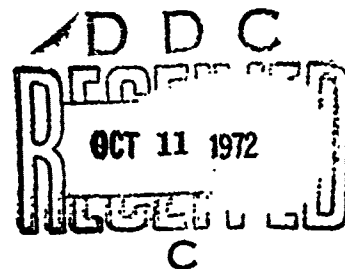


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Aerospace Synthesized Aerodynamic Heating Program



Prepared by M. J. Gyetvay and J. M. Kohlenberger
Technology Division and Mathematics and Computation Center

72 MAR 15

San Bernardino Operations
THE AEROSPACE CORPORATION

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Prepared by

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FOREWORD

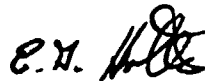
This report by The Aerospace Corporation, San Bernardino Operations, was prepared under Contract No. F04701-71-C-0172 as TR-0172(S2816-75)-1. The Air Force program monitor is Capt. T. W. Swartz. The dates of research for the report include the period July 1963 through April 1971. This report was submitted by the authors April 1971.

The method presented in this report for solving in-depth material heating was first proposed by D. J. Smith and L. Fisher (Ref. 1) of Convair. A preliminary program was formulated at Aerospace by R. Chambers, M. Kausch, and J. Kohlenberger in 1963. The authors have since developed the program into its present form, based on the work of the above named people.

Approved



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Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.



T. W. Swartz, Capt. USAF (RNSE)

UNCLASSIFIED ABSTRACT

**AEROSPACE SYNTHESIZED AERODYNAMIC
HEATING PROGRAM, by M. J. Gyetvay and
J. M. Kohlenberger**

**TR-0172(S2816-75)-1
72 MAR 15**

The Aerospace Synthesized Aerodynamic Heating Program is written in the Fortran IV language for the IBM 360/65 computer. This program calculates heating and internal conduction for shapes approximating those of missiles. To do this, it couples various correlations for external high speed convective aerodynamic, nonaerodynamic heating, with internal transient heat conduction and surface ablation. The heating may be computed for flat plates, wedges, cones, sphere-cones, spheres, or cylinders with laminar and/or turbulent heat transfer equations applied to the configurations listed. The method is sufficiently general to allow many variations in the physical properties of materials and boundary conditions that one might wish to consider.

Details of the method of analysis are covered in Section 2, while a program listing is in Appendix B, along with sample data cards. (Unclassified Report)

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NOMENCLATURE

A'	= conductance
C_f	= friction coefficient
Ch	= heat transfer coefficient
C_p	= coefficient of pressure
C_{he}	= heating multiplication factor
C_{he}	= enthalpy ratio
$DEL K$	= conductivity
H	= heat coefficient based on enthalpy
I	= enthalpy
J	= conversion factor
M	= Mach number
P	= pressure
Pr	= Prandtl number
Q	= heat transfer
$\dot{Q}$	= heat transfer rate
R	= radius of nose
Re	= Reynolds number
St	= Stanton number
T	= temperature
U	= velocity
X'	= diameter of sphere
Y	= Griffith-Lewis heating factor as function of Z
Z	= fictitious wetted distance (see eq. 18)
a	= nodal thickness
cp	= specific heat
g	= gravity (32.2)
r	= recovery factor
x	= wetted distance

Δt	= time step
α	= angle of attack
ϵ	= emissivity
θ	= cone 1/2 angle
Λ	= sweep angle
μ	= viscosity
ρ	= density

SUB AND SUPER SCRIPTS

abl	= ablation
b	= base temperature (400 °R)
eff	= effective
i	= calculated from reference enthalpy
n	= a particular nodal point, or time step
r	= recovery property
s	= stagnation property
sl	= sea level
sph	= sphere property
tan	= tangency point
v	= vaporization
w	= wall property
δ	= edge of boundary layer
*	= reference property
∞	= free stream property

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SECTION I

INTRODUCTION

The Aerospace Synthesized Aerodynamic Heating (ASAH) program is written in the FORTRAN IV language for the IBM 360/65 Computer. It is a flexible computer program that couples various correlations for external high speed convective aerodynamic heating with internal transient heat conduction. The flexibility of the program is derived from the many modes of operation available to a user and the ability to run parametric studies in a simple manner. A programmer may select from the following list of body configurations: flat plate, wedge, cone, sphere, cylinder, and nose blunting. An option is available for either ablating or nonablating surfaces. Laminar and/or turbulent heat transfer equations are available for each of the above configurations. Boundary layer transition is based upon either an input transition Reynolds number, an input transition altitude, or in the absence of an input altitude or Reynolds number value, the program will compute its own transition Reynolds number based upon a correlation by McCauley (Ref. 2).

For input, the program requires specification of a trajectory, physical and thermal properties, and control instructions. The trajectory input specifies altitude, velocity and angle of attack as a function of time (Fig. 1-1). Physical dimensions such as distance from forward edge (Fig. 1-2) and material segment thickness, and thermal properties such as material specific heat, density and conductivity must also be supplied. Specific heat, density, and conductivity may be inserted as functions of temperature. Control instructions define modes of operation such as configuration identification, transition criteria, boundary conditions, and computational time interval. The program will compute an optimum integration interval, after the first iteration. All inputs are entered by way of an IBM input routine called NAMELIST, which allows a large degree of freedom as to input format. Heating can be either internally computed aerodynamic, solar, or input as a function of time. Inputs are stored and kept until changed, thus facilitating parametric studies.

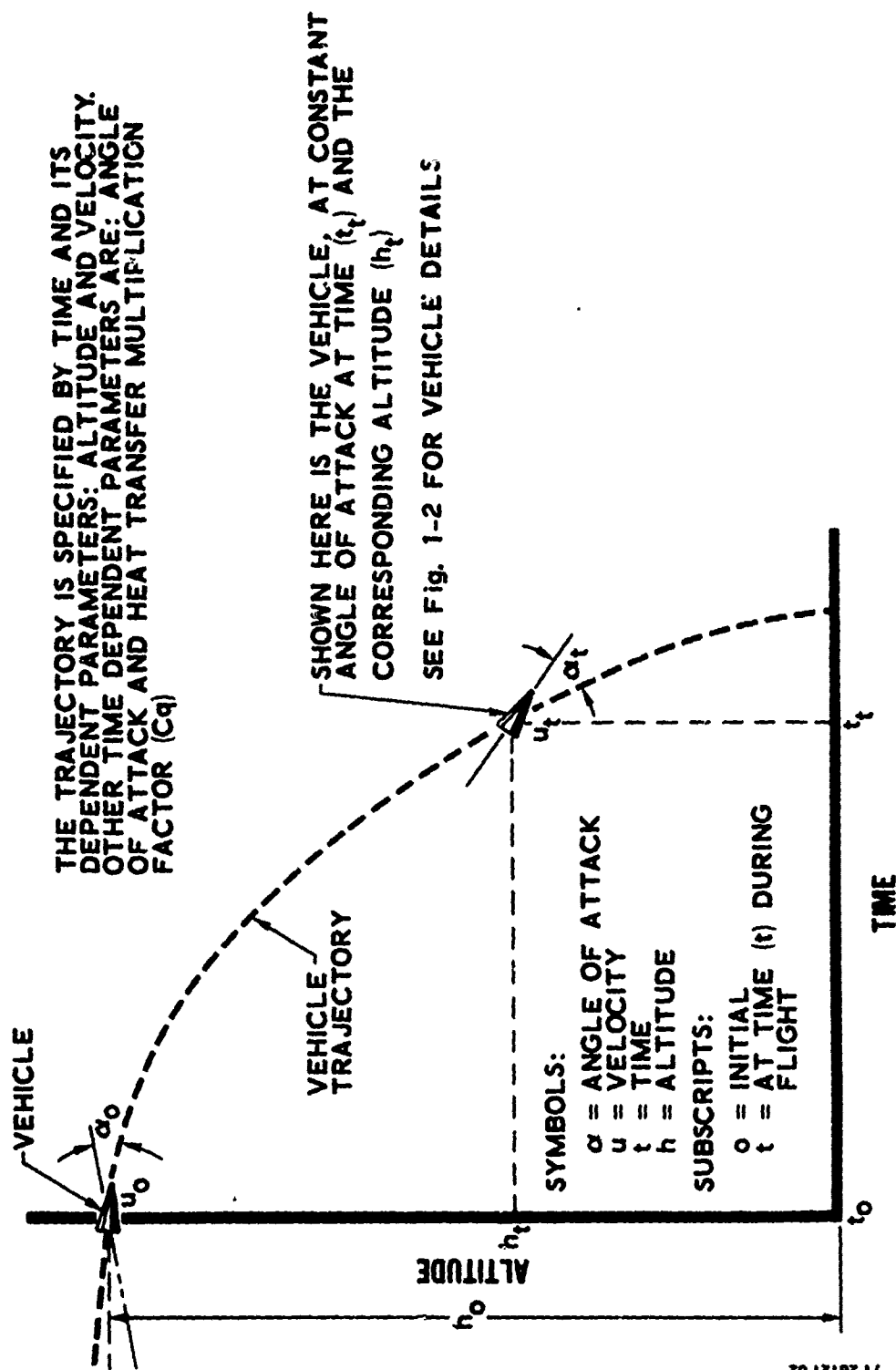


Figure 1-1. Trajectory

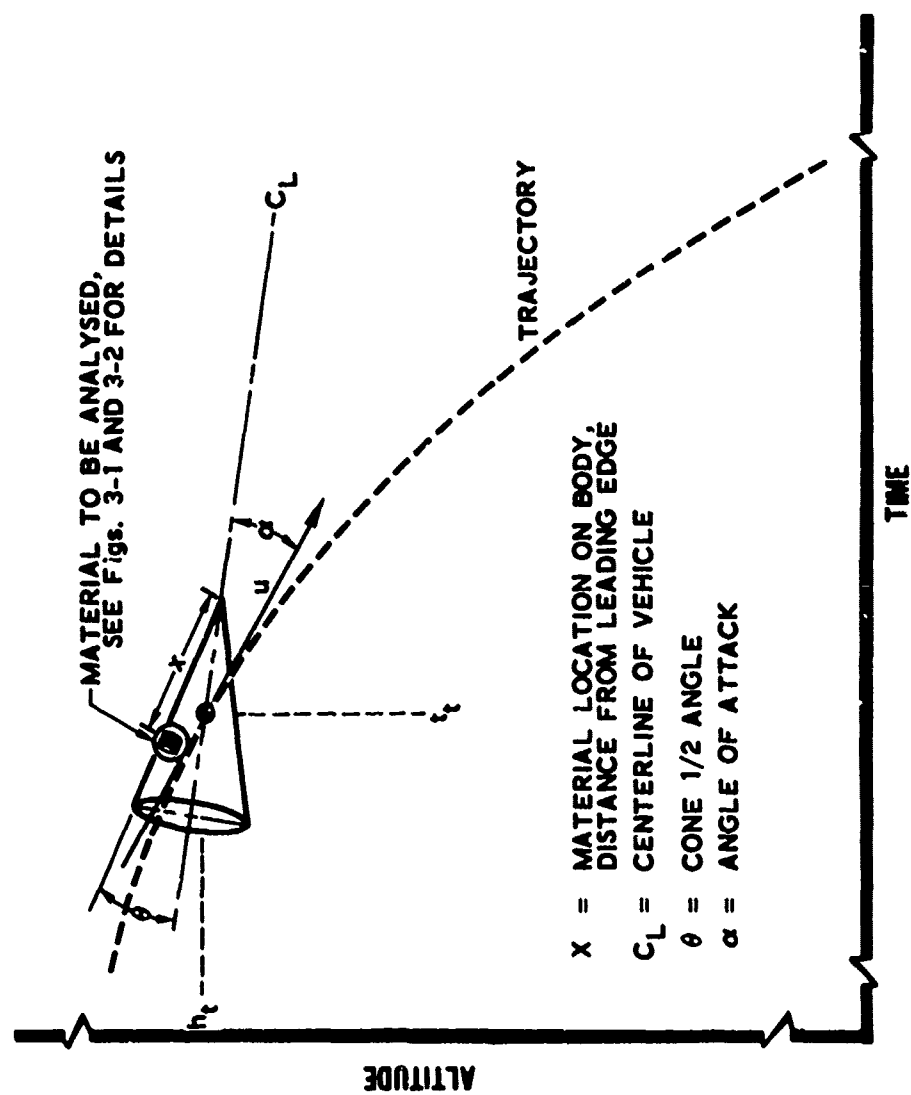


Figure 1-2. Vehicle (1-conical configuration shown)

The printed output for this program includes edge of boundary layer properties, reference conditions, free stream conditions, heat flux, dynamic pressure, Reynolds number, shear, material ablated when applicable, and temperature distribution through the heat protection system. When the nose blunting option is used, radius of a blunt nose, stagnation recession, sonic point heat rate, shear, and heat of ablation for a two-component ablative composite is also provided.

SECTION II

COMPUTATIONAL PROCEDURES

The actual flow of computation through the ASAH program is dependent on the particular problem being solved. A generalized discussion of the flow of typical computations and the subroutines involved will be given in the following paragraphs.

The variable, time, is used as the independent variable to control the overall flow of the program. Subroutine TRAJ linearly interpolates between appropriate trajectory inputs to corresponding free stream velocities and altitudes. These inputs are used in conjunction with subroutine ATMOS to provide the free stream atmospheric properties for any altitude up to 295,278 feet (Ref. 3).

When the wedge or cone shape configurations have been specified, the program algebraically adds the angle of attack to the body half-angle to determine if the SHOCK subroutine or PME (Prandtl-Meyer-Expansion) routine should be used. The SHOCK subroutine uses a similarity parameter to determine the edge of boundary layer stream properties behind the shock. The PME subroutine utilizes the Prandtl-Meyer isentropic relationships to determine fluid properties aft of a sharp corner.

Next, the program computes density, viscosity and Reynolds number. The program uses Eckert's reference enthalpy to evaluate high Mach number heat transfer. These calculations are basically carried out in, or under the control of, subroutine THERMO. The Aerodynamic heating calculation for flat plates, wedges and cones are carried out in subroutine ECKERT. Subroutine ECKERT uses the modified Reynolds analogy to correlate skin friction with heat transfer. In the case of laminar flows, skin friction is evaluated by the Blasius relationship. When the flow is turbulent, skin friction is determined using the Schultz-Grunow relationship. The aerodynamic heating calculations for spheres, cylinders, and blunted cones are handled in subroutine KEMP, using the Kemp-Riddell stagnation correlation (Ref. 4), or the Sibulkin equation for Mach numbers less than 3. There are also options for calculating heating inputs using the Hankey sonic point heating formulation, in subroutine HANKEY. Another option is available in subroutine CONSTQ. This routine provides heating values based on interpolation from tabular input.

Upon completion of the external heating calculations, the program calls on subroutine ENERGY. This routine performs an energy balance computation at the flow field - material interface.

The thermal protection system (heat sink or ablating surface) is divided into a number of segments. With the net heat load as a boundary condition, Fourier's transient conduction heat transfer equation is solved in finite-difference form. The calculations are carried out under the control of subroutines ONED or TWOD for either one or two spatial dimensions.

The one-dimensional option allows the heat protection system to be divided into a maximum of 40 segments. The two-dimensional option allows the system to be characterized by a 20 x 20 matrix of points. Material specific heat and conductivity can be inserted as functions of temperature. Each matrix element or segment may have different material properties. The program obtains particular values of the material properties, for use in computation, by accessing subroutine GETCPK or GPCPK2. These routines access the proper input material properties tables as a function of temperature and provide the needed values.

When the ablation option is exercised, the energy balance at the body surface allows for energy to be absorbed by the ablating material. This adjustment is carried out in subroutine ABLATE. A gross effective heat of ablation is computed as a function of heat of vaporization and enthalpy difference. The rate at which material is removed from the surface is determined by the difference between net heat flux to the surface and the heat conducted away into the next material segment. When the surface temperature reaches the ablation temperature and net heat flux to the surface is positive, the ablation is performed.

The nose-blunting option uses the Kemp stagnation point heating and engineering correlations to obtain heating at the sonic or tangency positions. These calculations are carried out under the control of subroutine ABLUNT.

The computations that have been, so far, described comprise those required to advance one step in time. The main program now performs various checks relating to the print and punch options. It then does a stability check to select a proper

time step for the next step in the computation. Control is then transferred to the beginning of the computational loop and reenters subroutine TRAJ. This mode of operation is continued until such time as the case is completed, or an unrecoverable problem is encountered. When this occurs, the program transfers to a call to subroutine INPUT to look for subsequent cases.

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SECTION III

METHOD OF ANALYSIS

This section of the report reviews the various methodologies that are used by the computer program to handle the individual aspects of the overall problem. The intent is to document the equations and data that are in the program and indicate the source of major portions of the formulation. No attempt is made to derive the equations used or to justify the assumptions inherent in the computer program.

3.1 HEATING RATES FOR FLAT PLATES, WEDGES AND CONES

The reference enthalpy method proposed by Eckert (Ref. 5) is used to compute the convective aerodynamic heating rates. This method is based on the assumption that the incompressible mass, momentum, and energy equations can be used for compressible flow solutions, providing the transport properties of the gas are known and evaluated at a reference enthalpy. Real gas effects, including gas disassociation and ionization, must be taken into account also in the determination of the thermodynamic properties of the gas just outside the boundary layer.

3.1.1 Laminar Boundary Layer

The Blasius solution for an incompressible boundary layer is

$$St = \frac{Cf}{2} Pr^{-2/3} \quad (1)$$

and

$$Cf = \frac{0.664}{\sqrt{Re}} \quad (2)$$

where St is the Stanton number, while Pr is the Prandtl number ($= 0.65$) and $Re = \rho UX'/\mu$ is the Reynolds number. Using Eckert's reference enthalpy

$$Re^* = \frac{\rho^* UX'}{\mu^*} \quad (2a)$$

$$H_i = 3600 St \rho_o U_o g \quad (3)$$

where ρ and μ are evaluated at a reference enthalpy, I^* , and U is evaluated just outside the boundary layer, and g is gravity.

When computing recovery enthalpy the recovery factor is Pr^n with $n = 1/2$ for laminar flow and $n = 1/3$ for turbulent flow. Since Pr was assumed = 0.65 the following values for recovery factor (r) are used:

- = 0.866 for turbulent flow
- = 0.806 for laminar flow in nonstagnation areas
- = 1.0 in stagnation areas (sphere and cylinder).

$$\dot{Q} = H_i (I_r - I_w) \quad (4)$$

The thermodynamic properties of the air ahead of the shock, P_∞ , T_∞ , and the free stream velocity and Mach number, U_∞ and M_∞ , can be determined from the given flight conditions. An approximation of the ARDC 1959 atmosphere is used. The free stream and wall enthalpies can be determined once the ambient temperature and wall surface temperature are known. The thermodynamic properties just outside the boundary layer are determined from the properties given by Schadt and Livett (Ref. 6) once the hypersonic similarity parameters, $M_\infty \sin \alpha$ and $M_r \sin \alpha$ are known (α , here is total of $\alpha + \theta$). Eckert states that

$$I^* = I_\delta + 0.5 (I_w - I_\delta) + 0.22 (I_r - I_\delta) \quad (5)$$

where

$$I_r = I_\delta + \frac{rU_\delta^2}{2Jg} \quad (6)$$

The transport properties are given by Hansen (Ref. 7). Curve fit equations were written making ρ^* and μ^* dependent on temperature. The terms ρ_b and μ_b are evaluated at a base temperature equal to 400°R suggested by M. F. Romig (Ref. 8). For cones the following correlations are used to define edge flow field properties:

when $M_r \sin \alpha < 4.0$:

$$\begin{aligned} (U_\infty^2 - U_\delta^2) \times 10^{-6} = & -0.107 (M_r \sin \alpha)^3 + 1.91 (M_r \sin \alpha)^2 \\ & + 0.04 M_r \sin \alpha + 1.57 \end{aligned} \quad (7)$$

when $M_r \sin \alpha \geq 4.0$:

$$(U_\infty^2 - U_\delta^2) \times 10^{-6} = -0.0062 (M_r \sin \alpha)^3 + 1.414 (M_r \sin \alpha)^2 + 1.038 M_r \sin \alpha + 6.187 \quad (8)$$

with $M_r = U_\infty/1086$.

The following hypersonic similarity equations for $\frac{P_\delta}{P_\infty}$ and $\frac{I_\delta}{I_\infty}$ are then employed:

when $1.5 \leq M_\infty \sin \alpha \leq 5.0$

$$\frac{P_\delta}{P_\infty} = 0.0489 (M_\infty \sin \alpha)^3 + 1.06 (M_\infty \sin \alpha)^2 + 1.16 (M_\infty \sin \alpha) \quad (3a)$$

when $M_\infty \sin \alpha > 5.0$

$$\frac{P_\delta}{P_\infty} = 0.0216 (M_\infty \sin \alpha)^3 + 0.8373 (M_\infty \sin \alpha)^2 + 4.177 (M_\infty \sin \alpha) - 3.182 \quad (9b)$$

and when $M_\infty \sin \alpha \leq 8$.

$$I_\delta = I_\infty [1.03 + 0.0827 M_\infty \sin \alpha + 0.2174 (M_\infty \sin \alpha)^2 - 0.0006956 (M_\infty \sin \alpha)^3] \quad (10a)$$

or, when $M_\infty \sin \alpha > 8$.

$$I_\delta = I_\infty [1.106 - 0.3685 M_\infty \sin \alpha + 0.3466 (M_\infty \sin \alpha)^2 - 0.007766 (M_\infty \sin \alpha)^3] \quad (10b)$$

with $M_\infty = U_\infty/1036$.

Similar correlations are used to compute edge of boundary layer fluid properties for a wedge geometry. In the case of the flat plate P_∞ and U_∞ are used in place of P_δ and U_δ ; the ambient air properties are assumed at the edge of the boundary layer. The density is obtained from the ideal gas equation, and the viscosity from the Sutherland equation. The heat transfer parameter obtained by Eq. (3) is multiplied by a factor of 1.73 for conical flow with laminar conditions (Mangler transformation).

3.1.2 Turbulent Boundary Layer

The Schultz-Grunow correlation for an incompressible turbulent boundary layer is used with the modified Reynolds analogy to predict turbulent heat rate at high velocities

$$St = \frac{Cf}{2} Pr^{-2/3} \quad (11)$$

with

$$Cf = \frac{0.370}{[\log(Re^*)/2.303]^{2.584}} \quad (12)$$

The equation for the heat transfer parameter can be reduced to the form

$$H_i = 3600 g St U_\delta \rho_\delta \quad (13)$$

and

$$\dot{Q} = H_i (I_R - I_W) \quad (14)$$

$$Re^* = \frac{\rho^* U_\delta X'}{\mu^*} \quad (15)$$

For a cone the heat transfer parameter is increased by a factor of 1.176 (Mangler transformation) over the flat plate heat transfer rate.

Hypersonic similarity parameter correlations yield I_δ , U_δ , P_δ . Other fluid properties at the edge of the boundary layer, are evaluated with the following real gas correlations:

when $I_\delta < 1300$

$$\rho_\delta = 5.76 \times 10^{-5} I_\delta^{-0.849} P_\delta \quad (16a)$$

$$\mu_\delta = 4.2642 \times 10^{-8} I_\delta^{0.493} \quad (16b)$$

when $I_\delta \geq 1300$

$$\rho_\delta = 8.65 \times 10^{-6} I_\delta^{-0.584} P_\delta \quad (17a)$$

$$\mu_{\delta} = 2.8428 \times 10^{-7} I_{\delta}^{0.228} \quad (17b)$$

$$Re_{\delta} = U_{\delta} \rho_{\delta} X' / \mu_{\delta} \quad (18)$$

This local Reynolds number is tested against a transition criteria to determine laminar or turbulent flow.

For laminar and turbulent flow, X' the input wetted-distance, is used to compute local Reynolds number.

3.3 SPHERE-CONE

3.2.1 Laminar Flow

When the flow over a sphere-cone is laminar, the heating correlation is identically that recommended by Griffith-Lewis (Ref. 9).

