	N	KRAD	MASSTR	ISWRL	MODEL	INERT	IFLUX	ITEMP
2								

(5(I5, 5X))

	NSTAT	NPROF	NPLOT	ITEST	LASTEP			
3								

(8E10.4)

	ZUI	ZUE	ZULAST	FRA	ZEND	ZOUT	PRESS	POWER
4								

(8(I2, 8X))

	NBP	ICURV	NRCVI	NRCVE				
5								

(8E10.4)

	RI_1	XI_1	RI_2	XI_2	RI_3	XI_3	RI_4	XI_4...
6								

(8E10.4)

	RE_1	XE_1	RE_2	XE_2	RE_3	XE_3	RE_4	XE_4...

(8E10.4)

	ZI_1	$RCVI_1$	ZI_2	$RCVI_2$	ZI_3	$RCVI_3$	ZI_4	$RCVI_4$...
7								

(8E10.4)

	ZE_1	$RCVE_1$	ZE_2	$RCVE_2$	ZE_3	$RCVE_3$	ZE_4	$RCVE_4$...

(8E10.4)

	RA	RB	RD					
8								

NAMELIST

9	$INPUT							$

(8E10.4)

	UA	UD						
10								

(8E10.4)

	F2A	F2D	TA	TD	T_{wall}			
11								

(I2)

	NIN							
12								

Y VALUES (8E10.4)

13								

U VALUES (8E10.4)

14								

15								

TEMPERATURE VALUES (8E10.4)

16								

17								

18								

19								

TURBULENT KINETIC ENERGY (8E10.4)

20								

TURBULENCE LENGTH SCALE (8E10.4)

21								

TRANSITION MIXING MODEL
INPUT SHEET DESCRIPTION

Card Set	Description
1	Case title cards
2	N - Number of cross stream intervals
	KRAD - 00 For plane geometry 01 For axisymmetric geometry
	MASSTR - 00 Always
	ISWRL - 00 Always
	MODEL - 01 Laminar viscosity 02 Two-equation K-E viscosity model
	INERT - 01 Always
	IFLUX - 00 Walls are adiabatic 01 Wall temperature is specified
	ITEMP - 00 Isothermal 01 Enthalpy solved
3	TAT - Number of steps between printout of output variables
	NPROF - Number of steps between printout of output variables and profiles
	NPLOT - Number of steps between line-printer plots
	ITEST - 00 No extra printout 01 Extra printout
	LASTEP - Maximum number of marching steps
4	ZUI - Initial Z-location on inner boundary
	ZUE - Initial Z-location on outer boundary
	ZULAST - Final Z location
	FRA - Fraction of grid height to be used as step size
	ZEND - Z-location of end of inner wall
	ZOUT - Z-location of end of outer wall
	PRESS - Pressure
	POWER - Control for node spacing
5	NBP - Number of boundary pairs
	ICURV - 00 No radius of curvature effects 01 Radius of curvature effects
	NRCVI - Number of radius of curvature points specified on inner boundary
	NRCVE - Number of radius of curvature points specified on outer boundary
6	RI_i - Inner boundary radius
	XI_i - Inner boundary X-location
	RE_i - Outer boundary radius
	XE_i - Outer boundary X-location

7 ZI_i - Z-location on inner boundary at which radius of curvature is specified
$RCVI_i$ - Radius of curvature of inner boundary
ZE_i - Z-location on outer boundary at which radius of curvature is specified
$RCVE_i$ - Radius of curvature of outer boundary

8 RA - Radius of axis of symmetry
RB - Inner boundary radius at initial Z-location
RD - Outer boundary radius at initial Z-location

9 Namelist, see page 164 for variables

10 UA - Axial velocity at "free" inner boundary
UD - Axial velocity at "free" outer boundary

11 F2A - Fuel mass fraction at "free" inner boundary
F2D - Fuel mass fraction at "free" outer boundary
TA - Temperature at "free" inner boundary
TD - Temperature at "free" outer boundary
TWALL - Wall temperature

12 NIN - Number of points on input initial profile

13 Y values of input initial profile (NIN values)

14 U values of input initial profile

15 Blank card(s)

16 Temperature values of input initial profile

17 Blank card(s)

18 Blank card(s)

19 Blank card(s)

20 KE values of input initial profile
(Read only if KREAD = 1)

21 ℓm values of input initial profile
(Read only if KREAD = 1)

TRANSITION MIXING MODEL
NAMELIST INPUT

VBL	Value	Description
IUTRAP	2	Test for negative U's, see STRIDE(2)
ULIM	0.05	Entrainment control
PEILIM	0.01	Max. fractional mass flow change per step
AFAC	0.2	Relaxation on duct area deviation
AEXDLM	0.02	Max. duct area fractional deviation per step
NOVEL	2	01 - U not solved for, 02 - solve for U
ARCON1	28500	Activation energy divided by gas constant for fuel reaction
PREXP1	5E + 15	Preexponent for fuel reaction
CR1	6.0	Eddy break-up constant for fuel reaction
ARCON2	12500	Activation energy divided by gas constant for CO reaction
PREXP2	6E + 8	Preexponent for CO reaction
CR2	6.0	Eddy break-up constant for CO reaction
CP	1255	Specific heat
IDPDX	01	01 - Std genmix pressure grad. calculation 02 - "grid filling duct" version
C1	1.42	Turb. Constant
C2	1.92	Turb. Constant
CD	0.09	Turb. Constant
C2VT	0.36	Turb. Constant
AKFAC	0.03	Factor for internally generated turb. kinetic energy profiles, $KE = AKFAC*U^2$
ALFAC	0.02	Factor for internally generated length scale profiles, $\ell m = ALFAC*\Delta Y$
PREF	--	Turbulent Prandtl numbers
CX	1.0	Molecular carbon value of fuel
HY	4.0	Molecular hydrogen value of fuel
HFU	4E + 7	Heat of combustion of fuel
MODER	2	01 - Kinetic only, 02 - Kinetic + Diffusion
ITHIN	1	Thins output profiles by printing every ITHIN value
KREAD	0	00 - KE & ℓm profiles generated internally 01 - KE & ℓm read in

EMISSIONS MODEL INPUT SHEET

CASE TITLE CARD (12A6)

1								

CASE TITLE CARD (12A6)

(8(I2, 8X))

	N	KRAD	MASSTR	ISWRL	MODEL	INERT	IFLUX	ITEMP
2								

(5(I5, 5X))

	NSTAT	NPROF	NPLOT	ITEST	LASTEP			
3								

	XU	XULAST	FRA	XEND	XOUT	PRESS	POWER	(8E10.4)
4								

	NBP							(I2)
5								

	X_1	RI_1	RE_1	X_2	RI_2	RE_2	X_3	RI_3
6								

RE_3	X_4	RI_4	RE_4	X_5	RI_5	RE ...	(8E10.4)

	RA	RB	RD					(8E10.4)
7								

	NAMELIST							
8	$INPUT							$
	UA	UD	VTA	VTD				(8E10.4)
9								
	F2A	F2D	TA	TD	T_{wall}			(8E10.4)
10								
	NIN	NUI	NUE	NVI	NVE			(5(I2, 8X))
11								
	Y VALUES							(8E10.4)
12								
	U VALUES							(8E10.4)
13								
	$V\theta$ VALUES							(8E10.4)
14								
	TEMPERATURE VALUES							(8E10.4)
15								
	MFU VALUES							(8E10.4)
16								
	MCO_2 VALUES							(8E10.4)
17								

MCO VALUES (8E10.4)

18

MOX VALUES (8E10.4)

19

MH_2O VALUES (8E10.4)

20

MH_2 VALUES (8E10.4)

21

TURBULENT KINETIC ENERGY (8E10.4)

22

TURBULENCE LENGTH SCALE (8E10.4)

23

SKIP FOLLOWING CARD SET IF NUI = 0

X - LOC. OF INTERNAL COOLING SLOTS (8E10.4)

24

LIP LENGTH OF INTERNAL COOLING SLOTS (8E10.4)

25

U - VELOCITY OF INTERNAL COOLING SLOTS (8E10.4)

26

VT - VELOCITY OF INTERNAL COOLING SLOTS (8E10.4)

27

TEMPERATURE OF INTERNAL COOLING SLOTS (8E10.4)

FLOW RATE OF INTERNAL COOLING SLOTS (8E10.4)
29

SLOT HEIGHT OF INTERNAL COOLING SLOTS (8E10.4)
30

SLOT TO METERING AREA RATIO FOR INT SLOTS (8E10.4)
31

SKIP FOLLOWING CARD SET IF NUE = 0

X-LOC OF EXTERNAL COOLING SLOTS (8E10.4)
32

LIP LENGTH OF EXTERNAL COOLING SLOTS (8E10.4)
33

U - VELOCITY OF EXTERNAL COOLING SLOTS (8E10.4)
34

V_T - VELOCITY OF EXTERNAL COOLING SLOTS (8E10.4)
35

TEMPERATURE OF EXTERNAL COOLING SLOTS (8E10.4)

36								

FLOW RATE OF EXTERNAL COOLING SLOTS (8E10.4)

37								

SLOT HEIGHT OF EXTERNAL COOLING SLOTS (8E10.4)

38								

SLOT TO METERING AREA RATIO FOR EXT SLOTS (8E10.4)

39								

SKIP FOLLOWING CARD SET IF NVI = 0

X - LOC OF INTERNAL RADIAL INJECTION (8E10.4)

40								

U - VELOCITY OF INTERNAL RADIAL INJECTION (8E10.4)

41								

V - VELOCITY OF INTERNAL RADIAL INJECTION (8E10.4)

42								

VT - VELOCITY OF INTERNAL RADIAL INJECTION (8E10.4)

43								

TEMPERATURE OF INTERNAL RADIAL INJECTION (8E10.4)

44

FLOW RATE OF INTERNAL RADIAL INJECTION (8E10.4)

45

SKIP FOLLOWING CARD SET IF NVE = 0

X - LOC. OF EXTERNAL RADIAL INJECTION (8E10.4)

46

U - VELOCITY OF EXTERNAL RADIAL INJECTION (8E10.4)

47

V - VELOCITY OF EXTERNAL RADIAL INJECTION (8E10.4)

48

VT - VELOCITY OF EXTERNAL RADIAL INJECTION (8E10.4)

49

TEMPERATURE OF EXTERNAL RADIAL INJECTION (8E10.4)

50

FLOW RATE OF EXTERNAL RADIAL INJECTION (8E10.4)

51

EMISSIONS MODEL
INPUT SHEET DESCRIPTION

Card Set	Description
1	Case title cards
2	N - Number of cross stream intervals
	KRAD - 00 For plane geometry 01 For axisymmetric geometry
	MASSTR - 00 Species equations not solved 01 Species equations solved
	ISWRL - 00 Swirl velocity not solved 01 Swirl velocity solved
	MODEL - 01 Laminar viscosity 02 Two-equation, K-E, viscosity model
	INERT - 01 Species are inert 02 Species will react
	IFLUX - 00 Wall adiabatic 01 Wall temperature specified
	ITEMP - 00 Isothermal 01 Enthalpy solved
3	NSTAT - Number of steps between printout of output variables
	NPROF - Number of steps between printout of output variables and profiles
	NPLOT - Number of steps between line printer plots
	ITEST - 00 No extra printout 01 Extra printout
	LASTEP - Maximum number of marching steps
4	XU - Initial X location
	XULAST - Final X location
	FRA - Fraction of grid height to be used as step size
	XEND - X location of end of inner wall
	XOUT - X location of end of outer wall
	PRESS - Pressure
	POWER - Control for node spacing
5	NBP - Number of boundary pairs
6	X_i - X location at which boundary is specified
	RI_i - Inner boundary radius
	RE_i - Outer boundary radius
7	RA - Radius of axis of symmetry
	RB - Inner boundary radius at initial X-location
	RD - Outer boundary radius at initial X-location

8	Namelist, see page 174 for variables	
9	UA	- Axial velocity at "free" inner boundary
	UD	- Axial velocity at "free" outer boundary
	VTA	- Tang. velocity at "free" inner boundary
	VTD	- Tang. velocity at "free" outer boundary
10	F2A	- Fuel mass fraction at "free" inner boundary
	F2D	- Fuel mass fraction at "free" outer boundary
	TA	- Temperature at "free" inner boundary
	TD	- Temperature at "free" outer boundary
	TWALL	- Wall temperature
11	NIN	- Number of points on the input initial profile
	NUI	- Number of cooling slots on inner boundary
	NUE	- Number of cooling slots on outer boundary
	NVI	- Number of radial injection points on inner boundary
	NVE	- Number of radial injection points on outer boundary
12	Y values of input initial profile (NIN values)	
13	U values of input initial profile	
14	V_θ values of input initial profile	
15	Temperature values of input initial profile	
16	M_{FU} values of input initial profile	
17	M_{CO2} values of input initial profile	
18	M_{CO} values of input initial profile	
19	M_{OX} values of input initial profile	
20	M_{H2O} values of input initial profile	
21	M_{H2} values of input initial profile	
22	KE values of input initial profile (Read only if KREAD = 1)	
23	ℓm values of input initial profile (Read only if KREAD = 1)	
24 to 31	Information pertaining to cooling slots on inner boundary	

32 to 39	Information pertaining to cooling slots on outer boundary
40 to 45	Information pertaining to radial injections on inner boundary
46 to 51	Information pertaining to radial injections on outer boundary

EMISSIONS MODEL
NAMELIST INPUT

VBL	Value	Description
IUTRAP	2	Test for negative U's, see STRIDE(2)
ULIM	0.05	Entrainment control
PEILIM	0.01	Max. fractional mass flow change per step
AFAC	0.2	Relaxation on duct area deviation
AEXDLM	0.02	Max. duct area fractional deviation per step
NOVEL	2	01 - U not solved for, 02 - Solve for U
ARCON1	28500	Activation energy for fuel reaction
PREXP1	5E + 15	Preexponent for fuel reaction
CR1	6.0	Eddy breakup constant for fuel reaction
CP	1048	Specific heat
IPDDX	1	01 - Std genmix pressure grad. calculation 02 - "grid filling duct" version
C1	1.42	Turb. Constant
C2	1.92	Turb. Constant
CD	0.09	Turb. Constant
C2VT	0.36	Turb. Constant
AKFAC	0.03	Factor for internally generated kinetic energy profiles, KE = AKFAC*U
ALFAC	0.02	Factor for internally generated length scale profiles, ℓm = ALFAC*ΔY
PREF	--	Turbulent Prandtl numbers
CX	1.0	Molecular carbon value of fuel
HY	4.0	Molecular hydrogen value of fuel
HFU	-49317	Heat of formation of fuel
MODER	2	1 - Kinetic only, 02 - Kinetic + Diffusion
ITHIN	1	Thins output profiles by printing every ITHIN value
KREAD	0	0 - K & E profiles generated internally 1 - K & ℓm read in
URAT	0.83	Cooling slot velocity shape factor
TERM1	0.1	Control on specie equation step size
TERM2	1.E-4	Control on specie equation step size
ISMAX	500	Maximum specie equation steps
EFU	1.0	Power on fuel in fuel reaction rate
E_{O2}	0.5	Power on O_2 in fuel reaction rate
E_{H_2O}	0.5	Power on H_2O in fuel reaction rate
ERO	2.0	Power on density in fuel reaction rate
EPR	0.0	Power on pressure in fuel reaction rate

FUEL INSERTION MODEL INPUT

	TITLE	
	1	80

	* ATOM TYPE	** AIR ASSIST	PRIM FLOW NO. (JP4) PPH/$\sqrt{PSI}$	SEC. FLOW NO. (JP4)	CONE ANGLE DEG	AIR ASSIST SHROUD EFF AREA IN^2	PRIM ORIFICE DIA, IN	SEC ORIFICE DIA, IN	
	1 →	6 →	11	21	31	41	51	61	71 80
2									

*ATOMIZER TYPE: 00001 = SIMPLEX
00002 = DUAL ORF
00003 = AIR BLAST

**AIR ASSIST: 00001 = NO ASSIST
00002 = WITH ASSIST

*FOR ATOM TYPE = 00002 (DUAL ORIF) ONLY (LEAVE OUT FOR OTHERS)
INPUT SECONDARY FLOW SCHEDULE

W_S = SECONDARY FUEL FLOW, LB/HR

$\Delta P_S = \Delta P_{\text{SEC. ORIF}} + \Delta P_{\text{FLOW DIVIDER VALVE}}$, P/D

	CRACK POINT FLOW W_{S1}	W_{S2}	W_{S3}	W_{S4}	W_{S5}	
	1	11	21	31	41	51
3						

	CRACK PRESSURE ΔP_1	ΔP_2	ΔP_3	ΔP_4	ΔP_5	
	1	11	21	31	41	51
4						

*FOR ATOM TYPE = 00003 (AIRBLAST) ONLY (LEAVE OUT FOR OTHERS)

	FILMING DIA IN.	NOZZLE AIRFLOW LB/SEC	FLOW AREA IN^2	AIR TEMP °R	
	1	11	21	31	
5					

6

*** FUEL TYPE	**** AIR FLOW OPTION	FUEL TEMP °R	FUEL FLOW LB/HR	FUEL ΔP PSI	AIR ASSIST ΔP PSI	AIR ASSIST TEMP °R		
1 →	6 →	11	21	31	41	51	61	71

***FUEL TYPE: 0.00002=JP5, 0.00004=JP4

****AIR FLOW OPTION: 0.00001=UNIFORM GAS STREAM, 0.00002=2-D FIELD OPTION

7

	1	11	21	31	4	51
← UNIFORM STREAM OPTION	T_{GAS}, °R	V_{GAS}, FPS	P_{GAS}, PSIA	X_{MAX}, IN.	Y_{MAX}, °R	
← Z-D FIELD OPTION	X_{NOZ} ℄ IN.	Y_{NOZ} ℄ IN.	P_{GAS} PSIA	X_{MAX} IN.	Y_{MAX} IN.	

CARDS 8 THROUGH 13 SKIPPED IF AIR FLOW OPTION = 00001

8

IN JN (2(I2, 8X))

IN = NO. OF X-DIR POINTS IN 2-D FIEL

JN = NO. OF Y- DIR POINTS

9

X VALUES (8E10.4) X - LOCATIONS OF GRID POINTS (FT)

10

Y VALUES (8E10.4) Y - LOCATIONS OF GRID POINTS (FT)

11

U VALUES (8E10.4) READ ALONG + X LINES STARTING WITH SMALLEST Y VALUE (FT/SEC)

V VALUES (8E10.4)

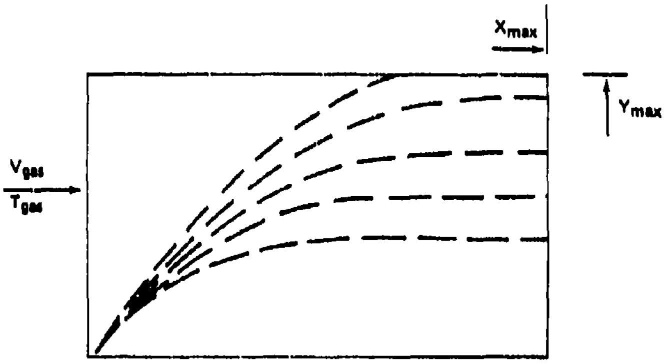
READ ALONG + X LINES STARTING WITH SMALLEST Y VALUE (FT/SEC)

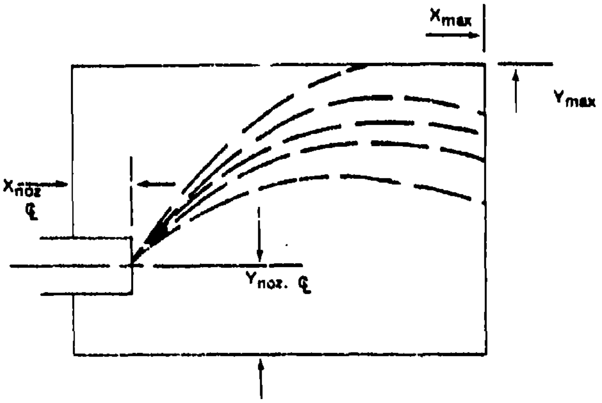
12								

T VALUES (8E10.4)

READ ALONG + X LINES STARTING WITH SMALLEST Y VALUE (DEG. R)

13								





APPENDIX B

LISTING OF ANNULUS LOSS MODEL

```
PROGRAM MAIN        73/74    OPT=0 TRACE                    FTN 4.6+439          09/24/79  09.59.30          PAGE      1

                 PROGRAM MAIN (INPUT=65,OUTPUT=513,TAPE60=INPUT,TAPE61=OUTPUT,       MA          2
               1  TAPE4=519,TAPE7=519)                                                MA          3
                 COMMON/CPICT/XNO,YNO,XFV,YFV,XGV,YGV,XRB(080),YBR(080),XG,YG,       CD1         2
               1  SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),PXYL(1,1)                        CD1         3
                 COMMON/INPUTC/DP,BLKF,SK,RE,FRIC,TANS,COR,NFL,TITLE(10),NELTOT,     CD2         2
               +  NELEM(080),NETYP(080),RD(080),XR(080),XI(080),CL(080),RI(080),     CD2         3
               2  TLIN(080),BLKI(080),DALK(080),WRPCT(080),NHOLES(080),NHTYP(080),   CD2         4
               3  ISEP(080),IDBUG,NFA(080),TPIC,ABETA(080),SIGM,SIGM2,IRUN,ICASE     CD2         5
                 COMMON/OUTPUT/PTOIS,CDOV,WCORRT,CUMSA,CUMWJ,RB(080),H(080),         CD2         6
               1  AX(080),BLKM(080),BLKS(080),FAT(080),FAF(080),BETA(080),PS(080),   CD2         7
               2  W(080),TT(080),PT(080),TS(080),RHO(080),FM(080),V(080),VX(080),    CD2         8
               3  VTH(080),Q(080),QP(080),BLKN(080),WL(080),WAKDEC(080),             CD2         9
               4  CD(080),ANGJ(080),DHOLES(080),ANHLES(080),FAM(080),CUMEA(080),     CD2        10
               5  VJET(080),ATCML(080),RR(080),CUMLE                                 CD2        11
                 COMMON/CODMIT/IN,NOUT,IREAD,ITER,SWFF,SWFD                          CD2        12
                 ICASE1=1                                                            MA          6
                 ICASE2=1                                                            MA          7
                 NELTOT=80                                                           MA          8
                 IN=60                                                               MA          9
                 NOUT=61                                                             MA         10
                 CALL PLOTS (0,0,0)                                                  MA         11
          C ------   FIRST PASS,  REVERSE FLOW OR AXIAL FLOW O.D. ORIFICES  -----    MA         12
            70 IRUN=1                                                                MA         13
                 ICASE=ICASE1                                                        MA         14
                 CALL COMANN                                                         MA         15
                 ICASE1=ICASE                                                        MA         16
                 IF (IREAD.EQ.0) GO TO 63                                            MA         17
                 DP1=DP                                                              MA         18
                 CDA1=CDOV*CUMGA                                                     MA         19
                 LI=NELEM(1)                                                         MA         20
                 WTOT=W(LI)                                                          MA         21
                 IRUN=2                                                              MA         22
                 ITER1=ITER                                                          MA         23
                 CALL WTAPE(4)                                                       MA         24
          C ------   SECOND PASS  AXIAL FLOW I.D. ORIFICES  --------                 MA         25
                 IRUN=1                                                              MA         26
                 ICASE=ICASE2                                                        MA         27
                 IF (ICASE.EQ.0) CALL RTAPE (7)                                      MA         28
                 CALL COMANN                                                         MA         29
                 ICASE2=ICASE                                                        MA         30
                 DP2=DP                                                              MA         31
                 CDA2=CDOV*CUMGA                                                     MA         32
                 LI=NELEM(1)                                                         MA         33
                 WTOT=WTOT+W(LI)                                                     MA         34
                 IRUN=2                                                              MA         35
                 ITER2=ITER                                                          MA         36
                 IF (ITER1.NE.ITER2) GO TO 60                                        MA         37
          C ------   START ITERATION LOOP FOR AXIAL FLOW ANNULAR BURNERS  ----       MA         38
            25 WRITE (61,36) DP1,DP2,W1,W2,CDA1,CDA2                                 MA         39
            36 FORMAT (' ** FLOW ITERATION LOOP ***/' DP1 =',G10.3,                  MA         40
               1  5X,'DP2 =',G10.3,5X,'W1 =',G10.3,5X,'W2 =',G10.3/                  MA         41
               2  ' CDA1 =',G10.3,5X,'CDA2 =',G10.3)                                 MA         42
            26 IF (ABS(1.-DP1/DP2).LT..005) GO TO 50                                 MA         43
                 IF (ITER.EQ.2) GO TO 50                                             MA         44
                 DPAVG=.5*(DP1+DP2)                                                  MA         45
                 W1=WTOT*CDA1/(CDA1+CDA2)                                            MA         46
                 W2=WTOT-W1                                                          MA         47
                 CALL WTAPE(7)                                                       MA         48
                 CALL RTAPE(4)                                                       MA         49
                 LI=NELEM(1)                                                         MA         50
                 W(LI)=W1                                                            MA         51
                 DP=DPAVG                                                            MA         52
                 CALL COMANN                                                         MA         53
                 CDA1=CDOV*CUMGA                                                     MA         54
                 DP1=DP                                                              MA         55
                 CALL WTAPE(4)                                                       MA         56
                 CALL RTAPE(7)                                                       MA         57
                 LI=NELEM(1)                                                         MA         58
                 W(LI)=W2                                                            MA         59
                 DP=DPAVG                                                            MA         60
                 CALL COMANN                                                         MA         61
                 CDA2=CDOV*CUMGA                                                     MA         62
                 DP2=DP                                                              MA         63
                 GO TO 25                                                            MA         64
          C ------      OUTPUT     ---------                                         MA         65
            50 CALL WTAPE(7)                                                         MA         66
                 CALL RTAPE(4)                                                       MA         67
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```
   80 CALL PROUT(NEL)                                                   MA   68
      IF (IPIC.EQ.1) CALL PICT(1)                                       MA   69
      IF (IREAX.EQ.0) GO TO 70                                          MA   70
      CALL WTAPE(4)                                                     MA   71
      CALL RTAPE(7)                                                     MA   72
      CALL PROUT(NEL)                                                   MA   73
      IF (IPIC.EQ.1) CALL PICT(1)                                       MA   74
      CALL WTAPE(7)                                                     MA   75
      CALL RTAPE(4)                                                     MA   76
      GO TO 70                                                          MA   77
C     ----------   ERROR MESSAGES  -----                                MA   78
   60 WRITE (NOUT,75) ITER1,ITER2                                       MA   79
   75 FORMAT (' **INCORRECT ITER SPECIFICATION, ITER1 = ',I5,           MA   80
     1 '   ,ITER2 = ',I5)                                               MA   81
      END                                                               MA   82
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SUBROUTINE TAPE        73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  09.50.39        PAGE     1

                SUBROUTINE TAPE(NT)                                                 TA          2
                COMMON/CPICT/XNO,YNO,XFV,YFV,XOV,YOV,XBB(080),YBB(080),XG,YG,       CD1         2
               1  SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),PTVL(1,1)                       CD1         3
                COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TANS,COS,NEL,TITLE(10),NELTOT,    CD2         2
               +  NELEM(080),NETYP(080),RO(080),XO(080),XI(080),CL(080),RI(080),   CD2         3
               2  TLIM(080),BLKI(080),DBLK(080),WBPCT(080),NHOLES(080),NHTYP(080), CD2         4
               3  ISEP(080),IDBUG,NFW(080),IPIC,ABETA(080),SIGN,SIGN2,IRUN,ICASE   CD2         5
                COMMON/OUTPUT/PTDIS,CDOV,WCORRI,CUMGA,CUMWJ,RB(080),M(080),         CD2         6
               1  AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080), CD2         7
               2  W(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080),  CD2         8
               3  VTH(080),Q(080),OP(080),BLKM(080),WL(080),WAKDEC(080),           CD2         9
               4  CD(080),ANGJ(080),DHOLES(080),AHOLES(080),EAN(080),CUMEA(080),   CD2        10
               5  VJET(080),ATCHL(080),XB(080),CUMLF                               CD2        11
                COMMON/CODBIT/IN,NOUT,IREAX,ITER,SWFF,SWFD                          CD2        12
                ENTRY RTAPE                                                         TA          5
                REWIND NT                                                           TA          6
                READ (NT) XNO,YNO,XFV,YFV,XOV,YOV,XBB,YBB,XG,YG,SIZE,XTI,           TA          7
               1  YTI,XMOVE,YMOVE,DATA,PTVL                                         TA          8
                READ  (NT) DP,BLKF,SK,RG,FRIC,TANS,COS,NEL,TITLE,NELTOT,NELEM,      TA          9
               1  NETYP,RO,XO,XI,CL,RI,TLIM,BLKI,DBLK,WBPCT,NHOLES,NHTYP,ISEP,      TA         10
               2  IDBUG,NFW,IPIC,ABETA,SIGN,SIGN2,IRUN,ICASE                        TA         11
                READ  (NT) PTDIS,CDOV,WCORRI,CUMGA,CUMWJ,RB,M,AX,BLKW,BLKS,EAX,     TA         12
               1  EAF,BETA,PS,W,TT,PT,TS,RHO,EM,V,VX,VTH,Q,OP,BLKM,WL,WAKDEC,       TA         13
               2  CD,ANGJ,DHOLES,AHOLES,EAN,CUMEA,VJET,ATCHL,XB,CUMLF               TA         14
                READ (NT) ITER,SWFF,SWFD                                            TA         15
                RETURN                                                              TA         16
          C     ---------------------                                               TA         17
                ENTRY WTAPE                                                         TA         18
                REWIND NT                                                           TA         19
                WRITE (NT) XNO,YNO,XFV,YFV,XOV,YOV,XBB,YBB,XG,YG,SIZE,XTI,          TA         20
               1  YTI,XMOVE,YMOVE,DATA,PTVL                                         TA         21
                WRITE (NT) DP,BLKF,SK,RG,FRIC,TANS,COS,NEL,TITLE,NELTOT,NELEM,      TA         22
               1  NETYP,RO,XO,XI,CL,RI,TLIM,BLKI,DBLK,WBPCT,NHOLES,NHTYP,ISEP,      TA         23
               2  IDBUG,NFW,IPIC,ABETA,SIGN,SIGN2,IRUN,ICASE                        TA         24
                WRITE (NT) PTDIS,CDOV,WCORRI,CUMGA,CUMWJ,RB,M,AX,BLKW,BLKS,EAX,     TA         25
               1  EAF,BETA,PS,W,TT,PT,TS,RHO,EM,V,VX,VTH,Q,OP,BLKM,WL,WAKDEC,       TA         26
               2  CD,ANGJ,DHOLES,AHOLES,EAN,CUMEA,VJET,ATCHL,XB,CUMLF               TA         27
                WRITE (NT) ITER,SWFF,SWFD                                           TA         28
                RETURN                                                              TA         29
                END                                                                 TA         30
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SUBROUTINE C3MANN      73/74    OPT=0 TRACE                          FTN 4.6+439        08/24/79  39.58.39        PAGE      1

                 SUBROUTINE C3MANN                                                  CO          2
                 COMMON/CPICT/XMO,YMO,XFV,YFV,XOV,YOV,XBB(080),YBB(080),XG,YG,      CO1         2
                1  SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),PFYL(1,1)                      CO1         3
                 COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TANS,CDM,NEL,TITLE(10),NELTOT,    CO2         2
                +  NELEM(080),NETYP(080),PD(080),XD(080),XI(080),CL(080),RI(080),   CO2         3
                2  TLIN(080),BLKI(080),BBLK(080),WBPCT(080),NHOLES(080),NHTYP(080), CO2         4
                3  ISEP(080),IDBUG,NFU(080),IPIC,ABETA(080),SIGM,SIGM2,IRUN,ICASE   CO2         5
                 COMMON/OUTPUT/PTDIS,CDOV,NCORRT,CUMGA,CUMWJ,RR(080),W(080),        CO2         6
                1  AX(080),BLKM(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080), CO2         7
                2  M(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080),  CO2         8
                3  VTH(080),Q(080),GP(080),BLKR(080),X (080),WAXBEC(080),           CO2         9
                4  CD(080),ANGJ(080),DHOLES(080),ANGLES(080),EAM(080),CUMEA(080),   CO2        10
                5  VJET(080),ATCML(080),XR(080),CUMLF                               CO2        11
                 COMMON/COMBIT/IN,NOUT,IREAK,ITER,SWFF,SWFD                         CO2        12
              10 ICAS=ICASE                                                         CO          5
                 IF (IRUN.GE.2) GO TO 15                                            CO          6
                 IF (ICASE.EQ.1) CALL ZERO                                          CO          7
                 ICASE=ICAS                                                         CO          8
           C --------   READ INPUT DATA AND COMPUTE INLET CONDITIONS --------        CO          9
                 CALL INPUT                                                         CO         10
              15 CALL INLET                                                         CO         11
           C ------   INITIALIZE OVERALL ITERATION VARIABLES  ------                CO         12
                 LI=NELEM(1)                                                        CO         13
                 RTP=SQRT(TT(LI)/518.7)/(PT(LI)/14.7)                               CO         14
                 NIT=0                                                              CO         15
                 NITMAX=20                                                          CO         16
           C  *************   START OF MAIN ITERATION LOOP  ***********             CO         17
              20 L=2                                                                CO         18
                 NIT=NIT+1                                                          CO         19
                 WRITE(61,4000) NIT                                                 CO         20
            4000 FORMAT(/1X,*START ITERATION NO. *,I2)                              CO         21
           C  ------ CALC P-DISCHARGE FROM ESTIMATED DP  -------                    CO         22
                 PTDIS=PT(LI)*(1.-DP)                                               CO         23
           C  ------    INITIALIZE LOOP ITERATION VARIABLES  -------                CO         24
                 SWFF=0.                                                            CO         25
                 SWFD=0.                                                            CO         26
                 CUMLF=0.                                                           CO         27
                 CUMGA=0.                                                           CO         28
                 CUMWJ=0.                                                           CO         29
                 CDOV=0.                                                            CO         30
                 RELAX=1.0-.006*AMAX1(FLOAT(NEL-20),0.)                             CO         31
           C  -------    LOOP OVER ALL ELEMENTS  -------                            CO         32
              30 LL=NELEM(L)                                                        CO         33
                 IF (NETYP(LL).EQ.INL.AND.NFU(LL).EQ.1)GO TO 40                     CO         34
                 IF (NETYP(LL).EQ.INL)CALL LENGTH(L)                                CO         35
                 IF (NETYP(LL).EQ.INF)CALL FLOW(L)                                  CO         36
                 IF (IDBUG.EQ.2)CALL PROUT(L)                                       CO         37
                 IF (EM(LL).LT.1.0) GO TO 40                                        CO         38
                 GO TO (210,310), ITER                                              CO         39
              40 IF (L.EQ.NEL)GO TO 50                                              CO         40
                 L=L+1                                                              CO         41
                 GO TO 30                                                           CO         42
           C --------  ERROR TEST ----------                                        CO         43
              50 WERR=CUMWJ-W(LI)                                                   CO         44
                 IF (ABS(WERR)/W(LI).LT..0005) GO TO 80                             CO         45
                 GO TO (200,300), ITER                                              CO         46
           C --------  ITERATE FOR DP/P ----------                                  CO         47
             200 DP=DP*(1.-RELAX*WERR/CUMWJ)                                        CO         48
                 WRITE (NOUT,90)  CUMWJ,WERR,DP                                     CO         49
                 GO TO 410                                                          CO         50
             210 DP=DP*2.                                                           CO         51
                 WRITE (NOUT,90) CUMWJ,WERR,DP                                      CO         52
                 GO TO 410                                                          CO         53
           C --------  ITERATE FOR INLET FLOW ----------                            CO         54
             300 IF (SWFF+SWFD.EQ.1.0) GO TO 304                                    CO         55
                 W(LI)=W(LI)*(1.+RELAX*(SWFD/(1.-SWFF)-1.))                         CO         56
             304 WRITE (NOUT,100) CUMWJ,WERR,W(LI),SWFF,SWFD                        CO         57
                 GO TO 400                                                          CO         58
             310 W(LI)=W(LI)/2.                                                     CO         59
                 WRITE (NOUT,100) CUMWJ,WERR,W(LI),SWFF,SWFD                        CO         60
             400 CALL INLET                                                         CO         61
             410 IF (NIT.LT.NITMAX) GO TO 20                                        CO         62
                 WRITE (NOUT,3000)  NIT                                             CO         63
           C -----    EXIT PATH AFTER CONVERGENCE    ------------                   CO         64
              80 IF (CUMGA.EQ.0.) GO TO 85                                          CO         65
                 CDOV=1.0106*CUMLF*RTP/(CUMGA*SQRT(DP))                             CO         66
              85 CONTINUE                                                           CO         67
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      SUBROUTINE CONANN     73/74   OPT=0 TRACE               FTN 4.6+439        08/24/78  09.58.39        PAGE    2

                    3000 FORMAT(* FLOW ITERATION DID NOT CONVERGE IN *,I2,* ITERATIONS*,/  CO         68
                        +10X,*1. CHECK LENGTH ELEMENTS FOR BAD DIMENSIONS.   */           CO         69
          80            +10X,*2. CHECK FLOW ELEMENTS FOR ERRORS IN HOLE DIA, FLOW FRACTION, CO         70
                        +* OR NUMBER OF HOLES. */                                          CO         71
                        +10X,*3. CHECK ORIFICE DISCH COEFFICIENTS. CHANGE FIXED CD TYPES TO CO         72
                        +* FLOATING CD TYPES.*/                                            CO         73
                        +10X,*4. INLET SWIRL ANGLE MAY BE TOO HIGH*/                       CO         74
          85            +10X,*5. CHECK FOR NEGATIVE PRESS. DROP ON FLOW ELEMENTS. MAY BE IN CO         75
                        +*PUT ERROR OR ANNULUS WIDTH TOO NARROW. *)                        CO         76
                         IF(ITER.EQ.1.AND.NIT.LT.NITMAX) WRITE(NOUT,110) CONVJ,VERR,DP     CO         77
                         IF(ITER.EQ.2.AND.NIT.LT.NITMAX) WRITE(NOUT,120) CONVJ,VERR        CO         78
                         RETURN                                                            CO         79
          90        C                                                                      CO         80
                      90 FORMAT (17H TOTAL JET FLOW= ,F8.4,13H FLOW ERROR= ,F9.6,20H NEW PR CO         81
                        +ESSURE DROP= ,F9.6/)                                              CO         82
                     100 FORMAT (18H TOTAL JET FLOW = ,F9.6,14H FLOW ERROR = ,F9.6,        CO         83
                       1  17H NEW FLOW RATE = ,F9.6,13H SUFF,SUFD = ,2F9.4)                CO         84
          95         110 FORMAT (37H SOLUTION CONVERGED, TOTAL JET FLOW= ,F8.4, 13H FLOW ER CO         85
                        +ROR= ,F9.6, 22H FINAL PRESSURE DROP= ,F9.6/)                      CO         86
                     120 FORMAT (37H SOLUTION CONVERGED, TOTAL JET FLOW= ,F8.4, 13H FLOW ER CO         87
                        +ROR= ,F9.6/)                                                      CO         88
                    C    END CONANN                                                        CO         89
         100             END                                                               CO         90

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

      69      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
      96      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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SUBROUTINE ZERO        73/74   OPT=0 TRACE                  FTN 4.6+439       08/24/78  09.58.39        PAGE     1

   1                SUBROUTINE ZERO                                                ZE          2
                    COMMON/CPICT/XMO,YMO,XFV,YFV,X9V,Y9V,XBB(000),YBB(000),XG,YG,  [illegible]
                   1  SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),PXYL(1,1)                  [illegible]
                    COMMON/INPUT/BP,BLKF,SK,[illegible],FRIC,TABS,[illegible],TITLE(10),NELTOT,  [illegible]
   5               +  NELEM(000),NETYP(000),RB(000),XB(000),[illegible]             [illegible]
                   2  [illegible]                                                   [illegible]
                   3  ISEF(000),IDBUG,[illegible],ICASE                             [illegible]
                    COMMON/OUTPUT/PTBIS,[illegible]                                 [illegible]
                   1  AX(000),[illegible],PS(000),                                  [illegible]
  10               2  [illegible],V(000),VX(000),                                   [illegible]
                   3  [illegible]                                                   [illegible]
                   4  CB(000),[illegible],CUMEA(000),                               [illegible]
                   5  VJET(000),[illegible],CUMLF                                   [illegible]
                    COMMON/CONSIT/IN,NOUT,IRFAX,ITER,SUFF,SUF9                     [illegible]
  15                CALL MEMSET (XMO,PXYL(1,1))                                     ZE     [illegible]
                    CALL MEMSET (BP,ICASE,0.0)                                      ZE     [illegible]
                    CALL MEMSET (PTBIS,CUMLF,0.0)                                   ZE     [illegible]
              C     END ZERO                                                        ZE     [illegible]
                    END                                                             ZE     [illegible]

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     15      I       3         ARGUMENT COUNT INCONSISTENT WITH PRIOR USAGE.
     17      I       3         ARGUMENT COUNT INCONSISTENT WITH PRIOR USAGE.
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      SUBROUTINE INPUT                                                  IN      2
      COMMON/CPICT/XMB,YMB,XFV,YFV,XOV,YOV,XBB(080),YBB(080),XG,YG,     CB1     2
     1 SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),PKYL(1,1)                      CB1     3
      COMMON/INPUTC/DP,BLKF,SK,PS,FRIC,TAMS,CDO,NEL,TITLE(10),NELTOT,   CB2     2
     + NELEM(080),NETYP(080),RO(080),XO(080),XI(080),CL(080),RI(080),   CB2     3
     2 TLIM(080),BLKI(080),DBLF(080),WPCT(080),NHOLES(080),NHTYP(080),  CB2     4
     3 ISEP(080),IDBUG,NFW(080),IPIC,ABETA(080),SIGN,SIGN2,IRMW,ICASE   CB2     5
      COMMON/OUTPUT/PTDIS,CDOV,WCORR,CUMGA,CUMWJ,RB(080),M(080),        CB2     6
     1 AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080), CB2     7
     2 W(080),TT(080),PT(080),TS(080),PHD(080),EM(080),V(080),VX(080),  CB2     8
     3 VTM(080),Q(080),OP(080),SLKM(080),W (080),WAKDEC(080),           CB2     9
     4 CD(080),ANGJ(080),DHOLES(080),AHOLES(080),EAM(080),CUMEA(080),   CB2    10
     5 VJET(080),ATCML(080),FB(080),CUMLF                               CB2    11
      COMMON/COBBIT/IN,NOUT,IREAK,ITER,SUFF,SUFS                        CB2    12
      ITER=0                                                            IN      5
      IBAD=0                                                            IN      6
      IF (ICASE.EQ.1)II=0                                               IN      7
      READ (60,120)TITLE,ITER,IPIC,IDBUG                                IN      8
      IF (EOF(60))110,10                                                IN      9
   10 READ (60,130)NTYP,NFMT,NELM,NELI,(DATA(J),J=1,8)                  IN     10
      IF(NELM.EQ.0.AND.NTYP.NE.1H..AND.NTYP.NE.1H ) IBAD=1+IBAD         IN     11
      IF(NELM.EQ.0.AND.NTYP.NE.1H..AND.NTYP.NE.1H ) NELM=NELTOT-IBAD    IN     12
      IF (NTYP.EQ.1HI)ICARD=1                                           IN     13
      IF (NTYP.EQ.1HF)ICARD=2                                           IN     14
      IF (NTYP.EQ.1HL)ICARD=3                                           IN     15
      IF (NTYP.EQ.1H.)ICARD=4                                           IN     16
      IF (NTYP.EQ.1H )ICARD=4                                           IN     17
      IF (NTYP.EQ.1HP)ICARD=5                                           IN     18
      IF (NTYP.EQ.1HB)ICARD=6                                           IN     19
      IF (NTYP.EQ.1HC)ICARD=7                                           IN     20
      ICKCGT=ICARD                                                      IN     21
      IF (ICKCGT.LE.1)GO TO 20                                          IN     22
      IF (ICKCGT.GE.7)GO TO 100                                         IN     23
      GO TO (20,30,50,60,70,90,100),ICKCGT                              IN     24
   20 I=NELI                                                            IN     25
      W(I)=DATA(1)                                                      IN     26
      PT(I)=DATA(2)                                                     IN     27
      TT(I)=DATA(3)                                                     IN     28
      BETA(I)=DATA(4)                                                   IN     29
      IF (NFMT.EQ.1HO)GO TO 10                                          IN     30
      DP=DATA(5)                                                        IN     31
      NEL=NELM                                                          IN     32
      GO TO 10                                                          IN     33
   30 IF (ICASE.EQ.1)II=II+1                                            IN     34
      IF (ICASE.EQ.1)NELEM(II)=NELM                                     IN     35
      I=NELM                                                            IN     36
      IM=NELEM(II-1)                                                    IN     37
      RO(I)=RO(IM)                                                      IN     38
      RI(I)=RI(IM)                                                      IN     39
      XO(I)=XO(IM)                                                      IN     40
      XI(I)=XI(IM)                                                      IN     41
      NETYP(I)=NTYP                                                     IN     42
      NFW(I)=NFMT                                                       IN     43
      WPCT(I)=DATA(1)                                                   IN     44
      BLKI(I)=1.0                                                       IN     45
      DBLF(I)=1.0                                                       IN     46
      CL(I)=0.                                                          IN     47
      IF (NFMT.EQ.1HI)GO TO 40                                          IN     48
      NHOLES(I)=DATA(2)                                                 IN     49
      NHTYP(I)=DATA(3)                                                  IN     50
      CD(I)=DATA(4)                                                     IN     51
      DHOLES(I)=DATA(5)                                                 IN     52
      ISEP(I)=DATA(6)                                                   IN     53
      VJET(I)=0.                                                        IN     54
      ANGJ(I)=0.                                                        IN     55
      ABETA(I)=0.                                                       IN     56
      GO TO 10                                                          IN     57
   40 VJET(I)=DATA(2)                                                   IN     58
      ANGJ(I)=DATA(3)                                                   IN     59
      ABETA(I)=DATA(4)                                                  IN     60
      NHOLES(I)=0.                                                      IN     61
      NHTYP(I)=0.                                                       IN     62
      CD(I)=0.                                                          IN     63
      DHOLES(I)=0.                                                      IN     64
      ISEP(I)=0                                                         IN     65
      GO TO 10                                                          IN     66
   50 IF (ICASE.EQ.1)II=II+1                                            IN     67
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SUBROUTINE INPUT       73/74    OPT=0 TRACE                  FTN 4.6+439        08/24/78  09.58.79         PAGE      2

                    IF (ICASE.EQ.1)NELEM(II)=NEL                                IN       68
                    I=NEL                                                       IN       69
  80                NFTYP(I)=NFTYP                                              IN       70
                    NFUT(I)=NFUT                                                IN       71
                    ID(I)=DATA(1)                                               IN       72
                    RC(I)=DATA(2)                                               IN       73
                    XI(I)=DATA(3)                                               IN       74
  85                HT(I)=DATA(4)                                               IN       75
                    CL(I)=DATA(5)                                               IN       76
                    TLIM(I)=DATA(6)                                             IN       77
                    LI=NELEM(I)                                                 IN       78
                    IF (TLIM(I).EQ.0..AND.NFUT.EQ.1H )TLIM(I)=TT(LI)            IN       79
  90                BLKI(I)=DATA(7)                                             IN       80
                    IF (BLKI(I).EQ.0.)BLKI(I)=1.0                               IN       81
                    BBLK(I)=DATA(8)                                             IN       82
                    IF (BBLK(I).EQ.0.)BBLK(I)=1.0                               IN       83
                    GO TO 10                                                    IN       84
  95             60 CALL PINPUT                                                 IN       85
                    IF (ICASE.EQ.1.AND.II.NE.NEL)WRITE (51,140)II,NEL           IN       86
                    IF (ICASE.EQ.1.AND.II.LT.NEL)NEL=II                         IN       87
                    IF (NFUT.EQ.1H )ICASE=0                                     IN       88
                    IF (NFUT.EQ.1H.)ICASE=1                                     IN       89
 100                RETURN                                                      IN       90
                 70 NCARDS=DATA(1)                                              IN       91
                    IF (J.GT.NCARDS)GO TO 5                                     IN       92
                    DO 80 J=1,NCARDS                                            IN       93
                 80 READ (60,150)(FXYL(J,M),M=1,12)                             IN       94
 105              5 CONTINUE                                                    IN       95
                    GO TO 10                                                    IN       96
                 90 NCARDS=DATA(1)                                              IN       97
                    READ (60,160)XMO,YMO,XFV,YFV,XOV,YOV,XG,YG,SIZF,XTI,YTI,XMOVE,YMOV IN 98
                   +E                                                           IN       99
 110                IF (J.GT.NCARDS) GO TO 6                                    IN      100
                    DO 95 J=1,NCARDS                                            IN      101
                    READ (60,170)X1,Y1,N1,X2,Y2,N2,X3,Y3,N3,X4,Y4,N4            IN      102
                    XBB(N1)=X1                                                  IN      103
                    XBB(N2)=X2                                                  IN      104
 115                XBB(N3)=X3                                                  IN      105
                    XBB(N4)=X4                                                  IN      106
                    YBB(N1)=Y1                                                  IN      107
                    YBB(N2)=Y2                                                  IN      108
                    YBB(N3)=Y3                                                  IN      109
 120                YBB(N4)=Y4                                                  IN      110
                 95 YBB(N4)=Y4                                                  IN      111
                  6 CONTINUE                                                    IN      112
                    GO TO 10                                                    IN      113
                100 FRIC=DATA(1)                                                IN      114
 125                BLFF=DATA(2)                                                IN      115
                    TANS=DATA(3)                                                IN      116
                    CDB=DATA(4)                                                 IN      117
                    SK=DATA(5)                                                  IN      118
                    RG=DATA(6)                                                  IN      119
 130                IREAD=IFIX(DATA(7))                                         IN      120
                    GO TO 10                                                    IN      121
                110 CALL PLOT(0,0,3)                                            IN      122
                    CALL PLOT(0,0,999)                                          IN      123
                    CALL EXIT                                                   IN      124
 135          C                                                                 IN      125
                120 FORMAT (9A8,A5,3I1)                                         IN      126
                130 FORMAT (A1,A1,I3,I3,2X,6F10.3,2F5.0)                        IN      127
                140 FORMAT (5X,33HNOTE - NUMBER OF ELEMENTS INPUT, ,I3,39H NOT EQUAL N IN 128
                   +UMBER SPECIFIED ON I CARD (,I3,1H))                         IN      129
 140            150 FORMAT (12F6.5)                                             IN      130
                160 FORMAT (13F6.0)                                             IN      131
                170 FORMAT (4(2F6.0,I3,3X))                                     IN      132
                    RETURN                                                      IN      133
              C     END INPUT                                                   IN      134
 145                END                                                         IN      135

CARD NO. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

  140      I      20C0 140  FIELD WIDTH OF A CONVERSION DESCRIPTOR SHOULD BE AS LARGE AS THE MINIMUM SPECIFIED FOR THAT DESCRIPTOR.
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```
          SUBROUTINE PINPUT                                             PIN      2
          COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TANS,CDB,NEL,TITLE(10),NELTOT,  CB2      2
         +  NELEM(080),NETYP(080),RO(080),XO(080),ZI(080),CL(080),RI(080),  CB2      3
         2  TLIN(080),BLEI(080),BELK(080),WSPCT(080),NHOLES(080),NHTYP(080), CB2      4
         3  ISEP(080),IDBUG,NFW(080),IPIC,ABETA(080),SIGM,SIGM2,IRUN,ICASE  CB2      5
          COMMON/OUTPUT/PTDIS,CDOV,WCOMP,CUMGA,CUMWJ,RB(080),H(080),     CB2      6
         1  XI(080),BLKA(080),BLKT(080),FAX(080),EAF(080),BETA(080),PS(080), CB2      7
         2  W(080),TT(080),PT(080),TS(080),PMD(080),EM(080),V(080),VX(080),  CB2      8
         3  VIN(080),Q(080),DP(080),SLEN(080),WL(080),MAXDEC(080),        CB2      9
         4  CD(080),ANGJ(080),DHOLES(080),ANNLET(080),EAP(080),CUMEA(080),  CB2     10
         5  VJET(080),ATCUL(080),XS(080),CUMLF                           CB2     11
          COMMON/CODBIT/IN,NOUT,IREAD,ITER,SUFF,SUFD                     CB2     12
          WRITE (61,20)TITLE                                             PIN      4
          IF (ITER.EQ.1)WRITE (61,40)                                    PIN      5
          IF (ITER.EQ.2)WRITE (61,50)                                    PIN      6
          IF (IPIC.EQ.0)WRITE (61,60)                                    PIN      7
          IF (IPIC.EQ.1)WRITE (61,70)                                    PIN      8
          IF (IDBUG.EQ.0)WRITE (61,80)                                   PIN      9
          IF (IDBUG.EQ.1)WRITE (61,90)                                   PIN     10
          IF (IDBUG.EQ.2)WRITE (61,100)                                  PIN     11
          WRITE (61,110)DP,BLKF,SK,RG,FRIC,TANS,CDB,NEL                  PIN     12
          WRITE (61,120)                                                 PIN     13
          IF (1.GT.NEL)GO TO 5                                           PIN     14
          DO 10 LL=1,NEL                                                 PIN     15
          L=NELEM(LL)                                                    PIN     16
          IF (NETYP(L).EQ.1HL)WRITE (61,130)NELEM(LL),NETYP(L),NFW(L),XO(L), PIN     17
         +RO(L),XI(L),RI(L),CL(L),TLIN(L),BLEI(L),BELK(L)                PIN     18
          IF (NETYP(L).EQ.1HF)WRITE (61,140)NELEM(LL),NETYP(L),NFW(L),DHOLES PIN     19
         +(L),NHOLES(L),NHTYP(L),CD(L),WSPCT(L)                          PIN     20
       10 CONTINUE                                                       PIN     21
        5 CONTINUE                                                       PIN     22
          RETURN                                                         PIN     23
    C                                                                    PIN     24
       20 FORMAT (1H1,10A8//8X,13HINPUT DATA - )                         PIN     25
       40 FORMAT (10X,95HCALCULATION CONTROLS - SOME (OR ALL) HOLES FIXED SI PIN     26
         +ZE, ITERATE TO FIND PRESSURE DROP (ITER = 1))                  PIN     27
       50 FORMAT (10X,110HCALCULATION CONTROLS - PRESSURE DROP FIXED - SOME  PIN     28
         +HOLES FIXED SIZE, SIZE VARIABLE HOLES BY ADJUSTING FLOW (ITER = 2) PIN     29
         +)                                                              PIN     30
       60 FORMAT (33X,38HPICTURE WILL NOT BE PLOTTED (IPIC = 0))         PIN     31
       70 FORMAT (33X,34HPICTURE WILL BE PLOTTED (IPIC = 1))             PIN     32
       80 FORMAT (33X,60HOUTPUT PRINTING OCCURS AFTER FINAL SOLUTION ONLY (I PIN     33
         +DBUG = 0))                                                     PIN     34
       90 FORMAT (33X,60HOUTPUT PRINTING OCCURS AFTER EACH FLOW ITERATION (I PIN     35
         +DBUG = 1))                                                     PIN     36
      100 FORMAT (33X,53HOUTPUT PRINTING OCCURS AFTER EACH ELEMENT (IDBUG =  PIN     37
         +2))                                                            PIN     38
      110 FORMAT (10X,24HOVERALL PRESSURE DROP - ,F6.4/10X,32HANNULUS EFFECT PIN     39
         +IVE AREA FACTOR - ,F6.4/10X,30HAIR RATIO OF SPECIFIC HEATS - ,F7.3 PIN     40
         +/10X,19HAIR GAS CONSTANT - ,F6.3/10X,32HANNULUS WALL ROUGHNESS FAC PIN     41
         +TOR - ,F7.4/10X,37HTANGENT OF SEPARATION SPREAD ANGLE - ,F7.4/10X, PIN     42
         +41HDRAG COEFFICIENT FOR INSERTED BLOCKAGE - ,F8.4/10X,30HNUMBER OF PIN     43
         + POSITION ELEMENTS - ,I3/)                                     PIN     44
      120 FORMAT (12X,35HDIMEN. AT DOWNSTREAM END OF ELEMENT,/12X,1H-,1H-,1H PIN     45
         +-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-, PIN     46
         +1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,/1 PIN     47
         +2X,40H  XO        RO        XI        RI        CL        WALL,4X,59HIUSE PIN     48
         +RT   INSERT    HOLE    NUMBER  HOLE  DISCH ORIFICE,/1X,61HELEM  E PIN     49
         +LEM   OUTER   OUTER    INNER   INNER   ELEMENT  TEMP,,3X,24H AREA PIN     50
         +   DIAMETER   DIAM      OF     TYPE  COEFF FLOW ,/,1X,50H NO.  TYP PIN     51
         +E  LENGTH   RADIUS   LENGTH   RADIUS   LENGTH    ,6X,55HFACTOR   PIN     52
         +IN.        IN.       HOLES               FLOW IN,/1X,1H-,1H-,1H-,1H-, PIN     53
         +1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H PIN     54
         +-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-, PIN     55
         +1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H PIN     56
         +-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-, PIN     57
         +1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H PIN     58
         +-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-, PIN     59
         +1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H-,1H PIN     60
         +-,//)                                                          PIN     61
      130 FORMAT (2X,I3,3X,A1,A1,2X,F7.3,2X,F7.3,2X,F7.3,2X,F7.3,2X,F7.3,2X, PIN     62
         +F6.1,2X,F6.3,2X,F7.3)                                          PIN     63
      140 FORMAT (2X,I3,3X,A1,A1,73X,F5.4,1X,I5,3X,I4,2X,F6.4,1X,F7.4)   PIN     64
    C     END PINPUT                                                     PIN     65
          END                                                            PIN     66
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      SUBROUTINE INLET                                                  INL     2
      COMMON/[illegible]/[illegible],BLKF,SK,RG,FRIC,TANS,CDS,NEL,TITLE(10),NELTOT,  CB2 2
     +  NELEM(080),NETYP(080),RO(080),XI(080),XT(080),CL(080),RI(080),  CB2 3
     1  [illegible],NETYP(080),[illegible]ES(080),NMTYP(080),           CB2 4
     2  TITLE(080),BLKI(080),[illegible],[illegible],STEP,[illegible],ICASE  CB2 5
     3  [illegible],IPIC,[illegible],[illegible],NCASE),                CB2 6
      COMMON/[illegible]/[illegible],EAX(080),EAF(080),BETA(080),PS(080),  CB2 7
     1  AX(080),[illegible],[illegible],EM(080),V(080),VX(080),         CB2 8
     2  WL(080),TT(080),PT(080),[illegible],[illegible],                CB2 9
     3  VTH(080),Q(080),WP(080),BLKW(080),W(080),NAMES(080),            CB2 10
     4  CU(080),[illegible],[illegible]ES(080),EAN(080),CAREA(080),     CB2 11
     5  RHO(080),ATCHL(080),XB(080),[illegible]                         CB2 12
      COMMON/[illegible]/[illegible],IREAD,ITER,SWFF,SWFB               INL     4
      I=1                                                               INL     5
      L=NELEM(1)                                                        INL     6
      WCORR=W(L)*SQRT(TT(L)/518.7)/(PT(L)/14.7)                         INL     7
   10 CALL IAREA(RO(L),RI(L),XO(L),XI(L),RB(L),R(L),AX(L),XB(L))        INL     8
      CAREA(L)=0.                                                       INL     9
      ATCHL(L)=0.                                                       INL    10
      EAX(L)=AX(L)*BLKF*BLKI(L)                                         INL    11
      RBETA=BETA(L)/57.296                                              INL    12
      EAF(L)=EAX(L)*COS(RBETA)                                          INL    13
      IMACH=0                                                           INL    14
      CALL MACH(IMACH,W(L),PT(L),TT(L),EAF(L),RBETA,SK,RG,EM(L),TS(L),PS INL  15
     +(L),RHO(L),V(L),VX(L),VTH(L),Q(L),WP(L))                          INL    16
      BLKC(L)=1.0                                                       INL    17
      BLKS(L)=1.0                                                       INL    18
      BLKW(L)=BLKI(L)                                                   INL    19
      WL(L)=0.                                                          INL    20
      IF (I.EQ.2)RETURN                                                 INL    21
      L=NELEM(2)                                                        INL    22
      IF (NETYP(L).NE.INL.OR.NFM(L).NE.1))RETURN                        INL    23
      I=2                                                               INL    24
      GO TO 10                                                          INL    25
C     END INLET                                                         INL    26
      END
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      SUBROUTINE LENGTH(LL)                                             LE         2
      COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TANS,CDD,NEL,TITLE(10),NELTOT,   CMN        2
     + NELEM(080),NETYP(080),RB(080),XD(080),XI(080),CL(080),PI(080),   CMN        3
     2 TLIN(080),BLKI(080),BLKX(080),WBPCT(080),ANGLES(080),ANNTYP(080), CMN       4
     3 ISEP(080),IDBUG,NFW(080),IPIC,ABETA(080),SIGM,SIGM2,IROW,ICASE   CMN        5
      COMMON/OUTPUT/PTBIS,CDDW,WCOMRT,COMGE,COMVJ,XB(080),H(080),       CMN        6
     1 AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080), CMN        7
     2 W(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080),  CMN        8
     3 VTH(080),Q(080),QP(080),BLKM(080),WL(080),ZAXDEC(080),           CMN        9
     4 CD(080),ANGJ(300),ONBLES(080),ANGLES(080),EAN(080),COMEA(080),   CMN       10
     5 VJET(080),ATCML(080),XB(080),COMLF                               CMN       11
      COMMON/CODBIT/IN,NOUT,IREAT,ITEP,SWFF,SWFD                        CMN       12
      II=LL-1                                                           LE         4
      L=NELEM(LL)                                                       LE         5
      I=NELEM(II)                                                       LE         6
      COMEA(L)=0.                                                       LE         7
      W(L)=W(I)                                                         LE         8
      EPB=EM(I)*EM(I)                                                   LE         9
      EAM(L)=0.                                                         LE        10
      MIT=0                                                             LE        11
      PBETAI=BETA(I)/57.296                                             LE        12
      CALL XAREA(PD(L),XI(L),XO(L),XI(L),RB(L),H(L),AX(L),XB(L))        LE        13
      IF (CL(L).EQ.0.)CL(L)=SQRT((ABS(XB(L)-XB(I)))**2.+(ABS(RB(L)-RB(I LE        14
     +))**2.)                                                           LE        15
      CALL DELTO(TT(I),V(I),RHO(I),H(I),PT(I),CL(L),W(I),TLIN(L),TT(L),D LE       16
     +TT,FRIC,FF,NFW(L))                                                LE        17
      THFR=FF*CL(L)/H(I)*TAN(PBETAI)                                    LE        18
      IF (THFR.LT.0.)THFR=0.                                            LE        19
      THFR=(1.+THFR)                                                    LE        20
      CALL WAKE(I,L,II)                                                 LE        21
      BLKS(L)=BLKS(I)*AX(I)/AX(L)*RB(L)/RB(I)+TANS*CL(L)/H(L)/COS(PBETAI LE       22
     +)                                                                 LE        23
      ATCML(L)=0.                                                       LE        24
      IF (BLKS(L).LE.1.)GO TO 10                                        LE        25
      BLKS(L)=1.0                                                       LE        26
      ATCML(L)=COS(PBETAI)*(H(L)-BLKS(I)*H(I))/TANS                     LE        27
      IF (ATCML(L).LT.0.)ATCML(L)=0.                                    LE        28
   10 EAX(L)=BLKS(L)*BLKW(L)*BLKI(L)*BLKF*AX(L)                         LE        29
      VX(L)=VX(I)*EAX(I)/EAX(L)                                         LE        30
      VTH(L)=VTH(I)*RB(I)/RB(L)/THFR                                    LE        31
      V(L)=SQRT(VX(L)**2+VTH(L)**2)                                     LE        32
      RHO(L)=RHO(I)                                                     LE        33
   20 RBETAL=ATAN(VTH(L)/VX(L))                                         LE        34
      EAF(L)=EAX(L)*COS(RBETAL)                                         LE        35
      DAA=ALOG(EAF(L)/EAF(I))                                           LE        36
      DF=2.*FF*CL(L)/COS(RBETAL)/H(L)*CDD*(1.-BLKI(I))                  LE        37
      DWW=0.                                                            LE        38
      Y=1                                                               LE        39
      CALL AKR(DAA,DTT,DF,DWW,Y,SK,EM(I),EMB,EM(L))                     LE        40
      IF (EM(L).GE.1.)RETURN                                            LE        41
      EMB=(EM(I)*EM(I)+EM(L)*EM(L))/2.                                  LE        42
      PAK=-SK*EMB/2.*(DTT+DF)                                           LE        43
      PT(L)=PT(I)*EXP(PAK)                                              LE        44
      CALL MAC4(I,W(L),PT(L),TT(L),EAF(L),RBETAL,SK,RG,EM(L),TS(L),PS(L) LE       45
     +,RHO(L),V(L),VX(L),VTH(L),Q(L),QP(L))                             LE        46
      MIT=MIT+1                                                         LE        47
      BETACK=RBETAL*57.2957795                                          LE        48
      BETA(L)=57.2957795*ATAN(VTH(L)/VX(L))                             LE        49
      IF (MIT.EQ.1)GO TO 20                                             LE        50
      IF (MIT.EQ.10)GO TO 30                                            LE        51
      IF (ABS(BETA(L)-BETACK).GT..05)GO TO 20                           LE        52
   30 RETURN                                                            LE        53
C     END LENGTH                                                        LE        54
      END                                                               LE        55
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SUBROUTINE WAKE        73/74    OPT=0 TRACE                    FTN 4.6+439         08/24/79  09.59.39          PAGE      1

                 SUBROUTINE WAKE(I,L,II)                                         WA        2
                 COMMON/INPUTC/DP,BLEF,SK,RG,FRIC,TANS,CWB,NEL,TITLE(13),NELTOT, CB2       2
               * NELEM(080),NETYP(080),RD(080),XO(080),XI(080),CL(080),PI(080),  CB2       3
               2 TLIN(080),BLKI(080),DBLK(080),DBPCT(080),NHOLES(080),NHTYP(080),CB2       4
               3 ISEP(080),IHOLE,NFI(080),FPIC,ABETA(080),STGM,STGM2,IRUN,ICASE  CB2       5
                 COMMON/OUTPUT/PTDIS,CMU,UCMRI,CUMGA,CUMMJ,RE(080),H(080),       CB2       6
               1 AX(080),BLEU(080),BLKS(080),EAX(080),FAF(080),BETA(080),PS(080),CB2       7
               2 VI(080),TT(080),PT(080),TS(080),RHO(080),EP(080),V(080),VI(080),CB2       8
               3 VTH(080),Q(080),DP(080),BLKN(080),WL(080),WAKDEC(080),          CB2       9
               4 CD(080),ANGI(080),ANGLES(080),ANGLES(080),EAN(080),CUMEA(080),  CB2      10
               5 VJET(080),ATCNL(080),RB(080),CUMLE                              CB2      11
                 COMMON/CONDIT/IN,NOUT,IREAD,ITER,SWFF,SWFD                      CB2      12
                 WL(I)=0.                                                        WA        4
                 WAKDEC(I)=(1.-BLKI(I))/(5.*DBLK(I))                             WA        5
                 WLI=CL(L)/COS(BETA(I)/57.296)                                   WA        6
                 BLKW(L)=1.0                                                     WA        7
                 IF (I.GT.II)GO TO 5                                             WA        8
                 DO 20 MM=I,II                                                   WA        9
                 M=NELEM(MM)                                                     WA       10
                 WL(M)=WL(M)+WLI                                                 WA       11
                 IF (MM.EQ.II)GO TO 10                                           WA       12
                 IF (BLKN(M).EQ.1.)GO TO 20                                      WA       13
              10 BLKN(M)=WAKDEC(M)*WL(M)+BLKI(M)                                 WA       14
                 IF (BLKN(M).GT.1.)BLKN(M)=1.0                                   WA       15
              20 BLKW(L)=BLKW(L)*BLKN(M)                                         WA       16
               5 CONTINUE                                                        WA       17
                 RETURN                                                          WA       18
        C        END WAKE                                                        WA       19
                 END                                                             WA       20
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SUBROUTINE FLOW        73/74    OPT=0 TRACE                  FTN 4.6+439        08/26/78  39.58.39        PAGE     1

                SUBROUTINE FLOW(LL)                                                    FL           2
                COMMON/INPUT/C/DP,BLKF,SX,RG,FRIC,TAMS,CDB,NEL,TITLE(10),NELTOT,      CB2          2
              +  NELEM(000),NETYP(G00),RO(000),XO(000),XI(000),CL(000),PT(000),       CB2          3
              2  TLIN(000),BLKI(000),BMLC(000),WBPCT(000),MOBLES(000),NNTYP(000),     CB2          4
              3  ISEP(000),IBDUG,NFU(000),IPIC,AREA(000),SIGN,SIGN2,IRUN,ICASE       CB2          5
                COMMON/OUTPUT/PTDIS,CDOW,NCOMPI,CUNCA,CUMWJ,RB(000),H(000),           CB2          6
              1  AX(000),BLKW(000),BLKS(000),EAX(000),EAF(000),BETA(000),PS(000),     CB2          7
              2  W(000),TT(000),PT(000),TS(000),RHO(000),EM(000),V(000),VX(000),      CB2          8
              3  VTN(000),Q(000),QP(000),BLCN(000),WL(000),WAKDEC(000),               CB2          9
              4  CD(000),ANGJ(000),SMBLES(000),ANBLES(000),EAM(000),CONEA(000),       CB2         10
              5  VJET(000),ATCML(000),XB(000),CUNLF                                   CB2         11
                COMMON/CONGIT/IN,NOUT,IREAX,ITER,SWFF,SWFD                            CB2         12
                II=LL-1                                                                FL           4
                L=NELEM(LL)                                                            FL           5
                I=NELEM(II)                                                            FL           6
                NIT=0                                                                  FL           7
                Y=1                                                                    FL           8
                ATCML(L)=0.                                                            FL           9
                PT(L)=PT(I)                                                            FL          10
                TT(L)=TT(I)                                                            FL          11
                RO(L)=RO(I)                                                            FL          12
                RI(L)=RI(I)                                                            FL          13
                XO(L)=XO(I)                                                            FL          14
                XI(L)=XI(I)                                                            FL          15
                AX(L)=AX(I)                                                            FL          16
                RB(L)=RB(I)                                                            FL          17
                XB(L)=XB(I)                                                            FL          18
                H(L)=H(I)                                                              FL          19
                TLIN(L)=TLIN(I)                                                        FL          20
                CL(L)=0.                                                               FL          21
                CALL WAKE(I,L,II)                                                      FL          22
                BLKS(L)=BLKS(I)                                                        FL          23
                IF (ISEP(L).EQ.1)BLKS(L)=1.0                                           FL          24
                EMB=EM(I)*EM(I)                                                        FL          25
                EAX(L)=BLKS(L)*BLKW(L)*BLKF*AX(L)                                      FL          26
                IF (NFU(L).EQ.1HI)GO TO 10                                             FL          27
                CALL JET(I,L,LL,WJW)                                                   FL          28
                VTN(L)=VTN(I)                                                          FL          29
                GO TO 20                                                               FL          30
             10 CALL MIX(I,L,WJW,Y)                                                    FL          31
             20 WR=1.-WJW                                                              FL          32
                IF (WR.LE.0. .AND. LL.LT.NEL) WR=1.0                                   FL          33
                IF (WR.LE.0. .AND. LL.GE.NEL) WR=.01                                   FL          34
                W(L)=W(I)*WR                                                           FL          35
                VX(L)=VX(I)*WR                                                         FL          36
             30 RBETAL=ATAN(VTN(L)/VX(L))                                              FL          37
                BETACH=RBETAL*57.2957795                                               FL          38
                EAF(L)=EAX(L)*COS(RBETAL)                                              FL          39
                DAA=ALOG(EAF(L)/EAF(I))                                                FL          40
                DWW=ALOG(W(L)/W(I))                                                    FL          41
                DTT=ALOG(TT(L)/TT(I))                                                  FL          42
                DF=0.                                                                  FL          43
                CALL AKM(DAA,DTT,DF,DWW,Y,SX,EM(I),EMB,EM(L))                          FL          44
                IF (EM(L).GE.1.)RETURN                                                 FL          45
                EMB=(EM(I)*EM(I)+EM(L)*EM(L))/2.                                       FL          46
                PAK=-SX*EMB/2.*(DTT+2.*(1.-Y)*DWW)                                     FL          47
                PT(L)=PT(I)*EXP(PAK)                                                   FL          48
                CALL MACH(I,W(L),PT(L),TT(L),EAF(L),RBETAL,SX,RG,EM(L),TS(L),PS(L)     FL          49
               +,RHO(L),V(L),VX(L),VTNR,Q(L),QP(L))                                   FL          50
                NIT=NIT+1                                                              FL          51
                BETA(L)=57.2957795*ATAN(VTN(L)/VX(L))                                  FL          52
                IF (NIT.GE.10)GO TO 40                                                 FL          53
                IF (NIT.EQ.1)GO TO 30                                                  FL          54
                IF (ABS(BETA(L)-BETACH).GT..05)GO TO 30                                FL          55
             40 RETURN                                                                 FL          56
C               END FLOW                                                               FL          57
                END                                                                    FL          58
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          SUBROUTINE MIX(I,L,WJW,Y)                                        MI           2
          COMMON/INPUTC/DP,BLKF,SK,RZ,FRIC,TANS,CDB,NEL,TITLE(10),NELTOT,  CD2          2
     +      NELEM(080),NETYP(080),RD(080),XO(080),XI(080),CL(080),RI(080), CD2          3
     2      TLIN(080),BLKI(080),PBLK(080),WBPCT(080),NHOLES(080),NHTYP(080), CD2        4
     3      ISEP(080),IDBUG,NFW(080),IPIC,ABETA(080),SIGM,SIGN2,IRUN,ICASE CD2          5
          COMMON/OUTPUT/PTDIS,CDOV,WCORRI,CUMGA,CUMWJ,RB(080),H(080),      CD2          5
     1      AI(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080), CD2        7
     2      W(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080), CD2         8
     3      VTH(080),Q(080),QP(080),BLKM(080),WL(080),WAKDEC(080),         CD2          9
     4      CD(080),ANGJ(080),DHOLES(080),AHOLES(080),EAH(080),CUMEA(080), CD2         10
     5      VJET(080),ATCHL(080),XR(080),CUMLF                             CD2         11
          COMMON/COMBIT/IN,NOUT,IREAK,ITER,SWFF,SWFD                       CD2         12
          II=NELEM(I)                                                      MI           4
          RAD=57.2957795                                                   MI           5
          WJ=WBPCT(L)*W(II)                                                MI           5
          WJW=WJ/W(I)                                                      MI           7
          CPJ=.24                                                          MI           8
          CPG=.3                                                           MI           9
          HJ=CPJ*TT(II)                                                    MI          10
          HI=CPG*TT(I)                                                     MI          11
          HL=(W(I)*HI-WJ*HJ)/(W(I)-WJ)                                     MI          12
          TT(L)=HL/.3                                                      MI          13
          WRITE (61,10)CPJ,CPG,HJ,HI,HL,W(I),WJ,TT(II),TT(I),TT(L)         MI          14
          VJCA=VJET(L)*COS(ANGJ(L)/RAD)                                    MI          15
          VTHJ=ABS(VJCA*SIN(ABETA(L)/RAD))                                 MI          16
          VXJ=VJCA*COS(ABETA(L)/RAD)                                       MI          17
          IF (VJCA.GE.0.) BA=COS((ABETA(L)-BETA(I))/RAD)                   MI          18
          IF (VJCA.LT.0.) BA=COS((ABETA(L)+BETA(I))/RAD)                   MI          19
          VXI=VJCA*BA                                                      MI          20
          VTH(L)=(W(I)*VTH(I)-WJ*VTHJ)/(W(I)-WJ)                           MI          21
          Y=VXJ/VX(I)                                                      MI          22
          Y=VXI/V(I)                                                       MI          23
          WRITE(61,20)VTHJ,VXJ,VXI,VTH(L),Y                                MI          24
       20 FORMAT (22H VTHJ VXJ VXI VTH(L) Y ,5F10.5)                       MI          25
          RETURN                                                           MI          26
    C                                                                      MI          27
       10 FORMAT (44H CPJ CPG HJ HI HL W(I) WJ TT(II) T(I) TT(L) ,/1X,2F6.3, MI        28
         +1X,2F10.3,1X,F12.3,1X,2F7.3,1X,3F12.3)                           MI          29
    C     END MIX                                                          MI          30
          END                                                              MI          31
```

```
      SUBROUTINE JET(I,L,LL,WJJ)
      COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TANS,CDB,NEL,TITLE(10),NELTOT,
     +  NELEM(080),NETYP(080),RD(080),XO(080),XI(080),CL(080),PI(080),
     2  TLIM(080),BLEI(080),DBLK(080),WBPCT(080),NHOLES(080),NHTYP(080),
     3  ISEP(080),IDBUG,NFW(080),IPIC,ABETA(080),SIGM,SIGM2,IRUN,ICASE
      COMMON/OUTPUT/PTDIS,CDGV,WCOPRI,CUMGA,CUMWJ,RE(080),M(080),
     1  AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080),
     2  W(080),TT(080),PT(080),TS(080),RHO(080),FM(080),V(080),VX(080),
     3  VTH(080),B(080),GP(080),BLKR(080),WL(080),WAKDEC(080),
     4  CD(080),ANGJ(080),DHOLES(080),AHOLES(080),EAH(080),CUMEA(080),
     5  VJET(080),ATCHL(080),XB(080),CUMLF
      COMMON/CODBIT/IN,NOUT,IPEAK,ITER,SWFF,SWFD
      LI=NELEM(1)
      NIT=0
      ITM=20
      C1= 2./(SK-1.)
      C2= (SK-1.)/SK
      C3=32.174*SK*RG
      WJ=WBPCT(L)*W(LI)
      IF (NFW(L).EQ.1HD)GO TO 35
      DPS=PS(I)-PTDIS
      IF (DPS.LE.0.) WRITE (61,130) L,DPS
  130 FORMAT ( 33H STATIC PRESSURE DROP AT ELEMENT ,I3, 21H ZERO OR NEGA
     *TIVE, = ,F12.5)
      PRJ=PT(I)/PTDIS
      IF (PRJ.GT.1.) GO TO 10
      WRITE (61,100) L
      IF (PRJ.EQ.1.) PRJ=.999999
      PRJ=1./PRJ
      EMJ=SQRT(C1*(PRJ**C2-1.))
      VJET(L)= EMJ*SQRT(C3*TS(I))
   35 IF (NFW(L).EQ.1HD) GO TO 37
      AHOLES(L)=0.
      DHOLES(L)=0.
      EAH(L)=0.
      IF (NFW(L).NE.1HD) WJ=0.
      WRITE(61,500) L
  500 FORMAT(1X,*FLOW ELEMENT *,I3,* HAS NEGATIVE PRESSURE DROP,  ORIFIC
     +E DIA AND FLOW SET TO ZERO. *)
      GO TO 70
   37 EAH(L)=AHOLES(L)*.1
      VJET(L)=SQRT(2.*32.174/RHO(I)*ABS(PTDIS-PS(I)))
      WJ=-EAH(L)*VJET(L)*RHO(I)/144.
      WRITE(61,501)L,WJ
  501 FORMAT(1X,*FLOW ELEMENT *,I3,* HAS NEGATIVE FLOW OF *,F12.6,* WITH
     + DISCH COEF SET TO 0.1*)
      GO TO 60
   10 EMJ=SQRT(C1*(PRJ**C2-1.))
      VJET(L)=EMJ*SQRT(C3*TS(I))
   20 AF=EAF(I)
      HV=V(I)/VJET(L)
      IF (NFW(L).EQ.1HD)GO TO 40
      WJW=WJ/W(I)
      EAH(L)=WJ/VJET(L)/RHO(I)*144.
      IF (HV.GE.1.) GO TO 35
      CALL DCOEF (HV,WJW,BLI,NHTYP(L),CD(L),ANGJ(L))
      AHAN=BLI
      CDH=CD(L)
   30 IF (CD(L).EQ.0.) CDH= .0001
      AHOLES(L)=EAH(L)/CDH
      AHOLE=AHOLES(L)/NHOLES(L)
      DHOLES(L)=SQRT(AHOLE/.78539816)
      SWFF=SWFF+WBPCT(L)
 1000 FORMAT(19H AH AHOLES CD AHAN ,4(F20.10,1X))
      GO TO 70
   40 AHOLE=.78539816*DHOLES(L)*DHOLES(L)
      AHOLES(L)=AHOLE*NHOLES(L)
      AHAN=AHOLES(L)/AF
      WJE=WJ
   50 WJW=WJE/W(I)
      IF (HV.GT.1.) GO TO 35
      IF (WJE.LE.0.) WJW=.05*W(LI)/W(I)
      CALL DCOEF (HV,WJW,BLI,NHTYP(L),CD(L),ANGJ(L))
      EAH(L)=AHOLES(L)*CD(L)
      WJ=EAH(L)*VJET(L)*RHO(I)/144.
 2000 FORMAT(1X,I3,21HO AHAN BLI CD EAH WJ ,5(F20.5,1X))
      IF (ABS(WJE-WJ).LT..0001)GO TO 60
```

```
      WJE=WJ
      IF (NIT.GT.ITM)GO TO 60
      NIT=NIT+1
      GO TO 50
   60 WJW=WJ/W(I)
      IF (WJW.GT.1.)WRITE (61,110)L
      WBPCT(L)=WJ/W(I)
      SWFD=SWFD+WBPCT(L)
   70 CUMWJ=CUMWJ+WJ
      CUMLF=CUMLF+WJ
      CUMGA=CUMGA+AHOLES(L)
      CUMEA(L)=0.
      IF (I.GT.LL)GO TO 5
      DO 80 MM=1,LL
      M=NELEM(MM)
   80 CUMEA(L)=CUMEA(L)+EAN(M)
    5 CONTINUE
      IF (NIT.GE.ITM) WRITE(61,120)L
      RETURN
   90 CUMWJ=CUMWJ+WJ
      WJW=WJ/W(I)
      SWFF=SWFF+WBPCT(L)
      RETURN
C
  100 FORMAT (    67H ANNULUS TOTAL PRESSURE LESS THAN LINER STATIC PRESS
     +URE AT ELEMENT ,I3)
  110 FORMAT(1X,*PRESSURE DROP TOO HIGH. TOTAL ORF FLOW AT ELEMENT *,I3,
     +* EXCEEDS INLET FLOW*)
  120 FORMAT (46H  ITERATIONS IN JET EXCEEDED LIMIT AT ELEMENT ,I3,/)
      END  JET
C
      END
```

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SUBROUTINE DCOEF       73/74    OPT=0 TRACE                  FTN 4.6+439        08/24/78  09.58.39        PAGE     1

                SUBROUTINE DCOEF (H,WJW,BLI,NHOTYP,CDJ,AJET)                          DC
                W=WJW                                                                 DC
                ICKCGT=NHOTYP                                                         DC
                IF (ICKCGT.LE.1)GO TO 10                                              DC
                IF(ICKCGT.GT.6) GO TO 73                                              DC
                GO TO (10,10,10,10,60,10),ICKCGT                                      DC
             10 PI=3.141592654                                                        DC
                RAD=57.2957795131                                                     DC
                IF (WJW.GT.1.)W=1.                                                    DC
                IF (W.LE.0.)GO TO 70                                                  DC
                IF(H.GT.1.) GO TO 70                                                  DC
                BLD=ACOS(1.-W/2.)*RAD                                                 DC
                R=ACOS(H*(1.-W/2.))                                                   DC
                B=R*RAD                                                               DC
                C1=COS(R)                                                             DC
                C2=1.-W/2.                                                            DC
                C3=1.-W                                                               DC
                C4=SIN(R)                                                             DC
                C5=(1.+C1)/(1.-C1)                                                    DC
                C6=(C2*C2+C1*C1)/(C2*C1)                                              DC
                C7=(C2+C1)/(C2-C1)                                                    DC
                C8=(C2*C2+C3*C3*C1*C1)/C2/C1                                          DC
                C9=(C2+C3*C1)/(C2-C3*C1)                                              DC
                BL=C1/PI/C2*((PI*C4*W)-C1*W*ALOG(C5)+C6*ALOG(C7)-C8*ALOG(C9))         DC
                BLI=BL                                                                DC
             30 CKB=2.*COS(R)/(BLI*(2./W-1.))                                         DC
                CDJ=CKB                                                               DC
                AJET=B                                                                DC
                IF(NHOTYP.EQ.2)GO TO 40                                               DC
                IF(NHOTYP.EQ.3)GO TO 50                                               DC
                IF(NHOTYP.EQ.4)GO TO 52                                               DC
                IF(NHOTYP.EQ.6) GO TO 54                                              DC
          C   HOLE TYPE 1, FLUSH HOLE, THIN WALL                                      DC
                RETURN                                                                DC
          C   HOLE TYPE 2, PLUNGED HOLE                                               DC
             40 CDJ=CDJ*1.475                                                         DC
                AJET=80.                                                              DC
                RETURN                                                                DC
          C   HOLE TYPE 3, COOLING SKIRT                                              DC
             50 CDJ=CDJ*1.4                                                           DC
                AJET=0.                                                               DC
                RETURN                                                                DC
          C   HOLE TYPE 4, FLUSH HOLE, THICK WALL                                     DC
             52 CDJ=CDJ                                                               DC
                AJET=80.                                                              DC
                RETURN                                                                DC
          C   HOLE TYPE 6, RECTANGULAR, THICK WALL                                    DC
             54 CDJ=CDJ*1.1                                                           DC
                AJET=60.                                                              DC
                RETURN                                                                DC
          C   HOLE TYPE 5, INPUT CD, SET JET ANGLE ONLY                               DC
             60 AJET=90.                                                              DC
                RETURN                                                                DC
             70 CDJ=0.                                                                DC
                AJET=0.                                                               DC
                RETURN                                                                DC
          C                                                                           DC
          C     END DCOEF                                                             DC
                END                                                                   DC
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SUBROUTINE DELTO       73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  09.55.39       PAGE     1

                    SUBROUTINE DELTO(T1,V,RHO,H,RI,CL,W,TW,T2,DTT,FRIC,FF,NFNT)        DE         2
                    TKO=.0260*(T1/1000.)**.84                                           DE         3
                    VISO=1.05E-5*(T1/1000.)**.65                                        DE         4
                    REV=2.*H/12.*RHO*V/VISO                                             DE         5
                    IF (NFNT.EQ.1HC)GO TO 10                                            DE         6
                    HO=TKO/2./(H/12.)*.0154*(REV**.8)                                   DE         7
                    AW=2.*3.14159*RI*CL/144.                                            DE         8
                    Q=HO*AW/(W*3600.)/.24                                               DE         9
                    T2=TW-(TW-T1)/(EXP(Q))                                              DE        10
                    GO TO 20                                                            DE        11
                 10 T2=TW+T1                                                            DE        12
                 20 DTT=ALOG(T2/T1)                                                     DE        13
                    IF (FRIC.LT.0.)GO TO 50                                             DE        14
                    PSRFFE=SQRT(REV**.25/.0791)                                         DE        15
                 30 PSRFF=3.48-4.*ALOG10(FRIC+9.35*PSRFFE/REV)                          DE        16
                    IF (ABS(PSRFF-PSRFFE)/PSRFF.LT..01)GO TO 40                         DE        17
                    PSRFFE=PSRFF                                                        DE        18
                    GO TO 30                                                            DE        19
                 40 FF=1./PSRFF/PSRFF                                                   DE        20
                    RETURN                                                              DE        21
                 50 FF=0.                                                               DE        22
                    RETURN                                                              DE        23
              C     END DELTO                                                           DE        24
                    END                                                                 DE        25
```

```
SUBROUTINE AKM          73/74    OPT=0 TRACE                    FTN 4.6+439         08/24/78  09.55.39         PAGE    1

                  SUBROUTINE AKM(DAA,DTT,DF,DWW,Y,SK,EM1,EMB,EM2)                      AK         2
                  FA=-2.                                                               AK         3
                  SIGK=(1.+(SK-1.)/2.*EMB)/(1.-EMB)                                    AK         4
                  EM1=EMB                                                              AK         5
                  FF=SK*EMB                                                            AK         6
                  FT=1.+FF                                                             AK         7
                  FW=2.*(1.+FF*(1.-Y))                                                 AK         8
                  ALPHA=FA*DAA+FT*DTT+FF*DF+FW*DWW                                     AK         9
                  AK=ALPHA*SIGK                                                        AK        10
                  EM2=EM1*EXP(AK/2.)                                                   AK        11
                  IF (EM2.GE.1.)GO TO 40                                               AK        12
               30 RETURN                                                               AK        13
               40 WRITE (61,50)AK,DAA,DTT,DF,DWW,EM1,EM2                               AK        14
                  RETURN                                                               AK        15
             C                                                                         AK        16
               50 FORMAT (43H    MACH NO. EXCEEDS 1 AND WILL NOT CONVERGE,/19H          AK        17
                 +  ALPHA-K  = ,F13.6,10X,7HDA/A = ,F13.6/19H         DT/T      = ,F13. AK        18
                 +6,10X,7HDF    = ,F13.6/19H          DW/W     = ,F13.6,10X,7HM 1  = ,F AK        19
                 +13.6/19H           M 2      = ,F13.6,/)                              AK        20
             C    END AKM                                                              AK        21
                  END                                                                  AK        22
```

```
SUBROUTINE MACH        73/74    OPT=2 TRACE                    FTN 4.6+439        09/24/79  09.58.39        PAGE     1

      SUBROUTINE MACH(IMACH,W,PT,TT,A,RBETA,SK,R,EM,TS,PS,RHO,V,VX,VTH,Q
     *,QP)
      C1=W/A/PT*SQRT(R*TT/SK/32.174)
      C2=(SK+1.)/2./(SK-1.)
      C3=(SK-1.)/2.
      IF (IMACH.EQ.1)GO TO 10
      EM=C1
   10 C4=1.+C3*EM*EM
      C5=SK/(SK-1.)
      C4C2=C4**C2
      IF (IMACH.EQ.1)GO TO 20
      ERR=EM/C4C2-C1
      DERR=(1.-(2.*EM*EM*C2*C3)/C4)/C4C2
      EM=EM-ERR/DERR
      IF (ABS(ERR/DERR).GT..0001)GO TO 10
   20 TS=TT/C4
      PS=PT/(C4**C5)
      RHO=144.*PS/R/TS
      V=W/RHO/A*144.
      VX=V*COS(RBETA)
      VTH=V*SIN(RBETA)
      Q=RHO*V*V/(2.*32.174*144.)
      QP=Q/PT
      RETURN
C     END MACH
      END
```

```
SUBROUTINE XAREA       73/74    OPT=2 TRACE                    FTN 4.6+439          08/24/78  09.50.30        PAGE     1

1                SUBROUTINE XAREA(RO,RI,XO,XI,RB,H,AX,XB)                            XA        2
                 PI=3.14159265                                                        XA        3
                 RB=ABS((RO+RI)/2.)                                                   XA        4
                 H=SQRT((XO-XI)*(XO-XI)+(RO-RI)*(RO-RI))                              XA        5
5                AX=2.*PI*RB*H                                                        XA        6
                 XB=(XO+XI)/2.                                                        XA        7
                 RETURN                                                               XA        8
          C      END XAREA                                                            XA        9
                 END                                                                  XA       10
```

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SUBROUTINE PROUT      73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/79  09.55.33        PAGE

                SUBROUTINE PROUT(LM)                                                  PR         3
                COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TAMS,CDM,NFL,TITLE(10),NELTOT,       CD2        2
               +  NELEM(080),NETYP(080),RO(080),XO(080),XI(080),CL(080),RI(080),      CD2        3
               2  TLIN(080),BLKI(080),DBLK(080),WBPCT(080),NHOLES(080),NHTYP(080),    CD2        4
               3  ISEP(080),IDBUG,NFW(080),TPIC,ABETA(080),SIGN,SIGN2,IRUN,ICASE      CD2        5
                COMMON/OUTPUT/PTDIS,CDOV,WCORRI,CUMSA,CUMVJ,RR(080),H(080),           CD2        6
               1  AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080),    CD2        7
               2  W(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080),     CD2        8
               3  VTH(080),Q(080),OP(080),BLKM(080),WL(080),WAKDEC(080),              CD2        9
               4  CD(080),ANGJ(080),DNHOLES(080),AHOLES(080),FAH(080),CUMEA(080),     CD2       10
               5  VJET(080),ATCHL(080),RB(080),CUMEF                                  CD2       11
                COMMON/CONBIT/IN,NOUT,IPFAX,ITER,SWFF,SWFD                            CD2       12
                WRITE (61,40)TITLE                                                    PR         4
                IF (1.GT.LM)GO TO 5                                                   PR         5
                DO 10 LL=1,LM                                                         PR         6
                L=NELEM(LL)                                                           PR         7
             10 WRITE (61,50)NELEM(LL),NETYP(L),NFW(L),BETA(L),W(L),EM(L),V(L),VX(    PR         8
               +L),VTH(L),TT(L),TS(L),PT(L),PS(L),RHO(L),Q(L),OP(L)                   PR         9
              5 CONTINUE                                                              PR        10
                WRITE (61,60)TITLE                                                    PR        11
                IF (1.GT.LM)GO TO 15                                                  PR        12
                DO 30 LL=1,LM                                                         PR        13
                L=NELEM(LL)                                                           PR        14
                IF (NETYP(L).EQ.1HF)GO TO 20                                          PR        15
                WRITE (61,70)NELEM(LL),NETYP(L),NFW(L),RR(L),H(L),AX(L),EAF(L),BLK    PR        16
               +W(L),BLKS(L),ATCHL(L)                                                 PR        17
                GO TO 30                                                              PR        18
             20 WRITE (61,70)NELEM(LL),NETYP(L),NFW(L),RR(L),H(L),AX(L),EAF(L),BLK    PR        19
               +W(L),BLKS(L),ATCHL(L),DNHOLES(L),CD(L),ANGJ(L),AHOLES(L),FAH(L),CUM   PR        20
               +EA(L),VJET(L),WBPCT(L)                                                PR        21
             30 CONTINUE                                                              PR        22
             15 CONTINUE                                                              PR        23
                WRITE (61,80)CDOV,WCORRI,PTDIS,DP,CUMSA                               PR        24
                RETURN                                                                PR        25
          C                                                                           PR        26
             40 FORMAT (1H1,1X,10A8//10X,23HOUTPUT RESULTS - PAGE 1,//116H ELEM  E    PR        27
               +LEM  SWIRL    FLOW     MACH    FLOW    AXIAL    TANG    TOTAL   STATI PR        28
               +C  TOTAL   STATIC  DENSITY  DYNAM   TEM 40,/116H  NO    TYPE   ANGLE  PR        29
               +   RATE       NO      VEL      VEL      VEL     TEMP,    TEMP,  PRESS, PR       30
               + PRESS,              HEAD,   /PTOT ,/115H                     LB/S    PR        31
               +          FPS      FPS      FPS       R        R      PSIA    PSIA   L PR       32
               +B/FT3    PSIA      --   ,/)                                           PR        33
             50 FORMAT (1X,I3,4X,A1,A1,2X,F6.2,2X,F7.3,2X,F5.4,1X,F7.2,1X,F7.2,1X,    PR        34
               +F7.2,2X,F6.1,2X,F6.1,2X,F6.2,2X,F5.2,2X,F7.4,2X,F6.3,2X,F6.4)         PR        35
             60 FORMAT (1H1,1X,10A8//10X,23HOUTPUT RESULTS - PAGE 2,//10X,1H/,1H*,    PR        36
               +1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1X,29HANNULUS GEOMETRIC PARAME    PR        37
               +TERS,1X,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1X,1H/,1X,1H*,1H*,1H*,1H*,    PR        38
               +1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1X,29H        PR        39
               +ORIFICE PARAMETERS,1X,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,    PR        40
               +1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1H*,1X,1H/,/1X,61HELEM ELEM MEAN      PR        41
               + CHANNEL ANN   AN EFF WAKE   SEPAR  ATTCH    ,59HHOLE    DISCH   JE   PR        42
               +T    ORIF    ORIF    ORIF     JET       ORIF,/1X,61H NO. TYPE RADIUS  PR        43
               +  WIDTH  AREA   AREA  AREA   AREA   LENGTH   ,59HDIAM    COEFF   ANG  PR        44
               +LE   GEOM     EFF      CUMUL  VELOCITY  FLOW,/1X,61H           IN.    PR        45
               +   IN.    IN2     IN2    FACTOR FACTOR   IN.     ,59H IN.     -     DE PR       46
               +G    AREA     AREA   EF AREA    FPS       /IN,/)                      PR        47
             70 FORMAT (1X,I3,3X,A1,A1,1X,F7.3,1X,F5.3,2X,F6.2,1X,F6.2,1X,F5.3,2X,    PR        48
               +F5.3,1X,F7.3,1X,F7.4,1X,F5.4,1X,F6.2,1X,F7.3,1X,F7.3,1X,F8.3,1X,F7    PR        49
               +.2,1X,F7.4)                                                           PR        50
             80 FORMAT (20X,29HOVERALL FLOW COEFFICIENT =   ,F6.4/20X,29HINLET COR    PR        51
               +RECTED FLOW, LB/S =  ,F7.3/20X,29HDISCHARGE PRESSURE, PSIA =   ,F6.   PR        52
               +2/20X,29HPRESSURE DROP / PT INLET    = ,F7.4/20X,29HTOTAL GEOMETRIC   PR        53
               + AREA, IN2 =   ,F8.3/)                                                PR        54
          C     END PROUT                                                             PR        55
                END                                                                   PR        56
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      SUBROUTINE PICTUR                                                   PI        2
      COMMON/CPICT/IMO,YNO,XFV,YFV,XOV,YOV,XBB(080),YBB(080),XG,YG,       CD1       2
     1 SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),PCYL(1,1)                        CD1       3
      COMMON/INPUTC/DP,BLMF,SK,PG,FRIC,TAMS,CDN,NEL,TITLE(10),NELTOT,     CD2       2
     + MELEM(080),METYP(080),PO(080),XO(080),XI(080),CL(080),PI(080),     CD2       3
     2 TLIN(080),SLFI(080),ORLK(080),DBPCT(080),NHOLES(080),NHTYP(080),   CD2       4
     3 ISEP(080),IDBUG,NFA(080),YPIC,ARETA(080),SIGN,SIGN2,IRUN,ICASE     CD2       5
      COMMON/OUTPUT/PTDIS,CDOV,WCORR,CUMCA,CUMWJ,RE(080),W(080),          CD2       6
     1 AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080),   CD2       7
     2 W(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080),    CD2       8
     3 VTH(080),S(080),QP(080),PLRM(080),W1(080),MAXDEC(080),             CD2       9
     4 CD(080),ANSJ(080),DHOLES(080),ANDLES(080),EAM(080),CUMEA(080),     CD2      10
     5 VJET(080),ATCHL(080),XA(080),CUMLF                                 CD2      11
      COMMON/CCDNIT/IN,NOUT,IPEAT,ITER,SUCC,SUFD                          CD2      12
C     ---------------------------------------------------------           PI        5
      ENTRY PICTUR1                                                       PI        6
C --------   DATA INITIALIZATION   ---------                              PI        7
      WBOX=0.9                                                            PI        8
      HBOX=3.875                                                          PI        9
      ILB=0                                                               PI       10
      ILT=0                                                               PI       11
      SPAC1=.125                                                          PI       12
      SPAC2=.5                                                            PI       13
      WINPUT=5.0                                                          PI       14
      WNOM=4.0                                                            PI       15
      XMAX=-1000.                                                         PI       16
      RMAX=-1000.                                                         PI       17
      XMIN=1000.                                                          PI       18
      RMIN=10000.                                                         PI       19
      WTOT=WBOX+SPAC1                                                     PI       20
      IDONE=0                                                             PI       21
C     -------------------------                                           PI       22
      DO 1000 I=1,NEL                                                     PI       23
      IM=MAX0(1,I-1)                                                      PI       24
      LL=MELEM(I)                                                         PI       25
      LLM=MELEM(IM)                                                       PI       26
      RMAX=AMAX1(RMAX,PO(LL),PI(LL))                                      PI       27
      RMIN=AMIN1(RMIN,PO(LL),PI(LL))                                      PI       28
      XMAX=AMAX1(XMAX,XO(LL),XI(LL))                                      PI       29
      XMIN=AMIN1(XMIN,XO(LL),XI(LL))                                      PI       30
      IF (PI(LL).GT.PO(LL)) GO TO 1010                                    PI       31
C     ------   UPPER HALF OF ANNULUS   --------                           PI       32
      IDONE=I                                                             PI       33
      IF (METYP(LL).EQ.IHL) ILT=ILT+1                                     PI       34
      IF (METYP(LL).EQ.IHF.AND.METYP(LLM).EQ.IHF)  ILT=ILT+1              PI       35
      GO TO 1000                                                          PI       36
C --------   LOWER HALF OF ANNULUS   --------                             PI       37
 1010 IF (METYP(LL).EQ.IHL) ILB=ILB+1                                     PI       38
      IF (METYP(LL).EQ.IHF.AND.METYP(LLM).EQ.IHF) ILB=ILB+1               PI       39
 1000 CONTINUE                                                            PI       40
      IDOMP=IDONE+1                                                       PI       41
C ------    DETERMINE MAXIMUM WIDTH OF TOTAL PLOT   -------               PI       42
      WPIC=XMAX-XMIN+SPAC2                                                PI       43
      HPIC=RMAX-RMIN+SPAC2                                                PI       44
      HPIC=AMAX1(HPIC,3.7)                                                PI       45
      WTOP=WTOT*FLOAT(ILT)                                                PI       46
      WMD=WINPUT+WNOM+WPIC+SPAC2+SPAC2                                    PI       47
      WBOTM=WTOT*FLOAT(ILB)                                               PI       48
      WMAX=AMAX1(WTOP,WMD,WBOTM)                                          PI       49
C     -------   ESTABLISH MASTER PLOT ORIGIN   -------                    PI       50
      XMO=WMAX/2.+1.0                                                     PI       51
      RTOT=2.*(HBOX+SPAC2)+HPIC                                           PI       52
      RMO=RTOT/2.+2.0                                                     PI       53
      FMULT=AMIN1(1.0,25./RTOT)                                           PI       54
      CALL FACTOR(FMULT)                                                  PI       55
      CALL PLOT (XMO,RMO,-3)                                              PI       56
C --------   DETERMINE XBB AND YBB   (BOX LOCATIONS)   ------------       PI       57
      IF (IDONE.EQ.0) GO TO 1027                                          PI       58
      LL=MELEM(1)                                                         PI       59
      RBL=HPIC/2.+SPAC2                                                   PI       60
      RBF=RBL+2.1+SPAC1                                                   PI       61
      YBB(LL)=RBL                                                         PI       62
      XBB(LL)=-WTOP/2.                                                    PI       63
      DO 1020 I=2,IDONE                                                   PI       64
      LL=MELEM(I)                                                         PI       65
      LLM=MELEM(I-1)                                                      PI       66
      IF (METYP(LL).EQ.IHL) YBB(LL)=RBL                                   PI       67
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            IF (METYP(LL).EQ.INF) YBB(LL)=BBF                                  PI      68
            IF (METYP(LL).EQ.INL) XBB(LL)=XBB(LLM)+WTOT                        PI      69
            IF (METYP(LL).EQ.INF.AND.METYP(LLM).EQ.INF) XBB(LL)=XBB(LLM)+WTOT  PI      70
            IF (METYP(LL).EQ.INF.AND.METYP(LLM).EQ.INL) XBB(LL)=XBB(LLM)       PI      71
       1020 CONTINUE                                                           PI      72
       1027 BBL=-WPIC/2.-SPAC2-2.1                                             PI      73
            BBF=BBL-1.05-SPAC1                                                 PI      74
            IF (IDONE.GE.NEL) GO TO 1030                                       PI      75
            LL=NELEM(IDONE)                                                    PI      76
            XBB(LL)=WBOTM/2.                                                   PI      77
            IF (IDONE.GT.0) GO TO 1028                                         PI      78
            XBB(LL)=-WBOTM/2.                                                  PI      79
            WTOT=-WTOT                                                         PI      80
       1028 IF (METYP(LL).EQ.INL) YBB(LL)=BBL                                  PI      81
            IF (METYP(LL).EQ.INF) YBB(LL)=BBF                                  PI      82
            IDONPP=IDONE+1                                                     PI      83
            DO 1025 I=IDONPP,NEL                                               PI      84
            LL=NELEM(I)                                                        PI      85
            LLM=NELEM(I-1)                                                     PI      86
            IF (METYP(LL).EQ.INL) YBB(LL)=BBL                                  PI      87
            IF (METYP(LL).EQ.INF) YBB(LL)=BBF                                  PI      88
            IF (METYP(LL).EQ.INL) XBB(LL)=XBB(LLM)-WTOT                        PI      89
            IF (METYP(LL).EQ.INF.AND.METYP(LLM).EQ.INF) XBB(LL)=XBB(LLM)-WTOT  PI      90
            IF (METYP(LL).EQ.INF.AND.METYP(LLM).EQ.INL) XBB(LL)=XBB(LLM)       PI      91
       1025 CONTINUE                                                           PI      92
      C --------   INITIALIZE DATA LOCATIONS   --------                        PI      93
       1030 XNO=WPIC/2.+SPAC2+0.2                                              PI      94
            YNO=-1.95                                                          PI      95
            XFV=-WPIC/2.-SPAC2-4.0-SPAC2                                       PI      96
            YFV=SPAC2                                                          PI      97
            XOV=XFV                                                            PI      98
            YOV=-SPAC2-1.0                                                     PI      99
            XS=0.                                                              PI     100
            YS=0.                                                              PI     101
            SIZE=0.                                                            PI     102
            XTT=-4.7                                                           PI     103
            YTT=WPIC/2.+SPAC2+HBCK+SPAC1                                       PI     104
            XMOVE=1.1*XMS                                                      PI     105
            YMOVE=-BMS                                                         PI     106
      C --------    DRAW PICTURE    --------                                   PI     107
            PMEAN=0.5*(PMAX+PMIN)                                              PI     108
            XMEAN=0.5*(XMAX+XMIN)                                              PI     109
            DO 1049 I=1,NEL                                                    PI     110
            LL=NELEM(I)                                                        PI     111
            PO(LL)=PO(LL)-PMEAN                                                PI     112
            PI(LL)=PI(LL)-PMEAN                                                PI     113
            XO(LL)=XO(LL)-XMEAN                                                PI     114
            XI(LL)=XI(LL)-XMEAN                                                PI     115
       1049 CONTINUE                                                           PI     116
            LL=NELEM(1)                                                        PI     117
            POA=PO(LL)+PMEAN                                                   PI     118
            YY=PO(LL)                                                          PI     119
            XX=XO(LL)-SPAC2                                                    PI     120
            CALL NUMBER (XX,YY,0.1,POA,0.,2)                                   PI     121
            PIA=PI(LL)+PMEAN                                                   PI     122
            YY=PI(LL)                                                          PI     123
            XX=XI(LL)-SPAC2                                                    PI     124
            CALL NUMBER (XX,YY,0.1,PIA,0.,2)                                   PI     125
            CALL PLOT (XI(LL),PI(LL),+3)                                       PI     126
            DO 1050 I=2,NEL                                                    PI     127
            LL=NELEM(I)                                                        PI     128
            CALL PLOT (XI(LL),PI(LL),+2)                                       PI     129
       1050 CONTINUE                                                           PI     130
            LL=NELEM(1)                                                        PI     131
            CALL PLOT (XO(LL),PO(LL),+3)                                       PI     132
            DO 1060 I=2,NEL                                                    PI     133
            LL=NELEM(I)                                                        PI     134
            CALL PLOT (XO(LL),PO(LL),+2)                                       PI     135
       1060 CONTINUE                                                           PI     136
            IF (IDONE.GE.NEL) GO TO 1065                                       PI     137
            LL=NELEM(NEL)                                                      PI     138
            POA=PO(LL)+PMEAN                                                   PI     139
            YY=PO(LL)                                                          PI     140
            XX=XO(LL)-SPAC2                                                    PI     141
            CALL NUMBER (XX,YY,0.1,POA,0.,2)                                   PI     142
            PIA=PI(LL)+PMEAN                                                   PI     143
            YY=PI(LL)                                                          PI     144
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  SUBROUTINE PICTUR     73/74   OPT=0 TRACE                FTN 4.6+439       08/24/78  09.58.39        PAGE     3

                  XX=XI(LL)-SPAC2                                                           PI       145
                  CALL NUMBER (XX,YY,0.1,RDA,0.,2)                                          PI       146
             1065 CONTINUE                                                                  PI       147
            C ---------    RESTORE VALUSE OF R'S AND X'S  -----------                       PI       148
                  DO 1070 I=1,NEL                                                           PI       149
                  LL=NELEM(I)                                                               PI       150
                  RO(LL)=RO(LL)+RMEAN                                                       PI       151
                  RI(LL)=RI(LL)+RMEAN                                                       PI       152
                  XO(LL)=XO(LL)+XMEAN                                                       PI       153
                  XI(LL)=XI(LL)+XMEAN                                                       PI       154
                  XB(LL)=XB(LL)-XMEAN                                                       PI       155
                  RB(LL)=RB(LL)-RMEAN                                                       PI       156
             1070 CONTINUE                                                                  PI       157
            C ---------    DRAW BOXES  ------                                                PI       158
                  CALL BOXES                                                                PI       159
                  RETURN                                                                    PI       160
            C     END CONMOD                                                                PI       161
                  END                                                                       PI       162
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      SUBROUTINE BOXES                                                  BD        2
      COMMON/CPICT/XNO,YNO,XFV,YFV,XOV,YOV,XBB(080),YBB(080),XG,YG,     CD1       2
     1  SIZE,XTI,YTI,XMOVE,YMOVE,DATA(12),FKYL(1,1)                     CD1       3
      COMMON/INPUTC/DP,BLKF,SK,RG,FRIC,TANS,CDR,NEL,TITLE(10),NELTOT,   CD2       2
     +  NELEM(080),NETYP(080),RD(080),XD(080),XT(080),CL(080),PI(080),  CD2       3
     2  TCIN(080),ELKI(080),DALK(080),WRPCT(080),NHOLES(080),NHTYP(080),CD2       4
     3  ISEP(080),IDBUG,NFW(080),IPIC,ANET1(080),SIGN,SIGN2,IRUN,ICASE  CD2       5
      COMMON/OUTPUT/PTDIS,CDOV,WCORR1,CUMGA,CUMWJ,RR(080),M(080),       CD2       6
     1  AX(080),BLKW(080),BLKS(080),EAX(080),EAF(080),BETA(080),PS(080),CD2       7
     2  W(080),TT(080),PT(080),TS(080),RHO(080),EM(080),V(080),VX(080), CD2       8
     3  VTH(080),Q(080),QP(080),BLKM(080),VJ(080),WAKDEC(080),          CD2       9
     4  CD(080),ANGJ(080),DHOLES(080),AHOLES(080),EAH(080),CUMEA(080),  CD2      10
     5  VJET(080),ATCHL(080),XR(080),CUMLF                              CD2      11
      COMMON/CDDBIT/IN,NOUT,IREAX,ITER,SWFF,SWFD                        CD2      12
      DIMENSION NOM(4),NOMEN(4,19),NOMF(5),NOMENF(5,6),NOMO(4),NOMENO(4,BD        5
     +5),FIV(6),DOV(5)                                                  BD        6
      DIMENSION YH(4),YN(11),XBOX(7),YBOXL(7),YBOXF(7),NDL(11),NDF(8),NABD        7
     +M(19),NHD(4),ENUM(11),FNUF(8)                                     BD        8
      DIMENSION XPB(080),YPB(080)                                       BD        9
      DATA YH    /1.95,1.8,1.50,1.35/                                   BD       10
      DATA YN    /.05,.2,.35,.5,.65,.8,.95,1.1,1.25,1.4,1.55/           BD       11
      DATA XBOX    /.9,.9,0.,0.,.9,0.,0./                               BD       12
      DATA YBOXL    /0.,2.1,2.1,1.75,1.75,1.75,0./                      BD       13
      DATA YBOXF    /0.,1.65,1.65,1.3,1.3,1.3,0./                       BD       14
      DATA NDL    /4,3,0,0,0,2,3,2,2,0,3/                               BD       15
      DATA NDF    /0,2,3,3,3,4,-1,4/                                    BD       16
      DATA NAM    /2HQ ,2HQE,2HTV,2HAV,2HV ,2HSA,2HM ,2HPS,2HPT,2HTT,2HW BD       17
     +,2HJV,2HJA,2HCD,2HEA,2HGA,2HDD,2HWD,2HWO/                         BD       18
      DATA NHD    /9HINLET    ,9HANNULUS  ,9HORIFICE  ,4HELEM/          BD       19
      DATA NOMEN     /8HJET INJE,8HCTION VE,8HLOCITY, ,8HFPS     ,8HJET BD       20
     +INJE,8HCTION AN,8HGLE, DEG,8HREES    ,8HORIFICE ,8HDISCHARG,8HE CO BD       21
     +EFFI,8HCIENT    ,8HSTATION ,8HEFFECTIV,8HE AREA, ,8HSQ. IN. ,8HSTAT BD       22
     +ION ,8HGEOMETRI,8HC AREA, ,8HSQ. IN. ,8HORIFICE ,8HDIAMETER,8H, IN BD       23
     +.   ,8H       ,8HNUMBER O,8HF ORIFIC,8HES     ,8H        ,8HORIF BD       24
     +ICE ,8HFLOW / I,8HNLET FLO,8HW        ,8HDYNAMIC ,8HHEAD / P,8HT CO BD       25
     +CAL ,8H        ,8HDENSITY,,8H LB/CU F,8HT       ,8H        ,8HTANG BD       26
     +ENTI,8HAL FLOW ,8HVELOCITY,8H, FPS   ,8HAXIAL FL,8HOW VELOC,8HITY, BD       27
     + FPS,8H        ,8HTOTAL FL,8HOW VELOC,8HITY, FPS,8H        ,8HSWIR BD       28
     +L AN,8HGLE, DEG,8HREES FRO,8HM AXIAL ,8HMACH NUM,8HBER      ,8H    BD       29
     +    ,8H        ,8HSTATIC P,8HRESSURE,,8H PSIA   ,8H        ,8HTOTA BD       30
     +L PR,8HESSURE, ,8HPSIA    ,8H        ,8HTOTAL TE,8HMPERATUR,8HE, R BD       31
     +    ,8H        ,8HAIR MASS,8H FLOW RA,8HTE, LB/S,8HEC      /      BD       32
      DATA NOMENF     /8HAIR GAS ,8HCONSTANT,8H        ,8H        ,8H   BD       33
     +    =,8HAIR RATI,8HO OF SPE,8HCIFIC HE,8HATS     ,8H        =,8HDRA BD       34
     +G COE,8HFFICIENT,8H FOR INS,8HERTED BL,8HOCKAGE =,8HTANGENT ,8HOF  BD       35
     +SEPAR,8HATION SP,8HREAD ANG,8HLE        =,8HANNULUS ,8HEFFECTIV,8HE A BD       36
     +REA F,8HACTOR    ,8H        =,8HANNULUS ,8HWALL ROU,8HGHNESS F,8HACT BD       37
     +OR   ,8H        =/                                                BD       38
      DATA NOMENO     /8HDISCHARG,8HE PRESSU,8HRE, PSIA,4H    =,8HOVERALL BD       39
     + ,8HFLOW COE,8HFFICIENT,4H    =,8HTOTAL GE,8HOMETRIC ,8HAREA, IN,4H BD       40
     +2   =,8HOVERALL ,8HPRESSURE,8H DROP   ,4H    =,8HINLET CO,8HRRECTED BD       41
     +,8HFLOW, LB,4H/S =/                                               BD       42
      DO 4 I=1,NEL                                                      BD       43
      LL=NELEM(I)                                                       BD       44
      XPB(I)=XBB(LL)                                                    BD       45
      YPB(I)=YBB(LL)                                                    BD       46
    4 CONTINUE                                                          BD       47
      WRITE (61,140)XNO,YNO,XFV,YFV,XOV,YOV,XG,YG,SIZE,XTI,YTI,XMOVE,YMO BD       48
     +VE,(XPB(L),YPB(L),NELEM(L),L=1,NEL)                               BD       49
      XNA=.05                                                           BD       50
      XNU=.3                                                            BD       51
      XL=.45                                                            BD       52
      XDF=.78                                                           BD       53
      X=XNO                                                             BD       54
      Y=YNO                                                             BD       55
      XEQ=X+.3                                                          BD       56
      XNOM=X+.5                                                         BD       57
      NN=12                                                             BD       58
      DO 20 I=1,19                                                      BD       59
      CALL SYMBR(X,Y,.1,NAM(NN),0.,2)                                   BD       60
      CALL SYMBR(XEQ,Y,.1,1H=,0.,1)                                     BD       61
      NN=NN+1                                                           BD       62
      IF (NN.EQ.20) NN=1                                                BD       63
      DO 10 J=1,4                                                       BD       64
   10 NOM(J)=NOMEN(J,I)                                                 BD       65
      CALL SYMBR(XNOM,Y,.1,NOM,0.,32)                                   BD       66
   20 Y=Y+.15                                                           BD       67
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      Y=Y+.15                                                           BD        68
      CALL SYMBB(X,Y,.1,43HORIFICE ELEMENT XX B - BLEED FLOW EXTRACTED,0 BD        69
     +.,43)                                                             BD        70
      Y=Y+.15                                                           BD        71
      CALL SYMBB(X,Y,.1,42HORIFICE ELEMENT XX D - FIXED HOLE DIAMETER,0. BD        72
     +,42)                                                              BD        73
      Y=Y+.15                                                           BD        74
      CALL SYMBB(X,Y,.1,42HORIFICE ELEMENT XX F - FIXED FLOW PERCENT ,0. BD        75
     +,42)                                                              BD        76
      Y=Y+.3                                                            BD        77
      X=X-.2                                                            BD        78
      CALL SYMBB(X,Y,.1,12HNOMENCLATURE,0.,12)                          BD        79
      FIV(1)=PG                                                         BD        80
      FIV(2)=SK                                                         BD        81
      FIV(3)=CDB                                                        BD        82
      FIV(4)=TAMS                                                       BD        83
      FIV(5)=BLEF                                                       BD        84
      FIV(6)=FRIC                                                       BD        85
      X=XFV                                                             BD        86
      Y=YFV                                                             BD        87
      XNUP=X+4.1                                                        BD        88
      DO 40 I=1,6                                                       BD        89
      DO 30 J=1,5                                                       BD        90
   30 NOMF(J)=NOMENF(J,I)                                               BD        91
      CALL SYMBB(X,Y,.1,NOMF,0.,40)                                     BD        92
      CALL NUMBER(XNUP,Y,.1,FIV(I),0.,4)                                BD        93
   40 Y=Y+.15                                                           BD        94
      Y=Y+.15                                                           BD        95
      X=X-.2                                                            BD        96
      CALL SYMBB(X,Y,.1,20HFIXED INPUT VALUES -,0.,20)                  BD        97
      DOV(1)=PTDIS                                                      BD        98
      DOV(2)=CDDV                                                       BD        99
      DOV(3)=CUMGA                                                      BD       100
      DOV(4)=DP                                                         BD       101
      DOV(5)=WCORRI                                                     BD       102
      X=XDV                                                             BD       103
      Y=YDV                                                             BD       104
      XNUP=X+2.9                                                        BD       105
      DO 60 I=1,5                                                       BD       106
      DO 50 J=1,4                                                       BD       107
   50 NOMD(J)=NOMEND(J,I)                                               BD       108
      CALL SYMBB(X,Y,.1,NOMD,0.,28)                                     BD       109
      CALL NUMBER(XNUP,Y,.1,DOV(I),0.,4)                                BD       110
   60 Y=Y+.15                                                           BD       111
      Y=Y+.15                                                           BD       112
      X=X-.2                                                            BD       113
      CALL SYMBB(X,Y,.1,23HOVERALL OUTPUT VALUES -,0.,23)               BD       114
      IF (1.GT.NEL)GO TO 5                                              BD       115
      DO 130 LE=1,NEL                                                   BD       116
      LL=NELEM(LE)                                                      BD       117
      L=LL                                                              BD       118
      IF (XBB(L) .EQ. 0.0 .AND. YBB(L) .EQ. 0.0) GO TO 130              BD       119
      FNUP(1)=SP(LL)                                                    BD       120
      FNUP(2)=AMD(LL)                                                   BD       121
      FNUP(3)=VTH(LL)                                                   BD       122
      FNUP(4)=VX(LL)                                                    BD       123
      FNUP(5)=V(LL)                                                     BD       124
      FNUP(6)=BETA(LL)                                                  BD       125
      FNUP(7)=EM(LL)                                                    BD       126
      FNUP(8)=PS(LL)                                                    BD       127
      FNUP(9)=PT(LL)                                                    BD       128
      FNUP(10)=TT(LL)                                                   BD       129
      FNUP(11)=W(LL)                                                    BD       130
      FNUP(1)=VJET(LL)                                                  BD       131
      FNUP(2)=ANGJ(LL)                                                  BD       132
      FNUP(3)=CD(LL)                                                    BD       133
      FNUP(4)=EAH(LL)                                                   BD       134
      FNUP(5)=AHOLES(LL)                                                BD       135
      FNUP(6)=DHOLES(LL)                                                BD       136
      FNUP(7)=NHOLES(LL)                                                BD       137
      FNUP(8)=WBPCT(LL)                                                 BD       138
      YCT=YBB(L)                                                        BD       139
      IF (XBB(LL).GT.YBB(L).AND.NETYP(LL).EQ.1HL)YCT=YCT+2.1            BD       140
      IF (NETYP(LL).EQ.1HL) CALL PLOT (XBB(LL),YBB(LL),3)               BD       141
      IF (NETYP(LL).EQ.1HL)CALL PLOT(XBB(L),YCT,2)                      BD       142
      IF (NETYP(LL).EQ.1HL)GO TO 70                                     BD       143
      IF (NETYP(LL).EQ.1HF)GO TO 100                                    BD       144
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SUBROUTINE BOXES      73/74    OPT=2 TRACE                    FTN 4.6+439        08/24/78  09.58.39        PAGE    3

      GO TO 130
   70 CALL PLOT(XBB(L),YBB(L),3)
      DO 80 M=1,7
      X=XBB(L)+XBOX(M)
      Y=YBB(L)+YBOX(M)
   80 CALL PLOT(X,Y,2)
      X=XBB(L)+XNA
      XU=XBB(L)+XNU
      DO 90 M=1,11
      Y=YBB(L)+YP(M)
      CALL SYMBOL(X,Y,.1,NAM(M),0.,2)
   90 CALL NUMBER(XU,Y,.1,FOUR(M),0.,NDL(M))
      NA=NMD(2)
      IF (LE.EQ.1) NA=NMD(1)
      Y=YBB(L)+YM(1)
      CALL SYMBOL(X,Y,.1,NA,0.,8)
      Y=YBB(L)+YM(2)
      CALL SYMBOL(X,Y,.1,NMD(4),0.,6)
      X=XBB(L)+XL
      EL=MELEM(LE)
      CALL NUMBER(X,Y,.1,EL,0.,-1)
      X=XBB(L)+XDF
      CALL SYMBOL(X,Y,.1,NFN(LL),0.,1)
      GO TO 130
  100 CALL PLOT(XBB(L),YBB(L),3)
      DO 110 M=1,7
      X=XBB(L)+XBOX(M)
      Y=YBB(L)+YBOX(M)
  110 CALL PLOT(X,Y,2)
      X=XBB(L)+XNA
      XU=XBB(L)+XNU
      DO 120 M=1,8
      MM=M+11
      Y=YBB(L)+YP(M)
      CALL SYMBOL(X,Y,.1,NAM(MM),0.,2)
  120 CALL NUMBER(XU,Y,.1,FOUR(M),0.,NDF(M))
      NA=NMD(3)
      X=XBB(L)+XNA
      Y=YBB(L)+YM(3)
      CALL SYMBOL(X,Y,.1,NA,0.,8)
      Y=YBB(L)+YM(4)
      CALL SYMBOL(X,Y,.1,NMD(4),0.,6)
      X=XBB(L)+XL
      EL=MELEM(LE)
      CALL NUMBER(X,Y,.1,EL,0.,-1)
      X=XBB(L)+XDF
      CALL SYMBOL(X,Y,.1,NFN(LL),0.,1)
  130 CONTINUE
    5 CONTINUE
      IF (SIZE.LE.0.0) GO TO 190
      CALL [illegible](XG,YG,SIZE)
  190 CALL SYMBOL(XTI,YTI,.14,TITLE,0.,70)
      CALL PLOT(XMOVE,YMOVE,-3)
      RETURN
C
  140 FORMAT (/1X,21HINPUT FOR SUB BOXES -,/I3(1X,F7.3)/(1X,4(2F4.3,I3,3
     1X)))
C     END BOXES
      END
```

```
  08/24/78 +CDC CY174 SCOPE VER3.3.4 DATED 09/16/76
09.58.31.B14TT1R
09.58.31.SEQUENCE=B14TT.
09.58.31.ZDD,CM55006,T119.
09.58.31.USER=REYNLDSRS,DEPT=93-352,EMD=3409-2458
09.58.31.39-05-0301,PROGRAM=0.
09.58.32.BANNER,DAYFILE.BIN 27
09.58.32. XXXX   XXX  X   X      XXX   XXXXX
09.58.32. X   X   X   XX  X     X   X      X
09.58.32. X   X   X   XX  X         X     X
09.58.32. XXXX    X   X X X        X     X
09.58.32. X   X   X   X  XX       X     X
09.58.32. X   X   X   X  XX      X     X
09.58.32. XXXX   XXX  X   X     XXXXX X
09.58.32.
09.58.32.
09.58.32.
09.55.32.REQUEST,OLD,PE,VPN=639274,LB=AVDATA,ID=0
09.58.32.EYNOLDS,FILES=49-67.
09.58.32. (OI ASSIGNED)
09.58.32.REWIND(OLD)
09.58.32.COPYBF(OLD,OLD40)
09.58.34.UPDATE(F,P=OLD40,L=1)
09.58.38. UPDATE COMPLETE.
09.58.38.GUF(I,OPT=0,PD=8)
09.59.18.     12.499 CP SECONDS COMPILATION TIME
09.59.18.TOTAL SRU      43.721
09.59.18.TOTAL CP       11.647 SEC.       2.312 SEC.
09.59.18.TOTAL PP       30.770 SEC.
09.59.18.TOTAL IO       11.615 SEC.
09.59.18.TOTAL RA+1 CALLS        566.

                B14TT1R  //// END OF LIST ////  EST 33
                B14TT1R  //// END OF LIST ////  EST 33
```