Local flow properties are evaluated at a nondimensionalized length:

$$Z = \frac{\theta^2 \cos \theta X}{0.802 R} \quad (19)$$

The following array of algebraic equations are solved to determine a local heating rate. The factor Y is determined from table lookup and is identical to the valve, suggested by reference 9.

$$I_{\infty} = 0.24 T_{\infty} \quad (20)$$

$$I^* = \frac{I_{\delta}}{6} \left(1 + 3 \frac{I_w}{I_{\delta}} \right) \quad (21)$$

$$Cs2 = \frac{2.58 I_{\infty}^{0.253}}{I^*^{0.338}} \quad (22)$$

$$\mu_{\infty} = 0.173 \times 10^{-5} + 0.00833 \times 10^{-5} I_{\infty} \quad (23)$$

$$Re_{\infty} = \frac{64.4 \rho_{\infty} U_{\infty} R}{U_{\infty}} \quad (24)$$

Then, if $Z \leq 1.5$ the coefficient of pressure is defined as

$$C_p = 2.46 \theta^2 \quad (25a)$$

or, if $Z > 1.5$

$$C_p = 2 \theta^2 (-6.3 Z^5 + 29.3 Z^4 - 52.2 Z^3 + 43.15 Z^2 - 15.5 Z + 2.76) \quad (25b)$$

$$Ch = \frac{M_\infty Y \theta^2 C_{s2} \left(1.0 + \frac{1.428}{M_\infty^2 C_p} \right)}{0.632 \sqrt{Re_\infty}} \quad (26)$$

Surface heating is then computed as

$$H_1 = \frac{1.2288 \times 10^6 Ch P_\infty M_\infty^2}{U_\infty} \quad (27)$$

Finally, the convective heat transfer, to a surface of unit area, is computed by the equation

$$\dot{Q} = H_1 (I_r - I_w) \quad (28)$$

3.2.2 Turbulent Flow

For turbulent flow on a sphere-cone, a Schultz-Grunow heating solution is employed. The flow field properties are computed by assuming isentropic expansion from the stagnation point to a given pressure. This pressure is obtained from the correlation suggested by Griffith and Lewis. The local flow field properties are computed as follows:

$$P_\delta = P_\infty (0.7 M_\infty^2 C_p + 1.0) \quad (29)$$

$$U_\delta = \sqrt{\frac{0.8333 U_\infty^2 \left(1.0 - \frac{P_\delta}{P_\infty} \right)^{0.286} \left(1.168 M_\infty^2 - 0.1668 \right)^{0.714}}{M_\infty^2}} \quad (30)$$

$$I_s = I_\infty + \frac{U_\infty^2}{50061.5} \quad (31)$$

$$I_\delta = I_s - \frac{U_\delta^2}{50061.5} \quad (32)$$

at this point Eckert's reference enthalpy, Eqs. (5) and (6) are used along with Eqs. (11) through (17).

The turbulent heat transfer coefficient to a cone is determined by increasing the flat plate correlations by $(2)^{1/5}$. Finally the convective heat transfer to a surface of unit area is computed from Eq. (27).

3.3 SPHERE AND CYLINDER

The heat transfer to the stagnation point of a sphere given by the Kemp and Riddell equation is used:

$$Q_{sph} = \frac{89.64 \times 10^6}{\sqrt{X'}} \sqrt{\frac{\rho_\infty}{\rho_{sl}}} \left(\frac{U_\infty}{26000} \right)^{3.15} \left[\frac{(i_s - i_w)}{(i_s - 129.5)} \right] \quad (33)$$

where ρ_{sl} is sea level density.

An approximation to the Sibulkin equation (Ref. 10) is used for $M_\infty \leq 3.0$

$$Q_{sph} = 174.0 \sqrt{\frac{\rho_\infty U_\infty}{X'}} (i_s - i_w) \quad (34)$$

On an unswept cylinder, the convective heat transfer to the stagnation point is

$$Q_{cyl} = Q_{sph} \times \text{factors} \quad (35)$$

The following equations are used to account for sweep angle effects

$$Q_{cyl} = 0.931 Q_{sph} (\cos \Lambda_{eff})^{1.5} \quad (36)$$

where

$$\Lambda_{\text{eff}} = \tan^{-1} \left[\frac{\cos \alpha \sin \Lambda}{\sqrt{1.0 - (\cos \alpha \sin \Lambda)^2}} \right] \quad (37)$$

A program option is available whereby Q_i , a heating input, can be found by way of a table look-up. If Cq is zero or negative, the program looks up the proper Q_i and sets $Cq = 1$ at which point QNET is found by the ordinary external energy balance used for all situations.

$$Q_{\text{NET}} = (Cq Q_i) - \left[0.174 \epsilon \left(\frac{T_w}{100} \right)^4 \right] \quad (38)$$

3.4 TEMPERATURE DETERMINATION

The material temperature is a function of both the net heat transfer to the wall (i.e., including radiation losses) and the diffusivity properties of the material. In order to evaluate the surface temperature and the material temperature gradients, the so called "lumped parameter" method is employed. The following section is a general description of this method.

The material is divided up into an arbitrary number of small segments, both perpendicular and parallel to the flow direction as shown in Figs. 3-1 and 3-2. Then for some small time increment (controlled by stability considerations) the net heat flux to the surface is determined. Knowing this value, the net heat transfer from segment (1) to all the adjacent segments is computed for the same small time increment. In this calculation it is assumed that all the mass is concentrated in a point source at the center of the segment and that the heat transfer takes place over an area equal to the interface between the segments and a distance equal to the spacing between the centers of the segments. The difference between the heat transferred to segment (1) by convection and radiation, and that which is transferred to all the adjacent segments by conduction causes a certain temperature rise in segment (1) during the calculation time interval. By making the calculation time interval and the size of the segments very small, the accuracy of the method may be made as good as is desired within the accuracy of the computer being used.

A forward marching explicit method of computing the temperatures is used where the temperature of a given segment at the end of a time interval is dependent upon the temperature of the given segment and adjoining segments at the beginning of the time interval.

3.4.1 One-Dimensional Conduction

The material or materials may be divided into n segments, as shown in Fig. 3-1, where $n \leq 40$. They are numbered from the outer surface inward.

The heat balance for conduction may be written as follows:

for internal segments,

$$T'_n = T_n + A' \left[\frac{T_{n-1} - T_n}{\frac{1}{2} \left(\frac{a_n}{K_n} + \frac{a_{n-1}}{K_{n-1}} \right)} + \frac{T_{n+1} - T_n}{\frac{1}{2} \left(\frac{a_n}{K_n} + \frac{a_{n+1}}{K_{n+1}} \right)} \right] \quad (39)$$

for the surface nodal point ($n = 1$)

$$T'_n = T_n + A' \left\{ \frac{Q_{\text{net}}}{12} + \frac{T_{n+1} - T_n}{\frac{1}{2} \left(\frac{a_n}{K_n} + \frac{a_{n+1}}{K_{n+1}} \right)} \right\} \quad (40)$$

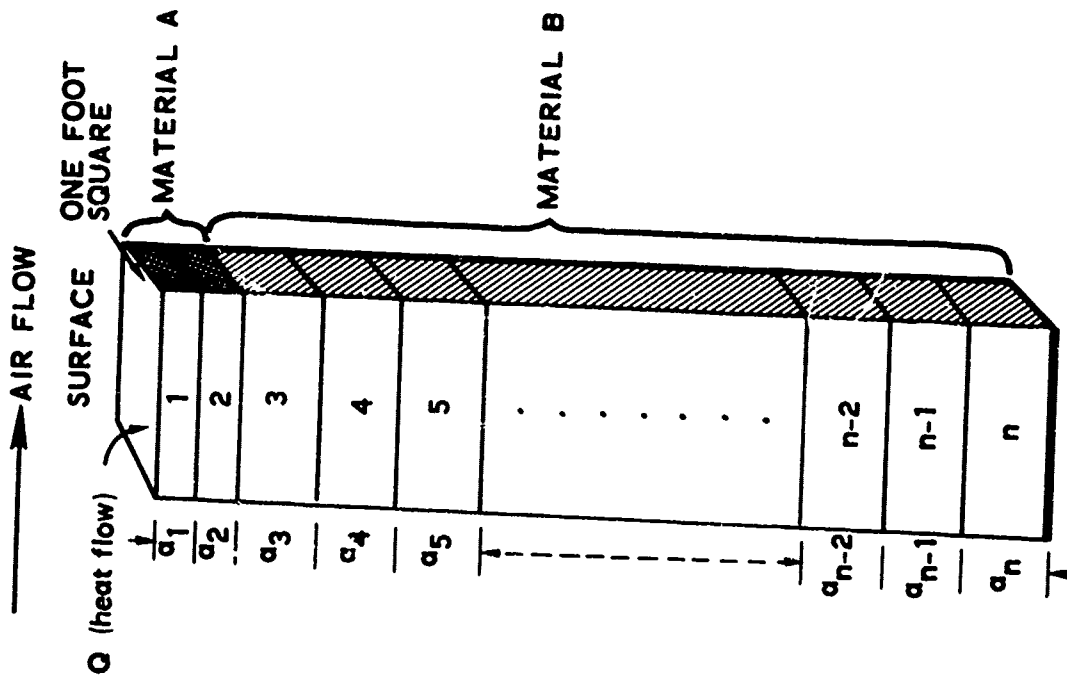
Where T'_n is the temperature at segment n for the succeeding time increment, " a " is the segment thickness, and K is conductivity. The conductance is defined as:

$$A' = \frac{\Delta t}{25.0 \rho_n c p_n a_n} \quad (41)$$

For the last segment a quantity $\text{HINSD} = 12 (T_{\text{INSD}} - T_n)$ is used to account for internal heating (if present).

3.4.2 Two-Dimensional Conduction

The two-dimensional heat conduction technique involves setting up a structure in a matrix such that the maximum number of rows = I and maximum number of columns = K . The material must be homogeneous in the X direction but not necessarily in the Y direction. This is shown in Fig. 3-2.



THE COLUMN AT THE LEFT REPRESENTS THE ONE-DIMENSIONAL CONDUCTION PROBLEM, WHICH IS LOCATED AT x IN Fig. 2, CONSISTING OF ONE OR MORE MATERIALS, EACH BEING SEGMENTED INTO LAYERS

THE NUMERALS, DOTS, AND "n" QUANTITIES NOT ONLY DENOTE THE SEGMENT NUMBER BUT ARE ASSUMED TO BE AT THE CENTER POINT OF THAT SEGMENT

MATERIAL B a = SEGMENT THICKNESS
THE SUBSCRIPT DENOTES THE SEGMENT

Figure 3-1. One-Dimensional Material

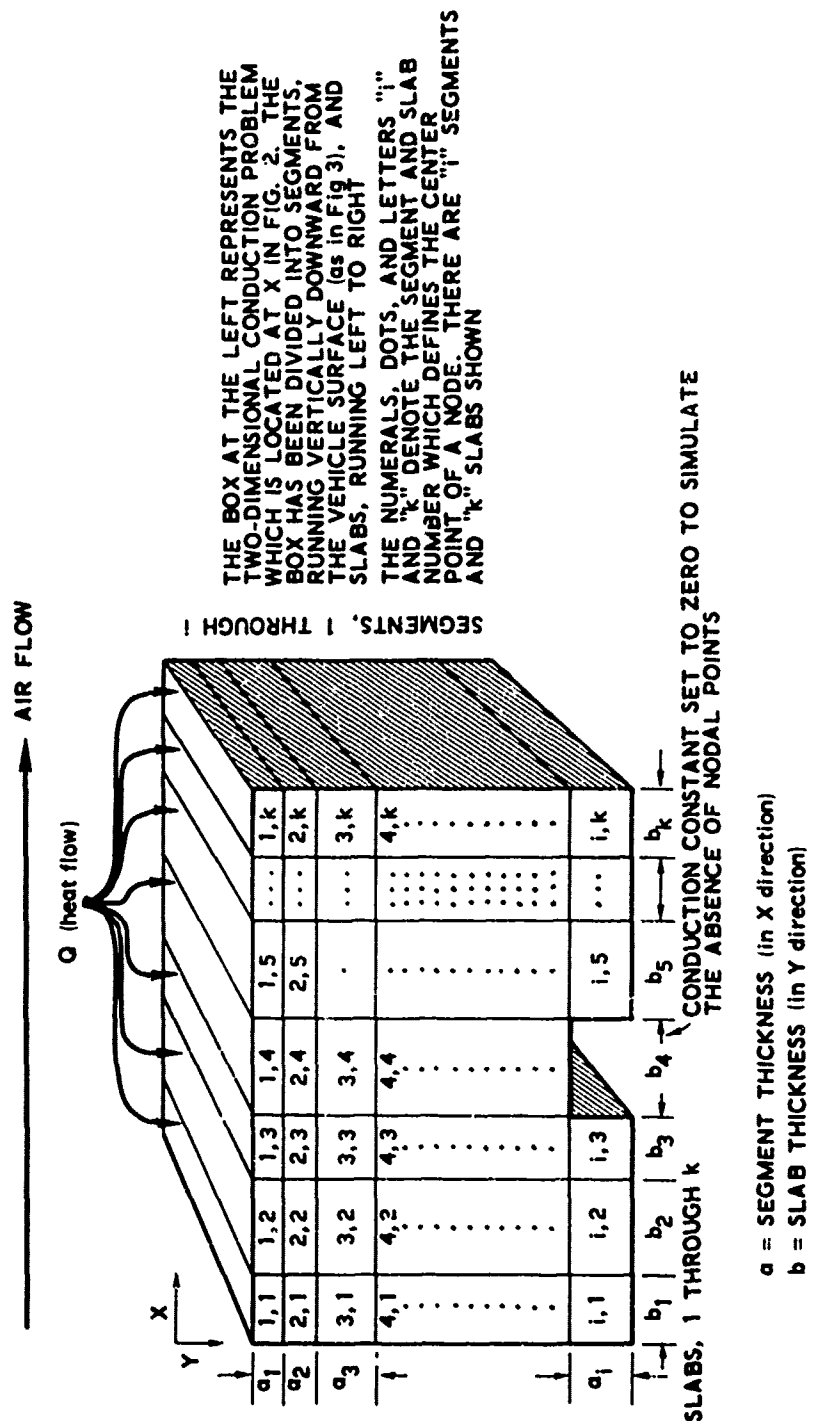


Figure 3-2. Two-Dimensional Material

The first slab in successive rows is numbered (1, 1), (2, 1),... (I, 1), there are $I \times K$ nodes, or elements, therefore the temperature at a node i, k , time $t + \Delta t$, is dependent upon the temperatures of the contiguous segments at time t . The general picture for a given nodal point is shown in Fig. 3-3.

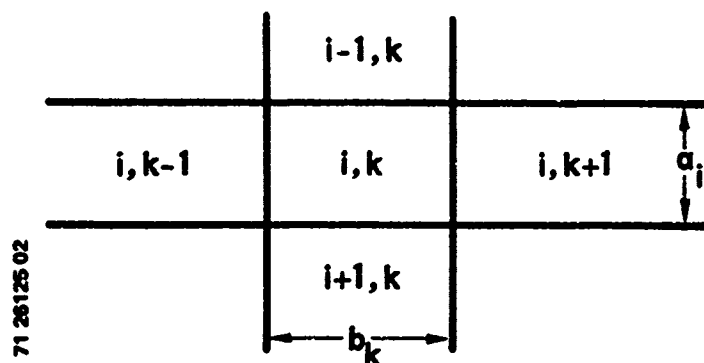


Figure 3-3. Nodal Subscript Relationships

As shown in Fig. 3-3, the equations for finding the temperature $T'_{n, k}$ for segment (i, k) are:

$$\text{FACTOR} = \frac{\Delta t}{25 \rho_i c p_{i, k} a_i b_k} \quad (42)$$

$$\text{TERM 1} = \frac{b_k \text{CC}_{i-1, k}}{\frac{1}{2} \left(\frac{a_{i-1}}{K_{i-1, k}} + \frac{a_i}{K_{i-1, k}} \right)} (T_{i-1, k} - T_{i, k}) \quad (43)$$

where K is conductivity, and CC is a multiplying constant that allows configuration flexibility,

($\text{CC} = 1$ if conduction desired and 0 if no conduction),

and $(T_{i-1, k} - T_{i, k}) = \text{heat from } (i-1, k) \text{ segment} \quad (44)$

TERM 2 in like manner with heat from $(i+1, k)$ segment

TERM 3 in like manner with heat from (i, k-1) segment

TERM 4 in like manner with heat from (1, k+1) segment

$$T'_{n_{i,k}} = \text{FACTOR}(\text{TERM1} + \text{TERM2} + \text{TERM3} + \text{TERM4}) \quad (44)$$

3.5 ABLATION TECHNIQUES

Some of the more promising types of heatshield materials for high speed flight include those whose surfaces melt or ablate because of the aerodynamic heating. In this kind of process it is necessary to compute the rate of surface ablation. This is done in the following manner. The heat transfer to the ablating surface is calculated as previously until the surface segment reaches ablation temperature. At this time two simplifying assumptions are invoked:

- (1) The segment temperature is maintained constant and equal to the ablating temperature. This is usually considered to be the melting temperature of the fibers (glass, quartz, asbestos, etc.) rather than the melting temperature of the binder.
- (2) The integrated heat flux to the segment is compared against the effective heat of ablation of the material. The effective heat of ablation is determined from test data and numerically represented by the following equation:

$$H_{abl} = H_v + \eta (I_r - I_w) \quad (45)$$

H_v and η are input parameters to the code.

Material weight loss is determined by integrating in time. When weight loss equals equivalent weight of a segment thickness that nodal point is removed from the solution temperature matrix.

3.6 NOSE BLUNTING TECHNIQUE

Nose blunting is accomplished with a two point computation. The assumption is made that a hemispherical geometry is always maintained during ablation, and that the ablating material is uniform throughout. The heat entering the stagnation point is found by means of the Kemp stagnation heating Eq. (32).

When the temperature of the outermost segment reaches ablation temperature, a new radius is calculated by the following equations using an effective heat of ablation to model surface recession. The effective heat of ablation formulation allows for a reduction of that parameter as a function of pressure or shear.

3.6.1 Laminar Flow

For laminar flow, the heating to the tangent point is computed with the correlation suggested by Stetson (Ref. 12). After determining the heat rate ($\dot{Q}_{tan}$), from a Ref. 11 table look-up, and $H_{abl_{min}}$ which is the minimum heat of ablation due to either shear or pressure degradation at both the stagnation and tangency point, the following equations are used:

$$DF = \frac{Q_{sph} \Delta t}{\sqrt{R_n} \rho (H_{abl})_{stag}} \quad \text{for recession, and for nose radius change} \quad (46)$$

$$R_n = R_{n-1} + DF \left[\frac{\sin(\theta)}{1.0 - \sin(\theta)} - \frac{Q_{TAN} (H_{abl})_{stag}}{1.0 - \sin(\theta) (H_{abl})_{tan}} \right] \quad (47)$$

Or, in the case where Stetson calculations are not prescribed:

$$FDF = 0.637 DF \quad (48)$$

and Eqs. (51) and (52) are used.

3.6.2 Turbulent Flow

For turbulent flow, the heating at the sonic point is computed using a correlation suggested by Hankey (Ref. 11), which is:

$$Q_i = \frac{18000 \left(\frac{\rho_{\infty}}{\rho_{sl}} \right)^{0.8} \left(\frac{U_{\infty}}{1000} \right)^3 \left(1 - \frac{i_w}{i_s} \right)}{R^{0.2}} \quad (49)$$

Equations (33) and (46) are again employed, with the following modifications to their results to reflect geometric changes.

$$DFF = 1.0 - DF/R \quad (50)$$

where

$$DF = \frac{17600 \sqrt{\frac{\rho_{\infty}}{\rho_{sl}}} \left(\frac{U_{\infty}}{26000} \right)^{3.15} \left(\frac{I^* - I_w}{I^* - 129.5} \right) \Delta t}{\sqrt{R} \rho_i H_{ABL}} \quad (50a)$$

$$FDF = 1.0 - \frac{DF \left[4.68 \left(\frac{\rho_{\infty}}{\rho_{sl}} \right)^{0.3} (R)^{0.3} \right]}{R} \quad (51)$$

$$FD = \left(1.0 - \frac{FDF}{R} \right) 0.74 \quad (51a)$$

Then the new nose radius is computed:

$$R_n = R_{n-1} \frac{FDF^2 - 2 DFF FD + DFF^2}{2.0 (DFF - FD)} \quad (52)$$

SECTION IV

SUBROUTINE DESCRIPTION

4.1 INPUT

This is the routine for listing the data cards and then reading them in according to NAMELIST "&BD06ØS." Input also makes minor adjustments on those data, such as filling in the QCØNS table with 1.0 when left blank.

4.2 OUTINT

This routine prints out the integer values, which were read in, before the computations start to allow easy inspection of that data input.

4.3 OUTPUT

This routine, following OUTINT, prints the rest of the data, as input.

4.4 TRAJ

Linear interpolation for tabular input data. The program increments time which is the controlling element in the tabular-interpolations. The tabular data evaluated within this routine include: altitude, velocity, angle of attack, internal convective coefficient, inside temperature and QCØNS.

4.5 ATMOS

The atmosphere subroutine determines the free stream pressure, density and temperature. The 1959 ARDC atmosphere (Ref. 13) has been assumed in this routine. The internal programming uses altitude in meters for the independent parameter table. Pressure and temperature are determined by exponential and linear curve fits valid over a limited altitude range. The coefficients to those curve fits are reevaluated at 33.5, 76.2, 143.5, 161.5, 241 and 275 Kft. Free stream density is computed using the perfect gas relationship. Internally the units are slugs/ft³. Figures 4-1 and 4-2 show the free stream pressure and temperature as a function of altitude.

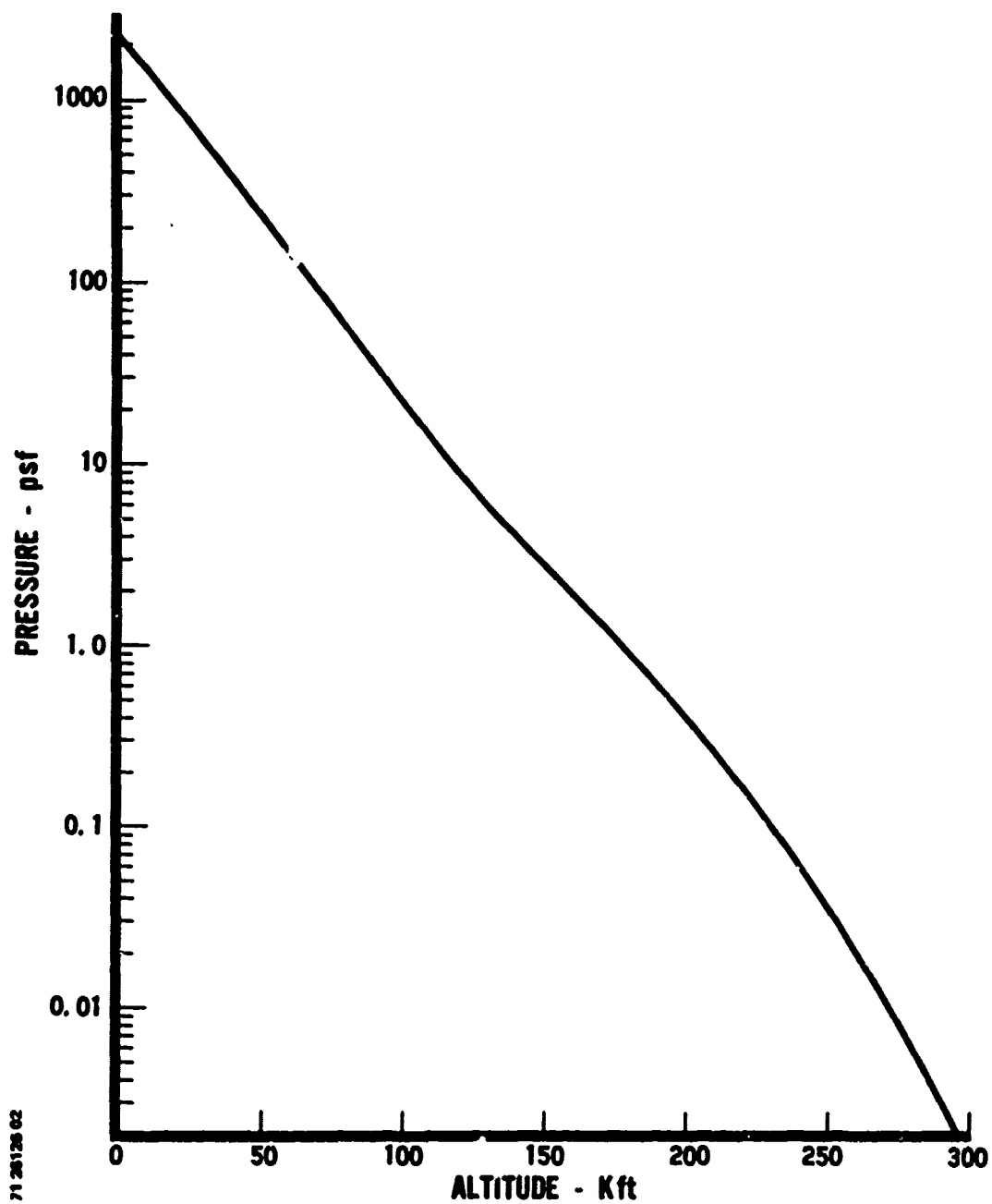


Figure 4-1. Pressure vs Altitude - 1959 ARDC Atmosphere

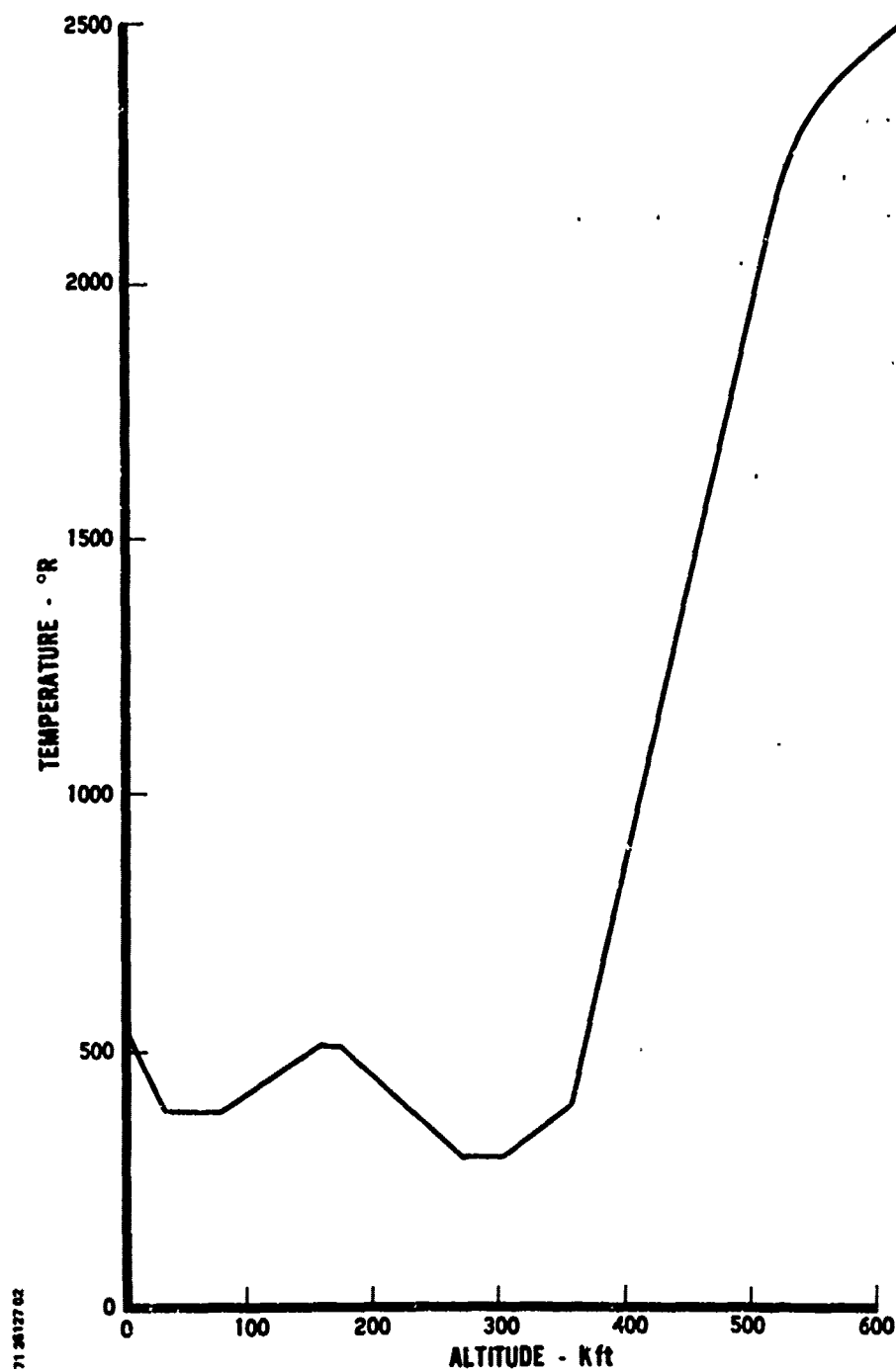


Figure 4-2. Temperature vs Altitude - 1959 ARDC Atmosphere

4.6 PRANDTL-MEYER EXPANSION (PME)

To enter the PRANDTL-MEYER EXPANSION routine the algebraic sum of the angle of attack and cone half-angle must be negative and the configuration must be either flat plate, cone, or wedge. Therefore, to enter this routine, angle of attack (AOFA) must be input as a negative term with either the flat plate, wedge or cone options. The PRANDTL-MEYER equations used in this subroutine assume a $\gamma = 1.4$. The equation used to determine the initial angle associated with the given free stream Mach number is:

$$\text{UNI} = \nu = 140.3 \tan^{-1} (0.408\beta) - 57.3 \tan^{-1}\beta \quad (53)$$

where

$$\beta = \left[M_{\infty}^2 - 1 \right]^{1/2} \quad (54)$$

$$\text{The expansion angle of interest is } \text{UNE} = \text{UNI} - \lambda + \alpha \quad (55)$$

Three curve fits were used to determine the expansion Mach number:

1. For $\text{UNE} \leq 50^\circ$

$$\text{AME} = \frac{-26.3}{\text{UNE} - 81.77} + 0.7895 + 0.0279 + \text{UNE} \quad (56)$$

2. For $50^\circ < \text{UNE} \leq 102.32^\circ$

$$\text{AME} = \frac{-280.09}{\text{UNE} - 130.20} + 0.8941 + 8.28 \times 10^{-3} \text{UNE} \quad (57)$$

3. For $\text{UNE} > 102.32^\circ$

$$\text{AME} = -\frac{284.85}{\text{UNE} - 130.43} - 1.0199 + 8.68 \times 10^{-3} \text{UNE} \quad (58)$$

Herein remains a problem. The free-stream Mach numbers are usually high, hence the third equation is usually used and, in fact, its limit of applicability is exceeded if unbounded. A SEPARATION stop should be placed upon this equation and a ratio limit of expansion pressure to upstream pressure imposed. Internally this limit is identified as "CONPR."

Once the pressure ratio is determined, pressure, temperature, density and velocity are determined using ideal gas isentropic expansion relationships with Mach number as the independent parameter. Reference viscosity and reference density, needed for the heating calculations, are computed from enthalpy and pressure dependent curve fits identical to those used in the shock subroutine.

4.7 SHOCK

The control subroutine calls the SHOCK subroutine if the configuration input is either flat plate, wedge, or cone, and if the algebraic sum of the cone half-angle and angle of attack is positive. In this routine the local (edge of boundary layer-inviscid, noninteraction) flow field properties, velocity, pressure and temperature, are computed. For a flat plate at zero angle of attack or for a wedge and cone at an effective angle of zero degrees to the stream flow, the local flow field properties are set equal to the free stream properties. If the configuration has any net positive angle of incidence to the free stream, oblique shock flow field data are computed for the effective body streamline. The basic property data utilized in this portion of the routine were based upon the real gas work of M. Romig. (Ref. 15) The equations are power series using the hypersonic similarity parameter as the independent parameter. The correlations were performed by Schadt and Livett of General Dynamics. (Ref. 13) The hypersonic similarity parameter for the local pressure is the product of free stream Mach number and sine of the cone half-angle. The parameter for velocity is the product of reference Mach number and sine of the cone half-angle. Figures 4-3 and 4-4 present pressure ratio and velocity difference across a shock developed from a wedge configuration. Figures 4-6 and 4-7 show similar results for the cone configuration. The correlation equations actually used within the program, and their range of applicability, are illustrated on each figure. Note that the local property data presented by these figures yield values at the edge of the boundary layer and not immediately behind the shock. Observe also that these data are for sharp bodies only or at that axial station where sharp cone conditions exist. This distance can be established from the entropy swallowing work done by Jacobs (Ref. 14).

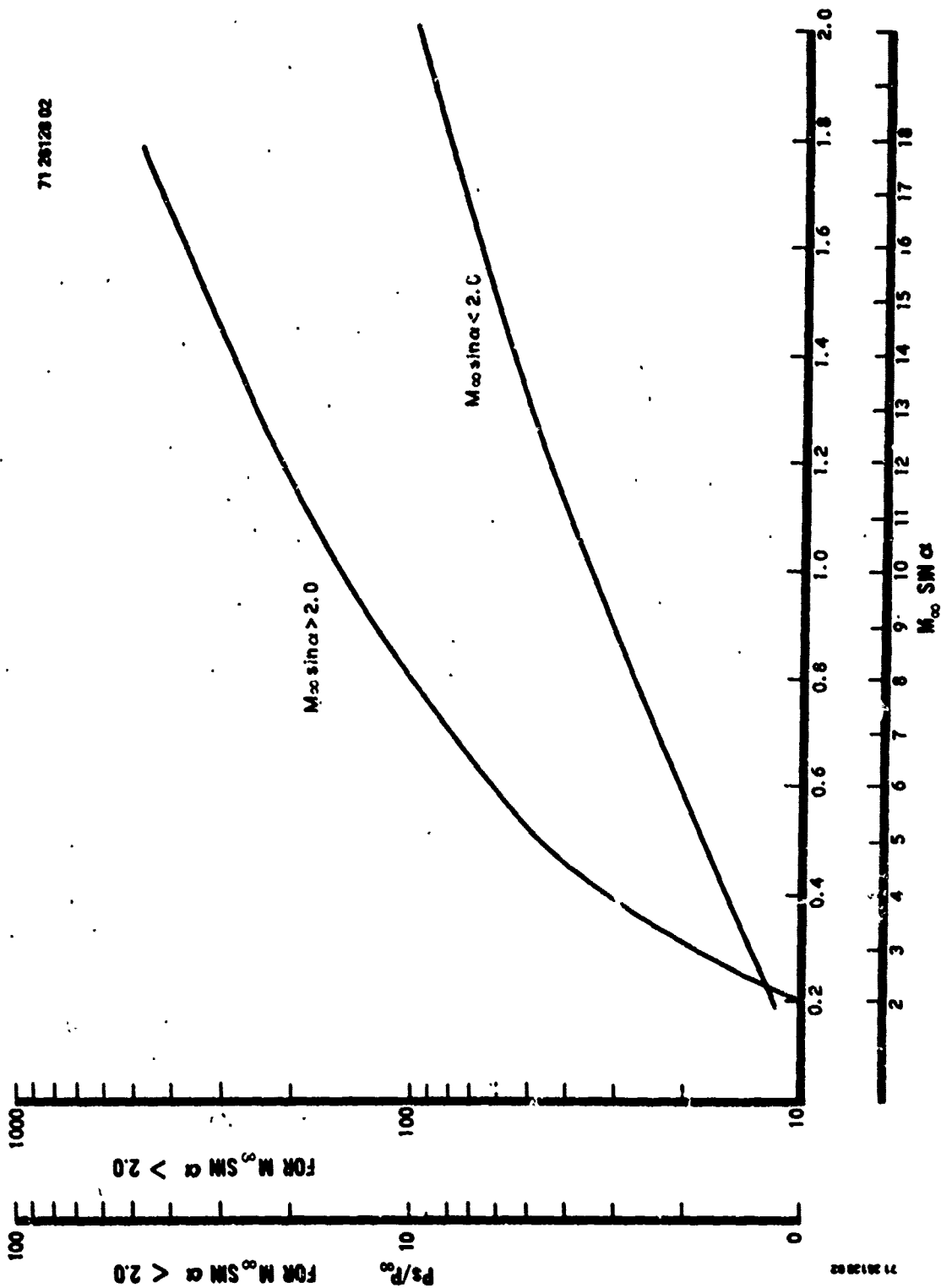


Figure 4-3. Wedge Pressure Ratio

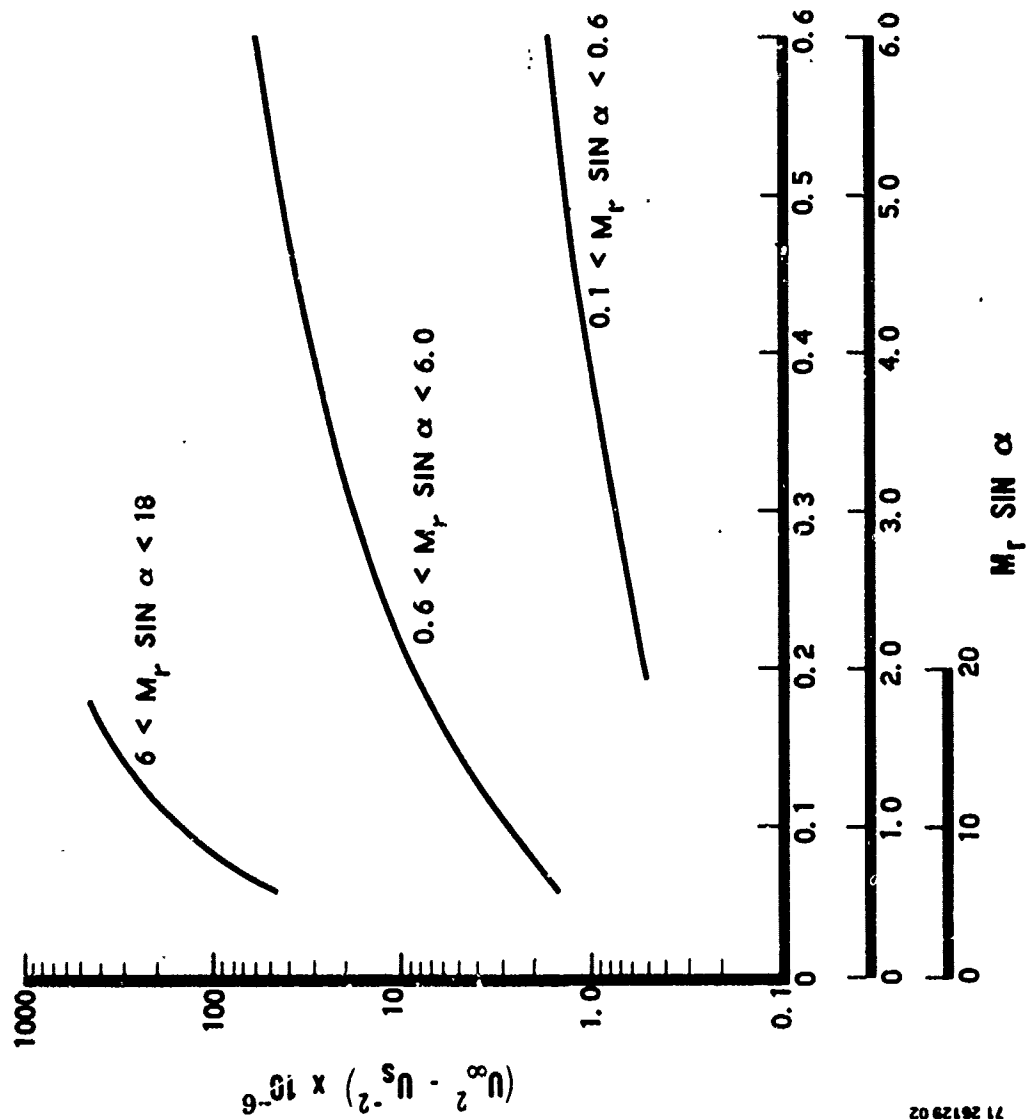


Figure 4-4. Wedge Velocity Parameter

4.8 THERMO

The THERMO subroutine computes enthalpy for the sharp cone and sharp wedge configurations. The enthalpy change across the shock is determined from correlations of M. Romig's work (Ref. 15). Figures 4-5 and 4-8 present the enthalpy data for the wedge and cone respectively. For blunted cones, the THERMO routine is also used to compute local properties (P , V , I) based upon a pressure distribution presented by Griffith-Lewis and isentropic expansion from the stagnation point to that prescribed local pressure. The isentropic expansion assumes $\gamma = 1.40$. Based upon entropy swallowing work by Jacobs, Ref. 13, this should be changed to $\gamma < 1.40$. In any case, the equations were programmed to determine heat transfer and estimate flow field properties in the overexpansion region where sharp cone heat transfer is too high. Within this subroutine, recovery enthalpy and reference conditions are computed for use in Eckert's reference enthalpy technique for high speed heat transfer. The computations for recovery factor assume a Prandtl number (PR) of 0.76. Recovery factor is evaluated as Prandtl number to the $1/2$ and $1/3$ power for laminar and turbulent flow respectively. Reference enthalpy, density and viscosity are computed from Eq. (4) and the following relationships:

for

$$I^* < 1300$$

$$\mu^* = 0.426 \times 10^{-7} I^{*0.493} \quad (59a)$$

$$\rho = 0.576 \times 10^{-4} I^{*-0.849} P_{\delta} \quad (60a)$$

for

$$I^* > 1300$$

$$\mu^* = 0.284 \times 10^{-6} I^{*0.228} \quad (59b)$$

$$\rho^* = 0.865 \times 10^{-5} I^{*-0.584} P_{\delta} \quad (60b)$$

The superscript * indicates reference conditions and the subscript δ is used to denote edge of boundary layer property. Viscosity, enthalpy, pressure and density have the usual μ , I , P and ρ symbols.