APPENDIX C

LISTING OF 3-D COMBUSTOR PERFORMANCE MODEL

```
PROGRAM MAIN        73/74    OPT=0 TRACE                    FTN 4.6+439          08/24/78  14.08.46          PAGE      1

          PROGRAM MAIN (INPUT=65,OUTPUT=519,TAPE5=INPUT,TAPE6=OUTPUT,           MA          2
         1  TAPE8,TAPE9,TAPE11=65)                                              MA          3
          COMMON F(500,7),DU(10,10,5),DV(10,10,5),DW(10,10,5),                  COMFA       2
         1  RHO(10,10,5),VISC(10,10,5),SU(10,10),SP(10,10),DRHODP(10,10,5),     COMFA       3
         1  AXP(10,10),AXM(10,10),AYP(10,10),AYM(10,10),AZP(10,10),             COMFA       4
         2  AZM(10,10),CZ(10,10),CY(10),CZU(10,10),CYU(10),                     COMFA       5
         3  CZP(10,10),CYP(10),DIVG(10,10),MTP1,MTP2                            COMFA       6
          DIMENSION U(10,10,5),V(10,10,5),W(10,10,5),PP(10,10,5)                COMFA       7
          DIMENSION P(10,10,5),TEMP(10,10,5),GAM(10,10,5)                       COMFA       8
          EQUIVALENCE (F(1,1),U(1,1,1)),(F(1,2),V(1,1,1)),(F(1,3),W(1,1,1))     COMFA       9
          EQUIVALENCE (F(1,4),PP(1,1,1)),(F(1,5),P(1,1,1))                      COMFA      10
          EQUIVALENCE (F(1,6),TEMP(1,1,1)),(F(1,7),GAM(1,1,1))                  COMFA      11
          COMMON/CYL/R(30),RM(30),RMV(30),YSR(30),YSVR(30),IPLAX                COMMON      2
          COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),           COMMON      3
         1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),         COMMON      4
         2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                             COMMON      5
          COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NINJ,NINJNK,NV,     COMMON      6
         1  NNV,NGDTO,K,ISTR,JSTR,KSTR,NVR(20),KM(30),JM(30),ISTEP,             COMMON      7
         2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISVP,JSVP,RELAX(16),NP,      COMMON      8
         3  ARHO,AGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,         COMMON      9
         4  IWEO,NM1,JWII,JWIO,JWOI,JWOO,IDW,JKIN(30,30),IKIN(40,30)            COMMON     10
          COMMON/INDEX/IPAR,LPREF,ISTUM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE      COMMON     11
         1  ,PLAXM1,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),        COMMON     12
         2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,        COMMON     13
         3  NVN2                                                                COMMON     14
          COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEN,IOK,FSTOIC,MFU,CP,       COMMON     15
         1  GASCON,RHOCON,UNICON,PRESS,NVFAV,TCYLW,TINLW,TLIP,ACOEF(4),         COMMON     16
         2  T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,NYY,CXX,RATIO1,RATIO2,            COMMON     17
         3  RATIO3,RATIO4,HCO,TAN,ITWALL                                        COMMON     18
          COMMON/CTOMA/KEND,ICTOMA(13)                                          COMMON     19
          COMMON/MIS/AMU,DEN,SMAX,SSUM,LASTEP,HTCEXT,CFR,EMISW,EMISIN,          COMGEN      2
         1  EMISR,TOUT,RICO,EMI,RADIN,RADSUR,FMA,FK,SOFK,                       COMGEN      3
         2  FKFU,FDFU,TFUEL,WFN2,FLO(40),TENTH(40),H(40),FUEL(40),FUOX(40) ,    COMGEN      4
         3  UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)                 COMGEN      5
          COMMON/TURB/NVK,NVD,C1,C2,CD,AK,DUIDXJ(3,3),AKFAC,ALFAC,              COMGEN      6
         1  MODEL,PR(13),PREF(13),PJAY(13),E                                    COMGEN      7
          COMMON/RAD/NVE,SIGMA,ABSOR,SCATR                                      COMGEN      8
          COMMON/REACT/ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,MODER                COMGEN      9
          COMMON/DROPL/EVAP(192),NTP4,NFN2,XO(3),YO(3),ZO(3),ALFA(3),           COMGEN     10
         1  BETA(3),DELTA(3),THETA1(3),THETA2(3),NSL(3),WFF(3),SMD(3),          COMGEN     11
         2  VFUEL(3),RFUEL(3),EVSU(64),NEVAP                                    COMGEN     12
          COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WUINJ(20),           COMGEN     13
         1  AUINJ(20),TUINJ(20),IVINJ(20),JVINJ(20),KVINJ(20),VINJ(20),         COMGEN     14
         2  EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),NUINJ,NVINJ,JSW1,JSW2,      COMGEN     15
         3  USW,VSW,AFSW,FSW,TSW,WSW,SDRO,RHOSW                                 COMGEN     16
          DIMENSION CLENO(2),CLENV(2),CENER(2),CMASS(2),CTEMP(2),CPRESS(2)      MA          7
          DIMENSION CANG(2)                                                     MA          8
          DATA CLENO/1.0,.0254/,CLENV/1.0,.3048/,CENER/1.0,1055./               MA          9
          DATA CMASS/1.0,.4536/,CTEMP/1.0,.55555/,CPRESS/1.0,101325./           MA         10
          DATA CANG/1.0,.01745/                                                 MA         11
CHAPTER 1 ------------------------PARAMETERS AND CONTROL INDICES--------        MA         12
          NTP1=8                                                                MA         13
          NTP2=9                                                                MA         14
          NTP4=11                                                               MA         15
          READ (5,30) TITLE                                                     MA         16
          READ (5,31) TITLE2                                                    MA         17
       31 FORMAT (20A4)                                                         MA         18
       30 FORMAT (10A4)                                                         MA         19
          READ (5,100) LP1,MP1,NP1,IPLAX,MODEL,MODER,IPAR,ITRAD                 MA         20
          READ (5,100) IU,MODEN,INTAPE,IDW,IRES                                 MA         21
      100 FORMAT (8(I2,8X))                                                     MA         22
          READ (5,100) ISOLVE                                                   MA         23
          READ (5,100) ICTOMA                                                   MA         24
          READ (5,100) IPRINT                                                   MA         25
          READ (5,101) RELAX                                                    MA         26
          READ (5,101) PR                                                       MA         27
          READ (5,101) PREF                                                     MA         28
      101 FORMAT (8E10.4)                                                       MA         29
          PLAXM1=FLOAT(IPLAX-1)                                                 MA         30
CHAPTER 2 --------------------------GRID AND GEOMETRY--------------------       MA         31
C-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+     MA         32
          CALL STRIDO                                                           MA         33
C-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+     MA         34
          READ (5,101) (X(I),I=1,LP1)                                           MA         35
          READ (5,101) (Y(J),J=1,MP1)                                           MA         36
          READ (5,101) (Z(K),K=1,NP1)                                           MA         37
          DO 200 I=1,LP1                                                        MA         38
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PROGRAM MAIN        73/74    OPT=0 TRACE                    FTN 4.6+439         08/24/78  14.08.46        PAGE    2

        200 X(I)=X(I)*CLENO(IU)
            DO 205 J=1,MP1
        205 Y(J)=Y(J)*CLENO(IU)
            DO 220 K=1,NP1
            GO TO (210,215), IPLAX
        210 Z(K)=Z(K)*CLENO(IU)
            GO TO 220
        215 Z(K)=Z(K)*CANG(IU)
        220 CONTINUE
            RI=Y(1)
            Y(1)=0.0
      C  -------  INCLINED WALL DATA
            DO 22 J=1,MP1
            IWLI(J,4)=2
         22 IWLO(J,4)=L
            DO 25 J=1,LP1
            JWLI(J,4)=1
         26 JWLO(J,4)=MP1
            IWEC=L
            JWII=1
            JWOI=1
            JWCO=MP1
            READ (5,100) IWEI,JWIO
            IF (IWEI.EQ.2) GO TO 82
            READ (5,100) (IWLI(J,4),J=JWIO,MP1)
            READ (5,100) (JWLO(I,4),I=1,IWEI)
         82 CONTINUE
            GO TO (23,24),IPAR
      24    IREF=L
            JREF=M
            KREF=N
            LPREF=KR(KREF)+JR(JREF)+IREF
      23    CONTINUE
            DO 25 J=1,MP1
            GO TO (260,265), IPLAX
        260 R(J)=1.0
            GO TO 25
        265 R(J)=RI+Y(J)
         25 CONTINUE
      C-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*
            CALL STRIP1
      C-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*
      CHAPTER 3 ------------------------DEPENDENT VARIABLES-------------
            READ (5,101) PRESS,DEN,ABSOR,SCATR,AKFAC,ALFAC
            READ (5,101) CIX,HTV,HFU,FORCO
            READ (5,101) PREXP1,ARCON1,CR1,PREXP2,ARCON2,CR2
            READ (5,101) C1,C2,CD,AMU,ERROR,TCYLM,TIMLM,ELIP
            READ (5,103) LASTEP,IJUMP,JSW1,JSW2,NUINJ,NVINJ
        103 FORMAT (2(I3,7X),6(I2,8X))
            READ (5,101) USW,VSW,SWNO,AFSW,FSW,TSW
            READ (5,102) NFNZ,ISPRAY,TFUEL
        102 FORMAT (2(I2,8X),6E10.4)
            IF (NFNZ.LE.0) GO TO 118
            DO 115 I=1,NFNZ
            READ (5,101) XO(I),YO(I),ZO(I),ALFA(I),BETA(I),DELTA(I),THETA1(I),
           1   THETA2(I),RNSL,WFF(I),SMD(I),VFUEL(I),RFUEL(I)
        115 NSL(I)=IFIX(RNSL)
            DO 120 II=1,NFNZ
            XO(II)=XO(II)*CLENO(IU)
            YO(II)=YO(II)*CLENO(IU)
            GO TO (125,130), IPLAX
        125 ZO(II)=ZO(II)*CLENO(IU)
            GO TO 135
        130 ZO(II)=ZO(II)*CANG(IU)
        135 ALFA(II)=ALFA(II)*CANG(IU)
            BETA(II)=BETA(II)*CANG(IU)
            DELTA(II)=DELTA(II)*CANG(IU)
            THETA1(II)=THETA1(II)*CANG(IU)
            THETA2(II)=THETA2(II)*CANG(IU)
            WFF(II)=WFF(II)*CMASS(IU)
            RFUEL(II)=RFUEL(II)*CLENO(IU)
        120 VFUEL(II)=VFUEL(II)*CLENV(IU)
        118 CONTINUE
            TFUEL=TFUEL*CTEMP(IU)
            AMU=AMU*CMASS(IU)/CLENV(IU)
            PRESS=PRESS*CPRESS(IU)
            DEN=DEN*CMASS(IU)/CLENO(IU)/CLENO(IU)/CLENO(IU)
```

```
      TCYLW=TCYLW*CTEMP(IU)
      TINLW=TINLW*CTEMP(IU)
      TLIP=TLIP*CTEMP(IU)
      USW=USW*CLENV(IU)
      VSW=VSW*CLENV(IU)
      AFSW=AFSW*CMASS(IU)
      FSW=FSW*CMASS(IU)
      TSW=TSW*CTEMP(IU)
      IF (NUINJ.LE.0) GO TO 85
      READ (5,100) (IUINJ(I),I=1,NUINJ)
      READ (5,100) (JUINJ(I),I=1,NUINJ)
      READ (5,101) (UINJ(I),I=1,NUINJ)
      READ (5,101) (WUINJ(I),I=1,NUINJ)
      READ (5,101) (AUINJ(I),I=1,NUINJ)
      READ (5,101) (TUINJ(I),I=1,NUINJ)
      DO 235 II=1,NUINJ
      UINJ(II)=UINJ(II)*CLENV(IU)
      WUINJ(II)=WUINJ(II)*CLENV(IU)
      AUINJ(II)=AUINJ(II)*CMASS(IU)
  235 TUINJ(II)=TUINJ(II)*CTEMP(IU)
   85 IF (NVINJ.LE.0) GO TO 88
      READ (5,100) (IVINJ(I),I=1,NVINJ)
      READ (5,100) (JVINJ(I),I=1,NVINJ)
      READ (5,100) (KVINJ(I),I=1,NVINJ)
      READ (5,101) (VINJ(I),I=1,NVINJ)
      READ (5,101) (EVINJ(I),I=1,NVINJ)
      READ (5,101) (DVINJ(I),I=1,NVINJ)
      READ (5,101) (AVINJ(I),I=1,NVINJ)
      READ (5,101) (TVINJ(I),I=1,NVINJ)
      DO 240 II=1,NVINJ
      VINJ(II)=VINJ(II)*CLENV(IU)
      EVINJ(II)=EVINJ(II)*CLENV(IU)*CLENV(IU)
      DVINJ(II)=DVINJ(II)*CLENV(IU)
      AVINJ(II)=AVINJ(II)*CMASS(IU)
  240 TVINJ(II)=TVINJ(II)*CTEMP(IU)
   88 CONTINUE
      WFU=12.*CXX*NYY
      ISTEP=IRES
      DFAC=1.0
      SUM1=.01
      SUM2=.05
CHAPTER 4 ----------------MATERIAL CONSTANTS------------------------------
      PREF(LVD)=AF*AK/(C2-C1)/SQRT(CD)
      DO 93 NV=1,NNV
      PRRAT=PE(NV)/PREF(NV)
   93 PJAY(NV)=E*(PRRAT-1.)/PRRAT**.25
      RHOCON=PRESS/UNICON
      GASCON=UNICON/WM2
CHAPTER 5 -----------------------INITIAL VALUES--------------------------
      CALL START
      CALL OUTPUT (INTAPE)
C------------- MAIN LOOP STARTS ------------------------------------------
60    CONTINUE
C+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
      IF (ISTEP.EQ.100) ISOLVE(LVR)=9
      IF (ISTEP.EQ.100) ISOLVE(LVD)=9
      CALL DENS
      ISP=ISPRAY
      IF (ISTEP-IRES.LE.5) ISP=1
      IF (MOD(ISTEP-IRES,ISP).EQ.0) CALL SPRAY
      CALL VISC3
C+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CHAPTER 6 ----------------SINGLE LINE PRINTOUT---------------------------
      IF (ISTEP.EQ.IRES) GO TO 16
      WRITE (6,10) ISTEP,SMAX,SSUM,SEXIT,P(2,M,2),P(L,M,2),
     1  U(IMAX,JMAX,KMAX),V(IMAX,JMAX,KMAX),W(IMAX,JMAX,KMAX),
     2  TEMP(IMAX,JMAX,KMAX),RHO(IMAX,JMAX,KMAX),IMAX,JMAX,KMAX
   10 FORMAT (1X,I4,10(1PE11.3),1X,3I3)
   16 CONTINUE
C+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
      CALL STRID2
C+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
CHAPTER 7 -----------------------OUTPUT---------------------------------
      IF (ERROR.GT.SSUM) ISTEP=LASTEP
      DFAC=AMAX1(0.,(SUM2-SSUM)/(SUM2-SUM1))
      DFAC=AMIN1(1.0,DFAC)
      CALL OUTPUT (NTP1)
```

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      PROGRAM MAIN       73/74    OPT=0 TRACE                   FTN 4.6+439        05/24/79  14.09.45        PAGE     4

                CHAPTER 8  -----------------TERMINATION ---------------------------              MA          193
                     IF (ISTEP-LASTEP) 60,80,90                                                  MA          194
  235             80 WRITE (6,10) ISTEP,SMAX,SSUM                                                MA          195
                C +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+          MA          196
                     STOP                                                                        MA          197
                     END                                                                         MA          198

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    81      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    82      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   105      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   111      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   112      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   128      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   198      I
```

```
      BLOCK DATA                                                        MA       199
      COMMON/CYL/R(30),RH(30),RHH(30),TSR(30),TSWR(30),IPLAK            COMMON     2
      COMMON/GEOM/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),       COMMON     3
     1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),     COMMON     4
     2  FYP(30),FYM(30),FZP(30),FZM(30),CT,TIME                         COMMON     5
      COMMON/INT/L,M,N,LCV,NCV,MCV,LP1,MP1,NP1,MI,MJ,MK,MIMJ,MIMJMK,MV, COMMON     6
     1  NNV,MSGT3,K,ISTI,JSTR,KSTR,NSM(20),KM(30),JM(30),ISTEP,         COMMON     7
     2  ISOLVE(13),IPRINT(22),TITLE(10,22),ITT,ISV?,JSWP,RELAX(13),NP,  COMMON     8
     3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,     COMMON     9
     4  IWEO,MM1,JWII,JWIO,JWOI,JWOO,IDW,JKIM(30,30),IKIM(40,30)        COMMON    10
      COMMON/INDEX/IPAR,LPREF,ISTUM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE  COMMON    11
     1  ,PLANE1,LVK,LVD,LVFUOX,LVFU,LVCO,LVM,LVRX,LVRY,LVRZ,NVF(13),    COMMON    12
     2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,    COMMON    13
     3  NVN2                                                            COMMON    14
      COMMON/THERM/MWW,MWFU,MWOX,MVFUOX,MVTE,MODEL,IDK,FSTOIC,HFU,CP,   COMMON    15
     1  GASCON,RHOCON,VMICON,PRESS,NVFAV,TCYLW,TIMEW,TLIP,ACOEF(4),     COMMON    16
     2  T4,OFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HVV,CXX,RATIO1,RATIO2,        COMMON    17
     3  RATIO3,RATIO4,NCO,IAM,ITWALL                                    COMMON    18
      COMMON/CTOMA/KEMD,ICTOMA(13)                                      COMMON    19
      COMMON/PIS/AMU,DEN,SMAX,SSUM,LASTEP,NICEET,CER,EMISW,EMISIN,      CONGEN     2
     1  EMISE,TOUT,XTCO,EMI,RADIN,ABSSUM,FMA,FK,SEFR,                   CONGEN     3
     2  FCFU,FOFU,TFUEL,WFNZ,FLD(40),TEMIN(40),M(40),FUEL(40),FUOX(40) ,CONGEN     4
     3  VIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)             CONGEN     5
      COMMON/TURB/NVK,NVD,C1,C2,CD,AK,DUIDX(3,3),AKFAC,ALFAC,           CONGEN     6
     1  MODEL,PR(13),PREF(13),PJAY(13),E                                CONGEN     7
      COMMON/RAD/NVE,SIGMA,ABSOR,SCATR                                  CONGEN     8
      COMMON/REACT/ARCOM1,PREXP1,CR1,ARCOM2,PREXP2,CR2,MODER            CONGEN     9
      COMMON/DEDPL/EVAP(132),NTPG,NFMZ,XO(3),YO(3),ZO(3),ALFA(3),       CONGEN    10
     1  BETA(3),DELTA(3),THETA1(3),THETA2(3),WSL(3),WFF(3),SMD(3),      CONGEN    11
     2  VFUEL(3),PFUEL(3),EVSU(64),NEVAP                                CONGEN    12
      COMMON/INJEC/FLOWIN,TUINJ(20),JUINJ(20),UINJ(20),RUINJ(20),       CONGEN    13
     1  AUINJ(20),TUINJ(20),TVINJ(20),JVINJ(20),RVINJ(20),VINJ(20),     CONGEN    14
     2  EVINJ(20),DVINJ(20),AVINJ(20),TWINJ(20),MUINJ,MVINJ,JSW1,JSW2,  CONGEN    15
     3  USW,VSW,AFSW,FSW,TSW,WSW,SWND,RHOSW                             CONGEN    16
      DATA NI,NJ,NK,NNV/10,10,5,10/                                     MA       202
      DATA AK,E/.43,9./                                                 MA       203
      DATA VMICON,SIGMA/8314.,5.669E-08/                                MA       204
      DATA NVK,NVD,NVFUOX,NVFU,NVCO,NVTE,NVM/4,5,4,5,8,6,9/             MA       205
      DATA NVFAV,NVRX,NVRY,NVRZ/10,1,2,3/                               MA       206
      DATA NVF/1,2,3,4,4,5,4,5,5,9,1,2,3/                               MA       207
      DATA LVK,LVD,LVFUOX,LVFU,LVCO,LVM/5,6,7,8,9,10/                   MA       208
      DATA LVRX,LVRY,LVRZ/11,12,13/                                     MA       209
      DATA NVH2O,NVOX,NVCO2,NVN2/1,2,3,4/                               MA       210
      DATA NP,NRHO,NGAM/14,15,15/                                       MA       211
      DATA WCO2,WCO,WOX,WH2O,WN2/44.,28.,32.,18.,28./                   MA       212
      DATA IGAM1,IGAM2/1,0,1,1,1,0,0,0,0,0,0,1,1,1,1,0,0,0,0,0/         MA       213
      DATA ACOEF/-1306.01,8420.37,-5167.08,1336.65/                     MA       214
      END                                                               MA       215
```

```
            SUBROUTINE INITIAL                                                  AL          2
            COMMON F(500,7),DU(10,10,5),DV(10,10,5),DW(10,10,5),                COMFA       2
          1  RHO(10,10,5),VISC(10,10,5),SU(10,10),SP(10,10),DRHODP(10,10,5),    COMFA       3
          1  AXP(10,10),AXM(10,10),AYP(10,10),AYM(10,10),AZP(10,10),            COMFA       4
          2  AZM(10,10),CZ(10,10),CY(10),CZU(10,10),CYU(10),                    COMFA       5
          3  CZP(10,10),CYP(10),DIVG(10,10),NTP1,NTP2                           COMFA       6
            DIMENSION U(10,10,5),V(10,10,5),W(10,10,5),PP(10,10,5)              COMFA       7
            DIMENSION P(10,10,5),TEMP(10,10,5),GAM(10,10,5)                     COMFA       8
            EQUIVALENCE (F(1,1),U(1,1,1)),(F(1,2),V(1,1,1)),(F(1,3),W(1,1,1))   COMFA       9
            EQUIVALENCE (F(1,4),PP(1,1,1)),(F(1,5),P(1,1,1))                    COMFA      10
            EQUIVALENCE (F(1,6),TEMP(1,1,1)),(F(1,7),GAM(1,1,1))                COMFA      11
            COMMON/CYL/R(30),RM(30),RMV(30),YSR(30),YSVR(30),IPLAX              COMMON      2
            COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),         COMMON      3
          1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),        COMMON      4
          2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                            COMMON      5
            COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NIMJ,NIMJNK,NV,   COMMON      6
          1  NNV,NGOTO,K,ISTR,JSTR,KSTR,NTM(20),KM(30),JM(30),ISTEP,            COMMON      7
          2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,     COMMON      8
          3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLG(40,5),JWLI(40,5),INSI,        COMMON      9
          4  IWEO,NM1,JWII,JWIO,JWOI,JWOO,IOW,JKIM(30,30),IKIM(40,30)           COMMON     10
            COMMON/INDEX/IPAR,IPREF,ISTUM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE    COMMON     11
          1  ,PLAXM1,LVK,LVD,LVFUOX,LVFU,LVCO,LVM,LVRX,LVRY,LVRZ,NVF(13),       COMMON     12
          2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FOMCO,NVH2O,NVCO2,       COMMON     13
          3  NVN2                                                               COMMON     14
            COMMON/THERM/NUM,NVFU,NVOX,NVFUOX,NVTE,MODEN,IDK,FSTOIC,MFU,CP,     COMMON     15
          1  GASCON,RHOCON,UNICON,PRESS,NVFAV,TCYLW,TINLW,TLIP,ACOEF(4),        COMMON     16
          2  T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HYY,CXX,RATIO1,RATIO2,           COMMON     17
          3  RATIO3,RATIO4,HCO,TAN,ITWALL                                       COMMON     18
            COMMON/CTOMA/KEND,ICTOMA(13)                                        COMMON     19
            COMMON/MIS/AMU,DEN,SMAX,SSUM,LASTEP,HTCEXT,CFR,EMISW,EMISIN,        COMGEN      2
          1  EMISR,TOUT,RTCD,EML,RADIN,RADSUR,FMA,FK,SQFK,                      COMGEN      3
          2  FKFU,FDFU,TFUEL,WFMZ,FLD(40),TENTH(40),H(40),FUEL(40),FUOX(40) ,   COMGEN      4
          3  UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)                COMGEN      5
            COMMON/TURB/NVK,NVD,C1,C2,CD,AK,DUIDXJ(3,3),AKFAC,ALFAC,            COMGEN      6
          1  NCDEL,PR(13),PREF(13),PJAY(13),E                                   COMGEN      7
            COMMON/RAD/NVE,SIGMA,ABSOR,SCATR                                    COMGEN      8
            COMMON/REACT/ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,MODER              COMGEN      9
            COMMON/DRCPL/EVAP(192),NTPL,NFMZ,XD(3),YD(3),ZD(3),ALFA(3),         COMGEN     10
          1  BETA(3),DELTA(3),THETA1(3),THETA2(3),MSL(3),WFF(3),SMD(3),         COMGEN     11
          2  VFUEL(3),RFUEL(3),EVSU(64),NEVAP                                   COMGEN     12
            COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WUINJ(20),         COMGEN     13
          1  AUINJ(20),KUINJ(20),IVINJ(20),JVINJ(20),KVINJ(20),VINJ(20),        COMGEN     14
          2  EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),NUINJ,NVINJ,JSW1,JSW2,     COMGEN     15
          3  USW,VSW,AFSW,FSW,TSW,WSW,SWNO,RHOSW                                COMGEN     16
            DIMENSION A(40)                                                     AL          5
      C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **     AL          7
            ENTRY START                                                         AL          8
      C  -----------   SOME PRELIMINARY VALUES   -------------------            AL          9
            HCO=1.0112E+7                                                       AL         10
            RATIO1=WOX*(CXX+HYY/4.)/WFU                                         AL         11
            RATIO2=.232                                                         AL         12
            RATIO3=WOX*0.5/WCO                                                  AL         13
            RATIO4=WCO*CXX/WFU                                                  AL         14
            FSTOIC=RATIO2/(RATIO1+RATIO2)                                       AL         15
            A(1)=COEF(MFU,1)                                                    AL         16
            A(1)=COEF(MFU,1)                                                    AL         17
            CFR=.003                                                            AL         18
            EMISW=.8                                                            AL         19
            EMISIN=1.                                                           AL         20
            EMISR=1.                                                            AL         21
            UMASS=0.                                                            AL         22
            SMASS=1.E-30                                                        AL         23
            ASW=AFSW-FSW                                                        AL         24
            FUMSW=FSW/AFSW                                                      AL         25
            FUOXSW=FUMSW                                                        AL         26
            WSW=SWNO*USW                                                        AL         27
            UMASS=AFSW*USW                                                      AL         28
            SMASS=AFSW                                                          AL         29
            FK=AMAX1(0.,AKFAC*(UMASS/SMASS)**2)*FLOAT(MODEL-1)                  AL         30
            SQFK=SQRT(FK)                                                       AL         31
            ASWRLR=0.                                                           AL         32
            DO 10 J=JSW1,JSW2                                                   AL         33
         10 ASWRLR=ASWRLR+YSR(J)*(Z(NP1)-Z(1))                                  AL         34
            ALIN=.5*ALFAC*(Y(JSW2)+Y(JSW2+1)-Y(JSW1)-Y(JSW1-1))                 AL         35
            RHOSW=AFSW/ASWRLR/USW                                               AL         36
            RTCD=SQRT(CD)                                                       AL         37
            DO 40 I=1,LPI                                                       AL         38
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   40 FUELS(I)=0.
      IF (NFMZ.LE.0) GO TO 48
      DO 165 II=1,NFMZ
      DO 165 I=2,L
      IF (XO(II).GT.0.5*(X(I)+X(I+1))) GO TO 165
      FUELS(I)=FUELS(I)+WFF(II)
  165 CONTINUE
   48 FUELS(LP1)=FUELS(L)
      WFMZ=FUELS(LP1)
      DO 88 K=1,MP1
      DO 82 J=1,MP1
   82 JWIM(J,K)=0
      DO 88 I=1,LP1
   85 IXIM(I,K)=0
      DO 86 K=1,MP1
      DO 86 J=JSM1,JSM2
   86 JWIM(J,K)=1
   84 CONTINUE
   88 IF (NVINJ.LE.0) GO TO 92
      DO 94 II=1,NVINJ
      I=IVINJ(II)
      J=JVINJ(II)
      K=KVINJ(II)
      IF (J.EQ.JWL(I,K)) GO TO 96
      IXIM(I,K)=IXIM(I,K)+2
      GO TO 94
   96 IXIM(I,K)=IXIM(I,K)+1
   94 CONTINUE
   92 IF (NUINJ.LE.0) GO TO 199
      DO 198 II=1,NUINJ
      I=IUINJ(II)-1
      J=JUINJ(II)
      IF (J.EQ.JWL(I,K)+1) GO TO 197
      DO 196 K=1,MP1
  196 IXIM(I,K)=IXIM(I,K)+2
      GO TO 198
  197 DO 195 K=1,MP1
  195 IXIM(I,K)=IXIM(I,K)+1
  198 CONTINUE
  199 CONTINUE
C     -------    COMPUTE TOTAL FLOW RATE    ------------------------------
   34 DO 499 I=1,LP1
      FLO(I)=0.
      FUEL(I)=0.
  499 TEMTM(I)=0.
      FLO(1)=AFSW
      FUEL(1)=FSW
      TEMTM(1)=AFSW*TSW
C     -------  AXIAL INJECTION
      IF (NUINJ.LE.0) GO TO 104
      DO 106 II=1,NUINJ
      I=IUINJ(II)-1
      FLO(I)=FLO(I)+AUINJ(II)
  106 TEMTM(I)=TEMTM(I)+TUINJ(II)*AUINJ(II)
C     -------  RADIAL INJECTION
  104 IF (NVINJ.LE.0) GO TO 108
      DO 110 II=1,NVINJ
      I=IVINJ(II)
      FLO(I)=FLO(I)+AVINJ(II)
  110 TEMTM(I)=TEMTM(I)+TVINJ(II)*AVINJ(II)
  108 CONTINUE
C     -------  FLOW RATE AT EACH I-STATION
      DO 135 I=2,LP1
      FLO(I)=FLO(I-1)+FLO(I)
      FUEL(I)=FUEL(I-1)+FUEL(I)
  135 TEMTM(I)=TEMTM(I-1)+TEMTM(I)
      FLOWT=FLO(LP1)+WFMZ
      DO 145 I=1,LP1
  145 FUDI(I)=FUEL(I)/FLO(I)
      FUTOT=FUEL(LP1)+WFMZ
      AMASS=FLO(LP1)-FUEL(LP1)
      FUARAT=FUTOT/AMASS
      DO 150 I=1,LP1
      FUELI=(FUEL(I)+FUELS(I))/(FLO(I)+FUELS(I))
      FUELF=AMAX1((FUELI-RATIO2*(1.-FUELI))/RATIO1,0.)
      PHI=FUELI/FSTOIC
      W1=FUELI*WGR(TSW,1)+(1.-FUELI)*RATIO2*WOR(TSW,4)+(1.-FUELI)*
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     1  (1.-RATIO2)*HDR(TSW,12)                                        AL      116
      TIN(1)=TSW                                                       AL      117
      FUB=FUELI-FUELF                                                  AL      118
      FLPCO2=WCO2*CXX*FUB/WFU-WCO2*FUNCO/WCO                           AL      119
      FLPOX=RATIO1*FUELF+RATIO3*FUNCO+RATIO2-(RATIO1+RATIO2)*FUELI     AL      120
      FLPOX=AMAX1(FLPOX,0.)                                            AL      121
      FLPH2O=HYY*WH2O*FUB/WFU/2.                                       AL      122
      FLPN2=1.-FUELF-FLPCO2-FUNCO-FLPOX-FLPH2O                         AL      123
      DO 151 II=1,10                                                   AL      124
      T=TIN(I)                                                         AL      125
      H2=FUELF*HDR(T,1)+FLPCO2*HDR(T,2)+FUNCO*HDR(T,3)+                AL      126
     1    FLPOX*HDR(T,4)+FLPH2O*HDR(T,5)+FLPN2*HDR(T,12)               AL      127
      CPI=FUELF*CPDR(T,1)+FLPCO2*CPDR(T,2)+FUNCO*CPDR(T,3)+            AL      128
     1    FLPOX*CPDR(T,4)+FLPH2O*CPDR(T,5)+FLPN2*CPDR(T,12)            AL      129
      TNEW=T+(H1-H2)/CPI                                               AL      130
      TMAX=ACOEF(1)+PHI*(ACOEF(2)+PHI*(ACOEF(3)+PHI*ACOEF(4)))         AL      131
      TMAX=AMAX1(TMAX,2000.)                                           AL      132
      TNEW=AMIN1(TNEW,TMAX)                                            AL      133
      IF (ABS(TIN(I)-TNEW).LT.10.) GO TO 150                           AL      134
  151 TIN(I)=TNEW                                                      AL      135
      WRITE (6,156)                                                    AL      136
  156 FORMAT ('  **ERROR-1**')                                         AL      137
  150 CONTINUE                                                         AL      138
      T4=TIN(LP1)                                                      AL      139
      CP=RATIO2*CPDR(T4,4)+(1.-RATIO2)*CPDR(T4,12)                     AL      140
      DO 231 I=3,LP1                                                   AL      141
      J1=[illegible](I-1)                                              AL      142
      J2=[illegible](I,1)                                              AL      143
      RHO4=PRESS/GASCON/TIN(I-1)                                       AL      144
      A4=.5*(Z(NP1)-Z(1))*(RM(J2)**2-RM(J1+1)**2)                      AL      145
      IF (IPLAX.EQ.2) GO TO 231                                        AL      146
      Y1=.5*(Y(J1)+Y(J1+1))                                            AL      147
      IF (J1.EQ.1) Y1=Y(J1)                                            AL      148
      Y2=.5*(Y(J2)+Y(J2-1))                                            AL      149
      IF (J2.EQ.NP1) Y2=Y(J2)                                          AL      150
      A4=(Z(NP1)-Z(1))*(Y2-Y1)                                         AL      151
  231 UIN(I)=FLD(I-1)/RHO4/A4                                          AL      152
      EMI=EMISW/(2.-EMISW)                                             AL      153
      RADIN=EMISIN*SIGMA*TSW**4                                        AL      154
      RADSUR=EMISR*SIGMA*T4**4                                         AL      155
C  -------    PRINTOUT INPUT DATA    ---------------------------       AL      156
      WRITE (6,1004) TITLE2                                            AL      157
 1004 FORMAT (/25X,20A4/25X,80(1H-)/)                                  AL      158
      HCRAT=HYY/CXX                                                    AL      159
      WRITE (6,2010) HCRAT,WFU,HFU                                     AL      160
 2010 FORMAT (2X,'I.    PHYSICAL INPUT'/8X,14(1H-)/10X,'1.FUEL-'/      AL      161
     4  30X,'HYDROGEN-CARBON RATIO ----------',1PE12.4,/               AL      162
     2  30X,'MOLECULAR WEIGHT----------------',1PE12.4,'  (KG/KGMOLE)'/ AL     163
     3  30X,'HEAT OF FORMATION---------------',1PE12.4,'  (CAL/GMOLE)') AL     164
      JJ=1                                                             AL      165
      WRITE (6,2014) JJ,FSW                                            AL      166
 2014 FORMAT (30X,'INLET-',I1,' MASS FLOW RATE-----------',1PE12.4,    AL      167
     1  '  (KG/S)')                                                    AL      168
      WRITE (6,2020) PRESS                                             AL      169
 2020 FORMAT (10X,'2.AIR -'/                                           AL      170
     3  30X,'PRESSURE-------------------------',1PE12.4,'  (NEW/SQ.M)') AL     171
      WRITE (6,2024) JJ,ASW,JJ,USW,JJ,SWNO                             AL      172
 2024 FORMAT (30X,'INLET-',I1,' MASS FLOW RATE-----------',1PE12.4,    AL      173
     1  '  (KG/S)'/30X,'INLET-',I1,' AXIAL VELOCITY-----------',1PE12.4, AL    174
     2  '  (M/S)'/30X,'INLET-',I1,' SWIRL NUMBER-------------',        AL      175
     3  1PE12.4)                                                       AL      176
      HEIGHT=2.*(Y(NP1)-Y(1))                                          AL      177
      ALNGHT=X(LP1)-X(1)                                               AL      178
      SECTOR=Z(NP1)-Z(1)                                               AL      179
      WRITE (6,2025) HEIGHT,ALNGHT,SECTOR                              AL      180
 2025 FORMAT (2X,'II.   GEOMETRICAL INPUT'/8X,18(1H-)/                 AL      181
     1  30X,'CHANNEL HEIGHT OF COMBUSTOR------',1PE12.4,'  (M)'/       AL      182
     2  30X,'LENGTH OF COMBUSTOR--------------',1PE12.4,'  (M)'/       AL      183
     2  30X,'ANGULAR SECTOR-------------------',1PE12.4,'  (RAD-M)')   AL      184
      WRITE (6,2029) JJ,ASWRLR                                         AL      185
 2029 FORMAT (30X,'INLET-',I1,' FLOW AREA----------------',1PE12.4,    AL      186
     1  '  (SQ.M)')                                                    AL      187
      IF (NUINJ+NVINJ+NFNZ.GT.0) WRITE (6,2030)                        AL      188
 2030 FORMAT (2X,'III.  AIR INJECTIONS'/8X,14(1H-))                    AL      189
      IF (NUINJ.LE.0) GO TO 770                                        AL      190
      WRITE (6,2031)                                                   AL      191
 2031 FORMAT (15X,'1.FILM COOLING AIR-')                               AL      192
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      WRITE (6,2033)                                                    AL       193
 2033 FORMAT (25X,'SLOT NO',4X,'I',5X,'J',6X,'K',8X,'U-VELOCITY',       AL       194
     1  5X,'V-VELOCITY',5X,'W-VELOCITY',6X,'MASS FLOW',6X,'FUEL FLOW'/  AL       195
     2  59X,'(M/S)',10X,'(M/S)',10X,'(M/S)',10X,'(KG/S)',9X,'(KG/S)')   AL       196
      DO 772 II=1,NUINJ                                                 AL       197
      I=IUINJ(II)                                                       AL       198
      J=JUINJ(II)                                                       AL       199
  772 WRITE (6,2090) II,I,J,K,UDEF,UINJ(II),UDEF,WUINJ(II),AUINJ(II)    AL       200
  770 IF (NVINJ.LE.0) GO TO 774                                         AL       201
      WRITE (6,2034)                                                    AL       202
 2034 FORMAT (/10X,'2.DILUTION AND SECONDARY AIR-')                     AL       203
      WRITE (6,2033)                                                    AL       204
      DO 776 II=1,NVINJ                                                 AL       205
      I=IVINJ(II)                                                       AL       206
      K=KVINJ(II)                                                       AL       207
      J=JVINJ(II)                                                       AL       208
  776 WRITE (6,2090) II,I,J,K,UDEF,VINJ(II),UDEF,AVINJ(II)              AL       209
  774 CONTINUE                                                          AL       210
 2090 FORMAT (27X,I3,4X,I3,3X,I3,2X,I3,8X,1PE10.3,4(5X,1PE10.3))        AL       211
  810 IF (NFNZ.LE.0) GO TO 813                                          AL       212
      WRITE (6,816)                                                     AL       213
  816 FORMAT (/10X,'3.FUEL NOZZLES-'/12X,'XO',8X,'YO',8X,'ZO',6X,'ALFA', AL      214
     1  6X,'BETA',5X,'DELTA',4X,'THETA1',4X,'THETA2',7X,'NSL',8X,'WF',  AL       215
     2  7X,'SMD',5X,'VFUEL'/11X,'(M)',7X,'(M)',6X,'(M-R)',4X,'(RAD)',   AL       216
     3  5X,'(RAD)',5X,'(RAD)',5X,'(RAD)',5X,'(RAD)',8X,'-',6X,'(KG/S)', AL       217
     4  3X,'(MICRON)',2X,'(M/S)')                                       AL       218
      DO 818 I=1,NFNZ                                                   AL       219
      RNSL=FLOAT(NSL(I))                                                AL       220
  818 WRITE (6,819) XO(I),YO(I),ZO(I),ALFA(I),BETA(I),DELTA(I),         AL       221
     1  THETA1(I),THETA2(I),RNSL,WFF(I),SMD(I),VFUEL(I)                 AL       222
  819 FORMAT (5X,1P12E10.2)                                             AL       223
  813 CONTINUE                                                          AL       224
      WRITE (6,2037) FUTOT,AMASS,FUARAT                                 AL       225
 2037 FORMAT (/2X,'IV.   AIR-FUEL BALANCE'/8X,16(1H-)/                  AL       226
     1  30X,'TOTAL FUEL FLOW RATE-------------',1PE12.4,'  (KG/S)'/     AL       227
     2  30X,'TOTAL AIR FLOW RATE--------------',1PE12.4,'  (KG/S)'/     AL       228
     3  30X,'FUEL TO AIR RATIO----------------',1PE12.4,/)              AL       229
      WRITE (6,2040) CP,ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,            AL       230
     1  C1,C2,CD,ABSOR,SCATR                                            AL       231
 2040 FORMAT (2X,'V.    SOME IMPORTANT QUANTITIES'/8X,24(1H-)/          AL       232
     1  30X,'SPECIFIC HEAT---------------------',1PE12.4,'  (J/KG-K)'/  AL       233
     2  30X,'ACTIVATION ENERGY (1ST) ----------',1PE12.4,'  (K)'/       AL       234
     3  30X,'PRE-EXPONENT (1ST) ---------------',1PE12.4,/              AL       235
     3  30X,'EDDY BREAKUP CONSTANT (1ST) ------',1PE12.4,/              AL       236
     7  30X,'ACTIVATION ENERGY (2ND) ----------',1PE12.4,'  (K)'/       AL       237
     8  30X,'PRE-EXPONENT (2ND) ---------------',1PE12.4,/              AL       238
     9  30X,'EDDY BREAKUP CONSTANT (2ND) ------',1PE12.4,/              AL       239
     4  30X,'TURB. CONSTANT (C1) --------------',1PE12.4,/              AL       240
     4  30X,'TURB. CONSTANT (C2) --------------',1PE12.4,/              AL       241
     4  30X,'TURB. CONSTANT (CD) --------------',1PE12.4,/              AL       242
     5  30X,'ABSORPTION COEFFICIENT------------',1PE12.4,/              AL       243
     6  30X,'SCATTERING COEFFICIENT------------',1PE12.4,/)             AL       244
      WRITE (6,2042) (RELAX(I),I=1,16)                                  AL       245
 2042 FORMAT (/8X,'RELAXATION PARAMETERS'/8X,21(1H-)/(5X,1P10E12.3))    AL       246
      GO TO (2050,2051), MODEL                                          AL       247
 2050 WRITE (6,2052) (PR(I),I=1,13)                                     AL       248
      GO TO 2053                                                        AL       249
 2051 WRITE (6,2052) (PREF(I),I=1,13)                                   AL       250
 2052 FORMAT (/8X,'PRANDTL NUMBERS'/8X,15(1H-)/(5X,1P10E12.3))          AL       251
 2053 CONTINUE                                                          AL       252
      WRITE (6,2044) (X(I),I=1,LP1)                                     AL       253
 2044 FORMAT (/9X,'X-COORDINATES'/8X,13(1H-)/(5X,1P10E12.3))            AL       254
      WRITE (6,2046) R(1),(Y(J),J=2,MP1)                                AL       255
 2046 FORMAT (/8X,'Y-COORDINATES'/8X,13(1H-)/(5X,1P10E12.3))            AL       256
      WRITE (6,2048) (Z(K),K=1,NP1)                                     AL       257
 2048 FORMAT (/8X,'Z-COORDINATES'/8X,13(1H-)/(5X,1P10E12.3))            AL       258
C +-+-+-+-+-+-+-+-+-   CREATE INITIAL DATA TAPE   +-+-+-+-+-+-+-+-+-+-  AL       259
C ---------      RESTART OPTIONS                                        AL       260
      IF (IRES.EQ.0) GO TO 201                                          AL       261
      REWIND NTP1                                                       AL       262
      DO 202 II=1,2                                                     AL       263
  202 READ (NTP1)                                                       AL       264
C ------- HERE PP IS PHI, P IS MFU, DU IS MCO                           AL       265
      READ (NTP1) PP,P,DU                                               AL       266
C ------- HERE DV IS ENTHALPY, DW IS FAV                                AL       267
      READ (NTP1) DV,DW                                                 AL       268
C--------- HERE U IS FX, V IS FY, W IS FZ                               AL       269
```

```
      READ (NTP1) U,V,W
      READ (NTP1) TEMP,AMU
      RETURN
C ------- ZERO ARRAYS
  201 DO 204 NV=1,12
      DO 204 K=1,NP1
      DO 204 J=1,MP1
      KJM=KM(K)+JM(J)
      DO 204 I=1,LP1
      LP=KJM+I
  204 F(LP,NV)=0.
C +-+-+-+-+-+-+-+-+-+-  U,V,W AND PRESSURE  -+-+-+-+-+-+-+-+-+-+-+-+
      DO 451 K=1,NP1
      DO 451 J=2,M
      IS=IWLI(J,4)
      IE=IWLO(J,4)
      DO 451 I=IS,IE
      IF (I.EQ.IS) GO TO 452
      U(I,J,K)=UIN(I)
  452 W(I,J,K)=.001
      IF (J.EQ.JWLI(I,4)+1) GO TO 451
      V(I,J,K)=.001
  451 CONTINUE
      IF (IPAR.EQ.2) GO TO 255
      DO 209 K=1,NP1
      DO 209 J=1,MP1
      IS=IWLI(J,5)
      IE=IWLO(J,5)
      DO 209 I=IS,IE
  209 P(I,J,K)=PRESS
C ------- BOUNDRY NODES
  255 DO 240 K=1,NP1
      IF (IDW.EQ.1) GO TO 241
      DO 242 I=3,LP1
      J=JWLI(I,4)
      U(I,J,K)=UIN(I)
  242 CONTINUE
  241 CONTINUE
      DO 244 J=JSW1,JSW2
      I=IWLI(J,4)-1
      U(I+1,J,K)=USW
      V(I,J,K)=VSW
  244 V(I,J+1,K)=VSW
  247 CONTINUE
      DO 245 J=1,MP1
      I=IWLO(J,4)+1
      IF (J.LE.JWOI.OR.J.GE.JWOO) GO TO 245
      U(I,J,K)=U(I-1,J,K)
  245 CONTINUE
C ------- INJECTION POINTS
      IF (NUINJ.LE.0) GO TO 240
      DO 246 II=1,NUINJ
      I=IUINJ(II)
      J=JUINJ(II)
      U(I,J,K)=UINJ(II)
      U(I-1,J,K)=0.
  246 W(I-1,J,K)=WUINJ(II)
  240 CONTINUE
      IF (NVINJ.LE.0) GO TO 249
      DO 250 II=1,NVINJ
      I=IVINJ(II)
      J=JVINJ(II)
      K=KVINJ(II)
      V(I,J,K)=VINJ(II)
      IF (J.EQ.JWLI(I,4)) V(I,J+1,K)=VINJ(II)
  250 CONTINUE
  249 CONTINUE
      REWIND NTP1
      WRITE (NTP1) U,V,W,P
C +-+-+-+-+-+-+-  TURBULENT KINETIC ENERGY AND DISSIPATION  -+-+-+-+-+-+
      DO 437 K=1,NP1
      DO 419 J=1,MP1
      KJM=KM(K)+JM(J)
      IS=IWLI(J,5)
      IE=IWLO(J,5)
      DO 419 I=IS,IE
      LP=KJM+I
```

```
          F(LP,NVK)=FK                                                    AL      347
          DY=Y(JWLO(I,4))-Y(J)                                            AL      348
          IF (IDW.EQ.1) DY=AMIN1(Y(JWLO(I,4))-Y(J),Y(J)-Y(JWLI(I,4)))     AL      349
          DY=AMAX1(DY,0.)                                                 AL      350
          AL=ALFAC*DY                                                     AL      351
      418 F(LP,NVD)=CD*FK**1.5/(AL+1.E-30)                                AL      352
          DO 775 J=JSW1,JSW2                                              AL      353
          LP=KM(K)+JM(J)+IWLI(J,4)-1                                      AL      354
      775 F(LP,NVD)=CD*FK**1.5/ALIN                                       AL      355
          IF (NUINJ.LE.0) GO TO 437                                       AL      356
          DO 270 II=1,NUINJ                                               AL      357
          I=IUINJ(II)-1                                                   AL      358
          J=JUINJ(II)                                                     AL      359
          LP=KM(K)+JM(J)+I                                                AL      360
          F(LP,NVK)=AKFAC*(UINJ(II)**2+WUINJ(II)**2)                      AL      361
          AL=ALFAC*YS(J)                                                  AL      362
      270 F(LP,NVD)=CD*F(LP,NVK)**1.5/(AL+1.E-30)                         AL      363
      437 CONTINUE                                                        AL      364
          IF (NVINJ.LE.0) GO TO 272                                       AL      365
          DO 274 II=1,NVINJ                                               AL      366
          I=IVINJ(II)                                                     AL      367
          J=JVINJ(II)                                                     AL      368
          K=KVINJ(II)                                                     AL      369
          LP=KM(K)+JM(J)+I                                                AL      370
          F(LP,NVK)=EVINJ(II)                                             AL      371
      274 F(LP,NVD)=CD*F(LP,NVK)**1.5/(DVINJ(II)+1.E-30)                  AL      372
      272 CONTINUE                                                        AL      373
C     ------- HERE PP IS KE, P IS DISSIPATION                             AL      374
          WRITE (NT1) PP,P                                                AL      375
C     +-+-+-+-+-+-+-+-+-+-+- PHI,FUEL,CO AND TEMP -+-+-+-+-+-+-+-+-+-+-+-+  AL      376
          DO 404 K=1,MP1                                                  AL      377
          DO 404 J=1,MP1                                                  AL      378
          KJM=KM(K)+JM(J)                                                 AL      379
          IS=IWLI(J,5)                                                    AL      380
          IE=IWLO(J,5)                                                    AL      381
          DO 406 I=IS,IE                                                  AL      382
          LP=KJM+I                                                        AL      383
      406 F(LP,NVTE)=TIN(I)                                               AL      384
          IS=IWLI(J,4)                                                    AL      385
          IE=IWLO(J,4)                                                    AL      386
          DO 404 I=IS,IE                                                  AL      387
          LP=KJM+I                                                        AL      388
          F(LP,NVFUOX)=FUOX(I)                                            AL      389
          F(LP,NVFU)=AMAX1(0.,F(LP,NVFUOX)-RATIO2*(1.-F(LP,NVFUOX))/RATIO1)  AL      390
      404 F(LP,NVCO)=FUMCO                                                AL      391
C     -----BOUNDRY NODES                                                  AL      392
          DO 495 K=1,MP1                                                  AL      393
          DO 206 I=1,LP1                                                  AL      394
          J=JWLI(I,4)                                                     AL      395
          LP=KM(K)+JM(J)+I                                                AL      396
          IF (IDW.EQ.0) GO TO 217                                         AL      397
          TEMP(I,J,K)=TCYLW                                               AL      398
          IF (J.EQ.1) GO TO 208                                           AL      399
          TEMP(I,J,K)=TINLW                                               AL      400
      208 F(LP,NVFUOX)=0.                                                 AL      401
          F(LP,NVFU)=0.                                                   AL      402
          F(LP,NVCO)=0.                                                   AL      403
          GO TO 216                                                       AL      404
      217 TEMP(I,J,K)=TIN(I)                                              AL      405
          F(LP,NVFUOX)=FUOX(I)                                            AL      406
          FEXIT=FUOX(I)-RATIO2*(1.-FUOX(I))/RATIO1                        AL      407
          F(LP,NVFU)=AMAX1(FEXIT,0.)                                      AL      408
          F(LP,NVCO)=0.                                                   AL      409
      216 J=JWLO(I,4)                                                     AL      410
          LP=KM(K)+JM(J)+I                                                AL      411
          TEMP(I,J,K)=TCYLW                                               AL      412
          IF (J.EQ.MP1) GO TO 444                                         AL      413
          TEMP(I,J,K)=TINLW                                               AL      414
      444 F(LP,NVFU)=0.                                                   AL      415
          F(LP,NVCO)=0.                                                   AL      416
      206 F(LP,NVFUOX)=0.                                                 AL      417
          DO 210 J=1,MP1                                                  AL      418
          I=IWLI(J,4)-1                                                   AL      419
          LP=KM(K)+JM(J)+I                                                AL      420
          IF (J.GE.JSW1.AND.J.LE.JSW2) GO TO 212                          AL      421
          TEMP(I,J,K)=TINLW                                               AL      422
          F(LP,NVFUOX)=0.                                                 AL      423
```

```
      F(LP,NVFU)=0.                                                     AL   424
      F(LP,NVCO)=0.                                                     AL   425
      GO TO 213                                                         AL   426
  212 TEMP(I,J,K)=TSW                                                   AL   427
      F(LP,NVFUOX)=FUOXSW                                               AL   428
      F(LP,NVFU)=FUMSW                                                  AL   429
      F(LP,NVCO)=0.                                                     AL   430
  213 I=IWLO(J,4)+I                                                     AL   431
      LP=KM(K)+JM(J)+I                                                  AL   432
      IF (J.GT.JWOI.AND.J.LT.JWOO) GO TO 214                            AL   433
      TEMP(I,J,K)=TINLW                                                 AL   434
      F(LP,NVFUOX)=0.                                                   AL   435
      F(LP,NVFU)=0.                                                     AL   436
      F(LP,NVCO)=0.                                                     AL   437
      GO TO 210                                                         AL   438
  214 F(LP,NVFUOX)=FUOX(LP1)                                            AL   439
      FEXIT=FUOX(LP1)-RATIO2*(1.-FUOX(LP1))/RATIO1                      AL   440
      F(LP,NVFU)=AMAX1(FEXIT,0.)                                        AL   441
      F(LP,NVTE)=TIN(I)                                                 AL   442
      F(LP,NVCO)=0.                                                     AL   443
  210 CONTINUE                                                          AL   444
C ----INJECTION POINTS                                                  AL   445
      IF (NUINJ.LE.0) GO TO 495                                         AL   446
      DO 218 II=1,NUINJ                                                 AL   447
      I=IUINJ(II)-1                                                     AL   448
      J=JUINJ(II)                                                       AL   449
      LP=KM(K)+JM(J)+I                                                  AL   450
      F(LP,NVFUOX)=0.                                                   AL   451
      F(LP,NVFU)=0.                                                     AL   452
      F(LP,NVCO)=0.                                                     AL   453
  218 TEMP(I,J,K)=TUINJ(II)                                             AL   454
  495 CONTINUE                                                          AL   455
      IF (NVINJ.LE.0) GO TO 220                                         AL   456
      DO 222 II=1,NVINJ                                                 AL   457
      I=IVINJ(II)                                                       AL   458
      J=JVINJ(II)                                                       AL   459
      K=KVINJ(II)                                                       AL   460
      LP=KM(K)+JM(J)+I                                                  AL   461
      F(LP,NVFUOX)=0.                                                   AL   462
      F(LP,NVFU)=0.                                                     AL   463
      F(LP,NVCO)=0.                                                     AL   464
  222 TEMP(I,J,K)=TVINJ(II)                                             AL   465
 220  CONTINUE                                                          AL   466
C ---------- HERE PP IS PHI, P IS MFU AND DU IS MCO                     AL   467
      WRITE (NT*1) PP,P,DU                                              AL   468
C +-+-+-+-+-+-+-+-+-+-+-+-+-+  ENTHALPY  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+  AL   469
      DO 276 K=1,NPI                                                    AL   470
      DO 275 J=1,NPI                                                    AL   471
      IS=IWLI(J,5)                                                      AL   472
      IE=IWLO(J,5)                                                      AL   473
      KJM=KM(K)+JM(J)                                                   AL   474
      DO 276 I=IS,IE                                                    AL   475
      LP=KJM+I                                                          AL   476
      T=TEMP(I,J,K)                                                     AL   477
      FUB=F(LP,NVFUOX)-F(LP,NVFU)                                       AL   478
      FLPOX=RATIO1*F(LP,NVFU)+RATIO3*F(LP,NVCO)+RATIO2-(RATIO1+RATIO2)* AL   479
     1F(LP,NVFUOX)                                                      AL   480
      FLPOX=AMAX1(FLPOX,0.)                                             AL   481
      FLPH2O=.5*YY*WH2O*FUB/WFU                                         AL   482
      FLPCO2=WCO2*CXX*FUB/WFU-WCO2*F(LP,NVCO)/WCO                       AL   483
      FLPN2=1.-F(LP,NVFU)-FLPCO2-F(LP,NVCO)-FLPOX-FLPH2O                AL   484
      HPI=F(LP,NVFU)*HDR(T,1)+FLPCO2*HDR(T,2)+F(LP,NVCO)*HDR(T,3)+      AL   485
     1    FLPOX*HDR(T,4)+FLPH2O*HDR(T,5)+FLPN2*HDR(T,12)                AL   486
      F(LP,NVH)=HPI                                                     AL   487
  276 CONTINUE                                                          AL   488
C +-+-+-+-+-+-+-+-+-+-+-+-+-+  FX,FY,FZ AND FAV  -+-+-+-+-+-+-+-+-+-+-+  AL   489
      DO 791 K=1,NPI                                                    AL   490
      DO 791 J=1,NPI                                                    AL   491
      KJM=KM(K)+JM(J)                                                   AL   492
      IS=IWLI(J,5)                                                      AL   493
      IE=IWLO(J,5)                                                      AL   494
      DO 791 I=IS,IE                                                    AL   495
      LP=KJM+I                                                          AL   496
      ST4=SIGMA*TEMP(I,J,K)**4                                          AL   497
      F(LP,NVRX)=ST4                                                    AL   498
      F(LP,NVRY)=ST4                                                    AL   499
      F(LP,NVRZ)=ST4                                                    AL   500
```

```
   540            701 FILP,NVFAV1=ST4                                              AL         501
                C ---------- HERE DY IS ENTHALPY, DW IS FAV                        AL         502
                      WRITE (NTP1) DY,DW                                           AL         503
                C ---------- HERE U IS FX, V IS FY, W IS FZ                        AL         504
                      WRITE (NTP1) U,V,W                                           AL         505
   545                RETURN                                                       AL         506
                      END                                                          AL         507


CARD NR. SEVERITY  DETAILS   DIAGNOSIS OF PROBLEM

     87      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     92      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    111      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
[illegible]  I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
[illegible]  I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
[illegible]  I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    314      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    321      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    333      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    348      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    379      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    416      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    432      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
[illegible]  I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    529      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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SUBROUTINE ALLMOD     73/74    OPT=0 TRACE                     FTN 4.5+439         08/24/79  14.09.46         PAGE     1

            SUBROUTINE ALLMOD                                                  AL        509
            COMMON F(500,7),DU(10,10,5),DV(10,10,5),DW(10,10,5),               COMFA       2
          1  RHO(10,10,5),VISC(10,10,5),SU(10,10),SP(10,10),DRHODP(10,10,5),   COMFA       3
          1  AXP(10,10),AXM(10,10),AYP(10,10),AYM(10,10),AZP(10,10),           COMFA       4
          2  AZM(10,10),CZ(10,10),CY(10),CZU(10,10),CYU(10),                   COMFA       5
          3  CZP(10,10),CYP(10),DIVG(10,10),NTP1,NTP2                          COMFA       6
            DIMENSION U(10,10,5),V(10,10,5),W(10,10,5),PP(10,10,5)             COMFA       7
            DIMENSION P(10,10,5),TEMP(10,10,5),GAM(10,10,5)                    COMFA       8
            EQUIVALENCE (F(1,1),U(1,1,1)),(F(1,2),V(1,1,1)),(F(1,3),W(1,1,1))  COMFA       9
            EQUIVALENCE (F(1,4),PP(1,1,1)),(F(1,5),P(1,1,1))                   COMFA      10
            EQUIVALENCE (F(1,6),TEMP(1,1,1)),(F(1,7),GAM(1,1,1))               COMFA      11
            COMMON/CYL/R(30),RM(30),RMV(30),YSR(30),YSVR(30),IPLAX             COMMON      2
            COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),        COMMON      3
          1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),       COMMON      4
          2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                           COMMON      5
            COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NIJ,NIJNK,NV,    COMMON      6
          1  NNV,NGOTO,K,ISTR,JSTR,KSTR,NVM(20),KM(30),JM(30),ISTEP,           COMMON      7
          2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,    COMMON      8
          3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,       COMMON      9
          4  IWEO,NNI,JWII,JWIO,JWOI,JWCO,IDW,JKIN(30,30),IKIN(40,30)          COMMON     10
            COMMON/INDEX/IPAR,LPREF,ISTUM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE   COMMON     11
          1  ,PLAXM1,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),      COMMON     12
          2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,      COMMON     13
          3  NVN2                                                              COMMON     14
            COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEN,IOX,FSTOIC,MFU,CP,    COMMON     15
          1  GASCON,RMOCON,UNICON,PRESS,NVFAV,TCYLW,TINLW,TLIP,ACOEF(4),       COMMON     16
          2  T4,OFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HYY,CXX,RATIO1,RATIO2,          COMMON     17
          3  RATIO3,RATIO4,HCO,TAN,ITWALL                                      COMMON     18
            COMMON/CTDMA/KEND,ICTDMA(13)                                       COMMON     19
            COMMON/MIS/APU,DEN,SMAX,SSUM,LASTEP,HTCEXT,CFR,EMISW,EMISIN,       COMGEN      2
          1  EMISR,IOUT,RTCO,EM1,RADIN,RADSUR,FMA,FK,SOFK,                     COMGEN      3
          2  FKFU,FOFU,TFUEL,WFMZ,FLO(40),TEMIN(40),MI(40),FUEL(40),FUOX(40) , COMGEN      4
          3  UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)               COMGEN      5
            COMMON/TURB/MUK,NVD,C1,C2,CD,AK,DUIDXJ(3,3),AKFAC,ALFAC,           COMGEN      6
          1  MODEL,PR(13),PREF(13),PJAY(13),E                                  COMGEN      7
            COMMON/RAD/NVE,SIGMA,ABSOR,SCATR                                   COMGEN      8
            COMMON/REACT/ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,MODER             COMGEN      9
            COMMON/DROPL/EVAP(192),NTP4,MFMZ,XG(3),YD(3),ZD(3),ALFA(3),        COMGEN     10
          1  BETA(3),DELTA(3),THETA1(3),THETA2(3),MSL(3),WFF(3),SMD(3),        COMGEN     11
          2  VFUEL(3),RFUEL(3),EVSU(64),NEVAP                                  COMGEN     12
            COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WUINJ(20),        COMGEN     13
          1  AUINJ(20),TUINJ(20),IVINJ(20),JVINJ(20),KVINJ(20),VINJ(20),       COMGEN     14
          2  EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),NUINJ,NVINJ,JSW1,JSW2,    COMGEN     15
          3  USW,VSW,AFSW,FSW,TSW,WSW,SWNO,RHOSW                               COMGEN     16
      C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  * AL        512
            ENTRY FMOD                                                         AL        513
            NVFF=NVF(NV)                                                       AL        514
      C -------------  CYCLIC BOUNDARY CONDITIONS  ----------------------      AL        515
       1044 DO 1002 J=1,MP1                                                    AL        516
            DO 1002 I=1,LP1                                                    AL        517
            LIJ=I+JM(J)                                                        AL        518
            LP2=I+JM(J)+KM(2)                                                  AL        519
            LPN=LIJ+KM(N)                                                      AL        520
            LPNP1=LIJ+KM(NP1)                                                  AL        521
            F(LIJ,NVFF)=F(LPN,NVFF)                                            AL        522
            F(LPNP1,NVFF)=F(LP2,NVFF)                                          AL        523
      1002  CONTINUE                                                           AL        524
      1001  CONTINUE                                                           AL        525
            IF (NV.NE.LVFU.AND.NV.NE.LVCO) GO TO 1010                          AL        526
            DO 1020 K=1,NP1                                                    AL        527
            DO 1020 J=1,MP1                                                    AL        528
            KJM=KM(K)+JM(J)                                                    AL        529
            DO 1020 I=1,LP1                                                    AL        530
            LP=KJM+I                                                           AL        531
            F(LP,NVFF)=AMAX1(F(LP,NVFF),0.)                                    AL        532
            IF (NV.EQ.LVCO) F(LP,NVFF)=AMIN1(F(LP,NVFF),.25)                   AL        533
       1020 CONTINUE                                                           AL        534
       1010 CONTINUE                                                           AL        535
            RETURN                                                             AL        536
      C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  * AL        537
            ENTRY VELMIC                                                       AL        538
            DO 1000 K=1,NP1                                                    AL        539
            DO 1000 J=JSW1,JSW2                                                AL        540
            WIN=WSW*R(J)/R(JSW2)                                               AL        541
            I=IWLI(J,4)-1                                                      AL        542
            W(I,J,K)=W(I,J,K)+.05*WIN                                          AL        543
            IF (ABS(W(I,J,K)).GT.ABS(WIN)) W(I,J,K)=WIN                        AL        544
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SUBROUTINE ALLMOD      73/74    OPT=2 TRACE                    FTN 4.6+439       09/24/78  14.08.46        PAGE    2

       1003  CONTINUE                                                          AL       545
        1003 CONTINUE                                                          AL       546
             DO 2005 J=2,M                                                     AL       547
             DO 2007 I=2,L                                                     AL       548
             W(I,J,2)=W(I,J,MP1)                                               AL       549
        2007 OW(I,J,2)=OW(I,J,MP1)                                             AL       550
       2005  CONTINUE                                                          AL       551
       C  ------   SATISFY CONTINUITY AT EXIT PLANE                            AL       552
             RHOA=0.0                                                          AL       553
             FLOWOT=0.0                                                        AL       554
             INDX=0                                                            AL       555
             DO 755 K=2,N                                                      AL       556
             JS=JWLI(LP1,4)+1                                                  AL       557
             JE=JWLO(LP1,4)-1                                                  AL       558
             DO 755 J=JS,JE                                                    AL       559
             RHO(LP1,J,K)=RHO(L,J,K)                                           AL       560
             ROA=YSR(J)*ZS(K)*RHO(LP1,J,K)                                     AL       561
             RHOA=RHOA+ROA                                                     AL       562
             FLOWOT=FLOWOT+U(L,J,K)*ROA                                        AL       563
             IF (U(L,J,K).GE.0.0) GO TO 755                                    AL       564
             INDX=1                                                            AL       565
         755 CONTINUE                                                          AL       566
             UADD=(FLOWIN-FLOWOT)/RHOA                                         AL       567
             SEXIT=1.-FLOWOT/FLOWIN                                            AL       568
             UMEAN=FLOWIN/RHOA                                                 AL       569
             DO 756 K=2,N                                                      AL       570
             JS=JWLI(LP1,4)+1                                                  AL       571
             JE=JWLO(LP1,4)-1                                                  AL       572
             DO 756 J=JS,JE                                                    AL       573
             IF (INDX) 757,757,758                                             AL       574
         757 U(LP1,J,K)=U(L,J,K)+UADD                                          AL       575
             GO TO 756                                                         AL       576
         758 U(LP1,J,K)=UMEAN                                                  AL       577
         756 CONTINUE                                                          AL       578
             RETURN                                                            AL       579
       C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  *  AL       580
             ENTRY DENMOD                                                      AL       581
             IF (NVINJ.LE.0) GO TO 750                                         AL       582
             DO 749 II=1,NVINJ                                                 AL       583
             I=IVINJ(II)                                                       AL       584
             K=KVINJ(II)                                                       AL       585
             J=JVINJ(II)                                                       AL       586
             M1=J                                                              AL       587
             IF (J.EQ.JWLI(I,4)) M1=J+1                                        AL       588
             AREA=XS(I)*RM(M1)*ZS(K)                                           AL       589
             RHOINJ=AVINJ(II)/ABS(VINJ(II))/AREA                               AL       590
         749 RHO(I,J,K)=RHOINJ                                                 AL       591
         750 CONTINUE                                                          AL       592
             DO 2060 J=2,M                                                     AL       593
             DO 2060 I=2,L                                                     AL       594
             RHO(I,J,MP1)=.5*(RHO(I,J,2)+RHO(I,J,N))                           AL       595
             RHO(I,J,1)=RHO(I,J,MP1)                                           AL       596
       2060  CONTINUE                                                          AL       597
             DO 759 K=1,MP1                                                    AL       598
             DO 2061 J=JSW1,JSW2                                               AL       599
             I=IWLI(J,4)-1                                                     AL       600
        2061 RHO(I,J,K)=RHOSW                                                  AL       601
        2099 CONTINUE                                                          AL       602
        2064 IF (NUINJ.LE.0) GO TO 760                                         AL       603
             DO 759 II=1,NUINJ                                                 AL       604
             I=IUINJ(II)-1                                                     AL       605
             J=JUINJ(II)                                                       AL       606
             AREA=YSR(J)*(Z(MP1)-Z(1))                                         AL       607
         759 RHO(I,J,K)=2.*AUINJ(II)/AREA/UINJ(II)-RHO(I+1,J,K)                AL       608
         760 CONTINUE                                                          AL       609
             RETURN                                                            AL       610
       C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  *  AL       611
             ENTRY GAMOD                                                       AL       612
             DO 3000 K=1,MP1                                                   AL       613
             DO 3007 I=1,LP1                                                   AL       614
             J=JWLO(I,4)                                                       AL       615
             IF (IKIN(I,K).EQ.2.OR.IKIN(I,K).EQ.3) GO TO 3003                  AL       616
             IF (IGAM1(NW).EQ.0) GO TO 3003                                    AL       617
             YPLUS=VISC(I,J,K)                                                 AL       618
             IF (YPLUS.GT.11.5) GO TO 3001                                     AL       619
             GAM(I,J,K)=AMU/PR(NW)                                             AL       620
             GO TO 3002                                                        AL       621
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      3001 GAM(I,J,K)=AMU*YPLUS/PREF(NV)/(ALOG(E*YPLUS)/AK+PJAY(NV))              AL       622
           GO TO 3002                                                             AL       623
      3003 GAM(I,J,K)=0.                                                          AL       624
      3002 J=JWLI(I,4)                                                            AL       625
           IF ((NV.EQ.0.OR.(KIN(I,K).EQ.1.OR.KIN(I,K).EQ.3)) GO TO 3004          AL       626
           IF ((IGAM1(NV).EQ.0) GO TO 3004                                        AL       627
           YPLUS=VISC(I,J,K)                                                      AL       628
           IF (YPLUS.GT.11.5) GO TO 3006                                          AL       629
           GAM(I,J,K)=AMU/PR(NV)                                                  AL       630
           GO TO 3007                                                             AL       631
      3006 GAM(I,J,K)=AMU*YPLUS/PREF(NV)/(ALOG(E*YPLUS)/AK+PJAY(NV))              AL       632
           GO TO 3007                                                             AL       633
      3004 GAM(I,J,K)=0.                                                          AL       634
      3007 CONTINUE                                                               AL       635
           DO 3000 J=2,M                                                          AL       636
           I=IWLI(J,4)-1                                                          AL       637
           IF (JKIN(J,K).EQ.1) GO TO 3009                                         AL       638
           IF ((IGAM2(NV).EQ.0) GO TO 3009                                        AL       639
           YPLUS=VISC(I,J,K)                                                      AL       640
           IF (YPLUS.GT.11.5) GO TO 3019                                          AL       641
           GAM(I,J,K)=AMU/PR(NV)                                                  AL       642
           GO TO 3011                                                             AL       643
      3019 GAM(I,J,K)=AMU*YPLUS/PREF(NV)/(ALOG(E*YPLUS)/AK+PJAY(NV))              AL       644
           GO TO 3011                                                             AL       645
      3009 GAM(I,J,K)=0.                                                          AL       646
      3011 I=IWLO(J,4)+1                                                          AL       647
           IF (J.GT.JWOI.AND.J.LT.JWOO) GO TO 3012                                AL       648
           IF ((IGAM2(NV).EQ.0) GO TO 3012                                        AL       649
           YPLUS=VISC(I,J,K)                                                      AL       650
           IF (YPLUS.GT.11.5) GO TO 3013                                          AL       651
           GAM(I,J,K)=AMU/PR(NV)                                                  AL       652
           GO TO 3000                                                             AL       653
      3013 GAM(I,J,K)=AMU*YPLUS/PREF(NV)/(ALOG(E*YPLUS)/AK+PJAY(NV))              AL       654
           GO TO 3000                                                             AL       655
      3012 GAM(I,J,K)=0.                                                          AL       656
      3000 CONTINUE                                                               AL       657
           DO 3014 I=2,L                                                          AL       658
           DO 3014 J=2,M                                                          AL       659
           GAM(I,J,1)=.5*(GAM(I,J,2)+GAM(I,J,N))                                  AL       660
           GAM(I,J,NP1)=GAM(I,J,1)                                                AL       661
           IF (NV.EQ.3) GAM(I,J,NP1)=GAM(I,J,2)                                   AL       662
      3014 CONTINUE                                                               AL       663
           RETURN                                                                 AL       664
C **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **          AL       665
           ENTRY SOMAS                                                            AL       666
           DO 124 I=1,LP1                                                         AL       667
           DO 124 J=1,MP1                                                         AL       668
       124 DIVG(I,J)=0.                                                           AL       669
           GO TO (266,267,268,269), NGOTO                                         AL       670
C ----------  U-VELOCITY                                                          AL       671
       266 CONTINUE                                                               AL       672
       270 IF (NFMZ.LE.0) GO TO 271                                               AL       673
           DO 273 J=2,M                                                           AL       674
           KJK=(K-2)*(MI-2)*(MJ-2)+(J-2)*(MI-2)                                   AL       675
           IS=IWLI(J,NGOTO)                                                       AL       676
           IE=IWLO(J,NGOTO)                                                       AL       677
           DO 273 I=IS,IE                                                         AL       678
           LPC=KJK+(I-1)                                                          AL       679
           LMPC=LPC-1                                                             AL       680
           DIVG(I,J)=DIVG(I,J)-FXM(I-1)*EVAP(LMPC)-FXP(I)*EVAP(LPC)               AL       681
           IF (I.EQ.3) DIVG(I,J)=DIVG(I,J)-FXP(2)*EVAP(LMPC)                      AL       682
           IF (I.EQ.L) DIVG(I,J)=DIVG(I,J)-FXM(L)*EVAP(LPC)                       AL       683
       273 CONTINUE                                                               AL       684
       271 CONTINUE                                                               AL       685
           RETURN                                                                 AL       686
C ----------  V-VELOCITY                                                          AL       687
       267 CONTINUE                                                               AL       688
       276 IF (NFMZ.LE.0) GO TO 274                                               AL       689
           DO 277 J=3,M                                                           AL       690
           KJK=(K-2)*(MI-2)*(MJ-2)+(J-2)*(MI-2)                                   AL       691
           IS=IWLI(J,NGOTO)                                                       AL       692
           IE=IWLO(J,NGOTO)                                                       AL       693
           DO 277 I=IS,IE                                                         AL       694
           LPC=KJK+(I-1)                                                          AL       695
           LYMC=LPC-(MI-2)                                                        AL       696
           DIVG(I,J)=DIVG(I,J)-FYM(J-1)*EVAP(LYMC)-FYP(J)*EVAP(LPC)               AL       697
           IF (J.EQ.3) DIVG(I,J)=DIVG(I,J)-FYP(2)*EVAP(LYMC)                      AL       698
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      IF (J.EQ.M) DIVG(I,J)=DIVG(I,J)-FYM(M)*EVAP(LPC)                  AL       699
  277 CONTINUE                                                          AL       700
  276 CONTINUE                                                          AL       701
      RETURN                                                            AL       702
C ---------- W-VELOCITY                                                 AL       703
  268 CONTINUE                                                          AL       704
  279 IF (NFMZ.LE.0) GO TO 281                                          AL       705
      DO 282 J=2,M                                                      AL       706
      KJK=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                              AL       707
      IS=INLI(J,NGOTO)                                                  AL       708
      IE=INLO(J,NGOTO)                                                  AL       709
      DO 282 I=IS,IE                                                    AL       710
      LPC=KJK+(I-1)                                                     AL       711
      LZMC=LPC-(NI-2)*(NJ-2)                                            AL       712
      LIJ=(J-2)*(NI-2)+(I-1)                                            AL       713
      DIVG(I,J)=DIVG(I,J)-FZM(K-1)*EVAP(LZMC)                           AL       714
      IF (K.LT.NP1) DIVG(I,J)=DIVG(I,J)-FZP(K)*EVAP(LPC)                AL       715
      IF (K.EQ.NP1) DIVG(I,J)=DIVG(I,J)-FZP(2)*EVAP(LIJ)                AL       716
  282 CONTINUE                                                          AL       717
  281 CONTINUE                                                          AL       718
      RETURN                                                            AL       719
C -------- OTHER VARIABLES                                              AL       720
  269 CONTINUE                                                          AL       721
  283 IF (NFMZ.LE.0) GO TO 285                                          AL       722
      DO 286 J=2,M                                                      AL       723
      KJK=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                              AL       724
      IS=INLI(J,NGOTO)                                                  AL       725
      IE=INLO(J,NGOTO)                                                  AL       726
      DO 286 I=IS,IE                                                    AL       727
      LPC=KJK+(I-1)                                                     AL       728
      DIVG(I,J)=DIVG(I,J)-EVAP(LPC)                                     AL       729
  286 CONTINUE                                                          AL       730
  285 CONTINUE                                                          AL       731
      RETURN                                                            AL       732
C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  *AL       733
      ENTRY SOMOD                                                       AL       734
COME HERE FOR SLOT COEFFICIENT MODS.                                    AL       735
   54 IF (NUINJ.LE.0) GO TO 52                                          AL       736
      DO 49 II=1,NUINJ                                                  AL       737
      I=IUINJ(II)                                                       AL       738
      J=JUINJ(II)                                                       AL       739
      IF (J.EQ.JNLI(I,4)+1) GO TO 149                                   AL       740
      M1=J-1                                                            AL       741
      IF (NV.EQ.1) AVP(I,M1)=.5*AVP(I,M1)                               AL       742
      IF (NV.EQ.1) AVP(I-1,M1)=.5*AVP(I-1,M1)                           AL       743
      IF (NV.GT.2) AVP(I-1,M1)=0.                                       AL       744
      IF (NV.NE.1) AIP(I-2,J)=0.                                        AL       745
      IF (NV.EQ.LVPR) AXM(I,J)=0.                                       AL       746
      GO TO 49                                                          AL       747
  149 M1=J+1                                                            AL       748
      IF (NV.EQ.1) AVM(I,M1)=.5*AVM(I,M1)                               AL       749
      IF (NV.EQ.1) AVM(I-1,M1)=.5*AVP(I-1,M1)                           AL       750
      IF (NV.GT.2) AVM(I-1,M1)=0.                                       AL       751
      IF (NV.NE.1) AIP(I-2,J)=0.                                        AL       752
      IF (NV.EQ.LVPR) AXM(I,J)=0.                                       AL       753
   49 CONTINUE                                                          AL       754
   52 CONTINUE                                                          AL       755
C *-*-*-*-*-*-*-*-*-*-*-   PRESSURE PERTABATION   *-*-*-*-*-*-*-*-*-*-*- AL       756
      IF(NV.NE.4) GO TO 200                                             AL       757
      IF (NUINJ.LE.0) GO TO 99                                          AL       758
      DO 98 II=1,NUINJ                                                  AL       759
      I=IUINJ(II)-1                                                     AL       760
      J=JUINJ(II)                                                       AL       761
      SU(I,J)=0.                                                        AL       762
   98 SP(I,J)=-1.E30                                                    AL       763
   99 CONTINUE                                                          AL       764
COME HERE FOR DROPLET EVAPORATION TERMS                                 AL       765
      IF (NFMZ.LE.0) GO TO 344                                          AL       766
      DO 344 J=2,M                                                      AL       767
      KJK=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                              AL       768
      IS=INLI(J,NGOTO)                                                  AL       769
      IE=INLO(J,NGOTO)                                                  AL       770
      DO 346 I=IS,IE                                                    AL       771
      LPC=KJK+(I-1)                                                     AL       772
  346 SU(I,J)=SU(I,J)+EVAP(LPC)                                         AL       773
  344 CONTINUE                                                          AL       774
      IF(K.NE.2) GO TO 101                                              AL       775
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```
      SMAX=0.
      SSUM=0.
  101 CONTINUE
      DO 100 J=2,M
      IS=IWLI(J,NGOTO)
      IE=IWLO(J,NGOTO)
      DO 100 I=IS,IE
      ASU=ABS(SU(I,J))
      SSUM=SSUM+ASU
      IF (ASU.LT.SMAX) GO TO 100
      IMAX=I
      JMAX=J
      KMAX=K
      SMAX=ASU
  100 CONTINUE
      IF(K.NE.N) GO TO 102
      SMAX=SMAX/FLOWIN
      SSUM=SSUM/FLOWIN
  102 CONTINUE
  200 CONTINUE
C ------------------   TURBULENCE DISSIPATION   ------------------
      IF (NV.NE.LVD) GO TO 300
COME HERE FOR CYLINDRICAL WALL SOURCE TERMS
      DO 201 I=2,L
      J=JWLO(I,NGOTO)-1
      IF (IKIN(I,K).EQ.2.OR.IKIN(I,K).EQ.3) GO TO 1201
      DIST=.5*YDIF(J+1)
      IF (J.EQ.M) DIST=YDIF(MP1)
      LP=KM(K)+JM(J)+I
      RTCDK=RTCDF(LP,NVK)
      SU(I,J)=1.E30*RTCDK*SQRT(RTCDK)/(AK*DIST)
      SP(I,J)=-1.E30
 1201 IF (IDK) 201,201,1202
 1202 J=JWLI(I,NGOTO)+1
      IF (IKIN(I,K).EQ.1.OR.IKIN(I,K).EQ.3) GO TO 201
      DIST=.5*YDIF(J)
      IF (J.EQ.2) DIST=YDIF(2)
      LP=KM(K)+JM(J)+I
      RTCDK=RTCDF(LP,NVK)
      SU(I,J)=1.E30*RTCDK*SQRT(RTCDK)/(AK*DIST)
      SP(I,J)=-1.E30
 201  CONTINUE
COME HERE FOR SLOT MODIFICATIONS
      IF (NUINJ.LE.0) GO TO 710
      DO 709 II=1,NUINJ
      I=IUINJ(II)-1
      J=JUINJ(II)
      M1=J-1
      IF (J.EQ.JWLI(I,NGOTO)+1) M1=J+1
      M2=AMAX0(M1,J)
      LP=KM(K)+JM(M2)+I
      RTCDK=RTCDF(LP,NVK)
      SKE=AKFAC*(UINJ(II)**2+VINJ(II)**2)
      SLM=ALFAC*YS(J)
      SU(I,J)=1.E30*CD*SKE**1.5/(SLM+1.E-30)
      SP(I,J)=-1.E30
      SU(I,M1)=1.E30*RTCDK*SQRT(RTCDK)/(AK*.5*YDIF(M2))
      SP(I,M1)=-1.E30
  709 CONTINUE
  710 CONTINUE
COME HERE FOR INLET WALL SOURCE TERMS
      DO 202 J=2,MM1
      I=IWLI(J,NGOTO)
      IF (JKIN(J,K).EQ.1) GO TO 2202
      LP=I+JM(J)+KM(K)
      RTCDK=RTCDF(LP,NVK)
      DIST=.5*XDIF(I)
      IF (I.EQ.2) DIST=XDIF(2)
      SU(I,J)=1.E30*RTCDK*SQRT(RTCDK)/(AK*DIST)
      SP(I,J)=-1.E30
 2202 I=IWLO(J,NGOTO)
      IF (J.GT.JWCI.AND.J.LT.JWCO) GO TO 202
      LP=I+JM(J)+KM(K)
      RTCDK=RTCDF(LP,NVK)
      DIST=.5*XDIF(I+1)
      IF (I.EQ.L) DIST=XDIF(LP1)
      SU(I,J)=1.E30*RTCDK*SQRT(RTCDK)/(AK*DIST)
```

```
      SP(I,J)=-1.E35
  202 CONTINUE
C  ------------------------ VELOCITY ----------------------------
  300 IF (NU.NE.1) GO TO [illegible]
C****-ONE FOR SLOT MODIFICATIONS
      IF (NJIN.LE.0) GO TO 720
      DO 719 II=1,NJIN
      I=IJIN(1,II)
      J=IJIN(2,II)
      SU(I,J)=1.E30*UIN(II)
      SP(I,J)=-1.E35
  719 SP(I-1,J)=-1.E35
  720 CONTINUE
C****-ONE FOR DROPLET EVAPORATION TERMS
      IF (NPHI.LE.0) GO TO 321
      IF (N.EQ.2) REWIND NTP4
      READ (NTP4) EVD
      DO 322 J=2,M
      [illegible]=(M-2)*(N-2)+(J-2)*(M-2)
      [illegible]
      [illegible]
      DO 322 I=2,[illegible]
      [illegible]
      L=[illegible]
      LI=(J-2)*(M-2)+(I-1)
      SU(I,J)=SU(I,J)+FSU(LI)
      SP(I,J)=SP(I,J)-FRP(1-1)*EVAP(LMC)-FRP(1)*EVAP(LPC)
      IF [illegible] SP(I,J)=SP(I,J)-FRP(2)*EVAP(LMC)
      IF [illegible] SP(I,J)=SP(I,J)-FRP(1)*EVAP(LPC)
  322 CONTINUE
  321 CONTINUE
C  ------------------------ V-VELOCITY ------------------------
  400 IF(NV.NE.1) GO TO 500
C****-ONE FOR SLOT MODIFICATIONS
      IF [illegible] GO TO 502
      DO 712 [illegible]
      [illegible]
      [illegible]
      [illegible]
      IF [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
  714 SP(I,J)=-1.E35
  502 CONTINUE
C****-ONE FOR DROPLET EVAPORATION TERMS
      IF (NPHI.LE.0) GO TO 325
      READ (NTP4) EVD
      DO 326 J=2,M
      [illegible]=(M-2)*(N-2)+(J-2)*(M-2)
      [illegible]
      [illegible]
      DO 326 I=2,[illegible]
      [illegible]
      LZ=[illegible]
      [illegible]
      [illegible]
      SP(I,J)=SP(I,J)-FZP(1)*EVAP(LZMC)
      IF [illegible] GO TO 347
      SP(I,J)=SP(I,J)-FZP(1)*EVAP(LPC)
      GO TO 326
  347 SP(I,J)=SP(I,J)-FZP(2)*EVAP(LIA)
  326 CONTINUE
  325 CONTINUE
C  ---------------- TURBULENT KINETIC ENERGY ------------------
  500 IF (NK.NE.1) GO TO 600
C****-ONE FOR SLOT MODIFICATIONS
      IF [illegible] GO TO 652
      DO 751 [illegible]
      I=[illegible]
      J=[illegible]
      [illegible]
```

```
            IF (J.EQ.JWLI(I,NGOTO)+1) M1=J+1                                      AL     930
            WALKE=CFPO.25*((U(I,M1,K)+U(I+1,M1,K))**2+(W(I,M1,K)+W(I,M1,K+1))     AL     931
          1  **2)/RTCO                                                            AL     932
            WALKE=AMAX1(WALKE,1.)                                                 AL     933
            SKE=AKFAC*(UINJ(II)**2+WINJ(II)**2)                                   AL     934
            SU(I,J)=1.E30*SKE                                                     AL     935
            SP(I,J)=-1.E30                                                        AL     936
            SU(I,M1)=1.E30*WALKE                                                  AL     937
        731 SP(I,M1)=-1.E30                                                       AL     938
        682 CONTINUE                                                              AL     939
      C ---------------------------  W-VELOCITY   ----------------------------    AL     940
      600   IF(NF.NE.2) GO TO 700                                                 AL     941
      COME HERE FOR SLOT MODIFICATIONS                                            AL     942
            IF (NUINJ.LE.0) GO TO 733                                             AL     943
            DO 730 II=1,NUINJ                                                     AL     944
            I=IUINJ(II)-1                                                         AL     945
            J=JUINJ(II)                                                           AL     946
            SP(I,J+1)=-1.E30                                                      AL     947
        730 SP(I,J)=-1.E30                                                        AL     948
        733 CONTINUE                                                              AL     949
      COME HERE FOR DROPLET EVAPORATION TERMS                                     AL     950
            IF (NFGZ.LE.2) GO TO 323                                              AL     951
            READ (NTP4) EVSU                                                      AL     952
            DO 324 J=3,M                                                          AL     953
            CMK=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                                  AL     954
            IS=IWLI(J,NGOTO)                                                      AL     955
            IE=IWLO(J,NGOTO)                                                      AL     956
            DO 324 I=IS,IE                                                        AL     957
            LPC=CMK+(I-1)                                                         AL     958
            LYMC=LPC-(NI-2)                                                       AL     959
            LIJ=(J-2)*(NI-2)+(I-1)                                                AL     960
            SU(I,J)=SU(I,J)+EVSU(LIJ)                                             AL     961
            SP(I,J)=SP(I,J)-FTP(J-1)*EVAP(LYMC)-FTP(J)*EVAP(LPC)                  AL     962
            IF (J.EQ.3) SP(I,J)=SP(I,J)-FTP(2)*EVAP(LYMC)                         AL     963
            IF (J.EQ.M) SP(I,J)=SP(I,J)-FTP(M)*EVAP(LPC)                          AL     964
        324 CONTINUE                                                              AL     965
        323 CONTINUE                                                              AL     966
      C ---------------------------   ENTHALPY   ----------------------------     AL     967
        700 IF (NF.NE.LWH) GO TO 800                                              AL     968
      COME HERE FOR CYLINDRICAL WALL SOURCE TERMS                                 AL     969
            DO 891 I=2,L                                                          AL     970
            J=JWLO(I,NGOTO)-1                                                     AL     971
            IF (IWIN(I,K).EQ.2.OR.IKIN(I,K).EQ.3) GO TO 1001                      AL     972
            WTC=.5*SQRT((U(I,J,K)+U(I+1,J,K))**2+(W(I,J,K)+W(I,J,K+1))**2)        AL     973
          1  *RHO(I,J,K)*CFB                                                      AL     974
            SU(I,J)=SU(I,J)+WTC*RM(J+1)*ZS(K)*XS(I)*CP*(TCYL-TEMP(I,J,K))         AL     975
            IF (IJW) 891,891,1001                                                 AL     976
       1001 J=JWLI(I,NGOTO)+1                                                     AL     977
            IF (IWIN(I,K).EQ.1.OR.IKIN(I,K).EQ.3) GO TO 891                       AL     978
            WTC=.5*SQRT((U(I,J,K)+U(I+1,J,K))**2+(W(I,J,K)+W(I,J,K+1))**2)        AL     979
          1  *RHO(I,J,K)*CFB                                                      AL     980
            SU(I,J)=SU(I,J)+WTC*RM(J)*ZS(K)*XS(I)*CP*(TCYL-TEMP(I,J,K))           AL     981
      891   CONTINUE                                                              AL     982
      COME HERE FOR SLOT MODIFICATIONS                                            AL     983
            IF (NUINJ.LE.0) GO TO 852                                             AL     984
            DO 736 II=1,NUINJ                                                     AL     985
            I=IUINJ(II)-1                                                         AL     986
            J=JUINJ(II)                                                           AL     987
            M1=J-1                                                                AL     988
            IF (J.EQ.JWLI(I,NGOTO)+1) M1=J+1                                      AL     989
            M2=AMAX0(J,M1)                                                        AL     990
            WTC=.5*(W(I-1,J,K)+W(I-1,J,K+1))*RHO(I-1,J,K)*CFB                     AL     991
            WTC=AMAX1(ABS(WTC),1.E-25)                                            AL     992
            SU(I-1,J)=SU(I-1,J)+WTC*RM(J)*ZS(K)*CP*(TLIP-TEMP(I-1,J,K))           AL     993
            WTC=.5*SQRT((U(I,M1,K)+U(I+1,M1,K))**2+(W(I,M1,K)+W(I,M1,K+1))        AL     994
          1  **2)*RHO(I,M1,K)*CFB                                                 AL     995
            SU(I,M1)=SU(I,M1)+WTC*RM(M2)*ZS(K)*XS(I)*CP*(TLIP-TEMP(I,M1,K))       AL     996
            HPI=SAT(2)*[illegible]*(1.-SAT(2))*[illegible]                        AL     997
            SU(I,J)=1.E30*HPI                                                     AL     998
        736 SP(I,J)=-1.E30                                                        AL     999
        852 CONTINUE                                                              AL    1000
      COME HERE FOR INLET WALL SOURCE TERMS                                       AL    1001
            DO 803 J=2,M                                                          AL    1002
            I=IWLI(J,NGOTO)                                                       AL    1003
            IF (JKI(J,K).EQ.1) GO TO 1803                                         AL    1004
            WTC=.5*(W(I,J,K)+W(I,J,K+1))*RHO(I,J,K)*CFB                           AL    1005
            WTC=ABS(WTC)                                                          AL    1006
```