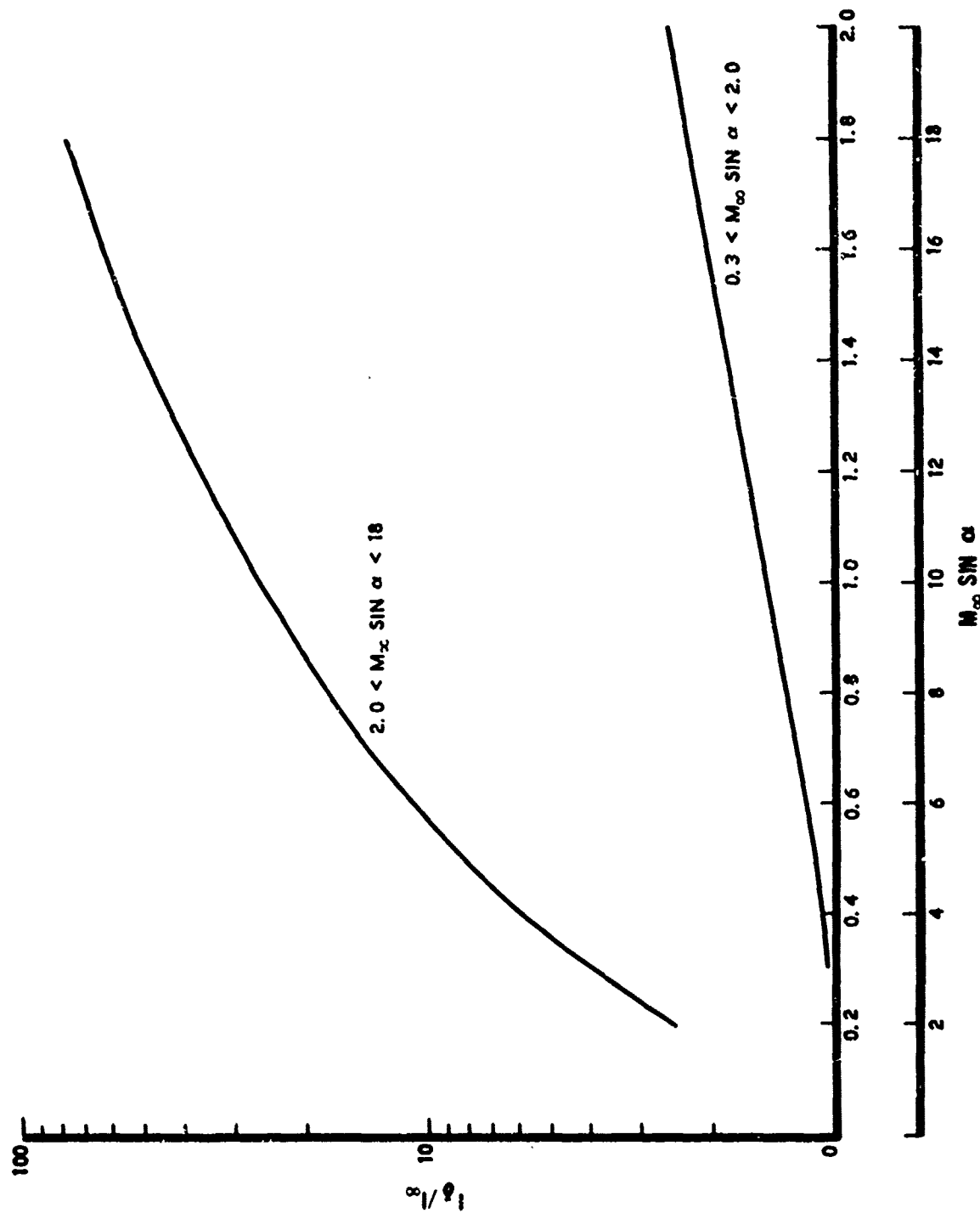


Figure 4-5. Wedge Enthalpy Ratio

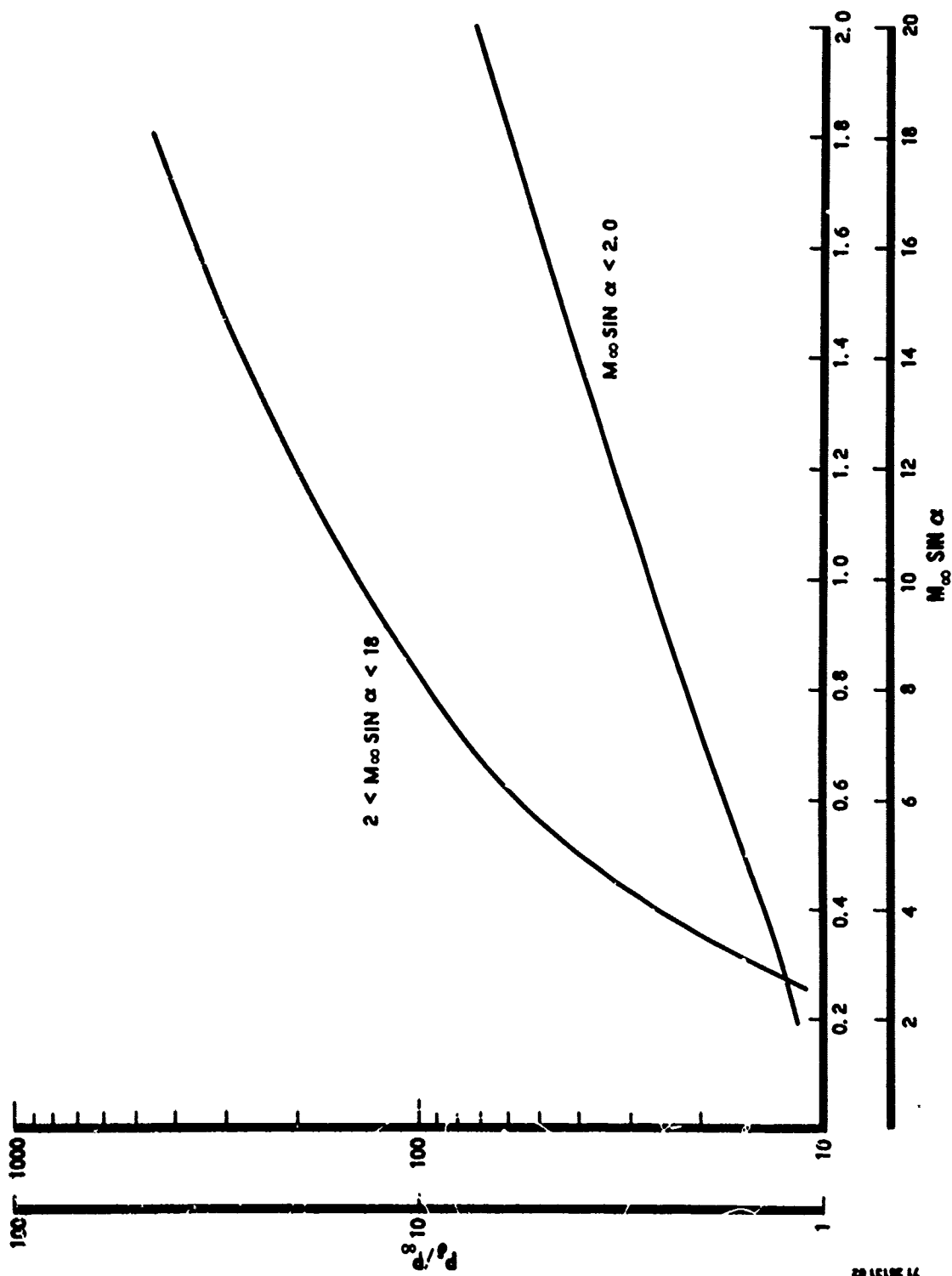


Figure 4-6. Cone Pressure Ratio

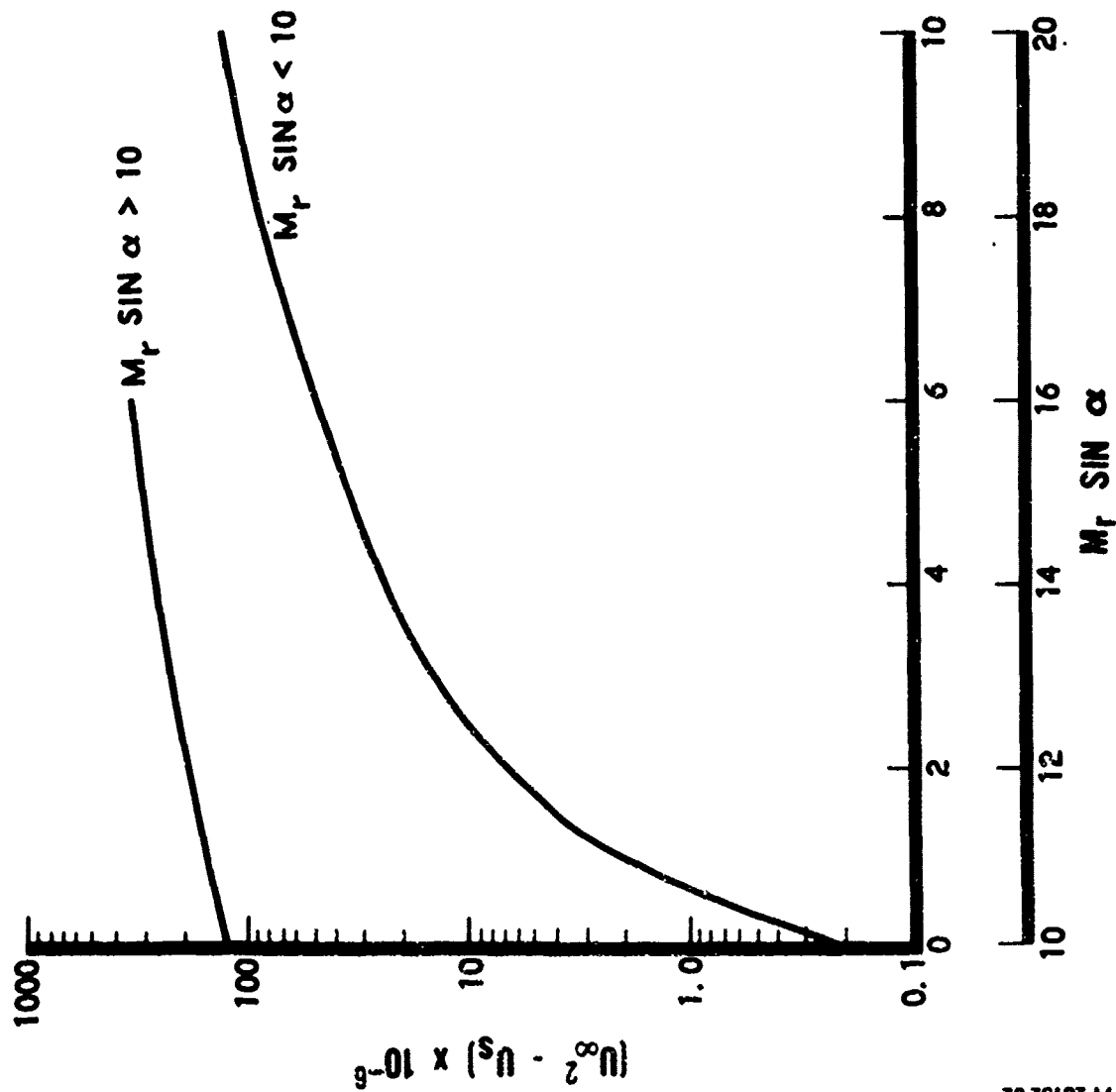


Figure 4-7. Cone Velocity Parameter

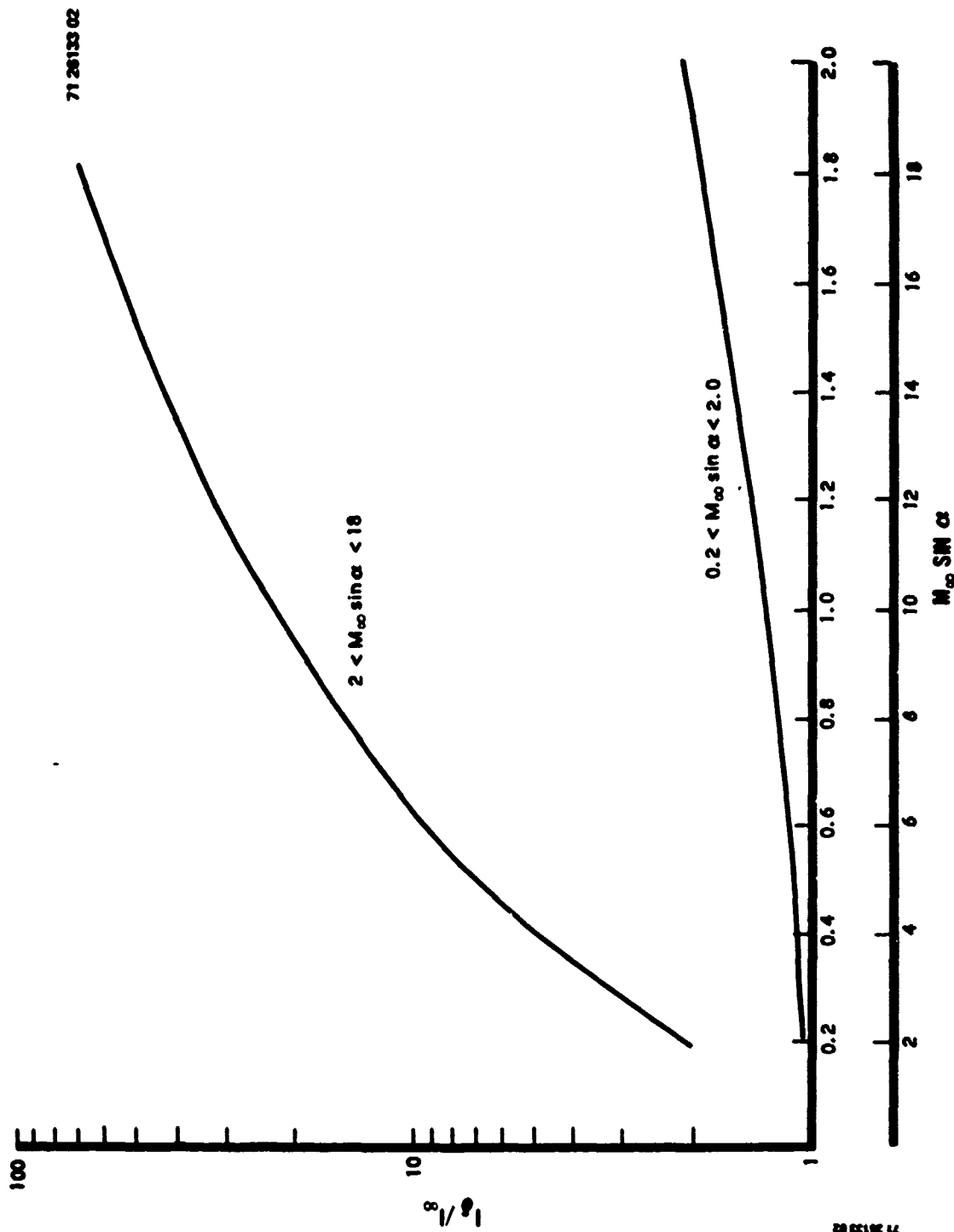


Figure 4-8. Cone Enthalpy Ratio

4.9 DIST

This routine historically modified the input wetted distance to allow for a combined run of laminar and turbulent flow. The input wetted distance was modified to match boundary layer velocity thickness at the Transition Reynolds number. With the computed laminar boundary layer thickness set as the turbulent thickness at transition, an imaginary turbulent wetted length was computed and used in the heat transfer calculations. Experience at Aerospace suggested that the matching of a boundary layer velocity thickness did not yield proper turbulent heat transfer rates. It has been suggested that a forced matching of the momentum thickness would produce more meaningful results. However, at this moment, no such computation is performed within ASAH. The input wetted length is maintained unchanged. The routine is essentially a dummy routine awaiting a reformulation of the mixed wetted length problem. For spheres and cylinders, however, this routine computes their diameter.

4.10 KEMP

This routine is entered whenever ICONF = 3, 4 or 5 (cone, sphere, or cylinder). The stagnation point calculation is performed for sphere and cylinder when ICONF = 4 or 5 respectively. When ICONF = 3 and NOSB = 1 (blunted cone), a stagnation heat transfer is generated for the stagnation point transient conduction problem with nose blunting. For the sphere, the Kemp-Riddell equation is used to compute hot wall heat transfer for high Mach numbers, whereas, the Sibulkin equation is utilized at low supersonic speeds (Mach number less than 3.0). Equations (33) and (34) compute the corresponding $\dot{Q}$ for spheres.

Note that internally the machine program computes heating on a per hour basis. The printout however shows the heat transfer rate in the more useful per second basis.

Eggers, Hansen and Cunningham (Ref. 16) provide the following relationship for the convective heat transfer to an unswept cylinder

$$\dot{Q}_{\text{cyl}} = 0.9319 \dot{Q}_{\text{sphere}} \quad (61)$$

Lees (Ref. 18) suggests $(2)^{-1/2}$ as the proportionality constant. The Eggers value is used to obtain conservative heat rates.

The following equations are employed within the ASAH program when considering a cylinder at a prescribed sweep angle geometry (Λ) and angle of attack (α) (useful when modeling the blunted leading edge of a supersonic aircraft for example)

$$ANG = \left[\cos (\alpha) \right] \left[\sin (\Lambda) \right] \quad (62)$$

$$S = \tan^{-1} \frac{ANG}{\sqrt{1 - ANG^2}} \quad (63)$$

$$\dot{Q}_{cyl} = 0.931 \dot{Q}_{sphere} (\cos S)^{3/2} \quad (64)$$

4.11 ECKERT

This subroutine computes convective heat transfer for the flat plate, cone, wedge, and blunted cone configurations. Sphere and cylinder configuration flags shift the calculation to subroutine KEMP.

For the blunted cone configuration, the program computes laminar heat transfer convective coefficient based upon the Griffith-Lewis correlation (Ref. 9). This correlation uses the nondimensionalized wetted distance as the entry parameter and interpolates from a heating table carried in the program. [Eq. (18)]

$$Z = \frac{\theta^2 \cos \theta X}{0.802 R}$$

If $Z > 10$ the program assumes bluntness effects have been dissipated by distance, and the program reverts to sharp cone computations.

Under turbulent heating conditions, the blunted cone heating is computed using normal shock-isentropic expansion property data generated in the THERMO subroutine, followed by the Schultz-Grunow turbulent skin friction equation.

For both the sharp cone and sharp wedge configurations this subroutine sequentially computes the following array of terms: skin friction, Stanton number, convective

heat transfer based upon the Blasius and Schultz-Grunow relationship for laminar and turbulent heating respectively. Implicit within this technique to determine heat transfer is the assumption that a modified Reynolds analogy is valid for both laminar and turbulent flow conditions, and that for high speed flow, Eckert's reference enthalpy parameter still correlates the skin friction data. Under extreme flight velocities, the reference enthalpy becomes a more significant measure (relative to reference temperature) of the energy within a flow stream as dissociation and ionization phenomenon affect the stream temperature. The following array of equations reflects this modeling to determine convective heat transfer. [Eq. (2a)]

$$Re^* = \rho^* U_\delta X' / \mu^*$$

For laminar flow conditions [Eq. (2)]

$$C_f = 0.664 / (Re^*)^{1/2}$$

For turbulent flow conditions [Eq. (12)]

$$C_f = \frac{0.370}{[\ln Re^*]^{2.584}}$$

Assuming modified Reynolds analogy [Eq. (11)]

$$St = \frac{C_f}{2} (Pr)^{-2/3}$$

Computing the convective coefficient and then the convection heating:

$$H_I = St U_\delta \rho_\delta (g) (3600) \quad (65)$$

$$\dot{Q}_{conv} = H_I (I_r - I_w) \quad (66)$$

Once again the superscript * refers to reference enthalpy conditions and Re , C_f , St , H_I , and $\dot{Q}_{conv}$ are Reynolds number, friction coefficient, Stanton number, convective coefficient based on enthalpy, and convection heating respectively. Note that the internal units for convective heating are Btu/ft^2-hr .

For the cone heating, both the film coefficient and the heat transfer parameter are multiplied by a transformation factor (from Eckert, Ref. 5) to allow for the thinning of the boundary layer as the cone surface area increases as a function of axial length. These transformation terms are $\sqrt{3}$ and $(2)^{0.234}$ for laminar and turbulent flow respectively.

4.12 HANKEY-SONIC POINT SUBROUTINE

The HANKEY subroutine requires an input of ICHK = 1 and radius (RADIUS) of the nose. Calculations at the sonic point are completed for either laminar or turbulent flow. Transition criteria within this routine are based upon either an input transition altitude or a Reynolds number based upon free stream properties and nose radius. For laminar heating the following equation is employed

$$\dot{Q}_{\text{sonic}} = (10,800) \left(\frac{\rho_{\infty}}{\rho_{sl}} \right)^{1/2} \left(\frac{U_{\infty}}{26,000} \right)^{3.15} \left(\frac{I_s - I_w}{I_s - 129.5} \right) \left(\frac{1}{R} \right)^{1/2} \quad (67a)$$

For turbulent heating at the sonic point

$$\dot{Q}_{\text{sonic}} = 5.0 \left(\frac{\rho_{\infty}}{\rho_{sl}} \right)^{0.8} \left(\frac{U_{\infty}}{1000} \right)^3 \left(1 - \frac{I_w}{I_s} \right) \left(\frac{1}{R} \right)^{0.2} \quad (67b)$$

The heating rate that is provided as a boundary condition for the transient condition solution is based upon an hourly rate.

$$\dot{Q}_{\text{conv}} = 3600 \dot{Q}_{\text{sonic}} \quad (68)$$

4.13 GETCPK

The GETCPK subroutine provides an interpolation subroutine to determine specific heat and conductivity as a function of temperature. The flag needed to direct the calculation is KFUNT. The following code delineates the options on specific heat and conductivity.

- KFUNT = 1 specific heat and conductivity are both functions of temperature.
- KFUNT = 2 conductivity is a function of temperature; specific heat is constant.
- KFUNT = 3 specific heat is a function of temperature; conductivity is constant.
- KFUNT = 4 both specific heat and conductivity are constants.
- $5 \leq \text{KFUNT} \leq 10$ tabular input of specific heat, conductivity and density versus temperature. KFUNT in this case is the number of points describing the temperature curve, with an equal number describing ρ , Cp, K

In general ($1 \leq \text{KFUNT} \leq 4$) the specific heat and conductivity are written as power series expansions of temperature. The general form for the equation is

$$C_p \text{ or } K = C_0 + C_1 T + C_2 T^2 + C_3 T^3 \quad (69)$$

with C_0 , C_1 , C_2 , and C_3 being input constants. The values of these constants are assumed zero if omitted in the input. The specific heat and conductivity (and density if $\text{KFUNT} \geq 5$) for a given time increment are computed for the nodal temperature distribution of the previous time interval.

4.14 ENERGY

This subroutine performs the energy balance at the flow field/material interface. It accounts for high speed convection to the vehicle surface, corrects for current vehicle surface temperature, and for energy radiated away to a zero degree space environment [Eq. (40)]. Internal conduction is evaluated in subroutine ONED.

$$\dot{Q}_{\text{NET}} = C_q Q_i - \left[(0.174) \epsilon \left(\frac{T_w}{100} \right)^4 \right]$$

$$Q_i = Q_{\text{CONV}}$$

The symbol C_q may be interpreted as an adjustment parameter that modifies the internally computed convective heating. For example, under turbulent flow conic heating conditions, some experts do not utilize the $(2)^{1/5}$ correction factor resulting from the Mangler Conic three-dimensional transformation. If one desires to reproduce this effect within ASAH, a $C_q = \frac{1}{(2)^{1/5}}$ may be used to cancel the programmed turbulent transformation factor for the cone configuration. Another example would be to use C_q as a factor of safety on the predicted heat transfer rates. Factors ranging from 1.2 to 1.5 have been used in the conservative design of reentry heatshields.

4.15 CONSTQ

If NPQ(NPGAS internally) is set equal to a positive number, the CONSTQ subroutine is called from the Main Program. This subroutine provides a heating input based upon a tabular input, and the program bypasses its normal convective heating calculations. If NPQ is a number greater than 2, a linear interpolation of the QI table is completed and set into the convective heating program slot. If NPQ is less than 2, the convective heating term is set equal to QSOLAR, an input constant. The program next computes net heating by subtracting the radiation term, based upon current wall temperature, from the prescribed input cold-wall heating component. This option is useful if the program is to be used to solve the Fourier conduction equation only, bypassing the normal aerodynamic heating routines.

4.16 ONED

This particular subroutine solves the transient one-dimensional conduction problem using the finite-difference form of Fourier's conduction equation. Utilizing subroutine GETCPK, density, conductivity and specific heat for a given point may be obtained as a function of current nodal temperature. The subroutine is programmed such that heat energy may be removed from the back face of the insulative system by an input convective coefficient. Within the system, conduction is the only mode of heat transfer; internal radiation and heat generation are not allowed.

For a thin-skin (one nodal point), the following equation is used to predict temperature change.

$$T_{J+1} = \left(\frac{\Delta t}{\rho a_i C_p 25.0} \right) \left(\frac{Q_{NET}}{12} \right) + (HINS D) \left(\frac{T_{INSD} - T_J}{12} \right) + T_J \quad (70)$$

The net energy into the system (Q_{NET}) is computed in the ENERGY subroutine. The heat energy removed from the system is computed from an input convective coefficient ($HINS D$) and an input heat sink temperature (T_{INSD}). Density, specific heat, nodal thickness and temperature are represented by ρ , C_p , a_i and T respectively. The subscript J refers to conditions at the beginning of time interval Δt , whereas the subscript $J+1$ refers to the temperature at the end of the time interval.

For conduction problems that are divided into more than one nodal point, the following array of difference equations are employed.

Aerodynamic nodal point:

$$T_{n(J+1)} = A_1 \left\{ \frac{Q_{NET}}{12} + \frac{T_{n+1} - T_n}{0.5 \left[\frac{a_n}{K_n} + \frac{a_{n+1}}{K_{n+1}} \right]} \right\} \text{ evaluated at } J \quad (40)$$

Interior nodal point:

$$T_{n(J+1)} = A_1 \left\{ \frac{T_{n-1} + T_n}{0.5 \left[\frac{a_{n-1}}{K_{n-1}} + \frac{a_n}{K_n} \right]} + \frac{T_{n+1} - T_n}{0.5 \left[\frac{a_{n+1}}{K_{n+1}} + \frac{a_n}{K_n} \right]} \right\} + T_{n,J} \quad (39)$$

Internal exposed nodal point:

$$T_{n(J+1)} = A_1 \left\{ \frac{T_{n-1} - T_n}{0.5 \left[\frac{a_{n-1}}{K_{n-1}} + \frac{a_n}{K_n} \right]} + HINS D \left[\frac{T_{INSD} - T_N}{12} \right] \right\} + T_{n,J} \quad (71)$$

The above equations were written around the n^{th} element and were centrally differenced in the interior points. In this case, the subscripts J and $J+1$ refer to the temperature at the beginning and ending of the calculation time interval (Δt).

The other symbols have the same meaning as previously, with the addition of K for conductivity. $A1$ represents the heat storage term for the n^{th} element and is defined below.

$$A1 = \frac{\Delta t}{25.0 \rho_n a_n C_{p_n}} \quad (41)$$

For the situation where convection to an internal sink is specified (HINS and TINS), the internal heat flux is integrated numerically so that it can be printed out at a later time.

4.17 ABLATE

If an ablation temperature is provided in the input, the control routine calls the ablation subroutine. This routine uses a simple effective heat of ablation thermal model to estimate surface recession for an ablative heatshield system. If net heat flux into the system is positive, and if the temperature of the aerodynamically exposed nodal point is equal to the prescribed ablation temperature, this subroutine computes an effective heat of ablation [Eq. (46)]

$$H_{abl} = H_v + \eta (I_r - I_w) \quad (45)$$

The H_v and η used in the above equation are input parameters, usually determined from ground test correlations.

For common ablative materials, two values for η are accepted, ETAL and ETAT, the blowing corrections for laminar and turbulent flow respectively. Two equations are available to determine mass loss rate. If the input flag $NQI = 0$, the ablation rate is determined by subtracting the heat energy conducted inward from the net heat entering the system, and dividing the remaining energy by the materials effective heat of ablation. With $NQI > 0$, the convective heat transfer, rather than net heat transfer, is used in the mass loss computation. Results are printed in terms of WABDOT and WAB, the mass loss per unit area per calculation time interval and the integrated mass loss per unit area respectively.

For materials that are sensitive to stagnation pressure, the user has the option of degrading heat of ablation at a threshold value of pressure. At that pressure (input as PSTMAX) the program bases heat of ablation on a second set of ablation parameters

(HVPSTM, ETALP, ETATP), usually reflecting a material's inferior performance under a high stagnation pressure environment.

4.18 ABLUNT

The ABLUNT subroutine option is used to predict nose radius change for a sphere/cone configuration. The subroutine is entered by assigning NOSB = 1, and specifying a radius (RADIUS) and an ablation temperature (TWALL) in the input array. The blunting model assumes spherical geometry in the nose region, and uses an effective heat of ablation to predict surface recession. Laminar or turbulent heating is used at either the sonic point or the sphere/cone tangency point. Detailed thermodynamic computations are performed at the stagnation point and engineering correlations are employed to estimate heating at either the sonic or tangency position. The sonic calculation is performed if ISTETS = 0; tangency computations are completed if ISTETS = 1.

Transition may be controlled by specification of a transition Reynolds number or by stipulation of a transition altitude or McCauley criteria (Ref. 2) if neither is specified. With respect to transition, Reynolds number is evaluated at the nose sonic point using sonic point flow field properties (valid only when freestream Mach number is hypersonic), and current nose radius. The flow field properties are evaluated as follows:

$$P_{\delta} = P_{\text{sonic}} = 1160 P_s \quad (72)$$

$$U_{\delta} = U_{\text{sonic}} = 0.301 U_{\infty} \quad (73)$$

$$\rho_{\delta} = \rho_{\text{sonic}} = 7.24 \rho_{\infty} \quad (74)$$

$$\mu_{\delta} = \mu_{\text{sonic}} = 1.511 \times 10^{-10} U_{\infty} \quad (75)$$

$$I_{\delta} = I_{\text{sonic}} = (I_s - U_{\text{sonic}}^2) / 5.01 \times 10^4 \quad (76)$$

The Kemp-Ridell equation, discussed earlier, is used to evaluate stagnation heating. Sonic point heating is evaluated using a $(\cos \theta)^{3/2}$ relationship for laminar conditions, and Hankey's equation for turbulent conditions. These relationships are

reproduced below

$$\text{LAMINAR } \dot{Q} = 0.637 \dot{Q}_s \quad (77)$$

(assumes $\gamma = 1.2$)

$$\text{TURBULENT } \dot{Q} = \frac{5.0}{(R)^{0.2}} \left(\frac{\rho_\infty}{\rho_{sl}} \right)^{0.8} \left(\frac{U_\infty}{1000} \right)^{0.3} \left(1 - \frac{I_w}{I_s} \right) \quad (78)$$

For laminar conditions, using the Stetson option, the heating is evaluated at the sphere/cone tangency point. Figure 4-9, due to Stetson, shows the tangent to stagnation heating ratio for laminar flow conditions. For turbulent conditions, independent of option, computations are always performed at the sonic point.

It should be noted that the conduction problem is solved at only one station (stagnation point) when the blunting option is exercised. The program tacitly assumes that when the ablative temperature is attained at the stagnation point, it is simultaneously achieved at either the sonic or tangent points.

Since it has become evident that material thermal performance is degraded at high pressure and/or high shear, this subroutine has been extended to compute effective heat of ablation in a manner that admits variable material performance as a function of external environment. The following equation defines effective heat of ablation in the nose blunting subroutine, using ΔI as $(I_r - I_w)$.

$$\begin{aligned} H_{abl} = & (X_1) (FV_1) \left[HV_1 + \eta_1 \Delta I \right] + (X_1) (1 - FV_1) \left[HF + \eta_1 \Delta I \right] \\ & + (1 - X_1) (FV_2) \left[HV_2 + \eta_2 \Delta I \right] \end{aligned} \quad (79)$$

The subscripts 1 and 2 refer to the constituents of a two component material (for example the silica and phenolic of OTWR). The weight fraction of component one is designated X_1 . FV represents the fraction of material vaporized and is input as a tabular function of pressure and shear. The program user may adjust material performance by operating on the fraction vaporized term. The terms, HV, HF,

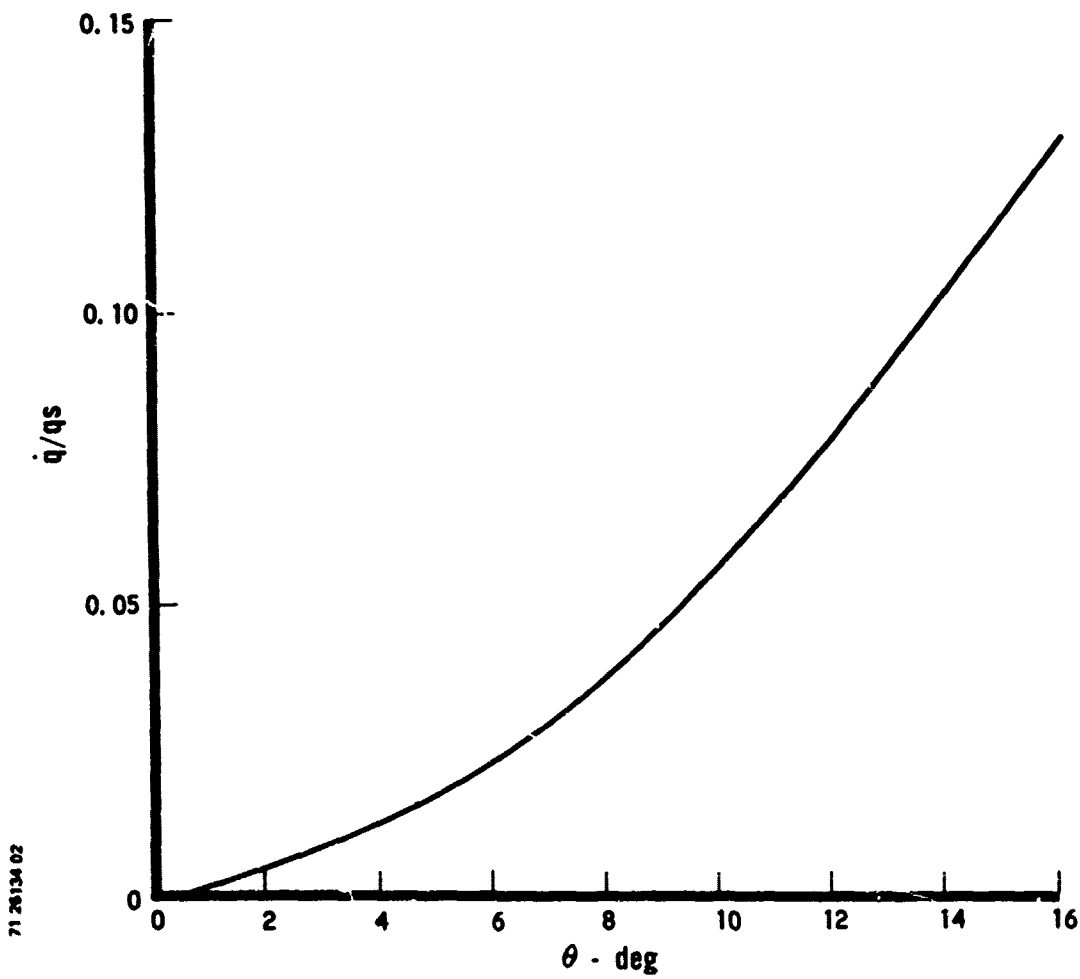


Figure 4-9. STETSON - Tangency to Cone
Laminar Heating Ratio

and η refer to heat of vaporization, heat of fusion and blowing factor. If FV and X_1 are not input, the program internally assumes $FV = 1$ and $X_1 = 1$. When this is the case, the heat of ablation equation in the nose blunting option reverts to the simplified form used in the ablation subroutine Eq. (45).

When using the nose blunting option, the printout has the following meaning. Sonic point pressure, velocity and enthalpy are termed PSHK, VSHK and SHKI respectively. The stagnation heating, stagnation pressure and temperature distribution are printed in their normal array. The Reynolds number displayed is based upon sonic point properties and current nose radius. The stagnation point heat of ablation is termed HOABL.

Additionally, the changing radius and stagnation recession are called RADIUS and F respectively. Further the heat rate at the sonic point (tangent point when "Stetson" option is used), the shear (sonic or tangent points) and the minimum heat of ablation (at sonic or tangent point) are also printed out and are called QSONIC, SHEAR and HOABLM respectively.

With regard to degradation, the program will independently compute a degraded heat of ablation for both pressure and shear conditions, and will use the smaller of the calculated values to determine surface recession.

4.19 PRINT

The PRINT subroutine, called for all normal printing, defines those internal quantities that will be printed out at those times specified by the WRITE input variable. This subroutine has no engineering interest except that several closed-end calculations are performed at this juncture. Free-stream dynamic pressure, shear and stagnation pressure are computed at this point. The following equations are utilized.

$$DYNP = \rho_{\infty} U_{\infty}^2 / 2 \quad (80)$$

$$SHEAR = \frac{0.025 \dot{Q}_1 U_{\delta}}{(I_r - I_w) * 3600} * QCONS \quad (81)$$

QCONS is an input multiplicative factor used to adjust shear for various reasons (protuberances for example).

Stagnation pressure is computed assuming $\gamma = 1.4$. Units for stagnation pressure are atmospheres.

$$P_{\text{STAG}} = (1.20 M_{\infty}^2)^{3.5} \left[\frac{6}{(7M_{\infty}^2 - 1)} \right]^{2.5} \rho_{\infty}/2116 \quad (82)$$

The variables printed are: TIME, ALTITUDE, U_{∞} , angle of attack (α), Q_i , H_i , QNET, Reynolds number, time step, Δ weight ablated per time step, total weight ablated, I_r , I_w , Q_{inside} , transition Reynolds number, heat of ablation, temperature of ablation, P_{δ} , dynamic pressure, U_{δ} , I_{δ} , I^* , total Q , Shear, P_s (atmospheres), P_s (PSF), emissivity, and Δ weight ablated per second. The calculation interval number is printed on the tear strip.

In addition, if the nose blunting option is used, the radius (in feet and inches), estimated nose recession, Q_{sonic} , shear at nose, and heat of ablation at surface are printed.

All this is followed by a list of temperatures at each node.

4.20 GECPK2

This is a two-dimensional version of GETCPK, for finding C_p , K , ρ . Recent modifications now enable the engineer, as an option, to input these as tabular functions of temperature, as described under GETCPK.

4.21 TWOD

The two-dimensional conduction routine, similar to ONED, is discussed under 2.4.2.

4.22 PRINTH

PRINTH is used to print the Hollerith name of the type of configuration used.

4.23 FINTRP

This is an interpolation routine, used for all linear interpolation except that for finding ALT, VINP, AOFA, HINS, and TINS in subroutine TRAJ.

4.24 AERSOP

Prints the large Aerospace Corporation symbol at the beginning of each run.

SECTION V

INPUT DESCRIPTION

Input to this program is accomplished by use of IBM supplied utility called NAMELIST (Ref. 17). The data are read from input cards, in subroutine INPUT, and placed on an auxiliary storage device to enable the listing of separate data cases.

Below (Section 5.1) is a description of the method of entry for such items as; Title Cards, Variables, and End of Data cards.

Following this (Section 5.2) is an alphabetic list of variables used in one-dimensional problems, followed by those used for two-dimensional problems.

Section 5.3 then shows typical input examples so that the reader may see how all these tie together.

5.1 DESCRIPTION OF METHOD OF INPUT

5.1.1 Title Card(s)

See "TITLE" in one-dimensional inputs section. (5.2.1)

5.1.2 Variable Entry

5.1.2.1 One-Dimensional

To begin data entry, "&BD06ØS" is entered in columns 2 - 8, followed by at least one blank. The variables and their values then follow, with "=" between the variable and its corresponding values, and a comma (,) following each value. The values corresponding to variable names beginning with any of the letters, I, J, K, L, M, or N, are not entered with a decimal point although one is not necessary for other numbers which have no fractional part. If two or more consecutive values are the same, enter a fixed point number telling how many, followed by an asterisk (*) and the value. Following is an example of entry:

EXAMPLE: A1 = 30., 25., 25., 25., 25., 30.7

The data card would look like this:

A1 = 30, 4*25, 30.7, or A1 = 30., A1(2) = 4*25, A1(6) = 30.7,

NOTE: When entering two-dimensional arrays, such as CPTBL (if the element numbers are not specified) the first element number (subscript) varies the most rapidly, i.e., for CPTBL they would vary as: (1, 1), (2, 1), (3, 1)...(I, 1), (1, 2), (2, 2)...(I, 2).....(I, J)

It would be well to note, also at this point, that once a value is entered for a given variable, that value will remain in the computer memory, until changed. Should the same value be entered more than once within one data case, however, the last value entered will be used. This particular feature makes this program particularly applicable to running parametric studies.

A "&END" entered in columns 2-5 terminates the data case.

5.1.2.2 Two-Dimensional

For two-dimensional problems the AA, BB, CP2, DK, T2, NARØW, and NBCØL values follow a "&TWØDIM" entered beginning in column 2. As above, equal signs and commas separate the variables and values and a "&END" in columns 2-5 terminates each data case. For multiple cases a "&BD06ØS" card and a "&END" must precede each "&TWØDIM" card.

5.1.2.3 End of Data

To end each set of cases place, on the last card, "ENDDATA" beginning in column 2 with no data following it. Should a comment follow, this comment must not begin before column 9. The card images for each set of cases will be printed preceding the processing of each case. To terminate all processing, place two "ENDDATA" cards together. For further clarification, see Section 5.3 of this writeup and refer to the bottom of Aerospace Form 3703, "4 FIELD NAMELIST INPUT." For easiest data entry for the novice, Aerospace Form 2944, "80 Column FREE Key punch Form" may be used. However, for orderly results put variable names in columns 2, 22, 42, or 62 as indicated on Form 3703.

5.2 LIST OF INPUT VARIABLES (ALPHABETIC)

5.2.1 One-dimensional Problems (Begin with "&BD060S")

The equation for computing the conductivity [Btu/(ft °F hr)] for node J, is as follows:

$K_J = A1_J + A2_J T + A3_J T^2 + A4_J T^3$ where T is temperature [°R]
or entered separately as:

$A1(J)^1$	Corresponds to $A1_J$ above
$A2(J)$	Corresponds to $A2_J$ above
$A3(J)$	Corresponds to $A3_J$ above
$A4(J)$	Corresponds to $A4_J$ above
$ALT(N)^2$	Altitude [ft] corresponding to TIME(N)
$ALTCM(NT)^3$	Altitude [cm] defining a new atmosphere (see TFB)
ANGLE	Cone or wedge half angle [degrees]
$A0FA(N)$	Angle of attack [degrees] corresponding to TIME(N)

The equation for computing the specific heat [Btu/lb °F] for node J; the equation used is:

$$CP_J = B1_J + B2_J T + B3_J T^2 + B4_J T^3$$

where T is temperature (°R)
or entered separately as:

$B1(J)$	Corresponds to $B1_J$ above
$B2(J)$	Corresponds to $B2_J$ above
$B3(J)$	Corresponds to $B3_J$ above
$B4(J)$	Corresponds to $B4_J$ above

¹(J) (is less than or equal NSEG) refers to nodal distance dependent variables.

²(N) (cannot be greater than NTRAJ) refers to time dependent variables.

³(NT) (cannot be greater than TRVRSL) refers to altitude dependent atmospheric variables.

J and N will be used in this same context in the rest of this writeup.

CONPR	Limiting cone pressure ratio for Prandtl Meyer Expansion. The program will not lower the pressure ratio below this constraint.
CPTBL(I, J) ⁴	Specific heat of segment J corresponding to TEMTBL(I, J) [Btu/lb °F]
DELTA	Time step size [sec]. This is no longer a fixed increment. After program start-up the maximum stable increment will be used. A number must be entered. DELTA will not exceed WRITE, however.
EKTBL(I, J) ⁴	Thermal conductivity of segment J corresponding to TEMTBL(I, J) [Btu/(ft °F hr)]
EL(J)	Thickness [inches] of the Jth segment
EMIS	Surface emissivity
EMTAB(L) ⁵	Emissivity table, each value corresponding to TWTAB(L)
ETAL	Eta laminar and Eta turbulent, used in the calculation of the heat of ablation (see HV), a blowing correction
ETAT	
ETAL2	Same as ETAL or ETAT, but for the second component within a composite (see HV2)
ETAT2	
ETALP	Same as ETAL and ETAT, but used only when PSTAG is greater than PSTMAX
ETATP	

⁴(I)Max. of KFUNT, minimum of 5, refers to individual TEMTBL vs RHOTBL, EKTBL, CPTBL points for material properties interpolation.

NOTE: Only the properties of the first segment of a given material need be entered for the TEMTBL vs RHOTBL, EKTBL, CPTBL option, provided all were initialized to zero, which they are for the first data case.

⁵(L) maximum of 20, refers to individual TMTAB vs EMTAB values (wall temperature °R vs emissivity), when emissivity is variable. (See NEMIS)

FV1S(K) ⁶	{	{	Fraction vaporized component 1 (shear dependent) of two component composite material (see XI).
FV2S(K)			
FV1P(K)	{	{	Fraction vaporized component 1 (pressure dependent).
FV2P(K)			
			entered as tables (max. 10 points) vs SHRTBL(K).
HEDGE(N)			Input table from Entropy Swallowing Program when INPCW ≥ 1 , corresponds to SHKI (I_0 internally)
HF			Heat of fusion for component 1, if not all vaporized (see XI) [Btu/lb]
HINSD1(N)			Inside heat transfer at TIME(N) [Btu/hr ft ² °R]
HØABL			Heat of ablation [Btu/lb]
HRECØV(N)			Corresponds to HSTAG in Entropy Swallowing Program (table input vs TIME1 of INPCW ≥ 1 and corresponds to RECI inside this program)
HV			Heat of vaporization for first component of a heatshield [Btu/lb]
HV2			Heat of ablation for second component of a composite heatshield
HVPSTM			HV for PSTAG greater than PSTMAX [Btu/lb]
ICØNF			= 1 Flat plate calculation = 2 Wedge = 3 Cone or blunt cone (see NØSB) = 4 Sphere (see NØSB) = 5 Cylinder

⁶(K) Max. of 10 refers to pressure dependent variables.

IHANK Hankey sonic point flag if $IC\emptyset NF = 4$
Set to 1 to use, set to 0 to block usage.
RADIUS must also be specified.

INPCW If greater than zero, signals that cold wall inputs
(TIME, QINT, HEDGE, UEDGE, PEDGE, and
HREC $\emptyset$ V) will be processed and used for computing
QSUBI instead of Aero-Heating. The value of
INPCW tells how many points in the above tables
(maximum of 50).

ISTETS For Ste' on type laminar nose blunting heating
when positive.

KASE Case identification number ($-99 \leq KASE \leq 999$)

KFUNT Determines if K and/or C_p are functions of
temperature
= 1 both are functions of temperature
= 2 K only is a function of temperature
= 3 C_p only is a function of temperature
= 4 neither is a function of temperature, but
both are constant. (see A1 and B1)
 ≥ 5 is the number of points (no more than 10) in ρ ,
K, C_p vs temperature tables, from which
material properties are interpolated, for each
segment at their particular segment temperatures
(see TEMTBL, RH $\emptyset$ TBL, EKTBL, CPTBL)

NDEBUG Debugging flag, gives a print each time through one of
the routines listed for certain sections of each
= 1 PRINT, ABLATE, GETCPK when $5 \leq KFUNT \leq 10$
 ≥ 1 ABLUNT, ABLATE, INPUT, KEMP, PRINT

≥ 1 , $\neq 3$ TRAJ
 $= 2$ ABLUNT
 ≥ 2 DIST, GEC PK2
 $= 3$ PME, ATMØS
 $= 4$ SHOCK
 $= 5$ THERMØ
 $= 8$ HANKEY
 $= 14$ ENERGY/ENCO
 ≥ 14 TWØD

NDIM $= 1$ for 1-dimensional problems
 $= 2$ for 2-dimensional problems

NEMIS Normally zero, used as number of entries in variable emissivity table (EMTAB vs TWTAB), maximum = 20

NØPSTG No. of entries in FV1P and FV2P vs STGTBL tables, maximum = 10

NØPSHR No. of entries in FV1S and FV2S vs SHRTBL tables, maximum = 10

NØSB Used with ICØNF = 3 or 4, Set = 1 for Nose Blunting. RADIUS and TWALL must be entered. Set = 0 if no blunting.

NPQ Set to one of the positive numbers below for NON-AERO Heating Option
 $= 1$ QSUBI = QSØLAR (constant value that must be input.)
 $= 2 \leq NPQ \leq 100$, QSUBI will be interpolated from the QI vs TIME tables from NPQ (number of) values.

NPQS Normally zero, used as number of entries in QSTAR vs PSTAGN tables (10 maximum)

NPU Punch flag - Set positive to punch cards that serve as input for Char Ablator Program. These punched inputs are:

TIME = TSTØR
 QSUBI = QØ
 PS = PØ
 RECI = HSTAB
 SHKI = HLTAB
 VSHK = UETAB

Since a value is stored for each of the above variables at time of print, it is recommended that

$WRITE \geq \frac{STOP}{50 - NSEG}$ to be ablated

so that NTMP, NTME, NØP, NHS, NUE, NHLØC (No. table values) will be less than 50.

NQI When set positive will cause the ablation routine to use QSUBI in place of QNET in the weight ablated (WABDØT) calculation. If NQI = 0, QNET will be used in the calculation.

NSEG Number of segments in heated material, ($1 \leq NSEG \leq 40$)

NTRAJ Number of points in trajectory table ($1 \leq NTRAJ \leq 100$) for TIME vs VINP, vs ALT, vs AØFA, QCØNS, TINSØ, HINSØ, etc.

PEDGE(N) Table input from Entropy Swallowing Program when INPCW ≤ 1 corresponding to PSHK [Atmosphere]

PFB(NT) Pressure [dynes/cm²] corresponding to TFB(NT) and ALTØM(NT)

PSTAGN(K)⁷ Table of stagnation pressures corresponding to QSTAR(K) (see NPQS)

PSTMAX Maximum value for PSTAG before switching from equation 4G to $H\phi ABL = HVPSTM \times \eta \times (I_S - I_W)$

QCØNS(N) Table of multiplying constants vs TIME used in the Aero Heating QSUBI equation. If QCØNS (NTRAJ) = 0, all QCØNS will = 1.

QI(N) Table values, at Time = TIME(N), for QSUBI when NPQ > 1. [Btu/ft²-sec]

QINSD(N) Back wall Q vs TIME(N)

QINT(N) Cold wall Q from Entropy Swallowing Program (vs TIME) to be used when INPCW $\geq$ 1. This is converted to hot wall Q internal to the program.

QSØLAR A single value for heating, either above 295274.7 ft (90,000 meters) or if NPQ = 1 below that altitude.

QSTAR(K) Used as HV, interpolated from PSTAGN(K)

RADIUS Of sphere, cylinder, or of blunt nose when NOSB = 1 [ft]. Otherwise use XDIST for sphere or cylinder diameter. With NOSB = 0, RADIUS will trigger the Griffith-Lewis Heating for cones.

RHØ(J) Density of Jth material segment [lb/ft³]

RHØFB(NT) Density of atmosphere [gm/cm³] at ALTCM(NT)

RHØTBL(I,J) Material density of segment J corresponding to TEMTBL(I,J) [lb/ft³]

START Starting time of desired trajectory if other than zero, may be greater than TIME (1) [sec]

⁷ K has a maximum value of 10.

STGTBL(K)	Independent parameter in vaporization vs pressure table [atmospheres]
SWEEP	Sweep angle [deg] for cylinder with axis not perpendicular to velocity vector
TABL	Temperature of ablation [$^{\circ}$ R] ; nose blunting requires an additional input, TWALL
TEMP(J)	Initial temperature of node "J" [$^{\circ}$ R]
TEMTBL(I, J)	Temperature table values (when $KFUNT \geq 5 \geq 10$) from which material properties of segment J will be interpolated [$^{\circ}$ R]
TFB(NT)	Temperature [$^{\circ}$ K] at ALTCM(NT) ⁸ (See TRVRSL)
TITLE	A - 1 to 72 alphanumeric character title which is printed preceding each case. Must begin and end with an apostrophe
TIME(N)	Time corresponding in trajectory to VINFIN(N), ALT(N)
TINSD1(N)	Temperature inside [$^{\circ}$ R] at TIME(N)
TRANLT ⁹	Transition Altitude [ft] only if TRANR = 0
TRANR	Transition Reynolds number
TRVRSL	No. of points defining new atmosphere (see TFB)
TWALL	Temperature of Ablation if NØSB = 1 [$^{\circ}$ R] must be input each case or TABL will be used.
TWTAB(L)	Temperature at wall corresponding to EMTAB(L)

⁸If any two consecutive TFB values are zero, the program will use standard atmosphere during that portion of the trajectory when two or more TFB values are positive, an interpolation for TINF, RHØINF, PINF vs ALTCM is accomplished, but only between positive TFB values.

⁹If both TRANLT and TRANR = 0, McCauley Transition Criteria will be used.

UEDGE(N)	Table input from Entropy Swallowing Program when INPCW > 1 corresponding to VSHK internally
VINF(N)	Free-stream velocity at TIME(N) [fps]
WRITE	Print interval for problem [sec]
XDIST	The distance back from the leading edge of a wedge or cone at which temperature profile is desired, or the diameter of sphere or cylinder [ft] .
XI	Fractional portion of component 1 of a two component composite ablative material (see ETAT2, ETAL2, HF, HV2, FV1, and FV2) XI taken to be 1, unless otherwise specified.

5.2.2 Two-Dimensional Problems (Begin with "&TWØDIM")

Following the normal one-dimensional inputs, the additional inputs needed for two-dimensional problems (beginning with "&TWØDIM" instead of "&BD06ØS") are:

AA(J)	Segment thickness (in Y direction) corresponding to EL(J) [inches]
BB(M)	Segment width (in X direction) [inches] axial flow direction
CC(J, M)	≥ 1 for conduction into and out of grid point = 0 for no conduction, such as perfect insulators
CP2(J)	Corresponds to B1(J), specific heat capacitance ¹⁰
DK(J)	Corresponds to A1(J) conductivity
T2(J, M)	Initial temperature distribution in two-dimensional grid [°R]

¹⁰Two-dimensional problems are assumed to be homogeneous in the X, (Parallel to surface) (Subscript M) direction, but not necessarily in the Y (in depth) (subscript J). J and M for two-dimensional problems may not exceed 10.

NARØW	Number of rows of AA (Max. = 10)
NBCØL	Number of columns of BB (Max. = 10)

5.3 EXAMPLE INPUTS

Following are examples for inputting both one-dimensional (5.3.1) and two-dimensional (5.3.2) problems. These problems show certain features and uses of the program. The following is a general description of each of the problems.

CASE 1 is a one-dimensional, single segment problem using fixed material properties and deriving its heating from aerodynamic criteria which come from an input trajectory using McCauley transition criteria.

CASE 2 is a one-dimensional, five segment problem, with C_p input as a function of temperature, while ρ and K are held constant. Heating, for this problem, comes from the cold wall input parameters associated with "INPCW = 1". This problem uses altitude for transition criteria.

CASE 3 is a modification of Case 2, and adds another segment of different material to the face of the five segments, thus making it a six segment problem with all the features described in the above paragraph.

CASE 4 shown on the printed listing (as made by the ASAH Program) as Cases 4 and 5, is a two-dimensional problem with segment 2 in slab 2 not present. The "START" feature was employed, allowing the program to start at some time other than at the first time entry. The second "T2" card, it should be noted, supersedes the first "T2" card. The values on the second "T2" card were obtained from the values on the first "T2" card after running the problem for 68.7 seconds. All other parameters are as described in Case 2, above.

The following is a listing made by the ASAH program illustrating both the actual input cards used, and the standard output as given by Subroutine INPUT.

COMPLETE LIST OF ALL INPUT CARDS TO BE PROCESSED

```

SAMPLE 1 AND 2 DIMENSIONAL PROBLEMS - FOR A.S.A.H. MAR.3,'71
&BDJ6CS
TITLE= SAMPLE ONE DIMENSIONAL PROBLEM, ONE SEGMENT, AERO HEAT',
ISTETS=0,AOFA=16*0,HVPSTM=0.,PSTMAX=0.,KASE=1,NDIM=1,
ICCNF=3,ANGLE=8.,DELTA=.05,WRITE=10.,NSEG=1,KFUNT=4, NTRAJ=16
EMIS=.85,TABL=10000.,HV=1000.,ETAL=1.,ETAT=1.,
TIME=0.,22.,40.,54.,60.,70.,80.,96.,112.,118.,124.,130.,136.,
140.,144.,148.,
ALT=200.,4350.,15500.,19540.,37000.,51570.,69210.,104800.,151270.,
172125.,195210.,220540.,245180.,261700.,277990.,294230.,
VINP=10.,410.,915.,1410.,1690.,1850.,2000.,2630.,4000.,5850.,7550.,
3690.,9350.,9750.,9970.,10110.,10270.,
AL=60, BL=.28, RHO=108., EL=.125, STOP=14.8, XDIST=.243,
&END ONE DIM., ONE SLAB, ONE MAT'L

&BDJ6CS KASE=2,TITLE(9)=' - W',ITH ','COLD', WAL',L IN',PUTS',
', 5',SEG.',
KFUNT=3,
XDIST=.243,TRANLT=80000.,NTRAJ=17,INPCW=17,
TIME=0.,22.,40.,54.,60.,67.,70.,80.,96.,112.,118.,124.,130.,136.,140.,
144.,148.,
QINT=.1.,28.,1.00,15.9,15.6,11.36,6.42,3.97,2.88,3.43,4.12,3.68,
2.57,1.57,1.08.,711.,375,
ALT=200.,4350.,15500.,19540.,37000.,47000.,51570.,69210.,104800.,
151300.,172125.,195210.,220540.,245180.,261700.,277990.,295000.,
PFCE=.995.,84.,55.,35.,25.,15.,13.,062.,010.,0033.,00131,6.6E-4,
2.65E-4,9.47E-5,4.23E-5,1.86E-5,7.69E-6,
HRECOV=123.,123.,126.,140.,146.,160.,167.,221.,400.,700.,1093.,1393.,
1574.,1683.,1753.,1800.,1907.,
UFCE=10.,400.,900.,1300.,1550.,1775.,1800.,2400.,3600.,5500.,7149.,
8320.,9084.,9593.,9802.,9977.,10000.,
HEUCE=123.,123.,120.,130.,165.,165.,170.,190.,210.,242.,240.,
195.,149.,153.,140.,127.,
TEMP=8*540., TRANLT=47000.,
NSEG=5,
AL=60.,.25.,.965,2*75.,
BL=.0.,.28.,.125,2*.034,82=.0003,4*.0,
RHC=108.,150.,334.,2*1192.,
EL=.125.,010.,050,2*.25,
WRITE=5.,
&END

```

NOTE - VARIABLE THERMAL PROPERTIES

5.3.1.1

END CASE 1

5.3.1.2

END CASE 2

```

&3D06GS QCONS=5*.495,
&END      CHANGED QCONS

```

5.3.1.2.1

END CASE 3

```

&3D06GS TITLE(15)='SI',X SE',GMEN',TS ', KASE=3,
NSEG=6,
QCONS=6*1.,
TEMP=6*540.,
A1=.14,60.,.25,.965,2*75.,
B1=.26,.0,.28,.125,2*.034, B2=.0,.0003,4*.0,
RHO=136.,108.,150.,334.,2*1192.,
EL=.010,.125,.010,.050,2*.25,
EMIS=.15,HV=950.,ETAL=.43,ETAT=.17,TABL=1800.,
&END      NOTE - CHANGED EMIS, HV, TABL, FCT.