```
      AREA=YSR(J)*ZS(K)                                                 AL     1007
      SU(I,J)=SU(I,J)+HTC*AREA*CP*(TINLW-TEMP(I,J,K))                   AL     1008
 1003 I=IWLO(J,NGOTO)                                                   AL     1009
      IF (J.GT.JADI.AND.J.LT.JWOD) GO TO 903                            AL     1010
      LP=I+JM(J)+KM(K)                                                  AL     1011
      HTC=.5*(W(I,J,K)+W(I,J,K+1))*P*D(I,J,K)*CFP                      AL     1012
      HTC=ABS(HTC)                                                      AL     1013
      AREA=YSR(J)*ZS(K)                                                 AL     1014
      SU(I,J)=SU(I,J)+HTC*AREA*CP*(TINLW-TEMP(I,J,K))                   AL     1015
  903 CONTINUE                                                          AL     1016
COME HERE FOR DROPLET EVAPORATION TERMS                                 AL     1017
      IF (NFMZ.LE.0) GO TO 315                                          AL     1018
      DO 316 J=2,M                                                      AL     1019
      KJK=(K-2)*(MI-2)*(MJ-2)+(J-2)*(MI-2)                              AL     1020
      IS=IWLI(J,NGOTO)                                                  AL     1021
      IE=IWLO(J,NGOTO)                                                  AL     1022
      DO 316 I=IS,IE                                                    AL     1023
      LPC=KJK+(I-1)                                                     AL     1024
      SU(I,J)=SU(I,J)+EVAP(LPC)*HDR(TFUEL,1)                            AL     1025
  316 SP(I,J)=SP(I,J)-EVAP(LPC)                                         AL     1026
  315 CONTINUE                                                          AL     1027
C     *-*-*-*-*-*-*-*-*-*-*-*  PHI (TOTAL FUEL)  *-*-*-*-*-*-*-*-*-*-*-*-*-*  AL     1028
  900 IF (NV.NE.LVFUOX) GO TO 950                                       AL     1029
COME HERE FOR SLOT MODIFICATIONS                                        AL     1030
      IF (NUINJ.LE.0) GO TO 851                                         AL     1031
      DO 737 II=1,NUINJ                                                 AL     1032
      I=IUINJ(II)-1                                                     AL     1033
      J=JUINJ(II)                                                       AL     1034
      SU(I,J)=0.                                                        AL     1035
  737 SP(I,J)=-1.E30                                                    AL     1036
  851 CONTINUE                                                          AL     1037
COME HERE FOR DROPLET EVAPORATION TERMS                                 AL     1038
      IF (NFMZ.LE.0) GO TO 317                                          AL     1039
      DO 318 J=2,M                                                      AL     1040
      KJK=(K-2)*(MI-2)*(MJ-2)+(J-2)*(MI-2)                              AL     1041
      IS=IWLI(J,NGOTO)                                                  AL     1042
      IE=IWLO(J,NGOTO)                                                  AL     1043
      DO 318 I=IS,IE                                                    AL     1044
      LPC=KJK+(I-1)                                                     AL     1045
      SU(I,J)=SU(I,J)+EVAP(LPC)                                         AL     1046
  318 SP(I,J)=SP(I,J)-EVAP(LPC)                                         AL     1047
  317 CONTINUE                                                          AL     1048
C     *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*      FUEL     *-*-*-*-*-*-*-*-*-*-*-*-*-*-*  AL     1049
  950 IF (NV.NE.LVFU) GO TO 961                                         AL     1050
COME HERE FOR SLOT MODIFICATIONS                                        AL     1051
      IF (NUINJ.LE.0) GO TO 899                                         AL     1052
      DO 742 II=1,NUINJ                                                 AL     1053
      I=IUINJ(II)-1                                                     AL     1054
      J=JUINJ(II)                                                       AL     1055
  742 SP(I,J)=-1.E30                                                    AL     1056
  899 CONTINUE                                                          AL     1057
COME HERE FOR DROPLET EVAPORATION TERMS                                 AL     1058
      IF (NFMZ.LE.0) GO TO 319                                          AL     1059
      DO 320 J=2,M                                                      AL     1060
      KJK=(K-2)*(MI-2)*(MJ-2)+(J-2)*(MI-2)                              AL     1061
      IS=IWLI(J,NGOTO)                                                  AL     1062
      IE=IWLO(J,NGOTO)                                                  AL     1063
      DO 320 I=IS,IE                                                    AL     1064
      LPC=KJK+(I-1)                                                     AL     1065
      SU(I,J)=SU(I,J)+EVAP(LPC)                                         AL     1066
  320 SP(I,J)=SP(I,J)-EVAP(LPC)                                         AL     1067
  319 CONTINUE                                                          AL     1068
C     *-*-*-*-*-*-*-*-*-*-*-*-*-*-*          CO           *-*-*-*-*-*-*-*-*-*-*-*-*  AL     1069
  961 IF(NV.NE.LVCO) GO TO 950                                          AL     1070
COME HERE FOR SLOT MODIFICATION                                         AL     1071
      IF(NUINJ.LE.0) GO TO 959                                          AL     1072
      DO 952 II=1,NUINJ                                                 AL     1073
      I=IUINJ(II)-1                                                     AL     1074
      J=JUINJ(II)                                                       AL     1075
      SU(I,J)=0.                                                        AL     1076
  952 SP(I,J)=-1.E30                                                    AL     1077
  959 CONTINUE                                                          AL     1078
COME HERE FOR DROPLET EVAPORATION TERMS                                 AL     1079
  951 IF (NFMZ.LE.0) GO TO 950                                          AL     1080
      DO 957 J=2,M                                                      AL     1081
      KJK=(K-2)*(MI-2)*(MJ-2)+(J-2)*(MI-2)                              AL     1082
      IS=IWLI(J,NGOTO)                                                  AL     1083
```

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      IE=IWLO(J,NGOTO)
      DO 957 I=IS,IE
      LPC=KJK+(I-1)
  957 SP(I,J)=SP(I,J)-EVAP(LPC)
  958 CONTINUE
C ++-+-+-+-+-+-+-+-+    X-DIRECTION RADIATION    +-+-+-+-+-+-+-+-+-+-+-
  900 IF (NV.NE.LVRX) GO TO 910
      DO 901 J=2,M
      I=IWLI(J,NGOTO)
      IF (IKIN(J,K).EQ.1) GO TO 902
      TEMPW=TEMP(I-1,J,K)
      SU(I,J)=SU(I,J)+EMI*SIGMA*TEMPW**4
      SP(I,J)=SP(I,J)-EMI
      GO TO 1901
902   CONTINUE
      SU(I,J)=SU(I,J)+RADIN
      SP(I,J)=SP(I,J)-1.
 1901 I=IWLO(J,NGOTO)
      IF (J.GT.JWOI.AND.J.LT.JWOO) GO TO 1902
      TEMPW=TEMP(I+1,J,K)
      SU(I,J)=SU(I,J)+EMI*SIGMA*TEMPW**4
      SP(I,J)=SP(I,J)-EMI
      GO TO 901
 1902 CONTINUE
      SU(L,J)=SU(L,J)+RADSUR
      SP(L,J)=SP(L,J)-1.
901   CONTINUE
COME HERE FOR SLOT MODIFICATIONS
      IF (NUINJ.LE.0) GO TO 903
      DO 743 II=1,NUINJ
      I=IUINJ(II)-1
      J=JUINJ(II)
      SU(I+1,J)=SU(I+1,J)+EMISR*SIGMA*TEMP(I,J,K)**4
      SP(I+1,J)=SP(I+1,J)-1
      TEMPW=TLIP
      SU(I-1,J)=SU(I-1,J)+EMI*SIGMA*TEMPW**4
  743 SP(I-1,J)=SP(I-1,J)-EMI
903   CONTINUE
C ++-+-+-+-+-+-+-+-+    Y-DIRECTION RADIATION    +-+-+-+-+-+-+-+-+-+-+-
  910 IF (NV.NE.LVRY) GO TO 920
      DO 911 I=2,L
      J=JWLO(I,NGOTO)-1
      IF (IKIN(I,K).EQ.2.OR.IKIN(I,K).EQ.3) GO TO 904
      TEMPW=TEMP(I,J+1,K)
      SU(I,J)=SU(I,J)+EMI*SIGMA*TEMPW**4*RM(J+1)
      SP(I,J)=SP(I,J)-EMI*RM(J+1)
      GO TO 905
  904 SU(I,J)=SU(I,J)+RADIN
      SP(I,J)=SP(I,J)-1.
  905 IF (IOW) 911,911,1911
 1911 J=JWLI(I,NGOTO)+1
      IF (IKIN(I,K).EQ.1.OR.IKIN(I,K).EQ.3) GO TO 906
      TEMPW=TEMP(I,J-1,K)
      SU(I,J)=SU(I,J)+EMI*SIGMA*TEMPW**4*RM(J)
      SP(I,J)=SP(I,J)-EMI*RM(J)
      GO TO 911
  906 SU(I,J)=SU(I,J)+RADIN
      SP(I,J)=SP(I,J)-1.
911   CONTINUE
      IF (NUINJ.LE.0) GO TO 912
      DO 744 II=1,NUINJ
      I=IUINJ(II)-1
      J=JUINJ(II)
      M1=J-1
      IF (J.EQ.JWLI(I,NGOTO)+1) M1=J+1
      M2=MAX0(J,M1)
      TEMPW=TLIP
      SU(I,M1)=SU(I,M1)+EMI*SIGMA*TEMPW**4*RM(M2)
  744 SP(I,M1)=SP(I,M1)-EMI*RM(M2)
912   CONTINUE
  920 CONTINUE
      RETURN
C **   **   **   **   **   **   **   **   **   **   **   **   **   **   **   **   **
C -+-+-+-+-+-+-+-+-+-+-+   Z-DIRECTION RADIATION   -+-+-+-+-+-+-+-+-+-+-+
      ENTRY SORDOZ
      IF (NUINJ.LE.0) GO TO 1106
      DO 1102 II=1,NUINJ
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                            IF (JUIMJ(II).NE.JPLANE) GO TO 1102                                  AL        1161
  695                       I=IUIMJ(II)-1                                                        AL        1162
                            DO 1104 K=2,N                                                        AL        1163
                            SU(I,K)=0.                                                           AL        1164
                       1104 SP(I,K)=-1.E30                                                       AL        1165
                       1102 CONTINUE                                                             AL        1166
  700                  1100 CONTINUE                                                             AL        1167
                            IS=IWLT(JPLANE,4)                                                    MM           1
                            IE=IWLO(JPLANE,4)                                                    MM           2
                            DO 921 I=IS,IE                                                       MM           3
                            LPZ=I+J9(JPLANE)+KM(2)                                               AL        1168
  705                       LPN=I+J9(JPLANE)+KM(N)                                               AL        1170
                            GAMODL=.5*(GAM(I,JPLANE,2)+GAM(I,JPLANE,N))/R(JPLANE)/(ZD)F(NP1)+    AL        1171
                           1         ZDIF(2))                                                    AL        1172
                            SU(I,2)=SU(I,2)+GAMODL*F(LPN,NVRZ)                                   AL        1173
                            SP(I,2)=SP(I,2)-GAMODL                                               AL        1174
  710                       SU(I,N)=SU(I,N)+GAMODL*F(LPZ,NVRZ)                                   AL        1175
                            SP(I,N)=SP(I,N)-GAMODL                                               AL        1176
                        921 CONTINUE                                                             AL        1177
                            RETURN                                                               AL        1178
                            END                                                                  AL        1179

 CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

       59      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
       72      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
       89      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
      103      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
      131      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
      146      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
      696      I                  CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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SUBROUTINE OUTPUT      73/74    OPT=0 TRACE                    FTN 4.6+439          09/24/79  14.09.46        PAGE     1

                 SUBROUTINE OUTPUT(NTP)                                                      DU            2
                 COMMON F(500,7),DU(10,10,5),DV(10,10,5),DW(10,10,5),                        COMFA         2
                1  RHO(10,10,5),VISC(10,10,5),SU(10,10),SP(10,10),DRHODP(10,10,5),           COMFA         3
                1  AXP(10,10),AXM(10,10),AYP(10,10),AYM(10,10),AZP(10,10),                   COMFA         4
                2  AZM(10,10),CZ(10,10),CY(10),CZU(10,10),CYU(10),                           COMFA         5
                3  CZP(10,10),CYP(10),DIVG(10,10),NTP1,NTP2                                  COMFA         6
                 DIMENSION U(10,10,5),V(10,10,5),W(10,10,5),PP(10,10,5)                      COMFA         7
                 DIMENSION P(10,10,5),TEMP(10,10,5),GAM(10,10,5)                             COMFA         8
                 EQUIVALENCE (F(1,1),U(1,1,1)),(F(1,2),V(1,1,1)),(F(1,3),W(1,1,1))           COMFA         9
                 EQUIVALENCE (F(1,4),PP(1,1,1)),(F(1,5),P(1,1,1))                            COMFA        10
                 EQUIVALENCE (F(1,6),TEMP(1,1,1)),(F(1,7),GAM(1,1,1))                        COMFA        11
                 COMMON/CYL/R(30),RM(30),RMV(30),YSP(30),YSVP(30),IPLAR                      COMMON        2
                 COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),                 COMMON        3
                1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),               COMMON        4
                2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                                   COMMON        5
                 COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NIMJ,NIMJNK,NV,          COMMON        6
                1  NNV,NGOTO,K,ISTP,JSTP,KSTP,NVP(20),KM(30),JM(30),ISTEP,                   COMMON        7
                2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,            COMMON        8
                3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWFI,               COMMON        9
                4  IWEO,NMI,JWII,JWIO,JWOI,JWOO,IOW,JWIW(30,30),IWIW(40,30)                  COMMON       10
                 COMMON/INDEX/IPAR,LPREF,ISTUM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE            COMMON       11
                1  ,PLAXM1,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),              COMMON       12
                2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCC,NWH2O,NVCO2,              COMMON       13
                3  NWN2                                                                      COMMON       14
                 COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEM,IOX,FSTOIC,HFU,CP,             COMMON       15
                1  GASCON,RHOCON,UNICON,PRESS,NVFAV,TCYLW,TINLW,TLIP,ACOEF(4),               COMMON       16
                2  T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HYY,CXX,RATIO1,RATIO2,                  COMMON       17
                3  RATIO3,RATIO4,HCO,TAM,ITWALL                                              COMMON       18
                 COMMON/CTDMA/KEND,ICTDMA(13)                                                COMMON       19
                 COMMON/MIS/ARU,DEM,SMAX,SSUM,LASTEP,HTCEXT,CFR,EMISW,EMISIN,                COMGEN        2
                1  EMISP,TOUT,RTCO,EMI,RADIN,RADSUM,FMA,FK,SGFK,                             COMGEN        3
                2  FKFU,FDFU,TFUEL,WFMZ,FLO(40),TEMTM(40),H(40),FUEL(40),FUOX(40) ,          COMGEN        4
                3  UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)                       COMGEN        5
                 COMMON/TURB/RVK,RVD,C1,C2,CD,AK,DUIDXJ(3,3),AKFAC,ALFAC,                    COMGEN        6
                1  MODEL,PR(13),PREF(13),PJAY(13),E                                          COMGEN        7
                 COMMON/RAD/NVE,SIGMA,ABSOR,SCATF                                            COMGEN        8
                 COMMON/REACT/ARCON1,PREXP1,CO1,ARCON2,PREXP2,CO2,MODER                      COMGEN        9
                 COMMON/DROPL/EVAP(192),NIP4,NFMZ,XD(3),YD(3),ZD(3),ALFA(3),                 COMGEN       10
                1  BETA(3),DELTA(3),THETA1(3),THETA2(3),NSL(3),WFF(3),SMD(3),                COMGEN       11
                2  VFUEL(3),RFUEL(3),EVSUM(64),NEVAP                                         COMGEN       12
                 COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WUINJ(20),                 COMGEN       13
                1  AUINJ(20),TUINJ(20),IVINJ(20),JVINJ(20),KVINJ(20),VINJ(20),               COMGEN       14
                2  EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),NUINJ,NVINJ,JSW1,JSW2,            COMGEN       15
                3  USW,VSW,AFSW,FSW,TSW,WSW,SWMD,RMCSW                                       COMGEN       16
                 IF (NTP.LE.0) GO TO 16                                                      DU            6
                 IF (ISTEP.EQ.LASTEP) GO TO 11                                               DU            7
                 IF (MOD(ISTEP,IJUMP)) 20,11,20                                              DU            8
              11 CONTINUE                                                                    DU            9
                 REWIND NTP                                                                  DU           10
                 READ (NTP) U,V,W,P                                                          DU           11
                 CALL FPRINT (1,3,1)                                                         DU           12
                 CALL FPRINT (5,5,4)                                                         DU           13
           C ---- HERE PP IS ACTUALLY KE,  P IS ACTUALLY DISSIPATION                         DU           14
                 READ (NTP) PP,P                                                             DU           15
                 DO 25 K=1,NP1                                                               DU           16
                 DO 25 J=1,MP1                                                               DU           17
                 KJM=KM(K)+JM(J)                                                             DU           18
                 DO 25 I=1,LP1                                                               DU           19
                 LP=KJM+I                                                                    DU           20
              25 F(LP,NVD)=CD*F(LP,NVK)**1.5/(F(LP,NVD)+1.0E-30)                             DU           21
                 CALL FPRINT (NVK,NVD,5)                                                     DU           22
           C ------- HERE PP IS PHI, P IS MFU, DU IS MCO                                     DU           23
                 READ (NTP) PP,P,DU                                                          DU           24
                 CALL FPRINT (NVFUOX,NVTE,7)                                                 DU           25
                 CALL FPRINT (NVCO,NVCO,15)                                                  DU           26
                 DO 50 K=1,NP1                                                               DU           27
                 DO 50 J=1,MP1                                                               DU           28
                 KJM=KM(K)+JM(J)                                                             DU           29
                 DO 50 I=1,LP1                                                               DU           30
                 LP=KJM+I                                                                    DU           31
                 FU3=F(LP,NVFUOX)-F(LP,NVFU)                                                 DU           32
                 F(LP,NVCO2)=WCO2*CXX*FU3/WFU-WCO2*F(LP,NVCO)/WCO                            DU           33
                 F(LP,NVOX)=RATIO1*F(LP,NVFU)+RATIO3*F(LP,NVCO)+RATIO2-                      DU           34
                1  (RATIO2+RATIO1)*F(LP,NVFUOX)                                              DU           35
                 F(LP,NVOX)=AMAX1(0.,F(LP,NVOX))                                             DU           36
                 F(LP,NWH2O)=HYY*WH2O*FU3/WFU/2.                                             DU           37
                 F(LP,NWN2)=1.-F(LP,NVFU)-F(LP,NVCO2)-F(LP,NVCO)-F(LP,NVOX)-                 DU           38
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                    1  F(LP,NVH2O)                                                         OU         39
                 50 CONTINUE                                                               OU         40
  80                CALL FPRINT (NVH2O,NVN2,16)                                            OU         41
                    IF (NFNZ.LE.0) GO TO 35                                                OU         42
                    DO 37 K=1,NP1                                                          OU         43
                    DO 37 J=1,MP1                                                          OU         44
                    KJM=KM(K)+JM(J)                                                        OU         45
  85                DO 37 I=1,LP1                                                          OU         46
                    LP=KJM+I                                                               OU         47
                 37 F(LP,NVFUOX)=0.                                                        OU         48
                    DO 39 K=2,N                                                            OU         49
                    DO 39 J=2,M                                                            OU         50
  90                KJM=KM(K)+JM(J)                                                        OU         51
                    KJK=(K-2)*(NI-2)*(MJ-2)+(J-2)*(NI-2)                                   OU         52
                    DO 39 I=2,L                                                            OU         53
                    LP=KJM+I                                                               OU         54
                    LPC=KJK+(I-1)                                                          OU         55
  95             39 F(LP,NVFUOX)=EVAP(LPC)                                                 OU         56
                    CALL FPRINT (NVFUOX,NVFUOX,22)                                         OU         57
                 35 CONTINUE                                                               OU         58
               C -------- HERE DV IS ENTHALPY, DW IS FAV                                   OU         59
                    READ (NTP) DV,DW                                                       OU         60
 100                CALL FPRINT (NVH,NVFAV,10)                                             OU         61
               C  ------- HERE U IS FX,  V IS FY,  W IS FZ                                 OU         62
                    READ (NTP) U,V,W                                                       OU         63
                    CALL FPRINT (NVRX,NVRZ,12)                                             OU         64
               C -------- RHO AND VISCOSITY                                                OU         65
 105                CALL FPRINT (11,11,20)                                                 OU         66
                    NV=4                                                                   OU         67
                    DO 56 K=1,NP1                                                          OU         68
                    DO 56 J=1,MP1                                                          OU         69
                    KJM=KM(K)+JM(J)                                                        OU         70
 110                DO 56 I=1,LP1                                                          OU         71
                    LP=KJM+I                                                               OU         72
                 56 F(LP,7)=0.                                                             OU         73
                    CALL GAMMA                                                             OU         74
                    CALL FPRINT (7,7,21)                                                   OU         75
 115                REWIND NTP1                                                            OU         76
                    DO 46 II=1,2                                                           OU         77
                 46 READ (NTP1)                                                            OU         78
               C -------- HERE PP IS PHI, P IS MFU, DU IS MCO                              OU         79
                    READ (NTP1) PP,P,DU                                                    OU         80
 120             16 CONTINUE                                                               OU         81
                    WRITE(6,19)                                                            OU         82
                 19 FORMAT (1H0,4HSTEP,5X,4HSMAX,7X,4HSSUM,6X,5HSEXIT,5X,                  OU         83
                   1  8HP(2,M,2),3X,8HP(L,M,2),3X,8HU(I,J,K),3X,8HV(I,J,K),3X,             OU         84
                   2  8HW(I,J,K),3X,8HT(I,J,K),2X,10HRHO(I,J,K),2X,7HI   J   K)            OU         85
 125           20   CONTINUE                                                               OU         86
                    RETURN                                                                 OU         87
                    END                                                                    OU         88


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     55     I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     66     I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     82     I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     98     I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    107     I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
```

```
      SUBROUTINE AUX
      COMMON F(3500),DU(500),DV(500),DW(500),
     1  RHO(500),VISC(500),SU(100),SP(100),DRHODP(500),
     1  AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),
     2  AZM(100),CZ(100),CY(10),CZU(100),CYU(10),
     3  CZP(100),CYP(10),DIVG(100),NTP1,NTP2
      DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)
      DIMENSION GAM(500)
      EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))
      EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1))
      EQUIVALENCE (F(3001),GAM(1))
      COMMON/CYL/R(30),RP(30),RMV(30),YSR(30),YSVR(30),IPLAX
      COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),
     1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),
     2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME
      COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NT,NJ,NK,NINJ,NINJNK,NV,
     1  NNV,NGOTO,K,ISTR,JSTR,KSTR,NVP(20),KM(30),JM(30),ISTEP,
     2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,
     3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,
     4  IWEO,MM1,JWII,JWIO,JWOI,JWOO,IDW,JKIN(30,30),IKIN(40,30)
      COMMON/INDEX/IPAR,LPREF,ISTUM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE
     1  ,PLAXMI,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),
     2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,
     3  NVN2
      COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEN,IDK,FSTOIC,HFU,CP,
     1  GASCON,RHOCON,UNICON,PRESS,NVFAV,TCYLW,TINLW,TLIP,ACOEF(4),
     2  T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HYY,CXX,RATIO1,RATIO2,
     3  RATIO3,RATIO4,HCO,TAN,ITWALL
      COMMON/CTOMA/MEND,ICTOMA(13)
      COMMON/MIS/AMU,DENO,SMAX,SSUM,LASTEP,HTCEXT,CFR,EMISW,EMISIN,
     1  EMISR,TOUT,RTCO,ERI,RADIN,RADSUR,FMA,FK,SOFK,
     2  FKFU,FOFU,TFUEL,WFNZ,FLO(40),TEMTM(40),H(40),FUEL(40),FUOX(40) ,
     3  UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)
      COMMON/TURB/NVK,NVD,C1,C2,CD,AK,DUIDXJ(3,3),AKFAC,ALFAC,
     1  MODEL,PR(13),PREF(13),PJAY(13),E
      COMMON/RAD/NVE,SIGMA,ABSOR,SCATR
      COMMON/REACT/ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,MODER
      COMMON/DROPL/EVAP(192),NTFG,NFNZ,XO(3),YO(3),ZO(3),ALFA(3),
     1  BETA(3),DELTA(3),THETA1(3),THETA2(3),NSL(3),WFF(3),SMD(3),
     2  VFUEL(3),RFUEL(3),EVSO(64),NEVAP
      COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WJINJ(20),
     1  AUINJ(20),TUINJ(20),IVINS(20),JVINJ(20),KVINJ(20),VINJ(20),
     2  EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),NUINJ,NVINJ,JSW1,JSW2,
     3  USW,VSW,AFSW,FSW,TSW,WSW,SWNO,RHOSW
      DIMENSION GENR(500),SUFU(500),SPFU(500),EDK(192)
C +-+-+-+-+-+-+-+-+-    BEWARE OF EQUIVALENCE STATEMENTS   +-+-+-+-+-+-+-+-
      EQUIVALENCE (GENR(1),DU(1)),(SUFU(1),DV(1)),(SPFU(1),DW(1))
C +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
      ENTRY DENS
      RELAXM=1.-RELAX(NRHO)
      KONTRO=2
      IF (ISTEP.EQ.0) KONTRO=1
      NVUE=8
      NVVE=9
      NVWE=10
      NVHP=7
      DO 1040 K=1,NP1
      DO 1040 J=1,MP1
      KJM=KM(K)+JM(J)
      DO 1040 I=1,LP1
      LP=KJM+I
      LPH=LP+NVM(NVH)
      LPHP=LP+NVM(NVHP)
 1040 F(LPHP)=F(LPH)
      GO TO (1034,1044,1034), MODEN
 1044 DO 1050 K=1,NP1
      DO 1050 J=2,M
      KJM=KM(K)+JM(J)
      IS=IWLI(J,4)
      IE=IWLO(J,4)
      DO 1050 I=IS,IE
      LP=KJM+I
      LPHP=LP+NVM(NVHP)
      LPFU=LP+NVM(NVFU)
      LPCO=LP+NVM(NVCO)
      LPFUOX=LP+NVM(NVFUOX)
      T=TEMP(LP)
```

```
      FUB=F(LPFUOX)-F(LPFU)
      FLPCO2=WCO2*CXX*FUB/WFU-WCO2*F(LPCO)/WCO
      FLPOX=RATIO1*F(LPFU)+RATIO3*F(LPCO)+RATIO2-(RATIO1+RATIO2)*
     1F(LPFUOX)
      FLPOX=AMAX1(FLPOX,0.)
      FLPH2O=WH2O*H2O*FUB/WFU/2.
      FLPN2=1.-F(LPFU)-FLPCO2-F(LPCO)-FLPOX-FLPH2O
      HPI=F(LPFU)*HOR(T,1)+FLPCO2*HOR(T,2)+F(LPCO)*HOR(T,3)+
     1    FLPOX*HOR(T,4)+FLPH2O*HOR(T,5)+FLPN2*HOR(T,12)
      CPI=F(LPFU)*CPOR(T,1)+FLPCO2*CPOR(T,2)+F(LPCO)*CPOR(T,3)+
     1    FLPOX*CPOR(T,4)+FLPH2O*CPOR(T,5)+FLPN2*CPOR(T,12)
      T=TEMP(LP)+(F(LPH)-HPI)/CPI
      TEMP(LP)=(1.-RELAX(NVH))*TEMP(LP)+RELAX(NVH)*T
      PHI=F(LPFUOX)/FSTOIC
      TMAX=ACOEF(1)+PHI*(ACOEF(2)+PHI*(ACOEF(3)+PHI*ACOEF(4)))
      TMAX=AMAX1(TMAX,2000.)
      TEMP(LP)=AMIN1(TEMP(LP),TMAX)
 1050 TEMP(LP)=AMAX1(TEMP(LP),300.)
C ------- HERE DU IS U, DV IS V, DW IS W
 1034 REWIND NTP1
      READ (NTP1) DU,DV,DW,P
 1040 READ (NTP1)
C ------- HERE PP IS PHI, DU IS MFU, DV IS MCO
      READ (NTP1) PP,DU,DV
      REWIND NTP1
      READ (NTP1) U,V,W,P
      GO TO (1060,1062,1064), MODEN
 1060 DO 1061 K=1,NPK
      DO 1061 J=1,NPJ
      KJ=KCM(K)+JP(J)
      IS=IALI(J,5)
      IE=IALO(J,5)
      DO 1061 I=IS,IE
      LP=KJ+I
      U(LP)=DEN
 1061 CONTINUE
      GO TO 1200
 1062 DO 1063 K=1,NPK
      DO 1063 J=1,NPJ
      KJ=KCM(K)+JP(J)
      IS=IALI(J,5)
      IE=IALO(J,5)
      DO 1063 I=IS,IE
      LP=KJ+I
      LPTE=LP+NVM(NVTE)
      LPFUOX=LP+NVM(NVFUOX)
C ------- CAUTION HERE
      LPFU=LP+NVM(NVFU+1)
      LPCO=LP+NVM(NVCO+1)
      FUB=F(LPFUOX)-F(LPFU)
      FLPH2O=WH2O*H2O*FUB/WFU/2.
      FLPCO2=WCO2*CXX*FUB/WFU-WCO2*F(LPCO)/WCO
      FLPOX=RATIO1*F(LPFU)+RATIO3*F(LPCO)+RATIO2-(RATIO2+RATIO1)*
     2F(LPFUOX)
      FLPOX=AMAX1(FLPOX,0.)
      FLPN2=1.-F(LPFU)-FLPCO2-F(LPCO)-FLPOX-FLPH2O
 1059 CONTINUE
      FLPTE=F(LPTE)
      FLPTE=AMAX1(FLPTE,100.)
      WMIX=F(LPFU)/WFU+FLPCO2/WCO2+F(LPCO)/WCO+FLPOX/WOX+FLPH2O/WH2O+
     1 FLPN2/WN2
      DENST=RHOCON/(WMIX*FLPTE)
      GO TO (1009,1010),KONTRO
 1009 RHO(LP)=DENST
 1010 RHO(LP)=RELAX(NRHO)*DENST+RELAXM*RHO(LP)
 1063 CONTINUE
 1064 CONTINUE
 1200 CONTINUE
      CALL DENMOD
      RETURN
C ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** ** *
      ENTRY VISCO
C ------- HERE DU IS WE, DV IS DISS
      READ (NTP1) DU,DV
      RELAXM=1.-RELAX(NGAM)
      KONTRO=2
      IF (ISTEP.EQ.IRES) KONTRO=1
```

```
      DO 2000 K=1,MP1                                                   AU     116
      DO 2000 J=2,M                                                     AU     117
      KJM=KM(K)+JM(J)                                                   AU     118
      IS=IWLI(J,4)                                                      AU     119
      IE=IWLO(J,4)                                                      AU     120
      DO 2000 I=IS,IE                                                   AU     121
      LP=KJM+I                                                          AU     122
      GO TO (2001,2002),MODEL                                           AU     123
 2001 CONTINUE                                                          AU     124
      VISC(LP)=AMU                                                      AU     125
      GO TO 2000                                                        AU     126
 2002 CONTINUE                                                          AU     127
      LPK=LP+NVM(NVK+4)                                                 AU     128
      LPD=LP+NVM(NVD+4)                                                 AU     129
      VISCOS=RHO(LP)*CD*F(LPK)**2/(F(LPD)+1.E-30)                       AU     130
      GO TO (2003,2004),KONTRO                                          AU     131
 2003 VISC(LP)=VISCOS                                                   AU     132
 2004 VISC(LP)=RELAX(NGAM)*VISCOS+RELAXM*VISC(LP)                       AU     133
 2000 CONTINUE                                                          AU     134
C ------- CALCULATE YPLUS                                               AU     135
      DO 2020 K=1,MP1                                                   AU     136
      DO 2022 I=1,LP1                                                   AU     137
      J=JWLO(I,4)                                                       AU     138
      LP=KM(K)+JM(J)+I                                                  AU     139
      LPK=LP+NVM(NVK+4)                                                 AU     140
      DIST=.5*YDIF(J)                                                   AU     141
      IF (J.EQ.MP1) DIST=YDIF(MP1)                                      AU     142
      YPLUS=RHO(LP-NI)*SQRT(F(LPK-NI)*RTCD)*DIST/AMU                    AU     143
      VISC(LP)=YPLUS                                                    AU     144
      J=JWLI(I,4)                                                       AU     145
      LP=KM(K)+JM(J)+I                                                  AU     146
      LPK=LP+NVM(NVK+4)                                                 AU     147
      DIST=.5*YDIF(J+1)                                                 AU     148
      IF (J.EQ.1) DIST=YDIF(2)                                          AU     149
      YPLUS=RHO(LP+NI)*SQRT(F(LPK+NI)*RTCD)*DIST/AMU                    AU     150
      VISC(LP)=YPLUS                                                    AU     151
 2022 CONTINUE                                                          AU     152
      DO 2024 J=2,M                                                     AU     153
      I=IWLI(J,4)-1                                                     AU     154
      LP=KM(K)+JM(J)+I                                                  AU     155
      LPK=LP+NVM(NVK+4)                                                 AU     156
      DIST=.5*XDIF(I+1)                                                 AU     157
      IF (I.EQ.1) DIST=XDIF(2)                                          AU     158
      YPLUS=RHO(LP+1)*SQRT(F(LPK+1)*RTCD)*DIST/AMU                      AU     159
      VISC(LP)=YPLUS                                                    AU     160
      I=IWLO(J,4)+1                                                     AU     161
      LP=KM(K)+JM(J)+I                                                  AU     162
      LPK=LP+NVM(NVK+4)                                                 AU     163
      DIST=.5*XDIF(I)                                                   AU     164
      IF (I.EQ.LP1) DIST=XDIF(LP1)                                      AU     165
      YPLUS=RHO(LP-1)*SQRT(F(LPK-1)*RTCD)*DIST/AMU                      AU     166
      VISC(LP)=YPLUS                                                    AU     167
 2024 CONTINUE                                                          AU     168
 2020 CONTINUE                                                          AU     169
      DO 3005 K=2,N                                                     AU     170
      DO 3005 J=2,M                                                     AU     171
      KJM=KM(K)+JM(J)                                                   AU     172
      IS=IWLI(J,4)                                                      AU     173
      IE=IWLO(J,4)                                                      AU     174
      DO 3005 I=IS,IE                                                   AU     175
      LP=KJM+I                                                          AU     176
      LPK=LP+NVM(NVK+4)                                                 AU     177
      LPD=LP+NVM(NVD+4)                                                 AU     178
      LPC=I-1+(J-2)*(NI-2)+(K-2)*(NI-2)*(NJ-2)                          AU     179
 3005 EDK(LPC)=F(LPD)/(F(LPK)+1.E-30)                                   AU     180
      RETURN                                                            AU     181
C **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  * AU     182
      ENTRY GAMMA                                                       AU     183
      DO 3000 K=1,NP1                                                   AU     184
      DO 3000 J=2,M                                                     AU     185
      KJM=KM(K)+JM(J)                                                   AU     186
      IS=IWLI(J,4)                                                      AU     187
      IE=IWLO(J,4)                                                      AU     188
      DO 3000 I=IS,IE                                                   AU     189
      LP=KJM+I                                                          AU     190
      GO TO (3001,3002),MODEL                                           AU     191
 3001 CONTINUE                                                          AU     192
```

```
              GAM(LP)=VISC(LP)/PE(NV)                                      AU      193
              GO TO 3004                                                   AU      194
        3002  CONTINUE                                                     AU      195
              GAM(LP)=VISC(LP)/PREF(NV)                                    AU      196
        3003  CONTINUE                                                     AU      197
              CALL GAMOS                                                   AU      198
        3004  CONTINUE                                                     AU      199
              RETURN                                                       AU      200
      C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  ** * AU      201
              ENTRY SOURCE                                                 AU      202
      CAUTION NOT ALL SOURCE TERMS ARE VALID - AT BOUNDARY NODES -         AU      203
      CHECK AND MODIFY ACCORDINGLY IN SOMOD                                AU      204
              GO TO (100,200,300,400),NGOTO                                AU      205
      C +-+-+-+-+-+-+-+-   SOURCE TERMS FOR U-VELOCITY    +-+-+-+-+-+-+-+- AU      206
      100     DO 101 J=2,M                                                 AU      207
              IS=IWL1(J,NGOTO)                                             AU      208
              IE=IWL3(J,NGOTO)                                             AU      209
              DO 101 I=IS,IE                                               AU      210
              LIJ=JM(J)+I                                                  AU      211
              LP=LIJ+KM(K)                                                 AU      212
              LXP=LP+1                                                     AU      213
              LXM=LP-1                                                     AU      214
              DUDXP=(U(LXP)-U(LP))/XS(I)                                   AU      215
              DUDXM=(U(LP)-U(LXM))/XS(I-1)                                 AU      216
              GAMLP=GAM(LP)                                                AU      217
              GAMLXM=GAM(LXM)                                              AU      218
              IF (I.EQ.IS) GAMLXM=GAM(LXM-1)                               AU      219
              IF (I.EQ.IE) GAMLP=GAM(LP+1)                                 AU      220
              SU(LIJ)=(GAMLP*DUDXP-GAMLXM*DUDXM)/XSU(I)                    AU      221
              LYP=LP+NI                                                    AU      222
              LYM=LP-NI                                                    AU      223
              LYP1=LYP-1                                                   AU      224
              LYM1=LYM-1                                                   AU      225
              GAMP=0.25*(GAM(LP)+GAM(LXM)+GAM(LYP)+GAM(LYP1))              AU      226
              GAMM=0.25*(GAM(LP)+GAM(LXM)+GAM(LYM)+GAM(LYM1))              AU      227
              DVDXP=(V(LYP)-V(LYP1))/XDIF(I)                               AU      228
              DVDXM=(V(LP)-V(LXM))/XDIF(I)                                 AU      229
              SU(LIJ)=SU(LIJ)+(GAMP*DVDXP*RR(J+1)-GAMM*DVDXM*RR(J))/YSR(J) AU      230
              LZP=LP+NINJ                                                  AU      231
              LZM=LP-NINJ                                                  AU      232
              LZP1=LZP-1                                                   AU      233
              LZM1=LZM-1                                                   AU      234
              GAMP=0.25*(GAM(LP)+GAM(LXM)+GAM(LZP)+GAM(LZP1))              AU      235
              GAMM=0.25*(GAM(LP)+GAM(LXM)+GAM(LZM)+GAM(LZM1))              AU      236
              DWDXP=(W(LZP)-W(LZP1))/XDIF(I)                               AU      237
              DWDXM=(W(LP)-W(LXM))/XDIF(I)                                 AU      238
              SU(LIJ)=SU(LIJ)+(GAMP*DWDXP-GAMM*DWDXM)*YS(J)/YSR(J)/ZS(K)   AU      239
              SP(LIJ)=0.                                                   AU      240
      101     CONTINUE                                                     AU      241
              GO TO 5000                                                   AU      242
      C +-+-+-+-+-+-+-+-   SOURCE TERMS FOR V-VELOCITY    +-+-+-+-+-+-+-+- AU      243
      200     DO 201 J=3,M                                                 AU      244
              IS=IWL2(J,NGOTO)                                             AU      245
              IE=IWL3(J,NGOTO)                                             AU      246
              DO 201 I=IS,IE                                               AU      247
              LIJ=JM(J)+I                                                  AU      248
              LP=LIJ+KM(K)                                                 AU      249
              LYP=LP+NI                                                    AU      250
              LYM=LP-NI                                                    AU      251
              DVDYP=(V(LYP)-V(LP))/YS(J)                                   AU      252
              DVDYM=(V(LP)-V(LYM))/YS(J-1)                                 AU      253
              GAMLP=GAM(LP)                                                AU      254
              GAMLYM=GAM(LYM)                                              AU      255
              IF (J.EQ.JWL1(I,NGOTO)+1) GAMLYM=GAM(LYM-NI)                 AU      256
              IF (J.EQ.JWL3(I,NGOTO)-1) GAMLP=GAM(LP+NI)                   AU      257
              SU(LIJ)=(GAMLP*DVDYP*RRV(J+1)-GAMLYM*DVDYM*RRV(J))/YSVR(J)   AU      258
              LXP=LP+1                                                     AU      259
              LXM=LP-1                                                     AU      260
              LXP1=LXP-NI                                                  AU      261
              LXM1=LXM-NI                                                  AU      262
              GAMP=0.25*(GAM(LP)+GAM(LYM)+GAM(LXP)+GAM(LXP1))              AU      263
              GAMM=0.25*(GAM(LP)+GAM(LYM)+GAM(LXM)+GAM(LXM1))              AU      264
              DUDYP=(U(LXP)-U(LXP1))/YDIF(J)                               AU      265
              DUDYM=(U(LP)-U(LYM))/YDIF(J)                                 AU      266
              SU(LIJ)=SU(LIJ)+(GAMP*DUDYP-GAMM*DUDYM)/XS(I)                AU      267
              LZP=LP+NINJ                                                  AU      268
              LZM=LP-NINJ                                                  AU      269
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```
           LZPI=LZP-NI                                                     AU     270
           LZMI=LZM-NI                                                     AU     271
           GAMP=0.25*(GAM(LP)+GAM(LYM)+GAM(LZP)+GAM(LZPI))                 AU     272
           GAMM=0.25*(GAM(LP)+GAM(LYM)+GAM(LZM)+GAM(LZMI))                 AU     273
           DWDYP=(W(LZP)-W(LZPI))/YDIF(J)                                  AU     274
           DWDYM=(W(LP)-W(LYM))/YDIF(J)                                    AU     275
           SU(LIJ)=SU(LIJ)+(GAMP*DWDYP-GAMM*DWDYM)*YSV(J)/YSVR(J)/ZS(K)     AU     276
           WMM=0.5*(W(LP)+W(LYM))                                          AU     277
           WMP=0.5*(W(LZP)+W(LZPI))                                        AU     278
           SU(LIJ)=SU(LIJ)+PLAXMI*(GAMM*WMM-GAMP*WMP)*YSV(J)/YSVR(J)/ZS(K)/ AU     279
          1RM(J)                                                           AU     280
           GAMPTZ=GAM(LP)+GAM(LYM)                                         AU     281
           SU(LIJ)=SU(LIJ)+PLAXMI*GAMPTZ*(WMM-WMP)/DM(J)/ZS(K)/RM(J)       AU     282
           SP(LIJ)=-GAMPTZ/RM(J)/RP(J)*PLAXMI                              AU     283
       201 CONTINUE                                                        AU     284
           GO TO 9030                                                      AU     285
C ------------------  SOURCE TERMS FOR W-VELOCITY    ---------------       AU     286
       300 DO 301 J=2,M                                                    AU     287
           IS=IWL1(J,NGCTW)                                                AU     288
           IE=IWL3(J,NGCTW)                                                AU     289
           DO 301 I=IS,IE                                                  AU     290
           LIJ=JM*(J)+I                                                    AU     291
           LP=LIJ+KM(K)                                                    AU     292
           LZP=LP+NIMJ                                                     AU     293
           IF (K.EQ.NP1) LZP=LIJ+KM(3)                                     AU     294
           LZM=LP-NIMJ                                                     AU     295
           DWDZP=(W(LZP)-W(LP))/ZS(K)                                      AU     296
           DWDZM=(W(LP)-W(LZM))/ZS(K-1)                                    AU     297
           GAMLP=GAM(LP)                                                   AU     298
           GAMLZM=GAM(LZM)                                                 AU     299
           IF(K.EQ.3) GAMLZM=GAM(LZM-NIMJ)                                 AU     300
           SU(LIJ)=(GAMLP*DWDZP-GAMLZM*DWDZM)/R(J) /YSR(J)/ZSW(K)*YS(J)     AU     301
           LXP=LP+1                                                        AU     302
           LXM=LP-1                                                        AU     303
           LXPI=LXP-NIMJ                                                   AU     304
           LXMI=LXM-NIMJ                                                   AU     305
           GAMP=0.25*(GAM(LP)+GAM(LZM)+GAM(LXP)+GAM(LXPI))                 AU     306
           GAMM=0.25*(GAM(LP)+GAM(LZM)+GAM(LXM)+GAM(LXMI))                 AU     307
           DUDZP=(U(LXP)-U(LXPI))/ZDIF(K)                                  AU     308
           DUDZM=(U(LP)-U(LZM))/ZDIF(K)                                    AU     309
           SU(LIJ)=SU(LIJ)+(GAMP*DUDZP-GAMM*DUDZM)/XS(I)/R(J)              AU     310
           LYP=LP+NI                                                       AU     311
           LYM=LP-NI                                                       AU     312
           LYPI=LYP-NIMJ                                                   AU     313
           LYMI=LYM-NIMJ                                                   AU     314
           GAMP=0.25*(GAM(LP)+GAM(LZM)+GAM(LYP)+GAM(LYPI))                 AU     315
           GAMM=0.25*(GAM(LP)+GAM(LZM)+GAM(LYM)+GAM(LYMI))                 AU     316
           DVDZP=(V(LYP)-V(LYPI))/ZDIF(K)                                  AU     317
           DVDZM=(V(LP)-V(LZM))/ZDIF(K)                                    AU     318
           SU(LIJ)=SU(LIJ)+(GAMP*DVDZP-GAMM*DVDZM)/YSR(J)                  AU     319
           WMM=0.5*(W(LP)+W(LYM))                                          AU     320
           WMP=0.5*(W(LP)+W(LYP))                                          AU     321
           SU(LIJ)=SU(LIJ)+PLAXMI*(GAMM*WMM-GAMP*WMP)/YSR(J)               AU     322
           VPTZ=V(LP)+V(LYP)                                               AU     323
           VMTZ=V(LZM)+V(LZM+NI)                                           AU     324
           SU(LIJ)=SU(LIJ)+PLAXMI*(GAM(LP)*VPTZ-VMTZ*GAM(LZM))*YS(J)/R(J)/  AU     325
          1YSR(J)/ZSW(K)                                                   AU     326
           GAMP=0.5*(GAM(LP)+GAM(LZM))                                     AU     327
           SU(LIJ)=SU(LIJ)+PLAXMI*GAMP/R(J)*((WMP-WMM)/YS(J)+0.5*(VPTZ-VMTZ AU     328
          1)/R(J)/ZSW(K))                                                  AU     329
           SP(LIJ)=-GAMP/R(J)/R(J)*PLAXMI                                  AU     330
       301 CONTINUE                                                        AU     331
           GO TO 5000                                                      AU     332
C ------------  SOURCE TERMS FOR TURBULENT KINETIC ENERGY  ---------       AU     333
       400 CONTINUE                                                        AU     334
           IF (NG.NE.LUK) GO TO 500                                        AU     335
           DO 401 J=2,M                                                    AU     336
           IS=IWL1(J,NGCTC)                                                AU     337
           IE=IWL3(J,NGCTC)                                                AU     338
           DO 401 I=IS,IE                                                  AU     339
           FIN=JWL1(I,NGCTC)+1                                             AU     340
           KAS=JWL3(I,NGCTC)-1                                             AU     341
           LIJ=JM*(J)+I                                                    AU     342
           LP=LIJ+KM(K)                                                    AU     343
           LXP=LP+1                                                        AU     344
           LXM=LP-1                                                        AU     345
           LZP=LP+NIMJ                                                     AU     346
```

```
      LXM=LP-1
      LYM=LP-NI
      LZM=LP-NINJ
      LPPO=LYP+1
      LPMO=LYM+1
      LPOM=LZM+1
      LPOP=LZP+1
      LMPO=LXM+NI
      LOPP=LZP+NI
      LOPM=LZM+NI
      LMOP=LXM+NINJ
      LOMP=LYM+NINJ
C     CALCULATE THE PRODUCTION TERM
      DUIDXJ(1,1)=(U(LXP)-U(LP))/XS(I)
      DUIDXJ(2,2)=(V(LYP)-V(LP))/YS(J)
      DUIDXJ(3,3)=(W(LZP)-W(LP))/ZS(K)/R(J)
     1 +PLAXM*0.5*(V(LP)+V(LYP))/R(J)
      IF (I-IS) 411,412,411
  411 VXM=0.5*(V(LXM)+V(LMPO))
      WXM=0.5*(W(LXM)+W(LMOP))
      XM=X(I-1)
      GO TO 413
  412 VXM=0.5*(V(LP)+V(LYP))
      WXM=0.5*(W(LP)+W(LZP))
      XM=X(I)
  413 IF (I-IE) 414,415,414
  414 VXP=0.5*(V(LXP)+V(LPPO))
      WXP=0.5*(W(LXP)+W(LPOP))
      XP=X(I+1)
      GO TO 416
  415 VXP=0.5*(V(LP)+V(LYP))
      WXP=0.5*(W(LP)+W(LZP))
      XP=X(I)
  416 DX=XP-XM
      DUIDXJ(2,1)=(VXP-VXM)/DX
      DUIDXJ(3,1)=(WXP-WXM)/DX
      IF (J-MIN) 421,422,421
  421 UYM=0.5*(U(LYM)+U(LPMO))
      WYM=.5*(W(LYM)+W(LOMP))
      YM=Y(J-1)
      GO TO 423
  422 UYM=0.5*(U(LP)+U(LXP))
      WYM=0.5*(W(LP)+W(LZP))
      YM=Y(J)
  423 IF (J-MAX) 424,425,424
  424 UYP=0.5*(U(LYP)+U(LPPO))
      WYP=0.5*(W(LYP)+W(LOPP))
      YP=Y(J+1)
      GO TO 426
  425 UYP=0.5*(U(LP)+U(LXP))
      WYP=0.5*(W(LP)+W(LZP))
      YP=Y(J)
  426 DY=YP-YM
      DUIDXJ(3,2)=(WYP-WYM)/DY-PLAXM*0.5*(W(LP)+W(LZP))/R(J)
      DUIDXJ(1,2)=(UYP-UYM)/DY
      IF(K-2) 431,432,431
  431 UZM=0.5*(U(LZM)+U(LPOM))
      VZM=0.5*(V(LZM)+V(LOPM))
      ZM=Z(K-1)
      GO TO 433
  432 UZM=0.5*(U(LP)+U(LXP))
      VZM=0.5*(V(LP)+V(LYP))
      ZM=Z(K)
  433 IF(K-M) 434,435,434
  434 UZP=0.5*(U(LZP)+U(LPOP))
      VZP=0.5*(V(LZP)+V(LOPP))
      ZP=Z(K+1)
      GO TO 436
  435 UZP=0.5*(U(LP)+U(LXP))
      VZP=0.5*(V(LP)+V(LYP))
      ZP=Z(K)
  436 DZ=ZP-ZM
      DUIDXJ(1,3)=(UZP-UZM)/DZ/R(J)
      DUIDXJ(2,3)=(VZP-VZM)/DZ/R(J)
      SUM=0.
      DO 402 II=1,3
      DO 402 JJ=1,3
```

```
  402 SUM=SUM+(DUIDXJ(II,JJ)+DUIDXJ(JJ,II))*DUIDXJ(II,JJ)
      GENR(LP)=SUM
CALCULATE THE SOURCE TERM
      LPK=LP+NVR(NVK)
      LPD=LP+NVR(NVD)
      SU(LIJ)=RHO(LP)*CD*F(LPK)**2/(F(LPD)+1.E-30)*SUM
      SP(LIJ)=-RHO(LP)*F(LPD)/(F(LPK)+1.E-30)
      IF (I.GT.IS) GO TO 440
      IF (IKIN(I,K).EQ.1) GO TO 440
      DIST=.5*XDIF(I)
      IF (I.EQ.2) DIST=XDIF(2)
      VP=.5*SQRT((V(LP)+V(LYP))**2+(W(LP)+W(LZP))**2)
      TAUP=AMAX1(GAM(LXM)*VP/DIST,1.E-20)
      GAM(LXM)=0.
      VXP=V(LP)+V(LYP)+V(LXP)+V(LPPO)
      WXP=W(LP)+W(LZP)+W(LXP)+W(LPOP)
      VC=.25*SQRT(VXP**2+WXP**2)
      DVDY=VC/XS(I)
      SU(LIJ)=TAUP*DVDY
      SP(LIJ)=-RHO(LP)*RHO(LP)*CD*F(LPK)*DVDY/TAUP
  440 IF (I.LT.IE) GO TO 442
      IF (J.GT.JWDI.AND.J.LT.JWDO) GO TO 442
      DIST=.5*XDIF(I+1)
      IF (I.EQ.L) DIST=XDIF(LP1)
      VP=.5*SQRT((V(LP)+V(LYP))**2+(W(LP)+W(LZP))**2)
      TAUP=AMAX1(GAM(LXP)*VP/DIST,1.E-20)
      GAM(LXP)=0.
      VXM=V(LP)+V(LYP)+V(LXM)+V(LMPO)
      WXM=W(LP)+W(LZP)+W(LXM)+W(LMOP)
      VC=.25*SQRT(VXM**2+WXM**2)
      DVDY=VC/XS(I)
      SU(LIJ)=TAUP*DVDY
      SP(LIJ)=-RHO(LP)*RHO(LP)*CD*F(LPK)*DVDY/TAUP
  442 IF (J.GT.MIN) GO TO 444
      IF (IBW.EQ.0.OR.IKIN(I,K).EQ.1.OR.IKIN(I,K).EQ.3) GO TO 444
      DIST=.5*YDIF(J)
      IF (J.EQ.2) DIST=YDIF(2)
      VP=.5*SQRT((U(LP)+U(LXP))**2+(W(LP)+W(LZP))**2)
      TAUP=AMAX1(GAM(LYM)*VP/DIST,1.E-20)
      GAM(LYM)=0.
      UYP=U(LP)+U(LXP)+U(LYP)+U(LPPO)
      WYP=W(LP)+W(LZP)+W(LYP)+W(LOPP)
      VC=.25*SQRT(UYP**2+WYP**2)
      DVDY=VC/YS(J)
      SU(LIJ)=TAUP*DVDY
      SP(LIJ)=-RHO(LP)*RHO(LP)*CD*F(LPK)*DVDY/TAUP
  444 IF (J.LT.MAX) GO TO 401
      IF (IKIN(I,K).EQ.2.OR.IKIN(I,K).EQ.3) GO TO 401
      DIST=.5*YDIF(J+1)
      IF (J.EQ.M) DIST=YDIF(MP1)
      VP=.5*SQRT((U(LP)+U(LXP))**2+(W(LP)+W(LZP))**2)
      TAUP=AMAX1(GAM(LYP)*VP/DIST,1.E-20)
      GAM(LYP)=0.
      UYM=U(LP)+U(LXP)+U(LYM)+U(LPMO)
      WYM=W(LP)+W(LZP)+W(LYM)+W(LOMP)
      VC=.25*SQRT(UYM**2+WYM**2)
      DVDY=VC/YS(J)
      SU(LIJ)=TAUP*DVDY
      SP(LIJ)=-RHO(LP)*RHO(LP)*CD*F(LPK)*DVDY/TAUP
  401 CONTINUE
      GO TO 5000
C +-+-+-+-+-+-+-    SOURCE TERMS FOR TURBULENCE DISSIPATION  +-+-+-+-+-+-+-
  500 CONTINUE
      IF (NV.NE.LVD) GO TO 600
      DO 501 J=2,M
      IS=IWLI(J,NGOTO)
      IE=IWLO(J,NGOTO)
      DO 501 I=IS,IE
      LIJ=JR(J)+I
      LP=LIJ+KR(K)
      LPK=LP+NVR(NVK)
      LPD=LP+NVR(NVD)
      SU(LIJ)=C1*CD*RHO(LP)*F(LPK)*GENR(LP)
      SP(LIJ)=-C2*RHO(LP)*F(LPD)/(F(LPK)+1.E-30)
  501 CONTINUE
      GO TO 5000
C +-+-+-+-+-+-+-+-+-+-    SOURCE TERMS FOR FUEL    +-+-+-+-+-+-+-+-+-+-+-+-+-
```

```
  600 CONTINUE
      IF (NV.NE.LVFU) GO TO 700
      DO 601 J=2,M
      IS=IWLI(J,NGOTO)
      IE=IWLO(J,NGOTO)
      DO 601 I=IS,IE
      LIJ=JM(J)+I
      LP=LIJ+KM(K)
      LPC=I-1+(J-2)*(NI-2)+(K-KSTR)*(NI-2)*(NJ-2)
      LPFU=LP+NVM(NVFU)
      LPFUOX=LP+NVM(NVFUOX)
      LPTE=LP+NVM(NVTE)
      FLPTE=F(LPTE)
      FLPTE=AMAX1(FLPTE,100.)
      F(LPFU)=AMIN1(F(LPFU),F(LPFUOX))
      LPCO=LP+NVM(NVCO)
      FLPOX=RATIO1*F(LPFU)+RATIO3*F(LPCO)+RATIO2-(RATIO2+RATIO1)*
     2F(LPFUOX)
      FLPOX=AMAX1(FLPOX,0.)
      RHOLP=ABS(RHO(LP))
      SOR1=-PREEXP1*RHOLP**1.5*SQRT(F(LPFU))*FLPOX*EXP(-ARCON1/FLPTE)
      GO TO (611,612),MODER
  611 SOR=SOR1
      GO TO 602
  612 LPK=LP+NVM(NVK)
      LPD=LP+NVM(NVD)
      PHI=AMIN1(F(LPFU),FLPOX/RATIO1)
      SOR2=-CR*PHI*RHO(LP)*EDK(LPC)
      SOR=AMAX1(SOR1,SOR2)
  602 FUB=AMAX1(0.,((RATIO2+RATIO1)*F(LPFUOX)-RATIO2-RATIO3*F(LPCO))/
     2RATIO1)
      FUO=.5*(F(LPFU)+FUB)
      DSDFU=SOR/(F(LPFU)-FUO+1.E-30)
      SU(LIJ)=SOR-DSDFU*F(LPFU)
      SP(LIJ)=DSDFU
      SUFU(LP)=SU(LIJ)
      SPFU(LP)=SP(LIJ)
  601 CONTINUE
      GO TO 5000
C *-*-*-*-*-*-*-*-*-   SOURCE TERMS FOR ENTHALPY   *-*-*-*-*-*-*-*-*-*-
  700 CONTINUE
      IF (NV.NE.LVH) GO TO 800
      DO 701 J=2,M
      IS=IWLI(J,NGOTO)
      IE=IWLO(J,NGOTO)
      DO 701 I=IS,IE
      LIJ=JM(J)+I
      SU(LIJ)=0.
      SP(LIJ)=0.
      GO TO (701,702),ITRAD
  702 CONTINUE
      LP=LIJ+KM(K)
      LPH=LP+NVM(NVH)
      LPFAV=LP+NVM(NVFAV)
      LPTE=LP+NVM(NVTE)
      FLPTE=F(LPTE)
      FLPE=SIGMA*FLPTE**4
      FAV=F(LPFAV)
      SOR=4.*ABSORB*(FAV-FLPE)
      TO=(FAV/SIGMA)**.25
      TO=TO+.001
      DSDH=SOR/(CP*(FLPTE-TO))
      SU(LIJ)=SU(LIJ)+SOR-DSDH*F(LPH)
      SP(LIJ)=SP(LIJ)+DSDH
  701 CONTINUE
      GO TO 5000
C *-*-*-*-*-*-*-*-*-*-*-*-   SOURCE TERMS FOR PHI   *-*-*-*-*-*-*-*-*-*-*-*-*-
  800 CONTINUE
      IF (NV.NE.LVFUOX) GO TO 900
      DO 801 J=2,M
      IS=IWLI(J,NGOTO)
      IE=IWLO(J,NGOTO)
      DO 801 I=IS,IE
      LIJ=JM(J)+I
      SU(LIJ)=0.
      SP(LIJ)=0.
  801  CONTINUE
```

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SUBROUTINE AUX        73/74    OPT=0 TRACE                    FTN 4.6+439      09/24/79  14.08.46        PAGE     9

            GO TO 5000                                                              AU         578
      C------------------------    SOURCE TERM FOR CC     ----------------------    AU         579
        900 IF(NY.NE.LPCO) GO TO 1900                                               AU         580
            DO 901 J=2,M                                                            AU         581
            IS=INLI(J,NGOTO)                                                        AU         582
            IE=INLO(J,NGOTO)                                                        AU         583
            DO 901 I=IS,IE                                                          AU         584
            LIJ=IR(J)+I                                                             AU         585
            LP=LIJ+KR(K)                                                            AU         586
            LPC=I-1+(J-2)*(NI-2)+(K-KSTR)*(NI-2)*(NJ-2)                             AU         587
            LPCO=LP+NVM(NVCO)                                                       AU         588
            LPFUOX=LP+NVM(NVFUOX)                                                   AU         589
            LPFU=LP+NVM(NVFU)                                                       AU         590
            LPTE=LP+NVM(NVTE)                                                       AU         591
            FLPTE=F(LPTE)                                                           AU         592
            FLPTE=AMAX1(FLPTE,300.)                                                 AU         593
            F(LPCO)=AMIN1(F(LPCO),RATIO4*(F(LPFUOX)-F(LPFU)))                       AU         594
            FLPOX=RATIO1*F(LPFU)+RATIO3*F(LPCO)+RATIO2-(RATIO2+RATIO1)*             AU         595
           2F(LPFUOX)                                                               AU         596
            FLPOX=AMAX1(FLPOX,0.)                                                   AU         597
            SOR3=-PREEXP2*DEN(LP)**2*F(LPCO)*FLPOX*EXP(-ARCON2/FLPTE)               AU         598
            GO TO (911,912),MODES                                                   AU         599
        911 SORCO=SOR3                                                              AU         600
            GO TO 902                                                               AU         601
        912 CONTINUE                                                                AU         602
            PHI=AMIN1(F(LPCO),FLPOX/RATIO3)                                         AU         603
            SOR4=-CR2*PHI*RHO(LP)*EDK(LPC)                                          AU         604
            SORCO=AMAX1(SOR3,SOR4)                                                  AU         605
        902 FUB=AMAX1(0.,((RATIO2+RATIO1)*F(LPFUOX)-RATIO2-RATIO1*F(LPFU))/         AU         606
           2RATIO3)                                                                 AU         607
            FUB=.5*(F(LPCO)+FUB)                                                    AU         608
            DSDCO=SORCO/(F(LPCO)-FUB+1.E-30)                                        AU         609
            SU(LIJ)=SORCO-DSDCO*F(LPCO)-RATIO4*(SUFU(LP)+SPFU(LP)*F(LPFU))          AU         610
            SP(LIJ)=DSDCO                                                           AU         611
        901 CONTINUE                                                                AU         612
       1900 CONTINUE                                                                AU         613
      COME HERE TO INTRODUCE FALSE INERTIA                                          AU         614
       5000 CONTINUE                                                                AU         615
            RETURN                                                                  AU         616
            END                                                                     AU         617


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

      57     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
      65     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
      86     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     104     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     105     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     115     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     140     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     155     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     162     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     170     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     175     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     209     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     223     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     230     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     561     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     589     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     638     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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      FUNCTION GASP (TT,I)
      DIMENSION AH(7,12),AL(7,12),W(12)
C
C     SPECIES ORDER - FUEL,CO2,CO,O2,H2O,OH,O,H,H2,N,NO,N2
C
      DATA ((AH(I,J),I=1,7),J=1,6)/
     1 0.25845935E+02, 0.46470059E-01,-0.22957813E-04, 0.49494616E-08,
     2-0.37080219E-12,-0.40857112E+05, 0.            ,
     3 .44608641E+01,  .30981719E-02, -.12392571E-05,  .22741325E-09,
     4 -.15525954E-13, -.48961442E+05, -.98635992E+00,
     5 .29840696E+01,  .14891390E-02, -.57899684E-06,  .10364577E-09,
     6 -.69353550E-14, -.14245228E+05,  .63479156E+01,
     7 .36219535E+01,  .73618264E-03, -.19652228E-06,  .36201558E-10,
     8 -.28945627E-14, -.12019825E+04,  .36150960E+01,
     9 .27167633E+01,  .29451374E-02, -.80224374E-06,  .10226682E-09,
     * -.48472145E-14, -.29905826E+05,  .66305671E+01,
     1 .29131230E+01,  .95418248E-03, -.19084325E-06,  .12730795E-10,
     2 .24803794E-15,  .39647060E+04,  .54288735E+01/
C
      DATA ((AH(I,J),I=1,7),J=7,12)/
     1 .25420596E+01, -.27550619E-04, -.31028033E-08,  .45510674E-11,
     2 -.43680515E-15,  .29230803E+05,  .49203080E+01,
     3 .25000000E+01, 0.            , 0.            , 0.            ,
     4 0.            ,  .25471627E+05, -.46011763E+00,
     5 .31001901E+01,  .51119464E-03,  .52644210E-07, -.34909973E-10,
     6 .36945345E-14, -.87738042E+03, -.19629421E+01,
     7 .24502652E+01,  .10661458E-03, -.74653373E-07,  .18796524E-10,
     8 -.10259839E-14,  .56116040E+05,  .44487581E+01,
     9 .31890000E+01,  .13382281E-02, -.52899318E-06,  .95919332E-10,
     * -.64847932E-14,  .98283290E+04,  .67458126E+01,
     1 .28963194E+01,  .15154866E-02, -.57235277E-06,  .99807393E-10,
     2 -.65223555E-14, -.90586184E+03,  .61615148E+01/
C
      DATA ((AL(I,J),I=1,7),J=1,6)/
     1 0.57793475E+01, 0.50561468E-01, 0.51144255E-04,-0.34888140E-07,
     2 0.39503975E-10,-0.29323482E+05, 0.            ,
     3 .24007797E+01,  .87350957E-02, -.66070878E-05,  .20021861E-08,
     4 .63274039E-15, -.48377527E+05,  .96951457E+01,
     5 .37100928E+01, -.16190964E-02,  .35923594E-05, -.20319674E-08,
     6 .23953344E-12, -.14356310E+05,  .29555351E+01,
     7 .36255985E+01, -.18782184E-02,  .70554544E-05, -.67635137E-08,
     8 .21555993E-11, -.10475226E+04,  .43052778E+01,
     9 .40701275E+01, -.11084499E-02,  .41521180E-05, -.29637404E-08,
     * .80702103E-12, -.30279722E+05, -.32270046E+00,
     1 .37365519E+01, -.13702014E-02,  .94649757E-06,  .18713972E-09,
     2 -.22571094E-12,  .36412823E+04,  .49370009E+00/
C
      DATA ((AL(I,J),I=1,7),J=7,12)/
     1 .29464287E+01, -.16381665E-02,  .24210316E-05, -.16028432E-08,
     2 .38906964E-12,  .29147644E+05,  .29639949E+01,
     3 .25000000E+01, 0.            , 0.            , 0.            ,
     4 0.            ,  .25471627E+05, -.46011762E+00,
     5 .30574451E+01,  .26765200E-02, -.58099162E-05,  .55210391E-08,
     6 -.18122739E-11, -.98890474E+03, -.22997056E+01,
     7 .25033714E+01, -.21800181E-04,  .54205287E-07, -.56475603E-10,
     8 .20999044E-13,  .56098904E+05,  .41675764E+01,
     9 .40459521E+01, -.34181783E-02,  .79819190E-05, -.61139316E-08,
     * .15919076E-11,  .97453934E+04,  .29974988E+01,
     1 .36748261E+01, -.12081500E-02,  .23240102E-05, -.63217559E-09,
     2 -.22577253E-12, -.10611558E+04,  .23580424E+01/
C
      DATA W/54.,44.,28.,32.,18.,17.,16.,1.,2.,14.,30.,28./,KOUNT/0/
      DATA TLIM/1500./
C     ***************************************************************
      ENTRY GHT
      T=TT
      IF (T.LT.1000.) GO TO 10
      ABG=AH(1,I)*(1.-ALOG(T))+AH(6,I)/T-(AH(7,I)+T*(AH(2,I)/2.+T*(AH(3,
     2I)/6.+T*(AH(4,I)/12.+T*AH(5,I)/20.))))
      GO TO 15
   10 ABG=AL(1,I)*(1.-ALOG(T))+AL(6,I)/T-(AL(7,I)+T*(AL(2,I)/2.+T*(AL(3,
     1I)/6.+T*(AL(4,I)/12.+T*AL(5,I)/20.))))
   15 GASP=ABG
      RETURN
C     ***************************************************************
      ENTRY CPOP
      T=TT
```

```
      IF (I.EQ.1) T=AMIN1(T,TLIM)
      IF (T.LT.1000.) GO TO 20
      ARG=AM(1,I)+T*(AM(2,I)+T*(AM(3,I)+T*(AM(4,I)+T*AM(5,I))))
      GO TO 25
   20 ARG=AL(1,I)+T*(AL(2,I)+T*(AL(3,I)+T*(AL(4,I)+T*AL(5,I))))
   25 GASP=ARG*1.987*4184./W(I)
      RETURN
C     ******************************************************************
      ENTRY HOR
      T=TT
      IF (I.EQ.1) T=AMIN1(T,TLIM)
      IF (T.LT.1000.) GO TO 30
      ARG=AM(6,I)+T*(AM(1,I)+T*(AM(2,I)/2.+T*(AM(3,I)/3.+T*(AM(4,I)/4.+T
     1*AM(5,I)/5.))))
      GO TO 35
   30 ARG=AL(6,I)+T*(AL(1,I)+T*(AL(2,I)/2.+T*(AL(3,I)/3.+T*(AL(4,I)/4.+T
     1*AL(5,I)/5.))))
   35 GASP=ARG*1.987*4184./W(I)
      IF (TT.LT.TLIM.OR.I.NE.1) RETURN
      CPI=AM(1,I)+T*(AM(2,I)+T*(AM(3,I)+T*(AM(4,I)+T*AM(5,I))))
      ARG=ARG+CPI*(TT-T)/W(I)
      GASP=ARG*1.987*4184./W(I)
      RETURN
C     ******************************************************************
      ENTRY COEF
      KOUNT=KOUNT+1
      IF (KOUNT.EQ.2) GO TO 40
      W(I)=TT
      GASP=W(I)
      RETURN
   40 HFU=TT
      AM(6,I)=HFU/1.987
      AL(6,I)=HFU/1.987
      GASP=AL(6,I)
      RETURN
      END
```

```
              SUBROUTINE AUXRAD                                            AUR        2
              COMMON F(3500),QU(500),QT(500),QV(500),                      COMFB      2
             1  PHI(500),VISC(500),SU(100),SP(100),[illegible](500),       COMFB      3
             1  AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),              COMFB      4
             2  AZM(100),CZ(100),CY(10),CZY(100),CYU(10),                  COMFB      5
             3  CZP(100),CYP(10),DIVG(100),MTP1,MTP2                       COMFB      6
              DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)      COMFB      7
              DIMENSION GAM(500)                                           COMFB      8
              EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))         COMFB      9
              EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1)) COMFB     10
              EQUIVALENCE (F(3001),GAM(1))                                 COMFB     11
              COMMON/CTL/R(30),RM(30),RMV(30),YSR(30),YSVR(30),IPLAX       COMMON     2
              COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),  COMMON     3
             1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40), COMMON    4
             2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                    COMMON     5
              COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NINJ,NINJNK,NV, COMMON 6
             1  NNV,NGOTO,K,ISTR,JSTR,KSTR,NVM(20),KM(30),JM(30),ISTEP,    COMMON     7
             2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP, COMMON 8
             3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI, COMMON    9
             4  IWEG,NNI,JWII,JWIO,JWOI,JWOO,IDW,KCIN(30,30),KKIN(40,30)   COMMON    10
              COMMON/INDEX/IPAR,LPREF,ISTUN,INCOMP,ITRAD,NVRX,NVRY,NVRZ,IP,ANE COMMON 11
             1  ,PLANE1,LVK,LVD,LVFOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13), COMMON   12
             2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCB,FUMCO,NVH2O,NVCO2, COMMON  13
             3  NVN2                                                       COMMON    14
              COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEM,IDK,FSTOIC,MFU,CP, COMMON 15
             1  GASCON,RMOCON,UNICON,PRESS,NVFAV,TCYLW,TIMLW,TLIP,ACOEF(4), COMMON   16
             2  T4,OFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,NYY,CKK,RATIO1,RATIO2,   COMMON    17
             3  RATIO3,RATIO4,NCO,TAN,ITWALL                               COMMON    18
              COMMON/CTDMA/KEND,ICTDMA(13)                                 COMMON    19
              COMMON/MIS/AMU,DEN,SMAX,SSUM,LASTEP,HTCEXT,CFR,EMISW,EMISIN, COMGEN     2
             1  EMISR,TOUT,RTCO,EMI,RADIN,RADSUM,FMA,FK,SOFK,              COMGEN     3
             2  FKFU,FOFU,TFUEL,MFMZ,FLD(40),TENTH(40),H(40),FUEL(40),FUOX(40) , COMGEN 4
             3  UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)        COMGEN     5
              COMMON/TURB/MVK,MVD,C1,C2,CD,AK,OMIDXJ(3,3),AKFAC,ALFAC,     COMGEN     6
             1  MODEL,PR(13),PREF(13),PJAY(13),E                           COMGEN     7
              COMMON/RAD/NVE,SIGMA,ABSOR,SCATR                             COMGEN     8
              COMMON/REACT/ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,MODER       COMGEN     9
              COMMON/DROPL/EVAP(192),NTP4,NFMZ,XD(3),YD(3),ZD(3),ALFA(3),  COMGEN    10
             1  BETA(3),DELTA(3),THETA1(3),THETA2(3),WSL(3),WFF(3),SMD(3), COMGEN    11
             2  VFUEL(3),RFUEL(3),EVSU(64),MEVAP                           COMGEN    12
              COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WUINJ(20),  COMGEN    13
             1  AUINJ(20),TUINJ(20),IVINJ(20),JVINJ(20),KVINJ(20),VINJ(20), COMGEN   14
             2  EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),MUINJ,MVINJ,JSW1,JSW2, COMGEN 15
             3  USW,VSW,AFSW,FSW,TSW,WSW,SWMD,RMOSW                        COMGEN    16
        C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **   AUR   6
              ENTRY GAMRAD                                                 AUR        7
              IF (NV.EQ.LVRY) GO TO 3100                                   AUR        8
              DO 3000 K=1,NP1                                              AUR        9
              DO 3000 J=1,MP1                                              AUR       10
              KJM=KM(K)+JM(J)                                              AUR       11
              IS=IWLI(J,4)                                                 AUR       12
              IE=IWLO(J,4)                                                 AUR       13
              DO 3000 I=IS,IE                                              AUR       14
              LP=KJM+I                                                     AUR       15
              GAM(LP)=1./(ABSOR+SCATR)                                     AUR       16
         3000 CONTINUE                                                     AUR       17
              GO TO 3300                                                   AUR       18
         3100 DO 3200 K=1,NP1                                              AUR       19
              DO 3200 J=1,MP1                                              AUR       20
              KJM=KM(K)+JM(J)                                              AUR       21
              IS=IWLI(J,4)                                                 AUR       22
              IE=IWLO(J,4)                                                 AUR       23
              DO 3200 I=IS,IE                                              AUR       24
              LP=KJM+I                                                     AUR       25
              GAM(LP)=1./(ABSOR+SCATR+1./(R(J)+1.E-30))                    AUR       26
         3200 CONTINUE                                                     AUR       27
         3300 RETURN                                                       AUR       28
        C  **  **  **  **  **  **  **  **  **  **  **  **  **  *-  **  **  **  **  * AUR 29
              ENTRY SORAD                                                  AUR       30
              IF (NV.EQ.LVRZ) GO TO 300                                    AUR       31
              DO 101 J=2,M                                                 AUR       32
              IS=IWLI(J,NGOTO)                                             AUR       33
              IE=IWLO(J,NGOTO)                                             AUR       34
              DO 101 I=IS,IE                                               AUR       35
              LIJ=JM(J)+I                                                  AUR       36
              LP=LIJ+KM(K)                                                 AUR       37
              LPRX=LP+NVM(NVRX)                                            AUR       38
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      SUBROUTINE AJIRAD      73/74    OPT=0 TRACE                  FTN 4.6+439        04/24/79  14.08.46       PAGE     2

                      LPRY=LP+NVM(NVRY)                                                       AUR        39
                      LPRZ=LP+NVM(NVRZ)                                                       AUR        40
  80                  LPTE=LP+NVM(NVTE)                                                       AUR        41
                      FLPTE=F(LPTE)                                                           AUR        42
                      FLPE=SIGMA*FLPTE**4                                                     AUR        43
                      SU(LIJ)=ABSOR*FLPE+SCATR*(F(LPRX)+F(LPRY)+F(LPRZ))/3.                   AUR        44
                      SP(LIJ)=-(ABSOR+SCATR)                                                  AUR        45
  85             101  CONTINUE                                                                AUR        46
                      RETURN                                                                  AUR        47
                 300  CONTINUE                                                                AUR        48
                      DO 301 K=2,N                                                            AUR        49
                      KJN=KN(K)+JN(JPLANE)                                                    AUR        50
  90                  IS=IULI(JPLANE,NGOTO)                                                   AUR        51
                      IE=IULO(JPLANE,NGOTO)                                                   AUR        52
                      DO 301 I=IS,IE                                                          AUR        53
                      LIK=JN(K)+I                                                             AUR        54
                      LP=KJN+I                                                                AUR        55
  95                  LPRX=LP+NVM(NVRX)                                                       AUR        56
                      LPRY=LP+NVM(NVRY)                                                       AUR        57
                      LPRZ=LP+NVM(NVRZ)                                                       AUR        58
                      LPTE=LP+NVM(NVTE)                                                       AUR        59
                      FLPTE=F(LPTE)                                                           AUR        60
 100                  FLPE=SIGMA*FLPTE**4                                                     AUR        61
                      SU(LIK)=ABSOR*FLPE+SCATR*(F(LPRX)+F(LPRY)+F(LPRZ))/3.                   AUR        62
                      SP(LIK)=-(ABSOR+SCATR)                                                  AUR        63
                 301  CONTINUE                                                                AUR        64
                      RETURN                                                                  AUR        65
 105                  END                                                                     AUR        66

 CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     48      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     58      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     88      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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      SUBROUTINE SPRAY                                                  SP         2
C ************** ****** SUBROUTINE SPRAY ****************************** SP         3
C     SUBROUTINE FOR AIRTRIP CODE WHICH CALCULATES THE TRAJECTORY       SP         4
C     AND EVAPORATION RATES FOR A FUEL NOZZLE SPRAY.  WRITTEN NOV. 1976 SP         5
C ******************************************************************** SP         6
      COMMON F(3500),DU(500),DV(500),DW(500),                           COMFB      2
     1 RHO(500),VISC(500),SU(100),SP(100),DRHODP(500),                  COMFB      3
     1 AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),                    COMFB      4
     2 AZM(100),CZ(100),CT(10),CZU(100),CYU(10),                        COMFB      5
     3 CZP(100),CYP(10),DIVG(120),KTP1,KTP2                             COMFB      6
      DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)           COMFB      7
      DIMENSION GAM(500)                                                COMFB      8
      EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))              COMFB      9
      EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1))      COMFB     10
      EQUIVALENCE (F(3001),GAM(1))                                      COMFB     11
      COMMON/CYL/R(30),RM(30),RMV(30),YSR(30),YSVR(30),IPLAX            COMMON     2
      COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),       COMMON     3
     1 YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),      COMMON     4
     2 FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                          COMMON     5
      COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NIMJ,NIMJNK,NV, COMMON     6
     1 NNV,NGOTO,K,ISTE,JSTE,KSTE,NVM(20),KM(30),JM(30),ISTEP,          COMMON     7
     2 ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,   COMMON     8
     3 NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,      COMMON     9
     4 IWEO,NM1,JWII,JWIO,JWOI,JWOO,IOW,JKIN(30,30),IKIN(40,30)         COMMON    10
      COMMON/INDEX/IPAR,LPREF,ISTUN,INCOMP,ITRAD,NVRX,NVRY,NVRZ,JPLANE  COMMON    11
     1 ,PLANMI,LLK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),     COMMON    12
     2 IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,     COMMON    13
     3 NVN2                                                             COMMON    14
      COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEN,IDK,FSTOIC,HFU,CP,   COMMON    15
     1 GASCON,RHOCON,UMICON,PRESS,MVFAV,TCYLW,TINLW,TLIP,ACDEF(4),      COMMON    16
     2 T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HCT,CXX,RATIO1,RATIO2,         COMMON    17
     3 RATIO3,RATIO4,HCO,TAR,ITWALL                                     COMMON    18
      COMMON/CTOMA/REND,ICTOM(13)                                       COMMON    19
      COMMON/MIS/AMU,DEN,SMAX,SSUM,LASTEP,MTCEXT,CFR,EMISW,EMISIN,      COMGEN     2
     1 EMISR,TOUT,RTCO,EMI,RADIN,RADSUR,FMA,FY,SOFK,                    COMGEN     3
     2 FKFU,FOFU,TFUEL,WFMZ,FLO(40),TEMTM(40),H(40),FUEL(40),FUOX(40) , COMGEN     4
     3 UIN(40),TIN(40),FUELS(40),SEXIT,IGAM1(10),IGAM2(10)              COMGEN     5
      COMMON/TURB/NVK,NVD,C1,C2,CD,AK,DUIDXJ(3,3),AKFAC,ALFAC,          COMGEN     6
     1 MODEL,PR(13),PREF(13),PJAT(13),E                                 COMGEN     7
      COMMON/RAD/NVE,SIGMA,ABSOR,SCATR                                  COMGEN     8
      COMMON/REACT/ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,MODER            COMGEN     9
      COMMON/DROVL/EVAP(192),NTP6,NFMZ,XO(3),YO(3),ZO(3),ALFA(3),       COMGEN    10
     1 BETA(3),DELTA(3),THETA1(3),THETA2(3),WSL(3),WFF(3),SMD(3),       COMGEN    11
     2 VFUEL(3),RFUEL(3),EVSU(64),HEVAP                                 COMGEN    12
      COMMON/INJEC/FLOWIN,IUINJ(20),JUINJ(20),UINJ(20),WUINJ(20),       COMGEN    13
     1 AUINJ(20),TUINJ(20),IVINJ(20),JVINJ(20),KVINJ(20),VINJ(20),      COMGEN    14
     2 EVINJ(20),DVINJ(20),AVINJ(20),TVINJ(20),NUINJ,NVINJ,JSW1,JSW2,   COMGEN    15
     3 USW,VSW,AFSW,FSW,TSW,WSW,SUMD,RHOSW                              COMGEN    16
      DIMENSION AXMK(192),AYMK(192),AZMK(192)                           SP        11
      DIMENSION VECX(30),VECY(30),VECZ(30),DSMD(5),XM(40),YM(30),ZM(30) SP        12
      DIMENSION PO(4),EE(4),FRACT(7),MW(7),MWCOND(4),ACOND(4),BCOND(4)  SP        13
      DIMENSION EVAPU(1),EVAPV(1),EVAPW(1),RVECX(30),RVECY(30),RVECZ(30) SP       14
      REAL MW,MWCOND,MWT                                                SP        15
C +-+-+-+-+-+-+-+-  BEWARE OF EQUIVALENCE STATEMENTS  +-+-+-+-+-+-+-+-- SP        16
      EQUIVALENCE (EVAPU(1),AXMK(1)),(EVAPV(1),AYMK(1))                 SP        17
      EQUIVALENCE (EVAPW(1),AZMK(1))                                    SP        18
C +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-- SP        19
      DATA DSMD/.6,.9,1.2,1.5,2.1/                                      SP        20
      DATA PO,EE/-114.,41.574,96.534,146.57,41.026,30.857,27.248,23.997/ SP       21
      DATA FRACT,MW/0.,.1,.3,.5,.7,.9,1.,93.26,114.6,126.61,138.16      SP        22
     1             ,150.59,173.21,204.76/                               SP        23
      DATA ACOND,BCOND,MWCOND/-6.362E-3,-6.356E-3,-6.286E-3,-6.01E-3    SP        24
     1,5.38E-5,4.91E-5,4.66E-5,4.23E-5,50.,100.,150.,300./              SP        25
      DATA NG,RNG,PI,PI2/5,5.,3.14159,6.28318/                          SP        26
C ******************************************************************** SP        27
C -----------SOME PRELIMINARIES                                         SP        28
      IF (NFMZ.LE.0) RETURN                                             SP        29
      SC3=.9283                                                         SP        30
      PR3=.9283                                                         SP        31
      DLIM=.1                                                           SP        32
      ULIM=.1                                                           SP        33
      TF=2300.                                                          SP        34
      HEVAP=30576.6*(1092.88-1.8*TFUEL)**.39                            SP        35
      MFUEL=4.5E+7                                                      SP        36
      RDFO=1000.*(.775+.208-.00072*TFUEL)                               SP        37
      ZSMALL=(Z(NP1)-Z(1))/FLOAT(NP1)/100.                              SP        38
      DO 7 K=2,N                                                        SP        39
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          DO 7 J=2,M                                                      SP        40
          DO 7 I=2,L                                                      SP        41
          LPC=I-1+(J-2)*(NI-2)+(K-2)*(NI-2)*(NJ-2)                        SP        42
          EVAPU(LPC)=0.                                                   SP        43
          EVAPV(LPC)=0.                                                   SP        44
          EVAPW(LPC)=0.                                                   SP        45
        7 EVAP(LPC)=0.                                                    SP        46
          XM(1)=X(1)                                                      SP        47
          DO 115 I=2,L                                                    SP        48
      115 XM(I)=XM(I-1)+XS(I)                                             SP        49
          XM(LP1)=XM(L)                                                   SP        50
          YM(1)=Y(1)                                                      SP        51
          DO 17 J=2,M                                                     SP        52
       17 YM(J)=YM(J-1)+YS(J)                                             SP        53
          YM(MP1)=YM(M)                                                   SP        54
          ZM(1)=Z(1)                                                      SP        55
          DO 19 K=2,N                                                     SP        56
       19 ZM(K)=ZM(K-1)+ZS(K)                                             SP        57
          ZM(NP1)=ZM(N)                                                   SP        58
      C ***************************************************************** SP        59
      C ----------LOOP OVER FUEL NOZZLES                                  SP        60
          DO 2000 NN=1,NFNZ                                               SP        61
          BEE=0.                                                          SP        62
          NSL2=NSL(NN)                                                    SP        63
          RNSL=NSL2                                                       SP        64
          WFI=WFF(NN)/RNSL                                                SP        65
      C ----------CALCULATE UNIT VECTORS OF SPRAY LINES                   SP        66
          SINA=SIN(ALFA(NN)/2.)                                           SP        67
          SINB=SIN(BETA(NN))                                              SP        68
          SIND=SIN(DELTA(NN))                                             SP        69
          COSA=COS(ALFA(NN)/2.)                                           SP        70
          COSB=COS(BETA(NN))                                              SP        71
          COSD=COS(DELTA(NN))                                             SP        72
          DTHETA=THETA2(NN)-THETA1(NN)                                    SP        73
          IF (DTHETA.LT.0.0) DTHETA=DTHETA+PT2                            SP        74
          DANG=DTHETA/(RNSL-1.)                                           SP        75
          IF (DTHETA.GT.0.98*PT2) DANG=DTHETA/RNSL                        SP        76
          THETA=THETA1(NN)                                                SP        77
          DO 10 IL=1,NSL2                                                 SP        78
          SINT=SIN(THETA)                                                 SP        79
          COST=COS(THETA)                                                 SP        80
          THETA=THETA+DANG                                                SP        81
          IF (THETA.GT.PT2) THETA=THETA-PT2                               SP        82
          VECX(IL)=-SINA*SINT*COSB-COSA*SINB                              SP        83
          VECY(IL)=SINA*COST*COSD+SINA*SINT*SINB*SIND-COSA*COSB*SIND      SP        84
          VECZ(IL)=SINA*COST*SIND-SINA*SINT*SINB*COSD+COSA*COSB*COSD      SP        85
          RVECX(IL)=-SINT*COSB                                            SP        86
          RVECY(IL)=COST*COSD+SINT*SINB*SIND                              SP        87
          RVECZ(IL)=COST*SIND-SINT*SINB*COSD                              SP        88
       10 CONTINUE                                                        SP        89
      C****************************************************************** SP        90
      C------START CALCULATIONS FOR EVAPORATION RATES-------------------- SP        91
          DO 1000 IL=1,NSL2                                               SP        92
          DO 1000 IG=1,NG                                                 SP        93
          UF=VECX(IL)*VFUEL(NN)                                           SP        94
          VF=VECY(IL)*VFUEL(NN)                                           SP        95
          WF=VECZ(IL)*VFUEL(NN)                                           SP        96
          DIA=SMD(NN)*1.E-6*DSMD(IG)                                      SP        97
          TFU=TFUEL                                                       SP        98
          ITYPE=1                                                         SP        99
          DIAO=DIA                                                        SP       100
          CONZ=0.                                                         SP       101
          IGPNT=-10                                                       SP       102
          IF (ISTEP.NE.IGPNT) GO TO 7746                                  SP       103
          WRITE (6,7747)                                                  SP       104
     7747 FORMAT (/10X,'UF',10X,'VF',10X,'WF',9X,'UST',9X,'VST',9X,'WST', SP       105
         1 7X,'FEVAP',10X,'XF',10X,'YF',10X,'ZF')                         SP       106
     7746 CONTINUE                                                        SP       107
          FEVAP=0.                                                        SP       108
          DO 11 I=1,LP1                                                   SP       109
          ILOC=I                                                          SP       110
          IF (XO(NN).GT.XM(I)) GO TO 11                                   SP       111
          GO TO 12                                                        SP       112
       11 CONTINUE                                                        SP       113
       12 DO 13 J=1,MP1                                                   SP       114
          JLOC=J                                                          SP       115
          IF (YO(NN).GT.YM(J)) GO TO 13                                   SP       116
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            GO TO 14                                                            SP       117
         13 CONTINUE                                                            SP       118
         14 DO 15 K=1,NP1                                                       SP       119
            KLOC=K                                                              SP       120
            IF (ZO(NN).GT.ZM(K)) GO TO 15                                       SP       121
            GO TO 16                                                            SP       122
         15 CONTINUE                                                            SP       123
         16 XF=XO(NN)+RFUEL(NN)*RVECX(IL)                                       SP       124
            YF=YO(NN)+RFUEL(NN)*RVECY(IL)                                       SP       125
            ZF=ZO(NN)+RFUEL(NN)*RVECZ(IL)/(R(1)+PLAXMI*YF)                      SP       126
      C-----LOCATION OF THE DROPLET-----------                                  SP       127
        110 CONTINUE                                                            SP       128
            IOLD=ILOC                                                           SP       129
            JOLD=JLOC                                                           SP       130
            KOLD=KLOC                                                           SP       131
      C -----X DROPLET LOCATION                                                 SP       132
            IF (XF.GE.XM(ILOC-1).AND.XF.LT.XM(ILOC)) GO TO 27                   SP       133
            DO 22 I=1,LP1                                                       SP       134
            ILOC=I                                                              SP       135
            IF (XF.GT.XM(I)) GO TO 22                                           SP       136
            GO TO 27                                                            SP       137
         22 CONTINUE                                                            SP       138
      C -----Y DROPLET LOCATION                                                 SP       139
         27 IF (YF.GE.YM(JLOC-1).AND.YF.LT.YM(JLOC)) GO TO 23                   SP       140
            DO 24 J=1,MP1                                                       SP       141
            JLOC=J                                                              SP       142
            IF (YF.GT.YM(J)) GO TO 24                                           SP       143
            GO TO 23                                                            SP       144
         24 CONTINUE                                                            SP       145
      C -----Z DROPLET LOCATION                                                 SP       146
         23 IF (ZF.GE.ZM(KLOC-1).AND.ZF.LT.ZM(KLOC)) GO TO 63                   SP       147
            DO 26 K=1,NP1                                                       SP       148
            KLOC=K                                                              SP       149
            IF (ZF.GT.ZM(K)) GO TO 26                                           SP       150
            GO TO 48                                                            SP       151
         26 CONTINUE                                                            SP       152
         48 IF (KLOC.GT.1) GO TO 28                                             SP       153
            KLOC=N                                                              SP       154
            ZF=Z(NP1)-ZSMALL                                                    SP       155
         28 IF (KLOC.LT.NP1) GO TO 63                                           SP       156
            KLOC=2                                                              SP       157
            ZF=Z(1)+ZSMALL                                                      SP       158
      C -----DROPLET NEAR A WALL                                                SP       159
         63 INDX=0                                                              SP       160
            IF (ILOC.GE.IWLI(JLOC,4)) GO TO 43                                  SP       161
            ILOC=IOLD                                                           SP       162
            XF=AMAX1(XF,XM(ILOC-1)+DIA/2.)                                      SP       163
            XF=AMIN1(XF,XM(ILOC)-DIA/2.)                                        SP       164
            INDX=1                                                              SP       165
         43 IF (ILOC.LE.IWLO(JLOC,4)) GO TO 47                                  SP       166
            IF (JLOC.GT.JWOI.AND.JLOC.LT.JWOO) GO TO 1000                       SP       167
            ILOC=IOLD                                                           SP       168
            XF=AMAX1(XF,XM(ILOC-1)+DIA/2.)                                      SP       169
            XF=AMIN1(XF,XM(ILOC)-DIA/2.)                                        SP       170
            INDX=2                                                              SP       171
         47 IF (JLOC.GT.JWLI(ILOC,4)) GO TO 44                                  SP       172
            IF (IOW.EQ.0) GO TO 50                                              SP       173
            JLOC=JOLD                                                           SP       174
            YF=AMAX1(YF,YM(JLOC-1)+DIA/2.)                                      SP       175
            YF=AMIN1(YF,YM(JLOC)-DIA/2.)                                        SP       176
            INDX=3                                                              SP       177
         44 IF (JLOC.LT.JWLO(ILOC,4)) GO TO 41                                  SP       178
            JLOC=JOLD                                                           SP       179
            YF=AMAX1(YF,YM(JLOC-1)+DIA/2.)                                      SP       180
            YF=AMIN1(YF,YM(JLOC)-DIA/2.)                                        SP       181
            INDX=4                                                              SP       182
      C -----CHECK FOR SLOTS                                                    SP       183
         41 IF (NUINJ.LE.0) GO TO 45                                            SP       184
            DO 149 II=1,NUINJ                                                   SP       185
            IU=IUINJ(II)-1                                                      SP       186
            JU=JUINJ(II)                                                        SP       187
            IF (ILOC.EQ.IU.AND.JLOC.EQ.JU) GO TO 50                             SP       188
        149 CONTINUE                                                            SP       189
         45 CONTINUE                                                            SP       190
            GO TO 63                                                            SP       191
      C ---------DROPLET HAS HIT SOLID BOUNDARY                                 SP       192
         50 ILOC=IOLD                                                           SP       193
```

```
      JLOC=JOLD
      KLOC=KOLD
      DEVAP=1.-FEVAP
      UF=0.
      VF=0.
      WF=0.
      FX=0.
      FY=0.
      FZ=0.
      GO TO 249
C ---------NO BOUNDRIES HAVE BEEN HIT
   60 CONTINUE
      LP=KM(KLOC)+JM(JLOC)+ILOC
      LXP=LP+1
      LYP=LP+NI
      LZP=LP+NIJ
      LPTE=LP+NVN(NVTE)
      LPFUOX=LP+NVR(NVFUOX)
C -------- CAREFUL HERE
      LPFU=LP+NVN(NVFU+3)
      LPCO=LP+NVN(NVCO+1)
C -----FREESTREAM PROPERTIES
      ROST=RHO(LP)
      TST=F(LPTE)
      UST=FXP(ILOC)*U(LP)+FXM(ILOC)*U(LXP)
      VST=FYP(JLOC)*V(LP)+FYM(JLOC)*V(LYP)
      WST=FZP(KLOC)*W(LP)+FZM(KLOC)*W(LZP)
      IB=IWLI(JLOC,4)
      IF (XF.GE.X(IB)) GO TO 51
      IF (JKIN(JLOC,KLOC).EQ.1) GO TO 51
      FAC=((XF-XM(IB-1))/(X(IB)-XM(IB-1)))**.14286
      UST=0.
      VST=VST*FAC
      WST=WST*FAC
      IF (INDX.NE.1) GO TO 51
      UF=UST
      VF=VST
      WF=WST
   51 IB=IWLO(JLOC,4)
      IF (XF.LE.X(IB)) GO TO 56
      IF (JLOC.GT.JWO1.AND.JLOC.LT.JWO3) GO TO 56
      FAC=((XM(IB)-XF)/(XM(IB)-X(IB)))**.14286
      UST=0.
      VST=VST*FAC
      WST=WST*FAC
      IF (INDX.NE.2) GO TO 56
      UF=UST
      VF=VST
      WF=WST
   56 JB=JWLI(ILOC,4)
      IF (YF.GE.Y(JB+1)) GO TO 53
      IF (IKIN(ILOC,KLOC).EQ.1.OR.IKIN(ILOC,KLOC).EQ.3) GO TO 53
      FAC=((YF-YM(JB))/(Y(JB+1)-YM(JB)))**.14286
      UST=UST*FAC
      VST=0.
      WST=WST*FAC
      IF (INDX.NE.3) GO TO 53
      UF=UST
      VF=VST
      WF=WST
   53 JB=JWLO(ILOC,4)
      IF (YF.LE.Y(JB-1)) GO TO 54
      IF (IKIN(ILOC,KLOC).EQ.2.OR.IKIN(ILOC,JLOC).EQ.3) GO TO 54
      FAC=((YM(JB-1)-YF)/(YM(JB-1)-Y(JB-1)))**.14286
      UST=UST*FAC
      VST=0.
      WST=WST*FAC
      IF (INDX.NE.4) GO TO 54
      UF=UST
      VF=VST
      WF=WST
   54 CONTINUE
      FLPOX=RATIO1*F(LPFU)+RATIO3*F(LPCO)+RATIO2-(RATIO2+RATIO1)*
     2F(LPFUOX)
      FLPOX=AMAX1(FLPOX,0.)
      IF (ISTEP.NE.IGPNT) GO TO 7744
      WRITE (6,7745) UF,VF,WF,UST,VST,WST,FEVAP,XF,YF,ZF
```

```
      7745 FORMAT (10E12.4)
      7744 CONTINUE
    C -----BOILING TEMPERATURE OF FUEL----------------------------------------
           POT=PG(4)
           ET=EE(4)
           IF(FEVAP.GE.0.5) GO TO 200
           POT=TAB(FEVAP,FRACT,PG,4)
           ET=TAB(FEVAP,FRACT,EE,4)
       200 TB=ET*ALOG(PRESS)+POT
           T1=(TB+TF)/2.
           TFU=AMIN1(TFU,TB)
    C------DENSITY OF LIQUID FUEL AT TB
           ROF=1.076/(1.+(1.076/.775-1.)*(1.-.67*FEVAP))
           ROF=1000.*(ROF+.209-.00072*TFU)
    C------MOLECULAR WEIGHT OF FUEL VAPORS
           MWT=TAB(FEVAP,FRACT,MW,7)
           AT=TAB(MWT,MWCOND,ACOND,4)
       300 BT=TAB(MWT,MWCOND,BCOND,4)
    C------THERMAL CONDUCTIVITY AND SPECIFIC HEAT OF FUEL VAPORS
           COND1=1.729*(AT+BT*T1)
           CP1=CPDR(T1,1)
       400 COND1=0.4*COND1+0.6*.064*SQRT(T1/1111.)
    C -----RELATIVE VEL, REYNOLDS NO.,DRAG COEF AND FORCE COMPONENTS
           VR=SQRT((UF-UST)**2+(VF-VST)**2+(WF-WST)**2)
           VISCO=4.464E-5*SQRT(TST/1111.)
           REI=ROST*VR*DIA/VISCO
           SREI=SQRT(REI)
           CDS=2.0
           IF (REI.GT.22.16.AND.REI.LE.80.) CDS=27./REI**.84
           IF (REI.GT.80..AND.REI.LT.10000.) CDS=.271*REI**.217
           CD1=AMAX1(CDS/2.,CDS/(1.+BEE))
           CONS=CD1*3.14159/4.*DIA**2/2.*ROST
           DM=PI*DIA**3*ROF/6.
           FX=CONS*ABS(UF-UST)*(UST-UF)
           FY=CONS*ABS(VF-VST)*(VST-VF)+PLAXM1*DM*WF*WF/R(JLOC)
           FZ=CONS*ABS(WF-WST)*(WST-WF)-PLAXM1*DM*VF*WF/R(JLOC)
           VFU=SQRT(UF**2+VF**2+WF**2)
           FAC=AMAX1(1.0,25./(VR*VR+1.E-20))
           DTI1=ULIM*VFU*DM*FAC/(ABS(FX)+1.E-30)
           DTI2=ULIM*VFU*DM*FAC/(ABS(FY)+1.E-30)
           DTI3=ULIM*VFU*DM*FAC/(ABS(FZ)+1.E-30)
           DTI4=DLIM/(COND2+1.E-30)
           DTI5=XS(ILOC)/(ABS(UF)+1.E-20)
           DTI6=YS(JLOC)/(ABS(VF)+1.E-20)
           DTI7=R(JLOC)*ZS(KLOC)/(ABS(WF)+1.E-20)
           DTI=AMIN1(DTI1,DTI2,DTI3,DTI4,DTI5,DTI6,DTI7)
           CONS=DM/DTI
    C------VELOCITY AND LOCATION OF THE DROPLET
           UFO=UF
           VFO=VF
           WFO=WF
           UF=UF+FX/CONS
           VF=VF+FY/CONS
           WF=WF+FZ/CONS
           IF (UFO.GT.UST) UF=AMAX1(UF,UST-.001)
           IF (UFO.LT.UST) UF=AMIN1(UF,UST+.001)
           IF (VFO.GT.VST) VF=AMAX1(VF,VST-.001)
           IF (VFO.LT.VST) VF=AMIN1(VF,VST+.001)
           IF (WFO.GT.WST) WF=AMAX1(WF,WST-.001)
           IF (WFO.LT.WST) WF=AMIN1(WF,WST+.001)
           DX=.5*(UF+UFO)*DTI
           DY=.5*(VF+VFO)*DTI
           DZ=.5*(WF+WFO)*DTI
           XF=XF+DX
           YF=YF+DY
           ZF=ZF+DZ/R(JLOC)
           IF (TFU.GE.TB) ITYPE=2
           GO TO (185,199), ITYPE
    C-------------        HEATING DROPLET  -----------------------------------------
    C -----HEAT TRANSFER
       185 HT=COND1*(2.+.6*PR3*SREI)/DIA
           AS=PI*DIA*DIA
           QDOT=AS*HT*(TST-TFU)
           CPLF=540.5+4.1372*TFU
           DTF=DTI*QDOT/DM/CPLF
           TFU=TFU+DTF
           GO TO 110
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SUBROUTINE SPRAY      73/74   OPT=0 TRACE                    FTN 4.6+439        08/24/78  14.08.46        PAGE    5

      C ----------    BOILING DROPLET  ---------------------------------          SP       348
      C------MASS TRANSFER NUMBER                                                 SP       349
        199 IF (F(LPF,NCI)-FSTOIC) 210,205,201                                    SP       350
        201 BEE=AMAX1(CP1*(TST-TB)/HEVAP,0.)                                      SP       351
            GO TO 215                                                             SP       352
        205 BEE=FLPOX/RATIO1                                                      SP       353
            GO TO 215                                                             SP       354
        210 BEE=(FLPOX*HFUEL/RATIO1+AMAX1(CP1*(TST-TB),0.))/HEVAP                 SP       355
        215 RATE=6./ROF*COND1/CP1*ALOG(1.+BEE)*(1.+0.276*SREI*SC3)                SP       356
      C------FRACTION EVAPORATED                                                  SP       357
            CON2=1.5/ROFU/DIA0**3*ROF*DIA*RATE                                    SP       358
            DEVAP=CON2*DTI                                                        SP       359
        240 FEVAP=FEVAP+DEVAP                                                     SP       360
            IF (FEVAP.LT.1.0) GO TO 250                                           SP       361
            DEVAP=DEVAP-FEVAP+1.                                                  SP       362
            FEVAP=1.                                                              SP       363
      C -----NEW DROPLET DIAMETER                                                 SP       364
        250 ARG=DIA*DIA-RATE*DTI                                                  SP       365
            IF (ARG.GT.0.0) GO TO 262                                             SP       366
            DEVAP=DEVAP+1.-FEVAP                                                  SP       367
            FEVAP=1.0                                                             SP       368
            GO TO 252                                                             SP       369
        262 DIA=SQRT(ARG)                                                         SP       370
      C ----------- FUEL EVAPORATION FLOW RATE   ----------------------           SP       371
        252 AMT=DEVAP*WFI/RMG                                                     SP       372
            LPC=(ILOC-1)+(JLOC-2)*(NI-2)+(KLOC-2)*(NI-2)*(NJ-2)                   SP       373
            EVAP(LPC)=EVAP(LPC)+AMT                                               SP       374
            EVAPU(LPC)=EVAPU(LPC)+AMT*UF                                          SP       375
            EVAPV(LPC)=EVAPV(LPC)+AMT*VF                                          SP       376
            EVAPW(LPC)=EVAPW(LPC)+AMT*WF                                          SP       377
        900 IF (FEVAP.LT.0.99) GO TO 110                                          SP       378
       1000 CONTINUE                                                              SP       379
       2000 CONTINUE                                                              SP       380
      C ***************************************************************           SP       381
      C ------- STORE MOMENTUM DATA ON TAPE4                                      SP       382
            REWIND NTP4                                                           SP       383
            DO 1100 K=2,N                                                         SP       384
            DO 1110 J=2,M                                                         SP       385
            KJC=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                                  SP       386
            DO 1110 I=3,L                                                         SP       387
            LIJ=(J-2)*(NI-2)+(I-1)                                                SP       388
            LPC=KJC+(I-1)                                                         SP       389
            LXMC=LPC-1                                                            SP       390
            EVSU(LIJ)=FXM(I-1)*EVAPU(LXMC)+FXP(I)*EVAPU(LPC)                      SP       391
            IF (I.EQ.3) EVSU(LIJ)=EVSU(LIJ)+FXP(2)*EVAPU(LXMC)                    SP       392
            IF (I.EQ.L) EVSU(LIJ)=EVSU(LIJ)+FXM(L)*EVAPU(LPC)                     SP       393
       1110 CONTINUE                                                              SP       394
            WRITE (NTP4) EVSU                                                     SP       395
       1100 CONTINUE                                                              SP       396
            DO 1200 K=2,N                                                         SP       397
            DO 1210 J=3,M                                                         SP       398
            KJC=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                                  SP       399
            DO 1210 I=2,L                                                         SP       400
            LIJ=(J-2)*(NI-2)+(I-1)                                                SP       401
            LPC=KJC+(I-1)                                                         SP       402
            LYMC=LPC-(NI-2)                                                       SP       403
            EVSU(LIJ)=FYM(J-1)*EVAPV(LYMC)+FYP(J)*EVAPV(LPC)                      SP       404
            IF (J.EQ.3) EVSU(LIJ)=EVSU(LIJ)+FYP(2)*EVAPV(LYMC)                    SP       405
            IF (J.EQ.M) EVSU(LIJ)=EVSU(LIJ)+FYM(M)*EVAPV(LPC)                     SP       406
       1210 CONTINUE                                                              SP       407
            WRITE (NTP4) EVSU                                                     SP       408
       1200 CONTINUE                                                              SP       409
            DO 1300 K=3,NP1                                                       SP       410
            DO 1310 J=2,M                                                         SP       411
            KJC=(K-2)*(NI-2)*(NJ-2)+(J-2)*(NI-2)                                  SP       412
            DO 1310 I=2,L                                                         SP       413
            LIJ=(J-2)*(NI-2)+(I-1)                                                SP       414
            LPC=KJC+(I-1)                                                         SP       415
            LZMC=LPC-(NI-2)*(NJ-2)                                                SP       416
            EVSU(LIJ)=FZM(K-1)*EVAPW(LZMC)                                        SP       417
            IF (K.EQ.NP1) GO TO 1309                                              SP       418
            EVSU(LIJ)=EVSU(LIJ)+FZP(K)*EVAPW(LPC)                                 SP       419
            GO TO 1310                                                            SP       420
       1309 EVSU(LIJ)=EVSU(LIJ)+FZP(2)*EVAPW(LIJ)                                 SP       421
       1310 CONTINUE                                                              SP       422
            WRITE (NTP4) EVSU                                                     SP       423
       1300 CONTINUE                                                              SP       424
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      SUBROUTINE SPRAY      73/74    OPT=0 TRACE                    FTN 4.6+439         08/24/78  14.06.46          PAGE     7

                      RETURN                                                              SP        423
                      END                                                                 SP        426


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     77      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     94      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    137      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    186      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    376      I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    422      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    435      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    449      I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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        FUNCTION TAB        73/74    OPT=0 TRACE                FTN 4.6+439         08/24/76  14.08.46        PAGE    1

                      FUNCTION TAB (X,XX,YY,NTAB)                                      SP        427
                      DIMENSION XX(1),YY(1)                                            SP        428
                      IF (NTAB.GT.0) GO TO 5                                           SP        429
                      TAB=0.0                                                          SP        430
                      RETURN                                                           SP        431
                    5 F=1.                                                             SP        432
                      IF (XX(1).GT.XX(2)) F=-F                                         SP        433
                      DO 10 J=1,NTAB                                                   SP        434
                      I=J                                                              SP        435
                      IF (F*(XX(I)-X)) 10,40,20                                        SP        436
                   10 CONTINUE                                                         SP        437
                   20 IF (I.NE.1) GO TO 30                                             SP        438
                      I=2                                                              SP        439
                   30 J=I-1                                                            SP        440
                      DEL=XX(I)-XX(J)                                                  SP        441
                      IF (DEL.EQ.0.0) GO TO 50                                         SP        442
                      TAB=(YY(I)*(X-XX(J))-YY(J)*(X-XX(I)))/DEL                        SP        443
                      RETURN                                                           SP        444
                   40 TAB=YY(I)                                                        SP        445
                      RETURN                                                           SP        446
                   50 WRITE (6,60) X,I,J                                               SP        447
                   60 FORMAT (* *** ERROR IN SUBROUTINE TAB ***,E15.4,2I5)             SP        448
                      STOP                                                             SP        449
                      END                                                              SP        450

  CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

       7     I       XX         ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
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SUBROUTINE STRIDE      73/74    OPT=2 TRACE                  FTN 4.6+439        09/24/79  14.08.46        PAGE      1

                  SUBROUTINE STRIDE                                                   ST         2
                  COMMON F(3500),DU(500),DV(500),DW(500),                             COMFB      2
                 1  RHO(500),VISC(500),SU(100),SP(100),DRHODP(500),                   COMFB      3
                 1  AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),                     COMFB      4
                 2  AZM(100),CZ(100),CY(100),CZG(100),CYU(10),                        COMFB      5
                 3  CZP(100),CYP(10),DIFF(100),NTPL,NTPZ                              COMFB      6
                  DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)             COMFB      7
                  DIMENSION GAM(500)                                                  COMFB      8
                  EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))                COMFB      9
                  EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1))        COMFB     10
                  EQUIVALENCE (F(3001),GAM(1))                                        COMFB     11
                  COMMON/CYL/R(30),RM(30),RMV(30),YSR(30),YSVR(30),IPLAX              COMMON     2
                  COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),         COMMON     3
                 1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),       COMMON     4
                 2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                           COMMON     5
                  COMMON/INTG/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NIMJ,NIMJNK,NV,  COMMON     6
                 1  NMJ,NCCTD,K,ISTR,JSTR,KSTR,NVP(20),KM(30),JM(30),ISTEP,           COMMON     7
                 2  ISOLVE(13),IPRINT(22),TITLE(10,22),ISV,ISWP,JSWP,RELAX(16),NP,    COMMON     8
                 3  NGAM,NGZP,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,       COMMON     9
                 4  IWEO,NNI,JWII,JWIO,JWOI,JWOO,IDW,JKIN(30,30),IKIN(40,30)          COMMON    10
                  COMMON/INDEX/IPAR,LPREF,ISTOM,INCOMP,ITRAD,NVRX,NVRY,NVRZ,IPLANE    COMMON    11
                 1  ,PLANEI,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),      COMMON    12
                 2  IJUMP,IRES,TITLE2(20),IPRK,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,      COMMON    13
                 3  NVN2                                                              COMMON    14
                  COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEM,IOX,FSTOIC,MFU,CP,     COMMON    15
                 1  GASCON,RHOCON,UMICON,PRESS,NVFAV,TCYLW,TINLW,TLIP,ACOEF(4),       COMMON    16
                 2  T0,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,NYY,CXX,RATIO1,RATIO2,          COMMON    17
                 3  RATIO3,RATIO4,NCG,TAW,ITCALL                                      COMMON    18
                  COMMON/CTOMA/KEND,ICTOMA(13)                                        COMMON    19
                  ENTRY STRIDO                                                        ST         5
                  ISV=1                                                               ST         6
                  ISWP=1                                                              ST         7
                  JSWP=1                                                              ST         8
                  TIME=0.                                                             ST         9
                  L=LP1-1                                                             ST        10
                  M=MP1-1                                                             ST        11
                  N=NP1-1                                                             ST        12
                  LCV=L-1                                                             ST        13
                  MCV=M-1                                                             ST        14
                  NCV=N-1                                                             ST        15
                  NM1=N-1                                                             ST        16
                  NIMJ=NI*NJ                                                          ST        17
                  NIMJNK=NIMJ*NK                                                      ST        18
                  NVP(1)=0                                                            ST        19
                  DO 1 NV=2,NGAM                                                      ST        20
          1       NVP(NV)=NVP(NV-1)+NIMJNK                                            ST        21
                  KM(1)=0                                                             ST        22
                  DO 2 K=2,NP1                                                        ST        23
          2       KM(K)=KM(K-1)+NIMJ                                                  ST        24
                  JM(1)=0                                                             ST        25
                  MAX=MAX0(MP1,NP1)                                                   ST        26
                  DO 3 J=2,MAX                                                        ST        27
          3       JM(J)=JM(J-1)+NI                                                    ST        28
                  RETURN                                                              ST        29
          C **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  * ST        30
                  ENTRY STRID1                                                        ST        31
                  DO 101 I=2,LP1                                                      ST        32
        101       XDIF(I)=X(I)-X(I-1)                                                 ST        33
                  DO 111 I=2,L                                                        ST        34
        111       XS(I)=0.5*(X(I+1)-X(I-1))                                           ST        35
                  XS(2)=XS(2)+0.5*XDIF(2)                                             ST        36
                  XS(L)=XS(L)+0.5*XDIF(LP1)                                           ST        37
                  DO 121 I=3,L                                                        ST        38
                  XSU(I)=XDIF(I)                                                      ST        39
                  FXP(I)=XDIF(I)/(2.*XS(I))                                           ST        40
        121       FXM(I)=1.-FXP(I)                                                    ST        41
                  XSU(3)=XSU(3)+XDIF(2)                                               ST        42
                  XSU(L)=XSU(L)+XDIF(LP1)                                             ST        43
                  FXP(2)=FXP(3)                                                       ST        44
                  FXM(2)=1.-FXP(2)                                                    ST        45
                  FXP(L)=FXP(L-1)                                                     ST        46
                  FXM(L)=1.-FXP(L)                                                    ST        47
                  DO 102 J=2,MP1                                                      ST        48
        102       YDIF(J)= Y(J)- Y(J-1)                                               ST        49
                  DO 112 J=2,M                                                        ST        50
        112       YS(J)= 0.5*(Y(J+1)-Y(J-1))                                          ST        51
                  YS(2)=YS(2)+0.5*YDIF(2)                                             ST        52
```

```
      YS(N)=YS(N)+0.5*YDIF(NP1)
      RM(2)=R(1)
      DO 122 J=3,N
      RM(J)=.5*(R(J)+R(J-1))
      RMV(J+1)=R(J)
      YSV(J)=YDIF(J)
      FYP(J)=YDIF(J)/(2.*YS(J))
  122 FYM(J)=1.-FYP(J)
      RM(NP1)=R(NP1)
      RMV(3)=R(1)
      RMV(NP1)=R(NP1)
      YSV(3)=YSV(3)+YDIF(2)
      YSV(N)=YSV(N)+YDIF(NP1)
      FYP(2)=FYP(3)
      FYM(2)=1.-FYP(2)
      FYP(N)=FYP(N-1)
      FYM(N)=1.-FYP(N)
      DO 132 J=2,N
  132 YSR(J)=.5*(RM(J+1)+RM(J))*YS(J)
      DO 142 J=3,N
  142 YSVR(J)=.5*(RMV(J+1)+RMV(J))*YSV(J)
      DO 103 K=2,NP1
  103 ZDIF(K)=Z(K)-Z(K-1)
      DO 113 K=2,N
  113 ZS(K)=0.5*(Z(K+1)-Z(K-1))
      ZS(2)=ZS(2)+0.5*ZDIF(2)
      ZS(N) = ZS(N)+0.5*ZDIF(NP1)
      ZS(NP1)=ZS(2)
      DO 123 K=3,N
      ZSW(K)=ZDIF(K)
      FZP(K)=ZDIF(K)/(2.*ZS(K))
  123 FZM(K)=1.-FZP(K)
      ZSW(NP1)=ZDIF(2)+ZDIF(NP1)
      FZP(NP1)=ZDIF(2)/ZS(NP1)
      FZM(NP1)=1.-FZP(NP1)
      FZP(2)=ZDIF(2)/ZS(2)
      FZM(2)=1.-FZP(2)
      DO 290 I=1,LP1
      IP=MIN0(I+1,LP1)
      IL=MAX0(I-1,1)
      JWLI(I,1)=MAX0(JWLI(I,4),JWLI(IL,4))
      JWLI(I,2)=JWLI(I,4)+1
      JWLI(I,3)=JWLI(I,4)
      JWLI(I,5)=MIN0(JWLI(IP,4),JWLI(I,4),JWLI(IL,4))
      JWLO(I,1)=MIN0(JWLO(I,4),JWLO(IL,4))
      JWLO(I,2)=JWLO(I,4)
      JWLO(I,3)=JWLO(I,4)
      JWLO(I,5)=MAX0(JWLO(IP,4),JWLO(I,4),JWLO(IL,4))
  290 CONTINUE
      DO 292 J=1,MP1
      JP=MIN0(J+1,MP1)
      JL=MAX0(J-1,1)
      IWLI(J,1)=IWLI(J,4)+1
      IWLI(J,2)=MAX0(IWLI(J,4),IWLI(JL,4))
      IWLI(J,3)=IWLI(J,4)
      IWLI(J,5)=MIN0(IWLI(JP,4),IWLI(J,4),IWLI(JL,4))-1
      IWLO(J,1)=IWLO(J,4)
      IWLO(J,2)=MIN0(IWLO(J,4),IWLO(JL,4))
      IWLO(J,3)=IWLO(J,4)
      IWLO(J,5)=MAX0(IWLO(JP,4),IWLO(J,4),IWLO(JL,4))+1
  292 CONTINUE
      RETURN
C  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  *
      ENTRY STRID2
C -+-+-+-+-+-+-+-+-+-+-+-+-+-+-    U-VELOCITY    -+-+-+-+-+-+-+-+-+-+-+-+-+-+-
      DO 360 LP=1,MINJMX
  360 SU(LP)=0.0
      IF(ISOLVE(1)) 303,302,302
  303 IF(MOD(ISTEP,ISOLVE(1))) 302,304,302
  304 CONTINUE
      ISTR=3
      JSTR=2
      KSTR=2
      NV=1
      NGOTO=1
      CALL GAMMA
      DO 30 J=2,M
```

```
            IS=IWLI(J,NGOTO)                                                ST        130
            IE=IWLO(J,NGOTO)                                                ST        131
            TZFAC=R(J)/(R(M)+DFAC*(R(J)-R(M)))                              ST        132
            DO 30 I=IS,IE                                                   ST        133
            LP=JM(J)+I                                                      ST        134
            LZP=LP+MINJ                                                     ST        135
            LPI1=LP-1                                                       ST        136
            LZPI=LZP-1                                                      ST        137
            AREA=XSU(I)*YS(J)                                               ST        138
            ALZ=RHO(LP)*W(LZP)*AREA                                         ST        139
            ALZI=RHO(LPI1)*W(LZPI)*AREA                                     ST        140
            ALZ=.5*(ALZ+ALZI)                                               ST        141
            ALZ=ALZ/2.                                                      ST        142
            TZ=.5*(GAM(LP)+GAM(LPI1))*AREA*TZFAC/(ZS(NPI)*R(J))             ST        143
            TZ=AMAX1(TZ,ABS(ALZ))                                           ST        144
            CZU(LP)=2.*ALZ                                                  ST        145
         30 CZ(LP)=TZ+ALZ                                                   ST        146
            DO 301 K=2,M                                                    ST        147
            CALL SOURCE                                                     ST        148
            CALL SOMAS                                                      ST        149
            DO 31 I=3,L                                                     ST        150
            JS=JWLI(I,NGOTO)+1                                              ST        151
            AREA=XSU(I)*ZS(K)*RM(JS)                                        ST        152
            LP=KM(K)+JM(JS)+I                                               ST        153
            LYM=LP-MI                                                       ST        154
            LXM1=LYM-1                                                      ST        155
            LXM=LP-1                                                        ST        156
            IF (JWLI(I,4).EQ.JS-1) GO TO 150                                ST        157
            ALY=.5*(RHO(LP)+RHO(LYM))*V(LP)*AREA                            ST        158
            TY=.5*(GAM(LP)+GAM(LYM))*AREA/YDIF(JS)                          ST        159
            GO TO 152                                                       ST        160
        150 ALY=RHO(LYM)*V(LP)*AREA                                         ST        161
            DIST=.5*YDIF(JS)                                                ST        162
            IF (JS.EQ.2) DIST=YDIF(2)                                       ST        163
            TY=GAM(LYM)*AREA/DIST                                           ST        164
        152 IF (JWLI(I-1,4).EQ.JS-1) GO TO 154                              ST        165
            ALY1=.5*(RHO(LXM)+RHO(LXM1))*V(LXM)*AREA                        ST        166
            TY1=.5*(GAM(LXM)+GAM(LXM1))*AREA/YDIF(JS)                       ST        167
            GO TO 156                                                       ST        168
        154 ALY1=RHO(LXM1)*V(LXM)*AREA                                      ST        169
            DIST=.5*YDIF(JS)                                                ST        170
            IF (JS.EQ.2) DIST=YDIF(JS)                                      ST        171
            TY1=GAM(LXM1)*AREA/DIST                                         ST        172
        156 ALY=.5*(ALY+ALY1)                                               ST        173
            TY=.5*(TY+TY1)                                                  ST        174
            TY=AMAX1(TY,-ALY)                                               ST        175
            CYU(I)=ALY                                                      ST        176
         31 CY(I)=TY+ALY                                                    ST        177
            DO 32 J=2,N                                                     ST        178
            KJM=KM(K)+JM(J)                                                 ST        179
            AREA=YSR(J)*ZS(K)                                               ST        180
            IS=IWLI(J,NGOTO)                                                ST        181
            IE=IWLO(J,NGOTO)                                                ST        182
            I=IS-1                                                          ST        183
            LXP=KJM+IS                                                      ST        184
            LP=LXP-1                                                        ST        185
            LXM=LP-1                                                        ST        186
        200 ALXM=RHO(LXM)*U(LP)*AREA                                        ST        187
            ALXP=0.                                                         ST        188
            TX=GAM(LXM)*AREA/XS(I)                                          ST        189
            CXU=ALXM                                                        ST        190
        202 TX=AMAX1(TX,ALXP)                                               ST        191
            TX=AMAX1(TX,-ALXM)                                              ST        192
            CX=TX+ALXM                                                      ST        193
            TZFAC=R(J)/(R(M)+DFAC*(R(J)-R(M)))                              ST        194
            DO 32 I=IS,IE                                                   ST        195
            MAX=IWLO(I,NGOTO)-1                                             ST        196
            LIJ=IM(J)+I                                                     ST        197
            LP=KJM+I                                                        ST        198
            LXP=LP+1                                                        ST        199
            LYP=LP+MI                                                       ST        200
            LZP=LP+MINJ                                                     ST        201
            LPI1=LP-1                                                       ST        202
            LYPI=LYP-1                                                      ST        203
            LZPI=LZP-1                                                      ST        204
            AXM(LIJ)=CX                                                     ST        205
            AYM(LIJ)=CY(I)                                                  ST        206
```

```
          AZM(LIJ)=CZ(LIJ)                                                  ST        207
          AREA=YSR(J)*ZS(K)                                                 ST        208
          IF (I.EQ.IE) GO TO 33                                             ST        209
          ALX=RHO(LP)*AREA*(FXP(I)*U(LXP)+FXM(I)*U(LP))                     ST        210
          ALXP=FXP(I)*ALX                                                   ST        211
          ALXM=FXM(I)*ALX                                                   ST        212
          TX=GAM(LP)*AREA/XS(I)                                             ST        213
          CXUP=ALX                                                          ST        214
          GO TO 34                                                          ST        215
   33     ALXP=RHO(LXP)*U(LXP)*AREA                                         ST        216
          ALXM=0.                                                           ST        217
          TX=GAM(LXP)*AREA/XS(I)                                            ST        218
          CXUP=ALXP                                                         ST        219
   34     TX=AMAX1(TX,ALXP)                                                 ST        220
          TX=AMAX1(TX,-ALXM)                                                ST        221
          AXP(LIJ)=TX-ALXP                                                  ST        222
          CX=TX+ALXM                                                        ST        223
          DIVG(LIJ)=DIVG(LIJ)+CXUP-CXU                                      ST        224
          CXU=CXUP                                                          ST        225
          AREA=ZS(K)*XSU(I)*RM(J+1)                                         ST        226
          IF (J.EQ.MAX) GO TO 35                                            ST        227
          ALY=.25*(RHO(LP)+RHO(LYP))*V(LYP)*AREA                            ST        228
          ALYI=.25*(RHO(LPI1)+RHO(LYPI1))*V(LYPI1)*AREA                     ST        229
          ALY=.5*(ALY+ALYI)                                                 ST        230
          TY=.25*(GAM(LP)+GAM(LYP)+GAM(LPI1)+GAM(LYPI1))*AREA/YDIF(J+2)     ST        231
          TY=AMAX1(TY,ABS(ALY))                                             ST        232
          CYUP=2.*ALY                                                       ST        233
          GO TO 36                                                          ST        234
   35     IF (JWLO(I,4).EQ.MAX+1) GO TO 157                                 ST        235
          ALY=.5*(RHO(LP)+RHO(LYP))*V(LYP)*AREA                             ST        236
          TY=.5*(GAM(LP)+GAM(LYP))*AREA/YDIF(MAX+1)                         ST        237
          GO TO 158                                                         ST        238
  157     ALY=RHO(LYP)*V(LYP)*AREA                                          ST        239
          DIST=.5*YDIF(MAX+1)                                               ST        240
          IF (MAX.EQ.M) DIST=YDIF(MP1)                                      ST        241
          TY=GAM(LYP)*AREA/DIST                                             ST        242
  158     IF (JWLO(I-1,4).EQ.MAX+1) GO TO 159                               ST        243
          ALYI=.5*(RHO(LPI1)+RHO(LYPI1))*V(LYPI1)*AREA                      ST        244
          TY=.5*(GAM(LPI1)+GAM(LYPI1))*AREA/YDIF(MAX+1)                     ST        245
          GO TO 160                                                         ST        246
  159     ALYI=RHO(LYPI1)*V(LYPI1)*AREA                                     ST        247
          DIST=.5*YDIF(MAX+1)                                               ST        248
          IF (MAX.EQ.M) DIST=YDIF(MP1)                                      ST        249
          TY1=GAM(LYPI1)*AREA/DIST                                          ST        250
  160     ALY=.5*(ALY+ALYI)                                                 ST        251
          TY=.5*(TY+TY1)                                                    ST        252
          TY=AMAX1(TY,ALY)                                                  ST        253
          CYUP=ALY                                                          ST        254
   36     AYP(LIJ)=TY-ALY                                                   ST        255
          CY(I)=TY+ALY                                                      ST        256
          DIVG(LIJ)=DIVG(LIJ)+CYUP-CYU(I)                                   ST        257
          CYU(I)=CYUP                                                       ST        258
          AREA=XSU(I)*YS(J)                                                 ST        259
          IF(K.EQ.N) GO TO 37                                               ST        260
          ALZ=.25*(RHO(LP)+RHO(LZP))*W(LZP)*AREA                            ST        261
          ALZ1=.25*(RHO(LPI1)+RHO(LZPI1))*W(LZPI1)*AREA                     ST        262
          ALZ=.5*(ALZ+ALZ1)                                                 ST        263
          GAMLP=.25*(GAM(LP)+GAM(LZP)+GAM(LPI1)+GAM(LZPI1))                 ST        264
          TZ=GAMLP*AREA*TZFAC/(ZDIF(K+1)*R(J))                              ST        265
          TZ=AMAX1(TZ,ABS(ALZ))                                             ST        266
          CZUP=2.*ALZ                                                       ST        267
          GO TO 38                                                          ST        268
   37     ALZ=RHO(LZP)*W(LZP)*AREA                                          ST        269
          ALZ1=RHO(LZPI1)*W(LZPI1)*AREA                                     ST        270
          ALZ=.5*(ALZ+ALZ1)                                                 ST        271
          ALZ=ALZ/2.                                                        ST        272
          TZ=.5*(GAM(LZP)+GAM(LZPI1))*AREA*TZFAC/(ZS(NP1)*R(J))             ST        273
          TZ=AMAX1(TZ,ABS(ALZ))                                             ST        274
          CZUP=2.*ALZ                                                       ST        275
   38     AZP(LIJ)=TZ-ALZ                                                   ST        276
          CZ(LIJ)=TZ+ALZ                                                    ST        277
          DIVG(LIJ)=DIVG(LIJ)+CZUP-CZU(LIJ)                                 ST        278
          CZU(LIJ)=CZUP                                                     ST        279
          VOL=XSU(I)*YSR(J)*ZS(K)                                           ST        280
          IF (I.EQ.IWLI(J,NGOTO).AND.I.GT.3) VOL=VOL*(1.+.5*XSU(I-1)/XSU(I))ST        281
          IF (I.EQ.IWLO(J,NGOTO).AND.I.LT.L) VOL=VOL*(1.+.5*XSU(I+1)/XSU(I))ST        282
          LPM=LP-1                                                          ST        283
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```
 39     ROT=0.
 392    DIVG(LIJ)=AMAX1(ROT,DIVG(LIJ))
        DU(LP)=VOL/XDIF(I)
        SU(LIJ)=SU(LIJ)*VOL+DU(LP)*(P(LIM)-P(LP))+DIVG(LIJ)*U(LP)
        SP(LIJ)=SP(LIJ)*VOL-DIVG(LIJ)
    32 CONTINUE
       CALL SORDD
       CALL SOLVE1
   301 CONTINUE
       CALL SOLVE2
       CALL FPDG
   302 CONTINUE
C *-*-*-*-*-*-*-*-*-*-*-*-*-*-    V-VELOCITY     *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-*-
       DO 400 LP=1,NIMJMK
   400 DV(LP)=0.0
       IF(ISOLVE(2)) 403,402,403
 403   IF(MOD(ISTEP,ISOLVE(2))) 402,404,402
 404   CONTINUE
       ISTR=2
       JSTR=3
       KSTR=2
       NV=2
       NGOTO=2
       CALL GAMMA
       DO 40 J=3,M
       IS=IWLI(J,NGOTO)
       IE=IWLO(J,NGOTO)
       TZFAC=RM(J)/(RM(M)+DFAC*(RM(J)-RM(M)))
       DO 40 I=IS,IE
       LP=JM(J)+I
       LZP=LP+NIJ
       LPI1=LP-NI
       LZPI1=LZP-NI
       AREA=XS(I)*YSV(J)
       ALZ=RHO(LP)*W(LZP)*AREA
       ALZ1=RHO(LPI1)*W(LZPI1)*AREA
       ALZ=.5*(ALZ+ALZ1)
       ALZ=ALZ/2.
       TZ=.5*(GAM(LP)+GAM(LPI1))*AREA*TZFAC/(ZSW(NP1)*RM(J))
       TZ=AMAX1(TZ,ABS(ALZ))
       CZM(LP)=TZ-ALZ
    40 CZ(LP)=TZ+ALZ
       DO 401 K=2,N
       CALL SOURCE
       CALL SOMAS
       DO 41 I=2,L
       J=JWLI(I,NGOTO)
       AREA=ZS(K)*XS(I)*RMV(J+1)
       LP=KM(K)+JM(J)+I
       LYP=LP+NI
       LYM=LP-NI
   206 ALYM=RHO(LYM)*V(LP)*AREA
       ALYP=0.
       TY=GAM(LYM)*AREA/YS(J)
       CYU(I)=ALYM
   209 TY=AMAX1(TY,ALYP)
       TY=AMAX1(TY,-ALYM)
    41 CY(I)=TY+ALYM
       DO 42 J=3,M
       KJM=KM(K)+JM(J)
       IS=IWLI(J,NGOTO)
        IE=IWLO(J,NGOTO)
       LXP=KJM+IS
       LP=LXP-1
       LPI1=LP-NI
       LXPI1=LXP-NI
       AREA=YSV(J)*ZS(K)
       IF (IWLI(J,4).EQ.IS) GO TO 162
       ALX=.5*(RHO(LP)+RHO(LPI1))*U(LXP)*AREA
       TX=.5*(GAM(LP)+GAM(LPI1))*AREA/XDIF(IS)
       GO TO 163
   162 ALX=RHO(LP)*U(LXP)*AREA
       DIST=.5*XDIF(IS)
       IF (IS.EQ.2) DIST=XDIF(2)
       TX=GAM(LP)*AREA/DIST
   163 IF (IWLI(J-1,4).EQ.IS) GO TO 164
       ALX1=.5*(RHO(LPI1)+RHO(LXPI1))*U(LXPI1)*AREA
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            TX1=.5*(GAM(LPI1)+GAM(LXP1))*AREA/XDIF(IS)                       ST      361
            GO TO 165                                                        ST      362
        164 ALX1=RHO(LPI1)*U(LXP1)*AREA                                      ST      363
            DIST=.5*XDIF(IS)                                                 ST      364
            IF (IS.EQ.2) DIST=XDIF(2)                                        ST      365
            TX1=GAM(LPI1)*AREA/DIST                                          ST      366
        165 ALX=.5*(ALX+ALX1)                                                ST      367
            TX=.5*(TX+TX1)                                                   ST      368
            TX=AMAX1(TX,-ALX)                                                ST      369
            CXU=ALX                                                          ST      370
            CX=TX+ALX                                                        ST      371
            TZFAC=RM(J)/(RM(M)+DFAC*(RM(J)-RM(M)))                           ST      372
            DO 42 I=IS,IE                                                    ST      373
            MAX=JWLO(I,NGOTO)-I                                              ST      374
            LIJ=JM(J)+I                                                      ST      375
            LP=KJM+I                                                         ST      376
            LXP=LP+1                                                         ST      377
            LYP=LP+NI                                                        ST      378
            LZP=LP+NINJ                                                      ST      379
            LPI1=LP-NI                                                       ST      380
            LXP1=LXP-NI                                                      ST      381
            LZP1=LZP-NI                                                      ST      382
            AXM(LIJ)=CX                                                      ST      383
            AYM(LIJ)=CY(I)                                                   ST      384
            AZM(LIJ)=CZ(LIJ)                                                 ST      385
            AREA=YSUR(J)*ZS(K)                                               ST      386
            IF (I.EQ.IE) GO TO 43                                            ST      387
            ALX=.25*(RHO(LP)+RHO(LXP))*U(LXP)*AREA                           ST      388
            ALX1=.25*(RHO(LPI1)+RHO(LXP1))*U(LXP1)*AREA                      ST      389
            ALX=.5*(ALX+ALX1)                                                ST      390
            TX=.25*(GAM(LP)+GAM(LXP)+GAM(LPI1)+GAM(LXP1))*AREA/XDIF(I+1)     ST      391
            TX=AMAX1(TX,ABS(ALX))                                            ST      392
            CXUP=2.*ALX                                                      ST      393
            GO TO 44                                                         ST      394
         43 IF (IWLO(J,4).EQ.IE) GO TO 167                                   ST      395
            ALX=.5*(RHO(LP)+RHO(LXP))*U(LXP)*AREA                            ST      396
            TX=.5*(GAM(LP)+GAM(LXP))*AREA/XDIF(I+1)                          ST      397
            GO TO 168                                                        ST      398
        167 ALX=RHO(LXP)*U(LXP)*AREA                                         ST      399
            DIST=.5*XDIF(I+1)                                                ST      400
            IF (I.EQ.L) DIST=XDIF(LP1)                                       ST      401
            TX=GAM(LXP)*AREA/DIST                                            ST      402
        168 IF (IWLO(J-1,4).EQ.IE) GO TO 169                                 ST      403
            ALX1=.5*(RHO(LPI1)+RHO(LXP1))*U(LXP1)*AREA                       ST      404
            TX1=.5*(GAM(LPI1)+GAM(LXP1))*AREA/XDIF(I+1)                      ST      405
            GO TO 170                                                        ST      406
        169 ALX1=RHO(LXP1)*U(LXP1)*AREA                                      ST      407
            DIST=.5*XDIF(I+1)                                                ST      408
            IF (I.EQ.L) DIST=XDIF(LP1)                                       ST      409
            TX1=GAM(LXP1)*AREA/DIST                                          ST      410
        170 ALX=.5*(ALX+ALX1)                                                ST      411
            TX=.5*(TX+TX1)                                                   ST      412
            TX=AMAX1(TX,ALX)                                                 ST      413
            CXUP=ALX                                                         ST      414
         44 AXP(LIJ)=TX-ALX                                                  ST      415
            CX=TX+ALX                                                        ST      416
            DIVG(LIJ)=DIVG(LIJ)+CXUP-CXU                                     ST      417
            CXU=CXUP                                                         ST      418
            AREA=ZS(K)*XS(I)*RMV(J+1)                                        ST      419
            IF (J.EQ.JWLO(I,NGOTO)-1) GO TO 45                               ST      420
            ALY=RHO(LP)*AREA*(FYP(J)*V(LYP)+FYM(J)*V(LP))                    ST      421
            ALYP=FYP(J)*ALY                                                  ST      422
            ALYM=FYM(J)*ALY                                                  ST      423
            TY=GAM(LP)*AREA/YS(J)                                            ST      424
            CYUP=ALY                                                         ST      425
            GO TO 46                                                         ST      426
      45    ALYP=RHO(LYP)*V(LYP)*AREA                                        ST      427
            ALYM=0.                                                          ST      428
            TY=GAM(LYP)*AREA/YS(J)                                           ST      429
            CYUP=ALYP                                                        ST      430
      46    TY=AMAX1(TY,ALYP)                                                ST      431
            TY=AMAX1(TY,-ALYM)                                               ST      432
            AYP(LIJ)=TY-ALYP                                                 ST      433
            CY(I)=TY+ALYM                                                    ST      434
            DIVG(LIJ)=DIVG(LIJ)+CYUP-CYU(I)                                  ST      435
            CYU(I)=CYUP                                                      ST      436
            AREA=XS(I)*YSV(J)                                                ST      437
```