```

5.3.1.3

END CASE 4

```

&3D06GS TITLE=' TWO-DIMENSIONAL PROBLEM, BASED ON KASE 3 (1-D)',
KASE=23, NDIM=2,
WRITE=.02,
START= 68.7,
&END

```

END CASE 5

5.3.2

```

&TWDDIM
AA=.125,.010,.050,2*.25,
BB=.303,.308,
(C=5*1,5*0,1,0,3*1,8*0.,
T2=5*540.,5*0,540,0,3*540,85*0,
NARCW=5,
NRCJL=2,
T2=657,632,577,546,545,5*C,665,0,3*544,85*0,
&END

```

END CASE 6

0

ENCUTATA

END OF INPUT.
66 CARDS READ

SECTION VI

SAMPLE OUTPUTS

Five cases are shown on the following pages. These correspond to the example input cards shown in Section 5.3 of this writeup. Descriptions of these cases are as follows:

- 6.1 One Dimensional, One Segment, Aerodynamic Heating
- 6.2 One Dimensional, Five Segments, Non-Aeroheating
- 6.3 One Dimensional, Five Segments, Non-Aeroheating, Q Correction
- 6.4 One Dimensional, Six Segments, Non-Aeroheating, No Q Correction
- 6.5 Two Dimensional, Five Segments x Two Slabs, Non-Aeroheating

Useful comments about the variables which are output, and what they mean may be found in Section 4.19.

6.1 ONE DIMENSIONAL, ONE SEGMENT, AERODYNAMIC HEATING

```

INPUT CARDS READ, DATA SET      1
SAMPLE 1 AND 2 DIMENSIONAL PROBLEMS - FOR A.S.A.H. MAR.3,'71
&BCD60S
TITLE= SAMPLE ONE DIMENSIONAL PROBLEM, ONE SEGMENT, AERO HEAT,
ISTETS=0,AOFA=16*C,HVPSTM=0.,PSTMAX= .KASE=1,NDIM=1,
ICCNF=3,ANGLE=8.,DELTA=.05,WRITE=10. JEG=1,KFUNT=4, NTRAJ=16
EMIS=.85,IABL=10000.,HV=1000.,ETAL=1.,ETAT=1.,
TIME=0.,22.,40.,54.,60.,7C.,80.,96.,112.,118.,124.,130.,136.,
140.,144.,148.,
ALT=200.,4350.,15500.,19540.,37000.,51570.,69210.,104800.,151270.,
172125.,195210.,220540.,245180.,261700.,277990.,294230.,
VINFL=10.,410.,915.,1410.,1690.,1850.,2000.,2630.,4000.,5850.,7550.,
8690.,9350.,9750.,997C.,10110.,10270.,
AL=50,      BL=.28,      RHO=108.,      EL=.125,
&END      ONE DIM., ONE SLAB, ONE MAT'L
KARC =      14,      TO GO =      52      STOP=14.8, XDIST=.243,

END OF INPUT.

```

SAMPLE ONE DIMENSIONAL PROBLEM, ONE SEGMENT, AERO HEAT
 IDENTIFICATION = 6BD06QS

KASE 1

CCNE

INTEGERS
 ICONF 3

NOPSHR 0

-1

ICHK 0	IHANK 0	INPCW 0	ISTETS 0	KASE 1	KFUNT 4	NRCOL 0	NDBG 0	NDIM 1
NOPSTG 0	NOSB 0	NPGAS 0	NPQ 0	NPU 0	NQI 0	NSEG 1	NTRAJ 16	NOCHEK 0

SA4PLE ONE DIMENSIONAL PROBLEM, ONE SEGMENT, AERO HEAT

TRANR 0.0 TRANLT 0.0 ANGLE C.8000000E 01 SWEEP 0.24299997E 00 CONPR 0.0

DELTA 0.49999997E-01 WRITE C.10C00000E 02 STOP 0.14799999E 02

TABL 0.10000000E 05 HV C.10C00000E 04 ETAL 0.10000000E 01 EMIS 0.84999996E 00

J 1 0.6C000000E 02 0.0 A2(J) 0.0 A3(J) 0.0 A4(J)

J 1 0.27999997E 00 0.0 B2(J) 0.0 B3(J) 0.0 B4(J)

RHO(I), I=1, 1
0.10800000E 03

EL(I), I=1, 1
0.12500000E 00

TEMP(I), I=1, 1
0.54000000E 03

I	TIME	ALT	VINF	AOFA	HINS	TINS	QCONS	QI*3600	TEMPW	VAPRES
1	0.0	200.0	10.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
2	22.0	4350.0	410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
3	40.0	15500.0	915.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
4	54.0	19540.0	1410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
5	60.0	37000.0	1650.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
6	70.0	51570.0	1850.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
7	80.0	69210.0	2000.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
8	96.0	104800.0	2630.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
9	112.0	151270.0	4000.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
10	118.0	172125.0	5850.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
11	124.0	195210.0	7550.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
12	130.0	220540.0	8650.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
13	136.0	245180.0	9350.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
14	140.0	261700.0	9750.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
15	144.0	277990.0	9970.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
16	146.0	294230.0	10110.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
QSOLAR										

INITIAL CONDITIONS

TIME	ALT	VINF	AOFA	QSUBI	HSUBI
0.0	REYN	0.0	WABDCT	0.0	0.0
0.0	QSAV	0.0	TRANR	0.0	0.0
0.0	DYNP	0.0	SHKI	0.0	0.0
0.0	PS	0.0	EMIS	0.0	0.0
0.2509883CE 00		0.0	0.94999996E 00	0.0	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG FOLLOW.
540.0

INITIAL CONDITIONS

TRANSITION HAS OCCURRED * * * * CONDITIONS BELOW, FROM UNKNOWN TO TURBULENT TRANLT= 0.0

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.49599977E-01	REYN	0.0	WABDCT	0.0	0.0
0.11743426E 05	QSAV	0.0	TRANR	0.0	0.0
0.12838574E 03	DYNP	0.0	SHKI	0.0	0.0
0.21072327E 04	PS	0.0	EMIS	0.0	0.0
0.1322125E-02		0.0	0.84999996E 00	0.0	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG FOLLOW.

STABILITY CHECK, DEL, CCN, JAV, WRI, DELTA
0.39843743

0.02499999 400.00000000 0.02500000 -1

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.20810214E 04	REYN	0.0	WABDCT	0.0	0.0
0.15582206E 06	QSAV	0.0	TRANR	0.0	0.0
0.12717236E 03	DYNP	0.0	SHKI	0.0	0.0
0.14614015E 04	PS	0.0	EMIS	0.0	0.0

0.19665718E 00 0.92712136E 00 0.94642693E 00 0.84999996E 00 0.10000000E 01 0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG FOLLOW.

534.9

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.14826788E 02	0.29964939E 04	0.27954150E 03	0.0	-0.20941544E 00	0.54173905E-01
QNET	REYN	DELTA	WABDGT	WAB	RECI
-0.24213862E 00	0.27899719E 06	0.24999999E-01	0.0	0.0	0.12242154E 03
WALLI	QSAV	QINSD	TPANR	HOABL	TABL
0.12628716E 03	0.0	0.0	0.16886055E 05	0.0	0.10000000E 05
PSHK	CYNP	VSHK	SHKI	REFI	QNSUM
0.18969067E 04	0.84804962E 02	0.27954150E 03	0.12099706E 03	0.12395549E 03	0.0
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
0.37859607E 00	0.89645975E 00	0.93653667E 00	0.84999996E 00	0.10000000E 01	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG FOLLOW.

531.2

(NT = 592)

6.2 ONE DIMENSIONAL, FIVE SEGMENTS, NON-AEROHEATING

```

INPUT CARDS READ, DATA SET      2
&RDJ60S KASE=2,TITLE(9)= ' - W',ITH ' , 'COLD', ' WAL', 'L IN', 'PUTS',
, 5 , 'SEG.',
KFUNT=3,
XDIST=.243,TRANLT=80000.,NTRAJ=17,INPCW=17,
TIME=0.,22.,40.,54.,60.,67.,70.,80.,96.,112.,118.,124.,130.,136.,140.,
144.,148.,
GINT=.1.,.28,1.00,15.9,15.6,11.36,6.42,3.97,2.88,3.43,4.12,3.68,
2.57,1.57,1.08,711.,375,
ALT=200.,4350.,15500.,19540.,37000.,47000.,51570.,69210.,104800.,
151300.,172125.,195210.,220540.,245180.,261700.,277990.,295000.,
PEDGE=.995.,84.,55.,35.,25.,15.,13.,062.,010.,0033.,00131,6.6E-4,
2.65E-4,9.47E-5,4.23E-5,1.86E-5,7.69E-6,
HRECOV=123.,123.,126.,140.,146.,160.,167.,221.,400.,700.,1093.,1353.,
1574.,1683.,1753.,1800.,1907.,
JECGE=10.,400.,900.,1300.,1550.,1775.,1800.,2400.,3600.,5500.,7149.,
8320.,9084.,9593.,9802.,9977.,10000.,
PEDGE=123.,123.,120.,130.,165.,165.,165.,170.,190.,210.,242.,240.,
199.,149.,153.,140.,127.,
TEMP=8*540., TRANLT=47000.,
NSEG=5,
A1=60.,.25.,.965,2*75.,
B1=.0.,.28.,125,2*.034,B2=.0003,4*.0,
RHO=108.,150.,334.,2*1192.,
EL=.125.,010.,050,2*.25,
WRITE=5.,
&END      NOTE - VARIABLE THERMAL PROPERTIES
KARD =    26,    TO GO =    26

END OF INPUT.

```

SAMPLE ONE DIMENSIONAL PROBLEM, - WITH COLD WALL INPUTS, 5 SEG.

IDENTIFICATION = 88D060S

KASE 2

CCNE

INTEGERS

ICONF

VOPSHR

3

0

0

ICHK

0

NOPSTG

0

IFANK

0

NOSR

0

INPCW

17

NPGAS

0

ISTETS

0

NPQ

0

KASE

2

NPU

0

KFUNT

3

NQI

0

NBCOL

0

NSEG

5

NDBUG

0

NTRAJ

17

NDIM

1

NOCHEK

0

SAMPLE ONE DIMENSIONAL PROBLEM, - WITH COLD WALL INPUTS, 5 SEG.

TRANR C.47600000E C5 C.80000000E 01 0.0 SWEEP 0.24299997E 00 C.0 CONPR
 DELTA 0.49999997E-01 WRITE STOP 0.14799999E 02
 FABL HV 0.10000000E 05 0.10000000E 04 ETAL ETAT EMIS
 0.10000000E 05 0.10000000E 04 0.10000000E 01 0.10000000E 01 0.84999996E 00

J 1 C.60000000E 02 0.0 A2(J) A3(J) A4(J)
 2 0.25000000E 00 0.0 0.0
 3 0.96499997E 00 0.0 0.0
 4 0.75000000E 02 0.0 0.0
 5 0.75000000E 02 0.0 0.0

J 1 0.0 B1(J) B2(J) B3(J) B4(J)
 2 0.27999997E 00 0.0 0.0
 3 0.12500000E 00 0.0 0.0
 4 0.33999998E-01 0.0 0.0
 5 0.33999998E-01 0.0 0.0

RHD(I), I=1, 5
 0.10800000E 03 C.15000000E 03 0.33400000E 03 0.11920000E 04
 EL(I), I=1, 5
 0.12500000E 00 C.99999997E-02 0.49999997E-01 0.25000000E 00
 TEMP(I), I=1, 5
 0.54000000E 03 C.54000000E 03 0.54000000E 03 0.54000000E 03

I	TIME	ALT	VINF	AOFA	HINSD	TINSD	QCCNS	QI*360	TEMPH	VAPRFS
1	0.0	200.0	10.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
2	22.0	4350.0	410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
3	40.0	15500.0	915.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
4	54.0	19540.0	1410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
5	60.0	37000.0	1650.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
6	67.0	47000.0	1850.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
7	70.0	51570.0	2000.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
8	80.0	69210.0	2630.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
9	96.0	104800.0	4000.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0

10	112.0	151300.0	5850.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	118.0	172125.0	7550.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	124.0	195210.0	8690.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	130.0	220540.0	9350.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	136.0	245180.0	9750.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	140.0	261700.0	9970.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	144.0	277990.0	10110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	148.0	295090.0	10270.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

GSOLAR
 0.0

NDEBUG= 0

END OF DATA PRINTOUT

CELD WALL INPUTS - AS PER ENTROPY SLOWING

NC. OF INPUTS = INPCM = 17

QINT	HEDGE	PEDGE	UEDE	HRECDV	TIME
0.15999999E-01	0.12300000E 03	0.99499999E 02	0.10000000E 02	0.12300000E 03	0.0
0.27999999E 00	0.12300000E 03	0.83999999E 02	0.40000000E 03	0.12300000E 03	0.22000000E 02
0.10000000E 01	0.12300000E 03	0.54999999E 02	0.90000000E 03	0.12300000E 03	0.40000000E 02
0.15900000E 02	0.13000000E 03	0.34999999E 00	0.13000000E 04	0.14000000E 03	0.54000000E 02
0.15999999E 02	0.16500000E 03	0.25000000E 00	0.15500000E 04	0.14600000E 03	0.60000000E 02
0.11360000E 02	0.16500000E 03	0.14999999E 00	0.17750000E 04	0.16000000E 03	0.67000000E 02
0.64199991E 01	0.16500000E 03	0.13700000E 00	0.19000000E 04	0.16700000E 03	0.70000000E 02
0.35699993E 01	0.17000000E 03	0.61999999E-01	0.24000000E 04	0.22100000E 03	0.80000000E 02
0.28799992E 01	0.19000000E 03	0.99999999E-02	0.36000000E 04	0.40000000E 03	0.96000000E 02
0.34299994E 01	0.20000000E 03	0.33000000E-02	0.55000000E 04	0.70000000E 03	0.11200000E 03
0.41199999E 01	0.20000000E 03	0.13100000E-02	0.71400000E 04	0.10930000E 04	0.11800000E 03
0.36799994E 01	0.24000000E 03	0.65999999E-03	0.93200000E 04	0.13930000E 04	0.12400000E 03
0.25699997E 01	0.19900000E 03	0.26499992E-03	0.93840000E 04	0.15740000E 04	0.13000000E 03
0.15699997E 01	0.14900000E 03	0.84699993E-04	0.95530000E 04	0.16830000E 04	0.13600000E 03
0.10799999E 01	0.15300000E 03	0.42299987E-04	0.98020000E 04	0.17530000E 04	0.14000000E 03
0.71099997E 00	0.14000000E 03	0.18599996E-04	0.99770000E 04	0.18000000E 04	0.14400000E 03
0.37500000E 00	0.12700000E 03	0.76899996E-05	0.10000000E 05	0.17070000E 04	0.14800000E 03

INITIAL CONDITIONS

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.0	REYN	0.2795415JE 03	WABDCT	WAB	0.0
0.0	QSAV	0.49999997E-01	TRANR	HQABL	0.0
0.12628716E 03	DYNP	0.0	SHKI	REFI	0.10000000E 05
0.18969067E 04	PS	0.0	EMIS	CCBNS	0.0
0.0	PS	0.93(53667E 03	0.849999956E 03	0.10000000E 01	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMPL(1), I=NSEG2,NSEG FOLLOW.
540.0 540.0 540.0

INITIAL CONDITIONS

TRANSITION (COLO WALL) HAS OCCURRED

FREQ *** TO 2

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.49999997E-01	0.20943181E 03	0.10909095E 02	0.0	0.65637946E-01	0.0

QNET	REYN	DELTA	WABDOT	HAB	RECI
0.30704618E-01	0.11796949E C5	0.49999997E-01	0.0	0.0	0.12300215E 03
WALLI	QSAV	QINSD	TRANR	HOABL	TABL
0.12838576E 03	0.0	0.0	0.0	0.99461621E 03	0.10000000E 05
PSHK	DYNP	VSHK	SHKI	REFI	QNSUM
0.21054497E 04	0.14025348E 00	0.10835363E 02	0.12300000E 03	0.12549334E 03	0.76761539E-03
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
-0.33182148E-02	0.95502349E 00	0.99261475E 00	0.84999996E 00	0.10000000E 01	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG3,NSEG FOLLOW.

540.0 540.0 540.0 540.0 540.0

STABILITY CHECK, DEL, CCN, CAY, WRI, DELTA

0.05695309 0.25000000 0.02499999 200.00000000 0.02500000 -1

TIME	ALT	VINE	ACFA	QSUBI	HSUBI
0.40749384E 01	0.11294541E 04	0.10045340E 03	0.0	0.11288923E 00	0.0
QNET	PEYN	DELTA	WABDOT	WAB	RECI
0.77648222E-01	0.10269356E 06	0.24999999E-01	0.0	0.0	0.12317575E 03
WALLI	QSAV	QINSD	TRANR	HOABL	TABL
0.12867006E 03	0.0	0.0	0.0	0.99450062E 03	0.10000000E 05
PSHK	DYNP	VSHK	SHKI	REFI	QNSUM
0.20320203E 04	0.11571953E 02	0.98192062E 02	0.12300000E 03	0.12587367E 03	0.26758307E 00
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
-0.50437782E-01	0.96031201E 00	0.96510357E 00	0.84999996E 00	0.10000000E 01	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG3 FOLLOW.

541.2 541.0 540.5 540.1 540.0

TIME	ALT	VINE	ACFA	QSUBI	HSUBI
0.59748621E 01	0.20816216E 04	0.19136111E 03	0.0	0.15560943E 00	0.0
QNET	REYN	DELTA	WABDOT	WAB	RECI
0.11990416E 00	0.18822169E 06	0.24999999E-01	0.0	0.0	0.12363628E 03
WALLI	QSAV	QINSD	TRANR	HOABL	TABL
0.12909567E 03	0.0	0.0	0.0	0.99454053E 03	0.10000000E 05
PSHK	DYNP	VSHK	SHKI	REFI	QNSUM
0.19574524E 04	0.40038104E 02	0.18682709E 03	0.12300000E 03	0.12619781E 03	0.76145631E 00
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
-0.13312852E 00	0.92507201E 00	0.94642693E 00	0.84999996E 00	0.10000000E 01	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG3 FOLLOW.

543.0 542.7 541.6 540.4 540.3

TIME	ALT	VINE	ACFA	QSUBI	HSUBI
0.14624780E 02	0.25966539E 04	0.27954150E 03	0.0	0.20843077E 00	0.0
QNET	REYN	DELTA	WABDOT	WAB	RECI
0.17208701E 00	0.26468169E 06	0.24999999E-01	0.0	0.0	0.12435663E 03

WALLI
0.12067349E 03
PSHK
0.18851216E 04
SHEAR
-0.20735902E 00

QSAV
0.0
DYNP
0.84804562F 02
PS
0.89088917E 00

QINSD
0.0
VSHK
0.27280298E 03
PSTAG
0.93653667E 00

TRANP
0.0
SHKI
0.12300000E 03
EMIS
0.84999996E 00

HCABL
0.99468311E 03
REFI
0.12663519E 03
QCDNS
0.10000000E 01

TARL
0.10000000E 05
QNSUM
0.14695253E 01
WAB/SEC
0.0

1) SEGMENT PRESENT=NSEG2 = 1. TFMP(1), I=NSEFG2,NSEG FOLLOW.
545.4 545.0 543.2 541.0 540.9

(NT = 592)

6.. ONE DIMENSIONAL, FIVE SEGMENTS, NON-AEROHEATING, Q CORRECTION

INPUT CARDS READ, DATA SET 3

&BDD6CS QCONS=5*.495,

&END

KARC = 2, TO GO = 24

END OF INPUT.

0

SAMPLE ONE DIMENSIONAL PROBLEM, - WITH COLD WALL INPUTS, 5 SEG.

IDENTIFICATION = 6BDC60S

KASE 2

CGNE

INTEGERS

ICONF

3

NCPSHR

0

0

ICLK

0

NOPSTG

0

IPANK

0

NOSB

0

INPCW

17

NPGAS

0

ISTETS

0

NPQ

0

KASE

2

NPU

0

KFUNT

3

NGI

0

NBCOL

0

NSEG

5

NBUG

0

NTRAJ

17

NDIM

1

NOCHEK

0

10	112.0	151300.0	5850.0	0.0	0.0	0.0	1.0	0.0	0.0
11	118.0	172125.0	7550.0	0.0	0.0	0.0	1.0	0.0	0.0
12	124.0	195210.0	8650.0	0.0	0.0	0.0	1.0	0.0	0.0
13	130.0	220540.0	9350.0	0.0	0.0	0.0	1.0	0.0	0.0
14	136.0	245180.0	9750.0	0.0	0.0	0.0	1.0	0.0	0.0
15	140.0	261700.0	9970.0	0.0	0.0	0.0	1.0	0.0	0.0
16	144.0	277990.0	10110.0	0.0	0.0	0.0	1.0	0.0	0.0
17	148.0	295000.0	10270.0	0.0	0.0	0.0	1.0	0.0	0.0

QSOLAR
0.0

END OF DATA PRINTOUT

NDEBUG= 0

COLD WALL INPUTS - AS PER ENTROPY SWALLOWING

NO. OF INPUTS = INPCM = 17

QINT	HEDGE	PEDGE	LEDGE	HRECCV	TIME
0.99999999E-01	0.12300000E 03	0.99499999E 00	0.10000000E 02	0.12300000E 03	0.22000000E 02
0.27999997E 00	0.12300000E 03	0.83999997E 00	0.40000000E 03	0.12300000E 03	0.40000000E 02
0.10000000E 01	0.12000000E 03	0.54999999E 00	0.90000000E 03	0.12600000E 03	0.54000000E 02
0.15900000E 02	0.13000000E 03	0.34999999E 00	0.13000000E 04	0.14000000E 03	0.60000000E 02
0.15999999E 07	0.15000000E 03	0.25000000E 00	0.15500000E 04	0.14600000E 03	0.67000000E 02
0.11360000E 02	0.16500000E 03	0.14999999E 00	0.17150000E 04	0.16000000E 03	0.67000000E 02
0.64195991E 01	0.16500000E 03	0.13000000E 00	0.18000000E 04	0.16700000E 03	0.70000000E 02
0.35699999E 01	0.17000000E 03	0.61999999E-01	0.24000000E 04	0.22100000E 03	0.80000000E 02
0.28795992E 01	0.19000000E 03	0.99999997E-02	0.36000000E 04	0.42000000E 03	0.96000000E 03
0.34295994E 01	0.21000000E 03	0.33000000E-02	0.55000000E 04	0.70000000E 03	0.11200000E 03
0.41199999E 01	0.24000000E 03	0.13100000E-02	0.71490000E 04	0.10930000E 04	0.11800000E 03
0.36799999E 01	0.24000000E 03	0.65999999E-03	0.83200000E 04	0.13930000E 04	0.12400000E 03
0.25699997E 01	0.19000000E 03	0.26499999E-03	0.95840000E 04	0.15740000E 04	0.13000000E 03
0.15695997E 01	0.14900000E 03	0.46499999E-04	0.95930000E 04	0.14830000E 04	0.13600000E 03
0.10799999E 01	0.15300000E 03	0.42299999E-04	0.98020000E 04	0.17530000E 04	0.14000000E 03
0.71095997E 00	0.14000000E 03	0.18599999E-04	0.99770000E 04	0.18000000E 04	0.14400000E 03
0.37500000E 00	0.12700000E 03	0.76899999E-05	0.10000000E 05	0.19700000E 04	0.14800000E 03

INITIAL CONDITIONS

TIME	ALT	VINF	ACFA	QSURI	HSURI
0.0	0.0	0.27954150E 03	0.0	0.0	0.0
0.0	0.0	0.49999997E-01	0.0	0.0	0.0
0.12967349E 03	0.0	0.0	0.0	0.0	0.0
0.13851216E 04	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1) = NSEG2*NSEG FOLLOW.
540.0 540.0

INITIAL CONDITIONS

TIME	ALT	VINF	ACFA	QSURI	HSURI
0.49999997E-01	0.20943191E 03	0.10909090E 02	0.0	0.55537946E-01	0.0
0.24425536E-02	0.11790549E 05	0.49999997E-01	0.0	0.0	0.12300000E 03
0.12338576E 03	0.0	0.0	0.0	0.99468311E 03	0.10000000E 05

SHEAR PS PSTAG EMIS QCONS WAB/SEC
 -).13223493E 00 0.85088917E 00 0.93653667E 00 0.84999996E 00 0.49499995E 00 0.0

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG FOLLOW.
 541.4 540.8 540.2

(NT = 5.2)

6.4 ONE DIMENSIONAL, SIX SEGMENTS, NON-AEROHEATING, NO Q CORRECTION

```

INPUT CARDS READ, DATA SET      4
$3D75CS  TITLE(15)=' ', SI', 'X SE', 'GMEN', 'TS ', KASE=3,
NSEG=6,
CCCNS=6*1.,
TEMP=6*540.,
A1=.14,60.,.25,.965,2*75.,
B1=.26,.0,.28,.125,2*.034, B2=.0,.0003,4*.0,
RHO=136.,108.,150.,334.,2*1192.,
EL=.010,.125,.010,.250,2*.25,
EMIS=.15,HV=950.,ETAL=.43,ETAT=.17,TABL=1800.,
SEND  NOTE - CHANGED EMIS, HV, TABL, ECT.
KARD = 10, TO GO = 14

```

END OF INPUT.

0

SAMPLE ONE DIMENSIONAL PROBLEM, - WITH COLD WALL INPUTS, SIX SEGMENTS
 IDENTIFICATION = 68D060S

KASE 3

CCNE

INTEGERS

ICONF

3

NCPSHR

0

0

YCHK

0

NOPSTG

0

IHANK

0

NOSB

0

INPCW

17

NPGAS

0

ISTETS

0

NPQ

0

KASE

3

NPU

0

KFUNT

3

NQI

0

NBCOL

0

NSEG

6

NDBG

0

NTRAJ

17

NDIM

1

NOCHEK

0

CAMPLE ONE DIMENSIONAL PROBLEM. - WITH COLD WALL INPUTS, SIX SEGMENTS

TRANR	TRANLT	ANGLE	SLEEP	XDIST	CONPR
...	0.47C000C0E C5	3.80000000E 01	0.0	0.24299997E 00	0.0

CELTA
0.49999997E-01
WRITE
C.5000000F 01
STOP
0.14799999E 02

TABL	HV	FYAL	ETAT	EMIS
C. 18000000E 04	C. 95000000E 03	0.42999995E 00	0.16999996E 00	0.14999998E 00

A1(J)	A2(J)	A3(J)	A4(J)
-------	-------	-------	-------

	A1(J)	A2(J)	A3(J)
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0
5	0.0	0.0	0.0
6	0.0	0.0	0.0

J	B1(J)	B2(J)	B3(J)	B4(J)
---	-------	-------	-------	-------

J	B1(J)	B2(J)	B3(J)
1	0.2599995E CC	0.0	0.0
2	0.0	0.20999996E-03	0.0
3	0.27999997E CC	0.0	0.0
4	0.12500000E CC	0.0	0.0
5	0.23999995E-01	0.0	0.0
6	0.33999995E-01	0.0	0.0

RHO(1),	I=1,	6			
0.1360000E 03			C.10PC000F 03		0.1500000F 03
0.1192000E 04					0.3340000E 03

EL(I), I=1, 6	C.125000NF 00	0.9999979E-02	0.9999979E-01	0.2500000E 00
C.9999979E-02				
0.2500000E 00				

```
TEMP(I), I=1, 6      C.54C000CF C3      7.5400000E 03      0.5400000E 03
7.5400000F C3      7.5400000E 03      7.5400000E 03      7.5400000E 03
7.5400000E 03      7.5400000E 03      7.5400000E 03      7.5400000E 03
```

I	TIME	ALT	VINF	AOFA	HINSD	TINSD	QCENS	QI*3600	TEMPW	VAPRES
1	3.0	260.0	10.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
2	22.0	4350.0	410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
3	40.0	15500.0	915.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
4	54.0	19560.0	1410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0

6-24

Reproduced from copy.

0.12938576E 03 0.00 CYNP 0.00 VSHK 0.00 SHFI.
 0.21034697E 04 -0.14025248E 00 0.10874343E 02 0.12300000E 03 QMSUM
 0.2312148E-02 0.05502345E 00 0.00201475E 00 0.14900000E 01 QCONS
 0.10000000E 01 0.00 WAB/SEC

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2, NSEG FOLLOW.
 540.1 540.0 540.0 540.0

STABILITY CHECK, DFL, CCN, CAY, WPI, DELTA 0.12400000 20.00000000 0.02500000 -1

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.49749384E 01	0.11384541E 04	0.10045340E 03	0.00	0.12011385E 00	0.00
0.11392318E 02	0.10260356E 06	0.24000000E-01	0.00	0.00	0.12317575E 03
0.12501635E 03	0.00	0.00	0.00	0.00	0.18000000E 04
0.20320203E 04	0.11571953E 02	0.00	0.00	0.00	0.42823595E 00
0.50493465E-01	0.96031201E 00	0.00	0.00	0.00	0.00

1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2, NSEG FOLLOW.
 542.6 541.5 541.3 542.6 540.1

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.0748621E 01	0.20815216E 04	0.19136111E 03	0.00	0.17183381E 00	0.00
0.16542202E 02	0.10822169E 06	0.24000000E-01	0.00	0.00	0.12363628E 03
0.12565014E 03	0.00	0.00	0.00	0.00	0.18000000E 04
0.19574524E 04	0.40838104E 02	0.00	0.00	0.00	0.11263523E 01
0.13223343E 00	0.92507201E 00	0.00	0.00	0.00	0.00

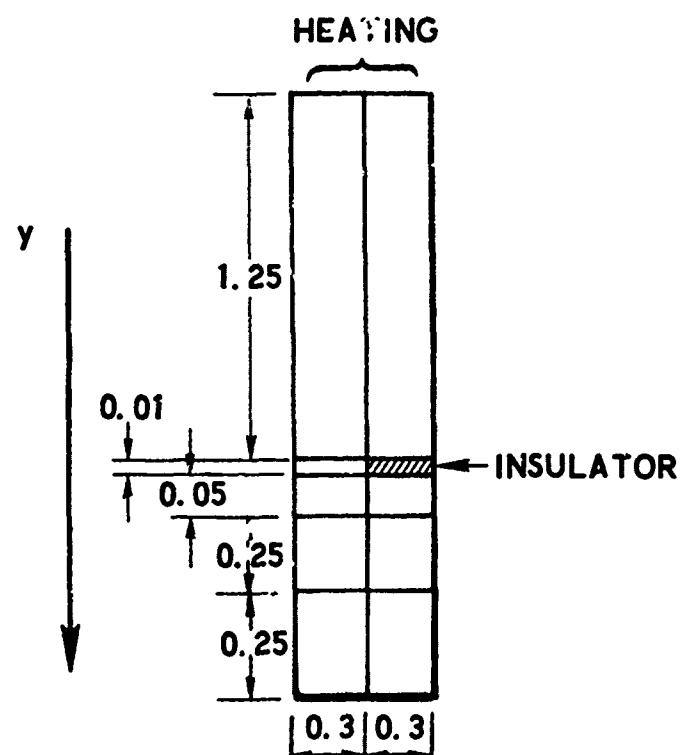
1ST SEGMENT PRESENT=NSEG2 = 1. TEMP(1), I=NSEG2, NSEG FOLLOW.
 545.3 543.7 543.4 542.0 540.5

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.14824788E 02	0.29964939E 04	0.27954151E 03	0.00	0.24147457E 00	0.00
0.23439525E 03	0.26468369E 06	0.24000000E-01	0.00	0.00	0.12435663E 03

WALL I	QSAV	QINSO	TRAR	MOABL	TABL
3.13C51186E 03	0.0	0.0	0.0	C.94895361E 03	0.18000000F 04
PSHK	CYNP	VSHK	SHKI	REFI	QNSUM
7.18051216E 04	0.84804962E 02	0.27280298E 03	0.12300000E 03	0.12705437E 03	0.20971088E 01
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
-7.26755697E 00	C.85C88917F 00	0.93653667E 00	0.14999998E 00	0.10000000E 01	0.0

1ST SEGMENT PRESFMT=NSEG2 = 1. TEMP(1), I=NSEG2,NSEG FOLLOW.
 548.9 546.6 546.1 541.2
 541.1

6.5 TWO DIMENSIONAL, FIVE SEGMENTS x TWO SLABS, NON-AEROHEATING



71 26135 02

Figure 6-1. Diagram of Two-Dimensional Problem (Section 6.5)

INPUT CARDS READ, DATA SET 5
ENDCJ6US TITLE=' TWO-DIMENSIONAL PROBLEM, BASED ON KASE 3 (1-D)',
KASE=23, NDIM=2,
WRITE=.02,
START= 68.7,
ENDC
KARC = 5, TO GC = 9
END OF INPUT.

TWO-DIMENSIONAL PROBLEM, BASED ON KASE 3 (1-D)
 IDENTIFICATION = 68D060S

KASE 23

CCNE

INTEGERS

ICONF	3	ICHK	0	IFANK	0	INPCW	17	ISTETS	0	KASE	23	KFUNT	3	NBCDL	0	NDBG	0	NDIM	2
VEPSHR	0	NCPSTG	0	NOSR	0	NPGAS	0	NPG	0	NPU	0	NQI	0	NSEG	6	NTRAJ	17	NOCHEK	0
	0																		

TWO-DIMENSIONAL OPTION BEING USED

VARC4 NBCDL NDIM

5 2 2

THICKNESS Y,AA

0.1250000E 00 0.99999979E-02 0.49999997E-01 0.25000000E 00

WIDTH X,BB

0.3079997E 00 0.3079997E 00

CCAD. CCNSF. ,CC

0.10000E 01	0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10000E 01	0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10000E 01	0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10000E 01	0.10000E 01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TEMPERATURE (R),T2																			
0.65700E 03	0.66500E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.63200E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.57700E 03	0.54400E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.54300E 03	0.54400E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.54300E 03	0.54400E 03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

1-DIMENSIONAL PROBLEM, BASED ON CASE 3 (1-D)

TRAN TRANLT ANGLE SWEEP XDIST CONPR
0.0 0.4700000E 05 0.8000000E 01 0.0 0.24299997E 00 0.0

DELTA WRITE STOP
0.49999997E-01 0.2000000E-01 0.14799999E 02

TABL HV ETAL ETAT EMIS
0.1300000E 04 0.5500000E 03 0.42999995E 00 0.16999996E 00 0.14999998E 00

J A1(J) A2(J) A3(J) A4(J)
1 0.13999999E 00 0.0 0.0 0.0
2 0.6000000E 02 0.0 0.0 0.0
3 0.2500000E 00 0.0 0.0 0.0
4 0.96499997E 00 0.0 0.0 0.0
5 0.7500000E 02 0.0 0.0 0.0

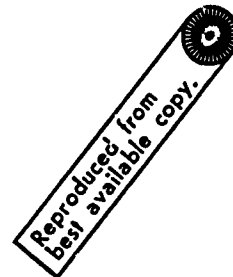
J B1(J) B2(J) B3(J) B4(J)
1 0.25999999E 00 0.0 0.0 0.0
2 0.0 0.24999999E-03 0.0 0.0
3 0.27999997E 00 0.0 0.0 0.0
4 0.1250000E 00 0.0 0.0 0.0
5 0.33999999E-01 0.0 0.0 0.0

RHO(I), I=1, 5
0.1360000E 03 0.1080000E 03 0.1500000E 03 0.3340000E 03 0.1192000E 04

5 VALUES OF AA
0.1250000E 00 0.99999997E-02 0.49999997E-01 0.2500000E 00 0.2500000E 00

2 VALUES OF BR
0.30799997E 00 0.30799997E 00

I, J CC(I,J) T2(I,J)
1 1 0.1000000E 01 0.6570000E 03
1 2 0.1000000E 01 0.6650000E 03
2 1 0.1000000E 01 0.6320000E 03
2 2 0.0 0.0
3 1 0.1000000E 01 0.5770000E 03
3 2 0.1000000E 01 0.5440000E 03
4 1 0.1000000E 01 0.5460000E 03
4 2 0.1000000E 01 0.5440000E 03
5 1 0.1000000E 01 0.5450000E 03
5 2 0.1000000E 01 0.5440000E 03



I	TIME	ALT	VINF	AOFA	HINSD	TINSD	QCONS	QI*3600	TEMPH	VAPRES
1	0.0	200.0	10.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
2	22.0	4350.0	410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
3	40.0	15500.0	915.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
4	54.0	19540.0	1410.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
5	60.0	37000.0	1690.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
6	67.0	47000.0	1850.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
7	70.0	51570.0	2000.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
8	80.0	69210.0	2630.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
9	96.0	104800.0	4000.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
10	112.0	151300.0	5850.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
11	118.0	172125.0	7550.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
12	124.0	195210.0	8690.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
13	130.0	220540.0	9350.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
14	136.0	245180.0	9750.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
15	140.0	261700.0	9970.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
16	144.0	277990.0	10110.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
17	148.0	295000.0	10270.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
	QSOLAR									
	0.0									

NDEBUG= 0

END CF DATA PRINTOUT

COLD WALL INPUTS - AS PER ENTROPY SWALLOWING NC. OF INPUTS = INPCM = 17

QINT	HEDGE	PEDGE	UEDGE	HRECOV	TIME
0.9999999999999999	0.1230000000000000	0.9949999999999999	0.1000000000000000	0.1230000000000000	0.0
0.2759999999999999	0.1230000000000000	0.8399999999999999	0.4000000000000000	0.1230000000000000	0.2
0.1000000000000000	0.1200000000000000	0.5499999999999999	0.9000000000000000	0.1260000000000000	0.3
0.1590000000000000	0.1300000000000000	0.3499999999999999	0.1300000000000000	0.1400000000000000	0.2
0.1559999999999999	0.1650000000000000	0.2500000000000000	0.1550000000000000	0.1460000000000000	0.2
0.1136000000000000	0.1650000000000000	0.1499999999999999	0.1775000000000000	0.1600000000000000	0.2
0.6419999999999999	0.1650000000000000	0.1300000000000000	0.1800000000000000	0.1670000000000000	0.2
0.3569999999999999	0.1700000000000000	0.6199999999999999	0.2400000000000000	0.2210000000000000	0.2
0.2679999999999999	0.1900000000000000	0.9999999999999999	0.3600000000000000	0.4000000000000000	0.2
0.3429999999999999	0.2100000000000000	0.3300000000000000	0.5500000000000000	0.7000000000000000	0.3
0.4119999999999999	0.2400000000000000	0.1310000000000000	0.7149000000000000	0.1093000000000000	0.4
0.3679999999999999	0.2400000000000000	0.6599999999999999	0.8320000000000000	0.1393000000000000	0.4
0.2569999999999999	0.1900000000000000	0.2649999999999999	0.9084000000000000	0.1574000000000000	0.4
0.1569999999999999	0.1490000000000000	0.9469999999999999	0.9593000000000000	0.1683000000000000	0.4
0.1079999999999999	0.1530000000000000	0.4229999999999999	0.9802000000000000	0.1753000000000000	0.4
0.7109999999999999	0.1400000000000000	0.1859999999999999	0.9977000000000000	0.1800000000000000	0.4
0.3750000000000000	0.1270000000000000	0.7689999999999999	0.1000000000000000	0.1907000000000000	0.4

INITIAL CONDITIONS

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.6869999999999999	0.6869999999999999	0.27954150E 03	0.0	0.0	0.0
QNET	REYN	DELTA	WABCT	WAB	RECI
0.0	0.0	0.4999999999999999	0.0	0.0	0.0
Q.13051186E 03	QSAV	QINSD	TRANR	HOARL	TABL
PSHK	CYNP	VSHK	SHKI	REFI	GNSUM
0.18851216E 04	0.84804562E 02	0.0	0.0	0.94895361E 03	0.18000000E 04
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
0.0	0.89088917E 00	0.93653667E 00	0.14999999E 00	0.10000000E 01	0.0

TEMPERATURES FOR 2D FOLLOW

657.0	665.0
632.0	0.0
577.0	544.0
546.0	544.0
545.0	544.0

INITIAL CONDITIONS

TRANSITION: (COLD WALL) HAS OCCURRED
FROM 2 TO 1

TIME	ALT	VINF	ACFA	QSUBI	HSUBI
0.68749985E 02	0.49665809E 05	0.19374990E 04	0.0	0.59073496E 01	0.0
QNET	REYN	DELTA	WABDCT	WAB	PECI
3.58938408E 01	0.0	0.49599997E-01	0.0	0.0	0.22077075E 03
WALLI	QSAV	QINSD	TRAAR	HDABL	TABL
0.15661850E 03	0.0	0.0	0.0	0.94895361E 03	0.18000000E 04
PSHK	DYMP	VSHK	SHKI	REFI	QNSUM
0.29282397E 03	0.69251538E 03	0.17895830E 04	0.16500000E 03	0.17307881E 03	0.14731002E 00
SHEAR	PS	PSTAG	EMIS	QCONS	WAB/SEC
3.41197662E 01	0.13888559E 00	0.65960044E 00	0.14999958E 00	0.10000000E 01	0.0

TEMPERATURES FOR 2D FOLLOW

657.8	665.8
627.2	0.0
577.4	544.0
546.0	544.C
545.0	544.C

(NT = 1)

SECTION VII

RECOMMENDATIONS

7.1 PROGRAM PHYSICAL MODIFICATIONS

During the program checkout process it became evident that with a variable degree of effort, the physical modeling within ASAH could be expanded to enhance the flexibility and performance of the computer code. Toward this end, the following list of recommended program changes was compiled. Several of these recommendations have already been implemented within ASAH and are so indicated.

7.1.1 Nose Blunting Option

The nose blunting option has been expanded to include both laminar and turbulent considerations at either the sonic or tangency points. The computations are still constrained by assumed sphere/cone geometry. These modifications have been completed. However, the ultimate solution within this option would eliminate the spherical geometry restriction that currently plagues this subroutine. It is recommended that the nose blunting option be further expanded to include calculations at many points along the nose configuration and to utilize polynomial curve fitting techniques to the ablated nose surface.

7.1.2 Cylindrical Coordinates

It is recommended that a cylindrical coordinate system option be included in the conduction subroutine (ONED) to complement the present rectangular coordinate system. The cylindrical coordinate system would be particularly useful in the nosetip region of a reentry vehicle.

7.1.3 Surface Temperature

The present ASAH computes temperatures at the midpoints of the nodal network. Since incipient ablation, reference flow field properties and the heat balance at the surface are dependent upon surface temperature, it is advisable to provide as accurate an estimate for surface temperature as possible. Therefore, it is recommended that

some extrapolation or analytical technique be incorporated into this program to allow determination of the surface temperature from the nodal midpoint.

7.1.4 Angle of Attack

At present ASAH accounts for angle of attack effects by simply adding the input angle of attack to the body angle to determine an effective flow incidence angle. Although this additive technique is adequate for very small angles of attack, it deteriorates rapidly as angle of attack increases. It is recommended that a more sophisticated angle of attack routine be included.

7.1.5 Ablation Temperature

At present, ASAH performs ablation computations holding surface temperature at a prescribed limiting value. It is recommended that the program be changed to accept a variable wall temperature as a boundary condition.

7.1.6 Mixed Flow Boundary Layer Growth

Heat transfer computations are performed assuming an all laminar or all turbulent boundary layer growth. Under actual flight conditions the boundary layer growth will be, at some point, determined by a partial run of laminar and turbulent flow conditions. The computer code should be modified to allow for this contingency by matching displacement or momentum thickness at the transition station.

7.1.7 Prandtl Number

The computer code performs calculations using a constant Prandtl number. Recent work by H. Jacobs of Aerospace has indicated that Prandtl number is a function of stream energy. Jacob's Prandtl number correlation should be added to ASAH.

7.1.8 Plotting Option

At present, the code does not have a plotting capability. Interpretation and assimilation of heat transfer results (heat transfer rate, mass loss rate, surface temperature, and backface temperature) could be improved if a plotting option were included in the computer code.

7.1.9 Insulation Thickness Selection

The usefulness of ASAH would be increased if the controls of the program were expanded to include a recycle feature that sized a heatshield based upon perhaps a backface temperature design criterion. With this option a heatshield thickness could be determined with a single computer simulation.

7.1.10 Wetted Distance Adjustment

For computations near the nosetip, wetted distance may significantly change as nosetip recession proceeds to grind away at the RV body. It is recommended that a change be made to ASAH to provide for variable wetted distance as a function of nosetip recession. This particular option would be most useful in the strong entropy swallowing regime near the RV nose.

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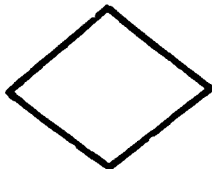
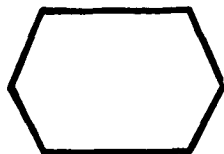
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14. H. R. Jacobs, Engineering Approximation of the Effects of Blunting on Cones in Laminar and Turbulent Flow. SAMSO TR-68-258.
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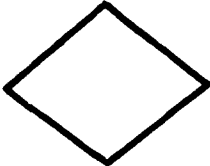
BIBLIOGRAPHY

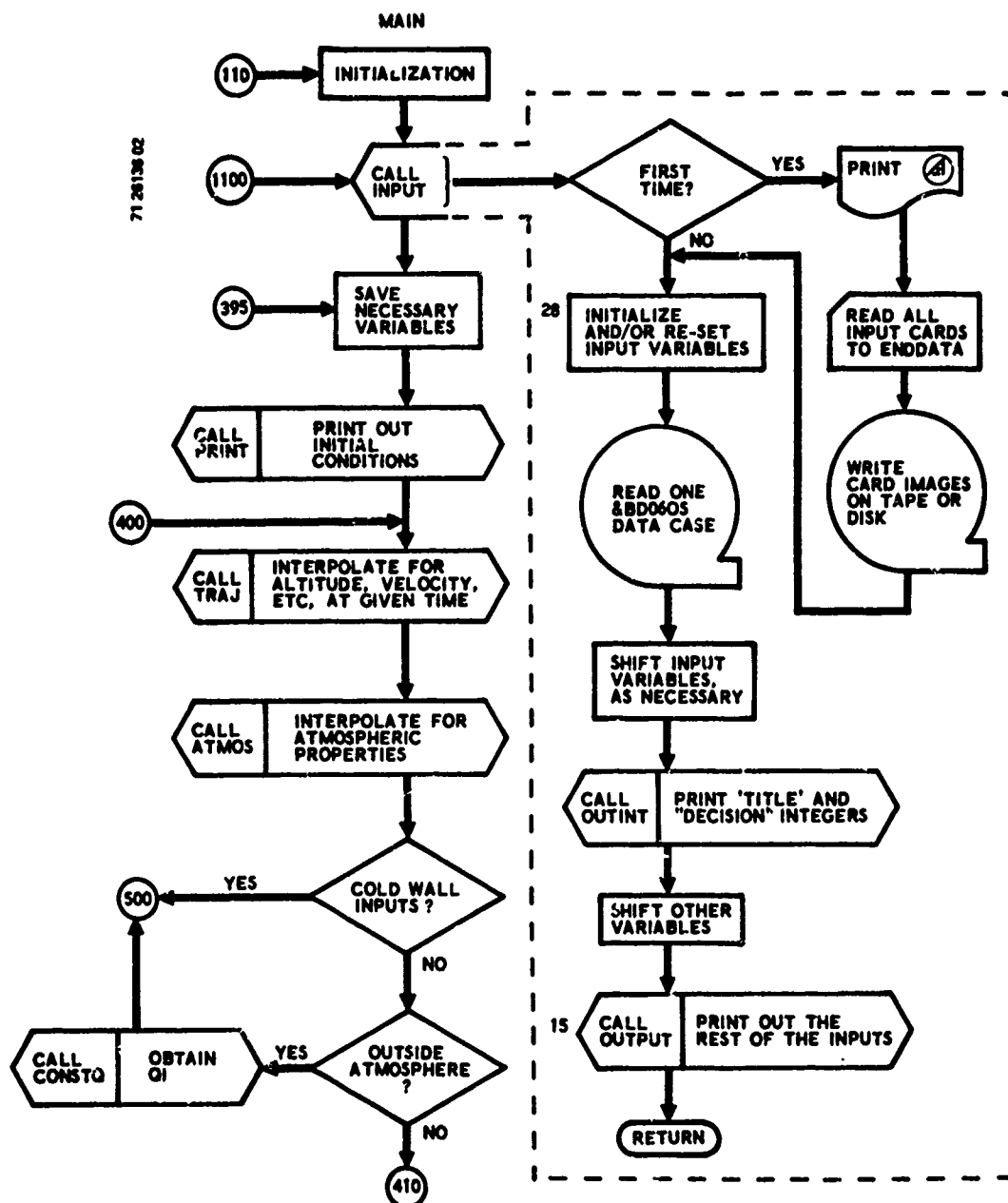
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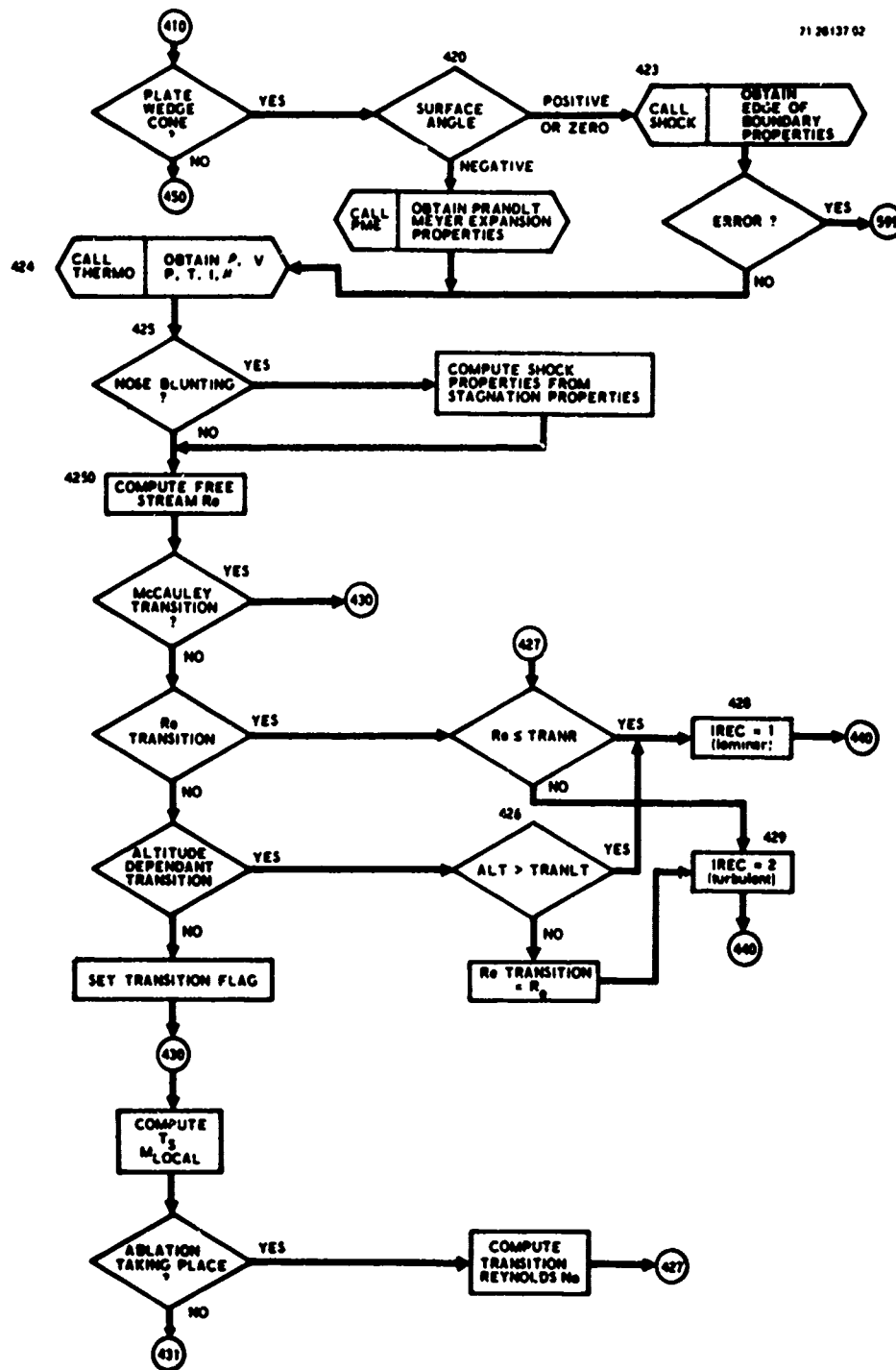
APPENDIX A
FLOW CHART NOMENCLATURE