```
      IF(K.EQ.N) GO TO 47                                               ST     438
      ALZ=.25*(RHO(LP)+RHO(LZP))*W(LZP)*AREA                            ST     439
      ALZ1=.25*(RHO(LP1)+RHO(LZP1))*W(LZP1)*AREA                        ST     440
      ALZ=.5*(ALZ+ALZ1)                                                 ST     441
      GAMLP=.25*(GAM(LP)+GAM(LZP)+GAM(LP1)+GAM(LZP1))                   ST     442
      TZ=GAMLP*AREA*TZFAC/(ZDIF(K+1)*RM(J))                             ST     443
      TZ=AMAX1(TZ,ABS(ALZ))                                             ST     444
      CZUP=2.*ALZ                                                       ST     445
      GO TO 49                                                          ST     446
   47 ALZ=RHO(LZP)*W(LZP)*AREA                                          ST     447
      ALZ1=RHO(LZP1)*W(LZP1)*AREA                                       ST     448
      ALZ=.5*(ALZ+ALZ1)                                                 ST     449
      ALZ=ALZ/2.                                                        ST     450
      TZ=GAM(LZP)*AREA*TZFAC/((ZS(NP1))*RM(J))                          ST     451
      TZ=AMAX1(TZ,ABS(ALZ))                                             ST     452
      CZUP=2.*ALZ                                                       ST     453
   49 AZP(LIJ)=TZ-ALZ                                                   ST     454
      CZ(LIJ)=TZ+ALZ                                                    ST     455
      DIVG(LIJ)=DIVG(LIJ)+CZUP-CZU(LIJ)                                 ST     456
      CZU(LIJ)=CZUP                                                     ST     457
      VOL=XS(I)*YSVR(J)*ZS(K)                                           ST     458
      IF (J.EQ.JMLI(I,NGOTO).AND.J.GT.3) VOL=VOL*(1.+.5*YSVR(J-1)/      ST     459
     1  YSVR(J))                                                        ST     460
      IF (J.EQ.JMLC(I,NGOTO).AND.J.LT.M) VOL=VOL*(1.+.5*YSVR(J+1)/      ST     461
     1  YSVR(J))                                                        ST     462
      LYM=LP-NI                                                         ST     463
 43   PDT=0.                                                            ST     464
 492  DIVG(LIJ)=AMAX1(PDT,DIVG(LIJ))                                    ST     465
      DV(LP)=VOL/YDIF(J)                                                ST     466
      SU(LIJ)=SU(LIJ)*VOL+DV(LP)*(P(LYM)-P(LP))+DIVG(LIJ)*V(LP)         ST     467
      SP(LIJ)=SP(LIJ)*VOL-DIVG(LIJ)                                     ST     468
      SU(LIJ)=SU(LIJ)+PLAXM*0.5*(RHO(LP)+RHO(LP-NI))*(0.25*(W(LP)+W(LP+ ST     469
     1NINJ)+W(LP+NINJ-NI)+W(LP-NI)))**2*VOL/RM(J)                       ST     470
   42 CONTINUE                                                          ST     471
      CALL SEMOD                                                        ST     472
      CALL SOLVE1                                                       ST     473
  401 CONTINUE                                                          ST     474
      CALL SOLVE2                                                       ST     475
      CALL FMOD                                                         ST     476
  402 CONTINUE                                                          ST     477
C +-+-+-+-+-+-+-+-+-+-+-+-+-+-   W-VELOCITY    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-   ST     478
      DO 505 LP=1,NINJNK                                                ST     479
  505 DW(LP)=0.0                                                        ST     480
      IF(ISOLVE(3)) 503,502,503                                         ST     481
 503  IF(MOD(ISTEP,ISOLVE(3))) 502,504,502                              ST     482
 504  CONTINUE                                                          ST     483
      ISTP=2                                                            ST     484
      JSTP=2                                                            ST     485
      KSTP=3                                                            ST     486
      NV=3                                                              ST     487
      NGOTO=3                                                           ST     488
      CALL GAMMA                                                        ST     489
      DO 55 J=2,M                                                       ST     490
      IS=IALI(J,NGOTO)                                                  ST     491
      IE=IALO(J,NGOTO)                                                  ST     492
      TZFAC=1.0                                                         ST     493
      DO 55 I=IS,IE                                                     ST     494
      LIJ=JM(J)+I                                                       ST     495
      LP=KM(2)+LIJ                                                      ST     496
      LZP=LP+NINJ                                                       ST     497
      AREA=XS(I)*YS(J)                                                  ST     498
      ALZ=RHO(LP)*AREA*(FZP(2)*W(LZP)+FZM(2)*W(LP))                     ST     499
      ALZP=FZP(2)*ALZ                                                   ST     500
      ALZM=FZM(2)*ALZ                                                   ST     501
      TZ=GAM(LP)*AREA*TZFAC/(ZS(2)*R(J))                                ST     502
      CZU(LIJ)=ALZ                                                      ST     503
      TZ=AMAX1(TZ,ALZP)                                                 ST     504
      TZ=AMAX1(TZ,-ALZM)                                                ST     505
   55 CZ(LIJ)=TZ+ALZM                                                   ST     506
      DO 501 K=3,NP1                                                    ST     507
      CALL SOURCE                                                       ST     508
      CALL SOMAS                                                        ST     509
      DO 51 I=2,L                                                       ST     510
      J=JMLI(I,NGOTO)+1                                                 ST     511
      LP=KM(K)+JM(J-1)+I                                                ST     512
      LYP=LP+NI                                                         ST     513
      LPI1=LP-NINJ                                                      ST     514
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      LYP1=LYP-NINJ                                                     ST    515
      AREA=ZSW(K)*XS(I)*RM(J)                                           ST    516
      ALY=RHO(LP)*V(LYP)*AREA                                           ST    517
      ALY1=RHO(LP1)*V(LYP1)*AREA                                        ST    518
      ALY=.5*(ALY+ALY1)                                                 ST    519
      DIST=.5*YDIF(J)                                                   ST    520
      IF (J.EQ.2) DIST=YDIF(2)                                          ST    521
      TY=.5*(GAM(LP)+GAM(LP1))*AREA/DIST                                ST    522
      TY=AMAX1(TY,-ALY)                                                 ST    523
      CYU(I)=ALY                                                        ST    524
   51 CY(I)=TY+ALY                                                      ST    525
      DO 52 J=2,M                                                       ST    526
      KJM=KM(K)+JM(J)                                                   ST    527
      IS=IWLI(J,NGOTO)                                                  ST    528
      IE=IWLO(J,NGOTO)                                                  ST    529
      LXP=KJM+IS                                                        ST    530
      LP=LXP-1                                                          ST    531
      LP1=LP-NINJ                                                       ST    532
      LXP1=LXP-NINJ                                                     ST    533
      AREA=YSR(J)*ZSW(K)                                                ST    534
      ALX=RHO(LP)*U(LXP)*AREA                                           ST    535
      ALX1=RHO(LP1)*U(LXP1)*AREA                                        ST    536
      ALX=.5*(ALX+ALX1)                                                 ST    537
      DIST=.5*XDIF(IS)                                                  ST    538
      IF (IS.EQ.2) DIST=XDIF(2)                                         ST    539
      TX=.5*(GAM(LP)+GAM(LP1))*AREA/DIST                                ST    540
      TX=AMAX1(TX,-ALX)                                                 ST    541
      CXU=ALX                                                           ST    542
      CX=TX+ALX                                                         ST    543
      TZFAC=1.0                                                         ST    544
      DO 52 I=IS,IE                                                     ST    545
      MAX=JWLO(I,NGOTO)-1                                               ST    546
      LIJ=JM(J)+I                                                       ST    547
      LP=KJM+I                                                          ST    548
      LXP=LP+1                                                          ST    549
      LYP=LP+NI                                                         ST    550
      LZP=LP+NINJ                                                       ST    551
      LP1=LP-NINJ                                                       ST    552
      LXP1=LXP-NINJ                                                     ST    553
      LYP1=LYP-NINJ                                                     ST    554
      AXM(LIJ)=CX                                                       ST    555
      AYM(LIJ)=CY(I)                                                    ST    556
      AZM(LIJ)=CZ(LIJ)                                                  ST    557
      AREA=YSR(J)*ZSW(K)                                                ST    558
      IF (I.EQ.IE) GO TO 53                                             ST    559
      ALX=.25*(RHO(LP)+RHO(LXP))*U(LXP)*AREA                            ST    560
      ALX1=.25*(RHO(LP1)+RHO(LXP1))*U(LXP1)*AREA                        ST    561
      ALX=.5*(ALX+ALX1)                                                 ST    562
      TX=.25*(GAM(LP)+GAM(LXP)+GAM(LP1)+GAM(LXP1))*AREA/XDIF(I+1)       ST    563
      TX=AMAX1(TX,ABS(ALX))                                             ST    564
      CXUP=2.*ALX                                                       ST    565
      GO TO 54                                                          ST    566
   53 ALX=RHO(LXP)*U(LXP)*AREA                                          ST    567
      ALX1=RHO(LXP1)*U(LXP1)*AREA                                       ST    568
      ALX=.5*(ALX+ALX1)                                                 ST    569
      DIST=.5*XDIF(I+1)                                                 ST    570
      IF (I.EQ.L) DIST=XDIF(LP1)                                        ST    571
      TX=.5*(GAM(LXP)+GAM(LXP1))*AREA/DIST                              ST    572
      TX=AMAX1(TX,ALX)                                                  ST    573
      CXUP=ALX                                                          ST    574
   54 AXP(LIJ)=TX-ALX                                                   ST    575
      CX=TX+ALX                                                         ST    576
      DIVG(LIJ)=DIVG(LIJ)+CXUP-CXU                                      ST    577
      CXU=CXUP                                                          ST    578
      AREA=ZSW(K)*XS(I)*RM(J+1)                                         ST    579
      IF (J.EQ.MAX) GO TO 55                                            ST    580
      ALY=.25*(RHO(LP)+RHO(LYP))*V(LYP)*AREA                            ST    581
      ALY1=.25*(RHO(LP1)+RHO(LYP1))*V(LYP1)*AREA                        ST    582
      ALY=.5*(ALY+ALY1)                                                 ST    583
      TY=.25*(GAM(LP)+GAM(LYP)+GAM(LP1)+GAM(LYP1))*AREA/YDIF(J+1)       ST    584
      TY=AMAX1(TY,ABS(ALY))                                             ST    585
      CYUP=2.*ALY                                                       ST    586
      GO TO 56                                                          ST    587
   55 ALY=RHO(LYP)*V(LYP)*AREA                                          ST    588
      ALY1=RHO(LYP1)*V(LYP1)*AREA                                       ST    589
      ALY=.5*(ALY+ALY1)                                                 ST    590
      DIST=.5*YDIF(J+1)                                                 ST    591
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      IF (J.EQ.M) DIST=YDIF(MP1)                                          ST     592
      TY=.5*(GAM(LYP)+GAM(LYP1))*AREA/DIST                                ST     593
      TY=AMAX1(TY,ALY)                                                    ST     594
      CYUP=ALY                                                            ST     595
   56 AYP(LIJ)=TY-ALY                                                     ST     596
      CY(I)=TY+ALY                                                        ST     597
      DIVG(LIJ)=DIVG(LIJ)+CYUP-CYU(I)                                     ST     598
      CYU(I)=CYUP                                                         ST     599
      AREA=XS(I)*YS(J)                                                    ST     600
      DENSTY=RHO(LP)                                                      ST     601
      IF(K.EQ.MP1) DENSTY=RHO(LIJ+NINJ)                                   ST     602
      IF (K.EQ.MP1) WLZP=W(LIJ+2*NINJ)                                    ST     603
      IF(K.LT.MP1) WLZP=W(LZP)                                            ST     604
      ALZ=DENSTY*AREA*(FZP(K)*WLZP+FZM(K)*W(LP))                          ST     605
      ALZP=FZP(K)*ALZ                                                     ST     606
      ALZM=FZM(K)*ALZ                                                     ST     607
      TZ=GAM(LP)*AREA*TZFAC/(ZS(K)*R(J))                                  ST     608
      CZUP=ALZ                                                            ST     609
      TZ=AMAX1(TZ,ALZP)                                                   ST     610
      TZ=AMAX1(TZ,-ALZM)                                                  ST     611
      AZP(LIJ)=TZ-ALZP                                                    ST     612
      CZ(LIJ)=TZ+ALZM                                                     ST     613
      DIVG(LIJ)=DIVG(LIJ)+CZUP-CZU(LIJ)                                   ST     614
      CZU(LIJ)=CZUP                                                       ST     615
      VOL=XS(I)*YSR(J)*ZSW(K)                                             ST     616
      LZM=LP-NINJ                                                         ST     617
 59   RDT=0.                                                              ST     618
 592  DIVG(LIJ)=AMAX1(RDT,DIVG(LIJ))                                      ST     619
      DW(LP)=VOL/ZDIF(K)/R(J)                                             ST     620
      IF (K.EQ.MP1) DW(LP)=DW(LP)*ZDIF(K)/ZSW(K)                          ST     621
      SU(LIJ)=SU(LIJ)*VOL+DW(LP)*(P(LZM)-P(LP))+DIVG(LIJ)*W(LP)           ST     622
      SP(LIJ)=SP(LIJ)*VOL-DIVG(LIJ)                                       ST     623
      SP(LIJ)=SP(LIJ)-0.5*(RHO(LP)+RHO(LP-NINJ))*0.25*(V(LP)+V(LP-NINJ)+  ST     624
     1V(LP+NI)+V(LP-NINJ+NI))/R(J)*VOL*PLANMI                             ST     625
   52 CONTINUE                                                            ST     626
      CALL SORDD                                                          ST     627
      CALL SOLVE1                                                         ST     628
  501 CONTINUE                                                            ST     629
      CALL SOLVE2                                                         ST     630
 502  CONTINUE                                                            ST     631
      CALL VELMOD                                                         ST     632
C +-+-+-+-+-+-+-+-+-+-   PRESSURE PERTABATION EQUATION  +-+-+-+-+-+-+-+- ST     633
      NGOTO=4                                                             ST     634
      IF(ISOLVE(4)) 603,602,603                                           ST     635
 603  IF(MOD(ISTEP,ISOLVE(4))) 602,604,602                                ST     636
 604  CONTINUE                                                            ST     637
      DO 605 LP=1,NINJNK                                                  ST     638
  605 PP(LP)=0.0                                                          ST     639
      ISTR=2                                                              ST     640
      JSTR=2                                                              ST     641
      KSTR=2                                                              ST     642
      NY=5                                                                ST     643
 6000 CONTINUE                                                            ST     644
      DO 62 J=2,M                                                         ST     645
      IS=IWLI(J,NGOTO)                                                    ST     646
      IE=IWLO(J,NGOTO)                                                    ST     647
      DO 60 I=IS,IE                                                       ST     648
      LP=JN(J)+I                                                          ST     649
      LZP=LP+NINJ                                                         ST     650
      RHOA=RHO(LP)*XS(I)*YS(J)                                            ST     651
      CZU(LP)=RHOA*W(LZP)                                                 ST     652
   60 CZ(LP)=RHOA*DW(LZP)                                                 ST     653
      DO 601 K=2,N                                                        ST     654
      DO 61 I=2,L                                                         ST     655
      J=JWLI(I,NGOTO)+1                                                   ST     656
      LP=KN(K)+JN(J-1)+I                                                  ST     657
      LYP=LP+NI                                                           ST     658
      RHOA=RHO(LP)*ZS(K)*XS(I)*RM(J)                                      ST     659
      CYU(I)=RHOA*V(LYP)                                                  ST     660
   61 CY(I)=RHOA*DV(LYP)                                                  ST     661
      DO 62 J=2,M                                                         ST     662
      KJN=KN(K)+JN(J)                                                     ST     663
      IS=IWLI(J,NGOTO)                                                    ST     664
      IE=IWLO(J,NGOTO)                                                    ST     665
      LP=KJN+IS-1                                                         ST     666
      LXP=LP+1                                                            ST     667
      RHOA=RHO(LP)*YSR(J)*ZS(K)                                           ST     668
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      CXU=RHOA*U(LXP)                                                   ST     669
      CX=RHOA*DU(LXP)                                                   ST     670
      DO 62 I=IS,IE                                                     ST     671
      MAX=JWLO(I,NGOTO)-I                                               ST     672
      LIJ=JM(J)+I                                                       ST     673
      LP=KJM+I                                                          ST     674
      LXP=LP+1                                                          ST     675
      LYP=LP+NI                                                         ST     676
      LZP=LP+NINJ                                                       ST     677
      AXM(LIJ)=CX                                                       ST     678
      AYM(LIJ)=CY(I)                                                    ST     679
      AZM(LIJ)=CZ(LIJ)                                                  ST     680
      IF (I.EQ.IE) GO TO 63                                             ST     681
      RHOA=0.5*(RHO(LP)+RHO(LXP))*YSR(J)*ZS(K)                          ST     682
      GO TO 64                                                          ST     683
   63 RHOA=RHO(LXP)*YSR(J)*ZS(K)                                        ST     684
     64 CX=RHOA*DU(LXP)                                                 ST     685
      CXUP=RHOA*U(LXP)                                                  ST     686
      SU(LIJ)=CXU-CXUP                                                  ST     687
      CXU=CXUP                                                          ST     688
      AXP(LIJ)=CX                                                       ST     689
      IF (J.EQ.MAX) GO TO 65                                            ST     690
      RHOA=0.5*(RHO(LP)+RHO(LYP))*ZS(K)*XS(I)*RM(J+1)                   ST     691
      GO TO 66                                                          ST     692
     65 RHOA=RHO(LYP)*ZS(K)*XS(I)*RM(J+1)                               ST     693
     66 CY(I)=RHOA*DV(LYP)                                              ST     694
      CYUP=RHOA*V(LYP)                                                  ST     695
      SU(LIJ)=SU(LIJ)+CYU(I)-CYUP                                       ST     696
      CYU(I)=CYUP                                                       ST     697
      AYP(LIJ)=CY(I)                                                    ST     698
      IF(K.EQ.N) GO TO 67                                               ST     699
      RHOA=0.5*(RHO(LP)+RHO(LZP))*XS(I)*YS(J)                           ST     700
      GO TO 68                                                          ST     701
   67 RHOA=RHO(LZP)*XS(I)*YS(J)                                         ST     702
     68 CZ(LIJ)=RHOA*DW(LZP)                                            ST     703
      CZUP=RHOA*W(LZP)                                                  ST     704
      SU(LIJ)=SU(LIJ)+CZU(LIJ)-CZUP                                     ST     705
      CZU(LIJ)=CZUP                                                     ST     706
      AZP(LIJ)=CZ(LIJ)                                                  ST     707
      SP(LIJ)=0.                                                        ST     708
   62 CONTINUE                                                          ST     709
      CALL SOMOD                                                        ST     710
      CALL SOLVE1                                                       ST     711
  601  CONTINUE                                                         ST     712
      CALL SOLVE2                                                       ST     713
    602 CONTINUE                                                        ST     714
CCOME HERE TO CORRECT VELOCITIES AND PRESSURES                          ST     715
      CALL FROD                                                         ST     716
      DO 620 K=2,NPI                                                    ST     717
      DO 620 J=2,MPI                                                    ST     718
      KJM=KM(K)+JM(J)                                                   ST     719
      IS=IWLI(J,NGOTO)                                                  ST     720
      IE=IWLO(J,NGOTO)+1                                                ST     721
      DO 620 I=IS,IE                                                    ST     722
      LP=KJM+I                                                          ST     723
      LXM=LP-1                                                          ST     724
      LYM=LP-NI                                                         ST     725
      LZM=LP-NINJ                                                       ST     726
      U(LP)=U(LP)+DU(LP)*(PP(LXM)-PP(LP))                               ST     727
      V(LP)=V(LP)+DV(LP)*(PP(LYM)-PP(LP))                               ST     728
      W(LP)=W(LP)+DW(LP)*(PP(LZM)-PP(LP))                               ST     729
  620 CONTINUE                                                          ST     730
      GO TO (621,622),IPAP                                              ST     731
    622 PLPREF=P(LPREF)+PP(LPREF)*RELAX(NP)                             ST     732
    621 CONTINUE                                                        ST     733
      DO 630 K=2,N                                                      ST     734
      DO 630 J=2,M                                                      ST     735
      KJM=KM(K)+JM(J)                                                   ST     736
      IS=IWLI(J,NGOTO)                                                  ST     737
      IE=IWLO(J,NGOTO)                                                  ST     738
      DO 630 I=IS,IE                                                    ST     739
      LP=KJM+I                                                          ST     740
      P(LP)=P(LP)+PP(LP)*RELAX(NP)                                      ST     741
      GO TO (631,632),IPAP                                              ST     742
    632 P(LP)=P(LP)-PLPREF                                              ST     743
    631 CONTINUE                                                        ST     744
  630 PP(LP)=0.                                                         ST     745
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          DO 641 J=1,MP1                                              ST      746
          DO 641 I=1,LP1                                              ST      747
          LPH=I+JM(J)+KM(MP1)                                         ST      748
          LP2=I+JM(J)+KM(2)                                           ST      749
          P(LPH)=P(LP2)                                               ST      750
      641 CONTINUE                                                    ST      751
          REWIND NTP2                                                 ST      752
          WRITE (NTP2) U,V,W,P                                        ST      753
    C +-+-+-+-+-+-+-+-+-+-+-+-+-   F-VARIABLES   +-+-+-+-+-+-+-+-+-+-+-+ ST   754
          DO 700 NV=5,NNV                                             ST      755
          IF (NV.NE.LVK) GO TO 710                                    ST      756
          REWIND NTP1                                                 ST      757
          READ (NTP1)                                                 ST      758
    C ----  HERE PP IS KE,  P IS DISSIPATION                          ST      759
          READ (NTP1) PP,P                                            ST      760
      710 IF (NV.NE.LVFUOX) GO TO 714                                 ST      761
    C -------- HERE PP IS KE, P IS DISS                               ST      762
          WRITE (NTP2) PP,P                                           ST      763
    C -------- HERE PP IS PHI, P IS MFU, DU IS MCO                    ST      764
          READ (NTP1) PP,P,DU                                         ST      765
      714 IF (NV.NE.LVH) GO TO 720                                    ST      766
    C -------- HERE DV IS ENTHALPY, DW IS FAV                         ST      767
          READ (NTP1) DV,DW                                           ST      768
          DO 716 K=1,MP1                                              ST      769
          DO 717 I=1,LP1                                              ST      770
          IF (IKIN(I,K).EQ.2.OR.IKIN(I,K).EQ.3) GO TO 712             ST      771
          LP=KM(K)+JM(JWLI(I,4))+I                                    ST      772
          LPH=LP+NVM(NVH)                                             ST      773
          F(LPH)=RATIO2*HDR(TEMP(LP),4)+(1.-RATIO2)*HDR(TEMP(LP),12)  ST      774
      712 IF (IKIN(I,K).EQ.1.OR.IKIN(I,K).EQ.3) GO TO 717             ST      775
          LP=KM(K)+JM(JWLO(I,4))+I                                    ST      776
          LPH=LP+NVM(NVH)                                             ST      777
          F(LPH)=RATIO2*HDR(TEMP(LP),4)+(1.-RATIO2)*HDR(TEMP(LP),12)  ST      778
      717 CONTINUE                                                    ST      779
          DO 716 J=1,MP1                                              ST      780
          IF (JKIN(J,K).EQ.1) GO TO 760                               ST      781
          LP=KM(K)+JM(J)+IWLI(J,4)-1                                  ST      782
          LPH=LP+NVM(NVH)                                             ST      783
          F(LPH)=RATIO2*HDR(TEMP(LP),4)+(1.-RATIO2)*HDR(TEMP(LP),12)  ST      784
      760 IF (J.GT.JWCI.AND.J.LT.JWCO) GO TO 716                      ST      785
          LP=KM(K)+JM(J)+IWLO(J,4)+1                                  ST      786
          LPH=LP+NVM(NVH)                                             ST      787
          F(LPH)=RATIO2*HDR(TEMP(LP),4)+(1.-RATIO2)*HDR(TEMP(LP),12)  ST      788
      716 CONTINUE                                                    ST      789
      720 IF (ISOLVE(NV)) 703,702,703                                 ST      790
      703 IF (MOD(ISTEP,ISOLVE(NV))) 702,704,702                      ST      791
      704 CONTINUE                                                    ST      792
          ISTR=2                                                      ST      793
          JSTR=2                                                      ST      794
          KSTR=2                                                      ST      795
          CALL GAMMA                                                  ST      796
          DO 70 J=2,M                                                 ST      797
          IS=IWLI(J,NGOTO)                                            ST      798
          IE=IWLO(J,NGOTO)                                            ST      799
          TZFAC=R(J)/(R(M)+DFAC*(R(J)-R(M)))                          ST      800
          DO 70 I=IS,IE                                               ST      801
          LP=JM(J)+I                                                  ST      802
          LZP=LP+NIM                                                  ST      803
          AREA=XS(I)*YS(J)                                            ST      804
          ALZ=RHO(LP)*W(LZP)*AREA                                     ST      805
          ALZ=ALZ/2.                                                  ST      806
          TZ=GAM(LP)*AREA*TZFAC/(ZSW(MP1)*R(J))                       ST      807
          TZ=AMAX1(TZ,ABS(ALZ))                                       ST      808
          CZU(LP)=TZ-ALZ                                              ST      809
       70 CZ(LP)=TZ+ALZ                                               ST      810
          DO 705 K=2,N                                                ST      811
          CALL SOURCE                                                 ST      812
          CALL SOMAS                                                  ST      813
          DO 71 I=2,L                                                 ST      814
          J=JWLI(I,NGOTO)+1                                           ST      815
          LP=KM(K)+JM(J-1)+I                                          ST      816
          LYP=LP+NI                                                   ST      817
          AREA=ZS(K)*XS(I)*RM(J)                                      ST      818
          ALY=RHO(LP)*V(LYP)*AREA                                     ST      819
          DIST=.5*YDIF(J)                                             ST      820
          IF (J.EQ.2) DIST=YDIF(2)                                    ST      821
          TY=GAM(LP)*AREA/DIST                                        ST      822
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          TY=AMAX1(TY,-ALY)                                             ST 823
          CYU(I)=ALY                                                    ST 824
   71     CY(I)=TY+ALY                                                  ST 825
          DO 72 J=2,M                                                   ST 826
          KJM=KM(K)+JM(J)                                               ST 827
          IS=IWLI(J,NGOTO)                                              ST 828
          IE=IWLO(J,NGOTO)                                              ST 829
          LXP=KJM+IS                                                    ST 830
          LP=LXP-1                                                      ST 831
          AREA=YSR(J)*ZS(K)                                             ST 832
          ALX=RHO(LP)*U(LXP)*AREA                                       ST 833
          DIST=.5*XDIF(IS)                                              ST 834
          IF (IS.EQ.2) DIST=XDIF(2)                                     ST 835
          TX=GAM(LP)*AREA/DIST                                          ST 836
          TX=AMAX1(TX,-ALX)                                             ST 837
          CXU=ALX                                                       ST 838
          CX=TX+ALX                                                     ST 839
          TZFAC=R(J)/(R(M)+BFAC*(R(J)-R(M)))                            ST 840
          DO 72 I=IS,IE                                                 ST 841
          MAX=JWLO(I,NGOTO)-1                                           ST 842
          LIJ=JM(J)+I                                                   ST 843
          LP=KJM+I                                                      ST 844
          LXP=LP+1                                                      ST 845
          LYP=LP+NI                                                     ST 846
          LZP=LP+NIMJ                                                   ST 847
          AXM(LIJ)=CX                                                   ST 848
          AYM(LIJ)=CY(I)                                                ST 849
          AZM(LIJ)=CZ(LIJ)                                              ST 850
          AREA=YSR(J)*ZS(K)                                             ST 851
          IF (I.EQ.IE) GO TO 73                                         ST 852
          ALX=.25*(RHO(LP)+RHO(LXP))*U(LXP)*AREA                        ST 853
          TX=.5*(GAM(LP)+GAM(LXP))*AREA/XDIF(I+1)                       ST 854
          TX=AMAX1(TX,ABS(ALX))                                         ST 855
          CXUP=2.*ALX                                                   ST 856
          GO TO 74                                                      ST 857
   73     ALX=RHO(LXP)*U(LXP)*AREA                                      ST 858
          DIST=.5*XDIF(I+1)                                             ST 859
          IF (I.EQ.L) DIST=XDIF(LP1)                                    ST 860
          TX=GAM(LXP)*AREA/DIST                                         ST 861
          TX=AMAX1(TX,ALX)                                              ST 862
          CXUP=ALX                                                      ST 863
   74     AXP(LIJ)=TX-ALX                                               ST 864
          CX=TX+ALX                                                     ST 865
          DIVG(LIJ)=DIVG(LIJ)+CXUP-CXU                                  ST 866
          CXU=CXUP                                                      ST 867
          AREA=ZS(K)*XS(I)*RM(J+1)                                      ST 868
          IF (J.EQ.MAX) GO TO 75                                        ST 869
          ALY=.25*(RHO(LP)+RHO(LYP))*V(LYP)*AREA                        ST 870
          TY=.5*(GAM(LP)+GAM(LYP))*AREA/YDIF(J+1)                       ST 871
          TY=AMAX1(TY,ABS(ALY))                                         ST 872
          CYUP=2.*ALY                                                   ST 873
          GO TO 76                                                      ST 874
   75     ALY=RHO(LYP)*V(LYP)*AREA                                      ST 875
          DIST=.5*YDIF(J+1)                                             ST 876
          IF (J.EQ.M) DIST=YDIF(MP1)                                    ST 877
          TY=GAM(LYP)*AREA/DIST                                         ST 878
          TY=AMAX1(TY,ALY)                                              ST 879
          CYUP=ALY                                                      ST 880
   76     AYP(LIJ)=TY-ALY                                               ST 881
          CY(I)=TY+ALY                                                  ST 882
          DIVG(LIJ)=DIVG(LIJ)+CYUP-CYU(I)                               ST 883
          CYU(I)=CYUP                                                   ST 884
          AREA=XS(I)*YS(J)                                              ST 885
          IF(K.EQ.N) GO TO 77                                           ST 886
          ALZ=.25*(RHO(LP)+RHO(LZP))*W(LZP)*AREA                        ST 887
          TZ=.5*(GAM(LP)+GAM(LZP))*AREA*TZFAC/(ZDIF(K+1)*R(J))          ST 888
          TZ=AMAX1(TZ,ABS(ALZ))                                         ST 889
          CZUP=2.*ALZ                                                   ST 890
          GO TO 78                                                      ST 891
   77     ALZ=RHO(LZP)*W(LZP)*AREA                                      ST 892
          ALZ=ALZ/2.                                                    ST 893
          TZ=GAM(LZP)*AREA*TZFAC/(ZSM(NP1)*R(J))                        ST 894
          TZ=AMAX1(TZ,ABS(ALZ))                                         ST 895
          CZUP=2.*ALZ                                                   ST 896
   78     AZP(LIJ)=TZ-ALZ                                               ST 897
          CZ(LIJ)=TZ+ALZ                                                ST 898
          DIVG(LIJ)=DIVG(LIJ)+CZUP-CZU(LIJ)                             ST 899
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SUBROUTINE STRIDE     73/74    OPT=0 TRACE                     FTN 4.6+439        08/24/78  14.08.44        PAGE    13

                CZU(LIJ)=CZUP                                                     ST        900
                VOL=XS(I)*YS(J)*ZS(K)                                             ST        901
         79     ROT=0.                                                            ST        902
         792    DIVG(LIJ)=AMAX1(ROT,DIVG(LIJ))                                    ST        903
                LPF=LP+NVM(NVF(NV))                                               ST        904
                SU(LIJ)=SU(LIJ)+VOL*DIVG(LIJ)*F(LPF)                              ST        905
                SP(LIJ)=SP(LIJ)+VOL-DIVG(LIJ)                                     ST        906
             72 CONTINUE                                                          ST        907
                CALL SORCD                                                        ST        908
                CALL SOLVE1                                                       ST        909
            701 CONTINUE                                                          ST        910
                CALL SOLVE2                                                       ST        911
                CALL FMOD                                                         ST        912
         702    CONTINUE                                                          ST        913
            700 CONTINUE                                                          ST        914
      C *-*-*-*-*-*-*-*-*-*-*-*-*-*-*-   RADIATION EQUATIONS   *-*-*-*-*-*-*-*-*-*-*-* ST   915
      C  ------ HERE U IS FX,   V IS FY,   W IS FZ                                 ST        916
                READ (NTP1) U,V,W                                                 ST        917
                IMD=0                                                             ST        918
                DO 730 NV=LVRX,LVRZ                                               ST        919
                IF (ISOLVE(NV)) 733,730,733                                       ST        920
            733 IF (MOD(ISTEP,ISOLVE(NV))) 730,734,730                            ST        921
            734 IF (IMD.EQ.0) CALL CAMRAD                                         ST        922
                IF (IPLAT.EQ.1) IMD=1                                             ST        923
                CALL STRAD                                                        ST        924
                CALL FMOD                                                         ST        925
            730 CONTINUE                                                          ST        926
      C  ----   COMPUTE AVG RADIATION FLUX  ------                                ST        927
                DO 740 K=1,NP1                                                    ST        928
                DO 740 J=1,NP1                                                    ST        929
                KJM=KM(K)+JM(J)                                                   ST        930
                DO 740 I=1,LP1                                                    ST        931
                LP=KJM+I                                                          ST        932
                LPRX=LP+NVM(NVRX)                                                 ST        933
                LPRY=LP+NVM(NVRY)                                                 ST        934
                LPRZ=LP+NVM(NVRZ)                                                 ST        935
                LPFAV=LP+NVM(NVFAV)                                               ST        936
            740 F(LPFAV)=(F(LPRX)+F(LPRY)+F(LPRZ))/3.                             ST        937
      C  -------- HERE PP IS PHI, P IS MFU, DU IS RCO                             ST        938
                WRITE (NTP2) PP,P,DU                                              ST        939
      C  -------- HERE DV IS ENTHALPY, DW IS FAV                                  ST        940
                WRITE (NTP2) DV,DW                                                ST        941
      C  ------ HERE U IS FX,   V IS FY,   W IS FZ                                 ST        942
                WRITE (NTP2) U,V,W                                                ST        943
                WRITE (NTP2) TEMP,RHO                                             ST        944
            799 NTPT=NTP1+NTP2                                                    ST        945
                NTP1=NTPT-NTP1                                                    ST        946
                NTP2=NTPT-NTP2                                                    ST        947
         800    ISTEP=ISTEP+1                                                     ST        948
                IXY= 3-IXY                                                        ST        949
                RETURN                                                            ST        950
                END                                                               ST        951


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    45      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    69      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    99      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   101      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   126      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   132      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   351      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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   679      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   742      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   756      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   759      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   767      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   780      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   794      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   836      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   944      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
   953      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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              SUBROUTINE STRAD                                                    STR       2
              COMMON/CDEF/A(40),B(40),EP(30),DP(30),APP(30),BPP(30)               STR       3
              COMMON F(3500),DU(500),DV(500),DW(500),                             COMFB     2
             1  RHO(500),VISC(500),SU(100),SP(100),DRHODP(500),                   COMFB     3
             1  AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),                     COMFB     4
             2  AZM(100),CZ(100),CY(10),CZU(100),CYU(10),                         COMFB     5
             3  CZP(100),CYP(10),DIVG(100),NTP1,NTP2                              COMFB     6
              DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)             COMFB     7
              DIMENSION GAM(500)                                                  COMFB     8
              EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))                COMFB     9
              EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1))        COMFB    10
              EQUIVALENCE (F(3001),GAM(1))                                        COMFB    11
              COMMON/CYL/R(30),RR(30),RRV(30),YSR(30),YSVR(30),IPLAX              COMMON    2
              COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),         COMMON    3
             1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),       COMMON    4
             2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                           COMMON    5
              COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NINJ,NINJNK,NV,   COMMON    6
             1  NNV,NGOTO,K,ISTR,JSTR,KSTR,NVR(20),KR(30),JM(30),ISTEP,           COMMON    7
             2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,    COMMON    8
             3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,       COMMON    9
             4  IWEO,NN1,JWII,JWIO,JWOI,JWOO,IOW,JKIN(30,30),IKIN(40,30)          COMMON   10
              COMMON/INDEX/IPAK,LPREF,ISTGN,NCOMP,ITRAD,NVRX,NVRY,NVRZ,IPLANE     COMMON   11
             1  ,PLANE1,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),      COMMON   12
             2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,      COMMON   13
             3  NVN2                                                              COMMON   14
              COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEN,IDK,FSTOIC,HFU,CP,     COMMON   15
             1  GASCON,RHOCON,VMICON,PRESS,NVFAV,TCYLW,TINLW,ILIP,ACOEF(4),       COMMON   16
             2  T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,NYY,CXX,RATIO1,RATIO2,          COMMON   17
             3  RATIO3,RATIO4,HCO,TAN,ITWALL                                      COMMON   18
              COMMON/CTDMA/KEND,ICTDMA(13)                                        COMMON   19
              KONTRO=NV-LVRX+1                                                    STR       6
              GO TO (100,200,300),KONTRO                                          STR       7
        C  -----   X-DIRECTION FLUX   ------                                      STR       8
          100 CONTINUE                                                            STR       9
              DO 101 K=2,N                                                        STR      10
              NVKM=NVR(NVRX)+KR(K)                                                STR      11
              CALL SORAD                                                          STR      12
              CALL SOMOD                                                          STR      13
              DO 102 J=2,M                                                        STR      14
              TX=0.                                                               STR      15
              IS=IWLI(J,NGOTO)                                                    STR      16
              IE=IWLO(J,NGOTO)                                                    STR      17
              DO 103 I=IS,IE                                                      STR      18
              LIJ=JM(J)+I                                                         STR      19
              LP=LIJ+KR(K)                                                        STR      20
              LXP=LP+1                                                            STR      21
              AXM(LIJ)=TX                                                         STR      22
              TX=.5*(GAM(LP)+GAM(LXP))/XDIF(I+1)                                  STR      23
              AXP(LIJ)=TX                                                         STR      24
              SU(LIJ)=SU(LIJ)*XS(I)                                               STR      25
              SP(LIJ)=SP(LIJ)*XS(I)                                               STR      26
          103 CONTINUE                                                            STR      27
              AXP(LIJ)=0.                                                         STR      28
          102 CONTINUE                                                            STR      29
              DO 104 J=2,M                                                        STR      30
              LPF=NVKM+JM(J)                                                      STR      31
              IS=IWLI(J,NGOTO)                                                    STR      32
              IE=IWLO(J,NGOTO)                                                    STR      33
              ISTRI=IS-1                                                          STR      34
              A(ISTRI)=0.                                                         STR      35
              B(ISTRI)=0.                                                         STR      36
              DO 105 I=IS,IE                                                      STR      37
              LIJ=JM(J)+I                                                         STR      38
              STORE=AXP(LIJ)+AXM(LIJ)-SP(LIJ)-AXM(LIJ)*A(I-1)                     STR      39
              A(I)=AXP(LIJ)/STORE                                                 STR      40
          105 B(I)=(SU(LIJ)+AXM(LIJ)*B(I-1))/STORE                                STR      41
              ISUM=IS+IE                                                          STR      42
              DO 106 II=IS,IE                                                     STR      43
              I=ISUM-II                                                           STR      44
              LP=LPF+I                                                            STR      45
          106 F(LP)=A(I)*F(LP+1)+B(I)                                             STR      46
          104 CONTINUE                                                            STR      47
          101 CONTINUE                                                            STR      48
              RETURN                                                              STR      49
        C  -----   Y-DIRECTION FLUX   ---                                         STR      50
          200 CONTINUE                                                            STR      51
              DO 201 K=2,N                                                        STR      52
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                NFK=NUM(NJBY)+NM(K)                                          STR      53
                CALL SORAD                                                   STR      54
                CALL SOMOD                                                   STR      55
                DO 202 I=2,L                                                 STR      56
                TY=0.                                                        STR      57
                JS=JML1(I,NGOTO)+1                                           STR      58
                JE=JML2(I,NGOTO)-1                                           STR      59
                DO 203 J=JS,JE                                               STR      60
                LIJ=JM(J)+I                                                  STR      61
                LP=LIJ+KM(K)                                                 STR      62
                LYP=LP+NI                                                    STR      63
                AYM(LIJ)=TY                                                  STR      64
                TY=.5*(GAM(LP)+GAM(LYP))/YDIF(J+1)*RP(J+1)                   STR      65
                AYP(LIJ)=TY                                                  STR      66
                SU(LIJ)=SU(LIJ)+YS(J)*RP(J)                                  STR      67
                SP(LIJ)=SP(LIJ)+YS(J)*R(J)                                   STR      68
            203 CONTINUE                                                     STR      69
                AYP(LIJ)=0.                                                  STR      70
            202 CONTINUE                                                     STR      71
                DO 204 I=2,L                                                 STR      72
                LPF=NF(K)+I                                                  STR      73
                JS=JML1(I,NGOTO)+1                                           STR      74
                JE=JML2(I,NGOTO)-1                                           STR      75
                JSTR=JS-1                                                    STR      76
                A(JSTR)=0.                                                   STR      77
                B(JSTR)=0.                                                   STR      78
                DO 205 J=JS,JE                                               STR      79
                LIJ=JM(J)+I                                                  STR      80
                STORE=AYP(LIJ)+AYM(LIJ)-SP(LIJ)-AYM(LIJ)*A(J-1)              STR      81
                A(J)=AYP(LIJ)/STORE                                          STR      82
            205 B(J)=(SU(LIJ)+AYM(LIJ)*B(J-1))/STORE                         STR      83
                JSUM=JS+JE                                                   STR      84
                DO 206 JJ=JS,JE                                              STR      85
                J=JSUM-JJ                                                    STR      86
                LP=LPF+JM(J)                                                 STR      87
                LYP=LP+NI                                                    STR      88
            206 F(LP)=A(J)*F(LYP)+B(J)                                       STR      89
            204 CONTINUE                                                     STR      90
            201 CONTINUE                                                     STR      91
                RETURN                                                       STR      92
C         ------      Z-DIRECTION FLUX    ---                                STR      93
            300 KSUM=2+N                                                     STR      94
                DO 301 J=2,M                                                 STR      95
                JPLANE=J                                                     STR      96
                NYJM=NUM(NCBZ)+JM(J)                                         STR      97
                CALL SORAD                                                   STR      98
                IS=IML1(J,NGOTO)                                             STR      99
                IE=IML2(J,NGOTO)                                             STR     100
                DO 302 I=IS,IE                                               STR     101
                LIJ=JM(J)+I                                                  STR     102
                TZ=0.                                                        STR     103
                DO 303 K=2,N                                                 STR     104
                LIK=JM(J)+I                                                  STR     105
                LP=LIJ+KM(K)                                                 STR     106
                LZP=LP+NIJ                                                   STR     107
                AZM(LIK)=TZ                                                  STR     108
                TZ=.5*(GAM(LP)+GAM(LZP))/(ZDIF(K+1))*R(J))                   STR     109
                AZP(LIK)=TZ                                                  STR     110
                SU(LIK)=SU(LIK)+ZS(K)*R(J)                                   STR     111
                SP(LIK)=SP(LIK)+ZS(K)*R(J)                                   STR     112
            303 CONTINUE                                                     STR     113
                AZP(LIK)=0.                                                  STR     114
            302 CONTINUE                                                     STR     115
                CALL SOMODZ                                                  STR     116
                DO 304 I=IS,IE                                               STR     117
                A(1)=0.                                                      STR     118
                B(1)=0.                                                      STR     119
                LPF=NY(J)+I                                                  STR     120
                DO 305 K=2,N                                                 STR     121
                LIK=JM(K)+I                                                  STR     122
                STORE=AZP(LIK)+AZM(LIK)-SP(LIK)-AZM(LIK)*A(K-1)              STR     123
                A(K)=AZP(LIK)/STORE                                          STR     124
            305 B(K)=(SU(LIK)+AZM(LIK)*B(K-1))/STORE                         STR     125
                DO 306 KK=2,N                                                STR     126
                K=KSUM-KK                                                    STR     127
                LP=LPF+KM(K)                                                 STR     128
                LZP=LP+NIJ                                                   STR     129
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      SUBROUTINE STRAD      73/74    OPT=0 TRACE                    FTN 4.6+439       08/24/78  14.08.46       PAGE     3

 155             300 F(LP)=A(K)*F(LZP)+B(K)                                              STR          130
                 304 CONTINUE                                                            STR          131
                 301 CONTINUE                                                            STR          132
                     RETURN                                                              STR          133
                     END                                                                 STR          134

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     32      I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     35      I               CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
     77      I               CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    129      I               CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
    146      I               CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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      SUBROUTINE SOLVE                                                  SO         2
      COMMON/COEF/AP(40),BP(40),EP(30),GP(30),APP(30),BPP(30)           SO         3
      COMMON F(3500),DU(500),DV(500),DW(500),                           COMFB      2
     1  RHO(500),VISC(500),SU(100),SP(100),DPMODP(500),                 COMFB      3
     1  AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),                   COMFB      4
     2  AZM(100),CZ(100),CY(10),CZU(100),CYU(10),                       COMFB      5
     3  CZP(100),CYP(10),DIVG(100),NTP1,NTP2                            COMFB      6
      DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)           COMFB      7
      DIMENSION GAM(500)                                                COMFB      8
      EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))              COMFB      9
      EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1))      COMFB     10
      EQUIVALENCE (F(3001),GAM(1))                                      COMFB     11
      COMMON/CYL/R(30),RV(30),RPV(30),YSR(30),YSVR(30),IPLAX            COMMON     2
      COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),       COMMON     3
     1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),     COMMON     4
     2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                         COMMON     5
      COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NINJ,NINJNK,NV, COMMON     6
     1  NRV,NGOTO,K,ISTR,JSTR,KSTR,NVM(20),KM(30),JM(30),ISTEP,         COMMON     7
     2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,  COMMON     8
     3  NRHO,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,     COMMON     9
     4  IWEO,NN1,JWII,JWIO,JWOI,JWOO,IOW,IKIN(30,30),IKIN(40,30)        COMMON    10
      COMMON/INDEX/IPAR,LPREF,ISTUN,INCOPP,ITRAD,NVRX,NVRY,NVRZ,JPLANE  COMMON    11
     1  ,PLAXM1,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVRX,LVRY,LVRZ,NVF(13),    COMMON    12
     2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUNCO,NVH2O,NVCO2,    COMMON    13
     3  NVN2                                                            COMMON    14
      COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MODEM,IDK,FSTOIC,HFU,CP,   COMMON    15
     1  GASCON,RHOCON,UNICON,PRESS,NVFAV,TCYLW,TIMLW,TLIF,ACOEF(4),     COMMON    16
     2  T4,DFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HTY,CXX,RATIO1,RATIO2,        COMMON    17
     3  RATIO3,RATIO4,NCO,TAM,ITWALL                                    COMMON    18
      COMMON/CTOMA/KEND,ICTOMA(13)                                      COMMON    19
      ENTRY SOLVE1                                                      SO         7
      RELAXM=1.-RELAX(NV)                                               SO         8
      DO 10 J=JSTR,M                                                    SO         9
      KJM=KM(K)+JM(J)                                                   SO        10
      IS=IWLI(J,NGOTO)                                                  SO        11
      IE=IWLO(J,NGOTO)                                                  SO        12
      DO 10 I=IS,IE                                                     SO        13
      LIJ=JM(J)+I                                                       SO        14
      LP=KJM+I                                                          SO        15
      LPF=LP+NVM(NVF(NV))                                               SO        16
      LZP=LPF+NINJ                                                      SO        17
      LZM=LPF-NINJ                                                      SO        18
      FLZP=F(LZP)                                                       SO        19
      IF (NV.EQ.3.AND.K.EQ.NP1) FLZP=W(LIJ+2*NINJ)                      SO        20
   15 CONTINUE                                                          SO        21
      SP(LIJ)=(AXP(LIJ)+AXM(LIJ)+AYM(LIJ)+AYP(LIJ)+AZM(LIJ)+AZP(LIJ)-   SO        22
     1SP(LIJ))/RELAX(NV)                                                SO        23
      SU(LIJ)=SU(LIJ)+SP(LIJ)*RELAXM*F(LPF)+AZM(LIJ)*F(LZM)+AZP(LIJ)*   SO        24
     1  FLZP                                                            SO        25
      GO TO (11,12,13,10),NGOTO                                         SO        26
   11 DU(LP)=DU(LP)/SP(LIJ)                                             SO        27
      GO TO 10                                                          SO        28
   12 DV(LP)=DV(LP)/SP(LIJ)                                             SO        29
      GO TO 10                                                          SO        30
   13 DW(LP)=DW(LP)/SP(LIJ)                                             SO        31
   10 CONTINUE                                                          SO        32
      NVKM=KM(K)+NVM(NVF(NV))                                           SO        33
      ISUM=ISTR+L                                                       SO        34
      JSUM=JSTR+M                                                       SO        35
      INOMAX=ICTOMA(NV)                                                 SO        36
      DO 65 INO=1,INOMAX                                                SO        37
      GO TO (20,30),IXY                                                 SO        38
   20 CONTINUE                                                          SO        39
      DO 21 JJ=JSTR,M                                                   SO        40
      GO TO (24,25),JSWP                                                SO        41
   24 J=JJ                                                              SO        42
      GO TO 26                                                          SO        43
   25 J=JSUM-JJ                                                         SO        44
   26 CONTINUE                                                          SO        45
      LPF=NVKM+JM(J)                                                    SO        46
      IS=IWLI(J,NGOTO)                                                  SO        47
      IE=IWLO(J,NGOTO)                                                  SO        48
      ISTR1=IS-1                                                        SO        49
      LPF1=LPF+ISTR1                                                    SO        50
      AP(ISTR1)=0.                                                      SO        51
      BP(ISTR1)=F(LPF1)                                                 SO        52
      DO 22 I=IS,IE                                                     SO        53
```

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SUBROUTINE SOLVE       73/74    OPT=0 TRACE                      FTN 4.6+439        04/24/79  14.09.45        PAGE      2

                         LIJ=JM(J)+I                                                             SO          54
                         LYP=LPF+NI+I                                                            SO          55
  80                     LYM=LPF-NI+I                                                            SO          56
                         STORE=SP(LIJ)-AXM(LIJ)*AP(I-1)+1.E-30                                   SO          57
                         AP(I)=AXP(LIJ)/STORE                                                    SO          58
               22        BP(I)=(SU(LIJ)+AYP(LIJ)*F(LYP)+AYM(LIJ)*F(LYM)+AXM(LIJ)*BP(I-1))/       SO          59
                        1STORE                                                                   SO          60
  85                     ISUM1=IS+IE                                                             SO          61
                         DO 23 II=IS,IE                                                          SO          62
                         I=ISUM1-II                                                              SO          63
                         LP=LPF+I                                                                SO          64
               23        F(LP)=AP(I)*F(LP+1)+BP(I)                                               SO          65
  90           21        CONTINUE                                                                SO          66
                         JSWP=3-JSWP                                                             SO          67
                         GO TO (28,20),JSWP                                                      SO          68
                      28 CONTINUE                                                                SO          69
                         GO TO (30,40),IXY                                                       SO          70
  95           30        DO 31 II=ISTR,L                                                         SO          71
                         GO TO (34,35),ISWP                                                      SO          72
               34        I=II                                                                    SO          73
                         GO TO 36                                                                SO          74
               35        I=ISUM-II                                                               SO          75
 100           36        CONTINUE                                                                SO          76
                         LPF=NVKM*I                                                              SO          77
                         JS=JWLI(I,NGOTO)+1                                                      SO          78
                         JE=JWLO(I,NGOTO)-1                                                      SO          79
                         JSTR1=JS-1                                                              SO          80
 105                     LPF1=LPF+JM(JSTR1)                                                      SO          81
                         AP(JSTR1)=0.                                                            SO          82
                         BP(JSTR1)=F(LPF1)                                                       SO          83
                         DO 32 J=JS,JE                                                           SO          84
                         LIJ=JM(J)+I                                                             SO          85
 110                     LXP=NVKM*LIJ+I                                                          SO          86
                         LXM=LXP-2                                                               SO          87
                         STORE=SP(LIJ)-AYM(LIJ)*AP(J-1)+1.E-30                                   SO          88
                         AP(J)=AYP(LIJ)/STORE                                                    SO          89
               32        BP(J)=(SU(LIJ)+AXP(LIJ)*F(LXP)+AXM(LIJ)*F(LXM)+AYM(LIJ)*BP(J-1))/       SO          90
 115                    1STORE                                                                   SO          91
                         JSUM1=JS+JE                                                             SO          92
                         DO 33 JJ=JS,JE                                                          SO          93
                         J=JSUM1-JJ                                                              SO          94
                         LP=LPF+JM(J)                                                            SO          95
 120                     LYP=LP+NI                                                               SO          96
               33        F(LP)=AP(J)*F(LYP)+BP(J)                                                SO          97
               31        CONTINUE                                                                SO          98
                         ISWP=3-ISWP                                                             SO          99
                         GO TO (38,30),ISWP                                                      SO         100
 125                  38 CONTINUE                                                                SO         101
                         GO TO (40,20),IXY                                                       SO         102
               40        CONTINUE                                                                SO         103
                      45 CONTINUE                                                                SO         104
                         RETURN                                                                  SO         105
 130           C    **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  *  SO         106
                         ENTRY SOLVE2                                                            SO         107
                         RETURN                                                                  SO         108
                         END                                                                     SO         109


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    62       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    65       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    92       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    94       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    96       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   124       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   126       I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

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SUBROUTINE FPRINT      73/74    OPT=0 TRACE                 FTN 4.6+439        08/24/79  14.08.46        PAGE      1

  1                SUBROUTINE FPRINT (ISTRT,ISTOP,NVVV)                                   FP          2
                   COMMON F(3500),DU(500),DV(500),DW(500),                                COMFB       2
                  1 RHO(500),VISC(500),SU(100),SP(100),DRHODP(500),                       COMFB       3
                  1  AXP(100),AXM(100),AYP(100),AYM(100),AZP(100),                        COMFB       4
  5               2  AZM(100),CZ(100),CY(10),CZU(100),CYU(10),                            COMFB       5
                  3  CZP(100),CYP(10),IEVG(100),NTP1,NTP2                                 COMFB       6
                   DIMENSION U(500),V(500),W(500),PP(500),P(500),TEMP(500)                COMFB       7
                   DIMENSION GAM(500)                                                     COMFB       8
                   EQUIVALENCE (F(1),U(1)),(F(501),V(1)),(F(1001),W(1))                   COMFB       9
 10                EQUIVALENCE (F(1501),PP(1)),(F(2001),P(1)),(F(2501),TEMP(1))           COMFB      10
                   EQUIVALENCE (F(3001),GAM(1))                                           COMFB      11
                   COMMON/CYL/R(30),RM(30),RMV(30),YSP(30),YSVP(30),IPLAT                 COMMON      2
                   COMMON/GRID/X(40),Y(30),Z(30),XS(40),YS(30),ZS(30),XSU(40),            COMMON      3
                  1  YSV(30),ZSW(30),XDIF(40),YDIF(30),ZDIF(30),FXP(40),FXM(40),          COMMON      4
 15               2  FYP(30),FYM(30),FZP(30),FZM(30),DT,TIME                              COMMON      5
                   COMMON/INT/L,M,N,LCV,MCV,NCV,LP1,MP1,NP1,NI,NJ,NK,NINJ,NINJNK,NV,      COMMON      6
                  1  NWD,NGOTO,K,ISTR,JSTR,KSTR,NVP(20),KR(30),JM(30),ISTEP,              COMMON      7
                  2  ISOLVE(13),IPRINT(22),TITLE(10,22),IXY,ISWP,JSWP,RELAX(16),NP,       COMMON      8
                  3  NPRD,NGAM,IWLI(30,5),IWLO(30,5),JWLO(40,5),JWLI(40,5),IWEI,          COMMON      9
 20               4  IWEO,JWEI,JWII,JWIO,JWOI,JWOO,IOW,JKIN(30,30),IKIN(40,30)            COMMON     10
                   COMMON/INDEX/IPAR,LPREF,ISTUN,INCOMP,ITRAD,NVPX,NVPY,NVPZ,JPLANE       COMMON     11
                  1  ,PLANE1,LVK,LVD,LVFUOX,LVFU,LVCO,LVH,LVPX,LVPY,LVPZ,NVF(13),         COMMON     12
                  2  IJUMP,IRES,TITLE2(20),IMAX,JMAX,KMAX,NVCO,FUMCO,NVH2O,NVCO2,         COMMON     13
                  3  NVN2                                                                 COMMON     14
 25                COMMON/THERM/NVH,NVFU,NVOX,NVFUOX,NVTE,MOLFN,IOX,FSTOIC,HFU,CP,        COMMON     15
                  1  GASCON,RHOCON,UNICON,PRESS,NVFAV,TCYL,TINLET,TLIP,ACOEF(6),          COMMON     16
                  2  T4,OFAC,WFU,WCO2,WCO,WOX,WH2O,WN2,HYY,CXX,RATIO1,RATIO2,             COMMON     17
                  3  RATIO3,RATIO4,HCO,TAN,ITWALL                                         COMMON     18
                   COMMON/CTOMA/IEND,ICTOMA(13)                                           COMMON     19
 30                DIMENSION INVV(22)                                                     FP          5
                   DATA INVV/2,1,1,3,1,1,4,4,4,1,1,1,1,1,4,1,1,1,1,1,1,5/                 FP          6
                   NVVV=NVVV-1                                                            FP          7
                   DO 108 NV=ISTRT,ISTOP                                                  FP          8
                   NVVV=NVVV+1                                                            FP          9
 35                IF (IPRINT(NVVV).EQ.0) GO TO 108                                       FP         10
                   WRITE (6,101) (TITLE(I,NVV),I=1,10)                                    FP         11
               101 FORMAT (1H0,20(2H*-),10A4,3X,20(2H-*))                                 FP         12
                   KONE=1                                                                 FP         13
                   IF (NVV.EQ.3) KONE=2                                                   FP         14
 40                NSKIP=IPRINT(NVV)                                                      FP         15
                   DO 100 K=KONE,MP1,NSKIP                                                FP         16
                   WRITE(6,102) K                                                         FP         17
               102 FORMAT(1H0,50X,6HK = ,I2)                                              FP         18
                   NVKP=NVP(NV)+KR(K)                                                     FP         19
 45                JONE=1                                                                 FP         20
                   IF (NVV.EQ.2) JONE=2                                                   FP         21
                   IONE=1                                                                 FP         22
                   IF (NVV.EQ.1) IONE=2                                                   FP         23
                   ISTART=IONE-12                                                         FP         24
 50           105  CONTINUE                                                               FP         25
                   ISTART=ISTART+12                                                       FP         26
                   IEND=ISTART+11                                                         FP         27
                   IEND=MIN0(IEND,LP1)                                                    FP         28
                   WRITE(6,103) (I,I=ISTART,IEND)                                         FP         29
 55           103  FORMAT(1H0,6H  I = ,I3,11I10)                                          FP         30
                   WRITE(6,104)                                                           FP         31
              104  FORMAT(2H J)                                                           FP         32
                   JSUM=JONE+MP1                                                          FP         33
                   DO 106 JJ=JONE,MP1                                                     FP         34
 60                J=JSUM-JJ                                                              FP         35
                   LPF=NVKP+JM(J)                                                         FP         36
                   LPL=LPF+IEND                                                           FP         37
                   LPF=LPF+ISTART                                                         FP         38
              106  WRITE(6,107) J,(F(LP),LP=LPF,LPL)                                      FP         39
 65           107  FORMAT(I3,1P12E10.2)                                                   FP         40
                   IF(IEND.LT.LP1) GO TO 105                                              FP         41
              100  CONTINUE                                                               FP         42
               108 CONTINUE                                                               FP         43
                    RETURN                                                                FP         44
 70                   END                                                                 FP         45


CARD NR. SEVERITY  DETAILS     DIAGNOSIS OF PROBLEM

    33      I                 CONTROL VARIABLE IN COMMON OR EQUIVALENCED. OPTIMIZATION MAY BE INHIBITED.
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        SUBROUTINE FPRINT     73/74   OPT=0 TRACE                     FTN 4.6+439        09/24/79  14.05.46        PAGE     2
CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM
    41     I                CONTROL VARIABLE IN COMMON OR EQUIVALENCED, OPTIMIZATION MAY BE INHIBITED.
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APPENDIX D

LISTING OF LINER COOLING MODEL

```
      PROGRAM MAIN (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)                 MA       2
C                                                                          MA       3
C     *****************************************************************    MA       4
C     *****************************************************************    MA       5
C     ****************** COMBUSTOR DESIGN CRITERIA ********************    MA       6
C     WALL COOLING MODEL                                                   MA       7
C                                                                          MA       8
C                                                                          MA       9
C     -----------------------------------------------------------------    MA      10
CHAPTERCC000000000000C000C   PRELIMINARIES   0000000000000000000000C0000000 MA      11
C     --------------------------- DIMENSIONS AND COMMON BLOCKS.            MA      12
      COMMON/COMA/A(43),AJE(16),AJI(16),B(43),C(43),CSALFA,D(43),          COMA     2
     1 DPDX(43),DX,EMU(43),F(15,43),FS(3,43),TAX,TEND,TFIN,INDE(16),       COMA     3
     2 INDI(16),IOUT,ISTEP,ITEST,IUTRAP,JS,ISW,JV,JY,KEX,KIN,KPAD,N,       COMA     4
     3 ND2,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(16),           COMA     5
     4 PREF(16),PSIE,PSII,R(43),RHO(43),RU(43),RMF,RMI,SD(43),SU(43),      COMA     6
     5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PS4RL(43),RDY(43),ISOLVE(16),     COMA     7
     6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,P16SCM,FDIFI(16),FDIFF(16),      COMA     8
     7 GE(16),GI(16),JLOC(12),W(12),JH,JFU,JCO2,JCO,JOX,JH2O,JOH,JO,JHS,   COMA     9
     8 JH2,JN,JNO,JN2,JVT,JD,JK,JT,JRY,NSP,NSPM,ABSMP,SCATR,BOMT200),      COMA    10
     9 EMI,SIGMA,CP,JFUOX,IFLUX,EVAP(43),TFJFL,MEN7                        COMA    11
      COMMON/COMB/AK,ALMG,EWALL,FP,H,HFU,INERT,MASSTP,MODEL,PRESS,         COMB     2
     1 UBAR,UFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,      COMB     3
     2 PREXP2,CR1,CR2,MODEP,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,      COMB     4
     3 CX,HY,DXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                        COMB     5
     4 WH2,WN,WNO,WN2                                                      COMB     6
      COMMON/COMC/API(40),APE(40),XP(40),NAP                               COMC     2
      COMMON/COMD/XUINJ(12),UINJ(12),TUINJ(12),VTUINJ(12),AUINJ(12),       COMD     2
     1 XVINJ(12),UVINJ(12),VINJ(12),VTVINJ(12),TVINJ(12),AVINJ(12),        COMD     3
     2 RUINJ(12),APUINJ(12),HJINJ(12),XLUINJ(12),TAN(2),VELA(2),           COMD     4
     3 PRAD(2),NUI,NUE,NVI,NVE                                             COMD     5
      DIMENSION TITLE(24),OUT(43),LAB(2)                                   MA      17
      DIMENSION XPLOT(43),YPLOT(10,43),YAXES(10,2),SYMBOL(10)              MA      18
      DIMENSION FLUX(16),DFI(16),DFE(16),AJTD(16),AJFD(16)                 MA      19
      DIMENSION YIN(40),UIN(40),VTIN(40),TIN(40),MFUIN(40),MCOIN(40)       MA      20
      DIMENSION TKIN(40),TLIN(40),MCO2IN(40),MH2IN(40)                     MA      21
      DIMENSION MFUOXIN(40)                                                MA      22
      DIMENSION IPLOT(19),IPRNT(19),SYM(19),LAB1(19),LAB2(19)              MA      23
      REAL MFUIN,MCOIN,MCO2IN,LAB,LAB1,LAB2,MH2IN,MFUOXIN                  MA      24
      NAMELIST/INPUT/IUTRAP,ULIM,PEILIM,AFAC,AEXOLM,POWER,NOVEL,           MA      25
     1 ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,FP,IOPDX,C1,C2,CD,              MA      26
     2 C2VT,AKFAC,ALFAC,PREF,CX,HY,HFU,MODEP,ITHIN,KSFAC,URAT,             MA      27
     3 ABSOP,SCATR,EMISW                                                   MA      28
      DATA JH,JFU,JCO2,JCO,JOX,JH2O,JOH,JO,JHS/1,2,3,4,5,6,7,8,9/          MA      29
      DATA JH2,JN,JNO,JVT,JK,JD,JN2,JT,JRY/10,11,12,13,14,15,1,2,3/        MA      30
      DATA JFUOX/16/                                                       MA      31
      DATA IPLOT/0,1,0,1,1,0,0,0,0,0,0,0,1,0,0,1,0,1,0/                    MA      32
      DATA SYM/1HE,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H*,1H+,            MA      33
     1 1HV,1HD,1HK,1HP,1H.,1HT,1HR/                                        MA      34
      DATA LAB1/6HENTH  ,6HFUEL  ,5HCO2  ,4HCO   ,6HOXYGEN,6HH2O   ,       MA      35
     1 6HOH    ,6HO     ,6HH     ,6HH2    ,5HN   ,6HNO    ,6HVT    ,       MA      36
     2 6HKE    ,6HLEN   ,6HPHT   ,6HN2    ,6HTEMP  ,6HRAD   /              MA      37
      DATA LAB2/19*2H  /                                                   MA      38
      DATA W/16.,44.,28.,32.,18.,17.,16.,1.,2.,14.,30.,28./                MA      39
      DATA WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,WH2,WN,WNO,WN2/16.,44.,28.,     MA      40
     1 32.,18.,17.,16.,1.,2.,14.,30.,28./                                  MA      41
      DATA SUM1,SUM2,SUM3,SUM4/0.,0.,0.,0./                                MA      42
C                                                                          MA      43
      READ(5,1) TITLE                                                      MA      44
    1 FORMAT(12A6)                                                         MA      45
C                                                                          MA      46
C     -----------------------------------------------------------------    MA      47
CHAPTER111111111111111111   PARAMETERS AND CONTROL INDICES   1111111111111 MA      48
      READ (5,2) N,KPAD,MASSTP,ISMPL,MODEL,INERT,IFLUX,ITEMP               MA      49
    2 FORMAT (8(I2,8X))                                                    MA      50
      READ (5,3) NSTAT,NPROF,NPLOT,ITEST,LASTEP                            MA      51
    3 FORMAT (8(I5,5X))                                                    MA      52
      IUTRAP=2                                                             MA      53
      ULIM=.05                                                             MA      54
      PEILIM=.01                                                           MA      55
      AFAC=.2                                                              MA      56
      AEXOLM=.02                                                           MA      57
      CSALFA=1.                                                            MA      58
      IOPDX=1                                                              MA      59
      H=.9                                                                 MA      60
      AK=.435                                                              MA      61
      ALMG=.09                                                             MA      62
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```
      FP=.033
      UFAC=.01
      NOVEL=2
      ITMIN=1
      KREAD=0
      UPAT=.83
      ABSOR=.1
      SCATR=.01
      EMISW=.8

C -----------------------------------------------------------------------
CHAPTER2222222222222222222222222  GRID AND GEOMETRY  2222222222222222222
      READ (5,4) XU,XULAST,FRA,XEND,XOUT,PRESS,POWER
      READ (5,2) NBP
      READ (5,4) (XR(I),ARI(I),ARE(I),I=1,NBP)
      RI=TAB(XU,XR,ARI,NBP)
      RE=TAB(XU,XR,ARE,NBP)
      READ (5,4) RA,RB,RD
    4 FORMAT (8E10.4)
C     ----- P(I) ADJUSTMENT MADE JUST BEFORE CALL STRIDE(1).
C     ----------STRIDE4----------STRIDE4-----------STRIDE4--------STRIDE4
      CALL STRIDE(4)
      IF(XEND.EQ.0.) IEND=0
      IF(XOUT.EQ.0.) IOUT=0
C     ------------------- CHANGE IEND, IAX AND IOUT, IF NECESSARY.
      DO 20 I=2,NP2
   20 OUT(I)=(FLOAT(I-2)/FLOAT(N))**ABS(POWER)
      IF (POWER.GT.0.0) GO TO 22
      DO 24 I=2,NP2
      II=NP2+2-I
   24 Y(II)=1.0-OUT(I)
      GO TO 26
   22 DO 28 I=2,NP2
   28 Y(I)=OUT(I)
   26 CONTINUE
C
C -----------------------------------------------------------------------
CHAPTER3333333333333333333333333  DEPENDENT VARIABLES SELECTION  3333333
C
      ISOLVE(JH)=ITEMP
      ISOLVE(JFU)=MASSTR
      ISOLVE(JCO2)=0
      ISOLVE(JCO)=MASSTR
      ISOLVE(JOX)=0
      ISOLVE(JH2O)=0
      ISOLVE(JOH)=0
      ISOLVE(JO)=0
      ISOLVE(JHS)=0
      ISOLVE(JH2)=0
      ISOLVE(JN)=0
      ISOLVE(JNO)=0
      ISOLVE(JVT)=ISWRL
      ISOLVE(JK)=MODEL-1
      ISOLVE(JD)=MODEL-1
      ISOLVE(JFUOX)=MASSTR
      NF=16
      NFS=3
      IPRNT(JH)=0
      IPRNT(JFU)=MASSTR
      IPRNT(JCO)=MASSTR
      IPRNT(JVT)=ISWRL
      IPRNT(JK)=MODEL-1
      IPRNT(JD)=MODEL-1
      IPRNT(JFUOX)=MASSTR
      IPRNT(JCO2)=0
      IPRNT(JOX)=MASSTR
      IPRNT(JH2O)=0
      IPRNT(JOH)=0
      IPRNT(JO)=0
      IPRNT(JHS)=0
      IPRNT(JH2)=0
      IPRNT(JN)=0
      IPRNT(JNO)=0
      INDX=NF
      IPRNT(JH2+INDX)=0
      IPRNT(JT+INDX)=ITEMP
      IPRNT(JRY+INDX)=IFLUX
```

```
      NSP=12
      NSPM=NSP-1
      JLOC(1)=JFU
      JLOC(2)=JCO2
      JLOC(3)=JCO
      JLOC(4)=JOX
      JLOC(5)=JH2O
      JLOC(6)=JOH
      JLOC(7)=JO
      JLOC(8)=JHS
      JLOC(9)=JH2
      JLOC(10)=JN
      JLOC(11)=JNO
      JLOC(12)=JN2
C
C  -----------------------------------------------------------------
CHAPTER4444444444444444444444444444444  MATERIAL CONSTANTS  444444444444444
C                                           S.I. UNITS
      GASCON=8314.
      WMIX=28.84
      CP=1048.
      CX=1.0
      HY=4.
      HFU=-49317.
C     ---ARRCON IS ACTIVATION ENERGY DIVIDED BY UNIVERSAL GAS CONSTANT.
      PREXP1=5.E+15
      ARCON1=26500.
      CP1=6.0
      PREXP2=6.E+09
      ARCON2=12500.
      CM2=4.0
      NCLEM=2
C
      DO 40 J=1,NF
      PR(J)=.7
      PREF(J)=.86
   40 IF (MODEL.EQ.1) PREF(J)=PR(J)
      PREF(JVT)=1.0
C  -----    TURBULENCE CONSTANTS      ------ ----
      C1=1.42
      C2=1.92
      CD=.09
      ANFAC=.03
      ALFAC=.02
      C2VT=0.36
      PREF(JK)=1.0
C   ----------       NAMELIST     -------
      READ (5,INPUT)
      PREF(JD)=AK**2/((C2-C1)/SQRT(CD))
      CD75=CD**.75
      GAMMA=CP/(CP-GASCON/WMIX)
      RCGSCN=PRESS*WMIX/GASCON
      WFU=12.*CX+HY
      W(1)=WFU
      RATIO1=WOX*(CX+HY/4.)/WFU
      RATIO2=.232
      RATIO3=WOX*0.5/WCO
      RATIO4=WCO*CX/WFU
      SLN=1./(1.-URAT)-1.
      DUM=COEF(WFU,1)
      DUM=COEFF(WFU,1)
      EPI=EMISW/(2.-EMISW)
C
C
C  -----------------------------------------------------------------
CHAPTER5555555555555555555555555555555  INITIAL CONDITIONS  5555555555
      READ (5,4) JE,UD,VTA,VTD
      READ (5,4) F2A,F2D,TA,TD,TWALL
C
      FIA=F2A*HDR(TA,1)+(1.-F2A)*RATIO2*HDR(TA,4)+(1.-F2A)*(1.-RATIO2)*
     1    HDR(TA,12)+.5*UA*UA
      FID=F2D*HDR(TD,1)+(1.-F2D)*RATIO2*HDR(TD,4)+(1.-F2D)*(1.-RATIO2)*
     1    HDR(TD,12)+.5*UD*UD
      READ (5,2) NIN,NUI,NUE,NWT,NWF
      READ (5,4) (YIN(I),I=1,NIN)
      READ (5,4) (JIN(I),I=1,NIN)
      READ (5,4) (VTIN(I),I=1,NIN)
      READ (5,4) (TIN(I),I=1,NIN)
```

```
      READ (5,4) (PFUIN(I),I=1,NIN)
      READ (5,4) (PFUCXIN(I),I=1,NIN)
      READ (5,4) (PCOIN(I),I=1,NIN)
      IF (KREAD.EQ.0) GO TO 19
      READ (5,4) (TKIN(I),I=1,NIN)
      READ (5,4) (TLIN(I),I=1,NIN)
   19 CONTINUE
C
C -------------- READ INJECTION VALUES
      IF (NUI.LE.0) GO TO 30
      READ (5,4) (XUINJ(I),I=1,NUI)
      READ (5,4) (XLUINJ(I),I=1,NUI)
      READ (5,4) (UINJ(I),I=1,NUI)
      READ (5,4) (VTUINJ(I),I=1,NUI)
      READ (5,4) (TUINJ(I),I=1,NUI)
      READ (5,4) (AUINJ(I),I=1,NUI)
      READ (5,4) (WUINJ(I),I=1,NUI)
      READ (5,4) (APUINJ(I),I=1,NUI)
      DO 31 I=1,NUI
      DEN=PDESCN/TUINJ(I)
   31 RUINJ(I)=DEN*UINJ(I)
   30 NI=NUI+1
      XUINJ(NI)=2.*ABS(XULAST)
      XLUINJ(NI)=2.*ABS(XULAST)
      NI=NI+1
      IF (NUE.LE.0) GO TO 32
      NE=NI+NUE-1
      READ (5,4) (XUINJ(I),I=NI,NE)
      READ (5,4) (XLUINJ(I),I=NI,NE)
      READ (5,4) (UINJ(I),I=NI,NE)
      READ (5,4) (VTUINJ(I),I=NI,NE)
      READ (5,4) (TUINJ(I),I=NI,NE)
      READ (5,4) (AUINJ(I),I=NI,NE)
      READ (5,4) (WUINJ(I),I=NI,NE)
      READ (5,4) (APUINJ(I),I=NI,NE)
      DO 33 I=NI,NE
      DEN=PDESCN/TUINJ(I)
   33 RUINJ(I)=DEN*UINJ(I)
   32 NE=NI+NUE
      XUINJ(NE)=2.*ABS(XULAST)
      XLUINJ(NE)=2.*ABS(XULAST)
      NUE=NUI+2
      NUI=1
      IF (NVI.LE.0) GO TO 35
      READ (5,4) (XVINJ(I),I=1,NVI)
      READ (5,4) (UVINJ(I),I=1,NVI)
      READ (5,4) (VINJ(I),I=1,NVI)
      READ (5,4) (VTVINJ(I),I=1,NVI)
      READ (5,4) (TVINJ(I),I=1,NVI)
      READ (5,4) (AVINJ(I),I=1,NVI)
   35 NI=NVI+1
      XVINJ(NI)=2.*ABS(XULAST)
      NI=NI+1
      IF (NVE.LE.0) GO TO 36
      NE=NI+NVE-1
      READ (5,4) (XVINJ(I),I=NI,NE)
      READ (5,4) (UVINJ(I),I=NI,NE)
      READ (5,4) (VINJ(I),I=NI,NE)
      READ (5,4) (VTVINJ(I),I=NI,NE)
      READ (5,4) (TVINJ(I),I=NI,NE)
      READ (5,4) (AVINJ(I),I=NI,NE)
   36 NE=NI+NVE
      XVINJ(NE)=2.*ABS(XULAST)
      NVE=NVI+2
      NVI=1
C
      READ (5,4) WFLA,TAN,FRAC
C
      DY=RE-RI
      Y(1)=0.0
      Y(NP3)=1.0
      DO 55 I=1,NP3
   55 Y(I)=Y(I)*DY
C
      DO 600 I=1,NP3
      U(I)=TAB(Y(I),YIN,UIN,NIN)
      F(JFU,I)=TAB(Y(I),YIN,PFUIN,NIN)
```

```
            F(JFUOX,I)=TAB(Y(I),YIN,WFUOXIN,NIN)                              MA      294
            F(JCO,I)=TAB(Y(I),YIN,WCOIN,NIN)                                  MA      295
            F(JVT,I)=TAB(Y(I),YIN,VTIN,NIN)                                   MA      296
            FS(JT,I)=TAB(Y(I),YIN,TIN,NIN)                                    MA      297
            IF (KREAD.EQ.0) GO TO 400                                         MA      298
            F(JK,I)=TAB(Y(I),YIN,TKIN,NIN)                                    MA      299
            F(JD,I)=CD*F(JK,I)**1.5/(TAB(Y(I),YIN,TLIN,NIN)+1.E-20)           MA      300
        400 CONTINUE                                                          MA      301
      C                                                                       MA      302
            DO 410 I=1,NP3                                                    MA      303
            DPDY(I)=0.0                                                       MA      304
            FS(JRY,I)=SIGMA*FS(JT,I)**4                                       MA      305
            R(I)=RI+Y(I)*CSALFA                                               MA      306
            FUB=F(JFUOX,I)-F(JFU,I)                                           MA      307
            F(JOX,I)=RATIO1*F(JFU,I)+RATIO3*F(JCO,I)+RATIO2-(RATIO2+RATIO1)   MA      308
           1 *F(JFUOX,I)                                                      MA      309
            F(JOX,I)=AMAX1(F(JOX,I),0.)                                       MA      310
            F(JCO2,I)=WCO2*CX*FUB/WFU-WCO2*F(JCO,I)/WCO                       MA      311
            F(JH2O,I)=HY*WH2O*FUB/WFU/2.                                      MA      312
            F(JOH,I)=0.                                                       MA      313
            F(JH2,I)=0.                                                       MA      314
            F(JO,I)=0.                                                        MA      315
            F(JOH,I)=0.                                                       MA      316
            F(JHS,I)=0.                                                       MA      317
            F(JNO,I)=0.                                                       MA      318
            F(JN,I)=0.                                                        MA      319
            FS(JN2,I)=1.0                                                     MA      320
            DO 412 JJ=1,NSPM                                                  MA      321
            J=JLOC(JJ)                                                        MA      322
        412 FS(JN2,I)=FS(JN2,I)-F(J,I)                                        MA      323
            HPI=0.                                                            MA      324
            DO 411 JJ=1,NSPM                                                  MA      325
            J=JLOC(JJ)                                                        MA      326
        411 HPI=HPI+F(J,I)*HDR(FS(JT,I),JJ)                                   MA      327
            F(JH,I)=HPI+FS(JN2,I)*HDR(FS(JT,I),12)+.5*U(I)*U(I)               MA      328
            IF (KREAD.EQ.1) GO TO 410                                         MA      329
            F(JK,I)=AKFAC*U(I)*U(I)                                           MA      330
            ALM=ALFAC*(Y(NP3)-Y(I))                                           MA      331
            IF (IOUT.NE.0) ALM=AMIN1(ALM,ALFAC*Y(I))                          MA      332
            ALM=AMAX1(ALM,ALFAC*Y(NP3)/100.)                                  MA      333
            F(JD,I)=CD*F(JK,I)**1.5/ALM                                       MA      334
        410 CONTINUE                                                          MA      335
            ALM=ALFAC*Y(NP3)                                                  MA      336
      C                                                                       MA      337
            DO 52 I=1,NP3                                                     MA      338
            P(I)=PRESS                                                        MA      339
            PSURL(I)=0.                                                       MA      340
            RII=R(I)                                                          MA      341
            IF (I.EQ.2) RII=.75*R(2)+.25*R(3)                                 MA      342
            IF (I.EQ.NP2) RII=.75*R(NP2)+.25*R(NP1)                           MA      343
            F(JVT,I)=RII*F(JVT,I)                                             MA      344
            VMIX=0.                                                           MA      345
            DO 413 JJ=1,NSPM                                                  MA      346
            J=JLOC(JJ)                                                        MA      347
        413 VMIX=VMIX+F(J,I)/W(JJ)                                            MA      348
            VMIX=VMIX+FS(JN2,I)/W(12)                                         MA      349
            RHO(I)=PRESS/FS(JT,I)/GASCON/VMIX                                 MA      350
            IF (I.EQ.1) GO TO 52                                              MA      351
            AFLO=.5*(R(I)**2-R(I-1)**2)                                       MA      352
            IF (KRAD.EQ.0) AFLO=Y(I)-Y(I-1)                                   MA      353
            OM(I)=.5*(RHO(I)*U(I)+RHO(I-1)*U(I-1))*AFLO                       MA      354
         52 CONTINUE                                                          MA      355
            DO 53 I=2,NP3                                                     MA      356
         53 OM(I)=OM(I-1)+OM(I)                                               MA      357
            FLOTOT=OM(NP3)                                                    MA      358
            DO 51 I=1,NP3                                                     MA      359
         51 OM(I)=OM(I)/FLOTOT                                                MA      360
      C                                                                       MA      361
            VMIX=F2A/WFU+(1.-F2A)*.03469                                      MA      362
            ROA=PRESS/TA/GASCON/VMIX                                          MA      363
            FLOA=ROA*UA*.5*(RB**2-RA**2)                                      MA      364
            PSII=FLOA                                                         MA      365
            PEI=FLOTOT                                                        MA      366
            PSIE=PSII+PEI                                                     MA      367
            DYOLD=0.0                                                         MA      368
      C                                                                       MA      369
      C     ----------------------------------------------------------------- MA      370
```

```
      CHAPTER6666666666666666666666666666555555  THERMODYNAMIC PROPERTIES  666666 MA        371
C     ********************  START OF MAIN LOOP  ********************              MA        372
   60 CONTINUE                                                                   MA        373
C                                                                                MA        374
C     ------------------------------------------------------ TEST 1              MA        375
      IF(ITEST) 602,601,602                                                      MA        376
  602 LAB(1)=6HTEST 1                                                            MA        377
      LAB(2)=6H                                                                  MA        378
      WRITE(6,100) LAB,P(1),PRESS,DX,PSII,PSIF,PFI,FPA,ULIM,PEILIM,AFAC,         MA        379
     1             AEXDLP                                                        MA        380
      LAB(1)=1HU                                                                 MA        381
      LAB(2)=6H                                                                  MA        382
      WRITE(6,100) LAB,(U(I),I=1,NP3)                                            MA        383
      LAB(1)=6HF(1,I)                                                            MA        384
      LAB(2)=6H                                                                  MA        385
      WRITE(6,100) LAB,(F(1,I),I=1,NP3)                                          MA        386
      LAB(1)=6HF(2,I)                                                            MA        387
      LAB(2)=6H                                                                  MA        388
      WRITE(6,100) LAB,(F(2,I),I=1,NP3)                                          MA        389
      LAB(1)=6HF(3,I)                                                            MA        390
      LAB(2)=6H                                                                  MA        391
      WRITE(6,100) LAB,(F(3,I),I=1,NP3)                                          MA        392
      LAB(1)=6HF(4,I)                                                            MA        393
      LAB(2)=6H                                                                  MA        394
      WRITE (6,100) LAB,(F(4,I),I=1,NP3)                                         MA        395
      LAB(1)=6HF(5,I)                                                            MA        396
      LAB(2)=6H                                                                  MA        397
      WRITE (6,100) LAB,(F(5,I),I=1,NP3)                                         MA        398
      LAB(1)=6HF(6,I)                                                            MA        399
      LAB(2)=6H                                                                  MA        400
      WRITE (6,100) LAB,(F(6,I),I=1,NP3)                                         MA        401
      LAB(1)=6HF(7,I)                                                            MA        402
      LAB(2)=6H                                                                  MA        403
      WRITE (6,100) LAB,(F(7,I),I=1,NP3)                                         MA        404
      LAB(1)=6HF(8,I)                                                            MA        405
      LAB(2)=6H                                                                  MA        406
      WRITE (6,100) LAB,(F(8,I),I=1,NP3)                                         MA        407
      LAB(1)=6HF(9,I)                                                            MA        408
      LAB(2)=6H                                                                  MA        409
      WRITE (6,100) LAB,(F(9,I),I=1,NP3)                                         MA        410
      LAB(1)=6HF(10,I                                                            MA        411
      LAB(2)=6H)                                                                 MA        412
      WRITE (6,100) LAB,(F(10,I),I=1,NP3)                                        MA        413
      LAB(1)=6H  11,I                                                            MA        414
      LAB(2)=6H,                                                                 MA        415
      WRITE (6,100) LAB,(F(11,I),I=1,NP3)                                        MA        416
      LAB(1)=6HF(12,I                                                            MA        417
      LAB(2)=6H)                                                                 MA        418
      WRITE (6,100) LAB,(F(12,I),I=1,NP3)                                        MA        419
      LAB(1)=6HF(13,I                                                            MA        420
      LAB(2)=6H)                                                                 MA        421
      WRITE (6,100) LAB,(F(13,I),I=1,NP3)                                        MA        422
      LAB(1)=6HF(14,I                                                            MA        423
      LAB(2)=6H)                                                                 MA        424
      WRITE (6,100) LAB,(F(14,I),I=1,NP3)                                        MA        425
      LAB(1)=6HF(15,I                                                            MA        426
      LAB(2)=6H)                                                                 MA        427
      WRITE (6,100) LAB,(F(15,I),I=1,NP3)                                        MA        428
      LAB(1)=6HF(16,I                                                            MA        429
      LAB(2)=2H)                                                                 MA        430
      WRITE (6,100) LAB,(F(16,I),I=1,NP3)                                        MA        431
  601 CONTINUE                                                                   MA        432
C                                                                                MA        433
      DO 200 I=1,NP3                                                             MA        434
  200 P(I)=P(I)+DPDX(I)*DX*RLD                                                   MA        435
      IF(MASSTR.NE.0) GO TO 64                                                   MA        436
      DO 65 I=1,NP3                                                              MA        437
      CPI=RATIC2*CPDP(FS(JT,I),4)+(1.-RATIC2)*CPDP(FS(JT,I),12)                  MA        438
      HPI=RATIC2*HDP(FS(JT,I),4)+(1.-RATIC2)*HDP(FS(JT,I),12)                    MA        439
      FS(JT,I)=AMAX1(1.,FS(JT,I)+(F(JH,I)-.5*U(I)*U(I)-HPI)/CPI)                 MA        440
   65 RHO(I)=P(I)*WMIX/FS(JT,I)/GASCON                                           MA        441
      GO TO 64                                                                   MA        442
   64 DO 61 I=1,NP3                                                              MA        443
      FUB=F(JFUOX,I)-F(JFU,I)                                                    MA        444
      F(JOX,I)=RATIO1*F(JFU,I)+RATIO3*F(JCO,I)+RATIO2-(RATIC2+RATIO1)            MA        445
     1  *F(JFUOX,I)                                                              MA        446
      F(JOX,I)=AMAX1(F(JOX,I),0.)                                                MA        447
```

```
      F(JCO2,I)=WCO2*CX*FUB/WFB-WCO2*F(JCO,I)/WCO                      MA       448
      F(JH2O,I)=HY*WH2O*FUB/WFU/2.                                     MA       449
      FS(JN2,I)=1.                                                     MA       450
      DO 607 JJ=1,NSPM                                                 MA       451
      J=JLOC(JJ)                                                       MA       452
  607 FS(JN2,I)=FS(JN2,I)-F(J,I)                                       MA       453
      HPI=0.                                                           MA       454
      CPI=0.                                                           MA       455
      DO 606 JJ=1,NSPM                                                 MA       456
      J=JLOC(JJ)                                                       MA       457
      HPI=HPI+F(J,I)*HOR(FS(JT,I),JJ)                                  MA       458
  606 CPI=CPI+F(J,I)*CPOR(FS(JT,I),JJ)                                 MA       459
      HPI=HPI+FS(JN2,I)*HOR(FS(JT,I),12)                               MA       460
      CPI=CPI+FS(JN2,I)*CPOR(FS(JT,I),12)                              MA       461
      FS(JT,I)=FS(JT,I)+(F(JH,I)-.5*U(I)*U(I)-HPI)/CPI                 MA       462
      FS(JT,I)=AMAX1(FS(JT,I),100.)                                    MA       463
      VMIX=0.                                                          MA       464
      DO 605 JJ=1,NSPM                                                 MA       465
      J=JLOC(JJ)                                                       MA       466
  605 VMIX=VMIX+F(J,I)/W(JJ)                                           MA       467
      VMIX=VMIX+FS(JN2,I)/WN2                                          MA       468
   61 RHO(I)=P(I)/FS(JT,I)/VMIX/GASCON                                 MA       469
   66 CONTINUE                                                         MA       470
      RHO(2)=RHO(1)                                                    MA       471
      RHO(NP2)=RHO(NP3)                                                MA       472
C     ------------------------------------------------------ TEST 2    MA       473
      IF(ITEST) 604,603,604                                            MA       474
  604 LAB(1)=6HTEST 2                                                  MA       475
      LAB(2)=4H                                                        MA       476
      WRITE(6,100) LAB,PRESS,DX,RPDDX,PDGSCW                           MA       477
      LAB(1)=6HFS(1,I                                                  MA       478
      LAB(2)=1H)                                                       MA       479
      WRITE(6,100) LAB,(FS(1,I),I=1,NP3)                               MA       480
      LAB(1)=6HFS(2,I                                                  MA       481
      LAB(2)=1H)                                                       MA       482
      WRITE(6,100) LAB,(FS(2,I),I=1,NP3)                               MA       483
      LAB(1)=6HRHO(I)                                                  MA       484
      LAB(2)=6H                                                        MA       485
      WRITE(6,100) LAB,(RHO(I),I=1,NP3)                                MA       486
  603 CONTINUE                                                         MA       487
C     -------------------------------------- ADJUST R(I)               MA       488
      IF (KIN.EQ.3) GO TO 609                                          MA       489
      R(1)=TAB(XU,XR,ARI,NRP)                                          MA       490
      IF (XU.LE.XUINJ(NUI)) GO TO 617                                  MA       491
      R(1)=SQRT(R(1)**2+2.*(AUINJ(NUI)-STRD)/RJINJ(NUI))               MA       492
  617 IF (IEND.GE.ISTEP.OR.KBC3.EQ.0) GO TO 609                        MA       493
      R(1)=SQRT(RA**2+2.*PSII/RHO(1)/U(1))                             MA       494
C                                                                      MA       495
C     ----------STRIDE1----------STRIDE1----------STRIDE1--------STRIDE1 MA     496
609   CALL STRIDE(1)                                                   MA       497
C                                                                      MA       498
C     --------------------------------------------------------------   MA       499
CHAPTER777777777777777777777777777777777777777  FORWARD STEP  777777777 MA      500
      DXOLD=AMAX1(.005*FRA*Y(NP3),DX)                                  MA       501
      DX=FRA*Y(NP3)                                                    MA       502
      IDXFIX=0                                                         MA       503
      IF(ISTEP.LT.50) DX=.1*DX                                         MA       504
      DX=AMIN1(DX,3.*DXOLD)                                            MA       505
C                                                                      MA       506
      IF(ISTEP.GE.IEND) GO TO 73                                       MA       507
      IF(DX.LT.XEND-XU) GO TO 70                                       MA       508
      DX=XEND-XU                                                       MA       509
      IDXFIX=1                                                         MA       510
      IEND=ISTEP+1                                                     MA       511
   70 IF(ISTEP.GE.IOUT) GO TO 71                                       MA       512
      IF(DX.LT.XOUT-XU) GO TO 71                                       MA       513
      DX=XOUT-XU                                                       MA       514
      IDXFIX=1                                                         MA       515
      IOUT=ISTEP+1                                                     MA       516
   71 IF (DX.LT.XULAST-XU) GO TO 72                                    MA       517
      DX=XULAST-XU                                                     MA       518
      IDXFIX=1                                                         MA       519
   72 IF( DX.GT.0.) GO TO 73                                           MA       520
      IFIN=1                                                           MA       521
      GO TO 1011                                                       MA       522
C                                                                      MA       523
   73 XD=XU+DX                                                         MA       524
```

```
C      ----- FURTHER ADJUSTMENTS TO BX ARE MADE IN CHAPTERS 8 AND 9.     MA        525
C                                                                        MA        526
C ---------------------------------------------------------------------- MA        527
CHAPTER8888888888888888888888888  ADJUST LONGITUDINAL CONDITIONS  8888888 MA        528
C                                                                        MA        529
C      CHAPTER8A ----------------------------BOUNDARY CONDITIONS         MA        530
C      ---------------- I BOUNDARY                                       MA        531
       IF(ISTEP-IAX) 8000,80,84                                          MA        532
  8000 IF(ISTEP-IEND) 8002,83,84                                         MA        533
C      ---------------------- WALL                                       MA        534
  8002 KIN=1                                                             MA        535
       U(1)=0.                                                           MA        536
       RMI=0.                                                            MA        537
       IF(ISTEP.EQ.0) TAUI=0.                                            MA        538
       EWALL=9.                                                          MA        539
       DO 81 JJ=1,NSPM                                                   MA        540
       J=JLOC(JJ)                                                        MA        541
       INDI(J)=2                                                         MA        542
    81 AJI(J)=0.                                                         MA        543
       INDI(JFUDX)=2                                                     MA        544
       AJI(JFUDX)=0.                                                     MA        545
       INDI(JM)=2                                                        MA        546
       AJI(JM)=0.                                                        MA        547
       DO 74 J=13,15                                                     MA        548
       INDI(J)=1                                                         MA        549
    74 F(J,1)=0.0                                                        MA        550
       IF (IFLUX.EQ.0) GO TO 84                                          MA        551
       FS(JT,1)=TWALL                                                    MA        552
       INDI(JH)=1                                                        MA        553
       HPI=0.                                                            MA        554
       DO 76 JJ=1,NSPM                                                   MA        555
       J=JLOC(JJ)                                                        MA        556
    76 HPI=HPI+F(J,1)*HDR(TWALL,JJ)                                      MA        557
       F(JH,1)=HPI+FS(JM2,1)*HDR(TWALL,12)                               MA        558
       GO TO 84                                                          MA        559
C      ------------------------ FREE                                     MA        560
    83 KIN=2                                                             MA        561
       TAUI=0.                                                           MA        562
       U(1)=UA                                                           MA        563
       RMI=0.                                                            MA        564
       RU(1)=RHO(1)*U(1)                                                 MA        565
       F(JH,1)=F1A                                                       MA        566
       F(JFM,1)=F2A                                                      MA        567
       F(JFUOX,1)=F2A                                                    MA        568
       DO 101 JJ=2,NSPM                                                  MA        569
       J=JLOC(JJ)                                                        MA        570
   101 F(J,1)=0.                                                         MA        571
       F(JOX,1)=RATIC2*(1.-F2A)                                          MA        572
       F(JVT,1)=R(1)*VTA                                                 MA        573
       F(JK,1)=AKFAC*UA*UA                                               MA        574
       F(JD,1)=CD*F(JK,1)**1.5/ALM                                       MA        575
       GO TO 84                                                          MA        576
C      ------------------- SYMMETRY AXIS                                 MA        577
    80 KIN=3                                                             MA        578
       RMI=0.                                                            MA        579
       R(1)=RA                                                           MA        580
       PSII=0.                                                           MA        581
       TAUI=0.                                                           MA        582
C      ---------------------------AXIAL INJECTION                        MA        583
    84 RI=TAB(XD,XR,ARI,NRP)                                             MA        584
       IF (XD.LE.XUINJ(NUI)) GO TO 382                                   MA        585
       IF (ABS(AUINJ(NUI)-SUM1).GT.1.E-10) GO TO 390                     MA        586
       NUI=NUI+1                                                         MA        587
       SUM1=0.                                                           MA        588
       GO TO 382                                                         MA        589
   390 KIN=2                                                             MA        590
       TAUI=0.                                                           MA        591
       ARG=2.*ABS(SUM1/AUINJ(NUI)-.5)                                    MA        592
       U(1)=UINJ(NUI)*(1.-ARG**(NI/UPAT                                  MA        593
       T=TUINJ(NUI)                                                      MA        594
       F(JH,1)=RATIC2*HDR(T,4)+(1.-RATIO2)*HDR(T,12)                     MA        595
       DO 387 JJ=1,NSPM                                                  MA        596
       J=JLOC(JJ)                                                        MA        597
   387 F(J,1)=0.                                                         MA        598
       F(JFUDX,1)=0.                                                     MA        599
       F(JOX,1)=RATIC2                                                   MA        600
       F(JVT,1)=R(1)*VTUINJ(NUI)                                         MA        601
```

```
      VECZ=UINJ(NUI)**2+VTUINJ(NUI)**2                                  MA    602
      F(JK,1)=AKFAC*VECZ                                                MA    603
      F(JD,1)=CD*F(JK,1)**1.5/ALM                                       MA    604
      FS(JT,1)=TUINJ(NUI)                                               MA    605
      RHO(1)=PDGSCN/FS(JT,1)                                            MA    606
      RU(1)=RHO(1)*U(1)                                                 MA    607
      RI=SQRT(RI**2+2.*(AUINJ(NUI)-SUM1)/RUINJ(NUI))                    MA    608
  382 CONTINUE                                                          MA    609
C     ------------------------------------RADIAL INJECTION              MA    610
      IF (XD.LE.XVINJ(NVI)) GO TO 394                                   MA    611
      IF (ABS(AVINJ(NVI)-SUM3).GT.1.E-10) GO TO 390                     MA    612
      NVI=NVI+1                                                         MA    613
      SUM3=0.                                                           MA    614
      GO TO 394                                                         MA    615
  390 IF (KIN.NE.2) GO TO 392                                           MA    616
      PSII=PSII-(AUINJ(NVI)-SUM1)                                       MA    617
      SUM1=AUINJ(NUI)                                                   MA    618
      KIN=1                                                             MA    619
      RI=TAB(XD,XR,ARI,NBP)                                             MA    620
  392 U(1)=UVINJ(NVI)                                                   MA    621
      T=TVINJ(NVI)                                                      MA    622
      F(JH,1)=RATIO2*HOR(T,4)+(1.-RATIO2)*HOR(T,12)                     MA    623
      DO 388 JJ=1,NSPM                                                  MA    624
      J=JLOC(JJ)                                                        MA    625
  388 F(J,1)=0.                                                         MA    626
      F(JFUOX,1)=0.                                                     MA    627
      F(JOX,1)=RATIO2                                                   MA    628
      F(JVT,1)=R(1)*VTVINJ(NVT)                                         MA    629
      VECZ=UVINJ(NVI)**2+VINJ(NVI)**2+VTVINJ(NVI)**2                    MA    630
      F(JK,1)=AKFAC*VECZ                                                MA    631
      F(JD,1)=CD*F(JK,1)**1.5/ALM                                       MA    632
      DO 207 J=1,NF                                                     MA    633
  207 INDI(J)=1                                                         MA    634
      FS(JT,1)=TVINJ(NVI)                                               MA    635
      RHO(1)=PDGSCN/FS(JT,1)                                            MA    636
      RMI=R(1)*RHO(1)*VINJ(NVI)                                         MA    637
      IF (ABS(RMI)*DX.LT.AVINJ(NVI)-SUM3) GO TO 394                     MA    638
      PMI=(AVINJ(NVI)-SUM4)/DX                                          MA    639
  394 CONTINUE                                                          MA    641
C     -------------------- E BOUNDARY                                   MA    642
      IF (ISTEP-IOUT) 8004,85,85                                        MA    643
C     --------------------- WALL                                        MA    644
 8004 KEX=1                                                             MA    645
      U(NP3)=0.                                                         MA    646
      PME=0.                                                            MA    647
      IF(ISTEP.EQ.0) TAUE=0.                                            MA    648
      EWALL=0.                                                          MA    649
      DO 82 JJ=1,NSPM                                                   MA    650
      J=JLOC(JJ)                                                        MA    651
      INDE(J)=2                                                         MA    652
   82 AJE(J)=0.                                                         MA    653
      INDE(JH)=2                                                        MA    654
      AJE(JH)=0.                                                        MA    655
      INDE(JFUOX)=2                                                     MA    656
      AJE(JFUOX)=0.                                                     MA    657
      DO 75 J=13,15                                                     MA    658
      INDE(J)=1                                                         MA    659
   75 F(J,NP3)=0.0                                                      MA    660
      IF (IFLUX.EQ.0) GO TO 86                                          MA    661
      INDE(JH)=1                                                        MA    662
      FS(JT,NP3)=TWALL                                                  MA    663
      HPI=0.                                                            MA    664
      DO 77 JJ=1,NSPM                                                   MA    665
      J=JLOC(JJ)                                                        MA    666
   77 HPI=HPI+F(J,NP3)*HOR(TWALL,JJ)                                    MA    667
      F(JH,NP3)=HPI+FS(JH2,NP3)*HOR(TWALL,12)                           MA    668
      GO TO 86                                                          MA    669
C     -----------------------------------------FREE                     MA    670
   85 KEX=2                                                             MA    671
      TAUE=0.                                                           MA    672
      U(NP3)=UD                                                         MA    673
      RU(NP3)=RHO(NP3)*U(NP3)                                           MA    674
      DO 158 JJ=1,NSPM                                                  MA    675
      J=JLOC(JJ)                                                        MA    676
  158 F(J,NP3)=0.                                                       MA    677
      F(JOX,NP3)=RATIO2*(1.-F2D)                                        MA    678
      F(JH,NP3)=F1D                                                     MA    679
```

```
      F(JFU,NP3)=F2D
      F(JFUOX,NP3)=FOD
      F(JVT,NP3)=R(NP3)*VTD
      F(JK,NP3)=AKFAC*UD*UD
      F(JD,NP3)=CD*F(JK,NP3)**1.5/ALM
C     ------------------------AXIAL INJECTION
   86 RE=TAB(XD,XR,ARE,NRP)
      IF (XD.LE.XUINJ(NUE)) GO TO 372
      IF (ABS(AUINJ(NUE)-SUM2).GT.1.E-10) GO TO 369
      NUE=NUE+1
      SUM2=0.
      GO TO 372
  369 KEX=2
      TAUE=0.
      ARG=2.*ABS(SUM2/AUINJ(NUE)-.5)
      U(NP3)=UINJ(NUE)*(1.-ARG**SLM)/HRAT
      T=TUINJ(NUE)
      F(JH,NP3)=RATIO2*HDR(T,4)+(1.-RATIO2)*HDR(T,12)
      DO 371 JJ=1,NSPR
      J=JLOC(JJ)
  371 F(J,NP3)=0.
      F(JFUOX,NP3)=0.
      F(JOX,NP3)=RATIO2
      F(JVT,NP3)=R(NP3)*VTUINJ(NUE)
      VEC2=UINJ(NUE)**2+VTUINJ(NUE)**2
      F(JK,NP3)=AKFAC*VEC2
      F(JD,NP3)=CD*F(JK,NP3)**1.5/ALM
      FS(JT,NP3)=TUINJ(NUE)
      RHO(NP3)=PDGSCN/FS(JT,NP3)
      RU(NP3)=U(NP3)*RHO(NP3)
      RE=SQRT(RE**2-2.*(AUINJ(NUE)-SUM2)/RUINJ(NUE))
  372 CONTINUE
C     ------------------------------RADIAL INJECTION
      IF (XD.LE.XVINJ(NVE)) GO TO 202
      IF (ABS(AVINJ(NVE)-SUM4).GT.1.E-10) GO TO 206
      SUM4=0.
      NVE=NVE+1
      GO TO 202
  206 IF (KEX.NE.2) GO TO 209
      PSIE=PSIE+(AUINJ(NUE)-SUM2)
      SUM2=AUINJ(NUE)
      KEX=1
      RE=TAB(XD,XP,ARE,NRP)
  209 U(NP3)=UVINJ(NVE)
      T=TVINJ(NVE)
      F(JH,NP3)=RATIO2*HDR(T,4)+(1.-RATIO2)*HDR(T,12)
      DO 389 JJ=1,NSPR
      J=JLOC(JJ)
  389 F(J,NP3)=0.
      F(JFUOX,NP3)=0.
      F(JOX,NP3)=RATIO2
      F(JVT,NP3)=R(NP3)*VTVINJ(NVE)
      VEC2=UVINJ(NVE)**2+VINJ(NVE)**2+VTVINJ(NVE)**2
      F(JK,NP3)=AKFAC*VEC2
      F(JD,NP3)=CD*F(JK,NP3)**1.5/ALM
      DO 208 J=1,NF
  208 INDE(J)=1
      FS(JT,NP3)=TVINJ(NVE)
      RHO(NP3)=PDGSCN/FS(JT,NP3)
      RME=R(NP3)*RHO(NP3)*VINJ(NVE)
      IF (ABS(RME)*DX.LT.AVINJ(NVE)-SUM4) GO TO 202
      RME=-(AVINJ(NVE)-SUM4)/DX
  202 CONTINUE
C -------------- CALCULATE WALL TEMPERATURE
C
      IF (IFLUX.EQ.0) GO TO 79
      IF (IEND.GT.ISTEP) CALL WTEMP (1)
      IF (IOUT.GT.ISTEP) CALL WTEMP (NP3)
C ---------- STRAD ----------- STRAD ------------ STRAD ---------------
      CALL STRAD
C -----------------------------------------------------------------
   79 CONTINUE
C
C
C     CHAPTER 3R ------------------------------------ DUCT GEOMETRY
      IF (ISTEP.GE.IOUT) GO TO 80
      IF(ISTEP.GT.3) GO TO 87
```

```
      ROUT=RO                                                             MA   758
      ADUD=(R(NP3)**2-R(1)**2)*.5                                         MA   759
      IF (KRAD.EQ.0) ADUD=Y(NP3)-Y(1)                                     MA   760
   87 ADUU=ADUD                                                           MA   761
      AIN=.5*R(1)**2                                                      MA   762
      IF (ISTEP.EQ.IOUT) ADUU=.5*ROUT**2                                  MA   763
      AFLU=R(NP3)**2*.5-AIN                                               MA   764
      IF (KRAD.EQ.0) AFLU=Y(NP3)-Y(1)                                     MA   765
      AEX=AFLU-ADUU                                                       MA   766
      AEXD=AEX/AFLU                                                       MA   767
      IF (IDIFIX.EQ.1) GO TO 88                                           MA   768
      IF(ABS(AEXD).GT.AEXDLM) DX=DX*AEXDLM/ABS(AEXD)                      MA   769
      XD=XU+DX                                                            MA   770
   88 ADUD=.5*(RE**2-RI**2)                                               MA   771
      IF (KRAD.EQ.0) ADUD=RE-RI                                           MA   772
      DA=AFAC*(ADUD-AFLU)                                                 MA   773
C                                                                         MA   774
C     CHAPTER 9C ---------------------- SUBSONIC PRESSURE GRADIENT        MA   775
C     ---------------------UBAR                                           MA   776
   89 UBAR=0.                                                             MA   777
      DO 820 I=2,NP2                                                      MA   778
  820 UBAR=UBAR+(U(I)+U(I+1))*DPSI(I)                                     MA   779
      UBAR=.5*UBAR                                                        MA   780
      IF(KIN.EQ.2) UBAR=(UBAR-UA)*PEI/PSIE+UA                             MA   781
C     ---------------------------SUBSONIC FLOW                            MA   782
  803 IF (ISTEP-IOUT) 822,823,823                                         MA   783
  823 DPDDX=0.                                                            MA   784
      GO TO 824                                                           MA   785
C     ------------------------------ CONFINED SUBSONIC FLOW               MA   786
  822 GO TO (830,835), IDFDX                                              MA   787
  835 IF (ISTEP.EQ.0.OR.KIN.EQ.2) GO TO 830                               MA   788
C  ------------- GRID FILLING DUCT VERSION ----------                     MA   789
      RDUBAR=PEI/ADUU                                                     MA   790
      RCBAR=RDUBAR/UBAR                                                   MA   791
      DUDP=-1./(RDUBAR*(TAUE**(NP3)-TAUI**(1))*DX/ADUU/UBAR)              MA   792
      UDRDDP=RDUBAR/GAMMA/P(NP3)                                          MA   793
      DPDU=RDUBAR*(AFLU/ADUU-1.)                                          MA   794
      DPC=DPDU/(RCBAR*DUDP+UDRDDP)                                        MA   795
      UFAC=DPC*DUDP/UBAR+1.                                               MA   796
C  ------- ADJUST VELOCITY PRESSURE AND DENSITY PROFILES --------         MA   797
      DO 840 I=1,NP3                                                      MA   798
      U(I)=U(I)*UFAC                                                      MA   799
      P(I)=P(I)+DPC                                                       MA   800
  840 RHO(I)=RHO(I)*(1.+GAMMA*DPC/P(I))                                   MA   801
      DP=DP+DPC                                                           MA   802
      DPDDX=DP/DXOLD                                                      MA   803
C  -------- RECALCULATE DISTANCES ---------                               MA   804
      CALL STRIDE(1)                                                      MA   805
      GO TO 824                                                           MA   806
C  ------------- STANDARD GENMIX VERSION ---------                        MA   807
  830 FLOTOT=PSIE-PSII*FLOAT(1/KIN)                                       MA   808
      DYNHED=UBAR*FLOTOT/AFLU                                             MA   809
      DPDDX=(DYNHED*DA/DX-TAUI**(1)-TAUE**(NP3)+2.*UBAR*(RPE-RPI))/ADUD   MA   810
      DP=DPDDX*DX                                                         MA   811
  824 CONTINUE                                                            MA   812
C  -------- Z*FLOW AREAS -----------                                      MA   813
      DO 307 I=2,NP2                                                      MA   814
  307 RDY(I)=PEI*(OM(I+1)-OM(I-1))/RHO(I)/U(I)                            MA   815
      GO TO (310,312,312), KIN                                            MA   816
  310 RDY(2)=(R(1)+.5*(R(2)+R(3)))*YI                                     MA   817
      GO TO 313                                                           MA   818
  312 RDY(2)=PEI*OM(3)/RHO(3)/U(3)                                        MA   819
  313 GO TO (314,315,315), KEX                                            MA   820
  314 RDY(NP2)=(R(NP3)+.5*(R(NP2)+R(NP1)))*YE                             MA   821
      GO TO 316                                                           MA   822
  315 RDY(NP2)=PEI*(1.-OM(NP1))/RHO(NP1)/U(NP1)                           MA   823
  316 CONTINUE                                                            MA   824
      RDY(1)=0.0                                                          MA   825
      RDY(NP3)=0.0                                                        MA   826
      IF (ISWRL.EQ.0) GO TO 227                                           MA   827
C  -------- PRESSURE GRADIENT W/SWIRL EFFECTS INCLUDED ----------         MA   828
      VOR2=(F(JVT,NP2)/(.75*R(NP2)+.25*R(NP1))**2)**2                     MA   829
      PALFA=0.5*PEI*CSALFA                                                MA   830
      PD=0.                                                               MA   831
      DPDX(NP2)=0.0                                                       MA   832
      DO 225 JI=3,NP2                                                     MA   833
      I=NP3-JI+1                                                          MA   834
```

```
      VOR2P1=VOR2                                                       MA  835
      RII=R(I)                                                          MA  836
      IF (I.EQ.2) RII=.75*R(2)+.25*R(3)                                 MA  837
      VOR2=(F(JVT,I)/RII**2)**2                                         MA  838
      PD=PD-PALFA*(VOR2/U(I)+VOR2P1/U(I+1))*RHO(I)                      MA  839
      IF (ISTEP.GT.0) GO TO 224                                         MA  840
      PSWRL(I)=PD                                                       MA  841
      P(I)=P(I)+PD                                                      MA  842
      IF (I.EQ.2) P(1)=P(2)                                             MA  843
  224 DPDX(I)=(PD-PSWRL(I))/DXOLD                                       MA  844
  225 PSWRL(I)=PD                                                       MA  845
      IF (KEX.EQ.2) GO TO 260                                           MA  846
      DPDXDA=0.0                                                        MA  847
      SRDY=0.0                                                          MA  848
      DO 250 I=2,NP2                                                    MA  849
      SRDY=SRDY+RDY(I)                                                  MA  850
250   DPDXDA=DPDXDA+DPDX(I)*DXOLD*RDY(I)                                MA  851
      DP=DP-DPDXDA/SRDY                                                 MA  852
      DO 255 I=2,NP2                                                    MA  853
  255 DPDX(I)=DPDX(I)+DP/DXOLD                                          MA  854
  260 CONTINUE                                                          MA  855
      DPDX(1)=DPDX(2)                                                   MA  856
      DPDX(NP3)=DPDX(NP2)                                               MA  857
      GO TO 242                                                         MA  858
C     --------      PRESSURE GRADIENT FOR NON-SWIRLING FLOW     ---------- MA  859
  227 DO 825 I=1,NP3                                                    MA  860
  825 DPDX(I)=DPDOX                                                     MA  861
C     ---------------------------------------------------------- TEST 3 MA  862
  242 IF (ITEST) 802,801,802                                            MA  863
  802 LAB(1)=6HTEST 3                                                   MA  864
      LAB(2)=6H                                                         MA  865
      WRITE(6,100) LAB,UBAR,DYNHED,DY,DA,DPDOX,GEXP,RMI                 MA  866
      WRITE(6,101) LAB,ISTEP,KIN,KEX,IAX,IEND,IOUT                      MA  867
      LAB(1)=4HY(I)                                                     MA  868
      LAB(2)=6H                                                         MA  869
      WRITE(6,100) LAB,(Y(I),I=1,NP3)                                   MA  870
      LAB(1)=4HR(I)                                                     MA  871
      LAB(2)=6H                                                         MA  872
      WRITE(6,100) LAB,(R(I),I=1,NP3)                                   MA  873
      LAB(1)=5HRU(I)                                                    MA  874
      LAB(2)=6H                                                         MA  875
      WRITE(6,100) LAB,(RU(I),I=1,NP3)                                  MA  876
      LAB(1)=6HDPDX(I                                                   MA  877
      LAB(2)=6H)                                                        MA  878
      WRITE (6,100) LAB,(DPDX(I),I=1,NP3)                               MA  879
      LAB(1)=6HPSWRL(                                                   MA  880
      LAB(2)=6HI)                                                       MA  881
      WRITE (6,100) LAB,(PSWRL(I),I=1,NP3)                              MA  882
  801 CONTINUE                                                          MA  883
C                                                                       MA  884
C     ----------------------------------------------------------------- MA  885
CHAPTER9999999999999999999999  TRANSPORT AND ENTRAINMENT PROPERTIES  9999 MA  886
C ----   LAMINAR VISCOSITY ASSUMED TO BE THAT OF AIR   ---------------- MA  887
 900  CONTINUE                                                          MA  888
      DO 98 I=1,NP3                                                     MA  889
      EMU(I)=VISCO(FS(JT,I))                                            MA  890
   98 CONTINUE                                                          MA  891
      EMU(2)=EMU(1)                                                     MA  892
      EMU(NP2)=EMU(NP3)                                                 MA  893
C     ---------------------------------------------------------- TEST 4 MA  894
      IF(ITEST) 902,901,902                                             MA  895
  902 LAB(1)=6HTEST 4                                                   MA  896
      LAB(2)=6H                                                         MA  897
      WRITE(6,100) LAB,RMI,GMF,REI                                      MA  898
      LAB(1)=6HEMU(I)                                                   MA  899
      LAB(2)=6H                                                         MA  900
      WRITE(6,100) LAB,(EMU(I),I=1,NP3)                                 MA  901
  901 CONTINUE                                                          MA  902
C                                                                       MA  903
C     ----------AUX----------AUX----------AUX----------AUX----------AUX MA  904
      CALL AUXC(0)                                                      MA  905
C     ------------------------------- ENTRAINMENT CONTROL.              MA  906
      IF(KIN.NE.2) GO TO 94                                             MA  907
      RAT=ABS((U(3)-U(1))/(U(NP3)-U(1)+1.E-30))                         MA  908
      IF(RAT.LT.ULIM) EM U(2)=EM U(2)*RAT/ULIM                          MA  909
      RMI=2.*EM U(2)                                                    MA  910
   94 CONTINUE                                                          MA  911
```

```
      IF(NEX.NE.2) GO TO 97
      RAT=ABS((U(NP1)-U(NP3))/(U(NP3)-U(1)+1.E-30))
      RME=-2.*EM U(NP1)
      IF(RAT.LT.ULIM) RME=RME*(RAT/ULIM)**2
   97 IF (IDXFIX.EQ.1) GO TO 96
C     ----------- LIMIT ON INCREMENT IN PET.
      IF((ABS(RMI)+ABS(RME))*DX.LT.PET*PEILIM) GO TO 96
      DX=PET*PEILIM/(ABS(RMI)+ABS(RME))
      XD=XU+DX
   96 CONTINUE
      IF (XD.LE.XUINJ(NUI)) GO TO 91
      IF (ABS(RMI)*DX.LT.AUINJ(NUI)-SUM1) GO TO 91
      RMI=(AUINJ(NUI)-SUM1)/DX
   91 IF (XD.LE.XUINJ(NUE)) GO TO 92
      IF (ABS(RME)*DX.LT.AUINJ(NUE)-SUM2) GO TO 92
      RME=-(AUINJ(NUE)-SUM2)/DX
   92 CONTINUE
C     ----------- ADJUSTMENT OF DX TO REACH AXIS.
      IF (IEND.GT.ISTEP) GO TO 95
      IF(ISTEP.GE.IAX) GO TO 95
      IF(PSII.GT.RMI*DX.OR.IAX.EQ.ISTEP+1) GO TO 95
      RMI=PSII/DX
      IAX=ISTEP+1
C
C ---------DROP------------DROP----------------DROP--------------------
   95 CALL DROP
C --------------------------------------------------------------------
C     -----------STRIDE2----------STRIDE2----------STRIDE2--------STRIDE2
      CALL STRIDE(2)
C
C ----------------------------------------------------------------------
CHAPTER 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10   OUTPUT   10 10 10
 1000 IF(ISTEP.GT.3) GO TO 106
      WRITE (6,9000)
 9000 FORMAT (1H1)
CHAPTER 106 -----------------------------------  HEADINGS
C
      WRITE (6,1013) TITLE,MODE2,IOPDX,MODEL,MASSTR,INERT,KRAD,IFLUX
 1013 FORMAT (1H1,12A6/12 5/7H MODE2=,I3,7H IOPDX=,I3,7H MODEL=,I3,
     1 8H MASSTR=,I3,7H INERT=,I3,6H KRAD=,I3,7H IFLUX=,I3)
C
      WRITE (6,1010) UA,UD,TA,TD,RA,RB,RD,XEND,XOUT,XULAST,PRESS,
     1 PREXP1,ARCOM1,CP1,VTA,VTD
 1010 FORMAT (1H ,1X,2HUA,8X,2HUD,9X,2HTA,9X,2HTD,9X,2HRA,9X,2HRB,8X,
     1 2HRD,8X,4HXEND,6X,4HXOUT,6X,6HXULAST/1H ,1P10E10.3/1H ,
     2 6H PRESS,5X,6HPREXP1,4X,6HARCOM1,4X,3HCP1,7X,3HVTA,7X,3HVTD/1X,
     2 1P10E10.3)
C
      LAB(1)=5HOMEGA
      LAB(2)=6H
      WRITE(6,100) (AB,(OM(I)),I=1,NP3)
      PRESS1=PRESS
      NINJ=12
      IF (XUINJ(NUI).GT.XULAST.AND.XUINJ(NUE).GT.XULAST) GO TO 1200
      WRITE (6,1205)
 1205 FORMAT (//6X,'AXIAL INJECTION'/6X,15(1H*)//6X,'SLOT',4X,
     1 'BOUNDRY',10X,'X',9X,'FL',10X,'U',9X,'VT',7X,'TEMP',7X,'PDOT',
     2 10X,'M',9X,'AP'/10(3X,8(1H*)))
      INDX=0
      IPT=0
      DO 1210 II=1,NINJ
      IF (INDX.EQ.2) GO TO 1210
      IF (XUINJ(II).GT.XULAST) INDX=INDX+1
      IF (XUINJ(II).GT.XULAST) GO TO 1210
      IB=1HI
      IF (II.GE.NUE) IB=1HE
      IPT=IPT+1
      WRITE (6,1215) IPT,IB,XUINJ(II),XLOINJ(II),UINJ(II),VTINJ(II),
     1 TUINJ(II),AUINJ(II),MUINJ(II),APUINJ(II)
 1215 FORMAT (7X,I2,9X,A1,3X,8(1PE11.3))
 1210 CONTINUE
 1200 IF (XVINJ(NVI).GT.XULAST.AND.XVINJ(NVE).GT.XULAST) GO TO 1223
      WRITE (6,1225)
 1225 FORMAT (//6X,'RADIAL INJECTION'/6X,16(1H*)//6X,'SLOT',4X,
     1 'BOUNDRY',13X,'X',10X,'V',9X,'VT',7X,'TEMP',7X,'MDOT'/
     2 8(3X,8(1H*)))
      INDX=0
```

```
      IPT=0
      DO 1230 II=1,NINJ
      IF (INDF.EQ.2) GO TO 1230
      IF (XVINJ(II).GT.XULAST) INDX=INDX+1
      IF (XVINJ(II).GT.XULAST) GO TO 1230
      IB=1HI
      IF (II.GE.NVE) IB=1HE
      IPT=IPT+1
      WRITE (6,1215) IPT,IB,XVINJ(II),UINJ(II),VTVINJ(II),TVINJ(II),
     1 AVINJ(II)
 1230 CONTINUE
 1220 IF (IFLUX.EQ.0) GO TO 1247
      WRITE (6,1235)
 1235 FORMAT (/3X,*BOUNDRY*,7X,*VELA*,8X,*TANW*,7X,*PRAD*/4(2X,9(1H-)))
      IB=1HI
      DO 1240 II=1,2
      WRITE (6,1245) IB,VELA(II),TANW(II),PRAD(II)
 1245 FORMAT (7X,A1,3X,3(1PE11.3))
      IB=1HE
 1240 CONTINUE
 1247 CONTINUE
  106 CONTINUE
C     ---------------------------------------------------------- TEST 5
      IF(ITEST) 1002,1001,1002
 1002 LAB(1)=6HTEST 5
      LAB(2)=6H
      WRITE(6,100) LAB,RMI,RME,DX
 1001 CONTINUE
C
CHAPTER 108 ------------------------------------------ TESTS FOR PRINTOUT
C     ----- IPRINT=0 GIVES NO OUTPUT,  =1 GIVES SINGLE VARIABLES ONLY,
C                  =2 GIVES BOTH SINGLE AND ARRAY (PROFILE) VARIABLES.
 1011 IPRINT=0
      IF (MOD(ISTEP,NSTAT).EQ.0) IPRINT=1
      IF (MOD(ISTEP,NPROF).EQ.0) IPRINT=2
      IF(ISTEP.EQ.IEND.OR.ISTEP.EQ.IAX.OR.ISTEP.EQ.IOUT) IPRINT=2
      IF(ITEST.NE.0.OR.IFIN.NE.0) IPRINT=2
      IF (MOD(ISTEP,NPLOT).EQ.0.AND.ISTEP.GT.0) IPRINT=3
C     ----- THE NEXT STATEMENT PROVIDES A PLOT JUST PRIOR TO TERMINATION
      IF(XU.GE.XULAST.OR.IFIN.NE.0.OR.ISTEP.EQ.LASTEP) IPRINT=3
C
CHAPTER 10C     ------------------------------SINGLE STATION VARIABLES.
      IF(IPRINT.EQ.0) GO TO 110
      PRESSD=P(NP3)/PRESS1-1.
      WRITE (6,1030) ISTEP,IAX,IEND,IOUT,KIN,KEX,DX,PSII,PSIE,RMI,RME,
     1  PEI,PRESSD,AERO
 1030 FORMAT(7H0ISTEP=,I5,5H IAX=,I5,6H IEND=,I5,6H IOUT=,I5,5H KIN=,I2,
     1 5H KEX=,I2,4H DX=,1PE11.3,6H PSII=,E11.3,6H PSIE=,E11.3/
     2 5H RMI=,E11.3,5H RME=,E11.3,5H PEI=,E11.3,8H PRESSD=,E11.3,
     3 6H AERO=,E11.3)
C
C
      UBAR=0.
      DO 1020 J=1,NF
      AJID(J)=0.0
      AJED(J)=0.0
 1020 FLUX(J)=0.
      PFLUX=0.0
      DO 1021 I=2,NP1
      UBAR=UBAR+DPD(I)*(U(I)+U(I+1))
      PFLUX=PFLUX+PSWPL(I)*PDY(I)
      DO 1021 J=1,NF
      FLUX(J)=FLUX(J)+OMD(I)*(F(J,I)+F(J,I+1))
 1021 CONTINUE
      UBAR=.5*UBAR
      UFLUX=PEI*UBAR+PFLUX
      DO 1022 J=1,NF
 1022 FLUX(J)=.5*PEI*FLUX(J)
C
      UREF=UBAR
      RUREF=PEI/.5/(R(1)+R(NP3))/Y(NP3)
      DO 1023 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 1023
      DFI(J)=FLUX(J)/PEI-F(J,1)
      DFE(J)=DFI(J)+F(J,1)-F(J,NP3)
 1023 CONTINUE
      UFLUX=UFLUX-PSIE*U(NP3)+U(1)*PSII
```

```
            FLUX(JFU)=FLUX(JFU)-PSIE*F2D+F2A*PSTI                           MA       1066
            FLUX(JH)=FLUX(JH)-PSIE*F1D+F1A*PSTI                             MA       1067
C                                                                           MA       1068
            WRITE (6,1031) XU,UFLUX,(FLUX(J),J=1,NF)                        MA       1069
 1031 FORMAT (4H XJ=,1PE11.3,7H UFLUX=,E11.3,9H FLUX(J)=,8E11.3/42X,        MA       1070
     1  8E11.3)                                                             MA       1071
C                                                                           MA       1072
            IF(KIN.NE.1) GO TO 1024                                         MA       1073
            TAUID=TAUI/UREF/RUREF                                           MA       1074
            DO 1025 J=1,NF                                                  MA       1075
            IF (ISOLVE(J).EQ.0) GO TO 1025                                  MA       1076
            AJID(J)=AJI(J)/RUREF/DFF(J)                                     MA       1077
 1025 CONTINUE                                                              MA       1078
            WRITE(6,1029) KIN,TAUID,(AJID(J),J=1,NF)                        MA       1079
 1029 FORMAT (5H KIN=,I2,7H TAUID=,1PE11.3,9H AJID(J)=,8E11.3/34X,          MA       1080
     1  8E11.3)                                                             MA       1081
C                                                                           MA       1082
 1024 IF(KEX.NE.1) GO TO 1026                                               MA       1083
            TAUED=TAUE/UREF/RUREF                                           MA       1084
            DO 1027 J=1,NF                                                  MA       1085
            IF (ISOLVE(J).EQ.0) GO TO 1027                                  MA       1086
            AJED(J)=AJE(J)/RUREF/DFF(J)                                     MA       1087
 1027 CONTINUE                                                              MA       1088
            WRITE(6,1028) KEX,TAUED,(AJED(J),J=1,NF)                        MA       1089
 1028 FORMAT (5H KEX=,I2,7H TAUED=,1PE11.3,9H AJED(J)=,8E11.3/34X,          MA       1090
     1  8E11.3)                                                             MA       1091
 1026 CONTINUE                                                              MA       1092
C                                                                           MA       1093
CHAPTER 100     --------------------------PROFILES AND OTHER ARRAYS.        MA       1094
            IF(IPRINT.EQ.1) GO TO 110                                       MA       1095
C                                                                           MA       1096
            LAB(1)=6HRI,T'S                                                 MA       1097
            LAB(2)=6H                                                       MA       1098
            DIV=1.                                                          MA       1099
            DO 1095 I=1,NP3                                                 MA       1100
 1095 OUT(I)=Y(I)/DIV                                                       MA       1101
            WRITE (6,100) LAB,R(1),(OUT(I),I=2,NP2,ITHIN),Y(NP3)            MA       1102
            XAXIS=4HY(I)                                                    MA       1103
            DO 1085 I=1,NP3                                                 MA       1104
 1085 XPLOT(I)=OUT(I)                                                       MA       1105
C                                                                           MA       1106
            LAB(1)=IHU                                                      MA       1107
            LAB(2)=6H                                                       MA       1108
            SUB=0.                                                          MA       1109
            DIV=1.                                                          MA       1110
            IF(KIN.EQ.3) DIV=U(1)+1.E-30                                    MA       1111
            DO 1094 I=1,NP3                                                 MA       1112
 1094 OUT(I)=(U(I)-SUB)/DIV                                                 MA       1113
            IF (NOVEL.NE.1) WRITE (6,100) LAB,U(1),(OUT(I),I=2,NP2,ITHIN),  MA       1114
     1 U(NP3)                                                               MA       1115
            NY=1                                                            MA       1116
            YAXES(1,1)=6HVELOCI                                             MA       1117
            YAXES(1,2)=2HTY                                                 MA       1118
            SYMBOL(1)=1HJ                                                   MA       1119
            DO 1084 I=1,NP3                                                 MA       1120
 1084 YPLOT(1,I)=OUT(I)                                                     MA       1121
C                                                                           MA       1122
            INDX=0                                                          MA       1123
            DO 1050 KV=1,NF                                                 MA       1124
            KVV=KV+INDX                                                     MA       1125
            IF (IPRNT(KVV).EQ.0) GO TO 1050                                 MA       1126
            LAB(1)=LAB1(KVV)                                                MA       1127
            LAB(2)=LAB2(KVV)                                                MA       1128
            DO 1082 I=1,NP3                                                 MA       1129
 1082 OUT(I)=F(KV,I)                                                        MA       1130
            IF (KV.NE.JVT) GO TO 1075                                       MA       1131
            VTMAX=0.                                                        MA       1132
            DO 1086 I=2,NP3                                                 MA       1133
            DIV=R(I)                                                        MA       1134
            IF (I.EQ.2) DIV=.75*R(2)+.25*R(3)                               MA       1135
            IF (I.EQ.NP2) DIV=.75*R(NP2)+.25*R(NP1)                         MA       1136
            OUT(I)=OUT(I)/DIV                                               MA       1137
 1086 VTMAX=AMAX1(VTMAX,OUT(I))                                             MA       1138
 1075 IF (KV.NE.JD) GO TO 1076                                              MA       1139
            DO 1077 I=1,NP3                                                 MA       1140
 1077 OUT(I)=CD*F(JK,I)**1.5/(OUT(I)+1.E-20)                                MA       1141
 1076 WRITE (6,100) LAB,F(KV,1),(OUT(I),I=2,NP2,ITHIN),F(KV,NP3)            MA       1142
```

```
                  IF (IPLOT(KVV).EQ.0) GO TO 1090                                      MA       1143
                  NY=NY+1                                                              MA       1144
                  YAXES(NY,1)=LAB1(KVV)                                                MA       1145
                  YAXES(NY,2)=LAB2(KVV)                                                MA       1146
 1160             SYMBOL(NY)=SYM(KVV)                                                  MA       1147
                  DO 1090 I=1,NP3                                                      MA       1148
            1090  YPLOT(NY,I)=OUT(I)                                                   MA       1149
            1080  CONTINUE                                                             MA       1150
         C                                                                             MA       1151
 1165             INDX=NF                                                              MA       1152
                  DO 1180 KV=1,NFS                                                     MA       1153
                  KVV=KV+INDX                                                          MA       1154
                  IF (IPRNT(KVV).EQ.0) GO TO 1180                                      MA       1155
                  LAB(1)=LAB1(KVV)                                                     MA       1156
 1170             LAB(2)=LAB2(KVV)                                                     MA       1157
                  DO 1182 I=1,NP3                                                      MA       1158
            1182  OUT(I)=FS(KV,I)                                                      MA       1159
                  WRITE (6,100) LAB,FS(KV,1),(OUT(I),I=2,NP2,ITHIN),FS(KV,NP3)         MA       1160
                  IF (IPLOT(KVV).EQ.0) GO TO 1180                                      MA       1161
 1175             NY=NY+1                                                              MA       1162
                  YAXES(NY,1)=LAB1(KVV)                                                MA       1163
                  YAXES(NY,2)=LAB2(KVV)                                                MA       1164
                  SYMBOL(NY)=SYM(KVV)                                                  MA       1165
                  DO 1190 I=1,NP3                                                      MA       1166
 1180       1190  YPLOT(NY,I)=OUT(I)                                                   MA       1167
            1180  CONTINUE                                                             MA       1168
         C                                                                             MA       1169
                  LAB(1)=6HPRESS                                                       MA       1170
                  IF (ISWL.EQ.0) GO TO 1100                                            MA       1171
 1185             LAB(2)=6H                                                            MA       1172
                  SUB=P(NP3)                                                           MA       1173
                  DIV=1.0                                                              MA       1174
                  DO 1112 I=1,NP3                                                      MA       1175
            1112  OUT(I)=(P(I)-SUB)/DIV                                                MA       1176
 1190             WRITE (6,100) LAB,P(1),(OUT(I),I=2,NP2,ITHIN),P(NP3)                 MA       1177
            1100  IF (MODEL.NE.2) GO TO 1104                                           MA       1178
                  LAB(1)=6HAMU(1)                                                      MA       1179
                  LAB(2)=6H                                                            MA       1180
                  WRITE (6,100) LAB,AMU(1),(AMU(I),I=2,NP2,ITHIN),AMU(NP3)             MA       1181
 1195       1104  CONTINUE                                                             MA       1182
                  IF(IPRINT.EQ.2) GO TO 110                                            MA       1183
                  WRITE(6,1070) XU,ISTEP                                               MA       1184
            1070  FORMAT(1H ,11HPLOT AT XU=,1PE11.3,8H, ISTEP=,I5)                     MA       1185
                  DO 1071 J=1,NY                                                       MA       1186
 1200             YPLOT(J,2)=YPLOT(J,1)                                                MA       1187
            1071  YPLOT(J,NF2)=YPLOT(J,NP3)                                            MA       1188
                  CALL PLOTS(XPLOT,43,NP3,XAXIS,YPLOT,10,NY,YAXES,SYMBOL)              MA       1189
         C ---------------------------------------------------------------------       MA       1190
         CHAPTER 11  11  11  11  11  11  11  11  11  11  11   END OF MAIN LOOP         MA       1191
 1205       110  IF(ISTEP.GE.LASTEP.OR.XU.GE.XULAST.OR.IFIN.NE.0) GO TO 111            MA       1192
         C                                                                             MA       1193
         C        ----------STRIDE3----------STRIDE3----------STRIDE3--------STRIDE3   MA       1194
                  CALL STRIDE(3)                                                       MA       1195
                  IF(IFIN) 1011,60,111                                                 MA       1196
 1210    C                                                                             MA       1197
         C        ----------------------------------------------- TERMINATION          MA       1198
            111  WRITE(6,112) ISTEP,LASTEP,XU,XULAST,IFIN                              MA       1199
            112  FORMAT(23H TERMINATED WITH ISTEP=,I5,8H LASTEP=,I5,                   MA       1200
                1 4H XU=,1PE11.3,8H XULAST=,E11.3,6H IFIN=,I3)                         MA       1201
 1215    C ---------------------------------------------------------------------       MA       1202
            120  CONTINUE                                                              MA       1203
                 STOP                                                                  MA       1204
            100  FORMAT (1H0,A6,A2,1P11E11.3/(9X,11E11.3))                             MA       1205
            101  FORMAT (1H0,A6,A2,11I11)                                              MA       1206
 1220            END                                                                   MA       1207


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   909     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   929     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   933     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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FUNCTION TAB        73/74   OPT=0 TRACE                  FTN 4.6+439       09/24/79  13.44.16        PAGE    1

   1                FUNCTION TAB (X,XX,YY,NTAB)                                          TA        2
                    DIMENSION XX(1),YY(1)                                                TA        3
                    IF (NTAB.GT.0) GO TO 5                                               TA        4
                    TAB=0.0                                                              TA        5
   5                RETURN                                                               TA        6
                  5 F=1.                                                                 TA        7
                    IF (XX(1).GT.XX(2)) F=-F                                             TA        8
                    DO 10 J=1,NTAB                                                       TA        9
                    I=J                                                                  TA       10
  10                IF (F*(XX(I)-X)) 10,40,20                                            TA       11
                 10 CONTINUE                                                             TA       12
                 20 IF (I.NE.1) GO TO 30                                                 TA       13
                    I=2                                                                  TA       14
                 30 J=I-1                                                                TA       15
  15                DEL=XX(I)-XX(J)                                                      TA       16
                    IF (DEL.EQ.0.0) GO TO 50                                             TA       17
                    TAB=(YY(I)*(X-XX(J))-YY(J)*(X-XX(I)))/DEL                            TA       18
                    RETURN                                                               TA       19
                 40 TAB=YY(I)                                                            TA       20
  20                RETURN                                                               TA       21
                 50 WRITE (6,60) X,I,J                                                   TA       22
                    CALL EXIT                                                            TA       23
                 60 FORMAT (* *** ERROR IN SUBROUTINE TAB ***,F15.4,2I5)                 TA       24
                    END                                                                  TA       25

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM
    7       I       XX        ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
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FUNCTION VISCO      73/74   OPT=0 TRACE                 FTN 4.6+439        09/24/79  13.44.16       PAGE     1

                    FUNCTION VISCO(T)                                          TA        26
                    IF (T.GT.667.) GO TO 10                                    TA        27
                    VISCO=1.808E-5*(T/294.4)**0.76                             TA        28
                    RETURN                                                     TA        29
                 10 VISCO=4.464E-5*SQRT(T/1111.)                               TA        30
                    RETURN                                                     TA        31
                    END                                                        TA        32
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SUBROUTINE AUX        73/74    OPT=2 TRACE                    FTN 4.6+439         08/24/78  13.44.18        PAGE    1

                  SUBROUTINE AUX(NV)                                                    AU        2
                  COMMON/COMA/A(43),AAE(12),AJT(12),B(43),C(43),CSALFA,D(43),           COMA      2
                 1 EPSI(43),DX,EMU(43),F(16,43),FS(3,43),IAX,IEND,IFIN,INDE(16),        COMA      3
                 2 INDI(16),IOUT,ISTEP,ITEST,IUTDAP,JE,JSW,JV,JY,KEX,KIN,KRAD,N,        COMA      4
                 3 NDZ,NE,NOVEL,NP1,NP2,NP3,OMF(43),OMP(43),P(43),PEI,PD(16),           COMA      5
                 4 PREF(16),PSIE,PSII,R(43),RHO(43),RU(43),RMF,RMT,SD(43),SU(43),       COMA      6
                 5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSDPL(43),RDY(43),ISOLVE(16),      COMA      7
                 6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PISSEM,FDIFI(16),FDIFE(16),       COMA      8
                 7 GE(16),GI(16),JLOC(12),W(12),J4,JFU,JCD2,JCD,JDF,J42C,JDM,JD,JMS,    COMA      9
                 8 JM2,JM,JMG,JM2,JUT,JD,JF,JY,JDY,NIS,NIM,AVSD,SCATR,RDM(200),         COMA     10
                 9 EMI,SIGMA,CP,JFUDX,IFLUX,EVAP(43),TFJEC,MFRT                         COMA     11
                  COMMON/COMB/AV,ALPG,EWALL,ED,H,MFU,IMESH,MASSTR,MODEL,PRESS,          COMB      2
                 1 UBAR,UFAC,C1,C2,CD,C2WT,AMFAC,ALFAC,RPSTN1,RPSTN2,PREXP1,CD75,       COMB      3
                 2 PREXP2,CB1,CB2,MSEED,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,       COMB      4
                 3 CK,HV,SEOLD,WFU,WCO2,WCO,WOX,WH2O,W34,W3,W4,                         COMB      5
                 4 WH2,WN,WMS,WN2                                                       COMB      6
            C/--------- SUBROUTINE FOR PROGRAM GENMIX 4A                                AU        5
                  DIMENSION LAB(2),EUDY(43),G-NP(43),EMUT(43),EMUL(43)                  AU        6
                  DIMENSION SUFL(43),SDFU(43)                                           AU        7
            C                                                                           AU        8
                  ENTRY AUXD                                                            AU        9
            C     -------  CALCULATE TURB VISCOSITY FROM TWO EQUATION MODEL  --------   AU       10
                  IF (MODEL.EQ.1) GO TO 200                                             AU       11
                  DO 112 I=1,NP3                                                        AU       12
                  EMUL(I)=EMU(I)                                                        AU       13
                  RT=RHO(I)*F(JK,I)**2/(F(JD,I)*EMUL(I)+1.0E-30)                        AU       14
                  CDD=CD*EXP(-2.5/(1.0+RT/50.))                                         AU       15
                  EMUT(I)=CDD*RHO(I)*F(JK,I)**2/(F(JD,I)+1.0E-30)                       AU       16
                  EMU(I)=EMUL(I)+EMUT(I)                                                AU       17
              112 AMU(I)=EMU(I)                                                         AU       18
            C ----------------------------------------------------    TEST 10           AU       19
              200 IF (ITEST) 202,201,202                                                AU       20
              202 LAB(1)=6HTEST 1                                                       AU       21
                  LAB(2)=6H0                                                            AU       22
                  WRITE (6,100) LAB                                                     AU       23
                  LAB(1)=6HEMU(I)                                                       AU       24
                  LAB(2)=6H                                                             AU       25
                  WRITE (6,100) LAB,(EMU(I),I=1,NP3)                                    AU       26
              201 CONTINUE                                                              AU       27
            C     -----------------  MODIFICATION OF EMU ARRAY                          AU       28
                  DO 23 I=2,NP2                                                         AU       29
               23 EMU(I)=.5*(EMU(I+1)+EMU(I))                                           AU       30
                  DO 24 I=2,NP1                                                         AU       31
               24 EMU(I)=EMU(I)/(Y(I+1)-Y(I))                                           AU       32
                  IF (KRAD.EQ.0) GO TO 300                                              AU       33
                  DO 26 I=2,NP1                                                         AU       34
               26 EMU(I)=EMU(I)*.5*(R(I)+R(I+1))                                        AU       35
              300 CONTINUE                                                              AU       36
                  RETURN                                                                AU       37
            C   *************************     SOURCE TERMS     *********************    AU       38
                  ENTRY SOURCE                                                          AU       39
                  IF (NV.NE.0) GO TO 500                                                AU       40
            C     ----- VELOCITY U                                                      AU       41
                  DO 308 I=2,NP2                                                        AU       42
                  SU(I)=-DPDX(I)*.5*RDY(I)                                              AU       43
              308 SD(I)=0.                                                              AU       44
                  IF (MFNZ.EQ.0) GO TO 1308                                             AU       45
                  DO 1309 I=2,NP2                                                       AU       46
                  SU(I)=SU(I)+U(I)*EVAP(I)                                              AU       47
             1309 SD(I)=SD(I)-EVAP(I)                                                   AU       48
             1308 CONTINUE                                                              AU       49
                  GO TO 6000                                                            AU       50
            C     ---------------------- KINETIC HEATING.                               AU       51
              500 IF (NV.NE.JH) GO TO 1000                                              AU       52
            C     ----- TEMPORARY USE OF SD ARRAY.                                      AU       53
                  GO TO (303,304), NOVEL                                                AU       54
              303 DO 305 I=1,NP3                                                        AU       55
                  SU(I)=0.                                                              AU       56
              305 SD(I)=0.                                                              AU       57
                  GO TO 306                                                             AU       58
              304 DO 30 I=2,NP2                                                         AU       59
               30 SD(I)=U(I)*U(I)                                                       AU       60
                  DO 31 I=2,NP1                                                         AU       61
               31 SD(I)=EMU(I)*(SD(I+1)-SD(I))                                          AU       62
                  SD(1)=0.                                                              AU       63
                  SD(NP2)=0.                                                            AU       64
                  DO 32 I=2,NP2                                                         AU       65
```

```
      T=(1.-1./PREF(I))**.5                                  AU    66
   32 SU(I)=(SD(I)-SD(I-1))*T                                AU    67
      DO 33 I=2,NP1                                          AU    68
   33 SD(I)=0.                                               AU    69
      IF (IFLUX.EQ.0) GO TO 941                              AU    70
      DO 940 I=2,NP2                                         AU    71
      FLPTE=SIGMA*FS(JT,I)**4                                AU    72
      SOR=2.*ABSOR*(FS(JRY,I)-FLPTE)                         AU    73
      TO=(FS(JRY,I)/SIGMA)**.25                              AU    74
      TO=TO+.001                                             AU    75
      DSDH=SOR/(CP*(FS(JT,I)-TO))                            AU    76
      SU(I)=SU(I)+(SOR-DSDH*F(JH,I))*.5*DY(I)                AU    77
  940 SD(I)=SD(I)+DSDH*.5*DY(I)                              AU    78
  941 CONTINUE                                               AU    79
      IF (NFRZ.EQ.0) GO TO 937                               AU    80
      HPI=HDR(TFUEL,1)                                       AU    81
      DO 963 I=2,NP2                                         AU    82
      SU(I)=SU(I)+HPI*EVAP(I)                                AU    83
  963 SD(I)=SD(I)-EVAP(I)                                    AU    84
  937 CONTINUE                                               AU    85
C     ------------------------------------  TEST II          AU    86
  306 IF(ITEST) 302,301,302                                  AU    87
  302 LAB(1)=6HTEST I                                        AU    88
      LAB(2)=1H1                                             AU    89
      WRITE(6,100) LAB                                       AU    90
      LAB(1)=6HSD(I                                          AU    91
      LAB(2)=1H)                                             AU    92
      WRITE(6,100) LAB,(SD(I),I=1,NP3)                       AU    93
      LAB(1)=6HSU(I                                          AU    94
      LAB(2)=1H)                                             AU    95
      WRITE(6,100) LAB,(SU(I),I=1,NP3)                       AU    96
  301 CONTINUE                                               AU    97
      GO TO 6000                                             AU    98
C     ------------------------------------ ---------------- FUEL ---------- AU    99
 1000 IF (NV.NE.JFS) GO TO 2000                              AU   100
      DO 98 I=2,NP2                                          AU   101
      IF(INERT-1) 45,41,45                                   AU   102
   45 F2=F(JFU,I)                                            AU   103
      F3=F(JFUOX,I)                                          AU   104
      F4=F(JCO,I)                                            AU   105
      F6=F(JH,I)                                             AU   106
      F7=F(JD,I)                                             AU   107
      FS1=F(JOX,I)                                           AU   108
      FS2=FS(JT,I)                                           AU   109
      IF(I-2) 42,46,42                                       AU   110
   46 F2=F2+.25*(F(JFU,3)-F2)                                AU   111
      F3=F3+.25*(F(JFUOX,3)-F3)                              AU   112
      F4=F4+.25*(F(JCO,3)-F4)                                AU   113
      F6=F6+.25*(F(JH,3)-F6)                                 AU   114
      F7=F7+.25*(F(JD,3)-F7)                                 AU   115
      FS1=FS1+.25*(F(JOX,3)-FS1)                             AU   116
      FS2=FS2+.25*(FS(JT,3)-FS2)                             AU   117
   42 IF(I-NP2) 43,47,43                                     AU   118
   47 F2=F2+.25*(F(JFU,NP1)-F2)                              AU   119
      F3=F3+.25*(F(JFUOX,NP1)-F3)                            AU   120
      F4=F4+.25*(F(JCO,NP1)-F4)                              AU   121
      F6=F6+.25*(F(JH,NP1)-F6)                               AU   122
      F7=F7+.25*(F(JD,NP1)-F7)                               AU   123
      FS1=FS1+.25*(F(JOX,NP1)-FS1)                           AU   124
      FS2=FS2+.25*(FS(JT,NP1)-FS2)                           AU   125
   43 IF(F2) 41,41,430                                       AU   126
  430 IF(FS1) 41,41,431                                      AU   127
  431 SOR1=-PREXP1*RHO(I)**2*FS1*F2*EXP(-ARCON/FS2)          AU   128
      GO TO (48,49), MODER                                   AU   129
   48 SOR=SOR1                                               AU   130
      GO TO 44                                               AU   131
   49 SOR2=-CR1*RHO(I)*F7/F6                                 AU   132
      SOR=AMAX1(SOR1,SOR2)                                   AU   133
   44 SOR1=SOR*F2*.5*DY(I)                                   AU   134
      PR=PFI*RCR(I)/7X                                       AU   135
      IF (-2.*SOR1-F2*F2) 95,95,94                           AU   136
   95 SU(I)=SOR1                                             AU   137
      SD(I)=0.                                               AU   138
      GO TO 40                                               AU   139
   94 FUR=AMAX1(0.,((RATIO1*RATIO2)*F3-RATIO2-RATIO3*F4)/RATIO1)) AU   140
      IF (F2-FUR) 41,41,96                                   AU   141
   96 DSDFU=SOR1/(F2-FUR)                                    AU   142
```

```
           SU(I)=-DSDFU*FUB                                                  AU       143
           SD(I)=DSDFU                                                       AU       144
           GO TO 40                                                          AU       145
        41 SU(I)=0.                                                          AU       146
           SD(I)=0.                                                          AU       147
        40 SUFU(I)=SU(I)                                                     AU       148
           SDFU(I)=SD(I)                                                     AU       149
        98 CONTINUE                                                          AU       150
           IF (NFRZ.EQ.0) GO TO 933                                          AU       151
           DO 932 I=2,NP2                                                    AU       152
           SU(I)=SU(I)+EVAP(I)                                               AU       153
       932 SD(I)=SD(I)-EVAP(I)                                               AU       154
       933 CONTINUE                                                          AU       155
C     ----------------------------------  TEST 12                            AU       156
           IF(ITEST) 402,401,402                                             AU       157
       402 LAB(1)=6HTEST 1                                                   AU       158
           LAB(2)=1H2                                                        AU       159
           WRITE(6,100) LAB                                                  AU       160
           LAB(1)=6HSD(I                                                     AU       161
           LAB(2)=1H)                                                        AU       162
           WRITE(6,100) LAB,(SD(I),I=1,NP3)                                  AU       163
           LAB(1)=6HSU(I                                                     AU       164
           LAB(2)=1H)                                                        AU       165
           WRITE(6,100) LAB,(SU(I),I=1,NP3)                                  AU       166
       401 CONTINUE                                                          AU       167
           GO TO 6000                                                        AU       168
C     -------------------------------------------- SF-FU*DSDFU ---------     AU       169
      2000 IF (NV.NE.JFUOX) GO TO 3000                                       AU       170
           DO 50 I=2,NP2                                                     AU       171
           SU(I)=0.                                                          AU       172
        50 SD(I)=0.                                                          AU       173
           IF (NFRZ.EQ.0) GO TO 931                                          AU       174
           DO 1932 I=2,NP2                                                   AU       175
           SU(I)=SU(I)+EVAP(I)                                               AU       176
      1932 SD(I)=SD(I)-EVAP(I)                                               AU       177
       931 CONTINUE                                                          AU       178
           GO TO 6000                                                        AU       179
C     ---------------    SOURCE TERMS FOR CO   ---------------------------   AU       180
      3000 IF (NV.NE.JCO) GO TO 3500                                         AU       181
           FZ=0.                                                             AU       182
           DO 140 I=2,NP2                                                    AU       183
           IF (INFDT-1) 145,141,145                                          AU       184
       145 F2=F(JFU,I)                                                       AU       185
           F3=F(JFUOX,I)                                                     AU       186
           F4=F(JCO,I)                                                       AU       187
           F6=F(JH,I)                                                        AU       188
           F7=F(JS,I)                                                        AU       189
           FS1=F(JOX,I)                                                      AU       190
           FS2=FS(JT,I)                                                      AU       191
           IF (I-2) 142,146,142                                              AU       192
       146 F2=F2+.25*(F(JFU,3)-F2)                                           AU       193
           F3=F3+.25*(F(JFUOX,3)-F3)                                         AU       194
           F4=F4+.25*(F(JCO,3)-F4)                                           AU       195
           F6=F6+.25*(F(JH,3)-F6)                                            AU       196
           F7=F7+.25*(F(JC,3)-F7)                                            AU       197
           FS1=FS1+.25*(F(JOX,3)-FS1)                                        AU       198
           FS2=FS2+.25*(FS(JT,3)-FS2)                                        AU       199
       142 IF (I-NP2) 143,147,143                                            AU       200
       147 F2=F2+.25*(F(JFU,NP1)-F2)                                         AU       201
           F3=F3+.25*(F(JFUOX,NP1)-F3)                                       AU       202
           F4=F4+.25*(F(JCO,NP1)-F4)                                         AU       203
           F6=F6+.25*(F(JH,NP1)-F6)                                          AU       204
           F7=F7+.25*(F(JC,NP1)-F7)                                          AU       205
           FS1=FS1+.25*(F(JOX,NP1)-FS1)                                      AU       206
           FS2=FS2+.25*(FS(JT,NP1)-FS2)                                      AU       207
       143 IF (F4) 141,141,1430                                              AU       208
      1430 IF (FS1) 141,141,1431                                             AU       209
      1431 SDP1=-PREXP2*RHOC(I)**2*FS1*EXP(-[illegible]/FS2)                 AU       210
           GO TO (148,149), MODEP                                            AU       211
       148 SDP=SDP1                                                          AU       212
           GO TO 144                                                         AU       213
       149 SDP2=-CP2*RHOC(I)*F7/F6                                           AU       214
           SDP=AMAX1(SDP1,SDP2)                                              AU       215
       144 SDP1=SDP*F4*.5*DCV(I)                                             AU       216
           PX=PEI*RCH(I)/DX                                                  AU       217
           IF (-2.*SDP1-PX*F4) 945,945,944                                   AU       218
       945 SU(I)=SDP1-RATIO4*(SUFU(I)+SDFU(I))*F2)                           AU       219
```

```
            SD(I)=0.                                                          AU   220
            GO TO 140                                                         AU   221
        946 FUB=AMAX1(0.,((RATIO1+RATIO2)*F3-RATIO2-RATIO1*F2)/RATIO3)        AU   222
            IF (F4-FUB) 141,141,944                                           AU   223
        944 DSDCO=SD(I)/(F4-FUB)                                              AU   224
            SU(I)=-DSDCO*FUB-RATIO4*(SUFU(I)+SDFU(I)*F2)                      AU   225
            SD(I)=DSDCO                                                       AU   226
            GO TO 140                                                         AU   227
        141 SU(I)=-RATIO4*(SUFU(I)+SDFU(I)*F2)                                AU   228
            SD(I)=0.                                                          AU   229
        140 CONTINUE                                                          AU   230
            IF (NFNZ.EQ.0) GO TO 929                                          AU   231
            DO 926 I=2,NP2                                                    AU   232
        926 SD(I)=SD(I)-EVAP(I)                                               AU   233
        929 CONTINUE                                                          AU   234
      C ---------------------------------------------------- TEST 13         AU   235
            IF (ITEST) 178,179,178                                            AU   236
        178 LAB(1)=6HTEST 1                                                   AU   237
            LAB(2)=6H3                                                        AU   238
            WRITE (6,100) LAB                                                 AU   239
            LAB(1)=6HSU(I                                                     AU   240
            LAB(2)=6H)                                                        AU   241
            WRITE (6,100) LAB,(SU(I),I=1,NP3)                                 AU   242
            LAB(1)=6HSD(I                                                     AU   243
            LAB(2)=6H)                                                        AU   244
            WRITE (6,100) LAB,(SD(I),I=1,NP3)                                 AU   245
        179 CONTINUE                                                          AU   246
            GO TO 6000                                                        AU   247
      C ---------        SWIRL VELOCITY     ----------------                  AU   248
       3500 IF (NV.NE.JVT) GO TO 4000                                         AU   249
            DO 60 I=2,NP2                                                     AU   250
            SU(I)=0.0                                                         AU   251
         60 SD(I)=0.0                                                         AU   252
            IF (NFNZ.EQ.0) GO TO 1315                                         AU   253
            DO 1316 I=2,NP2                                                   AU   254
       1316 SU(I)=SU(I)+F(JVT,I)*EVAP(I)                                      AU   255
       1315 CONTINUE                                                          AU   256
            GO TO 6000                                                        AU   257
      C ------------       TURBULENT KINETIC ENERGY     -----------------     AU   258
       4000 IF (NV.NE.JK) GO TO 5000                                          AU   259
            D22=Y(3)-Y(1)                                                     AU   260
            VT2=F(JVT,2)/(.75*R(2)+.25*R(3))                                  AU   261
            VT3=F(JVT,3)/R(3)                                                 AU   262
            RK2=SQRT(F(JK,2))                                                 AU   263
            RK3=SQRT(F(JK,3))                                                 AU   264
            DUDY(2)=(U(3)-U(2))/D22                                           AU   265
            DVTDY=(VT3-VT2)/D22                                               AU   266
            DK2=(RK3-RK2)/D22                                                 AU   267
            GENR(2)=DUDY(2)**2+(DVTDY-VT2/(.75*R(2)+.25*R(3)))**2             AU   268
      C ---------------------                                                 AU   269
            DO 70 I=3,NP1                                                     AU   270
            D11=D22                                                           AU   271
            D22=Y(I+1)-Y(I)                                                   AU   272
            IF (I.EQ.NP1) D22=Y(NP3)-Y(NP1)                                   AU   273
            D12=D11+D22                                                       AU   274
            DUDY(I)=D11*(U(I+1)-U(I))/(D12*D22)+D22*(U(I)-U(I-1))/(D12*D11)   AU   275
            VT1=VT2                                                           AU   276
            VT2=VT3                                                           AU   277
            VT3=F(JVT,I+1)/R(I+1)                                             AU   278
            IF (I.EQ.NP1) VT3=F(JVT,NP2)/(.75*R(NP2)+.25*R(NP1))              AU   279
            DVTDY=D11*(VT3-VT2)/(D12*D22)+D22*(VT2-VT1)/(D12*D11)             AU   280
            RK1=RK2                                                           AU   281
            RK2=RK3                                                           AU   282
            RK3=SQRT(F(JK,I+1))                                               AU   283
            DRKDY=D11*(RK3-RK2)/(D12*D22)+D22*(RK2-RK1)/(D12*D11)             AU   284
            GENR(I)=DUDY(I)**2+(DVTDY-VT2/R(I))**2                            AU   285
            SU(I)=EMUT(I)*GENR(I)                                             AU   286
         70 SD(I)=-(RHO(I)*F(JD,I)+2.*EMU(I)*DRKDY**2)/F(JK,I)                AU   287
      C -------------------                                                   AU   288
            DUDY(NP2)=(U(NP2)-U(NP1))/D22                                     AU   289
            DVTDY=(VT3-VT2)/D22                                               AU   290
            DKNP2=(RK3-RK2)/D22                                               AU   291
            GENR(NP2)=DUDY(NP2)**2+(DVTDY-VT3/(.75*R(NP2)+.25*R(NP1)))**2     AU   292
            F6=.75*F(JK,2)+.25*F(JK,3)                                        AU   293
            F7=.75*F(JD,2)+.25*F(JD,3)                                        AU   294
            SU(2)=EMUT(2)*GENR(2)                                             AU   295
            SD(2)=-(RHO(2)*F7+2.*EMU(2)*DK2**2)/F6                            AU   296
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                 F6=.75*F(JE,NP2)+.25*F(JE,NP1)                                  AU      297
                 F7=.75*F(JD,NP2)+.25*F(JD,NP1)                                  AU      298
                 SU(NP2)=EMUT(NP2)*GENR(NP2)                                     AU      299
                 SD(NP2)=-(RHO(NP2)*F7+2.*EMU(NP2)*D*(NP2**2))/F6                AU      300
              76 DO 77 I=2,NP2                                                   AU      301
                 SU(I)=SU(I)*0.5*DY(I)                                           AU      302
              77 SD(I)=SD(I)*0.5*DY(I)                                           AU      303
                 IF (NFNZ.EQ.0) GO TO 1310                                       AU      304
                 DO 1311 I=2,NP2                                                 AU      305
                 SU(I)=SU(I)+F(JK,I)*EVAP(I)                                     AU      306
            1311 SD(I)=SD(I)-EVAP(I)                                             AU      307
            1310 CONTINUE                                                        AU      308
           C     ---------------------------------------------   TEST 13         AU      309
                 IF (ITEST) 78,79,78                                             AU      310
              78 LAB(1)=6HTEST 1                                                 AU      311
                 LAB(2)=6H3                                                      AU      312
                 WRITE (6,103) LAB                                               AU      313
                 LAB(1)=6HSU(                                                    AU      314
                 LAB(2)=6H)                                                      AU      315
                 WRITE (6,100) LAB,(SU(I),I=1,NP3)                               AU      316
                 LAB(1)=6HSD(                                                    AU      317
                 LAB(2)=6H)                                                      AU      318
                 WRITE (6,100) LAB,(SD(I),I=1,NP3)                               AU      319
              79 CONTINUE                                                        AU      320
           C     ---------------------                                           AU      321
                 GO TO 6000                                                      AU      322
           C     ---------------    TURBULENCE DISSIPATION    ----------------   AU      323
            5000 IF (NV.NE.JD) GO TO 6000                                        AU      324
                 D22=Y(3)-Y(2)                                                   AU      325
                 DO 90 I=3,NP1                                                   AU      326
                 C2E=C2                                                          AU      327
                 IF (ISOLVE(JKT).EQ.0) GO TO 90                                  AU      328
                 D11=D22                                                         AU      329
                 D22=Y(I+1)-Y(I)                                                 AU      330
                 D12=D11+D22                                                     AU      331
                 DRWTDY=D11*(F(JWT,I+1)-F(JWT,I))/(D12*D22)+D22*(F(JWT,I)-F(JWT,I-1 AU   332
                *  ))/(D12*D11)                                                  AU      333
                 C2E=C2E+C24T*(F(JWT,I)/R(I)**3)*DRWTDY/(GENR(I)+1.0E-20)        AU      334
                 C2E=AMIN1(C2E,3.)                                               AU      335
                 C2E=AMAX1(C2E,1.)                                               AU      336
              90 DUDYDY=(DUDY(I+1)-DUDY(I-1))/(Y(I+1)-Y(I-1))                    AU      337
                 FACTOR=2.*EMUL(I)*EMUT(I)*DUDYDY*DUDYDY/RHO(I)                  AU      338
                 SU(I)=C1*F(JD,I)*EMUT(I)*GENR(I)/F(JE,I)+FACTOR                 AU      339
              95 SD(I)=-C2E*F(JD,I)*RHO(I)/F(JE,I)                               AU      340
           C     ---------------                                                 AU      341
                 F6=.75*F(JE,2)+.25*F(JE,3)                                      AU      342
                 F7=.75*F(JD,2)+.25*F(JD,3)                                      AU      343
                 GO TO (81,82,82), KIN                                           AU      344
              81 IF (RMI.GT.1.E-10) GO TO 82                                     MM        1
                 SU(2)=1.E30*CD75*F6**1.5/(YI*AK)                                MM        2
                 SD(2)=-1.E30                                                    AU      346
                 GO TO 83                                                        AU      347
              82 SU(2)=C1*F7*EMUT(2)*GENR(2)/F6                                  AU      348
                 SD(2)=-C2*F7*RHO(2)/F6                                          AU      349
              83 F6=.75*F(JE,NP2)+.25*F(JE,NP1)                                  AU      350
                 F7=.75*F(JD,NP2)+.25*F(JD,NP1)                                  AU      351
                 GO TO (84,85,85), KEX                                           AU      352
              84 IF (RME.LT.-1.E-10) GO TO 85                                    MM        3
                 SU(NP2)=1.E30*CD75*F6**1.5/(YE*AK)                              MM        4
                 SD(NP2)=-1.E30                                                  AU      354
                 GO TO 86                                                        AU      355
              85 SU(NP2)=C1*F7*EMUT(NP2)*GENR(NP2)/F6                            AU      356
                 SD(NP2)=-C2*F7*RHO(NP2)/F6                                      AU      357
              86 DO 87 I=2,NP2                                                   AU      358
                 SU(I)=SU(I)*0.5*DY(I)                                           AU      359
              87 SD(I)=SD(I)*0.5*DY(I)                                           AU      360
                 IF (NFNZ.LE.0) GO TO 1312                                       AU      361
                 DO 1313 I=2,NP2                                                 AU      362
                 SU(I)=SU(I)+F(JD,I)*EVAP(I)                                     AU      363
            1313 SD(I)=SD(I)-EVAP(I)                                             AU      364
            1312 CONTINUE                                                        AU      365
           C     -------------------------------------------   TEST 14           AU      366
                 IF (ITEST) 88,89,88                                             AU      367
              88 LAB(1)=6HTEST 1                                                 AU      368
                 LAB(2)=6H4                                                      AU      369
                 WRITE (6,103) LAB                                               AU      370
                 LAB(1)=6HSU(                                                    AU      371
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SUBROUTINE AUX        73/74    OPT=0 TRACE                          FTN 4.7+439        09/24/79  13.44.16       PAGE      6

                    LAB(2)=5H)                                                          AU       372
                    WRITE (6,100) LAB,(SU(I),I=1,NP3)                                   AU       373
                    LAB(1)=6HSD(I                                                       AU       374
                    LAB(2)=5H)                                                          AU       375
                    WRITE (6,100) LAB,(SD(I),I=1,NP3)                                   AU       376
                 89 CONTINUE                                                            AU       377
              C     ---------                                                           AU       378
               6000 CONTINUE                                                            AU       379
                    RETURN                                                              AU       380
                100 FORMAT(1H ,A5,A2,1P11E11.3/(7X,11F11.3))                            AU       381
                    END                                                                 AU       382


CARD NO. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     66     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    141     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    223     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    356     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    365     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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      SUBROUTINE DROP                                                   AUS       2
      COMMON/COMA/A(43),AJE(16),AJI(16),B(43),C(43),CSALFA,C(43),       COMA      2
     1 DPDX(43),DX,EPS(43),F(16,43),FS(3,43),IAX,IFND,IFIN,INDE(16),    COMA      3
     2 INDI(16),IOUT,ISTEP,ITEST,ITRAP,JS,JSW,JW,JY,KEX,KIN,KRAD,M,     COMA      4
     3 ND2,NF,NOVEL,NP1,NP2,NP3,PM(43),PMD(43),P(43),PEI,PP(16),        COMA      5
     4 PREF(16),PSIE,PSII,R(43),RHO(43),RU(43),RME,RMI,SD(43),SU(43),   COMA      6
     5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSIPL(43),RCY(43),ISOLVE(16),  COMA      7
     6 US(43),RPU(43),SUM1,SUM2,SUM3,SUM4,PDGSCM,FDIFI(16),FDIFE(16),   COMA      8
     7 GE(16),GI(16),JLOC(12),W(12),JH,JFU,JCO2,JCO,JOX,JH2O,JOH,JO,JHS, COMA     9
     8 JH2,JN,JNO,JN2,JVT,JD,JK,JT,JRV,NSP,NSPR,ASSDP,SCATP,BOM(200),   COMA     10
     9 EPI,SIGMA,CP,JFUOX,IFLUX,EVAP(43),TFUEL,NFNZ                     COMA     11
      COMMON/COMB/AK,ALPG,EMALL,FR,G,HFU,HEAT,MASSTR,MODEL,PRESS,       COMB      2
     1 UBAR,UFAC,C1,C2,CG,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,C075,   COMB      3
     2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,   COMB      4
     3 CX,HY,DXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                     COMB      5
     4 WH2,WN,WNO,WN2                                                   COMB      6
      DIMENSION YDL(5),UFD(5),VFD(5),DD(5),FEVAP(5),DO(5),PO(4),E(4)    AUS       5
      DIMENSION DSMD(5),FRACT(7),RW(7),RWCOND(4),ACOND(4),BCOND(4)      AUS       6
      DATA DSMD/.6,.9,1.2,1.5,2.1/,FRACT/0.,.1,.3,.5,.7,.9,1.0/         AUS       7
      DATA PO/2.79E+8,9.79E+8,2.14E+9,4.8E+9/                           AUS       8
      DATA ACOND/-5.302E-3,-6.358E-3,-6.296E-3,-6.91E-3/                AUS       9
      DATA BCOND/5.36E-5,4.91E-5,4.64E-5,4.73E-5/                       AUS      10
      DATA RW/96.28,114.6,126.51,139.15,159.59,173.21,294.76/           AUS      11
      DATA RWCOND/50.,100.,150.,300./,E/2655.,3494.,4007.,4514./        AUS      12
C **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  **  ** AUS      13
      IF (ISTEP.GT.0) GO TO 10                                          AUS      14
      READ (5,15) NFNZ,XDP,YDP,UF,VF,SMD,FNOZFLO,TFUEL                  AUS      15
   15 FORMAT (I2,8X,7E10.4)                                             AUS      16
      DO 20 I=1,5                                                       AUS      17
      YDL(I)=YDP                                                        AUS      18
      UFD(I)=UF                                                         AUS      19
      VFD(I)=VF                                                         AUS      20
      FEVAP(I)=0.                                                       AUS      21
      DD(I)=DSMD(I)*SMD*1.E-6                                           AUS      22
   20 DO(I)=DD(I)                                                       AUS      23
   10 CONTINUE                                                          AUS      24
      TF=2300.                                                          AUS      25
      SC=0.8                                                            AUS      26
      BB=0.                                                             AUS      27
      RHODO=0.775                                                       AUS      28
      POT=PO(I)                                                         AUS      29
      ET=E(I)                                                           AUS      30
      TB=ET/ALOG(POT/PRESS)                                             AUS      31
      RDFD=1000.*(RHODO+.208-.00072*TB)                                 AUS      32
      QCOMB=4.5E+7                                                      AUS      33
      QEVAP=3.3E+5                                                      AUS      34
      SMALL=1.E-20                                                      AUS      35
      DO 19 I=1,NP3                                                     AUS      36
   19 EVAP(I)=0.                                                        AUS      37
      JKSTORE=JK                                                        AUS      38
      IF (NFNZ.EQ.0.OR.XU.LT.XDP) RETURN                                AUS      39
   60 DO 370 I=1,5                                                      AUS      40
C ---------- S T A R T   O F   M A I N   L O O P ---------------------- AUS      41
      IF (FEVAP(I).GE.0.99) GO TO 370                                   AUS      42
      DXFD=0.0                                                          AUS      43
C ----- FIND CELL OCCUPIED BY THE ITH DROPLET -----                     AUS      44
  110 DO 140 J=3,NP1                                                    AUS      45
      YP=0.5*(Y(J+1)+Y(J))                                              AUS      46
      YM=0.5*(Y(J)+Y(J-1))                                              AUS      47
      IF (YDL(I).GE.YP.OR.YDL(I).LE.YM) GO TO 120                       AUS      48
      JK=J                                                              AUS      49
      GO TO 170                                                         AUS      50
  120 IF (YDL(I).NE.YP) GO TO 130                                       AUS      51
      IF (VFD(I).GE.0.0) JK=J                                           AUS      52
      IF (VFD(I).LT.0.0) JK=J-1                                         AUS      53
      GO TO 170                                                         AUS      54
  130 IF (YDL(I).NE.YM) GO TO 140                                       AUS      55
      IF (VFD(I).GE.0.0) JK=J+1                                         AUS      56
      IF (VFD(I).LT.0.0) JK=J                                           AUS      57
      GO TO 170                                                         AUS      58
  140 CONTINUE                                                          AUS      59
  150 IF (YDL(I).GE.0.5*(Y(3)+Y(2))) GO TO 160                          AUS      60
      JK=2                                                              AUS      61
      YP=0.5*(Y(JK+1)+Y(JK))                                            AUS      62
      YM=0.0                                                            AUS      63
      GO TO 175                                                         AUS      64
  160 IF (YDL(I).LE.(Y(NP2)+Y(NP1))/2.) GO TO 170                       AUS      65
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      JK=NP2
      YP=Y(NP3)
      YM=0.5*(Y(JK)+Y(JK-1))
C ----- FREESTREAM PROPERTIES -----
  170 ROST=RHO(JK)
      TST=FS(JT,JK)
      VISC=VISCO(TST)
      UST=U(JK)
      VST=0.0
C -------------- P R O P E R T I E S   O F   F U E L ------------------
C ----- BOILING TEMPERATURE -----
      POT=PO(4)
      ET=E(4)
      IF (FEVAP(I).GE.0.5) GO TO 180
      POT=TAB(FEVAP(I),FRACT,PO,4)
      ET=TAB(FEVAP(I),FRACT,E,4)
  180 TB=ET/ALOG(POT/PRESS)
      TI=(TB+TF)/2.
C ----- DENSITY OF LIQUID FUEL AT TB -----
      ROF=1.076/(1.+(1.076/.775-1.)*(1.-.67*FEVAP(I)))
      ROF=1000.*(ROF+.208-.00072*TB)
C ----- MOLECULAR WEIGHT OF FUEL VAPORS -----
      RWT=TAB(FEVAP(I),FRACT,RW,7)
      AT=TAB(RWT,RWCOND,ACOND,4)
      BT=TAB(RWT,RWCOND,BCOND,4)
C ----- THERMAL CONDUCTIVITY AND SPECIFIC HEAT OF FUEL VAPORS -----
      CONDI=1.729*(AT+BT*TI)
      CPI=4184.*(0.1536+.00081*TI)
      CONDI=0.4*CONDI+0.6*.064*SQRT(TI/1111.)
C ----- RELATIVE VEL,REYNOLDS NO.,DRAG COEF AND FORCE COMPONENTS -----
      VR=SQRT((UFO(I)-UST)**2+(VFO(I)-VST)**2)
      REI=ROST*VR*DD(I)/VISC
      CDS=0.32+4.6/SQRT(REI)+24./REI
      CDI=AMAX1(CDS/2.,CDS/(1.+RR))
      FCTR=CDI*3.14159/4.*DD(I)**2/2.*ROST
      UF=UFO(I)
      VF=VFO(I)
      DS1=AMIN1(DX,YP-YM)
      KOUNT=0
C     -----------------
      IF (ITEST.EQ.0) GO TO 190
      LAB=6HDROPI
      WRITE (6,980) LAB,POT,ET,TB,ROF,RWT,CONDI,VR,CP,FCTR,DS1
  980 FORMAT (/1H ,A8,1P11E11.3/(9X,11E11.3))
C     -----------------
  190 KOUNT=KOUNT+1
      IF (KOUNT.LT.15) GO TO 193
      LAB=8HDROPI
      RSTEP=ISTEP
      WRITE (6,980) LAB,DS,DS1,UFA,VFA,    FX,FY,    DTI,FCTR,CONS,
     +  YADX,YP,YM,DXF,DYF,RSTEP
  193 CONTINUE
      IF (KOUNT.GT.20) GO TO 245
      IF (KOUNT.LE.10) DS=DS1
      IF (KOUNT.GT.10) DS=0.5*(DS+DS1)
      UFA=0.5*(UF+UFO(I))
      VFA=0.5*(VF+VFO(I))
      FX=FCTR*ABS(UST-UFA)*(UST-UFA)
      FY=FCTR*ABS(VST-VFA)*(VST-VFA)
      DTI=DS/SQRT(UFA*UFA+VFA*VFA)
      CONS=ROF*3.14159/6.*DD(I)**3/DTI
C ----- VELOCITY AND LOCATION OF DROPLET -----
      UFO(I)=UF+FX/CONS
      VFO(I)=VF+FY/CONS
      DXF=(UFO(I)+UF)/2.*DTI
      DYF=(VFO(I)+VF)/2.*DTI
C ----- ADJUST DS DEPENDING UPON BOUNDARY HIT -----
      DYADX=DYF*(DX-DXFO)/(DXF+SMALL)
      YADX=YDL(I)+DYADX
  200 IF (YADX.GT.YP) GO TO 230
      IF (YADX.LT.YM) GO TO 220
  210 DXF=DX-DXFO
      DYF=DYADX
      IBOUND=0
      GO TO 240
  220 DYM=YM-YDL(I)
      DXF=(DX-DXFO)*DYM/(DYADX+SMALL)
```

```
      DYF=DYM                                                           AUS      143
      IBOUND=-1                                                         AUS      144
      GO TO 240                                                         AUS      145
  230 DYP=YP-YDL(I)                                                     AUS      146
      DXF=(DX-DXFO)*DYP/(DYACX+SMALL)                                   AUS      147
      DYF=DYP                                                           AUS      148
      IBOUND=1                                                          AUS      149
  240 DS1=SQRT(DXF*DXF+DYF*DYF)                                         AUS      150
      IF (ABS(DS1-DS).GT.ABS(.01*DS1)) GO TO 190                        AUS      151
  245 YDL(I)=YDL(I)+DYF                                                 AUS      152
      DXFO=DXFO+DXF                                                     AUS      153
      IF (IBOUND) 260,310,270                                           AUS      154
  260 YDL(I)=YP-.0025*(Y(JK+1)-Y(JK-1))                                 AUS      155
      GO TO 310                                                         AUS      156
  270 YDL(I)=YP+.0025*(Y(JK+1)-Y(JK-1))                                 AUS      157
  310 IF (YDL(I).LT.Y(NP3).AND.YDL(I).GT.Y(1)) GO TO 300                AUS      158
      DEVAP=1.0-FEVAP(I)                                                AUS      159
      FEVAP(I)=1.0                                                      AUS      160
      GO TO 320                                                         AUS      161
C ----- CALCULATE BURNING RATE CONSTANT -----                           AUS      162
C --- MASS TRANSFER NC ---                                              AUS      163
  300 BB=(F(JOX,JK)*GCOMB/RATIO1+AMAX1(CP1*(TST-TR),0.))/QEVAP          AUS      164
      RATE=8./ROF*CONDI/CP1*ALOG(1.+BB)*(1.+0.276*SQRT(REI)*SC**.33)    AUS      165
C ----- FRACTION EVAPORATED -----                                       AUS      166
      DEVAP=1.5/ROFO/DD(I)**3*RF*DD(I)*RATE*DS/SQRT(UFO(I)**2+VFO(I)**2 AUS      167
     1)                                                                 AUS      168
      FEVAP(I)=FEVAP(I)+DEVAP                                           AUS      169
      IF (FEVAP(I).LE.1.00) GO TO 320                                   AUS      170
      DEVAP=DEVAP-(FEVAP(I)-1.00)                                       AUS      171
      FEVAP(I)=1.00                                                     AUS      172
  320 EVAP(JK)=EVAP(JK)+DEVAP                                           AUS      173
C ----- NEW DROPLET DIAMETER -----                                      AUS      174
      ARG=DD(I)*DD(I)-RATE*DTT                                          AUS      175
      IF (ARG.LE.0.0) GO TO 330                                         AUS      176
      DD(I)=SQRT(ARG)                                                   AUS      177
      GO TO 340                                                         AUS      178
  330 DD(I)=0.0                                                         AUS      179
      FEVAP(I)=1.0                                                      AUS      180
C   ------------------                                                  AUS      181
      IF (ITEST.EQ.0) GO TO 340                                         AUS      182
      LAB=8HDROP2                                                       AUS      183
      WRITE (6,980)  LAB,UFD(I),VFD(I),             YDL(I),DXFO,        AUS      184
     1              DEVAP,FEVAP(I),DD(I),BB,RATE                        AUS      185
C   ------------------                                                  AUS      186
  340 IF (DXFO.LT..99*DX.AND.FEVAP(I).LT.0.99) GO TO 110                AUS      187
  370 CONTINUE                                                          AUS      188
      DO 390 I=2,NP2                                                    AUS      189
      EVAP(I)=EVAP(I)*FNCZFLO/5./DX                                     AUS      190
  390 CONTINUE                                                          AUS      191
      JK=JKSTORE                                                        AUS      192
C   ------------------                                                  AUS      193
      RETURN                                                            AUS      194
      END                                                               AUS      195
```

```
      FUNCTION GASP (TT,I)
      DIMENSION AH(7,12),AL(7,12),W(12)
C
C     SPECIES ORDER - FUEL,CO2,CO,O2,H2O,OH,O,H,H2,N,NO,N2
C
      DATA ((AH(I,J),I=1,7),J=1,6)/
     1 0.26845936E+02, 0.46470050E-01,-0.22767913E-04, 0.48494616E-08,
     2-0.37080219E-12,-0.40857112E+05, 0.              ,
     3  .44608041E+01,  .30981719E-02, -.12392571E-05,  .22741325E-09,
     4 -.15525954E-13, -.48961442E+05, -.98635982E+00,
     5  .29840696E+01,  .14891390E-02, -.57899684E-06,  .10364577E-09,
     6 -.69353550E-14, -.14245228E+05,  .63479156E+01,
     7  .36219535E+01,  .73618264E-03, -.19652228E-06,  .36201558E-10,
     8 -.28945627E-14, -.12019825E+04,  .36159950E+01,
     9  .27167633E+01,  .29451374E-02, -.80224374E-06,  .10226682E-09,
     * -.48472145E-14, -.29905826E+05,  .66305671E+01,
     1  .29131230E+01,  .95419265E-03, -.19086325E-06,  .12730795E-10,
     2  .24803941E-15,  .39647060E+05,  .54788735E+01/
C
      DATA ((AH(I,J),I=1,7),J=7,12)/
     1  .25420596E+01, -.27550619E-04, -.31028033E-08,  .45510674E-11,
     2 -.43680515E-15,  .29230803E+05,  .49203980E+01,
     3  .25000000E+01, 0.            , 0.            , 0.            ,
     4 0.            ,  .25471627E+05, -.46011763E+00,
     5  .31001901E+01,  .51119464E-03,  .52644210E-07, -.34909973E-10,
     6  .36945345E-14, -.87738042E+03, -.19629421E+01,
     7  .24502682E+01,  .10661458E-03, -.74653373E-07,  .18796524E-10,
     8 -.10259839E-14,  .56116040E+05,  .44487591E+01,
     9  .31690000E+01,  .13382281E-02, -.52899318E-06,  .95919332E-10,
     * -.64847932E-14,  .98283290E+04,  .67458126E+01,
     1  .28963194E+01,  .15154866E-02, -.57235277E-06,  .99807393E-10,
     2 -.65223555E-14, -.90586184E+03,  .61615148E+01/
C
      DATA ((AL(I,J),I=1,7),J=1,6)/
     1 0.57799475E+01, 0.50561445E-01, 0.51146255E-04,-0.94988140E-07,
     2 0.39603875E-10,-0.25323487E+05, 0.              ,
     3  .24007797E+01,  .87350957E-02, -.66070878E-05,  .20021861E-08,
     4  .63274039E-15, -.48377527E+05,  .96951457E+01,
     5  .37100928E+01, -.16190964E-02,  .36923594E-05, -.20319674E-08,
     6  .23953344E-12, -.14356310E+05,  .29555351E+01,
     7  .36255985E+01, -.18782184E-02,  .70554544E-05, -.67635137E-08,
     8  .21555993E-11, -.10475226E+04,  .43052778E+01,
     9  .40701275E+01, -.11084499E-02,  .41521180E-05, -.29637404E-08,
     *  .80702103E-12, -.30279722E+05, -.32270046E+00,
     1  .38365518E+01, -.10702014E-02,  .94659757E-06,  .18713972E-09,
     2 -.22571094E-12,  .36412823E+04,  .49370009E+00/
C
      DATA ((AL(I,J),I=1,7),J=7,12)/
     1  .29464287E+01, -.16381665E-02,  .24210316E-05, -.16028432E-08,
     2  .38906964E-12,  .29147644E+05,  .29639949E+01,
     3  .25000000E+01, 0.            , 0.            , 0.            ,
     4 0.            ,  .25471627E+05, -.46011762E+00,
     5  .30574451E+01,  .26765200E-02, -.58099162E-05,  .55210391E-08,
     6 -.18122739E-11, -.98890474E+03, -.22997056E+01,
     7  .25030714E+01, -.21800181E-04,  .54205287E-07, -.56475602E-10,
     8  .20999044E-13,  .56098904E+05,  .41675764E+01,
     9  .40459521E+01, -.34181783E-02,  .79819190E-05, -.61139316E-08,
     *  .15919076E-11,  .97453934E+04,  .29974988E+01,
     1  .36748261E+01, -.12081500E-02,  .23240102E-05, -.63217559E-09,
     2 -.22577253E-12, -.10611588E+04,  .23580424E+01/
C
      DATA W/44.,44.,28.,32.,18.,17.,16.,1.,2.,14.,30.,28./,KOUNT/0/
      DATA TLIM/1500./
C    ************************************************************
      ENTRY GTT
      T=TT
      IF (T.LT.1000.) GO TO 10
      ARG=AH(1,I)*(1.-ALOG(T))+AH(6,I)/T-(AH(7,I)+T*(AH(2,I)/2.+T*(AH(3,
     1I)/6.+T*(AH(4,I)/12.+T*AH(5,I)/20.))))
      GO TO 15
   10 ARG=AL(1,I)*(1.-ALOG(T))+AL(6,I)/T-(AL(7,I)+T*(AL(2,I)/2.+T*(AL(3,
     1I)/6.+T*(AL(4,I)/12.+T*AL(5,I)/20.))))
   15 GASP=ARG
      RETURN
C    ************************************************************
      ENTRY CPDR
      T=TT
```

```
      IF (I.EQ.1) T=AMIN1(T,TLIM)                                       GA        79
      IF (T.LT.1000.) GO TO 20                                          GA        80
      ARG=AH(1,I)+T*(AH(2,I)+T*(AH(3,I)+T*(AH(4,I)+T*AH(5,I))))         GA        81
      GO TO 25                                                          GA        82
   20 ARG=AL(1,I)+T*(AL(2,I)+T*(AL(3,I)+T*(AL(4,I)+T*AL(5,I))))         GA        83
   25 GASP=ARG*1.987*4184./W(I)                                         GA        84
      RETURN                                                            GA        85
C   *****************************************************************   GA        86
      ENTRY HOR                                                         GA        87
      T=TT                                                              GA        88
      IF (I.EQ.1) T=AMIN1(T,TLIM)                                       GA        89
      IF (T.LT.1000.) GO TO 30                                          GA        90
      ARG=AH(5,I)+T*(AH(1,I)+T*(AH(2,I)/2.+T*(AH(3,I)/3.+T*(AH(4,I)/4.+T GA        91
     1*AH(5,I)/5))))                                                    GA        92
      GO TO 35                                                          GA        93
   30 ARG=AL(5,I)+T*(AL(1,I)+T*(AL(2,I)/2.+T*(AL(3,I)/3.+T*(AL(4,I)/4.+T GA        94
     1*AL(5,I)/5))))                                                    GA        95
   35 GASP=ARG*1.987*4184./W(I)                                         GA        96
      IF (TT.LT.TLIM.OR.I.NE.1) RETURN                                  GA        97
      CPI=AH(1,I)+T*(AH(2,I)+T*(AH(3,I)+T*(AH(4,I)+T*AH(5,I))))         GA        98
      ARG=ARG+CPI*(TT-T)/W(I)                                           GA        99
      GASP=ARG*1.987*4184./W(I)                                         GA       100
      RETURN                                                            GA       101
C   *****************************************************************   GA       102
      ENTRY COEF                                                        GA       103
      KOUNT=KOUNT+1                                                     GA       104
      IF (KOUNT.EQ.2) GO TO 40                                          GA       105
      W(1)=TT                                                           GA       106
      GASP=W(1)                                                         GA       107
      RETURN                                                            GA       108
   40 HFU=TT                                                            GA       109
      AH(6,1)=HFU/1.987                                                 GA       110
      AL(6,1)=HFU/1.987                                                 GA       111
      GASP=AL(6,1)                                                      GA       112
      RETURN                                                            GA       113
      END                                                               GA       114
```

```
              SUBROUTINE STRAD                                                      SA        115
              COMMON/COMA/A(43),AJE(16),AJI(16),AP(43),B(43),CSALFA,D(43),          COMA        2
             1 DPDX(43),DX,EMU(43),F(16,43),FF(3,43),IAX,IEND,IFIN,INDE(16),        COMA        3
             2 INDI(16),IOUT,ISTEP,ITEST,IUTRAP,JS,JSM,JV,JY,KEX,KIN,KRAD,N,        COMA        4
             3 NDZ,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(16),            COMA        5
             4 PREF(16),PSIE,PSII,R(43),RHO(43),RU(43),RMS,RMI,SD(43),SU(43),       COMA        6
             5 TAUE,TAUI,U(43),UG,XU,Y(43),YE,YI,PSMPL(43),RDY(43),ISOLVE(16),      COMA        7
             6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PRESCM,FDIFI(16),FDIFE(16),       COMA        8
             7 GE(16),GI(16),JLOC(12),J(12),JH,JEN,JEPS,JCO,JDX,JM2C,JDH,JJ,JHS,    COMA        9
             8 JH2,JM,JMD,JMZ,JVT,JE,JK,JT,JRV,RSP,WTPM,ABSOR,SCATR,EDP(200),       COMA       10
             9 EMI,SIGMA,CP,JFUDJ,IFLUX,EYAP(43),TFUEL,NFNT                         COMA       11
              COMMON/COMB/AK,ALPG,EWALL,FB,H,HFU,INERT,MASSTR,MODEL,PRESS,          COMB        2
             1 UBAR,UFAC,C1,C2,CD,C2VT,AMFAC,ALFAC,ABSORB1,ABSORB2,PREXP1,CO75,     COMB        3
             2 PREXP2,CR1,CR2,POWER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,       COMB        4
             3 CK,HY,DXDLD,WFU,WCO2,WCO,WO2,WH2O,WN4,WN,W4,                         COMB        5
             4 WH2,WH,WNO,WN2                                                       COMB        6
              DIMENSION ATP(200),ATM(200),GAM(200)                                  SA        118
              IF (ISTEP.EQ.0) RETURN                                                SA        119
        C --------COMPUTE GAMA RADIATION                                            SA        120
              DO 10 I=2,NP3                                                         SA        121
              GAM(I)=1./(ABSOR+SCATR+1./(R(I)+1.E-20))                              SA        122
           10 CONTINUE                                                              SA        123
        C --------COMPUTE RADIATION SOURCE TERMS                                    SA        124
              DO 20 I=2,NP2                                                         SA        125
              FLPE=SIGMA*FS(JT,I)**4                                                SA        126
              SU(I)=ABSOR*FLPE                                                      SA        127
              SP(I)=-ABSOR                                                          SA        128
           20 CONTINUE                                                              SA        129
        C --------COMPUTE BOUNDARY MODIFICATIONS                                    SA        130
              IF (KIN.NE.1) GO TO 32                                                SA        131
              SU(2)=SU(2)+EMI*SIGMA*FS(JT,1)**4                                     SA        132
              SP(2)=SP(2)-EMI                                                       SA        133
           32 IF (KEX.NE.1) GO TO 34                                                SA        134
              SU(NP2)=SU(NP2)+EMI*SIGMA*FS(JT,NP3)**4                               SA        135
              SP(NP2)=SP(NP2)-EMI                                                   SA        136
        C --------COMPUTE COEFFICIENTS                                              SA        137
           34 TT=0.                                                                 SA        138
              DO 30 I=2,NP2                                                         SA        139
              ATM(I)=TT                                                             SA        140
              TT=.25*(R(I+1)+R(I))*(GAM(I+1)+GAM(I))/(Y(I+1)-Y(I))                  SA        141
              ATP(I)=TT                                                             SA        142
              SU(I)=SU(I)*.5*(Y(I+1)-Y(I-1))*R(I)                                   SA        143
              SP(I)=SP(I)*.5*(Y(I+1)-Y(I-1))*R(I)                                   SA        144
           30 CONTINUE                                                              SA        145
              ATP(NP2)=0.                                                           SA        146
        C --------SOLVE RADIATION EQUATION                                          SA        147
              A(1)=0.                                                               SA        148
              B(1)=0.                                                               SA        149
              DO 40 I=2,NP2                                                         SA        150
              STORE=ATP(I)+ATM(I)-SP(I)-ATM(I)*A(I-1)                               SA        151
              A(I)=ATP(I)/STORE                                                     SA        152
           40 B(I)=(SU(I)+ATM(I)*B(I-1))/STORE                                      SA        153
              DO 50 II=2,NP2                                                        SA        154
              I=2+NP2-II                                                            SA        155
           50 FS(JRV,I)=A(I)*FS(JRV,I+1)+B(I)                                       SA        156
              RETURN                                                                SA        157
              END                                                                   SA        158
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SUBROUTINE WTEMP      73/74   OPT=0 TRACE                    FTN 4.6+439         08/24/78  13.44.16        PAGE    1

      SUBROUTINE WTEMP (I)                                              WT        2
      COMMON/COMA/A(43),AJE(16),AJI(16),B(43),C(43),CSALFA,D(43),       COMA      2
     1 DPDX(43),DX,EMU(43),F(16,43),FS(3,43),IAX,IEND,IFIN,INDE(16),    COMA      3
     2 INDI(16),IOUT,ISTEP,ITEST,IUTPAP,JS,JSW,JW,JY,KEX,KIN,KRAD,N,    COMA      4
     3 NDZ,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(16),        COMA      5
     4 PREF(16),PSIE,PSII,R(43),RHO(43),RO(43),RME,RMI,SD(43),SU(43),   COMA      6
     5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSUBL(43),RDY(43),ISOLVE(16),  COMA      7
     6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PDGSCN,FDIFI(16),FDIFE(16),   COMA      8
     7 GE(16),GI(16),JLDC(12),W(12),JM,JFU,JCO2,JCO,JOX,JH2O,JOH,JO,JHS, COMA     9
     8 JH2,JN,JNO,JN2,JVT,JB,JK,JT,JRY,NSP,NSPM,ABSCP,SCATR,BOM(200),   COMA     10
     9 EMI,SIGMA,CP,JFUOX,IFLUX,EVAP(43),TFDEL,NFBZ                     COMA     11
      COMMON/COMB/AK,ALMG,EWALL,FN,H,HFU,INERT,MASSTP,MODEL,PRESS,      COMB      2
     1 UBAR,UFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,   COMB      3
     2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,   COMB      4
     3 CX,WY,DXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                     COMB      5
     4 WH2,WN,WNO,WN2                                                   COMB      6
      COMMON/COMC/API(40),ARE(40),XR(40),NBP                            COMC      2
      COMMON/COMD/XUINJ(12),UINJ(12),TUINJ(12),WTUINJ(12),AUINJ(12),    COMD      2
     1 XVINJ(12),UVINJ(12),VINJ(12),WTVINJ(12),TVINJ(12),AVINJ(12),     COMD      3
     2 RUINJ(12),ARUINJ(12),HUINJ(12),XLUINJ(12),TAM(2),VELA(2),        COMD      4
     3 PRAD(2),NUI,NUE,NVI,NVE                                          COMD      5
      DIMENSION RQ(4),XDIST(2),LAP(2),FLIP(2)                           WT        7
      DATA XDIST/0.,0./,FLIP/0.,0./                                     WT        8
      DATA XUL,RQ/-10000.,1.,1.,1.,1./                                  WT        9
      DATA SIGMA,EMLIN,EMPL/5.57E-9,.9,.9/                              WT       10
      IF (ISTEP.EQ.0) RETURN                                            WT       11
      IF (ND2-1) 5,5,6                                                  WT       12
    6 IMP1=3                                                            WT       13
      IMP2=2                                                            WT       14
      KW=1                                                              WT       15
      KB=KIN                                                            WT       16
      NV=NVI                                                            WT       17
      NU=NUI                                                            WT       18
      RW=TAB(XU,XR,API,NBP)                                             WT       19
      GO TO 7                                                           WT       20
    5 IMP1=NP1                                                          WT       21
      IMP2=NP2                                                          WT       22
      KW=2                                                              WT       23
      KB=KEX                                                            WT       24
      NV=NVE                                                            WT       25
      NU=NUE                                                            WT       26
      RW=TAB(XU,XR,ARE,NBP)                                             WT       27
    7 XDIST(1)=XDIST(1)+DXOLD                                           WT       28
      XDIST(2)=XDIST(2)+DXOLD                                           WT       29
      SMALL=1.E-20                                                      WT       30
      XUL=XU                                                            WT       31
  400 CONTINUE                                                          WT       32
      IF (XD.GE.XVINJ(NV)) RETURN                                       WT       33
C ------- DETERMINE COOLENT FLOW CONDITIONS                             WT       34
      IF (XU.GE.XLUINJ(NU)) GO TO 30                                    WT       35
   37 AF=.5*ABS(PRAD(KW)**2-RW**2)                                      WT       36
      CVEL=VELA(KW)                                                     WT       37
      CTEM=TAM(KW)                                                      WT       38
      CDEN=PDGSCN/CTEM                                                  WT       39
      FLO=CDEN*CVEL*AF                                                  WT       40
      GO TO 35                                                          WT       41
   30 IF (XU.GE.XUINJ(NU)) GO TO 37                                     WT       42
      XDIST(KW)=0.                                                      WT       43
      FLIP(KW)=XUINJ(NU)-XLUINJ(NU)                                     WT       44
      CVEL=UINJ(NU)                                                     WT       45
      CTEM=AMAX1(TUINJ(NU),TAM(KW))                                     WT       46
      CDEN=PDGSCN/CTEM                                                  WT       47
      FLO=AUINJ(NU)                                                     WT       48
   35 TA4=CTEM**4                                                       WT       49
      TW=FS(JT,I)                                                       WT       50
      IMGT=0                                                            WT       51
  101 TW15=TW**1.5                                                      WT       52
      TW4=TW**4                                                         WT       53
C ******************  COLD SIDE CONVECTION  ***************************** WT     54
      IF (IMOF) 33,33,36                                                WT       55
   33 IF (XU.GE.XLUINJ(NU)) GO TO 50                                    WT       56
   49 XDIST2=XDIST(KW)+FLIP(KW)                                         WT       57
      XDIST2=AMAX1(XDIST2,.001)                                         WT       58
      REI=CDEN*CVEL*XDIST2/VISCO(CTEM)                                  WT       59
      HW4=.0268*CDEN*CP*CVEL/REI**0.2                                   WT       60
      GO TO 36                                                          WT       61
C ------- IMPINGEMENT COOLING INSIDE SLOT LIP                           WT       62
```

```
 50 IF (XU.GE.XUINJ(NU)) GO TO 49                                    WT        63
    BIC=AF/(ARUINJ(NU)*R(I))                                         WT        64
    UFAC=AMIN1(1.,7.*BIC/HUINJ(NU))                                  WT        65
    UFAC=AMAX1(SMALL,UFAC)                                           WT        66
    UIC=UINJ(NU)*ARUINJ(NU)*SQRT(UFAC)                               WT        67
    RE1=UIC*RLIP(KW)*CDEN/VISCO(CTEM)                                WT        68
    RK4=0.36*RE1**0.62*1436.*VISCO(CTEM)/RLIP(KW)                    WT        69
 34 QCC=RK4*(TW-CTEM)                                                WT        70
    DQCC=RK4                                                         WT        71
C *****************  COLD SIDE RADIATION  ****************************** WT    72
    IF (INDX) 43,43,44                                               WT        73
 43 RK3=SIGMA/(1./EMLIN+RW*(1./EMWL-1.)/RRAD(KW))                    WT        74
 44 QRC=RK3*(TW4-TA4)                                                WT        75
    DQRC=4.*RK3*TW15*TW15                                            WT        76
C ********************  HOT SIDE RADIATION  *************************** WT     77
    IF (INDX) 53,53,54                                               WT        78
 53 TF=(FS(JRT,INP2)/SIGMA)**.25                                     WT        79
    TF15=TF**1.5                                                     WT        80
    RK1=2.*EMI*SIGMA*TF15                                            WT        81
 54 QRH=RK1*(TF15*TF-TW15*TW)                                        WT        82
    DQRH=-2.5*RK1*TW15                                               WT        83
C ********************  HOT SIDE CONVECTION  ************************* WT      84
    IF (XU.GE.XUINJ(NU)) GO TO 71                                    WT        85
    GO TO (70,75), KW                                                WT        86
 70 QCH=-GI(JH)*CP*(TW-FS(JT,INP1))                                  WT        87
    DQCH=-GI(JH)*CP                                                  WT        88
    GO TO 80                                                         WT        89
 75 QCH=GE(JH)*CP*(FS(JT,INP1)-TW)                                   WT        90
    DQCH=-GE(JH)*CP                                                  WT        91
    GO TO 80                                                         WT        92
C --------  ENTRAINMENT NOT COMPLETE                                  WT        93
 71 IF (INDX) 63,63,64                                               WT        94
 63 XDIST2=XDIST(KW)+RLIP(KW)                                        WT        95
    XDIST2=AMAX1(XDIST2,.001)                                        WT        96
    RE1=CDEN*CVEL*XDIST2/VISCO(CTEM)                                 WT        97
    RK2=.0268*CDEN*CP*CVEL/RE1**0.2                                  WT        98
 64 QCH=RK2*(TUINJ(NU)-TW)                                           WT        99
    DQCH=-RK2                                                        WT       100
 80 CONTINUE                                                         WT       101
C *************  NEWTON RAPHSON SOLUTION PROCEDURE  ****************** WT      102
    FT=QRH*RO(1)+QCH*RO(2)-QRC*RO(3)-QCC*RO(4)                       WT       103
    DFT=DQRH*RO(1)+DQCH*RO(2)-DQRC*RO(3)-DQCC*RO(4)                  WT       104
    TWO=TW                                                           WT       105
    TW=TWO-FT/DFT                                                    WT       106
    INDX=INDX+1                                                      WT       107
C   ------------ PRINTOUT FOR NON-CONVERGENCE                        WT       108
    IF (INDX.LT.20) GO TO 89                                         WT       109
    LAB(1)=6HWTERP                                                   WT       110
    LAB(2)=6H                                                        WT       111
    RNDX=ISTEP                                                       WT       112
    WRITE (6,105) LAB,RNDX,RK1,RK2,RK3,RK4,QRH,QCH,QRC,QCC           WT       113
    WRITE (6,105) LAB,DQRH,DQCH,DQRC,DQCC                            WT       114
    WRITE (6,105) LAB,FT,DFT,TW,TWO                                  WT       115
105 FORMAT (1H ,A6,A2,1P11E11.3/(9X,11E11.3))                        WT       116
    GO TO 110                                                        WT       117
C -------- ERROR TEST --------                                       WT       118
 89 IF (ABS(TW-TWO).GT.0.001*ABS(TW)) GO TO 181                      WT       119
C ----- COMPUTE NEW COOLANT TEMP -----                               WT       120
    DT=(QRC*RO(3)+QCC*RO(4))*DXOLD*R(I)/FLO/CP                       WT       121
    CVEL=CVEL*(1.+DT/CTEM)                                           WT       122
    CTEM=CTEM+DT                                                     WT       123
C ----------    UPDATE ANNULUS OR SLOT CONDITIONS     ------------   WT       124
    IF (XU.GE.XLUINJ(NU)) GO TO 100                                  WT       125
 99 VELA(KW)=CVEL                                                    WT       126
    TAN(KW)=CTEM                                                     WT       127
    GO TO 110                                                        WT       128
100 IF (XU.GE.XUINJ(NU)) GO TO 99                                    WT       129
    UINJ(NU)=CVEL                                                    WT       130
    TUINJ(NU)=CTEM                                                   WT       131
110 CONTINUE                                                         WT       132
    IF (KB.EQ.2) RETURN                                              WT       133
    FS(JT,I)=TW                                                      WT       134
    HPI=0.                                                           WT       135
    DO 203 JJ=1,NSPP                                                 WT       136
    J=JLOC(JJ)                                                       WT       137
203 HPI=HPI+F(J,I)*HOR(TW,JJ)                                        WT       138
    F(JN,I)=HPI+FS(JN2,I)*HOR(TW,17)                                 WT       139
```

```
   SUBROUTINE WTEMP      73/74   OPT=0 TRACE                    FTN 4.6+439       08/24/79  13.44.16       PAGE     3

     155                RETURN                                                     WT         140
                        END                                                        WT         141


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM
     131    I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

```
      SUBROUTINE STRIDE(ISW)
      COMMON/COMA/A(43),AJE(16),AJI(16),B(43),C(43),CSALFA,D(43),
     1 DPDS(43),DX,EMU(43),F(16,43),FS(3,43),IAX,IBND,IFIN,IMOE(16),
     2 IMCI(16),IOUT,ISTEP,ITEST,[illegible]
     3 MD2,MF,MOVE,MP1,MP2,MP3,OM(43),[illegible],P(43),PET,PS(16),
     4 PREF(16),PSIE,PSII,R(43),[illegible]
     5 TAVE,TAUI,U(43),[illegible]
     6 [illegible],SUM1,SUM2,SUM3,SUM4,[illegible]
     7 SE(16),SI(16),XLOC(12),[illegible]
     8 [illegible]
     9 EMI,SIGMA,CP,[illegible]
C/-------------------  SUBROUTINE FOR PROGRAM [illegible]  ----------------
C/ THIS SUBROUTINE PERFORMS THE SAME OPERATIONS AS THE ONE IN [illegible]
C   BUT MORE ECONOMICALLY. THE A,B,C ARRAYS ARE [illegible]. SOME
C   OFTEN USED FUNCTIONS OF CP ARE STORED, AND A [illegible] ARRAY SAVES
C   UNNECESSARY ARITHMETIC IN THE TIME OPERATION.
C------------------------------------------------------------------------
      DIMENSION [illegible](43),[illegible](43),[illegible](43),[illegible](43)
      DIMENSION [illegible](43),[illegible](43)
      DIMENSION [illegible](16),[illegible](16),[illegible](16)
      DIMENSION [illegible](16)
      DATA [illegible]
C
      GO TO (1000,2000,3000,4000), ISW
C
C***************************************  S T R I D E  ****************
 1000 IF(ISTEP) 1003,1003,1100
 1003 [illegible]
      [illegible]
      DO 1002 I=2,MP2
      [illegible]
      [illegible]
      [illegible]
 1002 [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      IF([illegible]) GO TO 1100
      DO 1001 I=1,MP3
 1001 [illegible]
      [illegible]
      [illegible]
      IF(ITEST.NE.0) WRITE([illegible]
C-------------------------  [illegible]  ------------------
 1100 DO 1101 I=1,MP3
      [illegible] GO TO 1101
      WRITE(6,1108) [illegible]
 1108 FORMAT([illegible] ********** [illegible] AT [illegible]
     1 [illegible] ******* STRIDE[illegible]
      [illegible]
 1101 [illegible]
      [illegible]
      [illegible]
      DO 1102 I=2,MP1
 1102 [illegible]
      IF(ITEST.NE.0) WRITE([illegible]
C-------------------------  [illegible]  ------------------
C   -----------------------------------  [illegible] PLANE GEOMETRY
      [illegible]
      [illegible]
      [illegible]
      DO 1103 [illegible]
 1103 [illegible]
      [illegible]
      [illegible]
      [illegible]
      [illegible]
      IF([illegible]) RETURN
C   ------------------------  [illegible] GEOMETRY
      IF(CSALFA.[illegible]) GO TO 1120
C   -----------------------------------  [illegible]
      [illegible]
      IF([illegible]) GO TO 1105
C-------------------------------------------  [illegible]
      DO 1106 I=2,MP3
      [illegible]
```

```
      1106 R(I)=Y(I)*CSALFA                                               ST      70
           YI=SQRT(ABS(YI/COSD2))                                         ST      71
           YN15=SQRT(ABS(YN15/COSD2))                                     ST      72
           GO TO 1107                                                     ST      73
     C ------------------------------------------ R(1) NE 0.              ST      74
      1105 R1D2=.5*R(1)                                                   ST      75
           R1D2SQ=R1D2*R1D2                                               ST      76
           DO 1104 I=2,NP3                                                ST      77
           Y(I)=Y(I)/(R1D2+SQRT(ABS(R1D2SQ+COSD2*Y(I))))                  ST      78
      1104 R(I)=R(1)+Y(I)*CSALFA                                          ST      79
           YI=YI/(R1D2+SQRT(ABS(R1D2SQ+COSD2*YI)))                        ST      80
           YN15=YN15/(R1D2+SQRT(ABS(R1D2SQ+COSD2*YN15)))                  ST      81
      1107 R25=R(1)+YI*CSALFA                                             ST      82
           RN15=R(1)+YN15*CSALFA                                          ST      83
           YE=Y(NP3)-YN15                                                 ST      84
           RETURN                                                         ST      85
     C ------------------------------------------ CSALFA EQ ZERO          ST      86
      1110 DO 1111 I=2,NP3                                                ST      87
           Y(I)=Y(I)/R(1)                                                 ST      88
      1111 R(I)=R(1)                                                      ST      89
           YI=YI/R(1)                                                     ST      90
           YN15=YN15/R(1)                                                 ST      91
           R25=R(1)                                                       ST      92
           RN15=R(1)                                                      ST      93
           YE=Y(NP3)-YN15                                                 ST      94
           RETURN                                                         ST      95
     C*************************************  S T R I D E 2  ************* ST      96
     C ------------------------------- PRELIMINARIES FOR COEFFICIENTS     ST      97
      2000 EVAPI=0.                                                       ST      98
           DO 2660 I=2,NPZ                                                ST      99
           HLPE(I)=0.                                                     ST     100
      2660 EVAPI=EVAPI+EVAP(I)                                            ST     101
           PX=PEI/DX                                                      ST     102
           PD8=.125*PX                                                    ST     103
           PD4=PD8+PD8                                                    ST     104
           G=PMI-PME                                                      ST     105
           APMI=ABS(PMI)                                                  ST     106
           APME=ABS(PME)                                                  ST     107
           GD4=.25*G                                                      ST     108
           G=G+EVAPI                                                      ST     109
           PG=PX*G                                                        ST     110
           PG08=.125*PG                                                   ST     111
           PG04=PG08+PG08                                                 ST     112
           PPID2=.5*PMI                                                   ST     113
           DO 2004 I=2,NPZ                                                ST     114
           DO 2670 K=2,NPZ                                                ST     115
           IF (K-I) 2671,2672,2672                                        ST     116
      2671 HLPE(K)=HLPE(K)-.25*EVAP(I)*OMEGM(K)                           ST     117
           GO TO 2670                                                     ST     118
      2672 HLPE(K)=HLPE(K)+.25*EVAP(I)*(2.-OMEGM(K))                      ST     119
      2670 CONTINUE                                                       ST     120
           PBOM(I)=PX*BOM(I)                                              ST     121
      2004 PGOM(I)=PG04*OMD(I)                                            ST     122
           P4OPP=PG4*BOP(2)                                               ST     123
     C ------------------------------------------ GRID POINT 2            ST     124
     C----------------------------------------- TAUI, BPI, T1             ST     125
           IF(KIN.NE.1) GO TO 2001                                        ST     126
           CALL WF(0,1,BPI,T1,TAUI)                                       ST     127
           GO TO 2002                                                     ST     128
      2001 T1=0.                                                          ST     129
           IF(NRAD.EQ.0) BPI=.33333+.66667*PU(1)/PU(2)                    ST     130
           IF(NRAD.EQ.1) BPI=(R(1)*(5.*PU(1)+PU(2))+3.*R25*               ST     131
          1                   (PU(1)+PU(2)))/6./(R(1)+R25)/PU(2)          ST     132
      2002 DO 2700 J=1,NF                                                 ST     133
           IF (ISOLVE(J).EQ.0) GO TO 2700                                 ST     134
           IF (KIN.NE.1) GO TO 2705                                       ST     135
           CALL WF (J,1,FDIFI(J),TIFF(J),SI(J))                           ST     136
           IF (INDI(J).EQ.2) GO TO 2700                                   ST     137
           AJI(J)=CI(J)*(F(J,1)-.5*(F(J,2)+F(J,3))-FDIFI(J))              ST     138
           GO TO 2700                                                     ST     139
      2705 TIFF(J)=0.                                                     ST     140
           FDIFI(J)=0.                                                    ST     141
      2700 CONTINUE                                                       ST     142
     C ------------------------------------------ GRID POINT NPZ          ST     143
     C----------------------------------------- TAUE, BPE, TNP3           ST     144
      2304 IF(KEX.NE.1) GO TO 2003                                        ST     145
           CALL WF(3,NP3,BPE,TNP3,TAUE)                                   ST     146
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      GO TO 2310                                                       ST        147
 2003 TMP3=0.                                                          ST        148
      IF(NRAD.EQ.0) BPE=.33333+.66667*RU(NP3)/RU(NP1)                  ST        149
      IF(NRAD.EQ.1) BPE=(R(NP3)*(5.*RU(NP3)+RU(NP1))+3.*RN15*          ST        150
     1                (RU(NP3)+RU(NP1)))/6./(R(NP3)+ RN15)/RU(NP1)     ST        151
 2310 DO 2720 J=1,NF                                                   ST        152
      IF (ISOLVE(J).EQ.0) GO TO 2720                                   ST        153
      IF (KEX.NE.1) GO TO 2730                                         ST        154
      CALL WF(J,NP3,FDIFE(J),TMP3FF(J),GE(J))                          ST        155
      IF (IMODE(J).EQ.2) GO TO 2720                                    ST        156
      AJE(J)=GE(J)*(.5*(F(J,NP2)+F(J,NP1))+FDIFE(J)-F(J,NP3))          ST        157
      GO TO 2720                                                       ST        158
 2730 TMP3FF(J)=0.                                                     ST        159
      FDIFE(J)=0.                                                      ST        160
 2720 CONTINUE                                                         ST        161
      RETURN                                                           ST        162
C*************************************   S T R I D E 3   **************** ST        163
 3000 CALL SOURCE(0)                                                   ST        164
C     ----------------------   BOUNDARY COEFFICIENTS FOR VELOCITY      ST        165
C     ---------   GRID POINT 2 COEFFICIENTS    -------------           ST        166
      AKASU=KASU                                                       ST        167
      HLP=RMID2-GD4*OMPOM(2)+HLPE(2)                                   ST        168
      AMLP=ABS(HLP)                                                    ST        169
      THLP=HLP+HLP                                                     ST        170
      THLPT(2)=THLP                                                    ST        171
      TP=EM U(2)                                                       ST        172
      TTP=TP+AMLP+ABS(TP-AMLP)                                         ST        173
      A(2)=TTP-THLP-T1-PGOM(2)*AKASU                                   ST        174
      B(2)=2.*T1+DMI+ARMI                                              ST        175
      C(2)=P4OMP*(3.*U(2)+U(3))+2.*SU(2)                               ST        176
      IF (KASU.EQ.0) C(2)=4.*P4OMP*U(2)+2.*SU(2)                       ST        177
      D(2)=A(2)+B(2)+PBOM(2)-2.*SD(2)                                  ST        178
C     -------    GRID POINT NP2 COEFFICIENTS      ------------         ST        179
      HLM=RMID2-GD4*OMPOM(NP1)+HLPE(NP1)                               ST        180
      AMLM=ABS(HLM)                                                    ST        181
      THLP=HLM+HLM                                                     ST        182
      THLPT(NP2)=THLP                                                  ST        183
      TM=EM U(NP1)                                                     ST        184
      TTM=TM+AMLM+ABS(TM-AMLM)                                         ST        185
      P4OMM=PD4*POP(NP2)                                               ST        186
      A(NP2)=2.*TMP3-BME+ABME                                          ST        187
      B(NP2)=TTM+THLM-TMP3-PGOM(NP1)*AKASU                             ST        188
      C(NP2)=P4OMM*(3.*U(NP2)+U(NP1))+2.*SU(NP2)                       ST        189
      IF (KASU.EQ.0) C(NP2)=4.*P4OMM*U(NP2)+2.*SU(NP2)                 ST        190
      D(NP2)=A(NP2)+B(NP2)+PBOM(NP2)-2.*SD(NP2)                        ST        191
C     -------      MID-STREAM COEFFICIENTS     ----------              ST        192
      DO 3005 I=3,NP1                                                  ST        193
      THLM=THLP                                                        ST        194
      HLP=RMID2-GD4*OMPOM(I)+HLPE(I)                                   ST        195
      THLP=HLP+HLP                                                     ST        196
      THLPT(I)=THLP                                                    ST        197
      AMLP=ABS(HLP)                                                    ST        198
      AMLPT(I)=AMLP                                                    ST        199
      TTM=TTP                                                          ST        200
      TP=EP U(I)                                                       ST        201
      TTP=TP+AMLP+ABS(TP-AMLP)                                         ST        202
      A(I)=TTP-THLP-PGOM(I)*AKASU                                      ST        203
      B(I)=TTM+THLM-PGOM(I-1)*AKASU                                    ST        204
      C(I)=PD4*(BOPT3(I)*U(I)+POP(I)*U(I+1)+POP(I-1)*U(I-1))+2.*SU(I)  ST        205
      IF (KASU.EQ.0) C(I)=4.*PD4*BTP(I)*U(I)+2.*SU(I)                  ST        206
      D(I)=A(I)+B(I)+PBOP(I)-2.*SD(I)                                  ST        207
 3005 CONTINUE                                                         ST        208
      GO TO (3021,3020), NOVEL                                         ST        209
 3020 IF(ITEST) 3900,3905,3905                                         ST        210
 3900 WRITE(6,3901) (A(I),I=2,NP2)                                     ST        211
      WRITE(6,3902) (B(I),I=2,NP2)                                     ST        212
      WRITE(6,3903) (C(I),I=2,NP2)                                     ST        213
      WRITE(6,3904) (D(I),I=2,NP2)                                     ST        214
 3901 FORMAT(7H  A(I) ,1P11E11.3/(7X,11E11.3))                         ST        215
 3902 FORMAT(7H  B(I) ,1P11E11.3/(7X,11E11.3))                         ST        216
 3903 FORMAT(7H  C(I) ,1P11E11.3/(7X,11E11.3))                         ST        217
 3904 FORMAT(7H  D(I) ,1P11E11.3/(7X,11E11.3))                         ST        218
 3905 CONTINUE                                                         ST        219
C-----------------------                          ---------------- ST        220
      IF(KIN.EQ.2.AND.RU(1).NE.0.) U(1)=U(1)-DPDY(1)*DX/RU(1)          ST        221
      IF(KEX.EQ.2.AND.RU(NP3).NE.0.) U(NP3)=U(NP3)-DPDX(NP3)*DX/RU(NP3) ST       222
C-----------------------    SOLVE FOR DOWNSTREAM U 'S   ------------ ST        223
```

```
      B(2)=(B(2)*U(1)+C(2))/D(2)                                       ST     224
      A(2)=A(2)/D(2)                                                   ST     225
      DO 3048 I=3,NP2                                                  ST     226
      T=D(I)-B(I)*A(I-1)                                               ST     227
      A(I)=A(I)/T                                                      ST     228
 3048 B(I)=(B(I)*B(I-1)+C(I))/T                                        ST     229
      DO 3050 IDASH=2,NP2                                              ST     230
      I=NP4-IDASH                                                      ST     231
      U(I)=A(I)*U(I+1)+B(I)                                            ST     232
C     ------------------------------------ TEST FOR NEGATIVE U'S       ST     233
C/IUTRAP=0,NO ACTION/ .GT.0,SET TO 1.E-30/ .GT.1,IFIN=-1/ .GT.2,ITEST=1/ ST    234
      IF(IUTRAP.EQ.0.OR.I.EQ.2.OR.I.EQ.NP2) GO TO 3050                 ST     235
      IF(U(I)) 3046,3046,3050                                          ST     236
 3046 J=ISTEP+1                                                        ST     237
      WRITE(6,3047) U(I),I,J                                           ST     238
 3047 FORMAT(25H ********** U (LE ZERO) =,1PE10.3,5H AT I=,I3,         ST     239
     1 8H, ISTEP=,I6,34H, SET U TO 1.E-30 ******** STRIDE3)            ST     240
      U(I)=1.E-30                                                      ST     241
      IFIN=-IUTRAP/2                                                   ST     242
      ITEST=IUTRAP/3                                                   ST     243
 3050 CONTINUE                                                         ST     244
C     ---------------------------------------------------------        ST     245
      IF(NIN.EQ.3) U(1)=.5*(U(2)+U(3))                                 ST     246
      IF(NEX.EQ.3)U(NP3)=.5*(U(NP1)+U(NP2))                            ST     247
 3021 IF (ITEST) 3011,3014,3011                                        ST     248
 3011 WRITE(6,3012) (U(I),I=1,NP3)                                     ST     249
 3012 FORMAT(3H U ,6X,1P11E11.3/(9X,11E11.3))                          ST     250
C     ---------------------------------------------------              ST     251
C     -----------------   SOLVE FOR DOWN STREAM F'S   ---------------- ST     252
 3014 DO 3321 J=1,NF                                                   ST     253
      IF (ISOLVE(J).EQ.0) GO TO 3321                                   ST     254
      AKAS=FLOAT(IKAS(J))                                              ST     255
C     -------   COMPUTE SOURCE TERMS   ---------                       ST     256
      CALL SOURCE(J)                                                   ST     257
C     --------  GRID POINT 2   --------                                ST     258
      TP=EM U(2)                                                       ST     259
      TPF2=TP/PREF(J)                                                  ST     260
      THLP=THLPT(2)                                                    ST     261
      AHLP=.5*ABS(THLP)                                                ST     262
      TTPF(J)=TPF2+AHLP+ABS(TPF2-AHLP)                                 ST     263
      TIF=TIFF(J)                                                      ST     264
      IF (KIN.NE.1) GO TO 2302                                         ST     265
      IF(INDI(J).EQ.2) GO TO 2303                                      ST     266
CC    -------------   EDGE VALUE SPECIFIED   -----------               ST     267
 2302 A(2)=TTPF(J)-THLP-TIF-(PGOM(2)-.5*SD(2))*AKAS                    ST     268
      B(2)=2.*TIF+RPI+ARPI                                             ST     269
      C(2)=A(2)+B(2)+PBOM(2)-2.*SD(2)                                  ST     270
      IF (J.NE.JVT) GO TO 510                                          ST     271
      RP=.5*(R(2)+R(3))                                                ST     272
      ATP=2.*(RP/R(3))**2                                              ST     273
      AT1=(R(1)/RP)**2                                                 ST     274
      DTP=2.*(RP/(.75*R(2)+.25*R(3)))**2                               ST     275
      A(2)=TTPF(J)*ATP-THLP-TIF*AT1-(PGOM(2)-.5*SD(2))*AKAS            ST     276
      TT=3.*PGOM(2)-1.5*SD(2)                                          ST     277
      IF (IKAS(J).EQ.0) TT=4.*PGOM(2)-2.*SD(2)                         ST     278
      D(2)=TTPF(J)*DTP+TIF+THLP+TT                                     ST     279
  510 T=-TIF*FDIFI(J)                                                  ST     280
      GO TO 2305                                                       ST     281
C     --------------   EDGE FLUX SPECIFIED   -----------               ST     282
 2303 A(2)=TTPF(J)-THLP-(PGOM(2)-.5*SD(2))*AKAS                        ST     283
      B(2)=0.                                                          ST     284
      D(2)=A(2)+PBOM(2)-2.*SD(2)+2*I*2.                                ST     285
      T=RMI*F(J,1)+AJI(J)*R(1)                                         ST     286
 2305 TT=3.*F(J,2)-F(J,3)                                              ST     287
      IF (IKAS(J).EQ.0) TT=4.*F(J,2)                                   ST     288
      C(2)=P4OPP*TT+2.*(T+SU(2))                                       ST     289
 2306 CONTINUE                                                         ST     290
C     ---------   GRID POINT NP2   -------                             ST     291
      TM=EM U(NP1)                                                     ST     292
      TMF=TM/PREF(J)                                                   ST     293
      THLM=THLPT(NP2)                                                  ST     294
      AHLM=.5*ABS(THLM)                                                ST     295
      TTMF=TMF+AHLM+ABS(TMF-AHLM)                                      ST     296
      TMP3F=TMP3FF(J)                                                  ST     297
      IF (KEX.NE.1) GO TO 2312                                         ST     298
      IF(INDE(J).EQ.2) GO TO 2313                                      ST     299
C     ---------------   EDGE VALUE SPECIFIED   --------                ST     300
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      2312 A(NP2)=2.*TNP3F-PRE+ARME
           B(NP2)=TTMF+THLM-TNP3F-(PGOM(NP1)-.5*SD(NP2))*AKAS
           D(NP2)=A(NP2)+B(NP2)+PBOM(NP2)-2.*SD(NP2)
           IF (J.NE.JVT) GO TO 520
           RM=.5*(R(NP2)+R(NP1))
           BTM=2.*(RM/R(NP1))**2
           BTNP3=(R(NP3)/RM)**2
           DTM=2.*(RM/(.75*R(NP2)+.25*R(NP1)))**2
           B(NP2)=TTMF*BTM+THLM-TNP3F*BTNP3-(PGOM(NP1)-.5*SD(NP2))*AKAS
           TT=3.*PGOM(NP1)-1.5*SD(NP2)
           IF (IKAS(J).EQ.0) TT=4.*PGOM(NP1)-2.*SD(NP2)
           D(NP2)=TTMF*DTM+TNP3F-THLM*TT
       520 T=-TNP3F*FDIFE(J)
           GO TO 2315
     C -----------     EDGE FLUX SPECIFIED   ---------
      2313 A(NP2)=0.
           B(NP2)=TTMF+THLM-(PGOM(NP1)-.5*SD(NP2))*AKAS
           D(NP2)=B(NP2)+PBOM(NP2)-2.*SD(NP2)-PME*2.
           T=-PME*F(J,NP3)-AJE(J)*R(NP3)
      2315 TT=3.*F(J,NP2)+F(J,NP1)
           IF (IKAS(J).EQ.0) TT=4.*F(J,NP2)
           C(NP2)=P4OMP*TT+2.*(T+SU(NP2))
      2320 CONTINUE
     C -------  MID-STREAM COEFFICIENTS    ---------
           DO 3002 I=3,NP1
           TTMF=TTPF(J)
           TPF=EM U(I)/PREF(J)
           TTPF(J)=TPF+AMLPT(I)+ABS(TPF-AMLPT(I))
           IF (J.EQ.JVT) GO TO 3015
           A(I)=TTPF(J)-THLPT(I)-PGOM(I)*AKAS
           B(I)=TTMF+THLPT(I-1)-PGOM(I-1)*AKAS
           D(I)=A(I)+B(I)+PBOM(I)-2.*SD(I)
           GO TO 2999
     C     -------------
      3015 RP=.5*(R(I)+R(I+1))
           RM=.5*(R(I)+R(I-1))
           RMM=R(I-1)
           IF (I.EQ.3) RMM=.75*R(2)+.25*R(3)
           RPP=R(I+1)
           IF (I.EQ.NP1) RPP=.75*R(NP2)+.25*R(NP1)
           ATP=2.*(RP/RPP)**2
           BTM=2.*(RM/RMM)**2
           DTP=2.*(RP/R(I))**2
           DTM=2.*(RM/R(I))**2
           A(I)=TTPF(J)*ATP-THLPT(I)-PGOM(I)*AKAS
           B(I)=TTMF*BTM+THLPT(I-1)-PGOM(I-1)*AKAS
           TT=PGD4*BOMT3(I)
           IF (IKAS(J).EQ.0) TT=4.*PGD4*POP(I)
           D(I)=TTPF(J)*DTP+TTMF*DTM+THLPT(I)-THLPT(I-1)+TT-2.*SD(I)
      2999 TT=BOMT3(I)*F(J,I)+OMC(I)*F(J,I+1)+OMD(I-1)*F(J,I-1)
           IF (IKAS(J).EQ.0) TT=4.*POM(I)*F(J,I)
      3002 C(I)=PD4*TT+2.*SU(I)
           IF(ITEST) 3906,3907,3906
      3906 WRITE(6,3901) (A(I),I=2,NP2)
           WRITE(6,3902) (B(I),I=2,NP2)
           WRITE(6,3903) (C(I),I=2,NP2)
           WRITE(6,3904) (D(I),I=2,NP2)
      3907 CONTINUE
     C     --------------------------------------
           B(2)=(B(2)*F(J,1)+C(2))/D(2)
           A(2)=A(2)/D(2)
           DO 3148 I=3,NP2
           T=D(I)-B(I)*A(I-1)
           A(I)=A(I)/T
      3148 B(I)=(B(I)*B(I-1)+C(I))/T
           DO 3150 IDASH=2,NP2
           I=N+4-IDASH
      3150 F(J,I)=A(I)*F(J,I+1)+B(I)
     C-------------------------------    ADJUST F(J,1) AND F(J,NP3)   ------------
           GO TO (3210,3220,3230),KIN
      3210 IF(INDI(J).EQ.2) F(J,1)=FDIFI(J)*.5*(F(J,2)+F(J,3))+AJI(J)/GI(J)
           GO TO 3220
      3230 F(J,1)=.5*(F(J,2)+F(J,3))
      3220 GO TO (3310,3320,3330),KEX
      3310 IF(INDE(J).EQ.2) F(J,NP3)=FDIFE(J)*.5*(F(J,NP2)+
          1                                 F(J,NP1))-AJE(J)/GE(J)
           GO TO 3320
```

```
                 3330 F(J,MP3)=.5*(F(J,MP1)+F(J,MP2))                              ST         378
                 3320 IF(ITEST) 3322,3321,3322                                     ST         379
                 3322 WRITE(6,3323) J,(F(J,I),I=1,MP3)                             ST         380
                 3323 FORMAT(5H F, J=,I3,1P11E11.3/(8X,11E11.3))                   ST         381
  390            3321 CONTINUE                                                     ST         382
                 3040 XU=XD                                                        ST         383
                      PSII=PSII-RMI*DX                                             ST         384
                      PSIE=PSIE-RME*DX                                             ST         385
                      PSIE=PSIE+EVAPI*DX                                           ST         386
  395                 PEI=PSIE-PSII                                                ST         387
                      IF (ISTEP.GE.IOUT) GO TO 3710                                ST         388
                      IF (KEX.NE.2) GO TO 3700                                     ST         389
                      SUM2=SUM2-RME*DX                                             ST         390
                      GO TO 3710                                                   ST         391
  400            3700 IF (KEX.NE.1) GO TO 3710                                     ST         392
                      SUM4=SUM4-RME*DX                                             ST         393
                 3710 IF (ISTEP.GE.IEND) GO TO 3750                                ST         394
                      IF (KIN.NE.2) GO TO 3740                                     ST         395
                      SUM1=SUM1+RMI*DX                                             ST         396
  405                 GO TO 3750                                                   ST         397
                 3740 IF (KIN.NE.1) GO TO 3750                                     ST         398
                      SUM3=SUM3+RMI*DX                                             ST         399
                 3750 CONTINUE                                                     ST         400
                      ISTEP=ISTEP+1                                                ST         401
  410                 RETURN                                                       ST         402
                C***************************  S T R I D E 4  **************/**********ST    403
                 4000 CONTINUE                                                     ST         404
                      M2=M/2                                                       ST         405
                      MP1=M+1                                                      ST         406
  415                 MP2=M+2                                                      ST         407
                      MP3=M+3                                                      ST         408
                      DP(1)=0.                                                     ST         409
                      DP(MP3)=1.                                                   ST         410
                      ISTEP=0                                                      ST         411
  420                 IEND=10000                                                   ST         412
                      IAX=10000                                                    ST         413
                      IOUT=10000                                                   ST         414
                      DX=1.E-30                                                    ST         415
                      IFIN=0                                                       ST         416
  425                 KIN=1                                                        ST         417
                      KEX=1                                                        ST         418
                      RETURN                                                       ST         419
                 7010 FORMAT(1H ,1P11E11.3)                                        ST         420
                      END                                                          ST         421


CARD NO. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     217     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     376     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     382     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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SUBROUTINE WF          73/74    OPT=0 TRACE                      FTN 4.6+439         08/24/78  13.44.16          PAGE     1

                 SUBROUTINE WF(J,I1,OUT1,OUT2,OUT3)                                        WF            2
                 COMMON/COMA/A(43),AJE(16),AJI(16),B(43),C(43),CSALFA,D(43),               COMA          2
                1 DPDX(43),DX,EMU(43),F(16,43),FS(3,43),IAX,IEND,IFIN,INDE(16),            COMA          3
                2 INDI(16),IOUT,ISTEP,ITEST,IUTRAP,JS,JSW,JV,JY,KEX,KIN,KRAD,N,             COMA          4
                3 NDZ,NF,NOVEL,NP1,NP2,NP3,OM(43),OMO(43),P(43),PEI,PR(16),                 COMA          5
                4 PREF(16),PSIE,PSII,R(43),RHO(43),RU(43),RME,RMI,SD(43),SU(43),            COMA          6
                5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSREL(43),RDY(43),ISOLVE(16),           COMA          7
                6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PRESCN,FDIFI(16),FDIFE(16),            COMA          8
                7 GE(16),GI(15),JLOC(12),W(12),JN,JFM,JCO2,JCO,JOX,JH2O,JOH,JO,JNS,         COMA          9
                8 JH2,JH,JNO,JN2,JVT,JD,JF,JT,JRV,NSP,NSPM,ARSNP,SCATR,SOP(200),             COMA         10
                9 EMI,SIGMA,CP,JFUOX,IFLUX,EVAP(43),TFUEL,RFMZ                              COMA         11
                 COMMON/COMB/AK,ALNG,EWALL,FR,H,HFU,INERT,MASSTR,MODEL,PRESS,              COMB          2
                1 UBAR,UFAC,C1,C2,CD,C2VT,ARFAC,ALFAC,ARCOM1,ARCOM2,PREXP1,CD75,           COMB          3
                2 PREXP2,CR1,CR2,PODER,RHOCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,           COMB          4
                3 CX,HY,DXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                             COMB          5
                4 WH2,WN,WNO,WN2                                                           COMB          6
           C/-------- SUBROUTINE FOR PROGRAM GENMIX 6A                                     WF            5
           C/---------------- D.B.SPALDING, IMPERIAL COLLEGE, 1972 ---------------         WF            6
           C                                                                               WF            7
           C      EFFECTS OF PRESSURE GRADIENT AND MASS TRANSFER ARE INCLUDED              WF            8
           C      EFFECTS OF RADIUS VARIATION ARE NEGLECTED                                WF            9
           C      FOR VELOCITY,     OUT1=RP,     OUT2=T,   OUT3=TAU                        WF           10
           C      FOR F'S,          OUT1=FIDIF,  OUT2=T,   OUT3=G                          WF           11
           C                                                                               WF           12
                 DATA SHALF/.04/, BPLAST/.9/                                               WF           13
                 INT=I/I1                                                                  WF           14
                 I2=I1-1+2*INT                                                             WF           15
                 I3=I1-2+4*INT                                                             WF           16
                 I25=I3-INT                                                                WF           17
                 IF(J) 100,100,200                                                         WF           18
           C ------------------------------------------------  VELOCITY                    WF           19
             100 UREF=.5*(U(I2)+U(I3))                                                     WF           20
                 RHOREF=.5*RHO(I1)+.25*(RHO(I2)+RHO(I3))                                   WF           21
                 RUREF=RHOREF*UREF                                                         WF           22
                 RREF=.5*(R(I2)+R(I3))                                                     WF           23
                 VREF=EMU(I1)                                                              WF           24
                 YREF=YI+(YE-YI)*OM(I1)                                                    WF           25
                 RE=UREF*RHOREF*YREF/VREF                                                  WF           26
                 RRUREF=RREF*RUREF                                                         WF           27
                 AM=(RMI-(RME+RMI)*OM(I1))/RRUREF                                          WF           28
                 EF=YREF*DPDX(I1)/RUREF/UREF                                               WF           29
                 IF(MODEL.EQ.1) GO TO 110                                                  WF           30
                 IF(RE.LT.132.25) GO TO 110                                                WF           31
           C---------------------------------------------------EXTENDED LOG LAW            WF           32
                 EP=RE*EWALL                                                               WF           33
                 NIT=0                                                                     WF           34
             101 SHALFI=SHALF                                                              WF           35
                 S=SHALF**2                                                                WF           36
                 SLOC=S+AM+EF                                                              WF           37
                 IF(SLOC.GT.0.) GO TO 104                                                  WF           38
                 SLOC=1.E-30                                                               WF           39
                 SHALF=SQRT(ABS(AM+EF))                                                    WF           40
             104 BEE=SQRT(SLOC)/AK                                                         WF           41
                 ARG=EP*(SHALF+(AM/(1.+BEE)+.5*EF)/SHALF)                                  WF           42
                 IF(ARG.GT.11.5*EWALL) GO TO 106                                           WF           43
                 GO TO 110                                                                 WF           44
             106 SHALF=AK/ALOG(ARG)                                                        WF           45
                 IF(ABS(SHALF-SHALFI).LT..0001.OR.NIT.GT.10) GO TO 102                     WF           46
                 NIT=NIT+1                                                                 WF           47
                 GO TO 101                                                                 WF           48
             102 S=SHALF**2                                                                WF           49
                 SAV=.5*(SHALF**2+SLOC)                                                    WF           50
                 OUT1=1./(1.+BEE)                                                          WF           51
                 EP U(I25)=.25*RHOREF*RREF*ABS(U(I3)-U(I2))*(AK/OUT1)**2                   WF           52
                 GO TO 103                                                                 WF           53
           C ------------------------------------------------  LAMINAR FLOW                WF           54
             110 AMRE=AM*RE                                                                WF           55
                 FRE=EF*RE                                                                 WF           56
                 IF(ABS(AMRE).LT..01) GO TO 111                                            WF           57
                 AMRE=AMAX1(-50.,AMIN1(50.,AMRE))                                          WF           58
                 EXPMRE=EXP(AMRE)                                                          WF           59
                 STORE=EXPMRE-1.-AMRE                                                      WF           60
                 AMRESQ=AMRE*AMRE                                                          WF           61
                 SRE=AMRE*(1.-STORE*FRE/AMRESQ)/(EXPMRE-1.)                                WF           62
                 OUT1=SRE+STORE/AMRESQ+FRE*(STORE-.5*AMRESQ)/(AMRESQ*AMRE)                 WF           63
                 GO TO 112                                                                 WF           64
             111 SRE=(2.-FRE*(1.+AMRE/3.))/(2.+AMRE)                                       WF           65
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      OUT1=SPE*(.5+AMRE/6.)+F*F*(.16567+AMRE/24.)                       WF        66
  112 IF(SRE.GT.1.E-30) GO TO 113                                       WF        67
      SRE=1.E-30                                                        WF        68
      OUT1=.33333                                                       WF        69
  113 S=SRE/RE                                                          WF        70
      F= U(I25)=VREF*RREF/ABS(Y(I3)-Y(I2))                              WF        71
  103 OUT2=S*RRUREF                                                     WF        72
      OUT3=OUT2*UREF/R(I1)                                              WF        73
C     ---------- UNDER-RELAX OUT1.                                      WF        74
      OUT1=.1*OUT1+.9*BPLAST                                            WF        75
      BPLAST=OUT1                                                       WF        76
      RETURN                                                            WF        77
C----------------  STAGNATION ENTHALPY, FIEL. DX-FU/DXDFU                WF        78
  200 IF(RE.LT.132.25) GO TO 210                                        WF        79
      IF(MODEL.EQ.1) GO TO 210                                          WF        80
      IF (ARG.LE.11.5*EWALL) GO TO 210                                  WF        81
      PRRAT=PR(J)/PREF(J)                                               WF        82
      PJAY=9.*(PRRAT-1.)/PRRAT**.25                                     WF        83
      S=SAV/PREF(J)/(1.+AMAX1(-.99999,PJAY*SQRT(ABS(SAV))))             WF        84
      OUT1=0.                                                           WF        85
      IF (J.EQ.JH) OUT1=(H-1.)*.5*UREF**2                               WF        86
      OUT2=S*RRUREF                                                     WF        87
      IF (J.EQ.JK) OUT2=0.                                              WF        88
      OUT3=OUT2/R(I1)                                                   WF        89
      RETURN                                                            WF        90
  210 IF(ABS(AMRE).LT..01) GO TO 211                                    WF        91
      S=AM/(EXP(PR(J)*AMRE)-1.)                                         WF        92
      GO TO 212                                                         WF        93
  211 S=1./PR(J)/RE/(1.+.5*PR(J)*AMRE)                                  WF        94
  212 OUT1=0.                                                           WF        95
      IF (J.EQ.JH) OUT1=(PR(J)-1.)*.5*UREF**2                           WF        96
      OUT2=S*RRUREF                                                     WF        97
      IF (J.EQ.JK) OUT2=0.                                              WF        98
      OUT3=OUT2/R(I1)                                                   WF        99
      RETURN                                                            WF       100
      END                                                               WF       101
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      SUBROUTINE PLOTS (X,IDIM,IMAX,XAXIS,Y,JDIM,JMAX,YAXES,SYMBOL)      PL       2
C*****14.5.72*********************************************************** PL       3
C                                                                     * PL       4
C   SUBROUTINE FOR PLOTTING J CURVES OF Y(J,I) AGAINST X(I).           PL       5
C                                                                     * PL       6
C   X AND Y ARE ASSUMED TO BE IN ANY RANGE EXCEPT THAT NEGATIVE VALUES * PL       7
C    ARE PLOTTED AS ZERO.                                             * PL       8
C   X AND Y ARE SCALED TO THE RANGE 0. TO 1. BY DIVISION BY THE MAXIMA, * PL     9
C    WHICH ARE ALSO PRINTED.                                          * PL      10
C   IDIM IS THE VARIABLE DIMENSION FOR X.                             * PL      11
C   IMAX IS THE NUMBER OF X VALUES.                                   * PL      12
C   XAXIS STORES THE NAME OF THE X-AXIS.                              * PL      13
C   JDIM IS THE VARIABLE DIMENSION FOR Y.                             * PL      14
C   JMAX IS THE NUMBER OF CURVES TO BE PLOTTED, (UP TO 10).           * PL      15
C   THE ARRAY YAXES(J) STORES THE NAMES OF THE CURVES.                * PL      16
C   THE ARRAY SYMBOL(J) STORES THE SINGLE CHARACTERS USED FOR PLOTTING. * PL    17
C                                                                     * PL      18
C*********************************************************************** PL      19
      DIMENSION X(IDIM),Y(JDIM,IDIM),YAXES(JDIM,2),SYMBOL(JDIM),         PL      20
     1 A(101),YMAX(10)                                                   PL      21
      DATA  DOT,CROSS,BLANK/1H.,1H+,1H /                                 PL      22
C*****  SCALING X ARRAY TO THE RANGE 0 TO 50                             PL      23
      XMAX=1.E-30                                                        PL      24
      DO 1 I=1,IMAX                                                      PL      25
    1 IF(X(I).GT.XMAX) XMAX=X(I)                                         PL      26
      DO 2 I=1,IMAX                                                      PL      27
      X(I)=X(I)/XMAX*50.                                                 PL      28
    2 IF(X(I).LT.0.) X(I)=0.                                             PL      29
C*****  SCALING Y ARRAY TO THE RANGE 0 TO 100                            PL      30
      DO 3 J=1,JMAX                                                      PL      31
      YMAX(J)=1.E-30                                                     PL      32
      DO 4 I=1,IMAX                                                      PL      33
    4 IF(Y(J,I).GT.YMAX(J)) YMAX(J)=Y(J,I)                               PL      34
      DO 3 I=1,IMAX                                                      PL      35
      Y(J,I)=Y(J,I)/YMAX(J)*100.                                         PL      36
    3 IF(Y(J,I).LT.0.) Y(J,I)=0.                                         PL      37
C*****  IDENTIFYING THE VARIOUS CURVES TO BE PLOTTED                     PL      38
      WRITE(6,103) XAXIS,XMAX                                            PL      39
      WRITE(6,100)((YAXES(I,J),J=1,2),I=1,JMAX)                          PL      40
      WRITE(6,106) (SYMBOL(I),I=1,JMAX)                                  PL      41
      WRITE(6,102) (YMAX(I),I=1,JMAX)                                    PL      42
      DO 5 I=1,11                                                        PL      43
    5 A(I)=0.1*FLOAT(I-1)                                                PL      44
      WRITE(6,101) (A(I),I=1,11)                                         PL      45
C*****  MAIN LOOP.  EACH PASS PRODUCES AN X-CONSTANT LINE.               PL      46
      DO 40 I=1,51                                                       PL      47
      IF(I.EQ.1.OR.I.EQ.51) GO TO 32                                     PL      48
      GO TO 33                                                           PL      49
C*****  ALLOCATE . OR + AS MARKED ON THE Y-AXIS                          PL      50
   32 DO 30 K=1,101                                                      PL      51
   30 A(K)=DOT                                                           PL      52
      DO 31 K=11,101,10                                                  PL      53
   31 A(K)=CROSS                                                         PL      54
C*****  ALLOCATE . OR + MARK ON THE X-AXIS, ALSO THE APPROPRIATE X VALUE PL      55
   33 A(1)=DOT                                                           PL      56
      A(101)=DOT                                                         PL      57
      K=I-1                                                              PL      58
   46 K=K-5                                                              PL      59
      IF(K)48,47,46                                                      PL      60
   47 A(1)=CROSS                                                         PL      61
      A(101)=CROSS                                                       PL      62
   48 XL=0.02*FLOAT(I-1)                                                 PL      63
C*****  CHECK IF ANY Y( X(I) ) VALUE LIES ON THIS X-CONSTANT LINE        PL      64
C*****  IF YES GO TO 41, OTHERWISE GO TO 43                              PL      65
      DO 43 K=1,IMAX                                                     PL      66
      IF(IFIX(X(K)+1.5)-I) 43,41,43                                      PL      67
C*****  LOCATE  Y(  X(I)  )                                              PL      68
   41 DO 44 J=1,JMAX                                                     PL      69
      NY=Y(J,K)+1.5                                                      PL      70
      A(NY)=SYMBOL(J)                                                    PL      71
   44 CONTINUE                                                           PL      72
      GO TO 42                                                           PL      73
   43 CONTINUE                                                           PL      74
C*****  PRINT X-CONSTANT LINE                                            PL      75
   42 WRITE(6,105) XL,(A(K),K=1,101),XL                                  PL      76
C*****  PUTTING BLANKS INTO X-CONSTANT LINE                              PL      77
      DO 49 K=1,101                                                      PL      78
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SUBROUTINE PLOTS      73/74   OPT=0 TRACE                      FTN 4.6+439        08/24/78  13.44.16        PAGE    2

             49 A(K)=BLANK                                                          PL        79
             40 CONTINUE                                                            PL        80
                DO 50 I=1,11                                                        PL        81
             50 A(I)=.1*FLOAT(I-1)                                                  PL        82
                WRITE(6,104) (A(I),I=1,11)                                          PL        83
                RETURN                                                              PL        84
            100 FORMAT(11H Y-AXES ARE,5X,10(1X,A6,A4))                              PL        85
            101 FORMAT(1H0,2X,11F10.1)                                              PL        86
            102 FORMAT(15H MAXIMUM VALUES,1P10E11.3)                                PL        87
            103 FORMAT(11H0X-AXIS IS ,A8,17H ,MAXIMUM VALUE =,1PE10.3)              PL        88
            104 FORMAT (3X,11F10.1)                                                 PL        89
            105 FORMAT(2H I,F6.2,3X,101A1,F6.2)                                     PL        90
            106 FORMAT(7H SYMBOL,11X,10(1X,A10))                                    PL        91
                END                                                                 PL        92
```

APPENDIX E

LISTING OF TRANSITION MIXING MODEL

```
PROGRAM MAIN       73/74   OPT=0 TRACE                FTN 4.6+439       08/24/79  10.30.04        PAGE     1

              PROGRAM MAIN (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)                 MA         2
      C                                                                            MA         3
      C       ******************************************************************  MA         4
      C       ******************************************************************* MA         5
      C       ****************** COMBUSTOR DESIGN CRITERIA ********************   MA         6
      C       TRANSITION MIXING MODEL,                                             MA         7
      C                                                                            MA         8
      C                                                                            MA         9
      C       ------------------------------------------------------------------- MA        10
      CHAPTER0000000000000000000  PRELIMINARIES  000000000000000000000000000000000 MA        11
      C       ---------------------------- DIMENSIONS AND COMMON BLOCKS.          MA        12
             COMMON/COMA/A(43),AJE(7),AJI(7),B(43),C(43),CSALFA,D(43),DPDX(43),   COMA       2
            1 DX,EMU(43),F(7,43),FS(5,43),IAX,IEND,IFIN,INJE(7),INDI(7),IOUT,     COMA       3
            2 ISTEP,ITEST,IUTRAP,JS,JSW,JV,JT,KEX,KIN,KRAD,N,NO2,NF,NOVEL,NP1,    COMA       4
            3 NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(7),PREF(7),PSIE,PSII,R(43),     COMA       5
            4 RHO(43),RME,RMI,RU(43),SD(43),SU(43),TAUE,TAUI,U(43),XD,XU,         COMA       6
            5 Y(43),YE,YI,PSWRL(43),RDY(43),ISOLVE(7),US(43),AMU(43),             COMA       7
            5 DZ(43),DZOLD(43),ZUI,ZUE,ZDI,ZDE,DPDOX(43),                         COMA       8
            6 JH,JFU,JFUOX,JCO,JVT,JK,JD,JOX,JT,JN2,JH2O,JCO2                     COMA       9
             COMMON/COMB/AK,ALMG,EWALL,FR,H,HFU,INERT,MASSTR,MODEL,PRESS,         COMB       2
            1 UBAR,UFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,      COMB       3
            2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4              COMB       4
             COMMON/COMC/ARE(40),ZRE(40),XRE(40),ARI(40),ZRI(40),XRI(40),         COMC       2
            1 NBP,NRCVI,NRCVE,ZSI(30),ZSE(30),RCVI(30),RCVE(30)                   COMC       3
             DIMENSION TITLE(24),OUT(43),LAB(2)                                   MA        16
             DIMENSION XPLOT(43),YPLOT(10,43),YAXES(10,2),SYMBOL(10)              MA        17
             DIMENSION FLUX(7),DFI(7),DFE(7),AJID(7),AJED(7)                      MA        18
             DIMENSION YIN(40),UIN(40),VTIN(40),TIN(40),MFUIN(40),MCOIN(40)       MA        19
             DIMENSION TKIN(40),TLIN(40),MCO2IN(40)                               MA        20
             DIMENSION IPLOT(12),IPRNT(12),SYM(12),LAB1(12),LAB2(12)              MA        21
             REAL MFUIN,MCOIN,MCO2IN,LAB,LAB1,LAB2                                MA        22
             NAMELIST/INPUT/IUTRAP,ULIM,PEILIM,AFAC,AEXDLM,POWER,NOVEL,           MA        23
            1 ARCON1,PREXP1,CR1,ARCON2,PREXP2,CR2,CP,IDPDX,C1,C2,CD,              MA        24
            2 C2VT,AKFAC,ALFAC,PREF,CX,HY,HFU,MODER,ITHIN,KREAD                   MA        25
             DATA JH,JFU,JFUOX,JCO,JVT,JK,JD/1,2,3,4,5,6,7/                       MA        26
             DATA JOX,JT,JN2,JH2O,JCO2/1,2,3,4,5/                                 MA        27
             DATA IPLOT/0,1,0,1,1,0,0,1,1,0,0,0/                                  MA        28
             DATA SYM/1HE,1HF,1HP,1HC,1HV,1HK,1HD,1HO,1HT,1HN,1HH,1HB/            MA        29
             DATA LAB1/6HENTH  ,6HFUEL  ,6HPHI   ,6HCO    ,6HVT    ,6HKE    ,     MA        30
            1 6HLEN SC,6HOXYGEN,6HTEMP  ,6HN2    ,6HH2O   ,6HCO2   /              MA        31
             DATA LAB2/2H  ,2H  ,2H  ,2H  ,2H  ,2H  ,2H  ,2H  ,2H  ,2H  ,         MA        32
            1     2H  ,2H  /                                                      MA        33
             DATA WOX,WCO2,WCO,WH2O,WN2/32.,44.,28.,18.,28./                      MA        34
      C                                                                            MA        35
             READ(5,1) TITLE                                                      MA        36
           1 FORMAT(12A6)                                                         MA        37
      C                                                                            MA        38
      C       ------------------------------------------------------------------- MA        39
      CHAPTER11111111111111111111  PARAMETERS AND CONTROL INDICES  11111111111111 MA        40
             READ (5,2) N,KRAD,MASSTR,ISWRL,MODEL,INERT,IFLUX,ITEMP               MA        41
           2 FORMAT (8(I2,8X))                                                    MA        42
             READ (5,3) NSTAT,NPROF,NPLOT,ITEST,LASTEP                            MA        43
           3 FORMAT (8(I5,5X))                                                    MA        44
             IUTRAP=2                                                             MA        45
             ULIM=.05                                                             MA        46
             PEILIM=.01                                                           MA        47
             AFAC=.2                                                              MA        48
             AEXDLM=.02                                                           MA        49
             IDPDX=1                                                              MA        50
             H=.9                                                                 MA        51
             AK=.435                                                              MA        52
             ALMG=.09                                                             MA        53
             FR=.033                                                              MA        54
             UFAC=.01                                                             MA        55
             NOVEL=2                                                              MA        56
             ITHIN=1                                                              MA        57
             KREAD=0                                                              MA        58
      C                                                                            MA        59
      C       ------------------------------------------------------------------- MA        60
      CHAPTER22222222222222222222222  GRID AND GEOMETRY  2222222222222222222222  MA        61
             READ (5,4) ZUI,ZUE,ZULAST,FRA,ZEND,ZOUT,PRESS,POWER                  MA        62
             READ (5,2) NBP,ICURV,NRCVI,NRCVE                                     MA        63
             READ (5,4) (ARI(I),XRI(I),I=1,NBP)                                   MA        64
             READ (5,4) (ARE(I),XRE(I),I=1,NBP)                                   MA        65
             IF (ICURV) 11,11,12                                                  MA        66
          12 READ (5,4) (ZSI(I),RCVI(I),I=1,NRCVI)                                MA        67
             READ (5,4) (ZSE(I),RCVE(I),I=1,NRCVE)                                MA        68
```

```
   14 FORMAT (6E12.6)
C  -------  CALCULATE Z-VALUES
   11 DO 15 I=2,NBP
      DELR=ARI(I)-ARI(I-1)
      DELX=XRI(I)-XRI(I-1)
      ZRI(I)=SQRT(DELR**2+DELX**2)
      DELR=ARE(I)-ARE(I-1)
      DELX=XRE(I)-XRE(I-1)
   15 ZRE(I)=SQRT(DELR**2+DELX**2)
      ZRI(1)=0.
      ZRE(1)=0.
      DO 16 I=2,NBP
      ZRI(I)=ZRI(I)+ZRI(I-1)
   16 ZRE(I)=ZRE(I)+ZRE(I-1)
      RI=TAB(ZUI,ZRI,ARI,NBP)
      RE=TAB(ZUE,ZRE,ARE,NBP)
      XI=TAB(ZUI,ZRI,XRI,NBP)
      XE=TAB(ZUE,ZRE,XRE,NBP)
      CSALFA=(RE-RI)/SQRT((RE-RI)**2+(XE-XI)**2)
      READ (5,4) RA,RB,RD
    4 FORMAT (8E10.4)
C     ------ R(1) ADJUSTMENT MADE JUST BEFORE CALL STRIDE(1).
C     ---------STRIDE4------------STRIDE4-----------STRIDE4---------STRIDE4
      CALL STRIDE(4)
      IF (ZEND.EQ.0.) IEND=0
      IF (ZOUT.EQ.0.) IOUT=0
C     ------------------ CHANGE IENS, IAX AND IOUT, IF NECESSARY.
      DO 20 I=2,NP2
   20 Y(I)=(FLOAT(I-2)/FLOAT(N))**POWER
C
C     ------------------------------------------------------------------
CHAPTER333333333333333333333333  DEPENDENT VARIABLES SELECTION  33333333
C
      ISOLVE(1)=ITEMP
      ISOLVE(2)=MASSTR
      ISOLVE(3)=MASSTR
      ISOLVE(4)=MASSTR
      ISOLVE(5)=ISWBL
      ISOLVE(6)=MODEL-1
      ISOLVE(7)=MODEL-1
      NF=7
      NFS=4
      IPRNT(JM)=0
      IPRNT(JFU)=MASSTR
      IPRNT(JFUOX)=MASSTR
      IPRNT(JCO)=MASSTR
      IPRNT(JVT)=ISWBL
      IPRNT(JK)=MODEL-1
      IPRNT(JD)=MODEL-1
      INDX=7
      IPRNT(JOX+INDX)=MASSTR
      IPRNT(JT+INDX)=ITEMP
      IPRNT(JH2+INDX)=0
      IPRNT(JH2O+INDX)=0
      IPRNT(JCO2+INDX)=0
C
C     ------------------------------------------------------------------
CHAPTER4444444444444444444444444444  MATERIAL CONSTANTS  44444444444444
C                                         S.I. UNITS
      GASCON=8314.
      WMIX=28.04
      CP=1255.
      CI=1.0
      NY=4.
      HFU=4.E7
C     ---ARRCON IS ACTIVATION ENERGY DIVIDED BY UNIVERSAL GAS CONSTANT.
      PREXP1=5.E+15
      ARCON1=28500.
      CR1=6.0
      PREXP2=6.4E+8
      ARCON2=12500.
      CR2=6.0
      MODER=2
C
      DO 40 J=1,NF
      PR(J)=.7
      PREF(J)=.86
```

```
   40 IF (MODEL.EQ.1) PREF(J)=PR(J)                                      MA      146
      PREF(JVT)=1.2                                                      MA      147
C  -----    TURBULENCE CONSTANTS    ------ ----                          MA      148
      C1=1.42                                                            MA      149
      C2=1.92                                                            MA      150
      CD=.09                                                             MA      151
      AKFAC=.03                                                          MA      152
      ALFAC=.02                                                          MA      153
      C2VT=0.36                                                          MA      154
      PREF(JK)=1.0                                                       MA      155
C  ---------      NAMELIST    -------                                    MA      156
      READ (5,INPUT)                                                     MA      157
      PREF(JD)=AK**2/(C2-C1)/SQRT(CD)                                    MA      158
      CD75=CD**.75                                                       MA      159
      GAMMA=CP/(CP-GASCON/WMIX)                                          MA      160
      PDGSCN=PRESS*WMIX/GASCON                                           MA      161
      WFU=12.*CX+HY                                                      MA      162
      RATIO1=WOX*(CX+HY/4.)/WFU                                          MA      163
      RATIO2=.232                                                        MA      164
      RATIO3=WOX*0.5/WCO                                                 MA      165
      RATIO4=WCO*CX/WFU                                                  MA      166
C                                                                        MA      167
C  ------------------------------------------------------------------    MA      168
CHAPTER555555555555555555555555555555555  INITIAL CONDITIONS  5555555555 MA      169
      READ (5,4) UA,UD,VTA,VTD                                           MA      170
      READ (5,4) F2A,F2D,TA,TD,TWALL                                     MA      171
C                                                                        MA      172
      F1A=CP*TA+.5*UA**2+HFU*F2A                                         MA      173
      F1D=CP*TD+.5*UD**2+HFU*F2D                                         MA      174
      F3A=F2A                                                            MA      175
      F3D=F2D                                                            MA      176
      READ (5,2) NIN                                                     MA      177
      READ (5,4) (YIN(I),I=1,NIN)                                        MA      178
      READ (5,4) (UIN(I),I=1,NIN)                                        MA      179
      READ (5,4) (VTIN(I),I=1,NIN)                                       MA      180
      READ (5,4) (TIN(I),I=1,NIN)                                        MA      181
      READ (5,4) (MFUIN(I),I=1,NIN)                                      MA      182
      READ (5,4) (MCO2IN(I),I=1,NIN)                                     MA      183
      READ (5,4) (MCOIN(I),I=1,NIN)                                      MA      184
      IF (KREAD.EQ.0) GO TO 19                                           MA      185
      READ (5,4) (TKIN(I),I=1,NIN)                                       MA      186
      READ (5,4) (TLIN(I),I=1,NIN)                                       MA      187
   19 CONTINUE                                                           MA      188
      DY=SQRT((RE-RI)**2+(XE-XI)**2)                                     MA      189
      Y(1)=0.0                                                           MA      190
      Y(NP3)=1.0                                                         MA      191
      DO 55 I=1,NP3                                                      MA      192
   55 Y(I)=Y(I)*DY                                                       MA      193
C                                                                        MA      194
      DO 400 I=1,NP3                                                     MA      195
      U(I)=TAB(Y(I),YIN,UIN,NIN)                                         MA      196
      F(JFU,I)=TAB(Y(I),YIN,MFUIN,NIN)                                   MA      197
      FS(JCO2,I)=TAB(Y(I),YIN,MCO2IN,NIN)                                MA      198
      F(JCO,I)=TAB(Y(I),YIN,MCOIN,NIN)                                   MA      199
      F(JVT,I)=TAB(Y(I),YIN,VTIN,NIN)                                    MA      200
      FS(JT,I)=TAB(Y(I),YIN,TIN,NIN)                                     MA      201
      IF (KREAD.EQ.0) GO TO 400                                          MA      202
      F(JK,I)=TAB(Y(I),YIN,TKIN,NIN)                                     MA      203
      F(JD,I)=CD*F(JK,I)**1.5/(TAB(Y(I),YIN,TLIN,NIN)+1.E-20)            MA      204
  400 CONTINUE                                                           MA      205
C                                                                        MA      206
      DO 410 I=1,NP3                                                     MA      207
      DPDX(I)=0.0                                                        MA      208
      DZOLD(I)=0.                                                        MA      209
      R(I)=RI+Y(I)*CSALFA+1.E-30                                         MA      210
      F(JH,I)=CP*FS(JT,I)+.5*U(I)*U(I)+HFU*F(JFU,I)                      MA      211
      FUB=(FS(JCO2,I)+WCO2*F(JCO,I)/WCO)*WFU/(WCO2*CX)                   MA      212
      F(JFUOX,I)=F(JFU,I)+FUB                                            MA      213
      FS(JOX,I)=RATIO1*F(JFU,I)+RATIO3*F(JCO,I)+RATIO2-(RATIO2+RATIO1)   MA      214
     1  *F(JFUOX,I)                                                      MA      215
      FS(JCO2,I)=WCO2*CX*FUB/WFU-WCO2*F(JCO,I)/WCO                       MA      216
      FS(JH2O,I)=HY*WH2O*FUB/WFU/2.                                      MA      217
      FS(JN2,I)=1.-F(JFU,I)-FS(JCO2,I)-F(JCO,I)-FS(JOX,I)-FS(JH2O,I)     MA      218
      IF (KREAD.EQ.1) GO TO 410                                          MA      219
      F(JK,I)=AKFAC*U(I)*U(I)                                            MA      220
      ALM=ALFAC*(Y(NP3)-Y(1))                                            MA      221
      IF (IOUT.NE.0) ALM=AMIN1(ALM,ALFAC*Y(I))                           MA      222
```

```
      ALM=AMAX1(ALM,Y(NP3)/100.)
      F(JO,I)=CD*F(JK,I)**1.5/ALM
  410 CONTINUE
C
      ALM=ALFAC*Y(NP3)
      DO 52 I=1,NP3
      P(I)=PRESS
      PSWRL(I)=0.
      RII=R(I)
      IF (I.EQ.2) RII=.75*R(2)+.25*R(3)
      IF (I.EQ.NP2) RII=.75*R(NP2)+.25*R(NP1)
      F(JVT,I)=RII*F(JVT,I)
      WMIX=F(JFU,I)/WFU+FS(JCO2,I)/WCO2+F(JCO,I)/WCO+FS(JOX,I)/WOX+
     1     FS(JH2O,I)/WH2O+FS(JN2,I)/WN2
      RHO(I)=PRESS/FS(JT,I)/GASCON/WMIX
      IF (I.EQ.1) GO TO 52
      AFLO=.5*(R(I)**2-R(I-1)**2)
      IF (KRAD.EQ.0) AFLO=Y(I)-Y(I-1)
      DM(I)=.5*(RHO(I)*U(I)+RHO(I-1)*U(I-1))*AFLO
   52 CONTINUE
      DO 53 I=2,NP3
   53 DM(I)=DM(I-1)+DM(I)
      FLOTOT=DM(NP3)
      DO 51 I=1,NP3
   51 DM(I)=DM(I)/FLOTOT
C
      WMIX=F2A/WFU+(1.-F2A)*.03448
      ROA=PRESS/TA/GASCON/WMIX
      FLOA=ROA*UA*.5*R0**2
      PSII=FLOA
      PEI=FLOTOT
      PSIE=PSII+PEI
C
C     ---------------------------------------------------------------
CHAPTER$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$  THERMODYNAMIC PROPERTIES  $$$$$$
C    ********************  START OF MAIN LOOP  ********************
   60 CONTINUE
C
C     ---------------------------------------------- TEST 1
      IF(ITEST) 602,601,602
  602 LAB(1)=6HTEST 1
      LAB(2)=6H
      WRITE(6,100) LAB,P(1),PRESS,BX,PSII,PSIE,PEI,FRA,ULIM,PEILIM,AFAC,
     1              AEIDLM
      LAB(1)=1HU
      LAB(2)=6H
      WRITE(6,100) LAB,(U(I),I=1,NP3)
      LAB(1)=6HF(1,I)
      LAB(2)=6H
      WRITE(6,100) LAB,(F(1,I),I=1,NP3)
      LAB(1)=6HF(2,I)
      LAB(2)=6H
      WRITE(6,100) LAB,(F(2,I),I=1,NP3)
      LAB(1)=6HF(3,I)
      LAB(2)=6H
      WRITE(6,100) LAB,(F(3,I),I=1,NP3)
      LAB(1)=6HF(4,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(4,I),I=1,NP3)
      LAB(1)=6HF(5,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(5,I),I=1,NP3)
      LAB(1)=6HF(6,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(6,I),I=1,NP3)
      LAB(1)=6HF(7,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(7,I),I=1,NP3)
  601 CONTINUE
C
      DO 203 I=1,NP3
  203 P(I)=P(I)+DPDX(I)*DZOLD(I)
      IF(MASSTR.NE.0) GO TO 64
      DO 65 I=1,NP3
      FS(JT,I)=AMAX1(1.,(F(JH,I)-.5*U(I)**2)/CP)
   65 RHO(I)=P(I)*WMIX/FS(JT,I)/GASCON
      GO TO 66
```

```
   64 DO 61 I=1,NP3
      GO TO (606,605), INERT
  605 FUB=F(JFUOX,I)-F(JFU,I)
      FS(JOX,I)=RATIO1*F(JFU,I)+RATIO3*F(JCO,I)+RATIO2-(RATIO2+RATIO1)
     1 *F(JFUOX,I)
      FS(JCO2,I)=WCO2*CI*FUB/WFU-WCO2*F(JCO,I)/WCO
      FS(JH2O,I)=HY*WH2O*FUB/WFU/2.
  606 FS(JN2,I)=1.-F(JFU,I)-FS(JCO2,I)-F(JCO,I)-FS(JOX,I)-FS(JH2O,I)
      ENTH=F(JH,I)-.5*U(I)*U(I)-HFU*F(JFU,I)
      FS(JT,I)=AMAX1(ENTH/CP,100.)
      WMIX=F(JFU,I)/WFU+FS(JCO2,I)/WCO2+F(JCO,I)/WCO+FS(JOX,I)/WOX+
     1  FS(JH2O,I)/WH2O+FS(JN2,I)/WN2
   61 RHO(I)=P(I)/FS(JT,I)/WMIX/GASCON
   66 CONTINUE
      RHO(2)=RHO(1)
      RHO(NP2)=RHO(NP3)
C     ------------------------------------------------------------ TEST 2
      IF(ITEST) 604,603,604
  604 LAB(1)=6HTEST 2
      LAB(2)=6H
      WRITE(6,100) LAB,PRESS,DX,DPDDX,PDGSCH
      LAB(1)=6HFS(1,I
      LAB(2)=1H)
      WRITE(6,100) LAB,(FS(1,I),I=1,NP3)
      LAB(1)=6HFS(2,I
      LAB(2)=1H)
      WRITE(6,100) LAB,(FS(2,I),I=1,NP3)
      LAB(1)=6HFS(3,I
      LAB(2)=1H)
      WRITE(6,100) LAB,(FS(3,I),I=1,NP3)
      LAB(1)=6HRHO(I)
      LAB(2)=6H
      WRITE(6,100) LAB,(RHO(I),I=1,NP3)
  603 CONTINUE
C     ---------------------------------------- ADJUST R(1)
      IF (KIN.EQ.2.AND.KRAD.EQ.1) R(1)=RA+SQRT(ABS(2.*PSI1/(RHO(1)*
     1                                                        U(1))))
C
      RI=TAB(ZUI,ZRI,ARI,NRP)
      RE=TAB(ZUE,ZRE,ARE,NRP)
      XI=TAB(ZUI,ZRI,XRI,NRP)
      XE=TAB(ZUE,ZRE,XRE,NRP)
      CSALFA=(RE-RI)/SQRT((RE-RI)**2+(XE-XI)**2)
      IF (KIN.EQ.1.AND.KRAD.EQ.1) R(1)=RI
C     -----------STRIDE1------------STRIDE1-----------STRIDE1---------STRIDE1
      CALL STRIDE(1)
C
C     ------------------------------------------------------------------------
CHAPTER77777777777777777777777777777777777777777777  FORWARD STEP  777777777
      I1=NODE(ZUE,ZRE,NRP)
      I2=NODE(ZUI,ZRI,NRP)
      IF (I2-I1) 68,69,68
   68 WRITE (6,67) ISTEP,I2,I1
   67 FORMAT (' **ERROR IN MAIN AT ISTEP=',I4,' I2=',I3,' I1=',I3,' **')
   69 I=AMIN0(I1,I2)
      DFACI=ZRI(I+1)-ZRI(I)
      DFACE=ZRE(I+1)-ZRE(I)
      DMAX=AMAX1(DFACI,DFACE)
      DFACI=DFACI/DMAX
      DFACE=DFACE/DMAX
      ISIFIX=0
C
      DZM=FRACT(NP3)
      IF (ISTEP.LT.50) DZM=.1*DZM
C
      DLI=ZRI(I+1)-ZUI
      DLE=ZRE(I+1)-ZUE
      IF (DZM*DFACI.LE.DLI.AND.DZM*DFACE.LE.DLE) GO TO 79
      RAT=(ZRE(I+2)-ZRE(I+1))/(ZRI(I+2)-ZRI(I+1))
      DFAC=(DLE+RAT*(DZM-DLI))/DZM
      IF (DFAC.GT.1.0) GO TO 78
      DFACI=1.0
      DFACE=DFAC
      GO TO 72
   78 DFAC=(DLI+(DZM-DLE)/RAT)/DZM
      IF (DFAC.GT.1.0) GO TO 79
      DFACE=1.0
```

```
      DFACI=DFAC
   72 IDZFIX=1
   79 IF (ISTEP.GE.IEND) GO TO 70
      IF (DZM*DFACI.LT.ZEND-ZUI) GO TO 70
      DZM=(ZEND-ZUI)/DFACI
      IDZFIX=1
      IEND=ISTEP+1
   70 IF (ISTEP.GE.IOUT) GO TO 71
      IF (DZM*DFACE.LT.ZOUT-ZUE) GO TO 71
      DZM=(ZOUT-ZUE)/DFACE
      IDZFIX=1
      IOUT=ISTEP+1
   71 IF (DZM*DFACE.LT.ZULAST-ZUE) GO TO 77
      DZM=(ZULAST-ZUE)/DFACE
      IDZFIX=1
   77 IF (DZM.GT.1.E-10) GO TO 73
      IFIN=1
      GO TO 1011
   73 DZMIN=.005*FRA*Y(NP3)
      DYFAC=(DFACE-DFACI)/(Y(NP3)-Y(1))
      DO 76 I=1,NP3
      DZOLD(I)=AMAX1(DZMIN,DZ(I))
   76 DZ(I)=DZM*(DFACI+DYFAC*(Y(I)-Y(1)))
      DZ(2)=DZ(1)
      DZ(NP2)=DZ(NP3)
      ZUI=ZUI+DZ(1)
      ZUE=ZUE+DZ(NP3)
C ----  FURTHER ADJUSTMENTS TO DZ ARE MADE IN CHAPTERS 8 AND 9.
C
C ------------------------------------------------------------------------
CHAPTER8888888888888888888888888  ADJUST LONGITUDINAL CONDITIONS  888888
C
C     CHAPTER8A ----------------------------------BOUNDARY CONDITIONS
C     ---------------- I BOUNDARY
      IF(ISTEP-IAB) 8000,80,84
 8000 IF(ISTEP-IEND) 8052,83,84
C     ---------------------------- WALL
 8052 KIN=1
      U(1)=0.
      RPI=0.
      IF(ISTEP.EQ.0) TAUI=0.
      EWALL=0.
      DO 81 J=1,4
      INDI(J)=2
   81 AJI(J)=0.
      DO 74 J=5,7
      INDI(J)=1
   74 F(J,1)=0.0
      IF (IFLUX.EQ.0) GO TO 84
      INDI(JH)=1
      FS(JT,1)=TWALL
      F(JH,1)=CP*TWALL+FLOAT(PASSTR)*HFU*F(JFU,1)
      GO TO 84
C     ------------------------- FREE
   83 KIN=2
      TAUI=0.
      U(1)=UA
      RU(1)=RHO(1)*U(1)
      F(JH,1)=F1A
      F(JFU,1)=F2A
      F(JFUOX,1)=F3A
      F(JCO,1)=0.0
      F(JVT,1)=R(1)*VTA
      F(JK,1)=AKFAC*UA*UA
      F(JD,1)=CD*F(JK,1)**1.5/ALM
      GO TO 84
C     --------------------- SYMMETRY AXIS
   80 KIN=3
      RPI=0.
      R(1)=RA
      PSII=0.
      TAUI=0.
C     --------------------- E BOUNDARY
   84 IF(ISTEP-IOUT) 8004,85,85
C     --------------------- WALL
 8004 KEX=1
      U(NP3)=0.
```

```
      RME=0.
      IF(ISTEP.EQ.0) TAUE=0.
      EWALL=0.
      DO 82 J=1,4
      IMOE(J)=2
   82 AJE(J)=0.
      DO 75 J=5,7
      IMOE(J)=1
   75 F(J,NP3)=0.0
      IF (IFLUX.EQ.0) GO TO 86
      IMOE(JM)=1
      FS(JT,NP3)=TWALL
      F(JH,NP3)=CP*TWALL+FLOAT(MASSTR)*HFU*F(JFU,NP3)
      GO TO 86
C     ----------------------------------------------FREE
   85 KEX=2
      TAUE=0.
      U(NP3)=UD
      RU(NP3)=RHO(NP3)*U(NP3)
      F(JH,NP3)=F1D
      F(JFU,NP3)=F2D
      F(JFUOX,NP3)=F3D
      F(JCO,NP3)=0.0
      F(JUT,NP3)=R(NP3)*UTD
      F(JK,NP3)=0.0
      F(JD,NP3)=0.0
C
C     CHAPTER 88 ---------------------------------- DUCT GEOMETRY
   86 IF(ISTEP.GE.IOUT) GO TO 89
      IF(ISTEP.GT.0) GO TO 87
      ADUD=.5*SQRT((R(NP3)-R(1))**2+(XE-XI)**2)*(R(NP3)+R(1))
      IF (KRAD.EQ.0) ADUD=Y(NP3)
   87 ADUU=ADUD
      AFLU=.5*SQRT((R(NP3)-R(1))**2+(XE-XI)**2)*(R(NP3)+R(1))
      IF (KRAD.EQ.0) AFLU=Y(NP3)
      AEX=AFLU-ADUU
      AEXD=AEX/AFLU
      IF (ABS(AEXD).LT.AEXDLM) GO TO 88
      IF (IDZFIX.EQ.1) GO TO 89
      DZFAC=AEXDLM/ABS(AEXD)
      DO 198 I=1,NP3
  198 DZ(I)=DZ(I)*DZFAC
      ZDI=ZUI+DZ(1)
      ZDE=ZUE+DZ(NP3)
   88 RID=TAB(ZDI,ZRI,ARI,NRP)
      IF (KIN.NE.1.AND.KRAD.EQ.1) RID=R(1)
      RED=TAB(ZDE,ZRE,ARE,NRP)
      XID=TAB(ZDI,ZRI,XRI,NRP)
      XED=TAB(ZDE,ZRE,XRE,NRP)
      ADUD=.5*SQRT((RED-RID)**2+(XED-XID)**2)*(RED+RID)
      IF (KRAD.EQ.0) ADUD=SQRT((RED-RID)**2+(XED-XID)**2)
      DA=(ADUD-ADUU)+AFAC*(ADUU-AFLU)
C
C     CHAPTER 8C ------------------------ SUBSONIC PRESSURE GRADIENT
C     ------------------------UBAR
   89 UBAR=0.
      DO 820 I=2,NP1
  820 UBAR=UBAR+(U(I)+U(I+1))*OMD(I)
      UBAR=.5*UBAR
      IF(KIN.EQ.2) UBAR=(UBAR-UA)*PEI/PSIE+UA
C     --------------------------------SUBSONIC FLOW
  803 IF (ISTEP-IOUT) 822,823,823
  823 DP=0.
      GO TO 824
C     ---------------------------------- CONFINED SUBSONIC FLOW
  822 GO TO (830,835), IDPDX
  835 IF (ISTEP.EQ.0.OR.KIN.EQ.2) GO TO 830
C -----------     GRID FILLING DUCT  VERSION    ----------
      RDUBAR=PEI/ADUU
      ROBAR=RDUBAR/UBAR
      DUDP=-1./(RDUBAR+(TAUE*R(NP3)*DZ(NP3)+TAUI*R(1)*DZ(1))/ADUU/UBAR)
      UDPDDP=RDUBAR/GAMMA/P(NP3)
      DROU=ROBAR*(AFLU/ADUU-1.)
      DPC=DROU/(ROBAR*DUDP+UDPDDP)
      UFAC=DPC*DUDP/UBAR+1.
C -------     ADJUST VELOCITY PRESSURE AND DENSITY PROFILES  -------
      DO 840 I=1,NP3
```

```
      U(I)=U(I)*UFAC                                                    MA       531
      P(I)=P(I)+DPC                                                     MA       532
  540 RHO(I)=RHO(I)*(1.+GAMMA*DPC/P(I))                                 MA       533
C     --------   RECALCULATE DISTANCES    ----------                    MA       534
      CALL STRIDE(1)                                                    MA       535
      DP=DP+DPC                                                         MA       536
      GO TO 824                                                         MA       537
C     ---------------        STANDARD GENMIX VERSION     ----------     MA       538
  830 FLOTOT=PSIE-PSII*FLOAT(I/KIN)                                     MA       539
      DYNHED=UBAR*FLOTOT/AFLU                                           MA       540
      SHRSTR=TAUI*R(I)*DZ(I)+TAUE*R(NP3)*DZ(NP3)                        MA       541
      DP=(DYNHED*DA-SHRSTR*2.*RME*DZ(NP3)*UBAR)/ADUD                    MA       542
  824 CONTINUE                                                          MA       543
C     ---------      2*FLOW AREAS     -------------                     MA       544
      DO 307 I=2,NP2                                                    MA       545
  307 RDY(I)=PEI*(OM(I+1)-OM(I-1))/RHO(I)/U(I)                          MA       546
      GO TO (310,312,312), KIN                                          MA       547
  310 RDY(2)=(R(1)+.5*(R(2)+R(3)))*YI                                   MA       548
      GO TO 313                                                         MA       549
  312 RDY(2)=PEI*OM(3)/RHO(3)/U(3)                                      MA       550
  313 GO TO (314,315,315), KEX                                          MA       551
  314 RDY(NP2)=(R(NP3)+.5*(R(NP2)+R(NP1)))*YE                           MA       552
      GO TO 316                                                         MA       553
  315 RDY(NP2)=PEI*(1.-OM(NP1))/RHO(NP1)/U(NP1)                         MA       554
  316 CONTINUE                                                          MA       555
      RDY(1)=0.0                                                        MA       556
      RDY(NP3)=0.0                                                      MA       557
C     ----------- PRESSURE GRADIENT W/SWIRL AND RADIUS ---------------- MA       558
C     ----------- OF CURVATURE EFFECTS INCLUDED ----------------------- MA       559
      VOR2=(F(JST,NP2)/(.75*R(NP2)+.25*R(NP1))**2)**2                   MA       560
      PALFA=0.5*PEI*CSALFA                                              MA       561
      PD=0.                                                             MA       562
      DPDX(NP2)=0.0                                                     MA       563
      DO 225 JI=3,NP2                                                   MA       564
      I=NP3-JI+1                                                        MA       565
      IF (ISWRL) 226,226,227                                            MA       566
  227 VOR2P1=VOR2                                                       MA       567
      RII=R(I)                                                          MA       568
      IF (I.EQ.2) RII=.75*R(2)+.25*R(3)                                 MA       569
      VOR2=(F(JST,I)/RII**2)**2                                         MA       570
      PD=PD-PALFA*(VOR2/U(I)+VOR2P1/U(I+1))*OMD(I)                      MA       571
  226 IF (ICURV) 228,229,229                                            MA       572
  229 RCV=RCURV(ZUI,ZUE,Y(I),Y(NP3))                                    MA       573
      IF (I.EQ.2) RCV1=RCV                                              MA       574
      IF (I.EQ.NP1) RCV2=RCV                                            MA       575
      ALFA=1.+Y(I)/RCV                                                  MA       576
      IF (RCV.LT.0.) ALFA=1.+(Y(NP3)-Y(I))/ABS(RCV)                     MA       577
      DY=Y(I+1)-Y(I)                                                    MA       578
      PD=PD-RHO(I)*U(I)*U(I)*DY/ALFA/RCV                                MA       579
  228 CONTINUE                                                          MA       580
      IF (ISTEP.GT.0) GO TO 224                                         MA       581
      PSWRL(I)=PD                                                       MA       582
      P(I)=P(I)+PD                                                      MA       583
      IF (I.EQ.2) P(1)=P(2)                                             MA       584
  224 DPDX(I)=(PD-PSWRL(I))/DZOLD(I)                                    MA       585
  225 PSWRL(I)=PD                                                       MA       586
      IF (KEX.EQ.2) GO TO 260                                           MA       587
      DPDXDA=0.                                                         MA       588
      SRDY=0.                                                           MA       589
      DO 250 I=2,NP2                                                    MA       590
      SRDY=SRDY+RDY(I)                                                  MA       591
  250 DPDXDA=DPDXDA+DPDX(I)*DZOLD(I)*RDY(I)                             MA       592
      DP=DP-DPDXDA/SRDY                                                 MA       593
      DO 255 I=2,NP2                                                    MA       594
  255 DPDX(I)=DPDX(I)+DP/DZOLD(I)                                       MA       595
  260 CONTINUE                                                          MA       596
      DPDX(1)=DPDX(2)                                                   MA       597
      DPDX(NP3)=DPDX(NP2)                                               MA       598
C     ---------------------------------------------------- TEST 3       MA       599
  242 IF (ITEST) 802,801,802                                            MA       600
  802 LAB(1)=6HTEST 3                                                   MA       601
      LAB(2)=6H                                                         MA       602
      WRITE(6,100) LAB,UBAR,DYNHED,DF,DA,DPDDX,AEXD,RMI                 MA       603
      WRITE(6,101) LAB,ISTEP,KIN,KEX,IAX,IEND,IOUT                      MA       604
      LAB(1)=4HY(I)                                                     MA       605
      LAB(2)=6H                                                         MA       606
      WRITE(6,100) LAB,(Y(I),I=1,NP3)                                   MA       607
```

```
      LAB(1)=6HR(I)                                                    MA   608
      LAB(2)=6H                                                        MA   609
      WRITE(6,100) LAB,(R(I),I=1,NP3)                                  MA   610
      LAB(1)=5HRU(I)                                                   MA   611
      LAB(2)=6H                                                        MA   612
      WRITE(6,100) LAB,(RU(I),I=1,NP3)                                 MA   613
      LAB(1)=6HDPDX(I                                                  MA   614
      LAB(2)=6H)                                                       MA   615
      WRITE (6,100) LAB,(DPDX(I),I=1,NP3)                              MA   616
      LAB(1)=6HPSWRL(                                                  MA   617
      LAB(2)=6HI)                                                      MA   618
      WRITE (6,100) LAB,(PSWRL(I),I=1,NP3)                             MA   619
  801 CONTINUE                                                         MA   620
C                                                                      MA   621
C -------------------------------------------------------------------- MA   622
CHAPTER 999999999999999999999  TRANSPORT AND ENTRAINMENT PROPERTIES  9999 MA   623
C ----  LAMINAR VISCOSITY ASSUMED TO BE THAT OF AIR  ---------------  MA   624
  900 CONTINUE                                                         MA   625
      DO 98 I=1,NP3                                                    MA   626
      IF (FS(JT,I).GT.567.) GO TO 90                                   MA   627
      EMU(I)=1.808E-5*(FS(JT,I)/294.4)**0.76                           MA   628
      GO TO 98                                                         MA   629
   90 EMU(I)=4.464E-5*SQRT(FS(JT,I)/1111.)                             MA   630
   98 CONTINUE                                                         MA   631
      EMU(2)=EMU(1)                                                    MA   632
      EMU(NP2)=EMU(NP3)                                                MA   633
C     ------------------------------------------------------ TEST 4    MA   634
      IF(ITEST) 902,901,902                                            MA   635
  902 LAB(1)=6HTEST 4                                                  MA   636
      LAB(2)=6H                                                        MA   637
      WRITE(6,103) LAB,RMI,RME,PEI                                     MA   638
      LAB(1)=6HEMU(I)                                                  MA   639
      LAB(2)=6H                                                        MA   640
      WRITE(6,100) LAB,(EMU(I),I=1,NP3)                                MA   641
  901 CONTINUE                                                         MA   642
C                                                                      MA   643
C     ----------AUX----------AUX----------AUX----------AUX----------AUX MA   644
      CALL AUX3(0)                                                     MA   645
C     ------------------------------ ENTRAINMENT CONTROL.              MA   646
      IF(KIN.NE.2) GO TO 94                                            MA   647
      RAT=ABS((U(3)-U(1))/(U(NP3)-U(1)+1.E-30))                        MA   648
      IF(RAT.LT.ULIM) EM U(2)=EM U(2)*RAT/ULIM                         MA   649
      RMI=2.*EM U(2)                                                   MA   650
   94 CONTINUE                                                         MA   651
      IF(KEX.NE.2) GO TO 97                                            MA   652
      RAT=ABS((U(NP1)-U(NP3))/(U(NP3)-U(1)+1.E-30))                    MA   653
      RME=-2.*EM U(NP1)                                                MA   654
      IF(RAT.LT.ULIM) RME=RME*(RAT/ULIM)**2                             MA   655
   97 IF (IDZFIX.EQ.1) GO TO 96                                        MA   656
C     ---------- LIMIT ON INCREMENT IN PEI.                            MA   657
      IF (ABS(RMI)*DZ(1)+ABS(RME)*DZ(NP3).LT.PEI*PEILIM) GO TO 96      MA   658
      DZFAC=PEI*PEILIM/(ABS(RMI)*DZ(1)+ABS(RME)*DZ(NP3))               MA   659
      DO 99 I=1,NP3                                                    MA   660
   99 DZ(I)=DZ(I)*DZFAC                                                MA   661
      ZDI=ZUI+DZ(1)                                                    MA   662
      ZDE=ZUE+DZ(NP3)                                                  MA   663
   96 CONTINUE                                                         MA   664
C     ---------- ADJUSTMENT OF DX TO REACH AXIS.                       MA   665
      IF(KIN.EQ.1) GO TO 95                                            MA   666
      IF(ISTEP.GE.IAX) GO TO 95                                        MA   667
      IF (PSII.GT.RMI*DZ(1).OR.IAX.EQ.ISTEP+1) GO TO 95                MA   668
      RMI=PSII/DZ(1)                                                   MA   669
      IAX=ISTEP+1                                                      MA   670
C                                                                      MA   671
C     ----------STRIDE2----------STRIDE2----------STRIDE2--------STRIDE2 MA   672
   95 CALL STRIDE(2)                                                   MA   673
C                                                                      MA   674
C -------------------------------------------------------------------- MA   675
CHAPTER 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10   OUTPUT   10 10 10 MA   676
 1000 IF(ISTEP.GT.0) GO TO 106                                         MA   677
      WRITE (6,9000)                                                   MA   678
 9000 FORMAT (1H1)                                                     MA   679
CHAPTER 10A  ----------------------------------------  HEADINGS        MA   680
C                                                                      MA   681
      WRITE (6,1013) TITLE,MODEP,IDPDX,MODEL,MASSTR,INERT,KRAD,IFLUX   MA   682
 1013 FORMAT (1H1,12A6/12A6/7H MODEP=,I3,7H IDPDX=,I3,7H MODEL=,I3,    MA   683
     1 8H MASSTR=,I3,7H INERT=,I3,6H KRAD=,I3,7H IFLUX=,I3)            MA   684
```

```
C
      WRITE (6,1010) UA,UD,TA,TD,RA,RB,ZEND,ZOUT,ZULAST,PRESS,
     1 PREXP1,ARCON1,CR1,PREXP2,ARCON2,CR2,VTA,VTD
 1010 FORMAT (1H ,1X,2HUA,8X,2HUD,8X,2HTA,8X,2HTD,8X,2HRA,8X,2HRB,8X,
     1 4HZEND,6X,4HZOUT,6X,6HZULAST,4X,5HPRESS/1H ,1P10E10.3/1H ,
     2 7H PREXP1,4X,6HARCON1,4X,3HCR1,7X,6HPREXP2,4X,6HARCON2,4X,
     3 3HCR2,7X,3HVTA,7X,3HVTD/1X,1P10E10.3)
C
      LAB(1)=5HOMEGA
      LAB(2)=6H
      WRITE(6,100) LAB,(OM(I),I=1,NP3)
      PRESS1=PRESS
      WRITE (6,1003)
 1003 FORMAT (//13X,*INTERNAL BOUNDARY*,27X,*EXTERNAL BOUNDARY*,/13X,
     1  16(1H-),28X,16(1H-)//2(3X,*I*,10X,*X*,11X,*R*,11X,*Z*,5X))
      DO 1004 I=1,NBP
 1004 WRITE (6,1005) I,XRI(I),ARI(I),ZRI(I),I,XRE(I),ARE(I),ZRE(I)
 1005 FORMAT (2(1X,I3,3(1X,E11.4),4X))
      IF (ICURV.EQ.0) GO TO 1009
      WRITE (6,1007)
 1007 FORMAT (//13X,*INTERNAL BOUNDARY*,27X,*EXTERNAL BOUNDARY*,/13X,
     1  16(1H-),28X,16(1H-)//2X,*I*,9X,*Z*,10X,*RCVI*,21X,*I*,9X,*Z*,
     2  16X,*RCVE*)
      NRCV=MAX0(NRCVI,NRCVE)
      DO 1051 I=1,NRCV
      WRITE (6,1054) I,ZSI(I),RCVI(I),I,ZSE(I),RCVE(I)
 1054 FORMAT (1X,I2,2X,E11.4,10X,E11.4,19X,I2,2X,E11.4,10X,E11.4)
 1051 CONTINUE
 1050 FORMAT (1H )
 1009 WRITE (6,1050)
  106 CONTINUE
C     ------------------------------------------------------- TEST 5
      IF(ITEST) 1002,1001,1002
 1002 LAB(1)=6HTEST 5
      LAB(2)=6H
      WRITE(6,100) LAB,RMI,RME,DX
 1001 CONTINUE
C
CHAPTER 108  ------------------------------------ TESTS FOR PRINTOUT
C     ------ IPRINT=0 GIVES NO OUTPUT,  =1 GIVES SINGLE VARIABLES ONLY,
C                 =2 GIVES BOTH SINGLE AND ARRAY (PROFILE) VARIABLES.
 1011 IPRINT=0
      IF (MOD(ISTEP,NSTAT).EQ.0) IPRINT=1
      IF (MOD(ISTEP,NPROF).EQ.0) IPRINT=2
      IF(ISTEP.EQ.IEND.OR.ISTEP.EQ.IAX.OR.ISTEP.EQ.IOUT) IPRINT=2
      IF(ITEST.NE.0.OR.IFIN.NE.0) IPRINT=2
      IF (MOD(ISTEP,NPLOT).EQ.0.AND.ISTEP.GT.0) IPRINT=3
C     ------ THE NEXT STATEMENT PROVIDES A PLOT JUST PRIOR TO TERMINATION
      IF (ZUE.GE.ZULAST.OR.IFIN.NE.0.OR.ISTEP.EQ.LASTEP) IPRINT=3
C
CHAPTER 10C     -----------------------------SINGLE STATION VARIABLES.
      IF(IPRINT.EQ.0) GO TO 110
      PRESSD=P(NP3)/PRESS1-1.
      WRITE (6,1030) ISTEP,IAX,IEND,IOUT,KIN,KEX,DZ(1),DZ(NP3),PSII,
     1 PSIE,RMI,RME,PEI,PRESSD,AEXD
 1030 FORMAT(7H0ISTEP=,I5,5H IAX=,I5,6H IEND=,I5,6H IOUT=,I5,5H KIN=,I2,
     1 5H KEX=,I2,5H DZI=,1PE11.3,5H DZE=,1PE11.3,5H PSII=,E11.3,
     2 6H PSIE=,E11.3/5H RMI=,E11.3,5H RME=,E11.3,5H PEI=,E11.3,
     3 8H PRESSD=,E11.3,6H AEXD=,E11.3)
      WRITE (6,1015) XI,XE,RI,RE,RCVI,RCV2,CSALFA
 1015 FORMAT (4H XI=,1PE11.3,4H XE=,1PE11.3,4H RI=,1PE11.3,4H RE=,
     1 1PE11.3,6H RCVI=,1PE11.3,6H RCVE=,1PE11.3,8H CSALFA=,1PE11.3)
C
C
      UBAR=0.
      DO 1020 J=1,NF
      AJID(J)=0.0
      AJED(J)=0.0
 1020 FLUX(J)=0.
      DO 1021 I=2,NP1
      UBAR=UBAR+OMD(I)*(U(I)+U(I+1))
      DO 1021 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 1021
      FLUX(J)=FLUX(J)+OMD(I)*(F(J,I)+F(J,I+1))
 1021 CONTINUE
      UBAR=.5*UBAR
      UFLUX=PEI*UBAR
```

```
      DO 1022 J=1,NF
 1022 FLUX(J)=.[illegible]*FI*FLUX(J)
C
      UREF=UBAR
      RUREF=PEI/.5/(R(1)+R(NP3))/Y(NP3)
      DO 1023 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 1023
      DFI(J)=FLUX(J)/PEI-F(J,1)
      DFE(J)=DFI(J)+F(J,1)-F(J,NP3)
 1023 CONTINUE
      UFLUX=UFLUX-PSIE*U(NP3)+U(1)*PSII
 1043 FLUX(3)=FLUX(3)-PSIE*F3D+F3A*PSII
 1042 FLUX(2)=FLUX(2)-PSIE*F2D+F2A*PSII
 1041 FLUX(1)=FLUX(1)-PSIE*F1D+F1A*PSII
C
      WRITE (6,1031) ZUI,ZUE,UFLUX,(FLUX(J),J=1,NF)
 1031 FORMAT (5H ZUI=,1PE11.3,5H ZUE=,1PE11.3,7H UFLUX=,E10.3,
     1 9H FLUX(J)=,(7E10.3))
C
      IF(KIN.NE.1) GO TO 1024
      TAUID=TAUI/UREF/RUREF
      DO 1025 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 1025
      AJID(J)=AJI(J)/RUREF/DFI(J)
 1025 CONTINUE
      WRITE(6,1029) KIN,TAUID,(AJID(J),J=1,NF)
 1029 FORMAT (5H KIN=,I2,7H TAUID=,1PE11.3,9H AJID(J)=,7E11.3)
C
 1024 IF(KEX.NE.1) GO TO 1026
      TAUED=TAUE/UREF/RUREF
      DO 1027 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 1027
      AJED(J)=AJE(J)/RUREF/DFE(J)
 1027 CONTINUE
      WRITE(6,1028) KEX,TAUED,(AJED(J),J=1,NF)
 1028 FORMAT (5H KEX=,I2,7H TAUED=,1PE11.3,9H AJED(J)=,7E11.3)
 1026 CONTINUE
C
CHAPTER 100   ---------------------------PROFILES AND OTHER ARRAYS.
      IF(IPRINT.EQ.1) GO TO 110
C
      LAB(1)=6HR1,Y'S
      LAB(2)=6H
      DIV=1.
      DO 1095 I=1,NP3
 1095 OUT(I)=Y(I)/DIV
      WRITE (6,100) LAB,R(1),(OUT(I),I=2,NP2,ITHIN),Y(NP3)
      XAXIS=4HY(I)
      DO 1085 I=1,NP3
 1085 XPLOT(I)=OUT(I)
C
      LAB(1)=1HU
      LAB(2)=6H
      SUB=0.
      DIV=1.
      IF(KIN.EQ.3) SUB=U(NP3)
      IF(KIN.EQ.3) DIV=U(1)+1.E-30
      DO 1094 I=1,NP3
 1094 OUT(I)=(U(I)-SUB)/DIV
      IF (NOVEL.NE.1) WRITE (6,100) LAB,U(1),(OUT(I),I=2,NP2,ITHIN),
     1 U(NP3)
      NV=1
      YAXES(1,1)=6HVELOCI
      YAXES(1,2)=2HTY
      SYMBOL(1)=1HU
      DO 1084 I=1,NP3
 1084 YPLOT(1,I)=OUT(I)
C
      INDX=0
      DO 1080 KV=1,NF
      KVV=KV+INDX
      IF (IPRNT(KVV).EQ.0) GO TO 1080
      LAB(1)=LAB1(KVV)
      LAB(2)=LAB2(KVV)
      DO 1052 I=1,NP3
 1052 OUT(I)=F(KV,I)
      IF (KV.NE.JVT) GO TO 1075
```

```
      VTMAX=0.
      DO 1086 I=2,NP3
      DIV=R(I)
      IF (I.EQ.2) DIV=.75*R(2)+.25*R(3)
      IF (I.EQ.NP2) DIV=.75*R(NP2)+.25*R(NP1)
      OUT(I)=OUT(I)/DIV
 1086 VTMAX=AMAX1(VTMAX,OUT(I))
 1075 IF (KV.NE.JD) GO TO 1076
      DO 1077 I=1,NP3
 1077 OUT(I)=CD*F(JK,I)**1.5/(OUT(I)+1.E-20)
 1076 WRITE (6,100) LAB,F(KV,1),(OUT(I),I=2,NP2,ITHIN),F(KV,NP3)
      IF (IPLOT(KVV).EQ.0) GO TO 1060
      NY=NY+1
      YAXES(NY,1)=LAB1(KVV)
      YAXES(NY,2)=LAB2(KVV)
      SYMBOL(NY)=SYM(KVV)
      DO 1090 I=1,NP3
 1090 YPLOT(NY,I)=OUT(I)
 1060 CONTINUE
C
      INDX=NF
      DO 1180 KV=1,NFS
      KVV=KV+INDX
      IF (IPRNT(KVV).EQ.0) GO TO 1180
      LAB(1)=LAB1(KVV)
      LAB(2)=LAB2(KVV)
      DO 1182 I=1,NP3
 1182 OUT(I)=FS(KV,I)
      WRITE (6,100) LAB,FS(KV,1),(OUT(I),I=2,NP2,ITHIN),FS(KV,NP3)
      IF (IPLOT(KVV).EQ.0) GO TO 1180
      NY=NY+1
      YAXES(NY,1)=LAB1(KVV)
      YAXES(NY,2)=LAB2(KVV)
      SYMBOL(NY)=SYM(KVV)
      DO 1190 I=1,NP3
 1190 YPLOT(NY,I)=OUT(I)
 1180 CONTINUE
C
      LAB(1)=6HPRESS
      IF (ISWRL.EQ.0.AND.ICURV.EQ.0) GO TO 1100
      LAB(2)=6H
      SUB=P(NP3)
      DIV=1.0
      DO 1112 I=1,NP3
 1112 OUT(I)=(P(I)-SUB)/DIV
      WRITE (6,100) LAB,P(1),(OUT(I),I=2,NP2,ITHIN),P(NP3)
 1100 IF (MODEL.NE.2) GO TO 1104
      LAB(1)=6HAMU(I)
      LAB(2)=6H
      WRITE (6,100) LAB,AMU(1),(AMU(I),I=2,NP2,ITHIN),AMU(NP3)
 1104 CONTINUE
      IF(IPRINT.EQ.2) GO TO 110
      WRITE (6,1070) ZUE,ISTEP
 1070 FORMAT (1H ,12HPLOT AT ZUE=,1PE11.3,8H, ISTEP=,I5)
      DO 1071 J=1,NY
      YPLOT(J,2)=YPLOT(J,1)
 1071 YPLOT(J,NP2)=YPLOT(J,NP3)
      CALL PLOTS(XPLOT,43,NP3,XAXIS,YPLOT,10,NY,YAXES,SYMBOL)
C ---------------------------------------------------------------------
CHAPTER 11  11  11  11  11  11  11  11  11  11  11  END OF MAIN LOOP
  110 IF (ISTEP.GE.LASTEP.OR.ZUE.GE.ZULAST.OR.IFIN.NE.0) GO TO 111
C
C     ----------STRIDE3----------STRIDE3----------STRIDE3--------STRIDE3
      CALL STRIDE(3)
      IF(IFIN) 1011,60,111
C
C     -------------------------------------------------- TERMINATION
  111 WRITE (6,112) ISTEP,LASTEP,ZUE,ZULAST,IFIN
  112 FORMAT(23H TERMINATED WITH ISTEP=,I5,8H LASTEP=,I5,
     1 5H ZUE=,1PE11.3,8H ZULAST=,E11.3,6H IFIN=,I3)
C ---------------------------------------------------------------------
  120 CONTINUE
      STOP
  100 FORMAT (1H0,A6,A2,1P11E11.3/(9X,11E11.3))
  101 FORMAT (1H0,A6,A2,11I11)
      END
```

```
                PROGRAM MAIN        73/74    OPT=0 TRACE                      FTN 4.6+439        08/24/78  10.3C.04        PAGE    13
CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    319       I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    528       I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    556       I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    560       I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

```
    FUNCTION RCURV      73/74    OPT=0 TRACE                        FTN 4.6+439       08/24/78  10.30.04       PAGE     1

                    FUNCTION RCURV (ZI,ZE,Y,YT)                                             RC          2
                    COMMON/CONC/ARE(40),ZRE(40),XRE(40),ARI(40),ZRI(40),XRI(40),          CONC        2
                   1 RSP,NRCVI,NRCVE,ZSI(30),ZSE(30),RCVI(30),RCVE(30)                   CONC        3
                    DATA RCVMX/1000./                                                       RC          4
              C ***************  INTERNAL BOUNDRY RADIUS OF CURVATURE  ***************     RC          5
                    IF (ZI.LT.ZSI(1).OR.ZI.GT.ZSI(NRCVI)) GO TO 10                          RC          6
                    RCV1=TAB(ZI,ZSI,RCVI,NRCVI)                                             RC          7
                    GO TO 15                                                                RC          8
                 10 RCV1=RCVMX                                                              RC          9
              C ***************  EXTERNAL BOUNDRY RADIUS OF CURVATURE  ***************     RC         10
                 15 IF (ZE.LT.ZSE(1).OR.ZE.GT.ZSE(NRCVE)) GO TO 20                          RC         11
                    RCV2=TAB(ZE,ZSE,RCVE,NRCVE)                                             RC         12
                    GO TO 25                                                                RC         13
                 20 RCV2=RCVMX                                                              RC         14
              C **************  ACTUAL RCV VALUE IS LINEAR INTERPOLATION  **************    RC         15
                 25 RCURV=RCV1+(RCV2-RCV1)*Y/YT                                             RC         16
                    RETURN                                                                  RC         17
                    END                                                                     RC         18
```

```
      FUNCTION TAB        73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  10.30.04       PAGE    1

  1                   FUNCTION TAB (X,XX,YY,NTAB)                                      TA        2
                      DIMENSION XX(1),YY(1)                                            TA        3
                      IF (NTAB.GT.0) GO TO 5                                           TA        4
                      TAB=0.0                                                          TA        5
  5                   RETURN                                                           TA        6
                    5 F=1.                                                             TA        7
                      IF (XX(1).GT.XX(2)) F=-F                                         TA        8
                      DO 10 J=1,NTAB                                                   TA        9
                      I=J                                                              TA       10
 10                   IF (F*(XX(I)-X)) 10,40,20                                        TA       11
                   10 CONTINUE                                                         TA       12
                   20 IF (I.NE.1) GO TO 30                                             TA       13
                      I=2                                                              TA       14
                   30 J=I-1                                                            TA       15
 15                   DEL=XX(I)-XX(J)                                                  TA       16
                      IF (DEL.EQ.0.0) GO TO 50                                         TA       17
                      TAB=(YY(I)*(X-XX(J))-YY(J)*(X-XX(I)))/DEL                        TA       18
                      RETURN                                                           TA       19
                   40 TAB=YY(I)                                                        TA       20
 20                   RETURN                                                           TA       21
                   50 WRITE (6,60) X,I,J                                               TA       22
                      CALL EXIT                                                        TA       23
                   60 FORMAT (' *** ERROR IN SUBROUTINE TAB ***',E15.4,2I5)            TA       24
                      END                                                              TA       25

 CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM
       7    I        XX          ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
```

```
FUNCTION MODE        73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  10.30.04        PAGE     1

                  FUNCTION MODE (X,XX,N)                                              MO         2
                  DIMENSION XX(1)                                                     MO         3
                  IF (X.LT.XX(1).OR.X.GT.XX(N)) GO TO 20                              MO         4
                  DO 10 I=2,N                                                         MO         5
                  II=I-1                                                              MO         6
                  IF (X.GE.XX(II).AND.X.LT.XX(I)) GO TO 15                            MO         7
               10 CONTINUE                                                            MO         8
               15 MODE=II                                                             MO         9
                  RETURN                                                              MO        10
               20 WRITE (6,25) X,XX(1),XX(N)                                          MO        11
               25 FORMAT (' ** ERROR IN FUNCTION MODE **',3G15.5)                     MO        12
                  RETURN                                                              MO        13
                  END                                                                 MO        14
```

```
      SUBROUTINE AUX(NV)                                                AU         2
      COMMON/COMA/A(43),AJE(7),AJI(7),B(43),C(43),CSALFA,D(43),DPDX(43), COMA      2
     1 DX,EMU(43),F(7,43),FS(5,43),IAX,IEND,IFIN,INDE(7),INDI(7),IOUT,  COMA       3
     2 ISTEP,ITEST,IUTRAP,JS,JSM,JV,JT,KEX,KIN,KRAD,N,NEQ,NF,NOVEL,NP1, COMA       4
     3 NP2,NP3,OM(43),OMO(43),P(43),PEI,PR(7),PREF(7),PSIE,PSII,R(43),  COMA       5
     4 RHO(43),RME,RMI,RU(43),SD(43),SU(43),TAUE,TAUI,U(43),XD,XU,      COMA       6
     5 Y(43),YE,YI,PSWRL(43),RDY(43),ISOLVE(7),US(43),AMU(43),          COMA       7
     5 DZ(43),DZOLD(43),ZUI,ZUE,ZDI,ZDE,DPDBX(43),                      COMA       8
     6 JM,JFU,JFUOX,JCB,JVT,JK,JB,JOX,JT,JM2,JM2O,JCB2                  COMA       9
      COMMON/COMB/AK,ALMG,EWALL,FR,N,MFU,INERT,MASSTR,MODEL,PRESS,      COMB       2
     1 UBAR,WFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,   COMB       3
     2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4           COMB       4
C/-------- SUBROUTINE FOR PROGRAM GENMIX 4A                             AU         5
      DIMENSION LAB(2),DUDY(43),GENR(43),EMUT(43),EMUL(43)              AU         6
      DIMENSION SUFU(43),SDFU(43)                                       AU         7
C                                                                       AU         8
      ENTRY AUXD                                                        AU         9
C     -------  CALCULATE TURB VISCOSITY FROM TWO EQUATION MODEL  ------- AU        10
      IF (MODEL.EQ.1) GO TO 200                                         AU        11
      DO 112 I=1,NP3                                                    AU        12
      EMUL(I)=EMU(I)                                                    AU        13
      RT=RHO(I)*F(JK,I)**2/(F(JB,I)*EMUL(I)+1.0E-30)                    AU        14
      CDD=CD*EXP(-2.5/(1.0+RT/50.))                                     AU        15
      EMUT(I)=CDD*RHO(I)*F(JK,I)*F(JK,I)/(F(JB,I)+1.0E-30)              AU        16
      EMU(I)=EMUL(I)+EMUT(I)                                            AU        17
  112 AMU(I)=EMU(I)                                                     AU        18
C     -----------------------------------------------  TEST 10          AU        19
  200 IF (ITEST) 202,201,202                                            AU        20
  202 LAB(1)=6HTEST 1                                                   AU        21
      LAB(2)=6H0                                                        AU        22
      WRITE (6,100) LAB                                                 AU        23
      LAB(1)=6HEMU(I)                                                   AU        24
      LAB(2)=6H                                                         AU        25
      WRITE (6,100) LAB,(EMU(I),I=1,NP3)                                AU        26
  201 CONTINUE                                                          AU        27
C     ------------------  MODIFICATION OF EMU ARRAY                     AU        28
      DO 23 I=2,NP2                                                     AU        29
   23 EMU(I)=.5*(EMU(I+1)+EMU(I))                                       AU        30
      DO 24 I=2,NP1                                                     AU        31
   24 EM U(I)=EMU(I)/(Y(I+1)-Y(I))                                      AU        32
      IF (KRAD.EQ.0) GO TO 300                                          AU        33
      DO 26 I=2,NP1                                                     AU        34
   26 EM U(I)=EM U(I)*.5*(R(I)+R(I+1))                                  AU        35
  300 CONTINUE                                                          AU        36
      RETURN                                                            AU        37
C    *************************    SOURCE TERMS      ******************** AU        38
      ENTRY SOURCE                                                      AU        39
      IF (NV.NE.0) GO TO 500                                            AU        40
C     ------ VELOCITY U                                                 AU        41
      DO 308 I=2,NP2                                                    AU        42
  308 US(I)=DPDX(I)*RDY(I)                                              AU        43
      GO TO 6000                                                        AU        44
C     --------------------- KINETIC HEATING.                            AU        45
  500 IF (NV.NE.JH) GO TO 1000                                          AU        46
C     ------ TEMPORARY USE OF SD ARRAY.                                 AU        47
      GO TO (303,304), NOVEL                                            AU        48
  303 DO 305 I=1,NP3                                                    AU        49
      SU(I)=0.                                                          AU        50
  305 SD(I)=0.                                                          AU        51
      GO TO 306                                                         AU        52
  304 DO 30 I=2,NP2                                                     AU        53
   30 S D(I)=U(I)*U(I)                                                  AU        54
      DO 31 I=2,NP1                                                     AU        55
   31 S D(I)=EM U(I)*(S D(I+1)-S D(I))                                  AU        56
      S D(1)=0.                                                         AU        57
      S D(NP2)=0.                                                       AU        58
      DO 32 I=2,NP2                                                     AU        59
      T=(1.-1./PREF(1))*0.5                                             AU        60
   32 SU(I)=(S D(I)-S D(I-1))*T                                         AU        61
      DO 33 I=2,NP1                                                     AU        62
   33 SD(I)=0.                                                          AU        63
C     ------------------------------------------  TEST 11               AU        64
  306 IF(ITEST) 302,301,302                                             AU        65
  302 LAB(1)=6HTEST 1                                                   AU        66
      LAB(2)=1H1                                                        AU        67
      WRITE(6,100) LAB                                                  AU        68
      LAB(1)=6HSD(I                                                     AU        69
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                 LAB(2)=1H)                                                              AU         70
                 WRITE(6,100) LAB,(SD(I),I=1,NP3)                                        AU         71
                 LAB(1)=6HSU(I                                                           AU         72
                 LAB(2)=1H)                                                              AU         73
                 WRITE(6,100) LAB,(SU(I),I=1,NP3)                                        AU         74
             301 CONTINUE                                                                AU         75
                 GO TO 6000                                                              AU         76
          C      ---------------------------------------------------- FUEL ------------ AU         77
            1000 IF (NV.NE.JFU) GO TO 2000                                               AU         78
                 DO 90 I=2,NP2                                                           AU         79
                 IF(INEXT-I) 45,41,45                                                    AU         80
              45 F2=F(JFU,I)                                                             AU         81
                 F3=F(JFUOX,I)                                                           AU         82
                 F4=F(JCO,I)                                                             AU         83
                 F6=F(JH,I)                                                              AU         84
                 F7=F(JO,I)                                                              AU         85
                 FS1=FS(JOX,I)                                                           AU         86
                 FS2=FS(JT,I)                                                            AU         87
                 IF(I-2) 42,46,42                                                        AU         88
              46 F2=F2+.25*(F(JFU,3)-F2)                                                 AU         89
                 F3=F3+.25*(F(JFUOX,3)-F3)                                               AU         90
                 F4=F4+.25*(F(JCO,3)-F4)                                                 AU         91
                 F6=F6+.25*(F(JH,3)-F6)                                                  AU         92
                 F7=F7+.25*(F(JO,3)-F7)                                                  AU         93
                 FS1=FS1+.25*(FS(JOX,3)-FS1)                                             AU         94
                 FS2=FS2+.25*(FS(JT,3)-FS2)                                              AU         95
              42 IF(I-NP2) 43,47,43                                                      AU         96
              47 F2=F2+.25*(F(JFU,NP1)-F2)                                               AU         97
                 F3=F3+.25*(F(JFUOX,NP1)-F3)                                             AU         98
                 F4=F4+.25*(F(JCO,NP1)-F4)                                               AU         99
                 F6=F6+.25*(F(JH,NP1)-F6)                                                AU        100
                 F7=F7+.25*(F(JO,NP1)-F7)                                                AU        101
                 FS1=FS1+.25*(FS(JOX,NP1)-FS1)                                           AU        102
                 FS2=FS2+.25*(FS(JT,NP1)-FS2)                                            AU        103
              43 IF(F2) 41,41,430                                                        AU        104
             430 IF(FS1) 41,41,431                                                       AU        105
             431 SOR1=-PREEXP1*RHOM(I)**2*FS1*EXP(-ARCON1/FS2)                           AU        106
                 GO TO (48,49), MODER                                                    AU        107
              48 SOR=SOR1                                                                AU        108
                 GO TO 44                                                                AU        109
              49 SOR2=-CB1*RHOM(I)*F7/F6                                                 AU        110
                 SOR=AMAX1(SOR1,SOR2)                                                    AU        111
              44 SOR1=SOR*F2*.5*RDY(I)                                                   AU        112
                 IF (-SOR*DZ(I)-1.) 95,95,96                                             AU        113
              95 SU(I)=SOR1                                                              AU        114
                 SD(I)=0.                                                                AU        115
                 GO TO 40                                                                AU        116
              96 FUB=AMAX1(0.,((RATIO1+RATIO2)*F3-RATIO2-RATIO3*F4)/RATIO2)              AU        117
                 IF (F2-FUB) 41,41,94                                                    AU        118
              94 DSDFU=SOR1/(F2-FUB)                                                     AU        119
                 SU(I)=-DSDFU*FUB                                                        AU        120
                 SD(I)=DSDFU                                                             AU        121
                 GO TO 40                                                                AU        122
              41 SU(I)=0.                                                                AU        123
                 SD(I)=0.                                                                AU        124
              40 SUFU(I)=SU(I)                                                           AU        125
                 SDFU(I)=SD(I)                                                           AU        126
              90 CONTINUE                                                                AU        127
          C      -------------------------------- TEST 12                                AU        128
                 IF(ITEST) 402,401,402                                                   AU        129
             402 LAB(1)=6HTEST 1                                                         AU        130
                 LAB(2)=1H2                                                              AU        131
                 WRITE(6,100) LAB                                                        AU        132
                 LAB(1)=6HSD(I                                                           AU        133
                 LAB(2)=1H)                                                              AU        134
                 WRITE(6,100) LAB,(SD(I),I=1,NP3)                                        AU        135
                 LAB(1)=6HSU(I                                                           AU        136
                 LAB(2)=1H)                                                              AU        137
                 WRITE(6,100) LAB,(SU(I),I=1,NP3)                                        AU        138
             401 CONTINUE                                                                AU        139
                 GO TO 6000                                                              AU        140
          C      ------------------------------------------- OX-FU*DFDFU -------------- AU        141
            2000 IF (NV.NE.JFUOX) GO TO 3000                                             AU        142
                 DO 50 I=2,NP2                                                           AU        143
                 SU(I)=0.                                                                AU        144
              50 SD(I)=0.                                                                AU        145
                 GO TO 6000                                                              AU        146
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C  ----------------    SOURCE TERMS FOR CO   -------------------------  AU     147
 3000 IF (NV.NE.JCO) GO TO 3500                                           AU     148
      F2=0.                                                               AU     149
      DO 140 I=2,NP2                                                      AU     150
      IF (IMEDT-1) 145,141,145                                            AU     151
  145 F2=F(JFU,I)                                                         AU     152
      F3=F(JFOX,I)                                                        AU     153
      F4=F(JCO,I)                                                         AU     154
      F6=F(JK,I)                                                          AU     155
      F7=F(JD,I)                                                          AU     156
      FS1=FS(JOX,I)                                                       AU     157
      FS2=FS(JT,I)                                                        AU     158
      IF (I-2) 142,146,142                                                AU     159
  146 F2=F2+.25*(F(JFU,3)-F2)                                             AU     160
      F3=F3+.25*(F(JFOX,3)-F3)                                            AU     161
      F4=F4+.25*(F(JCO,3)-F4)                                             AU     162
      F6=F6+.25*(F(JK,3)-F6)                                              AU     163
      F7=F7+.25*(F(JD,3)-F7)                                              AU     164
      FS1=FS1+.25*(FS(JOX,3)-FS1)                                         AU     165
      FS2=FS2+.25*(FS(JT,3)-FS2)                                          AU     166
  142 IF (I-NP2) 143,147,143                                              AU     167
  147 F2=F2+.25*(F(JFU,NP1)-F2)                                           AU     168
      F3=F3+.25*(F(JFOX,NP1)-F3)                                          AU     169
      F4=F4+.25*(F(JCO,NP1)-F4)                                           AU     170
      F6=F6+.25*(F(JK,NP1)-F6)                                            AU     171
      F7=F7+.25*(F(JD,NP1)-F7)                                            AU     172
      FS1=FS1+.25*(FS(JOX,NP1)-FS1)                                       AU     173
      FS2=FS2+.25*(FS(JT,NP1)-FS2)                                        AU     174
  143 IF (F4) 141,141,1430                                                AU     175
 1430 IF (FS1) 141,141,1431                                               AU     176
 1431 SOR1=-PRESP2*RHO(I)**2*FS1*EXP(-ARCOM2/FS2)                         AU     177
      GO TO (148,149), MODEO                                              AU     178
  148 SOR=SOR1                                                            AU     179
      GO TO 144                                                           AU     180
  149 SOR2=-CR2*RHO(I)*F7/F6                                              AU     181
      SOR=AMAX1(SOR1,SOR2)                                                AU     182
  144 SOR1=SOR*F4*.5*RBY(I)                                               AU     183
      IF (-SOR*DZ(I)-1.) 945,945,946                                      AU     184
  945 SU(I)=SOR1-RATIO4*(SUFU(I)+SDFU(I)*F2)                              AU     185
      SP(I)=0.                                                            AU     186
      GO TO 140                                                           AU     187
  946 FUB=AMAX1(0.,((RATIO1+RATIO2)*F3-RATIO2-RATIO1*F2)/RATIO3)          AU     188
      IF (F4-FUB) 141,141,944                                             AU     189
  944 DSDCO=SOR1/(F4-FUB)                                                 AU     190
      SU(I)=-DSDCO*FUB-RATIO4*(SUFU(I)+SDFU(I)*F2)                        AU     191
      SP(I)=DSDCO                                                         AU     192
      GO TO 140                                                           AU     193
  141 SU(I)=-RATIO4*(SUFU(I)+SDFU(I)*F2)                                  AU     194
      SP(I)=0.                                                            AU     195
  140 CONTINUE                                                            AU     196
C  -------------------------------------------------------- TEST 13      AU     197
      IF (ITEST) 178,179,178                                              AU     198
  178 LAB(1)=6HTEST 1                                                     AU     199
      LAB(2)=6H3                                                          AU     200
      WRITE (6,100) LAB                                                   AU     201
      LAB(1)=6HSU(I                                                       AU     202
      LAB(2)=6H)                                                          AU     203
      WRITE (6,130) LAB,(SU(I),I=1,NP3)                                   AU     204
      LAB(1)=6HSP(I                                                       AU     205
      LAB(2)=6H)                                                          AU     206
      WRITE (6,100) LAB,(SP(I),I=1,NP3)                                   AU     207
  179 CONTINUE                                                            AU     208
      GO TO 5000                                                          AU     209
C  -----------         SWIRL VELOCITY     -------------------             AU     210
 3500 IF (NV.NE.JVT) GO TO 4000                                           AU     211
      DO 60 I=2,NP2                                                       AU     212
      SU(I)=0.0                                                           AU     213
   60 SP(I)=0.0                                                           AU     214
      GO TO 5000                                                          AU     215
C  ----------------    TURBULENT KINETIC ENERGY    --------------------   AU     216
 4000 IF (NV.NE.JK) GO TO 5000                                            AU     217
      D22=R(3)-R(1)                                                       AU     218
      VT2=F(JVT,2)/(.75*R(2)+.25*R(3))                                    AU     219
      VT3=F(JVT,3)/R(3)                                                   AU     220
      RK2=SQRT(F(JK,2))                                                   AU     221
      RK3=SQRT(F(JK,3))                                                   AU     222
      DUDY(2)=(U(3)-U(2))/D22                                             AU     223
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      DVTDY=(VT3-VT2)/D22                                                 AU    224
      DK2=(RK3-RK2)/D22                                                   AU    225
      GENR(2)=DUDY(2)**2+(DVTDY-VT2/(.75*R(2)+.25*R(3)))**2               AU    226
C     ----------------------                                              AU    227
      DO 70 I=3,NP1                                                       AU    228
      D11=D22                                                             AU    229
      D22=Y(I+1)-Y(I)                                                     AU    230
      IF (I.EQ.NP1) D22=Y(NP3)-Y(NP1)                                     AU    231
      D12=D11+D22                                                         AU    232
      DUDY(I)=D11*(U(I+1)-U(I))/(D12*D22)+D22*(U(I)-U(I-1))/(D12*D11)     AU    233
      VT1=VT2                                                             AU    234
      VT2=VT3                                                             AU    235
      VT3=F(JVT,I+1)/R(I+1)                                               AU    236
      IF (I.EQ.NP1) VT3=F(JVT,NP2)/(.75*R(NP2)+.25*R(NP1))                AU    237
      DVTDY=D11*(VT3-VT2)/(D12*D22)+D22*(VT2-VT1)/(D12*D11)               AU    238
      RK1=RK2                                                             AU    239
      RK2=RK3                                                             AU    240
      RK3=SQRT(F(JK,I+1))                                                 AU    241
      DRKDY=D11*(RK3-RK2)/(D12*D22)+D22*(RK2-RK1)/(D12*D11)               AU    242
      GENR(I)=DUDY(I)**2+(DVTDY-VT2/R(I))**2                              AU    243
      SU(I)=EMUT(I)*GENR(I)                                               AU    244
   70 SD(I)=-(RHO(I)*F(JD,I)+2.*EMUL(I)*DRKDY**2)/F(JK,I)                 AU    245
C     ---------------------                                               AU    246
      DUDY(NP2)=(U(NP2)-U(NP1))/D22                                       AU    247
      DVTDY=(VT3-VT2)/D22                                                 AU    248
      DKNP2=(RK3-RK2)/D22                                                 AU    249
      GENR(NP2)=DUDY(NP2)**2+(DVTDY-VT3/(.75*R(NP2)+.25*R(NP1)))**2       AU    250
      F6=.75*F(JK,2)+.25*F(JK,3)                                          AU    251
      F7=.75*F(JD,2)+.25*F(JD,3)                                          AU    252
      SU(2)=EMUT(2)*GENR(2)                                               AU    253
      SD(2)=-(RHO(2)*F7+2.*EMUL(2)*DK2**2)/F6                             AU    254
      F6=.75*F(JK,NP2)+.25*F(JK,NP1)                                      AU    255
      F7=.75*F(JD,NP2)+.25*F(JD,NP1)                                      AU    256
      SU(NP2)=EMUT(NP2)*GENR(NP2)                                         AU    257
      SD(NP2)=-(RHO(NP2)*F7+2.*EMUL(NP2)*DKNP2**2)/F6                     AU    258
   76 DO 77 I=2,NP2                                                       AU    259
      SU(I)=SU(I)*0.5*RDY(I)                                              AU    260
   77 SD(I)=SD(I)*0.5*RDY(I)                                              AU    261
C     ------------------------------------------------   TEST 13          AU    262
      IF (ITEST) 78,79,78                                                 AU    263
   78 LAB(1)=6HTEST 1                                                     AU    264
      LAB(2)=6H3                                                          AU    265
      WRITE (6,100) LAB                                                   AU    266
      LAB(1)=6HSU(I                                                       AU    267
      LAB(2)=6H)                                                          AU    268
      WRITE (6,100) LAB,(SU(I),I=1,NP3)                                   AU    269
      LAB(1)=6HSD(I                                                       AU    270
      LAB(2)=6H)                                                          AU    271
      WRITE (6,100) LAB,(SD(I),I=1,NP3)                                   AU    272
   79 CONTINUE                                                            AU    273
C     -------------------                                                 AU    274
      GO TO 6000                                                          AU    275
C     -------------     TURBULENCE DISSIPATION      ------------------    AU    276
 5000 IF (NV.NE.JD) GO TO 6000                                            AU    277
      D22=Y(3)-Y(2)                                                       AU    278
      DO 80 I=3,NP1                                                       AU    279
      C2E=C2                                                              AU    280
      IF (ISOLVE(JVT).EQ.0) GO TO 90                                      AU    281
      D11=D22                                                             AU    282
      D22=Y(I+1)-Y(I)                                                     AU    283
      D12=D11+D22                                                         AU    284
      DRVTDY=D11*(F(JVT,I+1)-F(JVT,I))/(D12*D22)+D22*(F(JVT,I)-F(JVT,I-1  AU    285
     * ))/(D12*D11)                                                       AU    286
      C2E=C2E+C2VT*(F(JVT,I)/R(I)**3)*DRVTDY/(GENR(I)+1.0E-20)            AU    287
      C2E=AMIN1(C2E,3.)                                                   AU    288
      C2E=AMAX1(C2E,1.)                                                   AU    289
   90 DUDYDY=(DUDY(I+1)-DUDY(I-1))/(Y(I+1)-Y(I-1))                        AU    290
      FACTOR=2.*EMUL(I)*EMUT(I)*DUDYDY*DUDYDY/RHO(I)                      AU    291
      SU(I)=C1*F(JD,I)*EMUT(I)*GENR(I)/F(JK,I)+FACTOR                     AU    292
   80 SD(I)=-C2E*F(JD,I)*RHO(I)/F(JK,I)                                   AU    293
C     -------------------                                                 AU    294
      F6=.75*F(JK,2)+.25*F(JK,3)                                          AU    295
      F7=.75*F(JD,2)+.25*F(JD,3)                                          AU    296
      GO TO (81,82,82), KIN                                               AU    297
   81 SU(2)=1.E30*CD75*F6**1.5/(YI*AX)                                    AU    298
      SD(2)=-1.E30                                                        AU    299
      GO TO 83                                                            AU    300
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      SUBROUTINE AUX          73/74    OPT=0 TRACE                                  FTN 4.6+439        08/24/78  10.30.04         PAGE     5

 310               82 SU(2)=C1*F7*EMUT(2)*GENR(2)/F6                                                   AU          301
                      SD(2)=-C2*F7*RHO(2)/F6                                                           AU          302
                   83 F6=.75*F(JK,NP2)+.25*F(JK,NP1)                                                   AU          303
                      F7=.75*F(JB,NP2)+.25*F(JB,NP1)                                                   AU          304
                      GO TO (84,85,85), KEX                                                            AU          305
 315               84 SU(NP2)=1.E30*C875*F6**1.5/(YE*AK)                                               AU          306
                      SD(NP2)=-1.E30                                                                   AU          307
                      GO TO 86                                                                         AU          308
                   85 SU(NP2)=C1*F7*EMUT(NP2)*GENR(NP2)/F6                                             AU          309
                      SD(NP2)=-C2*F7*RHO(NP2)/F6                                                       AU          310
 320               86 DO 87 I=2,NP2                                                                    AU          311
                      SU(I)=SU(I)*0.5*RDY(I)                                                           AU          312
                   87 SD(I)=SD(I)*0.5*RDY(I)                                                           AU          313
                C                                                                                      AU          314
                      IF (ITEST) 88,89,88                                      TEST 14                 AU          315
 325               88 LAB(1)=6HTEST I                                                                  AU          316
                      LAB(2)=6H4                                                                       AU          317
                      WRITE (6,100) LAB                                                                AU          318
                      LAB(1)=6HSU(I                                                                    AU          319
                      LAB(2)=6H)                                                                       AU          320
 330                  WRITE (6,100) LAB,(SU(I),I=1,NP3)                                                AU          321
                      LAB(1)=6HSD(I                                                                    AU          322
                      LAB(2)=6H)                                                                       AU          323
                      WRITE (6,100) LAB,(SD(I),I=1,NP3)                                                AU          324
                   89 CONTINUE                                                                         AU          325
 335            C                                                                                      AU          326
                 6000 CONTINUE                                                                         AU          327
                      RETURN                                                                           AU          328
                  100 FORMAT(1H ,A6,A2,1P11E11.3/(9X,11E11.3))                                         AU          329
                      END                                                                              AU          330

CARD NR. SEVERITY  DETAILS   DIAGNOSIS OF PROBLEM

      56     I
     115     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     186     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     305     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     313     I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
                               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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SUBROUTINE STRIDE      73/74    OPT=0 TRACE                 FTN 4.6+439        08/24/78  13.30.04        PAGE      1

      SUBROUTINE STRIDE(ISW)                                            ST         2
      COMMON/COMA/A(43),AJE(7),AJI(7),B(43),C(43),CSALFA,D(43),DPDX(43), COMA       2
     1 DZ,EMU(43),F(7,43),FS(5,43),IAC,IEND,IFIN,INDE(7),INDI(7),IOUT,  COMA       3
     2 ISTEP,ITEST,IUTRAP,JS,JSW,JV,JY,KEX,KIN,KRAD,N,ND2,NF,NOVEL,NP1, COMA       4
     3 NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(7),PREF(7),PSIE,PSII,R(43),  COMA       5
     4 RHO(43),RME,RMI,RU(43),SD(43),SU(43),TAUE,TAUI,U(43),XD,XU,      COMA       6
     5 Y(43),YE,YI,PSUML(43),ROY(43),ISOLVE(7),US(43),AMU(43),          COMA       7
     5 BZ(43),DZOLD(43),ZUI,ZUE,ZDI,ZDE,DPDGZ(43),                      COMA       8
     6 JM,JFU,JFUDX,JCD,JUT,JK,JE,JDE,JT,JM2,JM20,JCD2                  COMA       9
C/------------------- SUBROUTINE FOR PROGRAM GEMINI 6A ----------------- ST         4
C/ THIS SUBROUTINE PERFORMS THE SAME OPERATIONS AS THE ONE IN GEMINI6A  ST         5
C  BUT MORE ECONOMICALLY. THE A,B,C ARRAYS ARE ONE-DIMENSIONAL. SOME    ST         6
C  OFTEN USED FUNCTIONS OF OM ARE STORED, AND A B ARRAY SAVES           ST         7
C  UNNECESSARY ARITHMETIC IN THE TDMA OPERATION.                        ST         8
C---------------------------------------------------------------------- ST         9
      DIMENSION AMLPT(43),BOMT3(43),FDIFI(7),FDIFE(7),GE(7),GI(7)       ST        10
      DIMENSION PBOM(43),PCOM(43),THLPT(43),TIPP(7),TIFF(7),BOM(43)     ST        11
      DIMENSION TMP3FF(7),OMPOM(43)                                     ST        12
      DIMENSION PD4(43),PG34(43)                                        ST        13
      DIMENSION IKAS(7)                                                 ST        14
      DATA IKAS/1,1,1,1,0,0,0/                                          ST        15
C                                                                       ST        16
      GO TO (1000,2000,3000,4000), ISW                                  ST        17
C                                                                       ST        18
C*********************************** S T R I D E 1 ***************.*  ST        19
 1000 IF(ISTEP) 1003,1003,1100                                          ST        20
 1003 OMI=.5*OM(3)                                                      ST        21
      OME=.5*(1.-OM(NP1))                                               ST        22
      DO 1002 I=2,NP2                                                   ST        23
      BOM(I)=OM(I+1)-OM(I-1)                                            ST        24
      BOMT3(I)=3.*BOM(I)                                                ST        25
      OMPOM(I)=OM(I)+OM(I+1)                                            ST        26
 1002 OMD(I)=OM(I+1)-OM(I)                                              ST        27
      OMD(1)=BOM(2)                                                     ST        28
      BPE=1.                                                            ST        29
      BPI=1.                                                            ST        30
      Y(1)=0.                                                           ST        31
      IF(KRAD.EQ.1) GO TO 1100                                          ST        32
      DO 1001 I=1,NP3                                                   ST        33
 1001 R(I)=1.                                                           ST        34
      R25=1.                                                            ST        35
      RM15=1.                                                           ST        36
      IF(ITEST.NE.0) WRITE(6,9010) (R(I),I=1,NP3),R25,RM15              ST        37
C------------------------- CALCULATION OF RHO*U 'S -------------------- ST        38
 1100 DO 1101 I=1,NP3                                                   ST        39
      IF(RHO(I).GT.0.) GO TO 1101                                       ST        40
      WRITE(6,1108) RHO(I),I,RHO(I)                                     ST        41
 1108 FORMAT(36H ********** NEGATIVE OR ZERO RHO(I)=,1PE11.3,6H AT I=,  ST        42
     1 I3,6X,21HSET TO ABS OF RHO(I)=,E11.3,17H ******** STRIDE1)       ST        43
      RHO(I)=ABS(RHO(I))                                                ST        44
 1101 RU(I)=RHO(I)*U(I)                                                 ST        45
      RU3=RU(3)                                                         ST        46
      RUM1=RU(NP1)                                                      ST        47
      DO 1102 I=2,NP1                                                   ST        48
 1102 RU(I)=.5*(RU(I)+RU(I+1))                                          ST        49
      IF(ITEST.NE.0) WRITE(6,9010) (RU(I),I=1,NP3),RUM1,RU3,PEI         ST        50
C------------------------- CALCULATION OF Y 'S AND R 'S --------------- ST        51
C     ------------------------------------- Y'S FOR PLANE GEOMETRY      ST        52
      YI=PEI*OMI/(BPI*RU(2))                                            ST        53
      Y(3)=YI+PEI*OM(3)/(RU(2)+RU3)                                     ST        54
      Y(2)=2.*YI-Y(3)                                                   ST        55
      DO 1103 I=4,NP1                                                   ST        56
 1103 Y(I)=Y(I-1)+PEI*OMD(I-1)/RU(I-1)                                  ST        57
      YM15=Y(NP1)+PEI*OMD(NP1)/(RU(NP1)+RUM1)                           ST        58
      YE=PEI*OME/(BPE*RU(NP1))                                          ST        59
      Y(NP3)=YM15+YE                                                    ST        60
      Y(NP2)=2.*YM15-Y(NP1)                                             ST        61
      IF(KRAD.EQ.0) RETURN                                              ST        62
C     ------------------- Y'S AND R'S FOR AXISYMMETRICAL GEOMETRY       ST        63
      IF(CSALFA.EQ.0.) GO TO 1119                                       ST        64
C     ------------------------------------- CSALFA NE ZERO              ST        65
      COSD2=.5*CSALFA                                                   ST        66
      IF(R(1).NE.0.) GO TO 1105                                         ST        67
C-------------------------------------------- R(1)=0.                   ST        68
      DO 1106 I=2,NP3                                                   ST        69
      Y(I)=SQRT(ABS(Y(I)/COSD2))                                        ST        70
 1106 R(I)=Y(I)*CSALFA                                                  ST        71
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```
      YI=SQRT(ABS(YI/COSD2))
      YN15=SQRT(ABS(YN15/COSD2))
      GO TO 1107
C     --------------------------------------------- R(1) NE 0.
 1105 R1D2=.5*R(1)
      R1D2SQ=R1D2*R1D2
      DO 1104 I=2,NP3
      Y(I)=Y(I)/(R1D2+SQRT(ABS(R1D2SQ+COSD2*Y(I))))
 1104 R(I)=R(I)+Y(I)*CSALFA
      YI=YI/(R1D2+SQRT(ABS(R1D2SQ+COSD2*YI)))
      YN15=YN15/(R1D2+SQRT(ABS(R1D2SQ+COSD2*YN15)))
 1107 R25=R(1)+YI*CSALFA
      RN15=R(1)+YN15*CSALFA
      YE=Y(NP3)-YN15
      RETURN
C     --------------------------------------------- CSALFA EQ ZERO
 1110 DO 1111 I=2,NP3
      Y(I)=Y(I)/R(I)
 1111 R(I)=R(1)
      YI=YI/R(1)
      YN15=YN15/R(1)
      R25=R(1)
      RN15=R(1)
      YE=Y(NP3)-YN15
      RETURN
C**************************************** S T R I D E 2 ****************
C     ---------------------------------- PRELIMINARIES FOR COEFFICIENTS
 2000 DO 2010 I=2,NP2
 2010 PD4(I)=PEI/DZ(I)
      G=RMI-RME
      ARMI=ABS(RMI)
      ARME=ABS(RME)
      GD4=.25*G
      RMIDR2=.5*RMI
      DO 2004 I=2,NP2
      PDOM(I)=PD4(I)*DOM(I)
      PD4(I)=.25*PD4(I)
      PGD4(I)=PD4(I)*GD4
 2004 PGOM(I)=PGD4(I)*OMD(I)
      P4DMP=PD4(2)*DOM(2)
C     --------------------------------------------- GRID POINT 2
C-------------------------------------------------- TAUI, BPI, TI
      IF(KIN.NE.1) GO TO 2001
      CALL WF(5,1,BPI,TI,TAUI)
      GO TO 2002
 2001 TI=0.
      IF(KRAD.EQ.0) BPI=.33333+.66667*RU(1)/RU(2)
      IF(KRAD.EQ.1) BPI=(R(1)*(5.*RU(1)+RU(2))+3.*R25*
     1                   (RU(1)+RU(2)))/6./(R(1)+R25)/RU(2)
 2002 DO 2700 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 2700
      IF (KIN.NE.1) GO TO 2705
      CALL WF (J,1,FDIFI(J),TIFF(J),GI(J))
      IF (INDI(J).EQ.2) GO TO 2700
      AJI(J)=GI(J)*(F(J,1)-.5*(F(J,2)+F(J,3))-FDIFI(J))
      GO TO 2700
 2705 TIFF(J)=0.
      FDIFI(J)=0.
 2700 CONTINUE
C     --------------------------------------------- GRID POINT NP2
C-------------------------------------------------- TAUE, BPE, TNP3
 2304 IF(KEX.NE.1) GO TO 2003
      CALL WF(0,NP3,BPE,TNP3,TAUE)
      GO TO 2310
 2003 TNP3=0.
      IF(KRAD.EQ.0) BPE=.33333+.66667*RU(NP3)/RU(NP1)
      IF(KRAD.EQ.1) BPE=(R(NP3)*(5.*RU(NP3)+RU(NP1))+3.*RN15*
     1                   (RU(NP3)+RU(NP1)))/6./(R(NP3)+ RN15)/RU(NP1)
 2310 DO 2720 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 2720
      IF (KEX.NE.1) GO TO 2730
      CALL WF(J,NP3,FDIFE(J),TNP3FF(J),GE(J))
      IF (INDE(J).EQ.2) GO TO 2720
      AJE(J)=GE(J)*(.5*(F(J,NP2)+F(J,NP1))+FDIFE(J)-F(J,NP3))
      GO TO 2720
 2730 TNP3FF(J)=0.
      FDIFE(J)=0.
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      2720 CONTINUE                                                       ST        149
           RETURN                                                         ST        150
C************************************  S T R I D E 3  ****************   ST        151
      3000 CALL SOURCE(0)                                                 ST        152
C   ------------------------  BOUNDARY COEFFICIENTS FOR VELOCITY          ST        153
C   ---------  GRID POINT 2 COEFFICIENTS  --------------                  ST        154
           HLP=RMID2-GD4*OMPOM(2)                                         ST        155
           AHLP=ABS(HLP)                                                  ST        156
           THLP=HLP+HLP                                                   ST        157
           THLPT(2)=THLP                                                  ST        158
           TP=EM U(2)                                                     ST        159
           TTP=TP+AHLP+ABS(TP-AHLP)                                       ST        160
           A(2)=TTP-THLP-T1-PGOM(2)                                       ST        161
           B(2)=2.*T1+RMI+ARMI                                            ST        162
           C(2)=P4OMP*(3.*U(2)+U(3))-US(2)                                ST        163
           D(2)=A(2)+B(2)+PBOM(2)                                         ST        164
C   --------   GRID POINT NP2 COEFFICIENTS    -------------               ST        165
           HLM=RMID2-GD4*OMPOM(NP1)                                       ST        166
           AHLM=ABS(HLM)                                                  ST        167
           THLM=HLM+HLM                                                   ST        168
           THLPT(NP2)=THLM                                                ST        169
           TM=EM U(NP1)                                                   ST        170
           TTM=TM+AHLM+ABS(TM-AHLM)                                       ST        171
           P4OMM=PO4(NP2)*BOM(NP2)                                        ST        172
           A(NP2)=2.*TNP3-RME+ARME                                        ST        173
           B(NP2)=TTM+THLM-TNP3-PGOM(NP1)                                 ST        174
           C(NP2)=P4OMM*(3.*U(NP2)+U(NP1))-US(NP2)                        ST        175
           D(NP2)=A(NP2)+B(NP2)+PBOM(NP2)                                 ST        176
C   --------      MID-STREAM COEFFICIENTS    ----------                   ST        177
           DO 3005 I=3,NP1                                                ST        178
           THLM=THLP                                                      ST        179
           HLP=RMID2-GD4*OMPOM(I)                                         ST        180
           THLP=HLP+HLP                                                   ST        181
           THLPT(I)=THLP                                                  ST        182
           AHLP=ABS(HLP)                                                  ST        183
           AHLPT(I)=AHLP                                                  ST        184
           TTM=TTP                                                        ST        185
           TP=EM U(I)                                                     ST        186
           TTP=TP+AHLP+ABS(TP-AHLP)                                       ST        187
           A(I)=TTP-THLP-PGOM(I)                                          ST        188
           B(I)=TTM+THLM-PGOM(I-1)                                        ST        189
           C(I)=PO4(I)*(BONT3(I)*U(I)+OMD(I)*U(I+1)+OMD(I-1)*U(I-1))-US(I)  ST      190
           D(I)=A(I)+B(I)+PBOM(I)                                         ST        191
      3005 CONTINUE                                                       ST        192
           GO TO (3021,3020), NOVEL                                       ST        193
      3020 IF(ITEST) 3900,3905,3900                                       ST        194
      3900 WRITE(6,3901) (A(I),I=2,NP2)                                   ST        195
           WRITE(6,3902) (B(I),I=2,NP2)                                   ST        196
           WRITE(6,3903) (C(I),I=2,NP2)                                   ST        197
           WRITE(6,3904) (D(I),I=2,NP2)                                   ST        198
      3901 FORMAT(7H  A(I) ,1P11E11.3/(7X,11E11.3))                       ST        199
      3902 FORMAT(7H  B(I) ,1P11E11.3/(7X,11E11.3))                       ST        200
      3903 FORMAT(7H  C(I) ,1P11E11.3/(7X,11E11.3))                       ST        201
      3904 FORMAT(7H  C(I) ,1P11E11.3/(7X,11E11.3))                       ST        202
      3905 CONTINUE                                                       ST        203
C-----------------------------                    --------------------    ST        204
           IF (KIN.EQ.2.AND.RU(1).NE.0.) U(1)=U(1)-DPDX(1)*DZ(1)/RU(1)    ST        205
           IF (KEX.EQ.2.AND.RU(NP3).NE.0.) U(NP3)=U(NP3)-DPDX(NP3)*DZ(NP3)  ST      206
         1 /RU(NP3)                                                       ST        207
C-----------------------------  SOLVE FOR DOWNSTREAM U 'S  ------------   ST        208
           B(2)=(B(2)*U(1)+C(2))/D(2)                                     ST        209
           A(2)=A(2)/D(2)                                                 ST        210
           DO 3048 I=3,NP2                                                ST        211
           T=D(I)-B(I)*A(I-1)                                             ST        212
           A(I)=A(I)/T                                                    ST        213
      3048 B(I)=(B(I)*B(I-1)+C(I))/T                                      ST        214
           DO 3050 IDASH=2,NP2                                            ST        215
           I=N+4-IDASH                                                    ST        216
           U(I)=A(I)*U(I+1)+B(I)                                          ST        217
C   ----------------------------------------  TEST FOR NEGATIVE U'S       ST        218
C/IUTRAP=0,NO ACTION/ .GT.0,SET TO 1.E-30/ .GT.1,IFIN=-I/ .GT.2,ITEST=1/  ST        219
           IF(IUTRAP.EQ.0.OR.I.EQ.2.OR.I.EQ.NP2) GO TO 3050               ST        220
           IF(U(I)) 3046,3046,3050                                        ST        221
      3046 J=ISTEP+1                                                      ST        222
           WRITE(6,3047) U(I),I,J                                         ST        223
      3047 FORMAT(25H ********** U (LE ZERO) =,1PE10.3,6H AT I=,I3,       ST        224
         1 8H, ISTEP=,I6,34H, SET U TO 1.E-30 ******** STRIDE3)           ST        225
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```
           U(1)=1.E-30                                                   ST      226
           IFIN=-IUTRAP/2                                                ST      227
           ITEST=IUTRAP/3                                                ST      228
      3050 CONTINUE                                                      ST      229
C     ----------------------------------------------------------        ST      230
           IF(KIN.EQ.3) U(1)=.5*(U(2)+U(3))                              ST      231
           IF(KEX.EQ.3)U(NP3)=.5*(U(NP1)+U(NP2))                         ST      232
      3021 IF (ITEST) 3011,3014,3011                                     ST      233
      3011 WRITE(6,3012) (U(I),I=1,NP3)                                  ST      234
      3012 FORMAT(3H U ,6X,1P11E11.3/(9X,11E11.3))                       ST      235
C          ------------------------------------------------              ST      236
C     ---------------    SOLVE FOR DOWN STREAM F'S    ----------------   ST      237
      3014 DO 3321 J=1,NF                                                ST      238
           IF (ISOLVE(J).EQ.0) GO TO 3321                                ST      239
           AKAS=FLOAT(IKAS(J))                                           ST      240
C     -------    COMPUTE SOURCE TERMS    ---------                       ST      241
           CALL SOURCE(J)                                                ST      242
C     --------   GRID POINT 2    --------                                ST      243
           TP=EM U(2)                                                    ST      244
           TPF2=TP/PREF(J)                                               ST      245
           THLP=THLPT(2)                                                 ST      246
           AMLP=.5*ABS(THLP)                                             ST      247
           TTPF(J)=TPF2+AMLP+ABS(TPF2-AMLP)                              ST      248
           T1F=T1FF(J)                                                   ST      249
           IF (KIN.NE.1) GO TO 2302                                      ST      250
           IF(INDI(J).EQ.2) GO TO 2303                                   ST      251
CC    -------------    EDGE VALUE SPECIFIED    -----------               ST      252
      2302 A(2)=TTPF(J)-THLP-T1F-(PGOM(2)-.5*SD(2))*AKAS                 ST      253
           B(2)=2.*T1F+RMI+ARMI                                          ST      254
           D(2)=A(2)+B(2)+PBOM(2)-2.*SD(2)                               ST      255
           IF (J.NE.JVT) GO TO 510                                       ST      256
           RP=.5*(R(2)+R(3))                                             ST      257
           ATP=2.*(RP/R(3))**2                                           ST      258
           AT1=(R(1)/RP)**2                                              ST      259
           DTP=2.*(RP/(.75*R(2)+.25*R(3)))**2                            ST      260
           A(2)=TTPF(J)*ATP-THLP-T1F*AT1-(PGOM(2)-.5*SD(2))*AKAS         ST      261
           TT=3.*PGOM(2)-1.5*SD(2)                                       ST      262
           IF (IKAS(J).EQ.0) TT=4.*PGOM(2)-2.*SD(2)                      ST      263
           D(2)=TTPF(J)*DTP+T1F+THLP+TT                                  ST      264
       510 T=-T1F*FBIFI(J)                                               ST      265
           GO TO 2305                                                    ST      266
C     --------------    EDGE FLUX SPECIFIED    -----------               ST      267
      2303 A(2)=TTPF(J)-THLP-(PGOM(2)-.5*SD(2))*AKAS                     ST      268
           B(2)=0.                                                       ST      269
           D(2)=A(2)+PBOM(2)-2.*SD(2)+RMI*2.                             ST      270
           T=RMI*F(J,1)+AJI(J)*R(1)                                      ST      271
      2305 TT=3.*F(J,2)+F(J,3)                                           ST      272
           IF (IKAS(J).EQ.0) TT=4.*F(J,2)                                ST      273
           C(2)=PGOMP*TT+2.*(T+SU(2))                                    ST      274
      2300 CONTINUE                                                      ST      275
C     ---------    GRID POINT NP2    --------                            ST      276
           TM=EM U(NP1)                                                  ST      277
           TMF=TM/PREF(J)                                                ST      278
           THLM=THLPT(NP2)                                               ST      279
           AMLM=.5*ABS(THLM)                                             ST      280
           TTMF=TMF+AMLM+ABS(TMF-AMLM)                                   ST      281
           TMP3F=TMP3FF(J)                                               ST      282
           IF (KEX.NE.1) GO TO 2312                                      ST      283
           IF(INDE(J).EQ.2) GO TO 2313                                   ST      284
C     ---------------    EDGE VALUE SPECIFIED    --------                ST      285
      2312 A(NP2)=2.*TMP3F-RME+ARME                                      ST      286
           B(NP2)=TTMF+THLM-TMP3F-(PGOM(NP1)-.5*SD(NP2))*AKAS            ST      287
           D(NP2)=A(NP2)+B(NP2)+PBOM(NP2)-2.*SD(NP2)                     ST      288
           IF (J.NE.JVT) GO TO 520                                       ST      289
           RM=.5*(R(NP2)+R(NP1))                                         ST      290
           BTM=2.*(RM/R(NP1))**2                                         ST      291
           BTMP3=(R(NP3)/RM)**2                                          ST      292
           DTM=2.*(RM/(.75*R(NP2)+.25*R(NP1)))**2                        ST      293
           B(NP2)=TTMF*BTM+THLM-TMP3F*BTMP3-(PGOM(NP1)-.5*SD(NP2))*AKAS  ST      294
           TT=3.*PGOM(NP1)-1.5*SD(NP2)                                   ST      295
           IF (IKAS(J).EQ.0) TT=4.*PGOM(NP1)-2.*SD(NP2)                  ST      296
           D(NP2)=TTMF*DTM+TMP3F-THLM+TT                                 ST      297
       520 T=-TMP3F*FDIFE(J)                                             ST      298
           GO TO 2315                                                    ST      299
C     ------------    EDGE FLUX SPECIFIED    ---------                   ST      300
      2313 A(NP2)=0.                                                     ST      301
           B(NP2)=TTMF+THLM-(PGOM(NP1)-.5*SD(NP2))*AKAS                  ST      302
```

```
            D(NP2)=B(NP2)+PBOM(NP2)-2.*D(NP2)-RME*Z.                          ST      303
            T=-RME*F(J,NP3)-AJE(J)*C(NP3)                                      ST      304
      2315  TT=2.*F(J,NP2)-F(J,NP1)                                            ST      305
            IF (IKAS(J).EQ.0) TT=4.*F(J,NP2)                                   ST      306
            C(NP2)=PBOMP*TT+2.*(T+SU(NP2))                                     ST      307
      2320  CONTINUE                                                           ST      308
     C -------   MID-STREAM COEFFICIENTS   ---------                           ST      309
            DO 3060 I=3,NP1                                                    ST      310
            TTMF=TTPF(J)                                                       ST      311
            TPF=EM U(I)/PREF(J)                                                ST      312
            TTPF(J)=TPF+AHLPT(I)+ABS(TPF-AHLPT(I))                             ST      313
            IF (J.EQ.JWT) GO TO 3015                                           ST      314
            A(I)=TTPF(J)-THLPT(I)-PGOM(I)*AKAS                                 ST      315
            B(I)=TTMF+THLPT(I-1)-PGOM(I-1)*AKAS                                ST      316
            D(I)=A(I)+B(I)+PBOM(I)-2.*D(I)                                     ST      317
            GO TO 2999                                                         ST      318
     C      ---------------                                                    ST      319
      3015  RP=.5*(R(I)+R(I+1))                                                ST      320
            RM=.5*(R(I)+R(I-1))                                                ST      321
            RMM=R(I-1)                                                         ST      322
            IF (I.EQ.3) RMM=.75*R(2)+.25*R(3)                                  ST      323
            RPP=R(I+1)                                                         ST      324
            IF (I.EQ.NP1) RPP=.75*R(NP2)+.25*R(NP1)                            ST      325
            ATP=2.*(RP/RPP)**2                                                 ST      326
            BTM=2.*(RM/RMM)**2                                                 ST      327
            DTP=2.*(RP/R(I))**2                                                ST      328
            DTM=2.*(RM/R(I))**2                                                ST      329
            A(I)=TTPF(J)*ATP-THLPT(I)-PGOM(I)*AKAS                             ST      330
            B(I)=TTMF*BTM+THLPT(I-1)-PGOM(I-1)*AKAS                            ST      331
            TT=PGO4(I)*BOMT3(I)                                                ST      332
            IF (IKAS(J).EQ.0) TT=4.*PGO4(I)*BOM(I)                             ST      333
            D(I)=TTPF(J)*DTP+TTMF*DTM+THLPT(I)-THLPT(I-1)+TT-2.*SD(I)          ST      334
      2999  TT=BOMT3(I)*F(J,I)+OMD(I)*F(J,I+1)+OMS(I-1)*F(J,I-1)               ST      335
            IF (IKAS(J).EQ.0) TT=4.*BOM(I)*F(J,I)                              ST      336
      3302  C(I)=PGO4(I)*TT+2.*SU(I)                                           ST      337
            IF(ITEST) 3906,3907,3906                                           ST      338
      3906  WRITE(6,3901) (A(I),I=2,NP2)                                       ST      339
            WRITE(6,3902) (B(I),I=2,NP2)                                       ST      340
            WRITE(6,3903) (C(I),I=2,NP2)                                       ST      341
            WRITE(6,3904) (D(I),I=2,NP2)                                       ST      342
      3907  CONTINUE                                                           ST      343
     C      ------------------------------------------------                   ST      344
            B(2)=(B(2)*F(J,1)+C(2))/D(2)                                       ST      345
            A(2)=A(2)/D(2)                                                     ST      346
            DO 3140 I=3,NP2                                                    ST      347
            T=D(I)-B(I)*A(I-1)                                                 ST      348
            A(I)=A(I)/T                                                        ST      349
      3140  B(I)=(B(I)*B(I-1)+C(I))/T                                          ST      350
            DO 3150 IDASH=2,NP2                                                ST      351
            I=N+4-IDASH                                                        ST      352
      3150  F(J,I)=A(I)*F(J,I+1)+B(I)                                          ST      353
     C-------------------------------- ADJUST F(J,1) AND F(J,NP3) -----------  ST      354
            GO TO (3210,3220,3230),KIN                                         ST      355
      3210  IF(INDI(J).EQ.2) F(J,1)=FD(FI(J))+.5*(F(J,2)+F(J,3))+AJI(J)/GI(J)  ST      356
            GO TO 3220                                                         ST      357
      3230  F(J,1)=.5*(F(J,2)+F(J,3))                                          ST      358
      3220  GO TO (3310,3320,3330),KEX                                         ST      359
      3310  IF(INDE(J).EQ.2) F(J,NP3)=FD(FE(J))+.5*(F(J,NP2)+                  ST      360
           1                          F(J,NP1))-AJE(J)/GE(J)                   ST      361
            GO TO 3320                                                         ST      362
      3330  F(J,NP3)=.5*(F(J,NP1)+F(J,NP2))                                    ST      363
      3320  IF(ITEST) 3322,3321,3322                                           ST      364
      3322  WRITE(6,3323) J,(F(J,I),I=1,NP3)                                   ST      365
      3323  FORMAT(5H F, J=,I3,1P11E11.3/(9X,11E11.3))                         ST      366
      3321  CONTINUE                                                           ST      367
     C      --------------------------------------------------                 ST      368
      3060  ZUI=ZI                                                             ST      369
            ZUE=ZE                                                             ST      370
            PSII=PSII-RMI*DZ(1)                                                ST      371
            PSIE=PSIE-RME*DZ(NP3)                                              ST      372
            PEI=PSIE-PSII                                                      ST      373
            ISTEP=ISTEP+1                                                      ST      374
            RETURN                                                             ST      375
     C****************************   S T R I D E 4   ************************* ST      376
      4000  CONTINUE                                                           ST      377
            NO2=N/2                                                            ST      378
            NP1=N+1                                                            ST      379
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          SUBROUTINE STRIDE      73/74   OPT=0 TRACE                      FTN 4.6+439         08/24/78  10.30.04        PAGE     6

                            NP2=N+2                                                                ST          380
                            NP3=N+3                                                                ST          381
                            DM(1)=0.                                                               ST          382
                            DM(NP3)=1.                                                             ST          383
      390                   ISTEP=0                                                                ST          384
                            IEND=10000                                                             ST          385
                            IAX=10000                                                              ST          386
                            IOUT=10000                                                             ST          387
                            DO 4010 I=1,NP3                                                        ST          388
      395            4010   DZ(I)=0.                                                               ST          389
                            IFIN=0                                                                 ST          390
                            KIN=1                                                                  ST          391
                            KEX=1                                                                  ST          392
                            RETURN                                                                 ST          393
      400            9010   FORMAT(1H ,1P11E11.3)                                                  ST          394
                            END                                                                    ST          395

   CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

      199       I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
      361       I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
      365       I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

```
                SUBROUTINE WF(J,I1,OUT1,OUT2,OUT3)                                   WF          2
                COMMON/COMA/A(43),AJE(7),AJI(7),B(43),C(43),CSALFA,D(43),DPDX(43),   COMA        2
               1 DX,EMU(43),F(7,43),FS(5,43),IAX,IEND,IFIN,INDE(7),INDI(7),IOUT,     COMA        3
               2 ISTEP,ITEST,IUTRAP,JS,JSU,JU,JT,KEX,KIN,KRAD,N,NEQ,NF,NOVEL,NP1,    COMA        4
               3 NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(7),PREF(7),PSIE,PSII,R(43),     COMA        5
               4 RHO(43),RME,RMI,RU(43),SD(43),SU(43),TAUE,TAUI,U(43),XD,XU,         COMA        6
               5 Y(43),YE,YI,PSWRL(43),RDY(43),ISOLVE(7),ZS(43),AMU(43),             COMA        7
               5 DZ(43),DZOLD(43),ZUI,ZUE,ZDI,ZDE,DPADZ(43),                         COMA        8
               6 JH,JFU,JFOOX,JCO,JVT,JK,JR,JDE,JT,JH2,JH2O,JCO2                     COMA        9
                COMMON/COMB/AK,ALMG,EWALL,GAMA,HPD,INDEXT,MASSTR,MODEL,PRESS,        COMB        2
               1 UGAS,WFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,      COMB        3
               2 PREXP2,CR1,CR2,POWER,PODCP,RATIO1,RATIO2,RATIO3,RSTIO4              COMB        4
          C/-------- SUBROUTINE FOR PROGRAM GENMIX 66                                WF          5
          C/--------------- D.B.SPALDING, IMPERIAL COLLEGE, 1972 ---------------     WF          6
          C                                                                          WF          7
          C     EFFECTS OF PRESSURE GRADIENT AND MASS TRANSFER ARE INCLUDED          WF          8
          C     EFFECTS OF RADIUS VARIATION ARE NEGLECTED                            WF          9
          C     FOR VELOCITY,      OUT1=BP,     OUT2=T,   OUT3=TAU                   WF         10
          C     FOR FS,            OUT1=FIDIF,  OUT2=T,   OUT3=G                     WF         11
          C                                                                          WF         12
                DATA SHALF/.04/, BPLAST/.9/                                          WF         13
                INT=1/I1                                                             WF         14
                I2=I1-1+2*INT                                                        WF         15
                I3=I1-2+4*INT                                                        WF         16
                I25=I3-INT                                                           WF         17
                IF(J) 100,190,200                                                    WF         18
          C ---------------------------------------------  VELOCITY                  WF         19
            100 UREF=.5*(U(I2)+U(I3))                                                WF         20
                RHOREF=.5*RHO(I1)+.25*(RHO(I2)+RHO(I3))                              WF         21
                RUREF=RHOREF*UREF                                                    WF         22
                RREF=.5*(R(I2)+R(I3))                                                WF         23
                VREF=EMU(I1)                                                         WF         24
                YREF=YI+(YE-YI)*OM(I1)                                               WF         25
                RE=UREF*RHOREF*YREF/VREF                                             WF         26
                RRUREF=RREF*RUREF                                                    WF         27
                AM=(RMI-(RME+RMI)*OM(I1))/RRUREF                                     WF         28
                EF=YREF*DPDX(I1)/RUREF/UREF                                          WF         29
                IF(MODEL.EQ.1) GO TO 110                                             WF         30
                IF(RE.LT.132.25) GO TO 110                                           WF         31
          C--------------------------------------------EXTENDED LOG LAW              WF         32
                ER=RE*EWALL                                                          WF         33
                NIT=0                                                                WF         34
            101 SHALF1=SHALF                                                         WF         35
                S=SHALF**2                                                           WF         36
                SLOC=S+AM+EF                                                         WF         37
                IF(SLOC.GT.0.) GO TO 104                                             WF         38
                SLOC=1.E-30                                                          WF         39
                SHALF=SQRT(ABS(AM+EF))                                               WF         40
            104 BEE=SQRT(SLOC)/AK                                                    WF         41
                ARG=ER*(SHALF+(AM/(1.+BEE)+.5*EF)/SHALF)                             WF         42
                IF(ARG.GT.11.5*EWALL) GO TO 106                                      WF         43
                GO TO 110                                                            WF         44
            106 SHALF=AK/ALOG(ARG)                                                   WF         45
                IF(ABS(SHALF-SHALF1).LT..0001.OR.NIT.GT.10) GO TO 102                WF         46
                NIT=NIT+1                                                            WF         47
                GO TO 101                                                            WF         48
            102 S=SHALF**2                                                           WF         49
                SAP=.5*(SHALF**2+SLOC)                                               WF         50
                OUT1=1./(1.+BEE)                                                     WF         51
                EMU(I25)=.25*RHOREF*RREF*ABS(U(I3)-U(I2))*(AK/OUT1)**2               WF         52
                GO TO 103                                                            WF         53
          C ---------------------------------------------  LAMINAR FLOW              WF         54
            110 AMRE=AM*RE                                                           WF         55
                FRE=EF*RE                                                            WF         56
                IF(ABS(AMRE).LT..01) GO TO 111                                       WF         57
                AMRE=AMAX1(-60.,AMIN1(60.,AMRE))                                     WF         58
                EXPMRE=EXP(AMRE)                                                     WF         59
                STORE=EXPMRE-1.-AMRE                                                 WF         60
                AMRESQ=AMRE*AMRE                                                     WF         61
                SRE=AMRE*(1.-STORE*FRE/AMRESQ)/(EXPMRE-1.)                           WF         62
                OUT1=SRE*STORE/AMRESQ+FRE*(STORE-.5*AMRESQ)/(AMRESQ*AMRE)            WF         63
                GO TO 112                                                            WF         64
            111 SRE=(2.-FRE*(1.+AMRE/3.))/(2.+AMRE)                                  WF         65
                OUT1=SRE*(.5+AMRE/6.)+FRE*(.16667+AMRE/24.)                          WF         66
            112 IF(SRE.GT.1.E-30) GO TO 113                                          WF         67
                SRE=1.E-30                                                           WF         68
                OUT1=.33333                                                          WF         69
```

```
  113 S=SRE/RE
      EM=U(I2+1)-UREF*RREF/ABS(Y(I3)-Y(I2))
  103 OUT2=S*RR*UREF
      OUT3=OUT2*UREF/R(I1)
C     ------------ UNDER-RELAX OUT1.
      OUT1=.5*OUT1+.5*EPLAST
      EPLAST=OUT1
      RETURN
C-------------------------  STAGNATION ENTHALPY, FUEL, OX-FU/OXDFU
  200 IF(RE.LT.132.25) GO TO 210
      IF(MODEL.EQ.1) GO TO 210
      IF (ARG.LE.11.5*EWALL) GO TO 210
      PRRAT=PR(J)/PREF(J)
      PJAY=9.*(PRRAT-1.)/PRRAT**.25
      S=SAV/PREF(J)/(1.+AMAX1(-.99999,PJAY*SQRT(ABS(SAV))))
      OUT1=0.
      IF (J.EQ.JH) OUT1=(H-1.)*.5*UREF**2
      OUT2=S*RR*UREF
      IF (J.EQ.JK) OUT2=0.
      OUT3=OUT2/R(I1)
      RETURN
  210 IF(ABS(AMPE).LT..01) GO TO 211
      S=AMPE/(EXP(PR(J)*AMPE)-1.)
      GO TO 212
  211 S=1./PR(J)/RE/(1.+.5*PR(J)*AMPE)
  212 OUT1=0.
      IF (J.EQ.JH) OUT1=(PR(J)-1.)*.5*UREF**2
      OUT2=S*RR*UREF
      IF (J.EQ.JK) OUT2=0.
      OUT3=OUT2/R(I1)
      RETURN
      END
```

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SUBROUTINE PLOTS       73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  10.30.04        PAGE     1

      SUBROUTINE PLOTS (X,IDIM,IMAX,XAXIS,Y,JDIM,JMAX,YAXES,SYMBOL)
C*****16.8.72*********************************************************
C                                                                    *
C   SUBROUTINE FOR PLOTTING J CURVES OF Y(J,I) AGAINST X(I).
C                                                                    *
C   X AND Y ARE ASSUMED TO BE IN ANY RANGE EXCEPT THAT NEGATIVE VALUES *
C    ARE PLOTTED AS ZERO.                                             *
C   X AND Y ARE SCALED TO THE RANGE 0. TO 1. BY DIVISION BY THE MAXIMA, *
C    WHICH ARE ALSO PRINTED.                                          *
C   IDIM IS THE VARIABLE DIMENSION FOR X.                             *
C   IMAX IS THE NUMBER OF X VALUES.                                   *
C   XAXIS STORES THE NAME OF THE X-AXIS.                              *
C   JDIM IS THE VARIABLE DIMENSION FOR Y.                             *
C   JMAX IS THE NUMBER OF CURVES TO BE PLOTTED, (UP TO 10).           *
C   THE ARRAY YAXES(J) STORES THE NAMES OF THE CURVES.                *
C   THE ARRAY SYMBOL(J) STORES THE SINGLE CHARACTERS USED FOR PLOTTING. *
C                                                                    *
C*********************************************************************
      DIMENSION X(IDIM),Y(JDIM,IDIM),YAXES(JDIM,2),SYMBOL(JDIM),
     1 A(101),YMAX(10)
      DATA  DOT,CROSS,BLANK/1H.,1H+,1H /
C*****  SCALING X ARRAY TO THE RANGE 0 TO 50
      XMAX=1.E-30
      DO 1 I=1,IMAX
    1 IF(X(I).GT.XMAX) XMAX=X(I)
      DO 2 I=1,IMAX
      X(I)=X(I)/XMAX*50.
    2 IF(X(I).LT.0.) X(I)=0.
C*****  SCALING Y ARRAY TO THE RANGE 0 TO 100
      DO 3 J=1,JMAX
      YMAX(J)=1.E-30
      DO 4 I=1,IMAX
    4 IF(Y(J,I).GT.YMAX(J)) YMAX(J)=Y(J,I)
      DO 3 I=1,IMAX
      Y(J,I)=Y(J,I)/YMAX(J)*100.
    3 IF(Y(J,I).LT.0.) Y(J,I)=0.
C*****  IDENTIFYING THE VARIOUS CURVES TO BE PLOTTED
      WRITE(6,103) XAXIS,XMAX
      WRITE(6,100)((YAXES(I,J),J=1,2),I=1,JMAX)
      WRITE(6,106) (SYMBOL(I),I=1,JMAX)
      WRITE(6,107) (YMAX(I),I=1,JMAX)
      DO 5 I=1,11
    5 A(I)=0.1*FLOAT(I-1)
      WRITE(6,101) (A(I),I=1,11)
C*****  MAIN LOOP.  EACH PASS PRODUCES AN X-CONSTANT LINE.
      DO 40 I=1,51
      IF(I.EQ.1.OR.I.EQ.51) GO TO 32
      GO TO 33
C*****  ALLOCATE . OR + AS MARKER ON THE Y-AXIS
   32 DO 30 K=1,101
   30 A(K)=DOT
      DO 31 K=1,101,10
   31 A(K)=CROSS
C*****  ALLOCATE . OR + MARK ON THE X-AXIS, ALSO THE APPROPRIATE X VALUE
   33 A(1)=DOT
      A(101)=DOT
      K=I-1
   46 K=K-5
      IF(K)48,47,46
   47 A(1)=CROSS
      A(101)=CROSS
   48 XL=0.02*FLOAT(I-1)
C*****  CHECK IF ANY Y( X(I) ) VALUE LIES ON THIS X-CONSTANT LINE
C*****  IF YES GO TO 41, OTHERWISE GO TO 42
      DO 43 K=1,IMAX
      IF(IFIX(X(K)+1.5)-I) 43,41,43
C*****  LOCATE  Y(  X(I)  )
   41 DO 44 J=1,JMAX
      NY=Y(J,K)+1.5
      A(NY)=SYMBOL(J)
   44 CONTINUE
      GO TO 42
   43 CONTINUE
C*****  PRINT X-CONSTANT LINE
   42 WRITE(6,105) XL,(A(K),K=1,101),XL
C*****  PUTTING BLANKS INTO X-CONSTANT LINE
      DO 49 K=1,101
```

```
      49 A(K)=BLANK                                                   PL      79
      40 CONTINUE                                                     PL      80
         DO 50 I=1,11                                                 PL      81
      50 A(I)=.1*FLOAT(I-1)                                           PL      82
         WRITE(6,104) (A(I),I=1,11)                                   PL      83
         RETURN                                                       PL      84
     100 FORMAT(11H Y-AXES ARE,5X,10(1X,A6,A4))                       PL      85
     101 FORMAT(1H0,2X,11F10.1)                                       PL      86
     102 FORMAT(15H MAXIMUM VALUES,1P10E11.3)                         PL      87
     103 FORMAT(11H0X-AXIS IS ,A6,17H ,MAXIMUM VALUE =,1PE10.3)       PL      88
     104 FORMAT (3X,11F10.1)                                          PL      89
     105 FORMAT(2H X,F6.2,3X,101A1,F6.2)                              PL      90
     106 FORMAT(7H SYMBOL,11X,10(1X,A10))                             PL      91
         END                                                          PL      92
```

APPENDIX F

LISTING OF EMISSIONS MODEL

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PROGRAM MAIN        73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  14.42.35          PAGE     1

      PROGRAM MAIN (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE4)                  MA        2
C                                                                                 MA        3
C     ****************************************************************            MA        4
C     ****************************************************************            MA        5
C     ****************** COMBUSTOR DESIGN CRITERA *********************            MA        6
C     EMISSIONS MODEL                                                             MA        7
C                                                                                 MA        8
C                                                                                 MA        9
C     ----------------------------------------------------------------            MA       10
CHAPTER0000000000000000000  PRELIMINARIES  000000000000000000000000000000          MA       11
C     ---------------------------- DIMENSIONS AND COMMON BLOCKS.                  MA       12
      COMMON/COMA/A(43),AJE(15),AJI(15),B(43),C(43),CSALFA,D(43),                 COMA      2
     1 DPDX(43),DX,EMU(43),F(15,43),FS(3,43),IAX,IEND,IFIN,INDE(15),              COMA      3
     2 INDI(15),IOUT,ISTEP,ITEST,IUTRAP,JS,JSM,JU,JY,KEX,KIN,KRAD,N,              COMA      4
     3 NO2,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(15),                  COMA      5
     4 PREF(15),PSIE,PSII,R(43),RHO(43),RU(43),RME,RPI,SD(43),SU(43),             COMA      6
     5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSMPL(43),RSY(43),ISOLVE(15),            COMA      7
     6 US(43),RMU(43),SUM1,SUM2,SUM3,SUM4,PDGSCM,FOIFI(15),FOIFE(15),             COMA      8
     7 SE(15),SI(15),JLOC(12),W(12),JM,JFU,JCO2,JCO,JO2,JH2O,JOH,JO,JH5,          COMA      9
     8 JH2,JN,JNO,JN2,JYT,JD,JE,JT,JRY,MSP,MSPP,ABSOR,SCATR,BCN(20C),             COMA     10
     9 TERM1,TERM2,ISMAX,EFU,EO2,EH2O,EPS,EPR                                     COMA     11
      COMMON/COMB/AK,ALMG,EWALL,FR,H,HFU,INERT,MASSTR,MODEL,PRESS,                COMB      2
     1 UBAR,UFAC,C1,C2,C3,C2WT,AKFAC,ALFAC,ARCOM1,ARCOM2,PREXP1,CD75,             COMB      3
     2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,             COMB      4
     3 CF,MT,DELG,WFU,WCO2,WCO,WO2,WH2O,WOH,WO,WH,                                COMB      5
     4 WH2,WN,WNO,WN2                                                             COMB      6
      COMMON/COMC/ABI(43),APE(43),XR(40),NBP                                      COMC      2
      COMMON/COMD/XUIMJ(12),UIMJ(12),YUIMJ(12),VTUIMJ(12),AUIMJ(12),              COMD      2
     1 XVIMJ(12),UVIMJ(12),VIMJ(12),VTVIMJ(12),TVIMJ(12),AVIMJ(12),               COMD      3
     2 RUIMJ(12),ARUIMJ(12),MUIMJ(12),XLUIMJ(12),TAN(2),RELA(2),                  COMD      4
     3 PRAD(2),MUI,MUE,MVI,MVE                                                    COMD      5
      DIMENSION TITLE(24),OUT(43),LAB(2)                                          MA       17
      DIMENSION XPLOT(43),YPLOT(10,43),TAXES(10,2),SYMBOL(10)                     MA       18
      DIMENSION FLUX(15),DFI(15),DFE(15),AJID(15),AJED(15)                        MA       19
      DIMENSION YIN(40),UIN(40),VTIN(40),TIN(40),MFUIN(40),MCOIN(40)              MA       20
      DIMENSION TKIN(40),TLIN(40),MCO2IN(40),MH2IN(40)                            MA       21
      DIMENSION MH2OIN(40),MO2IN(40)                                              MA       22
      DIMENSION IPLOT(18),IPRNT(18),SYM(18),LAB1(18),LAB2(18)                     MA       23
      REAL MFUIN,MCOIN,MCO2IN,LAB,LAB1,LAB2,MH2IN,MH2OIN,MO2IN                    MA       24
      NAMELIST/INPUT/IUTRAP,ULIM,RELLIM,AFAC,AEXOLM,POWER,NOVEL,                  MA       25
     1 ARCOM1,PREXP1,CR1,ARCOM2,PREXP2,CR2,CP,IDPDX,C1,C2,C3,                     MA       26
     2 C2WT,AKFAC,ALFAC,PREF,CI,MT,HFU,MODER,ITMIN,KREAD,UBAT,                    MA       27
     3 TERM1,TERM2,ISMAX,EFU,EO2,EH2O,EPS,EPR                                     MA       28
      DATA JM,JFU,JCO2,JCO,JO2,JH2O,JOH,JO,JH5/1,2,3,4,5,6,7,8,9/                 MA       29
      DATA JH2,JN,JNO,JOT,JE,JD,JN2,JT,JRY/10,11,12,13,14,15,1,2,3/               MA       30
      DATA IPLOT/0,1,0,1,1,0,0,0,0,0,0,0,0,1,0,0,0,1,0/                           MA       31
      DATA SYM/1HF,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9,1H*,1H+,                   MA       32
     1 1HY,1HO,1HR,1H.,1HT,1HB/                                                   MA       33
      DATA LAB1/9HENTH    ,6HMFUEL  ,6HMCO2   ,5HMCO    ,8HMOXYGEN,6HMH2O         MA       34
     1 5HOH    ,6HO     ,6HH      ,6HH2     ,6HN     ,6HNO     ,5HUT              MA       35
     2 6HRF     ,5HLEN   ,5HR2    ,5HTEMP  ,5HRAD   /                            MA       36
      DATA LAB2/18*2H  /                                                          MA       37
      DATA W/16.,44.,28.,32.,18.,17.,16.,1.,2.,14.,30.,28./                       MA       38
      DATA WFU,WCO2,WCO,WO2,WH2O,WOH,WO,WH,WH2,WN,WNO,WN2/16.,44.,28.,            MA       39
     1 32.,18.,17.,16.,1.,2.,14.,30.,28./                                         MA       40
      DATA SUM1,SUM2,SUM3,SUM4/0.,0.,0.,0./                                       MA       41
C                                                                                 MA       42
      READ(5,1) TITLE                                                             MA       43
    1 FORMAT(12A6)                                                                MA       44
C                                                                                 MA       45
C     ----------------------------------------------------------------            MA       46
CHAPTERIIIIIIIIIIIIIIIIIII  PARAMETERS AND CONTROL INDICES  IIIIIIIIIIIII          MA       47
      READ (5,2) N,KRAD,MASSTR,ISMPL,MODEL,INERT,IFLUX,ITERP                      MA       48
    2 FORMAT (8(I2,8X))                                                           MA       49
      READ (5,3) NSTAT,NPROF,NPLOT,ITEST,LASTEP                                   MA       50
    3 FORMAT (8(I5,5X))                                                           MA       51
      IUTRAP=2                                                                    MA       52
      ULIM=.05                                                                    MA       53
      RELLIM=.01                                                                  MA       54
      AFAC=.2                                                                     MA       55
      AEXOLM=.02                                                                  MA       56
      CSALFA=1.                                                                   MA       57
      IDPDX=1                                                                     MA       58
      H=.9                                                                        MA       59
      AK=.435                                                                     MA       60
      ALMG=.09                                                                    MA       61
      FR=.333                                                                     MA       62
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```
      UFAC=.01                                                          MA  63
      NOVEL=2                                                           MA  64
      ITMIN=1                                                           MA  65
      NREAD=0                                                           MA  66
      URAT=.03                                                          MA  67
      TERR1=.1                                                          MA  68
      TERR2=1.E-4                                                       MA  69
      EFU=1.0                                                           MA  70
       EO2=.5                                                           MA  71
      EH2O=.5                                                           MA  72
      ERO=2.0                                                           MA  73
      EPR=0.                                                            MA  74
      ISMAX=500                                                         MA  75
C                                                                       MA  76
C ----------------------------------------------------------------------MA  77
CHAPTER2222222222222222222222222  GRID AND GEOMETRY  222222222222222222222 MA  78
      READ (5,4) XU,XULAST,FRA,XEND,XOUT,PRESS,POWER                   MA  79
      READ (5,2) NBP                                                    MA  80
      READ (5,4) (XR(I),ARI(I),ARE(I),I=1,NBP)                          MA  81
      RI=TAB(XU,XR,ARI,NBP)                                             MA  82
      RE=TAB(XU,XR,ARE,NBP)                                             MA  83
      READ (5,4) RA,RB,RO                                               MA  84
    4 FORMAT (8E10.4)                                                   MA  85
C     ------ R(I) ADJUSTMENT MADE JUST BEFORE CALL STRIDE(I).           MA  86
C     -----------STRIDE4-----------STRIDE4-----------STRIDE4--------STRIDE4 MA  87
      CALL STRIDE(4)                                                    MA  88
      IF(XEND.EQ.0.) IEND=0                                             MA  89
      IF(XOUT.EQ.0.) IOUT=0                                             MA  90
C     -------------------- CHANGE IEND, IAX AND IOUT, IF NECESSARY.     MA  91
      DO 23 I=2,NP2                                                     MA  92
   23 OUT(I)=(FLOAT(I-2)/FLOAT(N))**ABS(POWER)                          MA  93
      IF (POWER.GT.0.0) GO TO 22                                        MA  94
      DO 24 I=2,NP2                                                     MA  95
      II=NP2+2-I                                                        MA  96
   24 Y(II)=1.0-OUT(I)                                                  MA  97
      GO TO 26                                                          MA  98
   22 DO 20 I=2,NP2                                                     MA  99
   20 Y(I)=OUT(I)                                                       MA 100
   26 CONTINUE                                                          MA 101
C                                                                       MA 102
C ----------------------------------------------------------------------MA 103
CHAPTER3333333333333333333333333  DEPENDENT VARIABLES SELECTION  3333333 MA 104
C                                                                       MA 105
      ISOLVE(JH)=ITEMP                                                  MA 106
      ISOLVE(JFU)=MASSTR                                                MA 107
      ISOLVE(JCO2)=MASSTR                                               MA 108
      ISOLVE(JCO)=MASSTR                                                MA 109
      ISOLVE(JOX)=MASSTR                                                MA 110
      ISOLVE(JH2O)=MASSTR                                               MA 111
      ISOLVE(JOH)=MASSTR                                                MA 112
      ISOLVE(JO)=MASSTR                                                 MA 113
      ISOLVE(JHS)=MASSTR                                                MA 114
      ISOLVE(JH2)=MASSTR                                                MA 115
      ISOLVE(JN)=MASSTR                                                 MA 116
      ISOLVE(JNO)=MASSTR                                                MA 117
      ISOLVE(JUT)=ISWRL                                                 MA 118
      ISOLVE(JK)=MODEL-1                                                MA 119
      ISOLVE(JD)=MODEL-1                                                MA 120
      NF=15                                                             MA 121
      NFS=3                                                             MA 122
      IPRNT(JH)=0                                                       MA 123
      IPRNT(JFU)=MASSTR                                                 MA 124
      IPRNT(JCO)=MASSTR                                                 MA 125
      IPRNT(JUT)=ISWRL                                                  MA 126
      IPRNT(JK)=MODEL-1                                                 MA 127
      IPRNT(JD)=MODEL-1                                                 MA 128
      IPRNT(JCO2)=MASSTR                                                MA 129
      IPRNT(JOX)=MASSTR                                                 MA 130
      IPRNT(JH2O)=MASSTR                                                MA 131
      IPRNT(JOH)=MASSTR                                                 MA 132
      IPRNT(JO)=MASSTR                                                  MA 133
      IPRNT(JHS)=MASSTR                                                 MA 134
      IPRNT(JH2)=MASSTR                                                 MA 135
      IPRNT(JN)=MASSTR                                                  MA 136
      IPRNT(JNO)=MASSTR                                                 MA 137
      INOF=NF                                                           MA 138
      IPRNT(JH2+INOF)=MASSTR                                            MA 139
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      IPRNT(JT+INDX)=ITEMP                                                  MA    140
      IPRNT(JRT+INDX)=0                                                     MA    141
      NSP=12                                                                MA    142
      NSPM=NSP-1                                                            MA    143
      JLOC(1)=JFU                                                           MA    144
      JLOC(2)=JCO2                                                          MA    145
      JLOC(3)=JCO                                                           MA    146
      JLOC(4)=JOX                                                           MA    147
      JLOC(5)=JH2O                                                          MA    148
      JLOC(6)=JOH                                                           MA    149
      JLOC(7)=JO                                                            MA    150
      JLOC(8)=JH                                                            MA    151
      JLOC(9)=JH2                                                           MA    152
      JLOC(10)=JN                                                           MA    153
      JLOC(11)=JNO                                                          MA    154
      JLOC(12)=JN2                                                          MA    155
C                                                                           MA    156
C   ----------------------------------------------------------------------  MA    157
CHAPTER4444444444444444444444444444  MATERIAL CONSTANTS  444444444444444    MA    158
C                                       S.I. UNITS                          MA    159
      GASCON=8314.                                                          MA    160
      WMIX=28.86                                                            MA    161
      CP=1048.                                                              MA    162
      CX=1.0                                                                MA    163
      HY=4.                                                                 MA    164
      HFU=-49317.                                                           MA    165
C     ---ARRCON IS ACTIVATION ENERGY DIVIDED BY UNIVERSAL GAS CONSTANT.     MA    166
      PREEX1=5.E+15                                                         MA    167
      ARCON1=28500.                                                         MA    168
      CPI=6.0                                                               MA    169
C                                                                           MA    170
      DO 40 J=1,NF                                                          MA    171
      PR(J)=.7                                                              MA    172
      PREF(J)=.86                                                           MA    173
   40 IF (MODEL.EQ.1) PREF(J)=PR(J)                                         MA    174
      PREF(JVT)=1.0                                                         MA    175
C   -----    TURBULENCE CONSTANTS      ----- ----                           MA    176
      C1=1.42                                                               MA    177
      C2=1.92                                                               MA    178
      CD=.09                                                                MA    179
      AKFAC=.03                                                             MA    180
      ALFAC=.02                                                             MA    181
      C2VT=0.36                                                             MA    182
      PREF(JK)=1.0                                                          MA    183
C    ---------      NAMELIST      -------                                   MA    184
      READ (5,INPUT)                                                        MA    185
      PREF(JD)=AK**2/(C2-C1)/SQRT(CD)                                       MA    186
      CD75=CD**.75                                                          MA    187
      GAMMA=CP/(CP-GASCON/WMIX)                                             MA    188
      RDGSCN=PRESS*WMIX/GASCON                                              MA    189
      WFU=12.*CX+HY                                                         MA    190
      W(1)=WFU                                                              MA    191
      RATIO1=WOX*(CX+HY/4.)/WFU                                             MA    192
      RATIO2=.232                                                           MA    193
      SLN=1./(1.-URAT)-1.                                                   MA    194
      DUM=COEF(WFU,1)                                                       MA    195
      DUM=COEF(HFU,1)                                                       MA    196
C                                                                           MA    197
C   ----------------------------------------------------------------------  MA    198
CHAPTER5555555555555555555555555555555555  INITIAL CONDITIONS  5555555555   MA    199
      READ (5,4) UA,UD,VTA,VTD                                              MA    200
      READ (5,4) F2A,F2D,TA,TD,TWALL                                        MA    201
C                                                                           MA    202
      F1A=F2A*HDR(TA,1)+(1.-F2A)*RATIO2*HDR(TA,4)+(1.-F2A)*(1.-RATIO2)*     MA    203
     1    HDR(TA,12)+.5*UA*UA                                               MA    204
      F1D=F2D*HDR(TD,1)+(1.-F2D)*RATIO2*HDR(TD,4)+(1.-F2D)*(1.-RATIO2)*     MA    205
     1    HDR(TD,12)+.5*UD*UD                                               MA    206
      READ (5,2) NIN,NUI,NUE,NVI,NVE                                        MA    207
      READ (5,4) (VIN(I),I=1,NVI)                                           MA    208
      READ (5,4) (UIN(I),I=1,NIN)                                           MA    209
      READ (5,4) (VTIN(I),I=1,NIN)                                          MA    210
      READ (5,4) (TIN(I),I=1,NIN)                                           MA    211
      READ (5,4) (MFUIN(I),I=1,NIN)                                         MA    212
      READ (5,4) (MCO2IN(I),I=1,NIN)                                        MA    213
      READ (5,4) (MCOIN(I),I=1,NIN)                                         MA    214
      READ (5,4) (MOXIN(I),I=1,NIN)                                         MA    215
      READ (5,4) (MH2OIN(I),I=1,NIN)                                        MA    216
```

```
      READ (5,4) (MWZIN(I),I=1,NIN)                                     MA       217
      IF (KREAD.EQ.0) GO TO 19                                          MA       218
      READ (5,4) (TKIN(I),I=1,NIN)                                      MA       219
      READ (5,4) (TLIN(I),I=1,NIN)                                      MA       220
   19 CONTINUE                                                          MA       221
C                                                                       MA       222
C ------------ READ INJECTION VALUES                                    MA       223
      IF (NUI.LE.0) GO TO 30                                            MA       224
      READ (5,4) (XUINJ(I),I=1,NUI)                                     MA       225
      READ (5,4) (XLUINJ(I),I=1,NUI)                                    MA       226
      READ (5,4) (UINJ(I),I=1,NUI)                                      MA       227
      READ (5,4) (VTUINJ(I),I=1,NUI)                                    MA       228
      READ (5,4) (TUINJ(I),I=1,NUI)                                     MA       229
      READ (5,4) (AUINJ(I),I=1,NUI)                                     MA       230
      READ (5,4) (MUINJ(I),I=1,NUI)                                     MA       231
      READ (5,4) (ARUINJ(I),I=1,NUI)                                    MA       232
      DO 31 I=1,NUI                                                     MA       233
      DEN=PDGSCM/TUINJ(I)                                               MA       234
   31 RUINJ(I)=DEN*UINJ(I)                                              MA       235
   30 NI=NUI+1                                                          MA       236
      XUINJ(NI)=2.*ABS(XULAST)                                          MA       237
      XLUINJ(NI)=2.*ABS(XULAST)                                         MA       238
      NI=NI+1                                                           MA       239
      IF (NUE.LE.0) GO TO 32                                            MA       240
      NE=NI+NUE-1                                                       MA       241
      READ (5,4) (XUINJ(I),I=NI,NE)                                     MA       242
      READ (5,4) (XLUINJ(I),I=NI,NE)                                    MA       243
      READ (5,4) (UINJ(I),I=NI,NE)                                      MA       244
      READ (5,4) (VTUINJ(I),I=NI,NE)                                    MA       245
      READ (5,4) (TUINJ(I),I=NI,NE)                                     MA       246
      READ (5,4) (AUINJ(I),I=NI,NE)                                     MA       247
      READ (5,4) (MUINJ(I),I=NI,NE)                                     MA       248
      READ (5,4) (ARUINJ(I),I=NI,NE)                                    MA       249
      DO 33 I=NI,NE                                                     MA       250
      DEN=PDGSCM/TUINJ(I)                                               MA       251
   33 RUINJ(I)=DEN*UINJ(I)                                              MA       252
   32 NE=NI+NUE                                                         MA       253
      XUINJ(NE)=2.*ABS(XULAST)                                          MA       254
      XLUINJ(NE)=2.*ABS(XULAST)                                         MA       255
      NUE=NUI+2                                                         MA       256
      NUI=1                                                             MA       257
      IF (NVI.LE.0) GO TO 35                                            MA       258
      READ (5,4) (XVINJ(I),I=1,NVI)                                     MA       259
      READ (5,4) (UVINJ(I),I=1,NVI)                                     MA       260
      READ (5,4) (VINJ(I),I=1,NVI)                                      MA       261
      READ (5,4) (VTVINJ(I),I=1,NVI)                                    MA       262
      READ (5,4) (TVINJ(I),I=1,NVI)                                     MA       263
      READ (5,4) (AVINJ(I),I=1,NVI)                                     MA       264
   35 NI=NVI+1                                                          MA       265
      XVINJ(NI)=2.*ABS(XULAST)                                          MA       266
      NI=NI+1                                                           MA       267
      IF (NVE.LE.0) GO TO 36                                            MA       268
      NE=NI+NVE-1                                                       MA       269
      READ (5,4) (XVINJ(I),I=NI,NE)                                     MA       270
      READ (5,4) (UVINJ(I),I=NI,NE)                                     MA       271
      READ (5,4) (VINJ(I),I=NI,NE)                                      MA       272
      READ (5,4) (VTVINJ(I),I=NI,NE)                                    MA       273
      READ (5,4) (TVINJ(I),I=NI,NE)                                     MA       274
      READ (5,4) (AVINJ(I),I=NI,NE)                                     MA       275
   36 NE=NI+NVE                                                         MA       276
      XVINJ(NE)=2.*ABS(XULAST)                                          MA       277
      NVE=NVI+2                                                         MA       278
      NVI=1                                                             MA       279
C                                                                       MA       280
C                                                                       MA       281
      DY=RE-RI                                                          MA       282
      Y(1)=0.0                                                          MA       283
      Y(NP3)=1.0                                                        MA       284
      DO 55 I=1,NP3                                                     MA       285
   55 Y(I)=Y(I)*DY                                                      MA       286
C                                                                       MA       287
      DO 400 I=1,NP3                                                    MA       288
      U(I)=TAB(Y(I),YIN,UIN,NIN)                                        MA       289
      F(JFU,I)=TAB(Y(I),YIN,MFUIN,NIN)                                  MA       290
      F(JCO2,I)=TAB(Y(I),YIN,MCO2IN,NIN)                                MA       291
      F(JCO,I)=TAB(Y(I),YIN,MCOIN,NIN)                                  MA       292
      F(JOX,I)=TAB(Y(I),YIN,MOXIN,NIN)                                  MA       293
```

```
      F(JH2O,I)=TAB(Y(I),YIN,XH2OIN,NIN)
      F(JH2,I)=TAB(Y(I),YIN,XH2IN,NIN)
      F(JVT,I)=TAB(Y(I),YIN,VTIN,NIN)
      FS(JT,I)=TAB(Y(I),YIN,TIN,NIN)
      IF (KREAD.EQ.0) GO TO 400
      F(JK,I)=TAB(Y(I),YIN,TKIN,NIN)
      F(JD,I)=CD*F(JK,I)**1.5/(TAB(Y(I),YIN,TLIN,NIN)+1.E-20)
  400 CONTINUE
C
      DO 410 I=1,NP3
      DPDX(I)=0.0
      R(I)=RI+Y(I)*CSALFA
      F(JQ,I)=0.
      F(JOM,I)=0.
      F(JMS,I)=0.
      F(JMB,I)=0.
      F(JML,I)=0.
      FS(JH2,I)=1.0
      DO 412 JJ=1,NSPR
      J=JLOC(JJ)
  412 FS(JH2,I)=FS(JH2,I)-F(J,I)
      WPI=0.
      DO 411 JJ=1,NSPR
      J=JLOC(JJ)
  411 WPI=WPI+F(J,I)*HBR(FS(JT,I),JJ)
      F(JH,I)=WPI+FS(JH2,I)*HBR(FS(JT,I),12)+.5*U(I)*U(I)
      IF (KREAD.EQ.1) GO TO 410
      F(JK,I)=AKFAC*U(I)*U(I)
      ALM=ALFAC*(Y(NP3)-Y(I))
      IF (IOUT.NE.0) ALM=AMIN1(ALM,ALFAC*Y(I))
      ALM=AMAX1(ALM,ALFAC*Y(NP3)/100.)
      F(JD,I)=CD*F(JK,I)**1.5/ALM
  410 CONTINUE
      ALM=ALFAC*Y(NP3)
C
      DO 52 I=1,NP3
      P(I)=PRESS
      PSWRL(I)=0.
      RII=R(I)
      IF (I.EQ.2) RII=.75*R(2)+.25*R(3)
      IF (I.EQ.NP2) RII=.75*R(NP2)+.25*R(NP1)
      F(JVT,I)=RII*F(JVT,I)
      WMIX=0.
      DO 413 JJ=1,NSPR
      J=JLOC(JJ)
  413 WMIX=WMIX+F(J,I)/W(JJ)
      WMIX=WMIX+FS(JH2,I)/W(12)
      RHO(I)=PRESS/FS(JT,I)/GASCON/WMIX
      IF (I.EQ.1) GO TO 52
      AFLO=.5*(R(I)**2-R(I-1)**2)
      IF (KRAD.EQ.0) AFLO=Y(I)-Y(I-1)
      GM(I)=.5*(RHO(I)*U(I)+RHO(I-1)*U(I-1))*AFLO
   52 CONTINUE
      DO 53 I=2,NP3
   53 GM(I)=GM(I-1)+GM(I)
      FLOTOT=GM(NP3)
      DO 51 I=1,NP3
   51 GM(I)=GM(I)/FLOTOT
C   -
      WMIX=F2A/WFU+(1.-F2A)*.03460
      ROA=PRESS/TA/GASCON/WMIX
      FLOA=ROA*UA*.5*(RB**2-RA**2)
      PSII=FLOA
      PEI=FLOTOT
      PSIE=PSII+PEI
      DTDLS=0.0
C
C     -----------------------------------------------------------------------
CHAPTER&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&  THERMODYNAMIC PROPERTIES  &&&&&&
C     *******************300  START OF MAIN LOOP  **********************
   60 CONTINUE
C
C     ------------------------------------------------------------ TEST 1
      IF(ITEST) 602,601,602
  602 LAB(1)=6HTEST 1
      LAB(2)=6H
      WRITE(6,700) LAB,R(1),PRESS,DX,PSII,PSIE,PEI,FRA,ULIN,PEILIM,AFAC,
```

```
      1               AEXDLM
      LAB(1)=1HU
      LAB(2)=6H
      WRITE(6,100) LAB,(U(I),I=1,NP3)
      LAB(1)=6HF(1,I)
      LAB(2)=6H
      WRITE(6,100) LAB,(F(1,I),I=1,NP3)
      LAB(1)=6HF(2,I)
      LAB(2)=6H
      WRITE(6,100) LAB,(F(2,I),I=1,NP3)
      LAB(1)=6HF(3,I)
      LAB(2)=6H
      WRITE(6,100) LAB,(F(3,I),I=1,NP3)
      LAB(1)=6HF(4,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(4,I),I=1,NP3)
      LAB(1)=6HF(5,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(5,I),I=1,NP3)
      LAB(1)=6HF(6,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(6,I),I=1,NP3)
      LAB(1)=6HF(7,I)
      LAB(2)=6H
      WRITE (5,100) LAB,(F(7,I),I=1,NP3)
      LAB(1)=6HF(8,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(8,I),I=1,NP3)
      LAB(1)=6HF(9,I)
      LAB(2)=6H
      WRITE (6,100) LAB,(F(9,I),I=1,NP3)
      LAB(1)=6HF(10,I
      LAB(2)=6H)
      WRITE (6,100) LAB,(F(10,I),I=1,NP3)
      LAB(1)=6HF(11,I
      LAB(2)=6H)
      WRITE (5,1GG) LAB,(F(11,I),I=1,NP3)
      LAB(1)=6HF(12,I
      LAB(2)=6H)
      WRITE (6,100) LAB,(F(12,I),I=1,NP3)
      LAB(1)=6HF(13,I
      LAB(2)=6H)
      WRITE (6,100) LAB,(F(13,I),I=1,NP3)
      LAB(1)=6HF(14,I
      LAB(2)=6H)
      WRITE (6,100) LAB,(F(14,I),I=1,NP3)
      LAB(1)=6HF(15,I
      LAB(2)=6H)
      WRITE (6,100) LAB,(F(15,I),I=1,NP3)
  601 CONTINUE
C
      DO 200 I=1,NP3
  200 P(I)=P(I)+DPOX(I)*BXOLD
      IF(NASSTR.NE.0) GO TO 64
      DO 65 I=1,NP3
      CPI=RATIO2*CPDR(FS(JT,I),4)+(1.-RATIO2)*CPDR(FS(JT,I),12)
      HPI=RATIO2*HDR(FS(JT,I),4)+(1.-RATIO2)*HDR(FS(JT,I),12)
      FS(JT,I)=AMAX1(1.,FS(JT,I)+(F(JM,I)-.5*U(I)*U(I)-HPI)/CPI)
   65 RHO(I)=P(I)*WMIX/FS(JT,I)/GASCON
      GO TO 66
   64 DO 61 I=1,NP3
      FS(JM2,I)=1.
      DO 607 JJ=1,NSPM
      J=JLOC(JJ)
  607 FS(JM2,I)=FS(JM2,I)-F(J,I)
      HPI=0.
      CPI=0.
      DO 606 JJ=1,NSPM
      J=JLOC(JJ)
      HPI=HPI+F(J,I)*HDR(FS(JT,I),JJ)
  606 CPI=CPI+F(J,I)*CPDR(FS(JT,I),JJ)
      HPI=HPI+FS(JM2,I)*HDR(FS(JT,I),12)
      CPI=CPI+FS(JM2,I)*CPDR(FS(JT,I),12)
      FS(JT,I)=FS(JT,I)+(F(JM,I)-.5*U(I)*U(I)-HPI)/CPI
      FS(JT,I)=AMAX1(FS(JT,I),100.)
      WMIX=0.
      DO 605 JJ=1,NSPM
```

```
      J=JLOC(JJ)                                                        MA        448
  605 VMIX=VMIX+F(J,I)/W(JJ)                                            MA        449
      VMIX=VMIX+FS(NM2,I)/WM2                                           MA        450
   61 RHO(I)=P(I)/FS(NT,I)/VMIX/GASCON                                  MA        451
   66 CONTINUE                                                          MA        452
      RHO(2)=RHO(1)                                                     MA        453
      RHO(NP2)=RHO(NP3)                                                 MA        454
C     ------------------------------------------------------ TEST 2     MA        455
      IF(ITEST) 604,603,604                                             MA        456
  604 LAB(1)=6HTEST 2                                                   MA        457
      LAB(2)=6H                                                         MA        458
      WRITE(6,100) LAB,PRESS,DX,DPDDX,PDGSCN                            MA        459
      LAB(1)=6HFS(1,I                                                   MA        460
      LAB(2)=1H)                                                        MA        461
      WRITE(6,100) LAB,(FS(1,I),I=1,NP3)                                MA        462
      LAB(1)=6HFS(2,I                                                   MA        463
      LAB(2)=1H)                                                        MA        464
      WRITE(6,100) LAB,(FS(2,I),I=1,NP3)                                MA        465
      LAB(1)=6HRHO(I                                                    MA        466
      LAB(2)=6H)                                                        MA        467
      WRITE(6,100) LAB,(RHO(I),I=1,NP3)                                 MA        468
  603 CONTINUE                                                          MA        469
C     ------------------------------- ADJUST R(1)                       MA        470
      IF (KIN.EQ.3) GO TO 609                                           MA        471
      R(1)=TAB(XU,XR,ARI,NRP)                                           MA        472
      IF (XU.LE.XUINJ(NUI)) GO TO 617                                   MA        473
      R(1)=SQRT(R(1)**2+2.*(AUINJ(NUI)-SUM1)/RUINJ(NUI))                MA        474
  617 IF (IEND.GE.ISTEP.OR.KRAD.EQ.0) GO TO 609                         MA        475
      R(1)=SQRT(RA**2+2.*PSII/RHO(1)/U(1))                              MA        476
C                                                                       MA        477
C     -----------STRIDE1-----------STRIDE1-----------STRIDE1--------STRIDE1 MA    478
609   CALL STRIDE(1)                                                    MA        479
C                                                                       MA        480
C     ------------------------------------------------------------------ MA        481
CHAPTER7777777777777777777777777777777777777  FORWARD STEP  777777777 MA        482
      DXOLD=AMAX1(.005*FRA*Y(NP3),DX)                                   MA        483
      DX=FRA*Y(NP3)                                                     MA        484
      IDXFIX=0                                                          MA        485
      IF(ISTEP.LT.50) DX=.1*DX                                          MA        486
      DX=AMIN1(DX,3.*DXOLD)                                             MA        487
C                                                                       MA        488
      IF(ISTEP.GE.IEND) GO TO 73                                        MA        489
      IF(DX.LT.XEND-XU) GO TO 70                                        MA        490
      DX=XEND-XU                                                        MA        491
      IDXFIX=1                                                          MA        492
      IEND=ISTEP+1                                                      MA        493
   70 IF(ISTEP.GE.IOUT) GO TO 71                                        MA        494
      IF(DX.LT.XOUT-XU) GO TO 71                                        MA        495
      DX=XOUT-XU                                                        MA        496
      IDXFIX=1                                                          MA        497
      IOUT=ISTEP+1                                                      MA        498
   71 IF (DX.LT.XULAST-XU) GO TO 72                                     MA        499
      DX=XULAST-XU                                                      MA        500
      IDXFIX=1                                                          MA        501
   72 IF( DX.GT.0. ) GO TO 73                                           MA        502
      IFIN=1                                                            MA        503
      GO TO 1011                                                        MA        504
C                                                                       MA        505
   73 XD=XU+DX                                                          MA        506
C     ------ FURTHER ADJUSTMENTS TO DX ARE MADE IN CHAPTERS 8 AND 9.    MA        507
C                                                                       MA        508
C     ------------------------------------------------------------------ MA        509
CHAPTER88888888888888888888888888  ADJUST LONGITUDINAL CONDITIONS  8888888 MA    510
C                                                                       MA        511
C     CHAPTER8A -------------------------------BOUNDARY CONDITIONS      MA        512
C     --------------- I BOUNDARY                                        MA        513
      IF(ISTEP-IAX) 9000,50,54                                          MA        514
 9000 IF(ISTEP-IEND) 9002,53,54                                         MA        515
C     ------------------------------ WALL                               MA        516
 9002 KIN=1                                                             MA        517
      U(1)=0.                                                           MA        518
      RMI=0.                                                            MA        519
      IF(ISTEP.EQ.0) TAUI=0.                                            MA        520
      EWALL=0.                                                          MA        521
      DO 81 JJ=1,NSPM                                                   MA        522
      J=JLOC(JJ)                                                        MA        523
      INDI(J)=2                                                         MA        524
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      81 AJI(J)=0.                                                        MA     525
         INDI(JM)=2                                                       MA     526
         AJI(JM)=0.                                                       MA     527
         DO 74 J=13,1.                                                    MA     528
         INDI(J)=1                                                        MA     529
      74 F(J,1)=0.0                                                       MA     530
         IF (I-LUX.EQ.0) GO TO 84                                         MA     531
         FS(JT,1)=TWALL                                                   MA     532
         INDI(JM)=1                                                       MA     533
         HPI=0.                                                           MA     534
         DO 76 JJ=1,NSPR                                                  MA     535
         J=JLOC(JJ)                                                       MA     536
      76 HPI=HPI+F(J,1)*HOR(TWALL,JJ)                                     MA     537
         F(JH,1)=HPI+FS(JH2,1)*HOR(TWALL,12)                              MA     538
         GO TO 84                                                         MA     539
C        ---------------------------- FREE                                MA     540
      93 KIN=2                                                            MA     541
         TAUI=0.                                                          MA     542
         U(1)=UA                                                          MA     543
         RMI=0.                                                           MA     544
         RU(1)=RHG(1)*U(1)                                                MA     545
         F(JH,1)=F1A                                                      MA     546
         F(JFU,1)=F2A                                                     MA     547
         DO 181 JJ=2,NSPR                                                 MA     548
         J=JLOC(JJ)                                                       MA     549
     181 F(J,1)=0.                                                        MA     550
         F(JOX,1)=RATIO2*(1.-F2A)                                         MA     551
         F(JVT,1)=R(1)*VTA                                                MA     552
         F(JK,1)=AKFAC*UA*UA                                              MA     553
         F(JD,1)=CD*F(JK,1)**1.5/ALM                                      MA     554
         GO TO 84                                                         MA     555
C        ------------------------ SYMMETRY AXIS                           MA     556
      80 KIN=3                                                            MA     557
         RMI=0.                                                           MA     558
         R(1)=RA                                                          MA     559
         PSII=0.                                                          MA     560
         TAUI=0.                                                          MA     561
C        -------------------------------AXIAL INJECTION                   MA     562
      84 RI=TAB(XO,XP,API,NBP)                                            MA     563
         IF (XO.LE.XUINJ(NUI)) GO TO 382                                  MA     564
         IF (ABS(AUINJ(NUI)-SUM1).GT.1.E-10) GO TO 380                    MA     565
         NUI=NUI+1                                                        MA     566
         SUM1=0.                                                          MA     567
         GO TO 382                                                        MA     568
380      KIN=2                                                            MA     569
         TAUI=0.                                                          MA     570
         ARG=2.*ABS(SUM1/AUINJ(NUI)-.5)                                   MA     571
         U(1)=UINJ(NUI)*(1.-ARG**SLS)/UDAT                                MA     572
         T=TUINJ(NUI)                                                     MA     573
         F(JH,1)=RATIO2*HOR(T,4)+(1.-RATIO2)*HOR(T,12)                    MA     574
         DO 387 JJ=1,NSPR                                                 MA     575
         J=JLOC(JJ)                                                       MA     576
     387 F(J,1)=0.                                                        MA     577
         F(JOX,1)=RATIO2                                                  MA     578
         F(JVT,1)=R(1)*VTUINJ(NUI)                                        MA     579
         VEC2=UINJ(NUI)**2+VTUINJ(NUI)**2                                 MA     580
         F(JK,1)=AKFAC*VEC2                                               MA     581
         F(JD,1)=CD*F(JK,1)**1.5/ALM                                      MA     582
         FS(JT,1)=TUINJ(NUI)                                              MA     583
         RHO(1)=PDGSCH/FS(JT,1)                                           MA     584
         RU(1)=RHO(1)*U(1)                                                MA     585
         RI=SQRT(RI**2+2.*(AUINJ(NUI)-SUM1)/RUINJ(NUI))                   MA     586
     382 CONTINUE                                                         MA     587
C        -----------------------------------RADIAL INJECTION              MA     588
         IF (XO.LE.XVINJ(NVI)) GO TO 394                                  MA     589
         IF (ABS(AVINJ(NVI)-SUM3).GT.1.E-10) GO TO 390                    MA     590
         NVI=NVI+1                                                        MA     591
         SUM3=0.                                                          MA     592
         GO TO 394                                                        MA     593
390      IF (KIN.NE.2) GO TO 392                                          MA     594
         PSII=PSII-(AUINJ(NVI)-SUM1)                                      MA     595
         SUM1=AUINJ(NUI)                                                  MA     596
         KIN=1                                                            MA     597
         RI=TAB(XO,XR,API,NBP)                                            MA     598
392      U(1)=UVINJ(NVI)                                                  MA     599
         T=TVINJ(NVI)                                                     MA     600
         F(JM,1)=RATIO2*HOR(T,4)+(1.-RATIO2)*HOR(T,12)                    MA     601
```

```
      DO 388 JJ=1,NSPM                                      MA     602
      J=JLOC(JJ)                                            MA     603
  388 F(J,1)=0.                                             MA     604
      F(JOX,1)=RATIO2                                       MA     605
      F(JVT,1)=R(1)*VTVINJ(NVI)                             MA     606
      VEC2=UVINJ(NVI)**2+VINJ(NVI)**2+VTVINJ(NVI)**2        MA     607
      F(JK,1)=AKFAC*VEC2                                    MA     608
      F(JO,1)=CD*F(JK,1)**1.5/ALM                           MA     609
      DO 207 J=1,NF                                         MA     610
  207 INDE(J)=1                                             MA     611
      FS(JT,1)=TVINJ(NVI)                                   MA     612
      RHO(1)=PDGSCM/FS(JT,1)                                MA     613
      RMI=R(1)*RHO(1)*VINJ(NVI)                             MA     614
      IF (ABS(RMI)*DX.LT.AVINJ(NVI)-SUM3) GO TO 394         MA     615
      RMI=(AVINJ(NVI)-SUM4)/DX                              MA     616
  394 CONTINUE                                              MA     618
C     ------------------------ E BOUNDARY                   MA     619
      IF (ISTEP-IOUT) 8004,85,85                            MA     620
C     ---------------------------- WALL                     MA     621
 8004 KEX=1                                                 MA     622
      U(NP3)=0.                                             MA     623
      RXE=0.                                                MA     624
      IF(ISTEP.EQ.0) TAUE=0.                                MA     625
      EWALL=9.                                              MA     626
      DO 82 JJ=1,NSPM                                       MA     627
      J=JLOC(JJ)                                            MA     628
      INDE(J)=2                                             MA     629
   82 AJE(J)=0.                                             MA     630
      INDE(JH)=2                                            MA     631
      AJE(JH)=0.                                            MA     632
      DO 75 J=13,15                                         MA     633
      INDE(J)=1                                             MA     634
   75 F(J,NP3)=0.0                                          MA     635
      IF (IFLUX.EQ.0) GO TO 86                              MA     636
      INDE(JH)=1                                            MA     637
      FS(JT,NP3)=TWALL                                      MA     638
      HPI=0.                                                MA     639
      DO 77 JJ=1,NSPM                                       MA     640
      J=JLOC(JJ)                                            MA     641
   77 HPI=HPI+F(J,NP3)*HDR(TWALL,JJ)                        MA     642
      F(JH,NP3)=HPI+FS(JN2,NP3)*HDR(TWALL,12)               MA     643
      GO TO 86                                              MA     644
C     --------------------------------------------FREE      MA     645
   85 KEX=2                                                 MA     646
      TAUE=0.                                               MA     647
      U(NP3)=UD                                             MA     648
      RU(NP3)=RHO(NP3)*U(NP3)                               MA     649
      DO 158 JJ=1,NSPM                                      MA     650
      J=JLOC(JJ)                                            MA     651
  158 F(J,NP3)=0.                                           MA     652
      F(JOX,NP3)=RATIO2*(1.-F2D)                            MA     653
      F(JH,NP3)=F1D                                         MA     654
      F(JFU,NP3)=F2D                                        MA     655
      F(JVT,NP3)=R(NP3)*VTD                                 MA     656
      F(JK,NP3)=AKFAC*UD*UD                                 MA     657
      F(JO,NP3)=CD*F(JK,NP3)**1.5/ALM                       MA     658
C     ------------------------------AXIAL INJECTION         MA     659
   86 RE=TAB(XD,XR,ARE,NRP)                                 MA     660
      IF (XD.LE.XUINJ(NUE)) GO TO 372                       MA     661
      IF (ABS(AUINJ(NUE)-SUM2).GT.1.E-10) GO TO 369         MA     662
      NUE=NUE+1                                             MA     663
      SUM2=0.                                               MA     664
      GO TO 372                                             MA     665
  369 KEX=2                                                 MA     666
      TAUE=0.                                               MA     667
      ARG=2.*ABS(SUM2/AUINJ(NUE)-.5)                        MA     668
      U(NP3)=UINJ(NUE)*(1.-ARG**SLN)/URAT                   MA     669
      T=TUINJ(NUE)                                          MA     670
      F(JH,NP3)=RATIO2*HDR(T,4)+(1.-RATIO2)*HDR(T,12)       MA     671
      DO 371 JJ=1,NSPM                                      MA     672
      J=JLOC(JJ)                                            MA     673
  371 F(J,NP3)=0.                                           MA     674
      F(JOX,NP3)=RATIO2                                     MA     675
      F(JVT,NP3)=R(NP3)*VTUINJ(NUE)                         MA     676
      VEC2=UINJ(NUE)**2+VTUINJ(NUE)**2                      MA     677
      F(JK,NP3)=AKFAC*VEC2                                  MA     678
      F(JO,NP3)=CD*F(JK,NP3)**1.5/ALM                       MA     679
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PROGRAM MAIN        73/74    OPT=0 TRACE                  FTN 4.6+439        06/24/78  14.42.35        PAGE     10

              FS(JT,NP3)=TVINJ(NVE)                                             MA        680
              RHO(NP3)=PDGSCN/FS(JT,NP3)                                        MA        681
              RU(NP3)=U(NP3)*RHO(NP3)                                           MA        682
              RE=SQRT(RE**2-2.*(AVINJ(NVE)-SUM2)/RUINJ(NVE))                    MA        683
          272 CONTINUE                                                          MA        684
        C     ---------------------------------RADIAL INJECTION                 MA        685
              IF (XD.LE.XVINJ(NVE)) GO TO 202                                   MA        686
              IF (ABS(AVINJ(NVE)-SUM4).GT.1.E-10) GO TO 206                     MA        687
              SUM4=0.                                                           MA        688
              NVE=NVE+1                                                         MA        689
              GO TO 202                                                         MA        690
        206   IF (KEX.NE.2) GO TO 209                                           MA        691
              PSIE=PSIE+(AVINJ(NVE)-SUM2)                                       MA        692
              SUM2=AVINJ(NVE)                                                   MA        693
              KEX=1                                                             MA        694
              RE=TAS(XD,XR,ARE,NBP)                                             MA        695
          209 U(NP3)=UVINJ(NVE)                                                 MA        696
              T=TVINJ(NVE)                                                      MA        697
              F(JH,NP3)=RATIO2*HDR(T,6)+(1.-RATIO2)*HDR(T,12)                   MA        698
              DO 399 JJ=1,NSPM                                                  MA        699
              J=JLCC(JJ)                                                        MA        700
          399 F(J,NP3)=0.                                                       MA        701
              F(JOX,NP3)=RATIO2                                                 MA        702
              F(JVT,NP3)=R(NP3)*VTVINJ(NVE)                                     MA        703
              VEC2=UVINJ(NVE)**2+VINJ(NVE)**2+VTVINJ(NVE)**2                    MA        704
              F(JK,NP3)=AKFAC*VEC2                                              MA        705
              F(JD,NP3)=CD*F(JK,NP3)**1.5/ALM                                   MA        706
              DO 208 J=1,NF                                                     MA        707
        208   INBE(J)=1                                                         MA        708
              FS(JT,NP3)=TVINJ(NVE)                                             MA        709
              RHO(NP3)=PDGSCN/FS(JT,NP3)                                        MA        710
              RME=R(NP3)*RHO(NP3)*VINJ(NVE)                                     MA        711
              IF (ABS(RME)*DX.LT.AVINJ(NVE)-SUM4) GO TO 202                     MA        712
              RME=-(AVINJ(NVE)-SUM4)/DX                                         MA        713
          202 CONTINUE                                                          MA        715
        C                                                                       MA        716
        C     CHAPTER 8B ---------------------------------------- DUCT GEOMETRY MA        717
              IF (ISTEP.GE.IOUT) GO TO 89                                       MA        718
              IF(ISTEP.GT.0) GO TO 87                                           MA        719
              ROUT=RO                                                           MA        720
              ADUD=(R(NP3)**2-R(1)**2)*.5                                       MA        721
              IF (KRAD.EQ.0) ADUD=Y(NP3)-Y(1)                                   MA        722
           87 ADUU=ADUD                                                         MA        723
              AIN=.5*R(1)**2                                                    MA        724
              IF (ISTEP.EQ.IOUT) ADUU=.5*ROUT**2                                MA        725
              AFLU=R(NP3)**2*.5-AIN                                             MA        726
              IF (KRAD.EQ.0) AFLU=Y(NP3)-Y(1)                                   MA        727
              AEX=AFLU-ADUU                                                     MA        728
              AEXD=AEX/AFLU                                                     MA        729
              IF (IDXFIX.EQ.1) GO TO 88                                         MA        730
              IF(ABS(AEXD).GT.AEXDLM) DX=DX*AEXDLM/ABS(AEXD)                    MA        731
              XD=XU+DX                                                          MA        732
        88    ADUD=.5*(RE**2-RI**2)                                             MA        733
              IF (KRAD.EQ.0) ADUD=RE-RI                                         MA        734
              DA=AFAC*(ADUD-AFLU)                                               MA        735
        C                                                                       MA        736
        C     CHAPTER 8C -------------------------- SUBSONIC PRESSURE GRADIENT  MA        737
        C     ---------------------------UBAR                                   MA        738
           89 UBAR=0.                                                           MA        739
              DO 920 I=2,NP1                                                    MA        740
          920 UBAR=UBAR+(U(I)+U(I+1))*DMD(I)                                    MA        741
              UBAR=.5*UBAR                                                      MA        742
              IF(KIN.EQ.2) UBAR=(UBAR-UA)*PEI/PSIE+UA                           MA        743
        C     ---------------------------------SUBSONIC FLOW                    MA        744
          803 IF (ISTEP-IOUT) 822,823,823                                       MA        745
          823 DPDX=0.                                                           MA        746
              GO TO 824                                                         MA        747
        C     ---------------------------------------- CONFINED SUBSONIC FLOW   MA        748
          822 GO TO (830,835), IDPDX                                            MA        749
          835 IF (ISTEP.EQ.0.OR.KIN.EQ.2) GO TO 830                             MA        750
        C     -------------     GRID FILLING DUCT  VERSION    ----------        MA        751
              ROUBAR=PEI/ADUU                                                   MA        752
              ROBAR=ROUBAR/UBAR                                                 MA        753
              DUDP=-1./(ROUBAR+(TAUE*R(NP3)-TAUI*R(1))*DX/ADUU/UBAR)            MA        754
              UDRODP=ROUBAR/GAMMA/P(NP3)                                        MA        755
              DRDU=ROUBAR*(AFLU/ADUU-1.)                                        MA        756
              DPC=DRDU/(ROBAR*DUDP+UDRODP)                                      MA        757
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```
      UFAC=DPC*DUDP/UBAR+1.
C     --------    ADJUST VELOCITY PRESSURE AND DENSITY PROFILES  --------
      DO 840 I=1,NP3
      U(I)=U(I)*UFAC
      P(I)=P(I)+DPC
  840 RHO(I)=RHO(I)*(1.+GAMMA*DPC/P(I))
      DP=DP+DPC
      DPDOX=DP/DXOLD
C     ---------    RECALCULATE DISTANCES    ----------
      CALL STRIDE(1)
      GO TO 824
C     ---------------      STANDARD GENMIX VERSION    ----------
  830 FLOTOT=PSIE-PSII*FLOAT(1/KIN)
      DYNHED=UBAR*FLOTOT/AFLU
      DPDOX=(DYNHED*DA/DX-TAUI*R(1)-TAUE*R(NP3)+2.*UBAR*(RME-RMI))/ADUD
      DP=DPDOX*DX
  824 CONTINUE
C     ---------       2*FLOW AREAS      -------------
      DO 307 I=2,NP2
  307 RDY(I)=PEI*(OM(I+1)-OM(I-1))/RHO(I)/U(I)
      GO TO (310,312,312), KIN
  310 RDY(2)=(R(1)+.5*(R(2)+R(3)))*YI
      GO TO 313
  312 RDY(2)=PEI*OM(3)/RHO(3)/U(3)
  313 GO TO (314,315,315), KEX
  314 RDY(NP2)=(R(NP3)+.5*(R(NP2)+R(NP1)))*YE
      GO TO 316
  315 RDY(NP2)=PEI*(1.-OM(NP1))/RHO(NP2)/U(NP2)
  316 CONTINUE
      RDY(1)=0.0
      RDY(NP3)=0.0
      IF (ISWRL.EQ.0) GO TO 227
C     --------     PRESSURE GRADIENT W/SWIRL EFFECTS INCLUDED    -----------
      VOR2=(F(JVT,NP2)/(.75*R(NP2)+.25*R(NP1))**2)**2
      PALFA=0.5*PEI*CSALFA
      PD=0.
      DPDX(NP2)=0.0
      DO 225 JI=3,NP2
      I=NP3-JI+1
      VOR2P1=VOR2
      RII=R(I)
      IF (I.EQ.2) RII=.75*R(2)+.25*R(3)
      VOR2=(F(JVT,I)/RII**2)**2
      PD=PD-PALFA*(VOR2/U(I)+VOR2P1/U(I+1))*DMB(I)
      IF (ISTEP.GT.0) GO TO 224
      PSWRL(I)=PD
      P(I)=P(I)+PD
      IF (I.EQ.2) P(1)=P(2)
  224 DPDX(I)=(PD-PSWRL(I))/DXOLD
  225 PSWRL(I)=PD
      IF (KEX.EQ.2) GO TO 260
      DPDXDA=0.0
      SRDY=0.0
      DO 250 I=2,NP2
      SRDY=SRDY+RDY(I)
 250  DPDXDA=DPDXDA+DPDX(I)*DXOLD*RDY(I)
      DP=DP-DPDXDA/SRDY
      DO 255 I=2,NP2
  255 DPDX(I)=DPDX(I)+DP/DXOLD
  260 CONTINUE
      DPDX(1)=DPDX(2)
      DPDX(NP3)=DPDX(NP2)
      GO TO 242
C     -------      PRESSURE GRADIENT FOR NON-SWRLING FLOW     ----------
  227 DO 825 I=1,NP3
  825 DPDX(I)=DPDOX
C     ------------------------------------------------------------- TEST 3
  242 IF (ITEST) 802,801,802
  802 LAB(1)=6HTEST 3
      LAB(2)=6H
      WRITE(6,100) LAB,UBAR,DYNHED,DX,DA,DPDOX,AEXD,RMI
      WRITE(6,101) LAB,ISTEP,KIN,KEX,IAX,IEND,IOUT
      LAB(1)=4HY(I)
      LAB(2)=6H
      WRITE(6,100) LAB,(Y(I),I=1,NP3)
      LAB(1)=4HR(I)
      LAB(2)=6H
```

```
      WRITE(6,100) LAB,(R(I),I=1,NP3)                                MA     835
      LAB(1)=5HRU(I)                                                 MA     836
      LAB(2)=6H                                                      MA     837
      WRITE(6,100) LAB,(RU(I),I=1,NP3)                               MA     838
      LAB(1)=6HDPDX(I                                                MA     839
      LAB(2)=6H)                                                     MA     840
      WRITE (6,100) LAB,(DPDX(I),I=1,NP3)                            MA     841
      LAB(1)=6HPSWRL(                                                MA     842
      LAB(2)=6HI)                                                    MA     843
      WRITE (6,100) LAB,(PSWRL(I),I=1,NP3)                           MA     844
  801 CONTINUE                                                       MA     845
C                                                                    MA     846
C ------------------------------------------------------------------ MA     847
CHAPTER9999999999999999999999  TRANSPORT AND ENTRAINMENT PROPERTIES  9999 MA     848
C ----  LAMINAR VISCOSITY ASSUMED TO BE THAT OF AIR ---------------- MA     849
  900 CONTINUE                                                       MA     850
      DO 98 I=1,NP3                                                  MA     851
      EMU(I)=VISCO(FS(JT,I))                                         MA     852
   98 CONTINUE                                                       MA     853
      EMU(2)=EMU(1)                                                  MA     854
      EMU(NP2)=EMU(NP3)                                              MA     855
C     ------------------------------------------------ TEST 4        MA     856
      IF(ITEST) 902,901,902                                          MA     857
  902 LAB(1)=6HTEST 4                                                MA     858
      LAB(2)=6H                                                      MA     859
      WRITE(6,100) LAB,RMI,RME,PEI                                   MA     860
      LAB(1)=6HEMU(I)                                                MA     861
      LAB(2)=6H                                                      MA     862
      WRITE(6,100) LAB,(EMU(I),I=1,NP3)                              MA     863
  901 CONTINUE                                                       MA     864
C                                                                    MA     865
C     -----------AUX-----------AUX-----------AUX-----------AUX------------AUX MA     866
      CALL AUXO(0)                                                   MA     867
C     ------------------------------ ENTRAINMENT CONTROL.            MA     868
      IF(KIN.NE.2) GO TO 94                                          MA     869
      RAT=ABS((U(3)-U(1))/(U(NP3)-U(1)+1.E-30))                      MA     870
      IF(RAT.LT.ULIM) EM U(2)=EM U(2)*RAT/ULIM                       MA     871
      RMI=2.*EM U(2)                                                 MA     872
   94 CONTINUE                                                       MA     873
      IF(KEX.NE.2) GO TO 97                                          MA     874
      RAT=ABS((U(NP1)-U(NP3))/(U(NP3)-U(1)+1.E-30))                  MA     875
      RME=-2.*EM U(NP1)                                              MA     876
      IF(RAT.LT.ULIM) RME=RME*(RAT/ULIM)**2                          MA     877
97    IF (IDXFIX.EQ.1) GO TO 96                                      MA     878
C     ----------- LIMIT ON INCREMENT IN PEI.                         MA     879
      IF((ABS(RMI)+ABS(RME))*DX.LT.PEI*PEILIM) GO TO 96              MA     880
      DX=PEI*PEILIM/(ABS(RMI)+ABS(RME))                              MC     881
      XD=XU+DX                                                       MA     882
   96 CONTINUE                                                       MA     883
      IF (XD.LE.XUINJ(NUI)) GO TO 91                                 MA     884
      IF (ABS(RMI)*DX.LT.AUINJ(NUI)-SUM1) GO TO 91                   MA     885
      RMI=(AUINJ(NUI)-SUM1)/DX                                       MA     886
   91 IF (XD.LE.XUINJ(NUE)) GO TO 92                                 MA     887
      IF (ABS(RME)*DX.LT.AUINJ(NUE)-SUM2) GO TO 92                   MA     888
      RME=-(AUINJ(NUE)-SUM2)/DX                                      MA     889
   92 CONTINUE                                                       MA     890
C     ----------- ADJUSTMENT OF DX TO REACH AXIS.                    MA     891
      IF (IEND.GT.ISTEP) GO TO 95                                    MA     892
      IF(ISTEP.GE.IAX) GO TO 95                                      MA     893
      IF(PSII.GT.RMI*DX.OR.IAX.EQ.ISTEP+1) GO TO 95                  MA     894
      RMI=PSII/DX                                                    MA     895
      IAX=ISTEP+1                                                    MA     896
C                                                                    MA     897
C     -----------STRIDE2-----------STRIDE2-----------STRIDE2---------STRIDE2 MA     898
   95 CALL STRIDE(2)                                                 MA     899
C                                                                    MA     900
C  ----------------------------------------------------------------- MA     901
C     -----------AUXS-----------AUXS-----------AUXS-----------AUXS-------- MA     902
      CALL AUXS                                                      MA     903
C     -------------------------------------------------------------- MA     904
CHAPTER 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10   OUTPUT   10 10 10 MA     905
 1000 IF(ISTEP.GT.0) GO TO 106                                       MA     906
      WRITE (6,9000)                                                 MA     907
 9000 FORMAT (1H1)                                                   MA     908
CHAPTER 10A  ------------------------------------   HEADINGS         MA     909
C                                                                    MA     910
      WRITE (6,1013) TITLE,MODER,IDPGX,MODEL,MASSTR,INERT,KRAD,IFLUX MA     911
```

```
 1013 FORMAT (1H1,12A6/12A6/7H MODER=,I3,7H IOPBX=,I3,7H MODEL=,I3,
     1 8H MASSTR=,I3,7H INERT=,I3,6H KRAD=,I3,7H IFLUX=,I3)
C
      WRITE (6,1010) UA,UD,TA,TD,RA,RB,RD,XEND,XOUT,XULAST,PRESS,
     1 PREXP1,ARCON1,CR1,VTA,VTD
 1010 FORMAT (1H ,1X,2HUA,8X,2HUD,8X,2HTA,8X,2HTD,8X,2HRA,8X,2HRB,8X,
     1 2HRD,8X,4HXEND,6X,4HXOUT,6X,6HXULAST/1H ,1P10E10.3/1H ,
     2 6H PRESS,5X,6HPREXP1,4X,6HARCON1,4X,3HCR1,7X,3HVTA,7X,3HVTD/1X,
     2 1P10E10.3)
C
      LAB(1)=5HOMEGA
      LAB(2)=6H
      WRITE(6,100) LAB,(OM(I),I=1,NP3)
      PRESS1=PRESS
      NINJ=12
      IF (XUINJ(NUI).GT.XULAST.AND.XUINJ(NUE).GT.XULAST) GO TO 1200
      WRITE (6,1205)
 1205 FORMAT (/6X,*AXIAL INJECTION*/6X,15(1H*)//6X,*SLOT*,4X,
     1 *BOUNDARY*,9X,*X*,9X,*XL*,10X,*U*,9X,*VT*,7X,*TEMP*,7X,*MDOT*,
     2 10X,*M*,9X,*AR*/10(3X,8(1H*)))
      INDX=0
      IPT=0
      DO 1210 II=1,NINJ
      IF (INDX.EQ.2) GO TO 1210
      IF (XUINJ(II).GT.XULAST) INDX=INDX+1
      IF (XUINJ(II).GT.XULAST) GO TO 1210
      IB=1HI
      IF (II.GE.NUE) IB=1HE
      IPT=IPT+1
      WRITE (6,1215) IPT,IB,XUINJ(II),XLUINJ(II),UINJ(II),VTUINJ(II),
     1 TUINJ(II),AUINJ(II),MUINJ(II),ARUINJ(II)
 1215 FORMAT (7X,I2,9X,A1,3X,8(1PE11.3))
 1210 CONTINUE
 1200 IF (XVINJ(NVI).GT.XULAST.AND.XVINJ(NVE).GT.XULAST) GO TO 1220
      WRITE (6,1225)
 1225 FORMAT (//6X,*RADIAL INJECTION*/6X,16(1H*)//6X,*SLOT*,4X,
     1 *BOUNDARY*,9X,*X*,10X,*U*,9X,*V*,9X,*VT*,7X,*TEMP*,7X,*MDOT*/
     2 8(3X,8(1H*)))
      INDX=0
      IPT=0
      DO 1230 II=1,NINJ
      IF (INDX.EQ.2) GO TO 1230
      IF (XVINJ(II).GT.XULAST) INDX=INDX+1
      IF (XVINJ(II).GT.XULAST) GO TO 1230
      IB=1HI
      IF (II.GE.NVE) IB=1HE
      IPT=IPT+1
      WRITE (6,1215) IPT,IB,XVINJ(II),UVINJ(II),VINJ(II),VTVINJ(II),
     1 TVINJ(II),AVINJ(II)
 1230 CONTINUE
 1220 CONTINUE
  106 CONTINUE
C     ---------------------------------------------------------- TEST 5
      IF(ITEST) 1002,1001,1002
 1002 LAB(1)=6HTEST 5
      LAB(2)=6H
      WRITE(6,100) LAB,RMI,RME,DX
 1001 CONTINUE
C
CHAPTER 10B  ------------------------------------------- TESTS FOR PRINTOUT
C  -  ------ IPRINT=0 GIVES NO OUTPUT,  =1 GIVES SINGLE VARIABLES ONLY,
C                  =2 GIVES BOTH SINGLE AND ARRAY (PROFILE) VARIABLES.
 1011 IPRINT=0
      IF (MOD(ISTEP,NSTAT).EQ.0) IPRINT=1
      IF (MOD(ISTEP,NPROF).EQ.0) IPRINT=2
      IF(ISTEP.EQ.IEND.OR.ISTEP.EQ.IAX.OR.ISTEP.EQ.IOUT) IPRINT=2
      IF(ITEST.NE.0.OR.IFIN.NE.0) IPRINT=2
      IF (MOD(ISTEP,NPLOT).EQ.0.AND.ISTEP.GT.0) IPRINT=3
C     ------ THE NEXT STATEMENT PROVIDES A PLOT JUST PRIOR TO TERMINATION
      IF(XU.GE.XULAST.OR.IFIN.NE.0.OR.ISTEP.EQ.LASTEP) IPRINT=3
C
CHAPTER 10C     ----------------------------SINGLE STATION VARIABLES.
      IF(IPRINT.EQ.0) GO TO 110
      PRESSD=P(NP3)/PRESS1-1.
      WRITE (6,1030) ISTEP,IAX,IEND,IOUT,KIN,KEX,DX,PSII,PSIE,RMI,RME,
     1  PEI,PRESSD,AFID
 1030 FORMAT(7H0ISTEP=,I5,5H IAX=,I5,6H IEND=,I5,6H IOUT=,I5,5H KIN=,I2,
```

```
      1 5H KEX=,I2,6H DX=,1PE11.3,6H PSII=,E11.3,6H PSIE=,E11.3/         MA        998
      2 5H RMI=,E11.3,5H RME=,E11.3,5H PEI=,E11.3,8H PRESSD=,E11.3,      MA        999
      3 6H AEXD=,E11.3)                                                  MA       1000
C                                                                        MA       1001
C                                                                        MA       1002
      UBAR=0.                                                            MA       1003
      DO 1020 J=1,NF                                                     MA       1004
      AJID(J)=0.0                                                        MA       1005
      AJED(J)=0.0                                                        MA       1006
 1020 FLUX(J)=0.                                                         MA       1007
      PFLUX=0.0                                                          MA       1008
      DO 1021 I=2,NP1                                                    MA       1009
      UBAR=UBAR+DMD(I)*(U(I)+U(I+1))                                     MA       1010
      PFLUX=PFLUX+PSWRL(I)*PDV(I)                                        MA       1011
      DO 1021 J=1,NF                                                     MA       1012
      IF (ISOLVE(J).EQ.0) GO TO 1021                                     MA       1013
      FLUX(J)=FLUX(J)+DMD(I)*(F(J,I)+F(J,I+1))                           MA       1014
 1021 CONTINUE                                                           MA       1015
      UBAR=.5*UBAR                                                       MA       1016
      UFLUX=PEI*UBAR+PFLUX                                               MA       1017
      DO 1022 J=1,NF                                                     MA       1018
 1022 FLUX(J)=.5*PEI*FLUX(J)                                             MA       1019
C                                                                        MA       1020
      UREF=UBAR                                                          MA       1021
      RUREF=PEI/.5/(R(1)+R(NP3))/Y(NP3)                                  MA       1022
      DO 1023 J=1,NF                                                     MA       1023
      IF (ISOLVE(J).EQ.0) GO TO 1023                                     MA       1024
      DFI(J)=FLUX(J)/PEI-F(J,1)                                          MA       1025
      DFE(J)=DFI(J)+F(J,1)-F(J,NP3)                                      MA       1026
 1023 CONTINUE                                                           MA       1027
      UFLUX=UFLUX-PSIE*U(NP3)+U(1)*PSII                                  MA       1028
      FLUX(JFU)=FLUX(JFU)-PSIE*F2D+F2A*PSII                              MA       1029
      FLUX(JH)=FLUX(JH)-PSIE*F1D+F1A*PSII                                MA       1030
C                                                                        MA       1031
      WRITE (6,1031) XU,UFLUX,(FLUX(J),J=1,NF)                           MA       1032
 1031 FORMAT (4H XU=,1PE11.3,7H UFLUX=,E11.3,9H FLUX(J)=,7E11.3/42X,     MA       1033
     1  8E11.3)                                                          MA       1034
C                                                                        MA       1035
      IF(KIN.NE.1) GO TO 1024                                            MA       1036
      TAUID=TAUI/UREF/RUREF                                              MA       1037
      DO 1025 J=1,NF                                                     MA       1038
      IF (ISOLVE(J).EQ.0) GO TO 1025                                     MA       1039
      AJID(J)=AJI(J)/RUREF/DFI(J)                                        MA       1040
 1025 CONTINUE                                                           MA       1041
      WRITE(6,1029) KIN,TAUID,(AJID(J),J=1,NF)                           MA       1042
 1029 FORMAT (5H KIN=,I2,7H TAUID=,1PE11.3,9H AJID(J)=,7E11.3/34X,       MA       1043
     1  8E11.3)                                                          MA       1044
C                                                                        MA       1045
 1024 IF(KEX.NE.1) GO TO 1026                                            MA       1046
      TAUED=TAUE/UREF/RUREF                                              MA       1047
      DO 1027 J=1,NF                                                     MA       1048
      IF (ISOLVE(J).EQ.0) GO TO 1027                                     MA       1049
      AJED(J)=AJE(J)/RUREF/DFE(J)                                        MA       1050
 1027 CONTINUE                                                           MA       1051
      WRITE(6,1028) KEX,TAUED,(AJED(J),J=1,NF)                           MA       1052
 1028 FORMAT (5H KEX=,I2,7H TAUED=,1PE11.3,9H AJED(J)=,7E11.3/34X,       MA       1053
     1  8E11.3)                                                          MA       1054
 1026 CONTINUE                                                           MA       1055
C                                                                        MA       1056
CHAPTER 10D    ---------------------------------PROFILES AND OTHER ARRAYS.  MA   1057
      IF(IPRINT.EQ.1) GO TO 110                                          MA       1058
C                                                                        MA       1059
      LAB(1)=6HR1,Y'S                                                    MA       1060
      LAB(2)=6H                                                          MA       1061
      DIV=1.                                                             MA       1062
      DO 1095 I=1,NP3                                                    MA       1063
 1095 OUT(I)=Y(I)/DIV                                                    MA       1064
      WRITE (6,190) LAB,R(1),(OUT(I),I=2,NP2,ITMI4),Y(NP3)               MA       1065
      XAXIS=4HY(I)                                                       MA       1066
      DO 1085 I=1,NP3                                                    MA       1067
 1085 XPLOT(I)=OUT(I)                                                    MA       1068
C                                                                        MA       1069
      LAB(1)=1HU                                                         MA       1070
      LAB(2)=6H                                                          MA       1071
      SUB=0.                                                             MA       1072
      DIV=1.                                                             MA       1073
      IF(KIN.EQ.3) DIV=U(1)+1.E-30                                       MA       1074
```

```
      DO 1094 I=1,NP3
 1094 OUT(I)=(U(I)-SUB)/DIV
      IF (MOVEL.NE.1) WRITE (6,100) LAB,U(1),(OUT(I),I=2,NP2,ITHIN),
     1 U(NP3)
      NY=1
      YAXES(1,1)=6HVELOCI
      YAXES(1,2)=2HTY
      SYMBOL(1)=1HU
      DO 1084 I=1,NP3
 1084 YPLOT(1,I)=OUT(I)
C
      INDX=0
      DO 1080 KV=1,NF
      KVV=KV+INDX
      IF (IPRNT(KVV).EQ.0) GO TO 1080
      LAB(1)=LAB1(KVV)
      LAB(2)=LAB2(KVV)
      DO 1082 I=1,NP3
 1082 OUT(I)=F(KV,I)
      IF (KV.NE.JVT) GO TO 1075
      VTMAX=0.
      DO 1086 I=2,NP3
      DIV=R(I)
      IF (I.EQ.2) DIV=.75*R(2)+.25*R(3)
      IF (I.EQ.NP2) DIV=.75*R(NP2)+.25*R(NP1)
      OUT(I)=OUT(I)/DIV
 1086 VTMAX=AMAX1(VTMAX,OUT(I))
 1075 IF (KV.NE.JD) GO TO 1076
      DO 1077 I=1,NP3
 1077 OUT(I)=CD*F(JK,I)**1.5/(OUT(I)+1.E-20)
 1076 WRITE (6,100) LAB,F(KV,1),(OUT(I),I=2,NP2,ITHIN),F(KV,NP3)
      IF (IPLOT(KVV).EQ.0) GO TO 1080
      NY=NY+1
      YAXES(NY,1)=LAB1(KVV)
      YAXES(NY,2)=LAB2(KVV)
      SYMBOL(NY)=SYM(KVV)
      DO 1090 I=1,NP3
 1090 YPLOT(NY,I)=OUT(I)
 1080 CONTINUE
C
      INDX=NF
      DO 1180 KV=1,NFS
      KVV=KV+INDX
      IF (IPRNT(KVV).EQ.0) GO TO 1180
      LAB(1)=LAB1(KVV)
      LAB(2)=LAB2(KVV)
      DO 1182 I=1,NP3
 1182 OUT(I)=FS(KV,I)
      WRITE (6,100) LAB,FS(KV,1),(OUT(I),I=2,NP2,ITHIN),FS(KV,NP3)
      IF (IPLOT(KVV).EQ.0) GO TO 1180
      NY=NY+1
      YAXES(NY,1)=LAB1(KVV)
      YAXES(NY,2)=LAB2(KVV)
      SYMBOL(NY)=SYM(KVV)
      DO 1190 I=1,NP3
 1190 YPLOT(NY,I)=OUT(I)
 1180 CONTINUE
C
      LAB(1)=6HPRESS
      IF (ISWRL.EQ.0) GO TO 1100
      LAB(2)=6H
      SUB=P(NP3)
      DIV=1.0
      DO 1112 I=1,NP3
 1112 OUT(I)=(P(I)-SUB)/DIV
      WRITE (6,100) LAB,P(1),(OUT(I),I=2,NP2,ITHIN),P(NP3)
 1100 IF (MODEL.NE.2) GO TO 1104
      LAB(1)=6HAMU(I)
      LAB(2)=6H
      WRITE (6,100) LAB,AMU(1),(AMU(I),I=2,NP2,ITHIN),AMU(NP3)
 1104 CONTINUE
      IF (IPRINT.EQ.2) GO TO 110
      WRITE(6,1070) XU,ISTEP
 1070 FORMAT(1H ,11HPLOT AT XU=,1PE11.3,8H, ISTEP=,I5)
      DO 1071 J=1,NY
      YPLOT(J,2)=YPLOT(J,1)
 1071 YPLOT(J,NP2)=YPLOT(J,NP3)
```

```
PROGRAM MAIN       73/74    OPT=0 TRACE                     FTN 4.6+439         08/24/78  14.42.35        PAGE    16

             CALL PLOTS(XPLOT,43,NP3,XAXIS,YPLOT,10,NY,YAXES,SYMBOL)                    MA        1152
      C     --------------------------------------------------------------------------- MA        1153
      CHAPTER 11  11  11  11  11  11  11  11  11  11  11  END OF MAIN LOOP              MA        1154
        110 IF(ISTEP.GE.LASTEP.OR.XU.GE.XULAST.OR.IFIN.NE.0) GO TO 111                  MA        1155
      C                                                                                 MA        1156
      C      -----------STRIDE3-----------STRIDE3-----------STRIDE3--------STRIDE3      MA        1157
             CALL STRIDE(3)                                                             MA        1158
             IF(I+IN) 1011,00,111                                                       MA        1159
      C                                                                                 MA        1160
      C      ------------------------------------------------ TERMINATION               MA        1161
        111 WRITE(6,112) ISTEP,LASTEP,XU,XULAST,IFIN                                    MA        1162
        112 FORMAT(23H TERMINATED WITH ISTEP=,I5,8H LASTEP=,I5,                          MA        1163
           1 4H XU=,1PE11.3,8H XULAST=,E11.3,6H IFIN=,I3)                               MA        1164
      C     --------------------------------------------------------------------------- MA        1165
        120 CONTINUE                                                                    MA        1166
             STOP                                                                       MA        1167
        100 FORMAT (1H0,A6,A2,1P11E11.3/(9X,11E11.3))                                   MA        1168
        101 FORMAT (1H0,A6,A2,11I11)                                                    MA        1169
             END                                                                        MA        1170

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

    162     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    791     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    795     I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
```

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      FUNCTION TAB         73/74    OPT=0 TRACE                    FTN 4.6+439       08/24/78  14.42.35       PAGE    1

        1                     FUNCTION TAB (X,XX,YY,NTAB)                                  TA        2
                              DIMENSION XX(1),YY(1)                                        TA        3
                              IF (NTAB.GT.0) GO TO 5                                       TA        4
                              TAB=0.0                                                      TA        5
        5                     RETURN                                                       TA        6
                            5 F=1.                                                         TA        7
                              IF (XX(1).GT.XX(2)) F=-F                                     TA        8
                              DO 10 J=1,NTAB                                               TA        9
                              I=J                                                          TA       10
       10                     IF (F*(XX(I)-X)) 10,40,20                                    TA       11
                           10 CONTINUE                                                     TA       12
                           20 IF (I.NE.1) GO TO 30                                         TA       13
                              I=2                                                          TA       14
                           30 J=I-1                                                        TA       15
       15                     DEL=XX(I)-XX(J)                                              TA       16
                              IF (DEL.EQ.0.0) GO TO 50                                     TA       17
                              TAB=(YY(I)*(X-XX(J))-YY(J)*(X-XX(I)))/DEL                    TA       18
                              RETURN                                                       TA       19
                           40 TAB=YY(I)                                                    TA       20
       20                     RETURN                                                       TA       21
                           50 WRITE (6,60) X,I,J                                           TA       22
                              CALL EXIT                                                    TA       23
                           60 FORMAT (' *** ERROR IN SUBROUTINE TAB ***',E15.4,2I5)        TA       24
                              END                                                          TA       25

 CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM
      7     I        XX        ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
```

```
FUNCTION VISCO       73/74    OPT=2 TRACE                     FTN 4.6+439        08/24/78  14.42.35        PAGE     1

1                       FUNCTION VISCO(T)                                          TA         26
                        IF (T.GT.667.) GO TO 10                                    TA         27
                        VISCO=1.800E-5*(T/294.4)**0.76                             TA         28
                        RETURN                                                     TA         29
5                    10 VISCO=4.464E-5*SQRT(T/1111.)                               TA         30
                        RETURN                                                     TA         31
                        END                                                        TA         32
```

```
SUBROUTINE AUX        73/74   OPT=0 TRACE                     FTN 4.6+439        08/24/78  14.42.35        PAGE     1

            SUBROUTINE AUX(NV)                                                  AU        2
            COMMON/COMA/A(43),AJE(15),AJI(15),B(43),C(43),CSALFA,D(43),         COMA      2
           1 DPDX(43),DX,EMU(43),F(15,43),FS(3,43),IAX,IEND,IFIN,INDE(15),      COMA      3
           2 INDI(15),IOUT,ISTEP,ITEST,IUTRAP,JS,JSW,JV,JY,KEX,KIN,KRAD,N,      COMA      4
           3 NO2,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(15),          COMA      5
           4 PREF(15),PSIE,PSII,R(43),RHO(43),RU(43),RME,RMI,SD(43),SU(43),     COMA      6
           5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSWRL(43),RDY(43),ISOLVE(15),    COMA      7
           6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PDGSCN,FDIFI(15),FDIFE(15),     COMA      8
           7 GE(15),GI(15),JLOC(12),W(12),JH,JFU,JCO2,JCO,JCX,JH2O,JOH,JO,JHS,  COMA      9
           8 JH2,JN,JNO,JN2,JVT,JO,JK,JT,JRY,JST,NSPN,ABSOR,SCATR,SORN(200),    COMA     10
           9 TERM1,TERM2,ISMAX,EFU,EO2,EH2O,ERO,EPR                             COMA     11
            COMMON/COMB/AK,ALNG,EWALL,FO,M,MFU,INERT,MASSTR,MODEL,PRESS,        COMB      2
           1 UBAR,UFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,     COMB      3
           2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,     COMB      4
           3 CE,HT,OXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                       COMB      5
           4 WH2,WN,WNO,WN2                                                     COMB      6
C/-------- SUBROUTINE FOR PROGRAM GENMIX 4A                                     AU        5
            DIMENSION LAB(2),DUDY(43),GENP(43),EMUT(43),EMUL(43)                AU        6
            DIMENSION TSOR(14)                                                  AU        7
C                                                                               AU        8
            ENTRY AUX0                                                          AU        9
C    -------- CALCULATE TURB VISCOSITY FROM TWO EQUATION MODEL  --------        AU       10
            IF (MODEL.EQ.1) GO TO 200                                           AU       11
            DO 112 I=1,NP3                                                      AU       12
            EMUL(I)=EMU(I)                                                      AU       13
            RT=RHO(I)*F(JK,I)**2/(F(JD,I)*EMUL(I)+1.0E-30)                      AU       14
            CDD=CD*EXP(-2.5/(1.0+RT/50.))                                       AU       15
            EMUT(I)=CDD*RHO(I)*F(JK,I)*F(JK,I)/(F(JD,I)+1.0E-30)                AU       16
            EMU(I)=EMU(I)+EMUT(I)                                               AU       17
        112 AMU(I)=EMU(I)                                                       AU       18
C   ----------------------------------------------------  TEST 10              AU       19
        200 IF (ITEST) 202,201,202                                              AU       20
        202 LAB(1)=6HTEST 1                                                     AU       21
            LAB(2)=6H0                                                          AU       22
            WRITE (6,100) LAB                                                   AU       23
            LAB(1)=6HEMU(I)                                                     AU       24
            LAB(2)=6H                                                           AU       25
            WRITE (6,100) LAB,(EMU(I),I=1,NP3)                                  AU       26
        201 CONTINUE                                                            AU       27
C           ----------------- MODIFICATION OF EMU ARRAY                         AU       28
            DO 23 I=2,NP2                                                       AU       29
         23 EMU(I)=.5*(EMU(I+1)+EMU(I))                                         AU       30
            DO 24 I=2,NP1                                                       AU       31
         24 EM U(I)=EMU(I)/(Y(I+1)-Y(I))                                        AU       32
            IF (KRAD.EQ.0) GO TO 300                                            AU       33
            DO 26 I=2,NP1                                                       AU       34
         26 EM U(I)=EM U(I)*.5*(R(I)+R(I+1))                                    AU       35
        300 CONTINUE                                                            AU       36
            RETURN                                                              AU       37
C    *************************    SOURCE TERMS      ********************        AU       38
            ENTRY SOURCE                                                        AU       39
            IF (NV.NE.0) GO TO 500                                              AU       40
C           ----- VELOCITY U                                                    AU       41
            DO 309 I=2,NP2                                                      AU       42
        309 US(I)=DPDX(I)*RDY(I)                                                AU       43
            GO TO 6000                                                          AU       44
C           ------------------- KINETIC HEATING.                                AU       45
        500 IF (NV.NE.JH) GO TO 1000                                            AU       46
C           ----- TEMPORARY USE OF SD ARRAY.                                    AU       47
            GO TO (303,304), NOVEL                                              AU       48
        303 DO 305 I=1,NP3                                                      AU       49
            SU(I)=0.                                                            AU       50
        305 SD(I)=0.                                                            AU       51
            GO TO 306                                                           AU       52
        304 DO 30 I=2,NP2                                                       AU       53
         30 S D(I)=U(I)*U(I)                                                    AU       54
            DO 31 I=2,NP1                                                       AU       55
         31 S D(I)=EM U(I)*(S D(I+1)-S D(I))                                    AU       56
            S D(1)=0.                                                           AU       57
            S D(NP2)=0.                                                         AU       58
            DO 32 I=2,NP2                                                       AU       59
            T=(1.-1./PREF(1))*.5                                                AU       60
         32 SU(I)=(S D(I)-S D(I-1))*T                                           AU       61
            DO 33 I=2,NP1                                                       AU       62
         33 SD(I)=0.                                                            AU       63
C   ------------------------------------------  TEST 11                         AU       74
        306 IF(ITEST) 302,301,302                                               AU       75
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  302 LAB(1)=6HTEST 1                                                       AU      76
      LAB(2)=1H1                                                            AU      77
      WRITE(6,100) LAB                                                      AU      78
      LAB(1)=6HSD(I                                                         AU      79
      LAB(2)=1H)                                                            AU      80
      WRITE(6,100) LAB,(SD(I),I=1,NP3)                                      AU      81
      LAB(1)=6HSU(I                                                         AU      82
      LAB(2)=1H)                                                            AU      83
      WRITE(6,100) LAB,(SU(I),I=1,NP3)                                      AU      84
  301 CONTINUE                                                              AU      85
      GO TO 6000                                                            AU      86
C ------------------- SPECIES EQUATIONS ---------------------------         AU      87
 1000 DO 145 JJ=1,NSPM                                                      AU      88
      J=JLOC(JJ)                                                            AU      89
      IF (NV.EQ.J) GO TO 146                                                AU      90
  145 CONTINUE                                                              AU      91
      GO TO 3500                                                            AU      92
  146 IF (INERT-1) 147,147,148                                              AU      93
  147 DO 150 I=2,NP2                                                        AU      94
      SU(I)=0.                                                              AU      95
  150 SD(I)=0.                                                              AU      96
      GO TO 6000                                                            AU      97
  148 REWIND 4                                                              AU      98
      DO 152 I=2,NP2                                                        AU      99
      READ (4) TSOR                                                         AU     100
      DO 154 K=1,NSPM                                                       AU     101
      KK=K                                                                  AU     102
      IF (NV.EQ.JLOC(K)) GO TO 155                                          AU     103
  154 CONTINUE                                                              AU     104
  155 SU(I)=TSOR(KK)                                                        AU     105
  152 SD(I)=0.                                                              AU     106
      GO TO 6000                                                            AU     107
C ----------        SWIRL VELOCITY    ---------------                       AU     108
 3500 IF (NV.NE.JVT) GO TO 4000                                             AU     109
      DO 60 I=2,NP2                                                         AU     110
      SU(I)=0.0                                                             AU     111
   60 SD(I)=0.0                                                             AU     112
      GO TO 6000                                                            AU     113
C ------------        TURBULENT KINETIC ENERGY    -----------------         AU     114
 4000 IF (NV.NE.JK) GO TO 5000                                              AU     115
      D22=Y(3)-Y(1)                                                         AU     116
      VT2=F(JVT,2)/(.75*R(2)+.25*R(3))                                      AU     117
      VT3=F(JVT,3)/R(3)                                                     AU     118
      RK2=SQRT(F(JK,2))                                                     AU     119
      RK3=SQRT(F(JK,3))                                                     AU     120
      DUDY(2)=(U(3)-U(2))/D22                                               AU     121
      DVTDY=(VT3-VT2)/D22                                                   AU     122
      DK2=(RK3-RK2)/D22                                                     AU     123
      GENR(2)=DUDY(2)**2+(DVTDY-VT2/(.75*R(2)+.25*R(3)))**2                 AU     124
C     ------------------------------                                        AU     125
      DO 70 I=3,NP1                                                         AU     126
      D11=D22                                                               AU     127
      D22=Y(I+1)-Y(I)                                                       AU     128
      IF (I.EQ.NP1) D22=Y(NP3)-Y(NP1)                                       AU     129
      D12=D11+D22                                                           AU     130
      DUDY(I)=D11*(U(I+1)-U(I))/(D12*D22)+D22*(U(I)-U(I-1))/(D12*D11)       AU     131
      VT1=VT2                                                               AU     132
      VT2=VT3                                                               AU     133
      VT3=F(JVT,I+1)/R(I+1)                                                 AU     134
      IF (I.EQ.NP1) VT3=F(JVT,NP2)/(.75*R(NP2)+.25*R(NP1))                  AU     135
      DVTDY=D11*(VT3-VT2)/(D12*D22)+D22*(VT2-VT1)/(D12*D11)                 AU     136
      RK1=RK2                                                               AU     137
      RK2=RK3                                                               AU     138
      RK3=SQRT(F(JK,I+1))                                                   AU     139
      DRKDY=D11*(RK3-RK2)/(D12*D22)+D22*(RK2-RK1)/(D12*D11)                 AU     140
      GENR(I)=DUDY(I)**2+(DVTDY-VT2/R(I))**2                                AU     141
      SU(I)=EMUT(I)*GENR(I)                                                 AU     142
   70 SD(I)=-(RHO(I)*F(JD,I)+2.*EMUL(I)*DRKDY**2)/F(JK,I)                   AU     143
C  -----------------------------                                            AU     144
      DUDY(NP2)=(U(NP2)-U(NP1))/D22                                         AU     145
      DVTDY=(VT3-VT2)/D22                                                   AU     146
      DKNP2=(RK3-RK2)/D22                                                   AU     147
      GENR(NP2)=DUDY(NP2)**2+(DVTDY-VT3/(.75*R(NP2)+.25*R(NP1)))**2         AU     148
      F6=.75*F(JK,2)+.25*F(JK,3)                                            AU     149
      F7=.75*F(JD,2)+.25*F(JD,3)                                            AU     150
      SU(2)=EMUT(2)*GENR(2)                                                 AU     151
      SD(2)=-(RHO(2)*F7+2.*EMUL(2)*DK2**2)/F6                               AU     152
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              F6=.75*F(JK,NP2)+.25*F(JK,NP1)                                        AU       153
              F7=.75*F(JD,NP2)+.25*F(JD,NP1)                                        AU       154
              SU(NP2)=EMUT(NP2)*GENR(NP2)                                           AU       155
              SD(NP2)=-(RHO(NP2)*F7+2.*EMUL(NP2)*DKNP2**2)/F6                       AU       156
           76 DO 77 I=2,NP2                                                         AU       157
              SU(I)=SU(I)*0.5*RDY(I)                                                AU       158
           77 SD(I)=SD(I)*0.5*RDY(I)                                                AU       159
        C     ------------------------------------------------   TEST 13            AU       160
              IF (ITEST) 78,79,78                                                   AU       161
           78 LAB(1)=6HTEST 1                                                       AU       162
              LAB(2)=6H3                                                            AU       163
              WRITE (6,100) LAB                                                     AU       164
              LAB(1)=6HSU(I                                                         AU       165
              LAB(2)=6H)                                                            AU       166
              WRITE (6,100) LAB,(SU(I),I=1,NP3)                                     AU       167
              LAB(1)=6HSD(I                                                         AU       168
              LAB(2)=6H)                                                            AU       169
              WRITE (6,100) LAB,(SD(I),I=1,NP3)                                     AU       170
           79 CONTINUE                                                              AU       171
        C     ---------------------                                                 AU       172
              GO TO 6000                                                            AU       173
        C     ---------------    TURBULENCE DISSIPATION    ------------------       AU       174
         5900 IF (NV.NE.JD) GO TO 6000                                              AU       175
              D22=Y(3)-Y(2)                                                         AU       176
              DO 80 I=3,NP1                                                         AU       177
              C2E=C2                                                                AU       178
              IF (ISOLVE(JVT).EQ.0) GO TO 90                                        AU       179
              D11=D22                                                               AU       180
              D22=Y(I+1)-Y(I)                                                       AU       181
              D12=D11+D22                                                           AU       182
              DRVTDY=D11*(F(JVT,I+1)-F(JVT,I))/(D12*D22)+D22*(F(JVT,I)-F(JVT,I-1    AU       183
            * ))/(D12*D11)                                                          AU       184
              C2E=C2E+C2VT*(F(JVT,I)/R(I)**3)*DRVTDY/(GENR(I)+1.0E-20)              AU       185
              C2E=AMIN1(C2E,3.)                                                     AU       186
              C2E=AMAX1(C2E,1.)                                                     AU       187
           90 DUDYDY=(DUDY(I+1)-DUDY(I-1))/(Y(I+1)-Y(I-1))                          AU       188
              FACTOR=2.*EMUL(I)*EMUT(I)*DUDYDY*DUDYDY/RHO(I)                        AU       189
              SU(I)=C1*F(JD,I)*EMUT(I)*GENR(I)/F(JK,I)+FACTOR                       AU       190
           80 SD(I)=-C2E*F(JD,I)*RHO(I)/F(JK,I)                                     AU       191
        C     ----------------                                                      AU       192
              F6=.75*F(JK,2)+.25*F(JK,3)                                            AU       193
              F7=.75*F(JD,2)+.25*F(JD,3)                                            AU       194
              GO TO (81,82,82), KIN                                                 AU       195
           81 IF (RMI.GT.1.E-10) GO TO 82                                           MM         2
              SU(2)=1.E30*CD75*F6**1.5/(YI*AK)                                      MM         3
              SD(2)=-1.E30                                                          AU       197
              GO TO 83                                                              AU       198
           82 SU(2)=C1*F7*EMUT(2)*GENR(2)/F6                                        AU       199
              SD(2)=-C2*F7*RHO(2)/F6                                                AU       200
           83 F6=.75*F(JK,NP2)+.25*F(JK,NP1)                                        AU       201
              F7=.75*F(JD,NP2)+.25*F(JD,NP1)                                        AU       202
              GO TO (84,85,85), KEX                                                 AU       203
           84 IF (RME.LT.-1.E-10) GO TO 85                                          MM         4
              SU(NP2)=1.E30*CD75*F6**1.5/(YE*AK)                                    MM         5
              SD(NP2)=-1.E30                                                        AU       205
              GO TO 86                                                              AU       206
           85 SU(NP2)=C1*F7*EMUT(NP2)*GENR(NP2)/F6                                  AU       207
              SD(NP2)=-C2*F7*RHO(NP2)/F6                                            AU       208
           86 DO 87 I=2,NP2                                                         AU       209
              SU(I)=SU(I)*0.5*RDY(I)                                                AU       210
           87 SD(I)=SD(I)*0.5*RDY(I)                                                AU       211
        C       ----------------------------------------------   TEST 14            AU       212
              IF (ITEST) 88,89,88                                                   AU       213
           88 LAB(1)=6HTEST 1                                                       AU       214
              LAB(2)=6H4                                                            AU       215
              WRITE (6,100) LAB                                                     AU       216
              LAB(1)=6HSU(I                                                         AU       217
              LAB(2)=6H)                                                            AU       218
              WRITE (6,100) LAB,(SU(I),I=1,NP3)                                     AU       219
              LAB(1)=6HSD(I                                                         AU       220
              LAB(2)=6H)                                                            AU       221
              WRITE (6,100) LAB,(SD(I),I=1,NP3)                                     AU       222
           89 CONTINUE                                                              AU       223
        C     ----------                                                            AU       224
         6000 CONTINUE                                                              AU       225
              RETURN                                                                AU       226
          100 FORMAT(1H ,A6,A2,1P11E11.3/(9X,11E11.3))                              AU       227
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                     END                                                                AD        220


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

      60     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     197     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
     206     I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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      SUBROUTINE AJS                                                    AUS      2
      COMMON/COMA/A(43),AJE(15),AJI(15),B(43),C(43),CSALFA,D(43),       COMA     2
     1 DPDF(43),DX,EMU(43),F(15,43),FS(3,43),IAX,IEND,IFIN,INDE(15),    COMA     3
     2 INDI(15),IOUT,ISTEP,ITEST,IUTRAP,JJ,JSW,JV,JT,KEE,KIN,KRAD,N,    COMA     4
     3 N02,NE,NEVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(15),        COMA     5
     4 PREF(15),PSIE,PSII,R(43),RHO(43),RU(43),RME,RMI,SC(43),SU(43),   COMA     6
     5 TAUE,TAUI,U(43),XE,XU,Y(43),YE,YI,PSWAL(43),RDY(43),ISOLVE(15),  COMA     7
     6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PDGSCN,FDIFI(15),FDIFE(15),   COMA     8
     7 SE(15),SI(15),JLOC(12),W(12),JH,JFU,JCO2,JCO,JO2,JH2O,JOH,JO,JHS, COMA    9
     8 JH2,JN,JNO,JN2,JNT,JJ,JK,JT,JPY,NSP,NSPM,ABSOR,SCATR,BOP(200),   COMA    10
     9 TEMP1,TEMP2,ISMAX,EFU,EO2,EH2O,EPO,EPR                            COMA    11
      COMMON/COMB/AK,ALMG,EWALL,FR,H,HFU,INERT,MASSTR,MODEL,PRESS,      COMB     2
     1 UBAR,UFAC,C1,C2,CD,C2KT,AKFAC,ALFAC,ARCOM1,ARCOM2,PREXP1,CO75,   COMB     3
     2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,   COMB     4
     3 CX,HY,SXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                     COMB     5
     4 WH2,WN,WNO,WN2                                                   COMB     6
C---------------------------------------------------------------------- AUS      5
C--------------------------- 16 STEP REACTION SCHEME ------------------ AUS      6
C                                                                       AUS      7
C                 CXHY + (X/2+FY/4) O2 = XCO + (FY/2)H2O + (1-F)(Y/2)H2 AUS      8
C                            CO + OH  = CO2 + H                         AUS      9
C                            CO + O2  = CO2 + O                         AUS     10
C                        M + CO + O   = CO2 + M                         AUS     11
C                            CO + H2O = CO2 + H2                        AUS     12
C                            O2 + H2  = OH + OH                         AUS     13
C                            OH + H2  = H2O + H                         AUS     14
C                            O2 + H   = OH + O                          AUS     15
C                            O + H2   = OH + H                          AUS     16
C                            O + H2O  = OH + OH                         AUS     17
C                        M + H + H    = H2 + M                          AUS     18
C                        M + O + O    = O2 + M                          AUS     19
C                        M + O + H    = OH + M                          AUS     20
C                            N + OH   = NO + H                          AUS     21
C                            N2 + O   = NO + N                          AUS     22
C                            O2 + N   = NO + O                          AUS     23
C                                                                       AUS     24
C---------------------------------------------------------------------- AUS     25
C------------------- DIMENSIONS AND DATA STATEMENTS ------------------- AUS     26
      DIMENSION RDAT(3,16),FU(16),TSCR(16),GPT(16),RF(16),RB(16)        AUS     27
      DIMENSION FOM(16),DSOM(16)                                        AUS     28
      REAL KF(16),KB(16),LAB(2)                                         AUS     29
      DATA ((RDAT(I,J),I=1,3),J=2,16)/                                  AUS     30
     1 5.60E+11,  0.0, -1080.,                                          AUS     31
     2 2.55E+12,  0.0,-48000.,                                          AUS     32
     3 1.00E+15,  0.0, -4000.,                                          AUS     33
     4 2.50E+09,  .55,    0.0,                                          AUS     34
     5 2.00E+14,  0.0,-45000.,                                          AUS     35
     6 2.19E+13,  0.0, -5150.,                                          AUS     36
     7 2.24E+14,  0.0,-16800.,                                          AUS     37
     8 1.74E+13,  0.0, -9450.,                                          AUS     38
     9 5.75E+13,  0.0,-18000.,                                          AUS     39
     0 5.00E+18,-1.15,    0.0,                                          AUS     40
     1 4.70E+15, -.28,    0.0,                                          AUS     41
     2 5.30E+15,  0.0,  2780.,                                          AUS     42
     3 3.99E+14,  0.0,    0.0,                                          AUS     43
     4 6.17E+13,  0.1,-75211.,                                          AUS     44
     5 6.43E+09,  1.0, -6250./                                          AUS     45
C---------------------------------------------------------------------- AUS     46
C                                                                       AUS     47
      REWIND 6                                                          AUS     48
      IF (INERT.EQ.1) RETURN                                            AUS     49
      IF (ISTEP.GT.1) GO TO 5                                           AUS     50
      NFU=1                                                             AUS     51
      NCO2=2                                                            AUS     52
      NCO=3                                                             AUS     53
      NO2=4                                                             AUS     54
      NH2O=5                                                            AUS     55
      NOH=6                                                             AUS     56
      NO=7                                                              AUS     57
      NH=8                                                              AUS     58
      NH2=9                                                             AUS     59
      NN=10                                                             AUS     60
      NNO=11                                                            AUS     61
      NN2=12                                                            AUS     62
      CIY=1.0                                                           AUS     63
      SMALL=1.E-20                                                      AUS     64
      BCKGND=1.E-20                                                     AUS     65
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            RDAT(1,1)=PREXP1                                              AUS      66
            RDAT(2,1)=0.                                                  AUS      67
            RDAT(3,1)=-ARCON1                                             AUS      68
      5     DO 6000 I=2,NP2                                               AUS      69
            SX=P(I)*9.8692E-06/(82.0575*FS(JT,I))                         AUS      70
            DO 5995 J=1,16                                                AUS      71
      5995  KF(J)=RDAT(1,J)*FS(JT,I)**RDAT(2,J)*EXP(RDAT(3,J)/            AUS      72
           1  (1.987*FS(JT,I)))                                           AUS      73
            DO 620 K=2,NSP                                                AUS      74
       620  GRT(K)=GTS(FS(JT,I),K)                                        AUS      75
            AFCTR=ALOG(82.06*FS(JT,I))                                    AUS      76
      C ------- SUM GIBBS FREE ENERGY ----------                          AUS      77
            KB(2)=GRT(NCO)+GRT(NOH)-GRT(NCO2)-GRT(NHS)                    AUS      78
            KB(3)=GRT(NCO)+GRT(NO2)-GRT(NCO2)-GRT(NO)                     AUS      79
            KB(4)=GRT(NCO)+GRT(NO)-GRT(NCO2)+AFCTR                        AUS      80
            KB(5)=GRT(NCO)+GRT(NH2O)-GRT(NCO2)-GRT(NH2)                   AUS      81
            KB(6)=GRT(NO2)+GRT(NH2)-2.*GRT(NOH)                           AUS      82
            KB(7)=GRT(NOH)+GRT(NH2)-GRT(NH2O)-GRT(NHS)                    AUS      83
            KB(8)=GRT(NO2)+GRT(NHS)-GRT(NOH)-GRT(NO)                      AUS      84
            KB(9)=GRT(NO)+GRT(NH2)-GRT(NOH)-GRT(NHS)                      AUS      85
            KB(10)=GRT(NO)+GRT(NH2O)-2.*GRT(NOH)                          AUS      86
            KB(11)=2.*GRT(NHS)-GRT(NH2)+AFCTR                             AUS      87
            KB(12)=2.*GRT(NO)-GRT(NO2)+AFCTR                              AUS      88
            KB(13)=GRT(NO)+GRT(NHS)-GRT(NOH)+AFCTR                        AUS      89
            KB(14)=GRT(NN)+GRT(NOH)-GRT(NNO)-GRT(NHS)                     AUS      90
            KB(15)=GRT(NN2)+GRT(NO)-GRT(NNO)-GRT(NN)                      AUS      91
            KB(16)=GRT(NO2)+GRT(NN)-GRT(NNO)-GRT(NO)                      AUS      92
      C -------  COMPUTE BACKWARD RATE CONSTANTS ----------                AUS      93
            DO 5990 J=2,16                                                AUS      94
      5990  KB(J)=KF(J)/EXP(KB(J))                                        AUS      95
      C ------ SOME PRELIMINARIES ---------                                AUS      96
      4150  RDK=RHO(I)/1000.                                              AUS      97
            RDK2=RDK*RDK                                                  AUS      98
            KOUNT=0                                                       AUS      99
      C ------ COMPUTE FWD AND BKD REACTION RATES --------                 AUS     100
            DO 7875 JJ=1,NSPM                                             AUS     101
            J=JLOC(JJ)                                                    AUS     102
      7875  FU(JJ)=F(J,I)                                                 AUS     103
            FU(NN2)=FS(JN2,I)                                             AUS     104
             XUI=XU                                                       AUS     105
      7880  KOUNT=KOUNT+1                                                 AUS     106
            IF (KOUNT.LT.ISMAX) GO TO 5987                                AUS     107
            IF (KOUNT.GT.ISMAX+15) STOP                                   AUS     108
      C  ---------------                                                   AUS     109
            LAB(1)=6HAUS1                                                 AUS     110
            LAB(2)=2H                                                     AUS     111
            WRITE (6,990) LAB,I,ISTEP,KOUNT                               AUS     112
            WRITE (6,980) LAB,XUI,XD,DXI                                  AUS     113
            WRITE (6,980) LAB,(TSOR(J),J=1,NSPM)                          AUS     114
            WRITE (6,980) LAB,(   FU(J),J=1,NSPM)                         AUS     115
      C ----------------                                                  AUS     116
      5987  DO 5988 J=1,NSP                                               AUS     117
            FU(J)=AMAX1(FU(J),BCKGND)                                     AUS     118
      5988  FDM(J)=FU(J)/W(J)                                             AUS     119
      C  ***************        SOURCE TERM CALCULATION  ******************* AUS     120
      C                                                                   AUS     121
            FH2O=AMAX1(BCKGND,FDM(NH2O))                                  AUS     122
            RF(1)=KF(1)*(FDM(NFU)**EFU)*(FDM(NO2)**EO2)*(FH2O**EH2O)*     AUS     123
           *  (RDK**ERO)*(P(I)/101315.)**EPR                              AUS     124
            RF1=CR1*RDK*FDM(NFU)*F(JO,I)/(F(JK,I)+1.E-30)                 AUS     125
            RF(1)=AMIN1(RF(1),RF1)                                        AUS     126
            RB(1)=0.0                                                     AUS     127
            RF(2)=KF(2)*FDM(NCO)*FDM(NOH)*RDK2                            AUS     128
            RB(2)=KB(2)*FDM(NCO2)*FDM(NHS)*RDK2                           AUS     129
            RF(3)=KF(3)*FDM(NCO)*FDM(NO2)*RDK2                            AUS     130
            RB(3)=KB(3)*FDM(NCO2)*FDM(NO)*RDK2                            AUS     131
            RF(4)=KF(4)*SX*FDM(NCO)*FDM(NO)*RDK2                          AUS     132
            RB(4)=KB(4)*SX*FDM(NCO2)*RDK                                  AUS     133
            RF(5)=KF(5)*FDM(NCO)*FDM(NH2O)*RDK2                           AUS     134
            RB(5)=KB(5)*FDM(NCO2)*FDM(NH2)*RDK2                           AUS     135
            RF(6)=KF(6)*FDM(NO2)*FDM(NH2)*RDK2                            AUS     136
            RB(6)=KB(6)*FDM(NOH)*FDM(NOH)*RDK2                            AUS     137
            RF(7)=KF(7)*FDM(NOH)*FDM(NH2)*RDK2                            AUS     138
            RB(7)=KB(7)*FDM(NH2O)*FDM(NHS)*RDK2                           AUS     139
            RF(8)=KF(8)*FDM(NO2)*FDM(NHS)*RDK2                            AUS     140
            RB(8)=KB(8)*FDM(NOH)*FDM(NO)*RDK2                             AUS     141
            RF(9)=KF(9)*FDM(NO)*FDM(NH2)*RDK2                             AUS     142
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```
      RB(7)=KB(7)*FDM(NOH)*FDM(NHS)*RDK2                                  AUS      143
      RF(10)=KF(10)*FDM(NO)*FDM(NH2O)*RDK2                                AUS      144
      RB(10)=KB(10)*FDM(NOH)*FDM(NOH)*RDK2                                AUS      145
      RF(11)=KF(11)*SX*FDM(NHS)*FDM(NHS)*RDK2                             AUS      146
      RB(11)=KB(11)*SX*FDM(NH2)*RDK                                       AUS      147
      RF(12)=KF(12)*SX*FDM(NO)*FDM(NO)*RDK2                               AUS      148
      RB(12)=KB(12)*SX*FDM(NO2)*RDK                                       AUS      149
      RF(13)=KF(13)*SX*FDM(NO)*FDM(NHS)*RDK2                              AUS      150
      RB(13)=KB(13)*SX*FDM(NOH)*RDK                                       AUS      151
      RF(14)=KF(14)*FDM(NH)*FDM(NOH)*RDK2                                 AUS      152
      RB(14)=KB(14)*FDM(NHO)*FDM(NHS)*RDK2                                AUS      153
      RF(15)=KF(15)*FDM(NH2)*FDM(NO)*RDK2                                 AUS      154
      RB(15)=KB(15)*FDM(NHO)*FDM(NH)*RDK2                                 AUS      155
      RF(16)=KF(16)*FDM(NO2)*FDM(NH)*RDK2                                 AUS      156
      RB(16)=KB(16)*FDM(NHO)*FDM(NO)*RDK2                                 AUS      157
C ------- CALCULATE SPECIES SOURCE TERMS --------                         AUS      158
 5932 TSOR(NFU)=RB(1)-RF(1)                                               AUS      159
      TSOR(NCO2)=RF(2)-RB(2)+RF(3)-RB(3)+RF(4)-RB(4)+RF(5)-RB(5)          AUS      160
      TSOR(NCO)=RB(2)-RF(2)+RB(3)-RF(3)+RB(4)-RF(4)+RB(5)-RF(5)+          AUS      161
     *          CX*(RF(1)-RB(1))                                          AUS      162
      TSOR(NO2)=RB(3)-RF(3)+RB(6)-RF(6)+RB(8)-RF(8)+RF(12)-RB(12)+        AUS      163
     *          ((CX/2.+DIV*HY/4.)*(RB(1)-RF(1))                          AUS      164
      TSOR(NH2O)=RB(5)-RF(5)+RF(7)-RB(7)+RB(10)-RF(10)+                   AUS      165
     *          (DIV*HY/2.)*(RF(1)-RB(1))                                 AUS      166
      TSOR(NOH)=RB(2)-RF(2)+2.*(RF(6)-RB(6))+RB(7)-RF(7)+RF(8)-RB(8)+     AUS      167
     *          RF(9)-RB(9)+2.*(RF(10)-RB(10))+RF(13)-RB(13)              AUS      168
      TSOR(NO)=RF(3)-RB(3)+RB(4)-RF(4)+RF(8)-RB(8)+RB(9)-RF(9)+           AUS      169
     *        RB(10)-RF(10)+2.*(RB(12)-RF(12))+RB(13)-RF(13)              AUS      170
      TSOR(NHS)=RF(2)-RB(2)+RF(7)-RB(7)+RB(8)-RF(8)+RF(9)-RB(9)+          AUS      171
     *          2.*(RB(11)-RF(11))+RB(13)-RF(13)                          AUS      172
      TSOR(NH2)=((1.-DIV)*HY/2.)*(RF(1)-RB(1))+RF(5)-RB(5)+RB(6)-RF(6)+   AUS      173
     *          RB(7)-RF(7)+RB(9)-RF(9)+RF(11)-RB(11)                     AUS      174
      TSOR(NO2)=TSOR(NO2)+RB(16)-RF(16)                                   AUS      175
      TSOR(NOH)=TSOR(NOH)+RB(14)-RF(14)                                   AUS      176
      TSOR(NO)=TSOR(NO)+RB(15)-RF(15)+RF(16)-RB(16)                       AUS      177
      TSOR(NHS)=TSOR(NHS)+RF(14)-RB(14)                                   AUS      178
      TSOR(NH)=RB(14)-RF(14)+RF(15)-RB(15)+RB(16)-RF(16)                  AUS      179
      TSOR(NHO)=RF(14)-RB(14)+RF(15)-RB(15)+RF(16)-RB(16)                 AUS      180
      TSOR(NH2)=RB(15)-RF(15)                                             AUS      181
      DSOR(NFU)=0.                                                        AUS      182
      DSOR(NCO2)= KB(2)*FDM(NHS)*RDK2     +  KB(3)*FDM(NO)*RDK2      +    AUS      183
     1            KB(4)*SX*RDK            +  KB(5)*FDM(NH2)*RDK2     +    AUS      184
      DSOR(NCO)=  KF(2)*FDM(NOH)*RDK2     +  KF(3)*FDM(NO2)*RDK2     +    AUS      185
     1            KF(4)*SX*FDM(NO)*RDK2   +  KF(5)*FDM(NH2O)*RDK2    +    AUS      186
      DSOR(NO2)=  KF(3)*FDM(NCO)*RDK2     +  KF(6)*FDM(NH2)*RDK2     +    AUS      187
     1            KF(8)*FDM(NHS)*RDK2     +  KB(12)*SX*RDK           +    AUS      188
     2            KF(16)*FDM(NH)*RDK2                                     AUS      189
      DSOR(NH2O)= KF(5)*FDM(NCO)*RDK2     +  KB(7)*FDM(NHS)*RDK2     +    AUS      190
     1            KF(10)*FDM(NO)*RDK2                                     AUS      191
      DSOR(NOH)=  KF(2)*FDM(NCO)*RDK2     +  2.*KB(6)*FDM(NOH)*RDK2  +    AUS      192
     1            KF(7)*FDM(NH2)*RDK2     +  KB(8)*FDM(NO)*RDK2      +    AUS      193
     2            KB(9)*FDM(NHS)*RDK2     +  2.*KB(10)*FDM(NOH)*RDK2 +    AUS      194
     3            KB(13)*SX*RDK           +  KF(14)*FDM(NH)*RDK2     +    AUS      195
      DSOR(NO)=   KB(3)*FDM(NCO2)*RDK2    +  KF(4)*SX*FDM(NCO)*RDK2  +    AUS      196
     1            KB(8)*FDM(NOH)*RDK2     +  KF(9)*FDM(NH2)*RDK2     +    AUS      197
     2            KF(10)*FDM(NH2O)*RDK2   +  2.*KF(12)*SX*FDM(NO)*RDK2+   AUS      198
     3            KF(13)*SX*FDM(NHS)*RDK2 +  KF(15)*FDM(NH2)*RDK2    +    AUS      199
     4            KB(16)*FDM(NHO)*RDK2                                    AUS      200
      DSOR(NHS)=  KB(2)*FDM(NCO2)*RDK2    +  KB(7)*FDM(NH2O)*RDK2    +    AUS      201
     1            KF(8)*FDM(NO2)*RDK2     +  KB(9)*FDM(NOH)*RDK2     +    AUS      202
     2        2.*KF(11)*SX*FDM(NHS)*RDK2  +  KF(13)*SX*FDM(NO)*RDK2  +    AUS      203
     3            KB(14)*FDM(NHO)*RDK2                                    AUS      204
      DSOR(NH2)=  KB(5)*FDM(NCO2)*RDK2    +  KF(6)*FDM(NO2)*RDK2     +    AUS      205
     1            KF(7)*FDM(NOH)*RDK2     +  KF(9)*FDM(NO)*RDK2      +    AUS      206
     2            KB(11)*SX*RDK                                           AUS      207
      DSOR(NH)=   KF(14)*FDM(NOH)*RDK2    + KB(15)*FDM(NHO)*RDK2     +    AUS      208
     1            KF(16)*FDM(NO2)*RDK2                                    AUS      209
      DSOR(NHO)=  KB(14)*FDM(NHS)*RDK2    +  KB(15)*FDM(NH)*RDK2     +    AUS      210
     1            KB(16)*FDM(NO)*RDK2                                     AUS      211
      DSOR(NH2)=  KF(15)*FDM(NO)*RDK2                                     AUS      212
C ----- CONVERT SOURCE TERMS TO PROPER UNITS ------                       AUS      213
      DO 5970 J=1,NSP                                                     AUS      214
      TSOR(J)=TSOR(J)*RDY(I)*1000.*W(J)                                   AUS      215
      DSOR(J)=DSOR(J)*RDY(I)*1000.*W(J)                                   AUS      216
 5970 CONTINUE                                                            AUS      217
C -------- DETERMINE STEP SIZE --------------                             AUS      218
      DXI=DX                                                              AUS      219
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      HPBOM=PEI*BOM(I)/2.
      DO 8000 J=1,NSP
      IF (ABS(TSOR(J)).LT.SMALL) GO TO 8000
      DF=AMAX1(TERM2,TERM1*FM(J))
      DXI=AMIN1(DXI,DF*HPBOM/ABS(TSOR(J)))
 8000 CONTINUE
      XDI=XUI+DXI
      IF (XDI.GT.XD) DXI=XD-XUI
      IF (DXI.GT.0.) GO TO 8010
C     ----------------------
      LAB(1)=6HAUS2
      LAB(2)=2H
      WRITE (6,990) LAB,I,ISTEP,KOUNT
      WRITE (6,980) LAB,DX,XUI,XDI,XD,DXI
  980 FORMAT (1H0,A6,A2,1P11E11.3/(9X,11E11.3))
  990 FORMAT (1H0,A6,A2,1I1I11)
      STOP
C     --------------------------
 8010 PXBOM=PEI*BOM(I)/DXI
C     ---------- SOLVE FOR DOWNSTREAM SPECIE VALUES ---------
      DO 7885 J=1,NSP
      FU(J)=(PXBOM*FU(J)+2.*(TSOR(J)+BSOR(J)*FDM(J)))/(PXBOM+2.*BSOR(J)/
     1 W(J))
 7885 CONTINUE
      XUI=XDI
      IF (XUI.LT.XD) GO TO 7880
      PXBOM=PEI*BOM(I)/DX
      DO 78 K=1,NSPM
      J=JLOC(K)
   78 TSOR(K)=.5*PXBOM*(FU(K)-F(J,I))
      WRITE (4) TSOR
 6000 CONTINUE
      RETURN
      END
```

```
      FUNCTION GASP (TT,I)                                              GA        2
      DIMENSION AM(7,12),AL(7,12),W(12)                                 GA        3
C                                                                       GA        4
C     SPECIES ORDER - FUEL,CO2,CO,O2,H2O,OH,O,H,H2,N,NO,N2              GA        5
C                                                                       GA        6
      DATA ((AM(I,J),I=1,7),J=1,6)/                                     GA        7
     1 0.26845936E+02, 0.46470050E-01,-0.22967813E-04, 0.48494616E-08,  GA        8
     2-0.37080219E-12,-0.40857112E+05, 0.             ,                 GA        9
     3  .44608041E+01,  .30981719E-02, -.12392571E-05,  .22741325E-09,  GA       10
     4 -.15525954E-13, -.40961442E+05, -.98635982E+00,                  GA       11
     5  .29840696E+01,  .14891390E-02, -.57899684E-06,  .10364577E-09,  GA       12
     6 -.69353550E-14, -.14245228E+05,  .63479156E+01,                  GA       13
     7  .36219535E+01,  .73618264E-03, -.19652228E-06,  .36201558E-10,  GA       14
     8 -.28945627E-14, -.12019825E+04,  .36150960E+01,                  GA       15
     9  .27167633E+01,  .29451374E-02, -.80224374E-06,  .10226682E-09,  GA       16
     0 -.48472145E-14, -.29905826E+05,  .66305671E+01,                  GA       17
     1  .29131230E+01,  .95418248E-03, -.19084373E-06,  .12730795E-10,  GA       18
     2  .24803941E-15,  .39647060E+04,  .54288735E+01/                  GA       19
C                                                                       GA       20
      DATA ((AM(I,J),I=1,7),J=7,12)/                                    GA       21
     1  .25420596E+01, -.27550619E-04, -.31028033E-08,  .45510674E-11,  GA       22
     2 -.43680515E-15,  .29230803E+05,  .49203080E+01,                  GA       23
     3  .25000000E+01, 0.             , 0.             , 0.             , GA       24
     4 0.             ,  .25471627E+05, -.46011763E+00,                  GA       25
     5  .31001901E+01,  .51119464E-03,  .52644210E-07, -.34909973E-10,  GA       26
     6  .36945345E-14, -.87738042E+03, -.19629421E+01,                  GA       27
     7  .24502682E+01,  .10661458E-03, -.74653373E-07,  .18796524E-10,  GA       28
     8 -.10299339E-14,  .56116040E+05,  .44487581E+01,                  GA       29
     9  .31890000E+01,  .13382281E-02, -.52899318E-06,  .95919332E-10,  GA       30
     0 -.64847932E-14,  .98283290E+04,  .67458126E+01,                  GA       31
     1  .28963194E+01,  .15154866E-02, -.57235277E-06,  .99807393E-10,  GA       32
     2 -.65223555E-14, -.90586194E+03,  .61615148E+01/                  GA       33
C                                                                       GA       34
      DATA ((AL(I,J),I=1,7),J=1,6)/                                     GA       35
     1 0.57799475E+01, 0.50561458E-01, 0.51144255E-04,-0.94958140E-07,  GA       36
     2 0.39603875E-10,-0.29323482E+05, 0.             ,                 GA       37
     3  .24007797E+01,  .87350957E-02, -.66070878E-05,  .20021861E-08,  GA       38
     4  .63274039E-15, -.48377527E+05,  .96951457E+01,                  GA       39
     5  .37100928E+01, -.16190964E-02,  .36923594E-05, -.20319674E-08,  GA       40
     6  .23953344E-12, -.14356310E+05,  .29555351E+01,                  GA       41
     7  .36255985E+01, -.18782184E-02,  .70554544E-05, -.67635137E-08,  GA       42
     8  .21555993E-11, -.10475226E+04,  .43052778E+01,                  GA       43
     9  .40701275E+01, -.11084499E-02,  .41521180E-05, -.29637404E-08,  GA       44
     0  .80702103E-12, -.30279722E+05, -.32270046E+00,                  GA       45
     1  .38365518E+01, -.10702014E-02,  .94049757E-06,  .18713972E-09,  GA       46
     2 -.22571094E-12,  .36412823E+04,  .49370009E+00/                  GA       47
C                                                                       GA       48
      DATA ((AL(I,J),I=1,7),J=7,12)/                                    GA       49
     1  .29464287E+01, -.16381665E-02,  .24210316E-05, -.16028432E-08,  GA       50
     2  .38906964E-12,  .29147644E+05,  .29639949E+01,                  GA       51
     3  .25000000E+01, 0.             , 0.             , 0.             , GA       52
     4 0.             ,  .25471627E+05, -.46011762E+00,                  GA       53
     5  .30574451E+01,  .26765200E-02, -.58099162E-05,  .55210391E-08,  GA       54
     6 -.18122739E-11, -.98890474E+03, -.22997056E+01,                  GA       55
     7  .25036714E+01, -.21800181E-04,  .54205287E-07, -.56475602E-10,  GA       56
     8  .20999044E-13,  .56098904E+05,  .41675764E+01,                  GA       57
     9  .40459521E+01, -.34181783E-02,  .79819190E-05, -.61139316E-08,  GA       58
     0  .15919076E-11,  .97453934E+04,  .29974098E+01,                  GA       59
     1  .36748261E+01, -.12081500E-02,  .23240102E-05, -.63217559E-09,  GA       60
     2 -.22577253E-12, -.10611588E+04,  .23580424E+01/                  GA       61
C                                                                       GA       62
      DATA W/44.,44.,28.,32.,18.,17.,16.,1.,2.,14.,30.,28./,KOUNT/0/    GA       63
      DATA TLIM/1500./                                                  GA       64
C     ****************************************************************** GA       65
      ENTRY GTT                                                         GA       66
      T=TT                                                              GA       67
      IF (T.LT.1000.) GO TO 10                                          GA       68
      ARG=AM(1,I)*(1.-ALOG(T))+AM(6,I)/T-(AM(7,I)+T*(AM(2,I)/2.+T*(AM(3, GA       69
     1I)/6.+T*(AM(4,I)/12.+T*AM(5,I)/20.))))                            GA       70
      GO TO 15                                                          GA       71
   10 ARG=AL(1,I)*(1.-ALOG(T))+AL(6,I)/T-(AL(7,I)+T*(AL(2,I)/2.+T*(AL(3, GA       72
     1I)/6.+T*(AL(4,I)/12.+T*AL(5,I)/20.))))                            GA       73
   15 GASP=ARG                                                          GA       74
      RETURN                                                            GA       75
C     ****************************************************************** GA       76
      ENTRY CPOR                                                        GA       77
      T=TT                                                              GA       78
```

```
FUNCTION GASP       73/74    OPT=0 TRACE                   FTN 4.6+439        08/24/78  14.42.35        PAGE     2

      IF (I.EQ.1) T=AMIN1(T,TLIM)
      IF (T.LT.1000.) GO TO 20
      ARG=AM(1,I)+T*(AM(2,I)+T*(AM(3,I)+T*(AM(4,I)+T*AM(5,I))))
      GO TO 25
   20 ARG=AL(1,I)+T*(AL(2,I)+T*(AL(3,I)+T*(AL(4,I)+T*AL(5,I))))
   25 GASP=ARG*1.987*4184./W(I)
      RETURN
C     ******************************************************************
      ENTRY HDR
      T=TT
      IF (I.EQ.1) T=AMIN1(T,TLIM)
      IF (T.LT.1000.) GO TO 30
      ARG=AM(6,I)+T*(AM(1,I)+T*(AM(2,I)/2.+T*(AM(3,I)/3.+T*(AM(4,I)/4.+T
     1*AM(5,I)/5))))
      GO TO 35
   30 ARG=AL(6,I)+T*(AL(1,I)+T*(AL(2,I)/2.+T*(AL(3,I)/3.+T*(AL(4,I)/4.+T
     1*AL(5,I)/5))))
   35 GASP=ARG*1.987*4184./W(I)
      IF (TT.LT.TLIM.OR.I.NE.1) RETURN
      CPI=AM(1,I)+T*(AM(2,I)+T*(AM(3,I)+T*(AM(4,I)+T*AM(5,I))))
      ARG=ARG+CPI*(TT-T)/W(I)
      GASP=ARG*1.987*4184./W(I)
      RETURN
C     ******************************************************************
      ENTRY COEF
      KOUNT=KOUNT+1
      IF (KOUNT.EQ.2) GO TO 40
      W(I)=TT
      GASP=W(I)
      RETURN
   40 HFU=TT
      AM(6,I)=HFU/1.987
      AL(6,I)=HFU/1.987
      GASP=AL([illegible],I)
      RETURN
      END
```

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      SUBROUTINE STRIDE(ISW)                                            ST         2
      COMMON/COMA/A(43),AJE(15),AJI(15),B(43),C(43),CSALFA,D(43),       COMA       2
     1 DPDX(43),DX,EMU(43),F(15,43),FS(3,43),IAX,IEND,IFIN,INDE(15),    COMA       3
     2 INDI(15),IOUT,ISTEP,ITEST,INTRAP,JS,JSU,JV,JY,KEX,KIN,KRAD,N,    COMA       4
     3 NOZ,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(15),        COMA       5
     4 PREF(15),PSIE,PSII,R(43),RHO(43),RU(43),RME,RMI,SO(43),SU(43),   COMA       6
     5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSWALL(43),RDY(43),ISOLVE(15), COMA       7
     6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PDESCH,FDIFI(15),FDIFE(15),   COMA       8
     7 CE(15),CI(15),XLOC(12),V(12),JH,JFU,JCOZ,JCO,JOX,JH2O,JOH,JO,JHS, COMA      9
     8 JN2,JN,JNO,JH2,JVT,JS,JK,JT,JRY,NSP,NSPM,ABSOR,SCAT,BOM(200),    COMA      10
     9 TERM1,TERM2,ISMAX,EPU,EOZ,EH2O,ERO,EPR                           COMA      11
C/-------------------  SUBROUTINE FOR PROGRAM GENMIX 4A  --------------- ST         4
C/ THIS SUBROUTINE PERFORMS THE SAME OPERATIONS AS THE ONE IN GENMIX4A  ST         5
C  BUT MORE ECONOMICALLY. THE A,B,C ARRAYS ARE ONE-DIMENSIONAL. SOME    ST         6
C  OFTEN USED FUNCTIONS OF OM ARE STORED, AND A D ARRAY SAVES           ST         7
C  UNNECESSARY ARITHMETIC IN THE TDMA OPERATION.                        ST         8
C----------------------------------------------------------------------  ST         9
      DIMENSION AMLPT(43),BOMT3(43),PBOM(43),PGOM(43),THLPT(43)         ST        10
      DIMENSION OMPOM(200)                                              ST        11
      DIMENSION TMP3FF(15),TTPF(15),TIFF(15)                            ST        12
      DIMENSION IKAS(15)                                                ST        13
      DATA IKAS/15*0/,KASU/0/                                           MA         6
C                                                                       ST        15
      GO TO (1000,2000,3000,4030), ISW                                  ST        16
C                                                                       ST        17
C*************************************  S T R I D E 1  **************** ST        18
 1000 IF(ISTEP) 1003,1003,1100                                          ST        19
 1003 OMI=.5*OM(3)                                                      ST        20
      OME=.5*(1.-OM(NP1))                                               ST        21
      DO 1002 I=2,NP2                                                   ST        22
      BOM(I)=OM(I+1)-OM(I-1)                                            ST        23
      BOMT3(I)=3.*BOM(I)                                                ST        24
      OMPOM(I)=OM(I)+OM(I+1)                                            ST        25
 1002 OMD(I)=OM(I+1)-OM(I)                                              ST        26
      OMD(1)=BOM(2)                                                     ST        27
      BPE=1.                                                            ST        28
      BPI=1.                                                            ST        29
      Y(1)=0.                                                           ST        30
      IF(KRAD.EQ.1) GO TO 1100                                          ST        31
      DO 1001 I=1,NP3                                                   ST        32
 1001 R(I)=1.                                                           ST        33
      R25=1.                                                            ST        34
      RN15=1.                                                           ST        35
      IF(ITEST.NE.0) WRITE(6,9010) (R(I),I=1,NP3),R25,RN15              ST        36
C--------------------------- CALCULATION OF RHO*U 'S ------------------ ST        37
 1100 DO 1101 I=1,NP3                                                   ST        38
      IF(RHO(I).GT.0.) GO TO 1101                                       ST        39
      WRITE(6,1108) RHO(I),I,RHO(I)                                     ST        40
 1108 FORMAT(36H ********** NEGATIVE OR ZERO RHO(I)=,1PE11.3,6H AT I=,  ST        41
     1 I3,6X,21HSET TO ABS OF RHO(I)=,E11.3,17H ******** STRIDE1)       ST        42
      RHO(I)=ABS(RHO(I))                                                ST        43
 1101 RU(I)=RHO(I)*U(I)                                                 ST        44
      RU3=RU(3)                                                         ST        45
      RUN1=RU(NP1)                                                      ST        46
      DO 1102 I=2,NP1                                                   ST        47
 1102 RU(I)=.5*(RU(I)+RU(I+1))                                          ST        48
      IF(ITEST.NE.0) WRITE(6,9010) (RU(I),I=1,NP3),RUN1,RU3,PEI         ST        49
C--------------------------- CALCULATION OF Y 'S AND R 'S ------------- ST        50
C  ---------------------------------------- Y'S FOR PLANE GEOMETRY      ST        51
      YI=PEI*OMI/(BPI*RU(2))                                            ST        52
      Y(3)=YI+PEI*OM(3)/(RU(2)+RU3)                                     ST        53
      Y(2)=2.*YI-Y(3)                                                   ST        54
      DO 1103 I=4,NP1                                                   ST        55
 1103 Y(I)=Y(I-1)+PEI*OMD(I-1)/RU(I-1)                                  ST        56
      YN15=Y(NP1)+PEI*OMD(NP1)/(RU(NP1)+RUN1)                           ST        57
      YE=PEI*OME/(BPE*RU(NP1))                                          ST        58
      Y(NP3)=YN15+YE                                                    ST        59
      Y(NP2)=2.*YN15-Y(NP1)                                             ST        60
      IF(KRAD.EQ.0) RETURN                                              ST        61
C  ------------------------ Y'S AND R'S FOR AXISYMMETRICAL GEOMETRY     ST        62
      IF(CSALFA.EQ.0.) GO TO 1110                                       ST        63
C  ---------------------------------------- CSALFA NE ZERO              ST        64
      COSD2=.5*CSALFA                                                   SI        65
      IF(R(1).NE.0.) GO TO 1105                                         ST        66
C------------------------------------------ R(1)=0.                     ST        67
      DO 1106 I=2,NP3                                                   ST        68
      Y(I)=SQRT(ABS(Y(I)/COSD2))                                        ST        69
```

```
 1106 R(I)=Y(I)*CSALFA
      YI=SQRT(ABS(YI/COSD2))
      YN15=SQRT(ABS(YN15/COSD2))
      GO TO 1107
C     --------------------------------------------------   R(1) NE 0.
 1105 R1D2=.5*R(1)
      R1D2SQ=R1D2*R1D2
      DO 1104 I=2,NP3
      Y(I)=Y(I)/(R1D2+SQRT(ABS(R1D2SQ+COSD2*Y(I))))
 1104 R(I)=R(1)+Y(I)*CSALFA
      YI=YI/(R1D2+SQRT(ABS(R1D2SQ+COSD2*YI)))
      YN15=YN15/(R1D2+SQRT(ABS(R1D2SQ+COSD2*YN15)))
 1107 R25=R(1)+YI*CSALFA
      RN15=R(1)+YN15*CSALFA
      YE=Y(NP3)-YN15
      RETURN
C     --------------------------------------------------  CSALFA EQ ZERO
 1110 DO 1111 I=2,NP3
      Y(I)=Y(I)/R(1)
 1111 R(I)=R(1)
      YI=YI/R(1)
      YN15=YN15/R(1)
      R25=R(1)
      RN15=R(1)
      YE=Y(NP3)-YN15
      RETURN
C************************************** S T R I D E 2 ***************
C     -----------------------------------    PRELIMINARIES FOR COEFFICIENTS
 2000 PX=PEI/DX
      P08=.125*PX
      P04=P08+P08
      G=RMI-RNE
      ARMI=ABS(RMI)
      ARNE=ABS(RNE)
      G04=.25*G
      PG=PX*G
      PG08=.125*PG
      PG04=PG08+PG08
      RMID2=.5*RMI
      DO 2004 I=2,NP2
      PBOM(I)=PX*BOM(I)
 2004 PGOM(I)=PG04*OMB(I)
      P4OMP=P04*BOM(2)
C     --------------------------------------------------  GRID POINT 2
C------------------------------------------------------  TAUI, BPI, TI
      IF(KIN.NE.1) GO TO 2001
      CALL WF(5,1,BPI,TI,TAUI)
      GO TO 2002
 2001 TI=0.
      IF(KRAD.EQ.0) BPI=.33333+.66667*RU(1)/RU(2)
      IF(KRAD.EQ.1) BPI=(R(1)*(5.*RU(1)+RU(2))+3.*R25*
     1                   (RU(1)+RU(2)))/6./(R(1)+R25)/RU(2)
 2002 DO 2700 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 2700
      IF (KIN.NE.1) GO TO 2705
      CALL WF (J,1,FDIFI(J),TIFF(J),GI(J))
      IF (INDI(J).EQ.2) GO TO 2700
      AJI(J)=GI(J)*(F(J,1)-.5*(F(J,2)+F(J,3))-FDIFI(J))
      GO TO 2700
 2705 TIFF(J)=0.
      FDIFI(J)=0.
 2700 CONTINUE
C     --------------------------------------------------  GRID POINT NP2
C------------------------------------------------------  TAUE, BPE, TNP3
 2304 IF(KEX.NE.1) GO TO 2003
      CALL WF(5,NP3,BPE,TNP3,TAUE)
      GO TO 2310
 2003 TNP3=0.
      IF(KRAD.EQ.0) BPE=.33333+.66667*RU(NP3)/RU(NP1)
      IF(KRAD.EQ.1) BPE=(R(NP3)*(5.*RU(NP3)+RU(NP1))+3.*RN15*
     1                  (RU(NP3)+RU(NP1)))/6./(R(NP3)+ RN15)/RU(NP1)
 2310 DO 2720 J=1,NF
      IF (ISOLVE(J).EQ.0) GO TO 2720
      IF (KEX.NE.1) GO TO 2730
      CALL WF(J,NP3,FDIFE(J),TNP3FF(J),GE(J))
      IF (INDE(J).EQ.2) GO TO 2720
      AJE(J)=GE(J)*(.5*(F(J,NP2)+F(J,NP1))+FDIFE(J)-F(J,NP3))
```

```
      GO TO 2720                                                        ST        147
 2730 TMP3FF(J)=0.                                                      ST        148
      FGIFF(J)=0.                                                       ST        149
 2720 CONTINUE                                                          ST        150
      RETURN                                                            ST        151
C************************************  S T R I D E 3  ***************** ST        152
 3000 CALL SOURCE(0)                                                    ST        153
C     ------------------  BOUNDARY COEFFICIENTS FOR VELOCITY            ST        154
C      ---------   GRID POINT 2 COEFFICIENTS     -------------          ST        155
      AKASU=KASU                                                        MM          7
      HLP=RWID2-GD4*DMPOM(2)                                            ST        156
      AMLP=ABS(HLP)                                                     ST        157
      THLP=HLP+HLP                                                      ST        158
      THLPT(2)=THLP                                                     ST        159
      TP=EM U(2)                                                        ST        160
      TTP=TP+AMLP+ABS(TP-AMLP)                                          ST        161
      A(2)=TTP-THLP-T1-PGOM(2)*AKASU                                    MM          8
      B(2)=2.*T1+RMI+ARMI                                               ST        163
      C(2)=P4OMP*(3.*U(2)+U(3))-US(2)                                   ST        164
      IF (KASU.EQ.0) C(2)=4.*P4OMP*U(2)-US(2)                           MM          9
      D(2)=A(2)+B(2)+PBOM(2)                                            ST        165
C     -------    GRID POINT NP2 COEFFICIENTS      ------------          ST        166
      HLM=RWID2-GD4*DMPOM(NP1)                                          ST        167
      AMLM=ABS(HLM)                                                     ST        168
      THLM=HLM+HLM                                                      ST        169
      THLPT(NP2)=THLM                                                   ST        170
      TM=EM U(NP1)                                                      ST        171
      TTM=TM+AMLM+ABS(TM-AMLM)                                          ST        172
      P4OMM=PD4*BOM(NP2)                                                ST        173
      A(NP2)=2.*TMP3-RME+ARME                                           ST        174
      B(NP2)=TTM+THLM-TMP3-PGOM(NP1)*AKASU                              MM         10
      C(NP2)=P4OMM*(3.*U(NP2)+U(NP1))-US(NP2)                           ST        176
      IF (KASU.EQ.0) C(NP2)=4.*P4OMM*U(NP2)-US(NP2)                     MM         11
      D(NP2)=A(NP2)+B(NP2)+PBOM(NP2)                                    ST        177
C     -------      MID-STREAM COEFFICIENTS    ----------                ST        178
      DO 3005 I=3,NP1                                                   ST        179
      THLM=THLP                                                         ST        180
      HLP=RMID2-GD4*DMPOM(I)                                            ST        181
      THLP=HLP+HLP                                                      ST        182
      THLPT(I)=THLP                                                     ST        183
      AMLP=ABS(HLP)                                                     ST        184
      AMLPT(I)=AMLP                                                     ST        185
      TTM=TTP                                                           ST        186
      TP=EM U(I)                                                        ST        187
      TTP=TP+AMLP+ABS(TP-AMLP)                                          ST        188
      A(I)=TTP-THLP-PGOM(I)*AKASU                                       MM         12
      B(I)=TTM+THLM-PGOM(I-1)*AKASU                                     MM         13
      C(I)=PD4*(BOMT3(I)*U(I)+DMD(I)*U(I+1)+DMD(I-1)*U(I-1))-US(I)      ST        191
      IF (KASU.EQ.0) C(I)=4.*PD4*BOM(I)*U(I)-US(I)                      MM         14
      D(I)=A(I)+B(I)+PBOM(I)                                            ST        192
 3005 CONTINUE                                                          ST        193
      GO TO (3021,3020), NOVEL                                          ST        194
 3020 IF(ITEST) 3900,3905,3900                                          ST        195
 3900 WRITE(6,3901) (A(I),I=2,NP2)                                      ST        196
      WRITE(6,3902) (B(I),I=2,NP2)                                      ST        197
      WRITE(6,3903) (C(I),I=2,NP2)                                      ST        198
      WRITE(6,3904) (D(I),I=2,NP2)                                      ST        199
 3901 FORMAT(7H  A(I) ,1P11E11.3/(7X,11E11.3))                          ST        200
 3902 FORMAT(7H  B(I) ,1P11E11.3/(7X,11E11.3))                          ST        201
 3903 FORMAT(7H  C(I) ,1P11E11.3/(7X,11E11.3))                          ST        202
 3904 FORMAT(7H  D(I) ,1P11E11.3/(7X,11E11.3))                          ST        203
 3905 CONTINUE                                                          ST        204
C-----------------------------                      ------------------- ST        205
      IF(KIN.EQ.2.AND.RU(1).NE.0.) U(1)=U(1)-DPDX(1)*DX/RU(1)           ST        206
      IF(KEX.EQ.2.AND.RU(NP3).NE.0.) U(NP3)=U(NP3)-DPDX(NP3)*DX/RU(NP3) ST        207
C--------------------------------------- SOLVE FOR DOWNSTREAM U'S ----- ST        208
      B(2)=(B(2)*U(1)+C(2))/D(2)                                        ST        209
      A(2)=A(2)/D(2)                                                    ST        210
      DO 3048 I=3,NP2                                                   ST        211
      T=D(I)-B(I)*A(I-1)                                                ST        212
      A(I)=A(I)/T                                                       ST        213
 3048 B(I)=(B(I)*B(I-1)+C(I))/T                                         ST        214
      DO 3050 IDASH=2,NP2                                               ST        215
      I=N+4-IDASH                                                       ST        216
      U(I)=A(I)*U(I+1)+B(I)                                             ST        217
C     ------------------------------------- TEST FOR NEGATIVE U'S       ST        218
C/IUTPAP=0,NO ACTION/ .GT.0,SET TO 1.E-30/ .GT.1,IFIN=-1/ .GT.2,ITEST=1/ ST        219
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```
      IF(IUTRAP.EQ.0.OR.I.EQ.2.OR.I.EQ.NP2) GO TO 3050                  ST      220
      IF(U(I)) 3046,3046,3050                                           ST      221
 3046 J=ISTEP+1                                                         ST      222
      WRITE(6,3047) U(I),I,J                                            ST      223
 3047 FORMAT(25H ********** U (LE ZERO) =,1PE10.3,6H AT I=,I3,          ST      224
     1 8H, ISTEP=,I6,34H, SET U TO 1.E-30 ******** STRIDE3)            ST      225
      U(I)=1.E-30                                                       ST      226
      IFIN=-IUTRAP/2                                                    ST      227
      ITEST=IUTRAP/3                                                    ST      228
 3050 CONTINUE                                                          ST      229
C     --------------------------------------------------------          ST      230
      IF(KIN.EQ.3) U(1)=.5*(U(2)+U(3))                                  ST      231
      IF(KEX.EQ.3)U(NP3)=.5*(U(NP1)+U(NP2))                             ST      232
 3021 IF (ITEST) 3011,3014,3011                                         ST      233
 3011 WRITE(6,3012) (U(I),I=1,NP3)                                      ST      234
 3012 FORMAT(3H U ,6X,1P11E11.3/(9X,11E11.3))                           ST      235
C     -------------------------------------------------------           ST      236
C     ------------------   SOLVE FOR DOWN STREAM F'S   ----------------- ST      237
 3014 DO 3321 J=1,NF                                                    ST      238
      IF (ISOLVE(J).EQ.0) GO TO 3321                                    ST      239
      AKAS=FLOAT(IKAS(J))                                               ST      240
C     ------   COMPUTE SOURCE TERMS   ---------                         ST      241
      CALL SOURCE(J)                                                    ST      242
C     -------   GRID POINT 2   ---------                                ST      243
      TP=EM U(2)                                                        ST      244
      TPF2=TP/PREF(J)                                                   ST      245
      THLP=THLPT(2)                                                     ST      246
      AMLP=.5*ABS(THLP)                                                 ST      247
      TTPF(J)=TPF2+AMLP+ABS(TPF2-AMLP)                                  ST      248
      TIF=TIFF(J)                                                       ST      249
      IF (KIN.NE.1) GO TO 2302                                          ST      250
      IF(INDI(J).EQ.2) GO TO 2303                                       ST      251
CC    -------------   EDGE VALUE SPECIFIED   -----------                ST      252
 2302 A(2)=TTPF(J)-THLP-TIF-(PGOM(2)-.5*SD(2))*AKAS                     ST      253
      B(2)=2.*TIF+RMI*ARMI                                              ST      254
      D(2)=A(2)+B(2)+PGOM(2)-2.*SD(2)                                   ST      255
      IF (J.NE.JVT) GO TO 510                                           ST      256
      RP=.5*(R(2)+R(3))                                                 ST      257
      ATP=2.*(RP/R(3))**2                                               ST      258
      AT1=(R(1)/RP)**2                                                  ST      259
      BTP=2.*(RP/(.75*R(2)+.25*R(3)))**2                                ST      260
      A(2)=TTPF(J)*ATP-THLP-TIF*AT1-(PGOM(2)-.5*SD(2))*AKAS             ST      261
      TT=3.*PGOM(2)-1.5*SD(2)                                           ST      262
      IF (IKAS(J).EQ.0) TT=4.*PGOM(2)-2.*SD(2)                          ST      263
      D(2)=TTPF(J)*BTP+TIF+THLP+TT                                      ST      264
  510 T=-TIF*FBIFI(J)                                                   ST      265
      GO TO 2305                                                        ST      266
C     --------------   EDGE FLUX SPECIFIED   -----------                ST      267
 2303 A(2)=TTPF(J)-THLP-(PGOM(2)-.5*SD(2))*AKAS                         ST      268
      B(2)=0.                                                           ST      269
      D(2)=A(2)+PGOM(2)-2.*SG(2)+RMI*2.                                 ST      270
      T=RMI*F(J,1)+AJI(J)*R(I)                                          ST      271
 2305 TT=3.*F(J,2)-F(J,3)                                               ST      272
      IF (IKAS(J).EQ.0) TT=4.*F(J,2)                                    ST      273
      C(2)=PGOMP*T.+2.*(T+SU(2))                                        ST      274
 2300 CONTINUE                                                          ST      275
C     -----------   GRID POINT NP2   --------                           ST      276
      TM=EM U(NP1)                                                      ST      277
      TMF=TM/PREF(J)                                                    ST      278
      THLM=THLPT(NP2)                                                   ST      279
      AMLM=.5*ABS(THLM)                                                 ST      280
      TTMF=TMF+AMLM+ABS(TMF-AMLM)                                       ST      281
      TMP3F=TMP3FF(J)                                                   ST      282
      IF (KEX.NE.1) GO TO 2312                                          ST      283
      IF(INDE(J).EQ.2) GO TO 2313                                       ST      284
C     ----------------   EDGE VALUE SPECIFIED   --------                ST      285
 2312 A(NP2)=2.*TMP3F-RME+APME                                          ST      286
      B(NP2)=TTMF+THLM-TMP3F-(PGOM(NP2)-.5*SD(NP2))*AKAS                ST      287
      D(NP2)=A(NP2)+B(NP2)+PGOM(NP2)-2.*SD(NP2)                         ST      288
      IF (J.NE.JVT) GO TO 520                                           ST      289
      RM=.5*(R(NP2)+R(NP1))                                             ST      200
      BTM=2.*(RM/R(NP1))**2                                             ST      291
      BTMP3=(R(NP3)/RM)**2                                              ST      292
      DTM=2.*(RM/(.75*R(NP2)+.25*R(NP1)))**2                            ST      293
      B(NP2)=TTMF*BTM+THLM-TMP3F*BTMP3-(PGOM(NP1)-.5*SD(NP2))*AKAS      ST      294
      TT=3.*PGOM(NP1)-1.5*SD(NP2)                                       ST      295
      IF (IKAS(J).EQ.0) TT=4.*PGOM(NP1)-2.*SD(NP2)                      ST      296
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      B(NP2)=TTNF*DTN+TNP3F-THLN+TT
  520 T=-TNP3F*FDIFE(J)
      GO TO 2315
C ------------   EDGE FLUX SPECIFIED  ---------
 2313 A(NP2)=0.
      B(NP2)=TINF+THLN-(PGOM(NP1)-.5*SD(NP2))*AKAS
      D(NP2)=B(NP2)+PDOM(NP2)-2.*SD(NP2)-RME*2.
      T=-RME*F(J,NP3)-AJE(J)*R(NP3)
 2315 TT=3.*F(J,NP2)+F(J,NP1)
      IF (IKAS(J).EQ.0) TT=4.*F(J,NP2)
      C(NP2)=P4OMN*TT+2.*(T+SU(NP2))
 2320 CONTINUE
C -------   MID-STREAM COEFFICIENTS   ---------
      DO 3002 I=3,NP1
      TTNF=TTPF(J)
      TPF=ER U(I)/PREF(J)
      TTPF(J)=TPF+ANLPT(I)*ABS(TPF-ANLPT(I))
      IF (J.EQ.JVT) GO TO 3015
      A(I)=TTPF(J)-THLPT(I)-PGOM(I)*AKAS
      B(I)=TTNF+THLPT(I-1)-PGOM(I-1)*AKAS
      D(I)=A(I)+B(I)+PBOM(I)-2.*SD(I)
      GO TO 2999
C     ---------------
 3015 RP=.5*(R(I)+R(I+1))
      RM=.5*(R(I)+R(I-1))
      RMM=R(I-1)
      IF (I.EQ.3) RMM=.75*R(2)+.25*R(3)
      RPP=R(I+1)
      IF (I.EQ.NP1) RPP=.75*R(NP2)+.25*R(NP1)
      ATP=2.*(RP/RPP)**2
      BTM=2.*(RM/RMM)**2
      DTP=2.*(RP/R(I))**2
      DTM=2.*(RM/R(I))**2
      A(I)=TTPF(J)*ATP-THLPT(I)-PGOM(I)*AKAS
      B(I)=TTNF*BTM+THLPT(I-1)-PGOM(I-1)*AKAS
      TT=PGD4*DOMT3(I)
      IF (IKAS(J).EQ.0) TT=4.*PGD4*POM(I)
      D(I)=TTPF(J)*DTP+TTNF*DTM+THLPT(I)-THLPT(I-1)+TT-2.*SD(I)
 2999 TT=DOMT3(I)*F(J,I)+OMD(I)*F(J,I+1)+OMD(I-1)*F(J,I-1)
      IF (IKAS(J).EQ.0) TT=4.*DOM(I)*F(J,I)
 3002 C(I)=PD4*TT+2.*SU(I)
      IF(ITEST) 3906,3907,3906
 3906 WRITE(6,3901) (A(I),I=2,NP2)
      WRITE(6,3902) (B(I),I=2,NP2)
      WRITE(6,3903) (C(I),I=2,NP2)
      WRITE(6,3904) (D(I),I=2,NP2)
 3907 CONTINUE
C     ------------------------------------------
      B(2)=(B(2)*F(J,1)+C(2))/D(2)
      A(2)=A(2)/D(2)
      DO 3148 I=3,NP2
      T=D(I)-B(I)*A(I-1)
      A(I)=A(I)/T
 3148 B(I)=(B(I)*B(I-1)+C(I))/T
      DO 3150 IDASH=2,NP2
      I=N+4-IDASH
 3150 F(J,I)=A(I)*F(J,I+1)+B(I)
C------------------------------  ADJUST F(J,1) AND F(J,NP3)  -------------
      GO TO (3210,3220,3230),KIN
 3210 IF(INDI(J).EQ.2) F(J,1)=FDIFI(J)+.5*(F(J,2)+F(J,3))+AJI(J)/GI(J)
      GO TO 3220
 3230 F(J,1)=.5*(F(J,2)+F(J,3))
 3220 GO TO (3310,3320,3330),KEX
 3310 IF(INDE(J).EQ.2) F(J,NP3)=FDIFE(J)+.5*(F(J,NP2)+
     1                                F(J,NP1))-AJE(J)/GE(J)
      GO TO 3320
 3330 F(J,NP3)=.5*(F(J,NP1)+F(J,NP2))
 3320 IF(ITEST) 3322,3321,3322
 3322 WRITE(6,3323) J,(F(J,I),I=1,NP3)
 3323 FORMAT(6H F, J=,I3,1P11E11.3/(9X,11E12.3))
 3321 CONTINUE
 3060 XU=XD
      PSII=PSII-RMI*DX
      PSIE=PSIE-RME*DX
      PEI=PSIE-PSII
      IF (ISTEP.GE.IOUT) GO TO 3710
      IF (KEX.NE.2) GO TO 3750
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                SUM2=SUM2-RNE*DX                                                   ST        374
                GO TO 3710                                                         ST        375
           3700 IF (KEX.NE.1) GO TO 3710                                           ST        376
                SUM4=SUM4-RNE*DX                                                   ST        377
           3710 IF (ISTEP.GE.IEND) GO TO 3750                                      ST        378
                IF (KIN.NE.2) GO TO 3740                                           ST        379
                SUM1=SUM1+RNI*DX                                                   ST        380
                GO TO 3750                                                         ST        381
           3740 IF (KIN.NE.1) GO TO 3750                                           ST        382
                SUM3=SUM3+RNI*DX                                                   ST        383
           3750 CONTINUE                                                           ST        384
                ISTEP=ISTEP+1                                                      ST        385
                RETURN                                                             ST        386
          C**************************  S T R I D E 4  **************************   ST        387
           4000 CONTINUE                                                           ST        388
                NH=N/2                                                             ST        389
                NP1=N+1                                                            ST        390
                NP2=N+2                                                            ST        391
                NP3=N+3                                                            ST        392
                DN(1)=0.                                                           ST        393
                DN(NP3)=1.                                                         ST        394
                ISTEP=0                                                            ST        395
                IEND=10000                                                         ST        396
                IAX=10000                                                          ST        397
                IOUT=10000                                                         ST        398
                DX=1.E-30                                                          ST        399
                IFIN=0                                                             ST        400
                KIN=1                                                              ST        401
                KEX=1                                                              ST        402
                RETURN                                                             ST        403
           9010 FORMAT(1H ,1P11E11.3)                                              ST        404
                END                                                                ST        405
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CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   206      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   367      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   371      I                 AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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      SUBROUTINE WF(J,I1,OUT1,OUT2,OUT3)                                WF         2
      COMMON/COMA/A(43),AJE(15),AJI(15),B(43),C(43),CSALFA,D(43),       COMA       2
     1 DPDX(43),DX,EMU(43),F(15,43),FS(3,43),IAX,IEND,IFIN,INDE(15),    COMA       3
     2 INDI(15),IOUT,ISTEP,ITEST,IUTRAP,JS,JSW,JV,JY,KEX,KIN,KRAD,N,    COMA       4
     3 NO2,NF,NOVEL,NP1,NP2,NP3,OM(43),OMD(43),P(43),PEI,PR(15),        COMA       5
     4 PREF(15),PSIE,PSII,R(43),RHO(43),RU(43),RME,RMI,SD(43),SU(43),   COMA       6
     5 TAUE,TAUI,U(43),XD,XU,Y(43),YE,YI,PSURL(43),RDY(43),ISOLVE(15),  COMA       7
     6 US(43),AMU(43),SUM1,SUM2,SUM3,SUM4,PDGSCH,FDIFI(15),FDIFE(15),   COMA       8
     7 GE(15),GI(15),JLOC(12),W(12),JH,JFU,JCO2,JCO,JOX,JH2O,JOH,JO,JHS,COMA       9
     8 JH2,JN,JNO,JN2,JVT,JD,JK,JT,JRY,NSP,NSPR,ABSOR,SCATR,BDM(200),   COMA      10
     9 TERM1,TERM2,ISMAX,EFU,EO2,EH2O,ERO,EPR                           COMA      11
      COMMON/COMB/AK,ALMG,EWALL,FR,H,HFU,INERT,MASSTR,MODEL,PRESS,      COMB       2
     1 UBAR,UFAC,C1,C2,CD,C2VT,AKFAC,ALFAC,ARCON1,ARCON2,PREXP1,CD75,   COMB       3
     2 PREXP2,CR1,CR2,MODER,MODCP,RATIO1,RATIO2,RATIO3,RATIO4,RATIO5,   COMB       4
     3 CK,HY,DXOLD,WFU,WCO2,WCO,WOX,WH2O,WOH,WO,WH,                     COMB       5
     4 WH2,WN,WNO,WN2                                                   COMB       6
C/-------- SUBROUTINE FOR PROGRAM GENMIX 4A                             WF         5
C/---------------- D.B.SPALDING, IMPERIAL COLLEGE, 1972 --------------- WF         6
C                                                                       WF         7
C     EFFECTS OF PRESSURE GRADIENT AND MASS TRANSFER ARE INCLUDED       WF         8
C     EFFECTS OF RADIUS VARIATION ARE NEGLECTED                         WF         9
C     FOR VELOCITY,      OUT1=BP,     OUT2=T,  OUT3=TAU                 WF        10
C     FOR F*S,           OUT1=FIDIF, OUT2=T,  OUT3=G                    WF        11
C                                                                       WF        12
      DATA SHALF/.04/, BPLAST/.9/                                       WF        13
      INT=1/I1                                                          WF        14
      I2=I1-1+2*INT                                                     WF        15
      I3=I1-2+4*INT                                                     WF        16
      I25=I3-INT                                                        WF        17
      IF(J) 100,100,200                                                 WF        18
C ------------------------------------------------ VELOCITY             WF        19
  100 UREF=.5*(U(I2)+U(I3))                                             WF        20
      RHOREF=.5*RHO(I1)+.25*(RHO(I2)+RHO(I3))                           WF        21
      RUREF=RHOREF*UREF                                                 WF        22
      RREF=.5*(R(I2)+R(I3))                                             WF        23
      VREF=EMU(I1)                                                      WF        24
      YREF=YI+(YE-YI)*OM(I1)                                            WF        25
      RE=UREF*RHOREF*YREF/VREF                                          WF        26
      RRUREF=RREF*RUREF                                                 WF        27
      AM=(RMI-(RME+RMI)*OM(I1))/RRUREF                                  WF        28
      EF=YREF*DPDX(I1)/RUREF/UREF                                       WF        29
      IF(MODEL.EQ.1) GO TO 110                                          WF        30
      IF(RE.LT.132.25) GO TO 110                                        WF        31
C-----------------------------------------------EXTENDED LOG LAW        WF        32
      ER=RE*EWALL                                                       WF        33
      NIT=0                                                             WF        34
  101 SHALF1=SHALF                                                      WF        35
      S=SHALF**2                                                        WF        36
      SLOC=S+AM+EF                                                      WF        37
      IF(SLOC.GT.0.) GO TO 104                                          WF        38
      SLOC=1.E-30                                                       WF        39
      SHALF=SQRT(ABS(AM+EF))                                            WF        40
  104 BEE=SQRT(SLOC)/AK                                                 WF        41
      ARG=ER*(SHALF+(AM/(1.+BEE)+.5*EF)/SHALF)                          WF        42
      IF(ARG.GT.11.5*EWALL) GO TO 106                                   WF        43
      GO TO 110                                                         WF        44
  106 SHALF=AK/ALOG(ARG)                                                WF        45
      IF(ABS(SHALF-SHALF1).LT..0001.OR.NIT.GT.10) GO TO 102             WF        46
      NIT=NIT+1                                                         WF        47
      GO TO 101                                                         WF        48
  102 S=SHALF**2                                                        WF        49
      SAV=.5*(SHALF**2+SLOC)                                            WF        50
      OUT1=1./(1.+BEE)                                                  WF        51
      EMU(I25)=.25*RHOREF*RREF*ABS(U(I3)-U(I2))*(AK/OUT1)**2            WF        52
      GO TO 103                                                         WF        53
C ---------------------------------------------- LAMINAR FLOW           WF        54
  110 AMRE=AM*RE                                                        WF        55
      FRE=EF*RE                                                         WF        56
      IF(ABS(AMRE).LT..01) GO TO 111                                    WF        57
      AMRE=AMAX1(-60.,AMIN1(60.,AMRE))                                  WF        58
      EXPMRE=EXP(AMRE)                                                  WF        59
      STORE=EXPMRE-1.-AMRE                                              WF        60
      AMRESQ=AMRE*AMRE                                                  WF        61
      SRE=AMRE*(1.-STORE*FRE/AMRESQ)/(EXPMRE-1.)                        WF        62
      OUT1=SRE*STORE/AMRESQ+FRE*(STORE-.5*AMRESQ)/(AMRESQ*AMRE)         WF        63
      GO TO 112                                                         WF        64
  111 SRE=(2.-FRE*(1.+AMRE/3.))/(2.+AMRE)                               WF        65
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         49 A(K)=BLANK                                                  PL       79
         40 CONTINUE                                                    PL       80
            DO 50 I=1,11                                                PL       81
         50 A(I)=.1*FLOAT(I-1)                                          PL       82
            WRITE(6,104) (A(I),I=1,11)                                  PL       83
            RETURN                                                      PL       84
        100 FORMAT(11H Y-AXES ARE,5X,10(1X,A6,A4))                      PL       85
        101 FORMAT(1H0,2X,11F10.1)                                      PL       86
        102 FORMAT(15H MAXIMUM VALUES,1P10E11.3)                        PL       87
        103 FORMAT(11H0X-AXIS IS ,A8,17H ,MAXIMUM VALUE =,1PE10.3)      PL       88
        104 FORMAT (3X,11F10.1)                                         PL       89
        105 FORMAT(2H I,F6.2,3X,101A1,F6.2)                             PL       90
        106 FORMAT(7H SYMBOL,11X,10(1X,A10))                            PL       91
            END                                                         PL       92
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APPENDIX G

LISTING OF FUEL INSTRUCTION MODEL

```
PROGRAM INJECT1     73/74    OPT=G TRACE                    FTN 4.6+439        05/24/78  14.28.13         PAGE     1

      PROGRAM INJECT1 (INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT)           INJ       2
C                                                                         INJ       3
C     PROGRAM TO CALCULATE TRAJECTORIES FOR SIMPLEX OR DUAL ORIFICE       INJ       4
C     INJECTORS                                                           INJ       5
C     CHANGES AND ADDITIONS MADE 3/2/71 TO INTERFACE SR EVAP              INJ       6
C     CHANGES AND ADDITIONS MADE 7/29/71  FOR GOSMAN COMPATIBILITY        INJ       7
C     CHANGES REFLECT PLANS FOR THIS ROUTINE TO BECOME PART OF GOSMAN     INJ       8
C                                                                         INJ       9
C     OUTPUT OF ROUTINE IS LOCATION OF E= .1,.2,.3,....,.9 FOR EACH OF 5  INJ      10
C               DROPLET GROUPS                                            INJ      11
      COMMON /OUTPT/ X1E(5,10),X2E(5,10)                                  INJ      12
      COMMON /KTMN/ X1(21),X2(21),G1(21,21),G2(21,21),RO(21,21),T(21,21)  INJ      13
     1,IN,JN,P(21),FEVAP(21,21)                                           INJ      14
CCCCCC                                                                    INJ      15
      DIMENSION DRD(102,5), EVP(102,5), TTF(102,5), VEF(102,5)            INJ      16
C                                                                         INJ      17
      COMMON /TABLES/ T1(7),VISAIR(7),T2(2,4),SGFUEL(2,4),T3(12,4),VISFU  INJ      18
     1L(12,4),NTAB1,NTAB2,NTAB3,NFUELS,DIASMD(5,2),NDIASM,T5(10),SRFTNS(  INJ      19
     210,4),NTAB5S,NTAB5T,SGTAB5(4)                                       INJ      20
      DIMENSION FLOWS(5), DELPS(5), X(102,5), Y(102,5), NNN(5), DIA(5),   INJ      21
     1LABELS(6), DUPDUP(4)                                                INJ      22
      DIMENSION LABELF(4)                                                 INJ      23
      COMMON /TRAJ/ VFUEL,TFUEL3,TFUELF,S3,FMU,RHOFUL,PS,PT,TS,TT,RHOAIR  INJ      24
     1,AMU,G,VAIRST,SMD                                                   INJ      25
      COMMON /INPUT/ KFUEL,DEQ,GAP,PPH,TITLE(8)                           INJ      26
      COMMON /QEVAP/ DUMMY(20),R(5),TF(5),VF(5),VREL(5),RN(5),CD(5),DRAG  INJ      27
     1(5),FN(5),CP(5),DELQ(5),SG(5),FRHO(5),DELTF(5),TIMS(5),FMASS(5),AL  INJ      28
     2PHA(5),DELV(5),E(5),DX,W(5),VFSAVE(5),TFSAVE(5),DSAVE(5),ESAVE(5),  INJ      29
     3DSTART(5),SGSG60(5),SG60(5),DELM(5),OPTION,VAIRH,VAIRV,SINT,COST,D  INJ      30
     4UM1,DUM2,WST(5),EW(5)                                               INJ      31
C                                                                         INJ      32
      DATA LABELF/10HSHELLDYN 4,10HJP5---JP8 ,10HJET A-1   ,3HJP4/        INJ      33
      DATA KPLOT/0/                                                       INJ      34
      DATA LABELS/8H 0 -  20,8H20 -  40,8H40 -  60,8H60 -  80,8H80 - 100  INJ      35
     1,10H / VOLUME /                                                     INJ      36
C                                                                         INJ      37
C     DIASMD IS TABLE OF DIA/SMD (DMLS) VALUES FOR 1= WITHOUT AIR ASSIST  INJ      38
C                                                  2= WITH AIR ASSIST     INJ      39
C     T1, VISAIR IS TABLE OF TEMPERATURE (F) VS.                          INJ      40
C                         VISCOSITY OF AIR (LB/SEC/FT)                    INJ      41
C     T2, SGFUEL IS TABLE OF TEMPERATURE (F) VS.                          INJ      42
C                         SPECIFIC GRAVITY (DMLS)                         INJ      43
C     FOR 4 FUELS-- SHELLDYNE 4, JP5---JP8, JET A-1, JP4                  INJ      44
C     T3, VISFUL IS TABLE OF TEMPERATURE (F) VS.                          INJ      45
C                         VISCOSITY OF FUEL (CENTISTOKES)                 INJ      46
C     FOR 4 FUELS LISTED ABOVE                                            INJ      47
      DATA DIASMD/.623,.932,1.18,1.45,1.90,.623,.932,1.18,1.45,1.90/      INJ      48
      DATA NTAB1,NTAB2,NTAB3,NFUELS/7,2,12,4/,NDIASM/5/                   INJ      49
      DATA (T1(I),I=1,7)/40.,540.,1040.,1540.,2040.,2540.,3040./,(VISAIR  INJ      50
     1(I),I=1,7)/1.17E-5,1.89E-5,2.50E-5,3.01E-5,3.48E-5,3.90E-5,4.29E-5  INJ      51
     2/                                                                   INJ      52
      DATA T2/24.,300.,0.,220.,36.,260.,55.,200./,SGFUEL/1.1,.975,.85,.7  INJ      53
     1625,.825,.7375,.775,.7125/                                          INJ      54
      DATA T3/-50.,0.,40.,60.,80.,100.,150.,200.,250.,300.,350.,400.,-50  INJ      55
     1.,0.,40.,60.,80.,100.,125.,150.,175.,200.,225.,250.,-50.,0.,40.,60  INJ      56
     2.,80.,100.,125.,150.,175.,200.,225.,250.,-50.,0.,40.,60.,80.,100.,  INJ      57
     3125.,150.,175.,200.,225.,250./,VISFUL/3000.,210.,55.,32.,20.,14.,6  INJ      58
     4.5,3.6,2.1,1.35,.9,.64,23.,6.2,3.25,2.5,2.,1.65,1.35,1.15,.98,.84,  INJ      59
     5.75,.67,19.,5.4,2.9,2.3,1.95,1.55,1.3,1.08,.92,.81,.72,.64,4.7,2.1  INJ      60
     65,1.43,1.23,1.04,.93,.79,.69,.61,.55,.49,.44/                       INJ      61
      DATA T5/50.,100.,150.,200.,250.,300.,350.,400.,450.,500./           INJ      62
      DATA SGTAB5/.72,.76,.80,.84/                                        INJ      63
      DATA NTAB5T,NTAB5S,NTAB5F/10,4,7/                                   INJ      64
      DATA SRFTNS/21.,18.2,15.5,13.,10.6,8.2,5.9,3.9,2.0,.2,23.1,20.5,18  INJ      65
     1.0,15.6,13.4,11.1,9.0,7.0,5.1,3.3,23.3,21.8,19.6,17.5,15.4,13.4,11  INJ      66
     2.4,9.5,7.7,6.,24.9,22.9,21.0,19.1,17.3,15.5,13.9,12.1,10.4,8.8/     INJ      67
      CALL PLOTS (0,0,0)                                                  INJ      68
C     INPUT DATA                                                          INJ      69
      XO=2.0                                                              INJ      70
      YO=2.0                                                              INJ      71
      YOT=0.0                                                             INJ      72
      ICASE=0                                                             INJ      73
   10 READ (60,530) TITLE                                                 INJ      74
      IF (EOF(60)) 20,30                                                  INJ      75
   20 CALL PLOT (0.,0.,999)                                               INJ      76
      CALL EXIT                                                           INJ      77
   30 WRITE (61,540) TITLE                                                INJ      78
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      ICASE=ICASE+1
      DO 40 I=1,500
      X(I)=0.
   40 Y(I)=0.
      XMAX=10.
      YMAX=10.
      XSTART=0.
      YSTART=0.
CCCCCC
      READ (60,550) KORIF,KAIRAS,FN1,FN2,CONEAN,AREASH,DORF1,DORF2
      IF (KORIF.EQ.1) WRITE (61,560) FN1,CONEAN,DORF1
      IF (KORIF.EQ.2) WRITE (61,570) FN1,FN2,CONEAN,DORF1,DORF2
      IF (KORIF.EQ.3) WRITE (61,1000) CONEAN
 1000 FORMAT (1X,*AIRBLAST ATOMIZER, CONE ANGLE =*,F8.1)
      IF (KORIF.EQ.4) WRITE (61,1105) CONEAN
 1105 FORMAT (1X,*PNEUMATIC IMPACT ATOMIZER, CONE ANGLE =*,F8.1)
      IF (KAIRAS.EQ.1) WRITE (61,590)
      IF (KAIRAS.EQ.2) WRITE (61,590) AREASH
      IF (KORIF.NE.2) GO TO 50
      READ (60,600) FLOWS
      WRITE (61,630) FLOWS
      READ (60,500) DELPS
      WRITE (61,640) DELPS
   50 IF (KORIF.NE.3.AND.KORIF.NE.4) GO TO 1010
      READ (60,600) DFILM,WNOZ,AFLO,T3S
      WRITE (61,1015) DFILM,WNOZ,AFLO,T3S
 1015 FORMAT (1X,*FILM DIA, NOZZLE AIRFLOW, FLOW AREA,T3S,*,
     1  4F10.4)
 1010 CONTINUE
CCCCCC
      READ (60,610) KFUEL,IOPT,TFUEL,PPH,DELP,DELPSH,TSH
      WRITE (61,620) KFUEL,IOPT,TFUEL,PPH,DELP,DELPSH,TSH
      IF (IOPT.NE.1) GO TO 60
CCCCCC
      READ (60,500) TAMB,VAIR,PS,XMAX,YMAX
      WRITE (61,660) TAMB,VAIR,PS
      GO TO 70
   60 CONTINUE
C     XSTART, YSTART ARE INPUT IN INCHES
CCCCCC
      READ (60,600) XSTART,YSTART,PS,XMAX,YMAX
      WRITE (61,650) XSTART,YSTART,PS,XMAX,YMAX
      XSTART=XSTART/12.
      YSTART=YSTART/12.
      XMAX=XMAX/12.
      YMAX=YMAX/12.
   70 CONTINUE
      VAA=0.
      WAIR=0
      IF (KAIRAS.EQ.1) GO TO 80
      PR=(PS+DELPSH)/PS
      FMA2=5.*(PR**.2857-1.)
      IF (FMA2.GT.1.) FMA2=1.
      TSA=TSH/(1.+.2*FMA2)
      VAA=49.02*SQRT(TSA*FMA2)
      RHOAIR=2.6995*PS/TSA
      PRP=(1.+.2*FMA2)**3.5
      PSP=(PS+DELPSH)/PRP
      WAIR=AREASH*VAA*2.6995*PSP/TSA/144.*3600.
      WRITE (61,810) WAIR,VAA
   80 TFUELR=TFUEL
      TFUEL=TFUEL-459.69
C     SPECIFIC GRAVITY (EMLS) FOR FUEL
      SGF=TAB(TFUEL,T2(1,KFUEL),SGFUEL(1,KFUEL),NTAB2)
      SG60F=TAB(60.,T2(1,KFUEL),SGFUEL(1,KFUEL),NTAB2)
      DO 90 I=1,NTAB5S
   90 DUMDUM(I)=TAB(TFUEL,TS,SURTNS(1,I),NTABST)
      TAU=TAB(SG60F,SSTAB5,DUMDUM,NTAB5S)
C     DENSITY OF FUEL
      RHOFUL=62.428*SGF
C     VISCOSITY OF FUEL (CENTISTOKES)
      FMU=TAB(TFUEL,T3(1,KFUEL),VISFUL(1,KFUEL),NTAB3)
      WRITE (61,740) SGF,FMU
      IF (KORIF.EQ.3.OR.KORIF.EQ.4) GO TO 1020
      CONX=COS(CONEAN/57.2957*.5)*SQRT(RHOFUL)
      SLM1=3.359*FN1/DORF1/CONX
      SLM2=0.
```

```
      IF (KORIF.NE.1) SLP2=3.359*FR2/(DORF2/*DMF
      SLP=SLP1+SLP2
      WRITE (61,800) SLP1,SLP2
C     CONSTANTS FOR CALCULATIONS
 1020 CON1=.764/SGF
      CON2=PPM**.295
      CON3=(FPU/1.5)**.3
      CON4=9266./PMOFUL
CCCCCC
      ELIP=.96
      SI=.01
      S=SI/12.
      DX=S
      CON9=39.37E-6/12.
C
      IF (ICASE.GT.1.AND.ICPT.EQ.2) GO TO 98
      IM=2
      JM=2
      VAIRM1=VAIR
      VAIRV1=0.
      TS1=TAMB
      VAIRM=VAIRM1
      VAIRV=VAIRV1
      TS=TS1
      X1(1)=0.
      X2(1)=0.
      X1(IM)=XMAX/12.
      X2(JM)=TMAX/12.
      IF (ICPT.EQ.1) GO TO 110
      READ (60,900) IM,JM
  900 FORMAT (8(I2,8X))
      READ (60,910) (X1(I),I=1,IM)
  910 FORMAT (8E10.4)
      READ (60,910) (X2(J),J=1,JM)
      DO 920 J=1,JM
  920 READ (60,910) (G1(I,J),I=1,IM)
      DO 930 J=1,JM
  930 READ (60,910) (G2(I,J),I=1,IM)
      DO 940 J=1,JM
  940 READ (60,910) (T(I,J),I=1,IM)
      DO 950 J=1,JM
      P(J)=X2(J)
      DO 950 I=1,IM
      RHO=PS*144./53.3/T(I,J)
      G1(I,J)=G1(I,J)*RHO
      G2(I,J)=G2(I,J)*RHO
  950 RC(I,J)=RHO
   98 DO 100 I=1,441
  100 FEVAP(I)=0.
  110 CONTINUE
C     CALCULATIONS BEGIN * * * * * * * * * *
      DELPI=(PPM*CON1/FM1)**2
      GO TO (120,1030,1035,1035), KORIF
 1030 IF (DELPI.GE.DELPS(I)) GO TO 150
      WRITE (61,670)
      KORIF=1
      GO TO 130
  120 IF (DELPI.NE.0.) GO TO 130
      DELPI=DELP
      PPM=FM1*SQRT(DELPI)/CON1
      CON2=PPM**.295
  130 VFUEL=SQRT(CON4*DELPI)
      IF (KAIRAS.EQ.2) GO TO 140
      SMD=225.*CON2*CON3/DELPI**.354
      GO TO 150
  140 GMR=WAIR/PPM
      VR=VFUEL/VAB
      VER=.63*GMR**.1*VAB*SQRT(.5+VR**2-VR)
      SMD=196.*SQRT(TAU*SL/(RHOAIR*VER))**.95/VER
  150 DELPED=DELPI
      DELPZ=0.
      DELPVM=0.
      PPM1=PPM
      PPM2=0.
      GO TO 240
  160 KPASS=0
      KCUNT=0
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      DO 210 I=1,5                                                       INJ    233
      DELPV4=DELPS(I)                                                    INJ    234
  170 PPM2=TAB1(DELPV4,DELPS,PLOSS,5)                                    INJ    235
      DELP2=(PPM2*C(N)/FN2)**2                                           INJ    236
      PM1=PP4-PPM2                                                       INJ    237
      DELP1=(PM1*C(N)/FN1)**2                                            INJ    238
      DELPV5=DELP1+DELP2                                                 INJ    239
      ERROR=DELPV4-DELPV5                                                INJ    240
      IF (ABS(ERROR).LE..1) GO TO 220                                    INJ    241
      IF (I.EQ.1) GO TO 200                                              INJ    242
      IF (ERROR*ERROR0.LT.0.) GO TO 180                                  INJ    243
      IF (PLOSS.EQ.0.) GO TO 200                                         INJ    244
      DELPV3=DELPV4                                                      INJ    245
      ERROR0=ERROR                                                       INJ    246
      GO TO 190                                                          INJ    247
  180 IF (PLOSS.NE.0) GO TO 190                                          INJ    248
C     ROOT IS BETWEEN DELPS(I-1) AND DELPS(I)                            INJ    249
      ICOSS=1                                                            INJ    250
      DELTA=DELPV4-DELPV3                                                INJ    251
  190 DELTA=DELTA*.5                                                     INJ    252
      DELPV4=DELPV3+DELTA                                                INJ    253
      ICOUNT=ICOUNT+1                                                    INJ    254
      IF (ICOUNT.LT.50) GO TO 170                                        INJ    255
      WRITE (61,590) DELPV3,DELPV4                                       INJ    256
      CALL EXIT                                                          INJ    257
  200 ERROR0=ERROR                                                       INJ    258
      DELPV3=DELPV4                                                      INJ    259
  210 CONTINUE                                                           INJ    260
      WRITE (61,592)                                                     INJ    261
      CALL EXIT                                                          INJ    262
C     CONVERGENCE                                                        INJ    263
  220 DELPF=(DELP1*PP1**2+DELP2*PP2**2)/PP4                              INJ    264
      VFDEL=SQRT(C2*64*DELPF)                                            INJ    265
      IF (NATPAS.EQ.2) GO TO 230                                         INJ    266
      TMD=330.*CDM2*(FMU/1.5)**.2/DELPF**.354                            INJ    267
      GO TO 240                                                          INJ    268
  230 [illegible]                                                        INJ    269
      [illegible]                                                        INJ    270
      [illegible]                                                        INJ    271
      [illegible]                                                        INJ    272
      GO TO 240                                                          INJ    273
C     -------------  AIRBLAST AND PNEUMATIC IMPACT  -------------         INJ    274
C     DATA FROM - "THE INFLUENCE OF AIR AND LIQUID PROPERTIES IN         INJ    275
C                 AIRBLAST ATOMIZATION",A.A.RIZKALLA AND A.H. LEFEBVRE,  INJ    276
C                 ASME FLUID MECHANICS OF COMBUSTION (1974)              INJ    277
C                                                                        INJ    278
 1035 [illegible]                                                        INJ    279
      [illegible]                                                        INJ    280
      [illegible]                                                        INJ    281
      [illegible]                                                        INJ    282
      [illegible]                                                        INJ    283
      [illegible]                                                        INJ    284
      [illegible]                                                        INJ    285
      [illegible]                                                        INJ    286
      [illegible]                                                        INJ    287
      [illegible]                                                        INJ    288
      [illegible]                                                        INJ    289
      [illegible]                                                        INJ    290
      [illegible]                                                        INJ    291
      [illegible]                                                        INJ    292
      [illegible]                                                        INJ    293
      [illegible]                                                        INJ    294
      [illegible]                                                        INJ    295
      DELP2=0.                                                           INJ    296
      [illegible]                                                        INJ    297
      PM2=0.0                                                            INJ    298
      DELPV4=0.                                                          INJ    299
      DELPF=0.                                                           INJ    300
  240 CONTINUE                                                           INJ    301
C     [illegible]                                                        INJ    302
C     [illegible]                                                        INJ    303
      THETA1=THETA/57.29578*.5                                           INJ    304
      STHT1=SIN(THETA1)                                                  INJ    305
      CSTT1=COS(THETA1)                                                  INJ    306
      [illegible]                                                        INJ    307
      IF (IOPT.EQ.2) CALL AIRPSB [illegible]                             INJ    308
      RETURN                                                             INJ    309
```

```
              WRITE (61,710) DELP1,PPHI,DELP2,PPH2,DELPVN,VFUEL,SMD             INJ      310
              WRITE (61,620) GPM,VEP                                            INJ      311
              DO 400 I=1,5                                                      INJ      312
        C     DIA IS IN MICRONS                                                 INJ      313
              DIA(I)=DIASMD(I,NAIRAS)*SMD                                       INJ      314
        C     D IS IN FEET                                                      INJ      315
              D(I)=DIA(I)*CON9                                                  INJ      316
              E(I)=0.                                                           INJ      317
              EW(I)=0.                                                          INJ      318
              W(I)=D(I)**3*RHOFUL*3.14159265/6./1.5                             INJ      319
              WST(I)=W(I)                                                       INJ      320
              VF(I)=VFUEL                                                       INJ      321
              TF(I)=TFUEL                                                       INJ      322
              INTER=1                                                           INJ      323
              KKK=1                                                             INJ      324
        C **  THETA= THETA1                                                     INJ      325
              SINT=SINT1                                                        INJ      326
              COST=COST1                                                        INJ      327
              X(1,I)=XSTART                                                     INJ      328
              Y(1,I)=YSTART                                                     INJ      329
              K1=0                                                              INJ      330
              EW1=EW(I)                                                         INJ      331
              IF (IOPT.EQ.2) CALL FEVAPC (XSTART,YSTART,K1,EW1,EW(I))           INJ      332
        CCCCCC                                                                  INJ      333
              DPD(1,I)=D(I)/CON9                                                INJ      334
              EVP(1,I)=0.                                                       INJ      335
              TTF(1,I)=TFUEL                                                    INJ      336
              VFF(1,I)=VFUEL                                                    INJ      337
        CCCCCC                                                                  INJ      338
              VAIRH=VAIRH1                                                      INJ      339
              VAIRV=VAIRV1                                                      INJ      340
              TS=TS1                                                            INJ      341
              KOVER=1                                                           INJ      342
              KOUNT=2                                                           INJ      343
              XOLD=XSTART                                                       INJ      344
              YOLD=YSTART                                                       INJ      345
              KOLD=1                                                            INJ      346
          250 IF (KOLD.LT.6) GO TO 260                                          INJ      347
              KOLD=1                                                            INJ      348
              KOUNT=KOUNT+1                                                     INJ      349
              IF (KOUNT.GT.100) GO TO 350                                       INJ      350
        CCCCCC                                                                  INJ      351
          260 IF (E(I).LT.ELIM) CALL EVAP (INTER,I)                             INJ      352
              IF (INTER.LT.0) GO TO 399                                         INJ      353
              INTER=2                                                           INJ      354
        C     X, Y IN FEET                                                      INJ      355
              X(KOUNT,I)=XOLD+S*COST                                            INJ      356
              Y(KOUNT,I)=YOLD-S*SINT                                            INJ      357
              W(I)=W(I)-DELW(I)                                                 INJ      358
              EW(I)=1.-W(I)/WST(I)                                              INJ      359
              IF (IOPT.EQ.2) CALL FEVAPC (X(KOUNT,I),Y(KOUNT,I),K1,EW1,EW(I))   INJ      360
        CCCCCC                                                                  INJ      361
              DPD(KOUNT,I)=D(I)/CON9                                            INJ      362
              EVP(KOUNT,I)=E(I)*100.                                            INJ      363
              IF (E(I).LT..001) EVP(KOUNT,I)=0.                                 INJ      364
              TTF(KOUNT,I)=TF(I)                                                INJ      365
              VFF(KOUNT,I)=VF(I)                                                INJ      366
        CCCCCC                                                                  INJ      367
        C     CHECK IF THIS INTERVAL CROSSED EVAP. STORE POINT                  INJ      368
              *****                                                             INJ      369
        CCCCCC                                                                  INJ      370
              DO 270 L=K,10                                                     INJ      371
              KK=L                                                              INJ      372
              EP=FLOAT(L)*.1                                                    INJ      373
              IF (L.EQ.10) EP=.95                                               INJ      374
              IF (ESAVE(I).GE.EP.OR.E(I).LT.EP) GO TO 280                       INJ      375
        C     INTERPOLATE FOR (X1,X2) IN FEET                                   INJ      376
              DUM=0.                                                            INJ      377
              TEMP=E(I)-ESAVE(I)                                                INJ      378
              IF (TEMP.NE.0.) DUM=(EP-ESAVE(I))/TEMP                            INJ      379
              X1E(I,L)=XOLD+DUM*(X(KOUNT,I)-XOLD)                               INJ      380
              X2F(I,L)=YOLD+DUM*(Y(KOUNT,I)-YOLD)                               INJ      381
              XINCH=X1E(I,L)*12.                                                INJ      382
              YINCH=X2F(I,L)*12.                                                INJ      383
          270 WRITE (61,730) I,EP,XINCH,YINCH                                   INJ      384
              GO TO 391                                                         INJ      385
        C     CHECK IF HAVE HIT A PRORY                                         INJ      386
```

```
  280 IF (X(KOUNT,I).GE.X1(1)) GO TO 290                                INJ     387
      DUM=4HLEFT                                                         INJ     388
      GO TO 320                                                          INJ     389
  290 IF (X(KOUNT,I).LE.X1(IM)) GO TO 300                               INJ     390
      DUM=5HRIGHT                                                        INJ     391
      GO TO 320                                                          INJ     392
  300 IF (Y(KOUNT,I).GE.X2(1)) GO TO 310                                INJ     393
      DUM=6HBOTTOM                                                       INJ     394
      GO TO 320                                                          INJ     395
  310 IF (Y(KOUNT,I).LE.X2(JM)) GO TO 350                               INJ     396
      DUM=3HTOP                                                          INJ     397
  320 WRITE (51,780) I,DUM                                               INJ     398
  330 DO 340 L=KKK,10                                                    INJ     399
      X1E(I,L)=X(KOUNT,I)                                                INJ     400
  340 X2E(I,L)=Y(KOUNT,I)                                                INJ     401
      GO TO 390                                                          INJ     402
  350 IF (INTER.LT.0) GO TO 330                                          INJ     403
C **  THETA= ATAN2(DUM1,DUM2)                                            INJ     404
      SINT=DUM1/VF(I)                                                    INJ     405
      COST=DUM2/VF(I)                                                    INJ     406
      XOLD=X(KOUNT,I)                                                    INJ     407
      YOLD=Y(KOUNT,I)                                                    INJ     408
      KOLD=KOLD+1                                                        INJ     409
      IF (IOPT.EQ.2) CALL AIRPRP (X(KOUNT,I),Y(KOUNT,I),VAIRH,VAIRV,TS)  INJ     410
      GO TO 250                                                          INJ     411
  360 KOVER=KOVER+1                                                      INJ     412
      IF (KOVER.LT.10) GO TO 370                                         INJ     413
      WRITE (61,760) I                                                   INJ     414
      KOUNT=KOUNT-1                                                      INJ     415
      GO TO 330                                                          INJ     416
C     COMPRESS 100 PTS INTO 50 AND CONTINUE                              INJ     417
  370 DO 380 J=4,100,2                                                   INJ     418
      K=J/2                                                              INJ     419
CCCCCC                                                                   INJ     420
      ORD(K,I)=ORD(J,I)                                                  INJ     421
      EVP(K,I)=EVP(J,I)                                                  INJ     422
      TTF(K,I)=TTF(J,I)                                                  INJ     423
      VFF(K,I)=VFF(J,I)                                                  INJ     424
CCCCCC                                                                   INJ     425
      X(K,I)=X(J,I)                                                      INJ     426
  380 Y(K,I)=Y(J,I)                                                      INJ     427
      KOUNT=51                                                           INJ     428
      GO TO 250                                                          INJ     429
  391 WRITE (61,750) I                                                   INJ     430
  390 NNN(I)=KOUNT                                                       INJ     431
      IF (MAXK.LT.KOUNT) MAXK=KOUNT                                      INJ     432
      K1=-1                                                              INJ     433
      IF (IOPT.EQ.2) CALL FEVAPC (X(KOUNT,I),Y(KOUNT,I),K1,EM1,EM(I))    INJ     434
  400 CONTINUE                                                           INJ     435
      IF (IOPT.EQ.1) GO TO 410                                           INJ     436
      IEND=0                                                             INJ     437
      WRITE (61,770)                                                     INJ     438
  401 ISTR=IEND+1                                                        INJ     439
      IEND=ISTR+11                                                       INJ     440
      IF (IEND.GT.IN) IEND=IN                                            INJ     441
      DO 405 JJ=1,JM                                                     INJ     442
      J=JM-JJ+1                                                          INJ     443
  405 WRITE (61,406) (FEVAP(I,J),I=ISTR,IEND)                            INJ     444
      WRITE (61,403)                                                     INJ     445
  403 FORMAT (1H0)                                                       INJ     446
  406 FORMAT (12E11.3)                                                   INJ     447
      IF (IEND.LT.IN) GO TO 401                                          INJ     448
  410 WRITE (61,750) (I,TF(I),VF(I),D(I),E(I),I=1,5)                     INJ     449
      WRITE (61,720) (LABELS(I),LABELS(6),I=1,5),(DTA(I),I=1,5)          INJ     450
      DO 430 I=1,5                                                       INJ     451
      N=NNN(I)+1                                                         INJ     452
      IF (N.GT.MAXK) GO TO 430                                           INJ     453
      DO 420 J=N,MAXK                                                    INJ     454
      ORD(J,I)=0.                                                        INJ     455
      TTF(J,I)=0.                                                        INJ     456
      VFF(J,I)=0.                                                        INJ     457
      EVP(J,I)=0.                                                        INJ     458
      X(J,I)=0.                                                          INJ     459
  420 Y(J,I)=0.                                                          INJ     460
  430 CONTINUE                                                           INJ     461
      DO 450 J=1,MAXK                                                    INJ     462
C     CONVERT TO INCHES FOR PLOTTING AND PRINTING                        INJ     463
```

```
      DO 446 I=1,5
      X(J,I)=X(J,I)*12.
  446 Y(J,I)=Y(J,I)*12.
CCCCCC
      WRITE (6,730) (X(J,I),Y(J,I),I=1,5),(DPD(J,I),TTF(J,I),VEF(J,I),E
     1VP(J,I),I=1,5)
  450 CONTINUE
C     PLOTTING
      RXMAX=0.
      RXMIN=100000.
      RYMAX=0.
      RYMIN=100000.
      DO 445 I=1,5
      N=NNN(I)
      DO 445 J=1,N
      RXMAX=AMAX1(RXMAX,X(J,I))
      RXMIN=AMIN1(RXMIN,X(J,I))
      RYMAX=AMAX1(RYMAX,Y(J,I))
  445 RYMIN=AMIN1(RYMIN,Y(J,I))
      CALL PLOT (XO,YO,-3)
      XO=0.0
      YO=8.5
      YOT=YOT+YO
      IF (YOT.LT.20.) GO TO 460
      XO=11.
      YO=-17.
      YOT=0.0
  460 CALL SCALES (RYMAX,RYMIN,5.0,STEPY,STARTY)
      CALL SCALES (RXMAX,RXMIN,9.0,STEPX,STARTX)
      CALL AXIS (0.,0.,1HX,-1,9.0,0.,STARTX,STEPX)
      CALL AXIS (0.,0.,1HY,1,5.0,90.,STARTY,STEPY)
CCCCCC
      YL=6.0
      DO 470 I=1,5
      N=NNN(I)
      X(N+1,I)=STARTX
      Y(N+1,I)=STARTY
      X(N+2,I)=STEPX
      Y(N+2,I)=STEPY
      CALL LINE (X(1,I),Y(1,I),N,1,10,I)
CCCCCC
      XL=4.5
      YL2=YL+.05
      CALL SYMBOL (XL,YL2,0.1,I,0.,-1)
      XL=XL+.2
      CALL SYMBOL (XL,YL,.10,LABELS(I),0.,9)
      XL=XL+.80
      CALL SYMBOL (XL,YL,.10,44,0.,-1)
      XL=XL+.2
      CALL SYMBOL (XL,YL,0.1,3HVOL,0.,3)
CCCCCC
      XL=XL+0.5
      CALL NUMBER (XL,YL,.1,DIA(I),0.,2)
      XL=XL+0.7
      CALL SYMBOL (XL,YL,.1,7HMICRONS,0.,7)
CCCCCC
      XL=XL+1.4
      CALL NUMBER (XL,YL,0.1,F(I),0.0,2)
      YL=YL+.2
  470 CONTINUE
      CALL SYMBOL (4.8,7.1,0.1,7HDROPLET,0.0,7)
      CALL SYMBOL (6.7,7.1,0.1,4HSIZE,0.0,4)
      CALL SYMBOL (8.1,7.1,0.1,13HFRAC.EVAP.,0.0,13)
CCCCCC
      YL=7.5
      CALL SYMBOL (0,0,YL,.15,TITLE,0.,80)
      YL=YL-0.5
      CALL SYMBOL (1.0,YL,.1,21HINJECTOR TRAJECTORIES,0.,21)
      YL=YL-0.2
      IF (NORIF.NE.1) GO TO 1045
      CALL SYMBOL (0.5,YL,0.1,7HSIMPLEX,0.,7)
      GO TO 490
 1045 IF (NORIF.NE.2) GO TO 1050
  480 CALL SYMBOL (0.5,YL,0.1,12HDUAL ORIFICE,0.,12)
      GO TO 490
 1050 IF (NORIF.NE.3) GO TO 1055
      CALL SYMBOL (0.5,YL,0.1,8HAIRBLAST,0.,8)
```

```
      GO TO 490
 1055 IF (KOPIF.NE.4) GO TO 490
      CALL SYMBOL (0.5,YL,0.1,19HPNEUMATIC IMPACT,0.,16)
  490 IF (KAIRAS.EQ.1) GO TO 500
      CALL SYMBOL (2.5,YL,0.1,4HWITH,0.,4)
      GO TO 510
  500 CALL SYMBOL (2.5,YL,0.1,7HWITHOUT,0.,7)
  510 CALL SYMBOL (3.2,YL,0.1,10HAIR ASSIST,0.,10)
      YL=YL-0.2
      CALL SYMBOL (0.5,YL,0.1,11HCONE ANGLE=,0.,11)
      CALL NUMBER (1.7,YL,0.1,CMEAN,0.,2)
      YL=YL-0.2
      CALL SYMBOL (0.5,YL,0.1,5HFUEL=,0.,5)
      CALL SYMBOL (1.1,YL,0.1,LABEL(KFUEL),0.,10)
      CALL SYMBOL (2.5,YL,0.1,7HFUEL T=,0.,7)
      CALL NUMBER (3.2,YL,0.1,TFUEL,0.,1)
CCCCCC
      YL=YL-0.2
      CALL SYMBOL (0.5,YL,0.1,4HSMD=,0.,4)
      CALL NUMBER (1.0,YL,0.1,SMD,0.,2)
      CALL SYMBOL (1.8,YL,0.1,7HMICRONS,0.,7)
CCCCCC
      YL=YL-0.4
      CALL SYMBOL (0.5,YL,0.1,28HFLOW NUMBER  PPH      DELTA P,0.,28)
      YL=YL-.15
      CALL NUMBER (0.5,YL,.1,FN1,0.,3)
      CALL NUMBER (1.7,YL,.1,PPH1,0.,2)
      CALL NUMBER (2.3,YL,.1,DELP1,0.,2)
      IF (KOPIF.NE.2) GO TO 520
      YL=YL-.15
      CALL NUMBER (0.5,YL,.1,FN2,0.,5)
      CALL NUMBER (1.7,YL,.1,PPH2,0.,2)
      CALL NUMBER (2.3,YL,.1,DELP2,0.,2)
      YL=YL-0.2
      CALL SYMBOL (0.5,YL,.1,12HFLOW DIVIDER,0.,12)
      YL=YL-0.15
      CALL SYMBOL (1.,YL,.1,14HCRACK DELTA P=,0.,14)
      CALL NUMBER (2.4,YL,.1,DELPS(I),0.,2)
      YL=YL-.15
      CALL SYMBOL (1.,YL,.1,14HVALVE DELTA P=,0.,14)
      CALL NUMBER (2.4,YL,.1,DELPVN,0.,2)
  520 CONTINUE
      GO TO 15
CCCCCC
CCCCCC
C
  530 FORMAT (8A10)
  540 FORMAT (1H1,8A10/)
  550 FORMAT (2I5,6F10.0)
  560 FORMAT (1X,32HSIMPLEX ATOMIZER, FLOW NUMBER = ,F10.5,14H CONE ANGL
     1E=  F10.5,15H ORIF DIA=F6.3)
  570 FORMAT (1X,38HDUAL ORIFICE ATOMIZER, PRIM FLOW NO = ,F10.5,15H SEC
     1 FLOW NO = F10.5,16H CONE ANGLE = F10.5/1X,14H PRIM ORIF DIA=F6.3,16H
     2 SEC ORIF DIA=F6.3)
  580 FORMAT (1X,18HWITHOUT AIR ASSIST)
  590 FORMAT (1X,32HWITH AIR ASSIST,  SHROUD AREA = ,F10.5,6H SQ IN)
  600 FORMAT (8F10.0)
  610 FORMAT (2I5,5F10.0)
  620 FORMAT (2I,33HFUEL ICPT TFUEL PPH DELP DELPSH TSH = ,2I5,5F10.5)
  630 FORMAT (1X,17HSEC FLOW SCHED = ,5F10.5)
  640 FORMAT (1X,17HSEC PRES SCHED = ,5F10.5)
  650 FORMAT (1X,62HARBITRARY FLOW OPTION, V START, V START, P GAS, R MA
     1X, T MAX =,5F10.5)
  660 FORMAT (1X,43HUNIFORM FLOW OPTION, T END, VAIR, P AMB = ,3F10.5)
  670 FORMAT (43HDUAL ORIFICE TO ACTING AS SIMPLEX ATOMIZER)
  680 FORMAT (22HOSCILLATIONS, DELPV=F12.4,4X,7HDFLOW=F12.4)
  690 FORMAT (38HOUT SOLUTION WITHIN VALVE TABLE VALUES)
  700 FORMAT (62HITERATION REACHED MAX. OF 500 FOR DROPLET,I5,21H, CALC
     1ULATION STOPPED)
  710 FORMAT (/13HODELTA P (1)=,F10.2,5X,24HPPH (1)=F10.2/13H DELTA P (2)
     1=,F10.2,5X,9HPPH (2)=,F10.2,13H DELTA P (V)=,F10.2,7X,4HFUEL=F10.
     22/6H SPD= ,F10.2)
  720 FORMAT (1H0,5X,A8,A10,6(8X,A8,A10)/1H ,10X,F8.3,6(1X,F8.3),1X,7H
     1ICRONS/1H0,8X,1HX,10X,1HV,6(16X,1HX,13X,1HV)/8X,5(5X,1HD,6X,2HTF.3
     2X,2HVF,2X,5HSP,10X,2H ////)
  730 FORMAT (2X,5(F10.2,F11.2,5X)/7X,5(3X,F8.3,F8.0,F5.0,F9.0,2H /))
  740 FORMAT (1H0,5X,F12.4,7H (TOTAL,4X,19HMASS FUEL=F12.4,12H CENTIGRAME
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                 1S)                                                                    INJ      618
               750 FORMAT (8H DROPLET,I3,15H HAS EVAPORATED)                             INJ      619
               760 FORMAT (26H0LAST DROPLET CONDITIONS--/6X,4HDROP,5X,2HTF,13X,2HVF,1   INJ      620
                  14X,1HD,14X,1HE/5(5X,I5,4F15.5/)/)                                    INJ      621
620            770 FORMAT (7H0FEVAP=/2(1H0,7F12.4/3(1X,7F12.4/)))                       INJ      622
               780 FORMAT (13H0***** DROPLET,I3,34H HAS HIT ,A7,8HBOUNDARY)             INJ      623
               790 FORMAT (8H0DROPLET,I3,3H F=F6.2,5X,4H X1, X2=2F9.5,3H IN)            INJ      624
               800 FORMAT (26H0FUEL SHEET THICK., PRIM =F9.1,7H, SEC =F9.1,8H MICRONS   INJ      625
                  1)                                                                    INJ      626
625            810 FORMAT (17H0ASSIST AIR FLOW=F9.3,6H LB/HR,10H VELOCITY=F7.1,4H FPS   INJ      627
                  1)                                                                    INJ      628
               820 FORMAT (21H0AIR/FUEL MASS RATIO=F12.3,19H EFF. AIR VELOCITY=F10.1)   INJ      629
                   END                                                                  INJ      630
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            SUBROUTINE FEVAPC (X,Y,K1,FW1,FW)
            COMMON /GEOM/ X1(21),X2(21),Y1(21,21),Y2(21,21),R3(21,21),T(21,21)
           1,IM,JM,R(21),FEVAP(21,21)
            COMMON /INPUT/ RFUEL,DEQ,CAP,RPM
      C     CALC. AND STORE FUEL EVAPORATION RATE FOR SOSWAN PROGRAM
      C
            IF (K1.LT.0) GO TO 50
      C     DETERMINE WHICH ELEMENT VOLUME
            JM1=JM-1
            DO 10 JJ=2,JM1
            S1=(X2(JJ)+X2(JJ-1))*0.5
            IF (JJ.EQ.2) S1=X2(1)
            S2=(X2(JJ)+X2(JJ+1))*0.5
            IF (JJ.EQ.JM1) S2=X2(JM)
            IF (Y.LT.S1.OR.Y.GE.S2) GO TO 10
            J=JJ
            GO TO 20
         10 CONTINUE
            GO TO 40
         20 IM1=IM-1
            DO 30 II=2,IM1
            S1=(R(II)+R(II-1))*0.5
            IF (II.EQ.2) S1=R(1)
            S2=(R(II)+R(II+1))*0.5
            IF (II.EQ.IM1) S2=R(IM)
            IF (X.LT.S1.OR.X.GE.S2) GO TO 30
            I=II
            GO TO 80
         30 CONTINUE
      C     NOT IN A VOLUME
         40 IF (K1.EQ.0) RETURN
            IF (ISAVE.EQ.0) RETURN
            I=0
      C     CALC. FEVAP(I,J) FOR ISAVE, JSAVE
         50 IF (ISAVE.EQ.0) RETURN
            VOL=(R(ISAVE+1)-R(ISAVE-1))*(X2(JSAVE+1)-X2(JSAVE-1))*0.25*R(ISAV
           1E)
            IF (R(JSAVE).NE.1..OR.R(JSAVE+1).NE.1.) VOL=VOL*6.2832
            DFW=FW-FW1
            FEVAP(ISAVE,JSAVE)=FEVAP(ISAVE,JSAVE)+DFW*RPM/1000./VOL
            FW1=FW
            IF (I.NE.0) GO TO 60
            ISAVE=0
            K1=0
            RETURN
         60 ISAVE=I
            JSAVE=J
         70 RETURN
         80 IF (K1.NE.0) GO TO 90
            K1=1
            GO TO 60
         90 IF (I.EQ.ISAVE.AND.J.EQ.JSAVE) GO TO 70
            GO TO 50
            END
```

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SUBROUTINE AIRPRP      73/74    OPT=1 TRACE                        FTN 4.6+439        08/26/79  14.28.13         PAGE      1

                     SUBROUTINE AIRPRP (X,Y,VAIRH,VAIRV,TS)                                    AIR        2
                     COMMON /AIRM/ X1(21),X2(21),G1(21,21),G2(21,21),DC(21,21),T(21,21)        AIR        3
                    1,IM,JM                                                                    AIR        4
               C     NOTE-- COORD. SYSTEM OF X=P IS HORIZ. + TO RIGHT, VERTICAL + TO           AIR        5
               C            BOTTOM                                                             AIR        6
                     DO 10 J=1,JM                                                              AIR        7
                     I=J                                                                       AIR        8
                     IF (X2(J)-Y) 10,70,20                                                     AIR        9
                  10 CONTINUE                                                                  AIR       10
                  20 IF (I.EQ.1) I=2                                                           AIR       11
                     KKK=1                                                                     AIR       12
                  30 T1=TAB(X,X1,T(1,I),IM)                                                    AIR       13
                     G11=TAB(X,X1,G1(1,I),IM)                                                  AIR       14
                     G21=TAB(X,X1,G2(1,I),IM)                                                  AIR       15
                     DC1=TAB(X,X1,DC(1,I),IM)                                                  AIR       16
                     IF (KKK) 50,80,40                                                         AIR       17
                  40 J=I                                                                       AIR       18
                     I=I-1                                                                     AIR       19
                     KKK=-1                                                                    AIR       20
                     T2=T1                                                                     AIR       21
                     G12=G11                                                                   AIR       22
                     G22=G21                                                                   AIR       23
                     DC2=DC1                                                                   AIR       24
                     GO TO 30                                                                  AIR       25
                  50 DEL=(Y-X2(I))/(X2(J)-X2(I))                                               AIR       26
                     TS=T1+(T2-T1)*DEL                                                         AIR       27
                     DUM=DC1+(DC2-DC1)*DEL                                                     AIR       28
                     VAIRH=(G11+(G12-G11)*DEL)/DUM                                             AIR       29
                     VAIRV=-(G21+(G22-G21)*DEL)/DUM                                            AIR       30
                  60 RETURN                                                                    AIR       31
                  70 KKK=0                                                                     AIR       32
                     GO TO 30                                                                  AIR       33
                  80 TS=T1                                                                     AIR       34
                     VAIRH=G11/DC1                                                             AIR       35
                     VAIRV=-G21/DC1                                                            AIR       36
                     GO TO 60                                                                  AIR       37
                     END                                                                       AIR       38
```

```
      FUNCTION TAB          73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/79  14.28.13        PAGE      1

  1                       FUNCTION TAB (X,XX,YY,NTAB)                                        TAB       2
                          DIMENSION XX(1), YY(1)                                             TAB       3
                          F=1.                                                               TAB       4
                          IF (XX(1).GT.XX(2)) F=-F                                           TAB       5
  5                       DO 10 J=1,NTAB                                                     TAB       6
                          I=J                                                                TAB       7
                          IF (F*(XX(I)-X)) 10,40,20                                          TAB       8
                       10 CONTINUE                                                           TAB       9
                       20 IF (I.NE.1) GO TO 30                                               TAB      10
 10                       I=2                                                                TAB      11
                       30 J=I-1                                                              TAB      12
                          DEL=XX(I)-XX(J)                                                    TAB      13
                          IF (DEL.EQ.0.) GO TO 50                                            TAB      14
                          TAB=(YY(I)*(X-XX(J))-YY(J)*(X-XX(I)))/DEL                          TAB      15
 15                       RETURN                                                             TAB      16
                       40 TAB=YY(I)                                                          TAB      17
                          RETURN                                                             TAB      18
                       50 WRITE (61,60) X,I,J                                                TAB      19
                          CALL EXIT                                                          TAB      20
 20                 C                                                                        TAB      21
                       60 FORMAT (24H0***ERROR IN ROUTINE TAB,E15.4,2I5)                     TAB      22
                          END                                                                TAB      23

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     4       I      XX        ARRAY REFERENCE OUTSIDE DIMENSION BOUNDS.
```

```
      SUBROUTINE EVAP (INTER,I)                                         EVA      2
C     DROPLET EVAPORATION.                                              EVA      3
C     PROGRAMMED 1-22-71 BY M. TAFT.                                    EVA      4
C                                                                       EVA      5
CCCCC THIS ROUTINE IS THE SAME AS IN PROGRAM IMPACT EXCEPT              EVA      6
C             FOR THE CARD CHANGE MARKED CSSS                           EVA      7
C                                                                       EVA      8
C     D,TF,VF,E          ARE INPUT FOR DROP NO. I                       EVA      9
C**** NOTE-- FUEL PROPERTY EQUATIONS ARE ONLY FOR JP4 AND JP5/JP8 ***   EVA     10
C                                                                       EVA     11
      COMMON /INPUT/ KFUEL,DEC,SAP,PPH,TITLE(8)                         EVA     12
      COMMON /DEVAP/ DUMMY(20),D(5),TF(5),VF(5),VREL(5),RN(5),CD(5),DRAG EVA     13
     1(5),FN(5),CP(5),DELC(5),SG(5),FRHO(5),DELTF(5),TIMS(5),FMASS(5),AL EVA     14
     2PHA(5),DELV(5),E(5),DX,W(5),VFSAVE(5),TFSAVE(5),DSAVE(5),ESAVE(5), EVA     15
     3DSTART(5),SGSG60(5),SG60(5),DELM(5),OPTION,VAIRH,VAIRV,SINT,COST,D EVA     16
     4UM1,DUM2                                                          EVA     17
      COMMON /TRAJ/ VFUEL,TFUEL,TFUELF,SGF,FMU,RHOF,PS,PT,TS,TT,DUMMZO(3 EVA     18
     1),VAIR                                                            EVA     19
      DIMENSION TAIRT8(7), AIRKT8(7), AIRMUT(7), AIRCPT(7)              EVA     20
      DATA TAIRT8/400.,600.,1000.,1500.,2000.,2500.,3000./,AIRKT8/.0114, EVA     21
     1.0165,.0252,.0344,.0422,.0486,.0547/,AIRMUT/1.E-5,1.3E-5,1.885E-5, EVA     22
     22.5E-5,3.015E-5,3.48E-5,3.9E-5/,AIRCPT/.2404,.2409,.249,.2642,.277 EVA     23
     32,.2868,.2531/,NTAB8/7/                                           EVA     24
      DATA G,GAMMA,R,PIO4,GOGM1,[illegible],PI/32.174,1.4,1545.327,.7853982,3. EVA     25
     15,.2,3.1415927/                                                   EVA     26
C                                                                       EVA     27
      AIRM=28.966                                                       EVA     28
      CONSTI=G*GAMMA*R*TS/AIRM                                          EVA     29
C     CHECK FOR FIRST ENTRY TO ROUTINE (INTER=1)                        EVA     30
      IF (INTER.NE.1) GO TO 10                                          EVA     31
C     ESTIMATE NEXT STATION CONDITIONS                                  EVA     32
      VF2=VF(I)                                                         EVA     33
      TF2=TF(I)                                                         EVA     34
      D2=D(I)                                                           EVA     35
      E2=E(I)                                                           EVA     36
      DSTART(I)=D(I)                                                    EVA     37
      GO TO 20                                                          EVA     38
C     ESTIMATE NEXT STATION CONDITIONS                                  EVA     39
   10 VF2=2.*VF(I)-VFSAVE(I)                                            EVA     40
      TF2=2.*TF(I)-TFSAVE(I)                                            EVA     41
      D2=2.*D(I)-DSAVE(I)                                               EVA     42
      IF (D2.LT.1.E-10) D2=1.E-10                                       EVA     43
      E2=2.*E(I)-ESAVE(I)                                               EVA     44
      IF (E2.GT..99) E2=.99                                             EVA     45
      IF (E2.LT.0.) E2=0.                                               EVA     46
C     INITIALIZE FOR ITERATION ON D                                     EVA     47
   20 KOUNTC=1                                                          EVA     48
      SGRESD=SGRFCT(E(I))                                               EVA     49
      SG(I)=SGFCT(TF(I),SGRESD)                                         EVA     50
      SG60(I)=SGFCT(519.69,SGRESD)                                      EVA     51
      IF (INTER.EQ.1) SGSG60(I)=SG(I)/SG60(I)                           EVA     52
      W(I)=PI/6.*D(I)**3*SG(I)*62.428                                   EVA     53
      DELDG=D2-D(I)                                                     EVA     54
      KOUNTD=0                                                          EVA     55
   30 KOUNTR=1                                                          EVA     56
      DZ=(D(I)+D2)*.5                                                   EVA     57
      CIRCUM=PI*DZ                                                      EVA     58
      TEMPA=PIO4*DZ**2                                                  EVA     59
      TEMPD=TEMPA*DZ/1.5                                                EVA     60
C     INITIALIZE FOR ITERATION ON TF                                    EVA     61
      DELTFG=TF2-TF(I)                                                  EVA     62
      EZ=(E(I)+E2)*.5                                                   EVA     63
      VAPM=VAPMF(EZ)                                                    EVA     64
      SGRESD=SGRFCT(EZ)                                                 EVA     65
C     AVERAGE TEMPERATURES, CALC. PROPERTIES                            EVA     66
   40 TFZ=(TF(I)+TF2)*.5                                                EVA     67
      TMX=(TS+TFZ)*.5                                                   EVA     68
      PAS=PASF(TFZ,EZ)                                                  EVA     69
      IF (PAS.LT.PS-.01) GO TO 50                                       EVA     70
C     AT BOILING POINT.                                                 EVA     71
      PAS=PS-.01                                                        EVA     72
      KOUNTD=1                                                          EVA     73
   50 VAPK=VAPKF(TMX,VAPM)                                              EVA     74
      VAPMU=VAPMUF(TMX)                                                 EVA     75
      VAPLAM=VAPLMF(TFZ)                                                EVA     76
      CP(I)=CPFCT(TFZ,SGRESD)                                           EVA     77
      VAPCP=VAPCPF(TMX)                                                 EVA     78
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```
      SG(I)=SGFCT(TFZ,SGRESD)
      RHOD(I)=SG(I)*62.428
      VAPD=VAPDF(TMX,PS)
      IF (VAPD.LT..00005) VAPD=.00005
      ALP=PS/PAS*ALOG(PS/(PS-PAS))
C     AIR PROPERTIES
      AIRK=TAB(TMX,TAIRTB,AIRKTB,NTABAR)
      AIRMU=TAB(TMX,TAIRTB,AIRMUT,NTABAR)
      AIRCP=TAB(TMX,TAIRTB,AIRCPT,NTABAR)
C     DIFFUSION ZONE PROPERTIES
      QK=PAS/PS*.5
      QJ=1.-QK
      QKMX=QJ*AIRK+QK*VAPK
      QMUMX=QJ*AIRMU+QK*VAPMU
      QMMX=QJ*AIRM+QK*VAPM
      QCPMX=(QJ*AIRM*AIRCP+QK*VAPM*VAPCP)/QMMX
      QRHOMX=PS*QMMX*144./R/TMX
      SC=QMUMX/VAPD/QRHOMX
      PR=QCPMX*QMUMX/QKMX*3600.
      TEMPE=DZ*QRHOMX/QMUMX
      QMASS=TEMPD*SG(I)*62.428
      TEMPF=.6*SC**.333333333
CCCCCC
      TEMPG=CIRCUM*VAPD*VAPM*PAS*ALP/R/TMX*144.
      TEMPH=.6*PR**.333333333
      TEMPI=VAPCP/CIRCUM/QKMX
      TEMPJ=CIRCUM*QKMX*(TS-TFZ)/3600.
      TEMPK=TEMPD*SG(I)*CP(I)*62.428
C     INITIALIZE FOR ITERATION ON VF
      DELVG=VF2-VF(I)
      KOUNTA=1
C     CALCULATE DELTA V FOR DROP
   60 VFZ=(VF(I)+VF2)*.5
      IF (OPTION.EQ.0.) GO TO 70
      VRV=VFZ*SINT-VAIRV
      VRH=VFZ*COST-VAIRH
      VREL(I)=SQRT(VRV**2+VRH**2)
      SPHI=VRV/VREL(I)
      CPHI=VRH/VREL(I)
      VSIGN=1.
      GO TO 80
   70 VREL(I)=VAIR-VFZ
      VSIGN=1.
      IF (VREL(I).GE.0.) GO TO 80
      VREL(I)=-VREL(I)
      VSIGN=-VSIGN
   80 RN(I)=VREL(I)*TEMPE
CCCCCC
      IF (RN(I).LT.22.16) CD(I)=2.0
      IF (RN(I).GE.22.16) CD(I)=27./RN(I)**.84
      IF (RN(I).GT.80.) CD(I)=.271*RN(I)**.217
      IF (RN(I).GT.10000.) CD(I)=2.0
CCCCCC
      FMACH2=VREL(I)**2/CONST1
      TEMPB=PS*((1.+GM1O2*FMACH2)**GGM1-1.)
      DRAG(I)=TEMPB*CD(I)*TEMPA*144.
      ALPHA(I)=DRAG(I)/QMASS*VSIGN*G
      IF (OPTION.EQ.0.) GO TO 90
C     MODIFY FOR EFFECT OF G
CSSS  DUM1= G - ALPHA(I) * SPHI
      DUM1=-ALPHA(I)*SPHI
      DUM2=-ALPHA(I)*CPHI
      ALPHA(I)=SQRT(DUM1**2+DUM2**2)
      SINB=DUM1/ALPHA(I)
      COSB=DUM2/ALPHA(I)
   90 TIMS(I)=DX/VF(I)
      DUMMY1=VF(I)**2
      DUMMY2=2.*DX*ALPHA(I)
C     CHECK IF ROUND/OFF ERROR IS A PROBLEM
      IF (ABS(DUMMY2/DUMMY1).LT.1.E-7) GO TO 100
      TIMS(I)=(SQRT(DUMMY1+DUMMY2)-VF(I))/ALPHA(I)
  100 DELV(I)=ALPHA(I)*TIMS(I)
      IF (OPTION.EQ.0.) GO TO 110
      VRV=VRV+DELV(I)*SINB
      VRH=VRH+DELV(I)*COSB
      DUM1=VRV+VAIRV
      DUM2=VRH+VAIRH
```

```
      VF2=SQRT(DUM1**2+DUM2**2)
      GO TO 120
  110 VF2=VF(I)+DELV(I)
C     CHECK IF WITHIN TOLERANCE
  120 IF (ABS(1.-DELVG/DELV(I)).LE..01) GO TO 160
      DELVG=DELV(I)
      IF (ABS(DELVG).LT..01) GO TO 140
      KOUNTA=KOUNTA+1
      IF (KOUNTA.LT.25) GO TO 60
  130 WRITE (61,210) KOUNTA,KOUNTB,KOUNTC,KOUNTD,I
      WRITE (61,220) TF2,VF2,D2,E2
      INTER=-1
      IF (OPTION.NE.0.) GO TO 200
      CALL EXIT
C     HAVE CONVERGED ON VF2.  NOW CALC. DELTA TF, WF
  140 TEMPC=SQRT(RN(I))
      QNUM=2.+TEMPF*TEMPC
      DELW=QNUM*TEMPG
CCCCCCIF ((DELW*TIMS(I)).GT.QMASS) DELW=QMASS/TIMS(I)
      QNUH=2.+TEMP4*TEMPC
  150 Z=DELW/QNUH*TEMPI
      ZZ=Z/(EXP(Z)-1.)
      QVZ=QNUH*ZZ*TEMPJ
      IF (KOUNTD.EQ.0) GO TO 170
C     AT BOILING POINT.  ASSUME DELTF= 0.
      IF (VAPLAM.EQ.0.) GO TO 130
      DELWN=QVZ/VAPLAM
CCCCCCIF ((DELWN*TIMS(I)).GT.QMASS) DELWN=QMASS/TIMS(I)
      IF (ABS(DELWN-DELW).LE..002*ABS(DELW)) GO TO 160
      DELW=DELWN
      KOUNTD=KOUNTD+1
      IF (KOUNTD.LT.25) GO TO 150
      GO TO 130
  160 IJK=1
      KOUNTD=1
C     AT BOILING POINT, CALC TF2 BASED ON PS AND E2
      TF2=PASF(-PS,E2)
      DELTF(I)=TF2-TF(I)
      GO TO 180
  170 DELTF(I)=(QVZ-DELW*VAPLAM)*TIMS(I)/TEMPE
      TF2=TF(I)+DELTF(I)
CCCCCCIF (KFUEL.EQ.4.AND.TF2.GT.1092.8) TF2=1092.8
CCCCCCIF (KFUEL.EQ.2.AND.TF2.GT.1210.4) TF2=1210.4
C     CHECK IF WITHIN TOLERANCE
  180 IF (ABS(DELTF(I)-DELTFG).LE..01*ABS(DELTF(I))) GO TO 190
      DELTFG=DELTF(I)
      IF (ABS(DELTFG).LT.1.) GO TO 190
      KOUNTB=KOUNTB+1
      IF (KOUNTB.LT.25) GO TO 40
      GO TO 130
C     HAVE CONVERGED ON TF2.  NOW CALC. DELTA D
  190 IJK=0
      W2=W(I)-DELW*TIMS(I)
      IF (W2.LT.1.E-30) W2=1.E-30
      SGRESD=SGRFCT(E2)
      SG(I)=SGFCT(TF2,SGRESD)
      SG60(I)=SGFCT(519.69,SGRESD)
      D2=(6.*W2/PI/SG(I)/62.428)**.3333333333
      IF (D2.LT.1.E-10) D2=1.E-10
      E2=1.-(D2/DSTART(I))**3*SG(I)/SG60(I)/SGSG60(I)
      IF (E2.GT..99) E2=.99
      IF (E2.LT.0.) E2=0.
      DELD=D2-D(I)
C     CHECK IF WITHIN TOLERANCE
      IF (ABS(1.-DELDG/DELD).LE..01) GO TO 200
      DELDG=DELD
      IF (ABS(DELDG).LT.1.E-7) GO TO 200
      KOUNTC=KOUNTC+1
      IF (KOUNTC.LT.20) GO TO 30
      GO TO 130
C     HAVE CONVERGED ON ALL PARAMETERS FOR THIS INTERVAL
C     SAVE OLD CONDITIONS. SET NEW ONES
  200 VFSAVE(I)=VF(I)
```

```
SUBROUTINE EVAP        73/74    OPT=0 TRACE                    FTN 4.6+439        09/24/79  14.29.13        PAGE     4

                VF(I)=VF2                                                      EVA       233
                TFSAVE(I)=TF(I)                                                EVA       234
                TF(I)=TF2                                                      EVA       235
                DSAVE(I)=D(I)                                                  EVA       236
                D(I)=D2                                                        EVA       237
                ESAVE(I)=E(I)                                                  EVA       238
                E(I)=E2                                                        EVA       239
                DELD(I)=DVZ*TIMS(I)                                            EVA       240
                DELP(I)=DELW*TIMS(I)                                           EVA       241
                RETURN                                                         EVA       242
          C                                                                    EVA       243
            210 FORMAT (18H0***** EVAP FAIL,I8F.4I5,5X,7HDROPLETI5)            EVA       244
            220 FORMAT (4E15.5)                                                EVA       245
                END                                                            EVA       246
```

```
FUNCTION PASF        73/74    OPT=0 TRACE                  FTN 4.6+439        08/24/79  14.28.13        PAGE     1

               FUNCTION PASF (T,E)                                                         PAS         2
C              T= TEMPER. (R), E= FRACTION EVAPORATED                                      PAS         3
C              PASF= FUEL VAPOR PRESSURE (PSIA) FOR JP4, JP5/JP8                           PAS         4
               COMMON /INPUT/ KFUEL,DEO,GAP,RPM,TITLE(8)                                   PAS         5
               DIMENSION CK1(7,4), CK2(7,4), ETAB(7)                                       PAS         6
               DATA ETAB/0.,.1,.3,.5,.7,.9,1.0/,CK1/0.,0.,0.,0.,0.,0.,0.,155810.,          PAS         7
              1386390.,585230.,617550.,1321290.,3175400.,10497000.,0.,0.,0.,0.,0.          PAS         8
              2,0.,0.,40497.,136750.,294430.,604200.,1399600.,7044100.,77600000./          PAS         9
              3,CK2/0.,0.,0.,0.,0.,0.,0.,7414.8,8548.4,9066.7,9494.0,10093.,11178          PAS        10
              4.,12670.,0.,0.,0.,0.,0.,0.,0.,4816.,5259.,7151.,8042.,9045.,10974.          PAS        11
              5,13839./                                                                    PAS        12
C                                                                                          PAS        13
               IF (KFUEL.NE.2.AND.KFUEL.NE.4) GO TO 110                                    PAS        14
C              IF (T .LT. 0 ) , ARGUMENT IS (-PSI).  FIND AND RETURN CORRES. TEMPERA       PAS        15
               PSTAT=-T                                                                    PAS        16
               DO 10 J=1,7                                                                 PAS        17
               I=J                                                                         PAS        18
               IF (E-ETAB(J)) 20,80,10                                                     PAS        19
            10 CONTINUE                                                                    PAS        20
               GO TO 30                                                                    PAS        21
            20 IF (I.EQ.1) I=2                                                             PAS        22
            30 K=1                                                                         PAS        23
            40 IF (PSTAT.LT.0.) GO TO 50                                                   PAS        24
               PASF=CK2(I,KFUEL)/ALOG(CK1(I,KFUEL)/PSTAT)                                  PAS        25
               GO TO 60                                                                    PAS        26
            50 PASF=CK1(I,KFUEL)*EXP(-CK2(I,KFUEL)/T)                                      PAS        27
            60 IF (K) 100,90,70                                                            PAS        28
            70 PSAVE=PASF                                                                  PAS        29
               J=I                                                                         PAS        30
               I=I-1                                                                       PAS        31
               K=-1                                                                        PAS        32
               GO TO 40                                                                    PAS        33
            80 K=0                                                                         PAS        34
               GO TO 40                                                                    PAS        35
            90 RETURN                                                                      PAS        36
           100 PASF=PASF+(PSAVE-PASF)/(ETAB(J)-ETAB(I))*(E-ETAB(I))                        PAS        37
               GO TO 90                                                                    PAS        38
           110 WRITE (61,120) KFUEL                                                        PAS        39
               CALL EXIT                                                                   PAS        40
C                                                                                          PAS        41
           120 FORMAT (25HOPASF CANNOT HANDLE FUEL=I5)                                     PAS        42
               END                                                                         PAS        43
```

```
FUNCTION VAPCPF      73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  14.28.13        PAGE     1

                    FUNCTION VAPCPF (T)
          C         T= TEMPER. (F), VAPCPF= CP FOR JP4, JP5/JP8 FUEL VAPOR       PROP       2
                    COMMON /INPUT/ KFUEL,DEQ,GAP,PPM,TITLE(8)                    PROP       3
                    IF (KFUEL.EQ.2) GO TO 10                                     PROP       4
                    VAPCPF=.180+.000565*T                                        PROP       5
                    GO TO 20                                                     PROP       6
                 10 VAPCPF=.069+.000530*T                                        PROP       7
                 20 RETURN                                                       PROP       8
                    END                                                          PROP       9
                                                                                 PROP      10
```

```
FUNCTION VAPMUF      73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/78  14.28.13        PAGE     1

                    FUNCTION VAPMUF (T)                                                  PROP       11
          C         T= TEMPER. (R), VAPMUF= MU FOR JP4, JP5/JP8 FUEL VAPOR               PROP       12
                    COMMON /INPUT/ KFUEL,DEG,GAP,PPH,TITLE(8)                            PROP       13
                    IF (KFUEL.EQ.2) GO TO 10                                             PROP       14
                    VAPMUF=808.E-9+7.64E-9*T                                             PROP       15
                    GO TO 20                                                             PROP       16
                 10 VAPMUF=248.E-9+6.31E-9*T                                             PROP       17
                 20 RETURN                                                               PROP       18
                    END                                                                  PROP       19
```

```
FUNCTION VAPKF      73/74   OPT=0 TRACE                  FTN 4.6+439        08/24/78  14.28.13        PAGE    1

      FUNCTION VAPKF (T,W)                                                PROP     20
C     T= TEMPER. (R), VAPKF= K FOR FUEL VAPOR                              PROP     21
C     W= MOLECULAR WEIGHT                                                 PROP     22
      DIMENSION WTAB(4), ATAB(4), BTAB(4), TABK(4)                        PROP     23
      DATA WTAB/50.,100.,150.,300./,NTAB/4/,ATAB/-.006362,-.006358,-.006 PROP     24
     1284,-.006019/,BTAB/.0000297,.0000273,.0000298,.0000235/            PROP     25
C                                                                         PROP     26
      DO 10 I=1,NTAB                                                      PROP     27
   10 TABK(I)=ATAB(I)+BTAB(I)*T                                           PROP     28
      VAPKF=TAB(W,WTAB,TABK,NTAB)                                         PROP     29
      RETURN                                                              PROP     30
      END                                                                 PROP     31
```

```
FUNCTION SGFCT       73/74   OPT=0 TRACE                FTN 4.6+439        08/24/78  14.29.13        PAGE     1

                   FUNCTION SGFCT (T,SG60R)                                          PROP       32
          C        SG60R =  SG RESIDUE AT 60 DEG F                                   PROP       33
          C        T= TEMPER. (R), SGFCT= SG FOR JP4 AND JP5 LIQUID FUEL             PROP       34
                   SGFCT=SG60R+.200-.0004*T                                          PROP       35
                   RETURN                                                            PROP       36
                   END                                                               PROP       37
```

```
FUNCTION SGRFCT     73/74   OPT=0 TRACE              FTN 4.6+439        08/24/79  14.28.13       PAGE    1

            FUNCTION SGRFCT (E)                                                 PROP      38
      C     E= FRACTION EVAPORATED, SG60= SG AT 60 DEG F                        PROP      39
      C     SGRFCT= SG RESIDUE AT 60 DEG F FOR JP4, JP5/JP8 LIQUID FUEL         PROP      40
            COMMON /INPUT/ KFUEL,DEQ,GAP,PPM,TITLF(8)                           PROP      41
            DATA SG604/.775/,SG6058/.806/                                       PROP      42
            SG60=SG604                                                          PROP      43
            IF (KFUEL.NE.4) SG60=SG6058                                         PROP      44
            SGRFCT=1.076/((1.076/SG60-1.)*(1.-.67*E)+1.)                        PROP      45
            RETURN                                                              PROP      46
            END                                                                 PROP      47
```

```
      FUNCTION VAPOF      73/74   OPT=0 TRACE                    FTN 4.6+439     08/20/79  14.29.13       PAGE    1

                    FUNCTION VAPOF (T,P)                                         PROP      48
              C     T= TEMPER. (R) , P= STATIC PRESSURE                          PROP      49
              C     VAPOF= DIFFUSIVITY FOR HEPTANE-OXYGEN                        PROP      50
                    VAPOF=2.063/P*(T*(T*1.1319E-9+1.979E-6)-9.915E-4)            PROP      51
                    RETURN                                                       PROP      52
                    END                                                          PROP      53
```

```
FUNCTION VAPMF       73/74   OPT=0 TRACE                FTN 4.6+430        08/24/78  14.29.13        PAGE    1

              FUNCTION VAPMF (E)                                                   PROP   54
        C     E= FRACTION EVAPORATED, VAPMF= MOLECULAR WEIGHT OF JP4, JP5/JP8     PROP   55
        C                           FUEL VAPOR                                      PROP   56
              COMMON /INPUT/ KFUEL,DEQ,SAR,PP4,TITLE(9)                             PROP   57
              DIMENSION ETAB(7), TABMV(7,4)                                          PROP   58
              DATA ETAB/0.,.1,.3,.5,.7,.9,1.0/,NTAB/7/,TABMV/0.,0.,0.,0.,0.,0.,0    PROP   59
             1.,148.12,163.29,169.88,175.06,187.25,194.96,211.07,0.,0.,0.,0.,0.,    PROP   60
             20.,0.,93.26,114.60,126.61,139.16,153.49,173.21,204.76/                PROP   61
        C                                                                            PROP   62
              VAPMF=TAB(E,ETAB,TABMV(1,KFUEL),NTAB)                                 PROP   63
              RETURN                                                                 PROP   64
              END                                                                    PROP   65
```

```
FUNCTION VAPLNF     73/74   OPT=0 TRACE                     FTN 4.6+439       08/24/78  14.28.13        PAGE      1

                  FUNCTION VAPLNF (T)                                                      PROP        66
            C     T= TEMPER (R), VAPLNF= LATENT HEAT OF VAPORISATION FOR JP4,BTU/LB       PROP        67
            C                ALSO, JP5/JP8                                                PROP        68
                  COMMON /INPUT/ KFUEL,DEQ,SAP,PP4,TITLE(9)                               PROP        69
                  IF (KFUEL.EQ.2) GO TO 10                                                PROP        70
                  VAPLNF=0.                                                               PROP        71
                  IF (T.LT.1092.88) VAPLNF=13.20*(1092.99-T)**.39                         PROP        72
                  GO TO 20                                                                PROP        73
               10 VAPLNF=0.                                                               PROP        74
                  IF (T.LT.1210.45) VAPLNF=10.75*(1210.45-T)**.41                         PROP        75
               20 RETURN                                                                  PROP        76
                  END                                                                     PROP        77
```

```
FUNCTION CPFCT      73/74    OPT=0 TRACE                   FTN 4.6+439        08/24/78  14.28.13        PAGE      1

               FUNCTION CPFCT (T,SGR60)                                       PROP       78
         C     T= TEMPER (R), CPFCT, CP FOR LIQUID JP4, JP5/JP8               PROP       79
         C     SGR60= SG RESIDUE AT 60 DEG F FOR JP4                          PROP       80
               CPFCT=(.181+.00045*T)/SQRT(SGR60)                              PROP       81
               RETURN                                                         PROP       82
               END                                                            PROP       83
```

```
SUBROUTINE SCALES      73/74    OPT=0 TRACE                    FTN 4.6+439        08/24/79  14.29.13        PAGE      1

              SUBROUTINE SCALES (MAX,MIN,LENGTH,STEP,START)                    SCA      2
              REAL MAX,MIN,LENGTH                                              SCA      3
              DIMENSION FACTOR1(11)                                            SCA      4
              DATA FACTOR1/.001,.00125,.0015,.00175,.002,.0025,.003,.004,.005,.0 SCA    5
             106,.0075/                                                        SCA      6
              FACT=.001                                                        SCA      7
              DO 20 I=1,12                                                     SCA      8
              FACT=FACT*10.                                                    SCA      9
              DO 10 J=1,11                                                     SCA     10
              STEP=FACTOR1(J)*FACT                                             SCA     11
              ITE=MAX/STEP                                                     SCA     12
              ITS=MIN/STEP                                                     SCA     13
              IF (ITE.LT.0) ITE=ITE-1                                          SCA     14
              IF (ITS.LT.0) ITS=ITS-1                                          SCA     15
              DELT1=FLOAT(ITE+1-ITS)*STEP                                      SCA     16
              DELT2=STEP*LENGTH                                                SCA     17
              IF (DELT2.GE.DELT1) GO TO 30                                     SCA     18
           10 CONTINUE                                                         SCA     19
           20 CONTINUE                                                         SCA     20
              WRITE (61,40) MAX,MIN                                            SCA     21
              RETURN                                                           SCA     22
           30 N6=IFIX(MIN/STEP)                                                SCA     23
              IF (N6.LE.0.AND.MIN.LT.0.0) N6=N6-1                              SCA     24
              START=FLOAT(N6)*STEP                                             SCA     25
              RETURN                                                           SCA     26
        C                                                                      SCA     27
        C                                                                      SCA     28
           40 FORMAT (///44H VARIABLES OUTSIDE RANGE OF SUBROUTINE SCALE,//10X,6 SCA   29
             1HMAX = ,E12.4,10X,6HMIN = ,E12.4)                                SCA     30
              END                                                              SCA     31
```

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