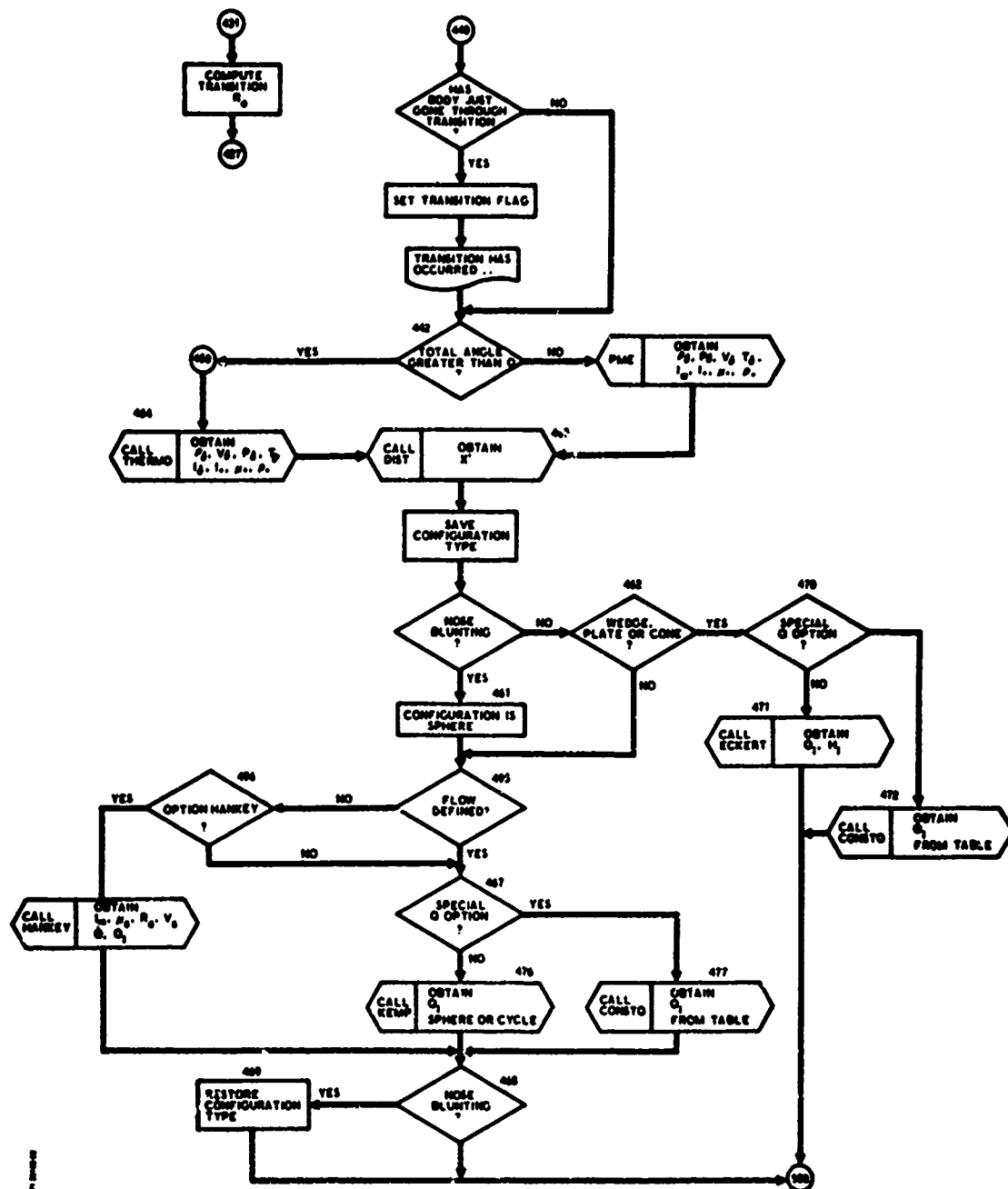
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	Decision
	Subroutine
	Inline Computations
	Inline Printing
	Inline Card Punching or reading
	Read or Write Auxiliary Storage Device (Tape or Disk)
	Return from Subroutine to Main Flow

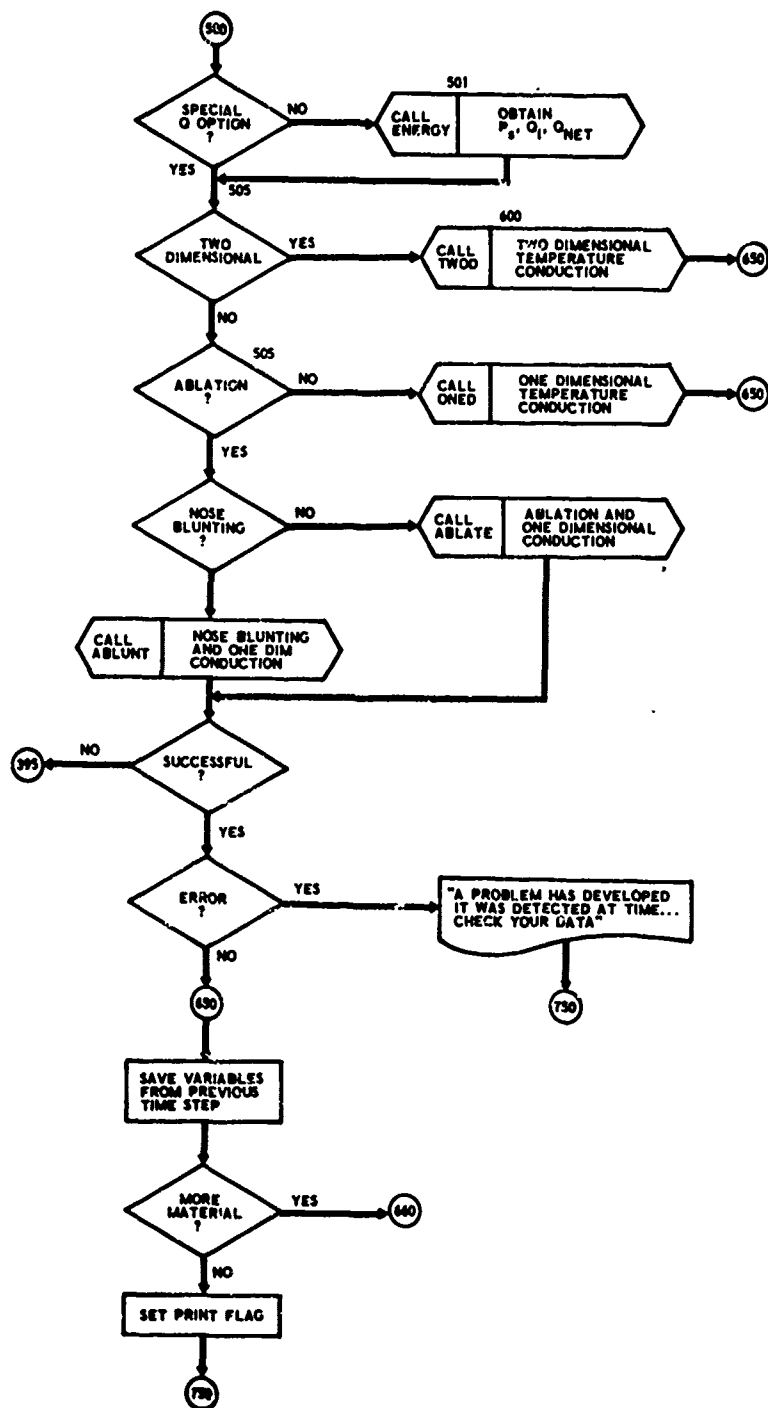
APPENDIX A
FLOW CHART NOMENCLATURE

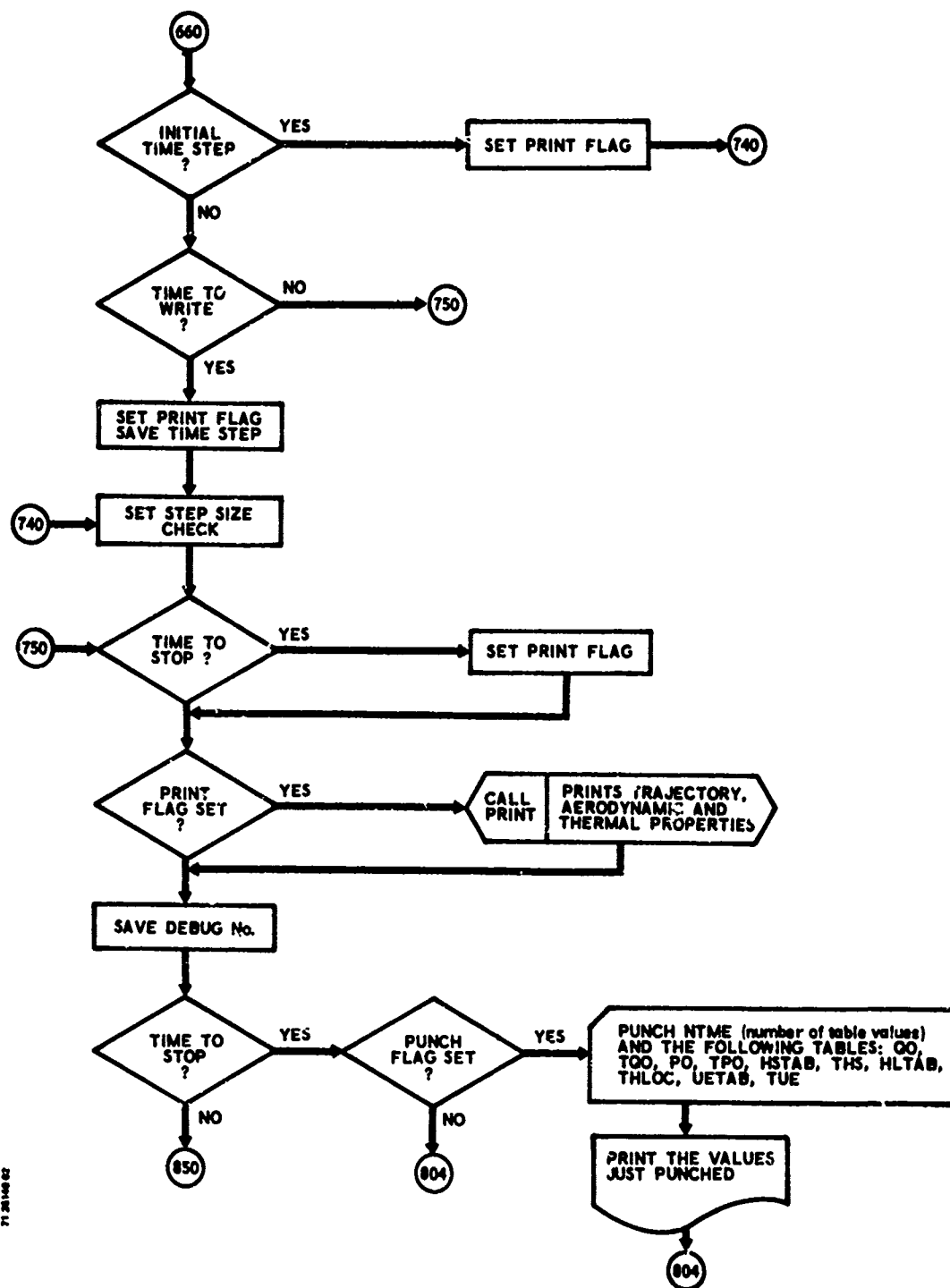
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	Decision
	Subroutine
	Inline Computations
	Inline Printing
	Inline Card Punching or reading
	Read or Write Auxiliary Storage Device (Tape or Disk)
	Return from Subroutine to Main Flow

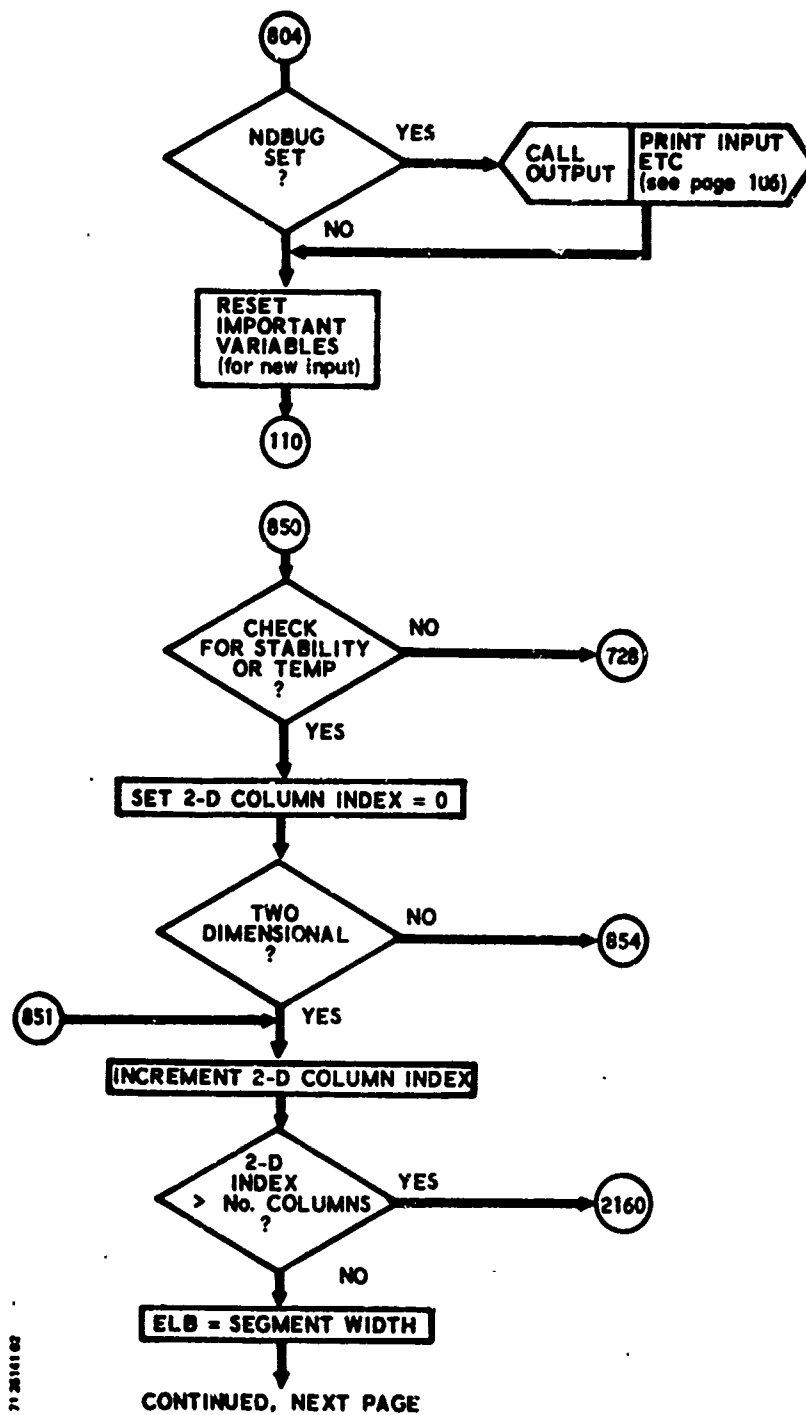




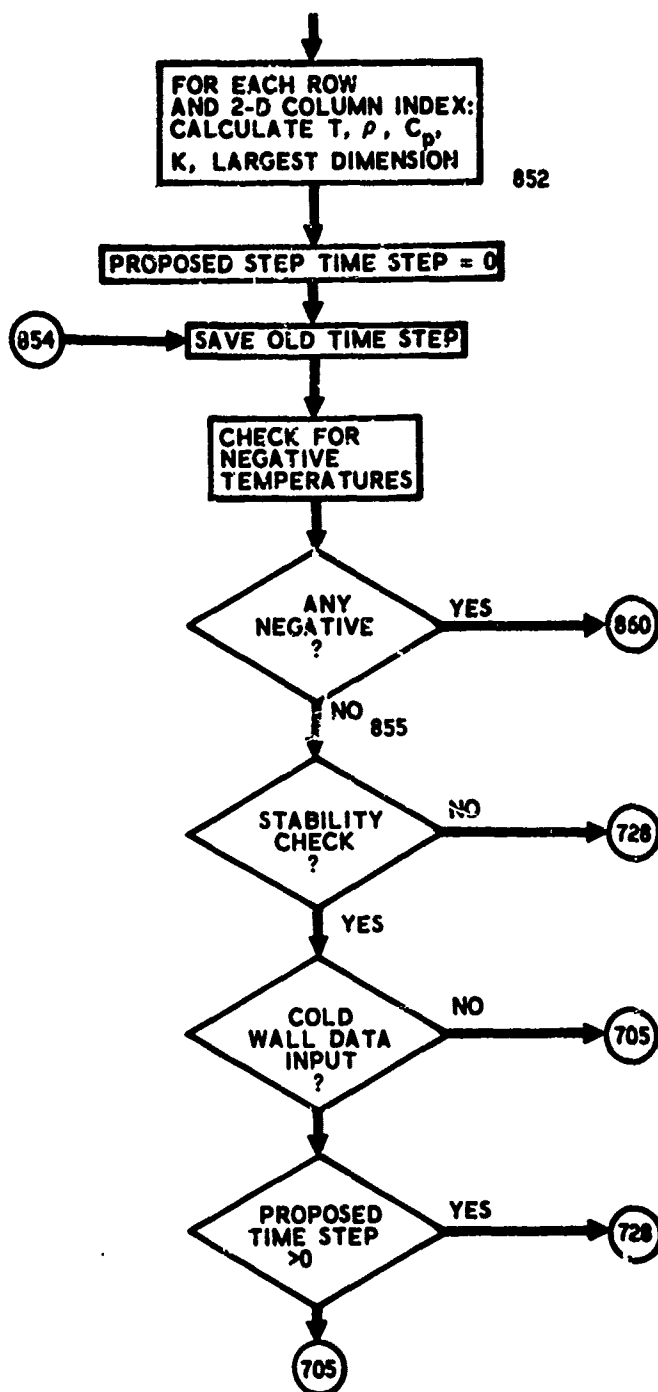




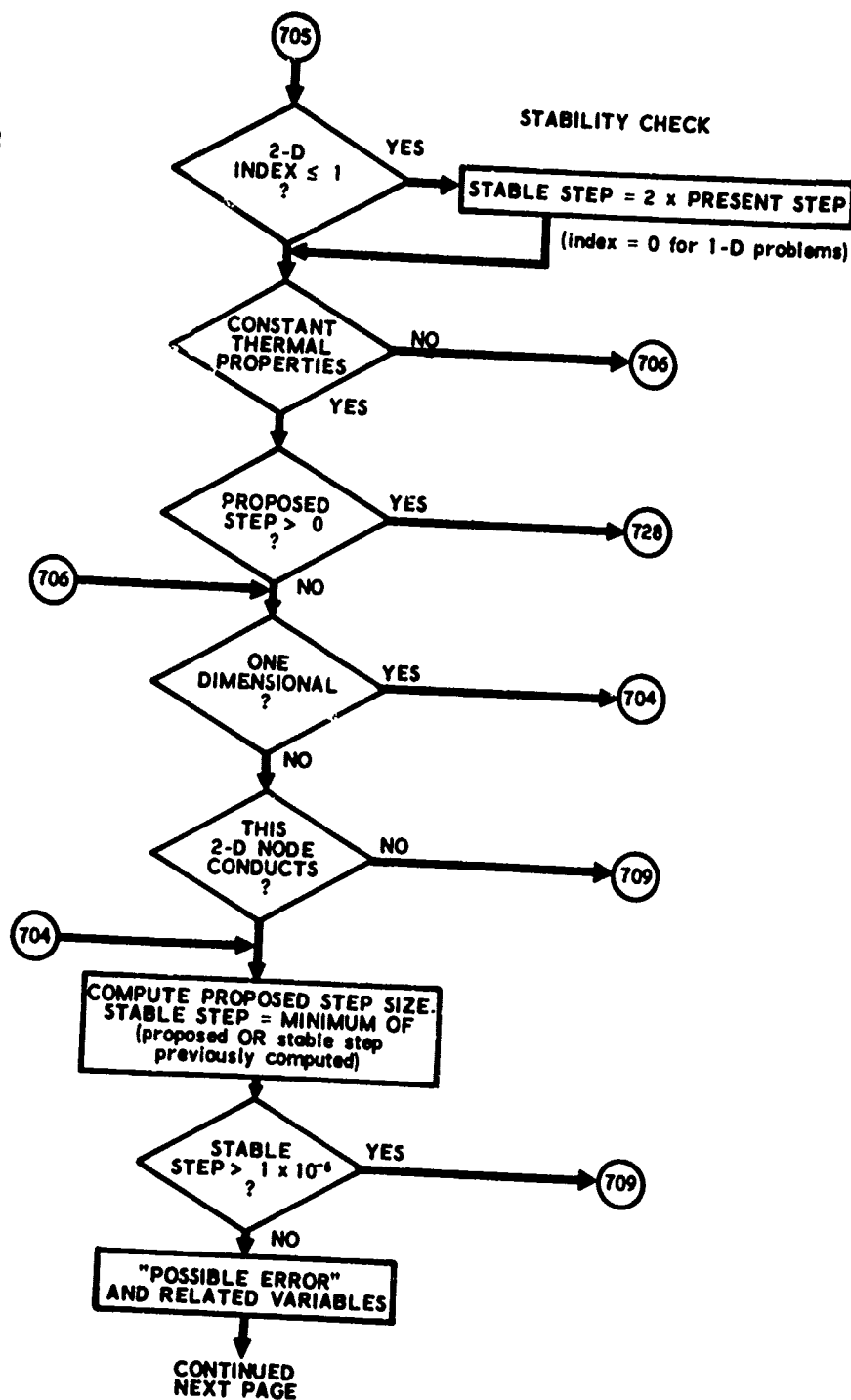




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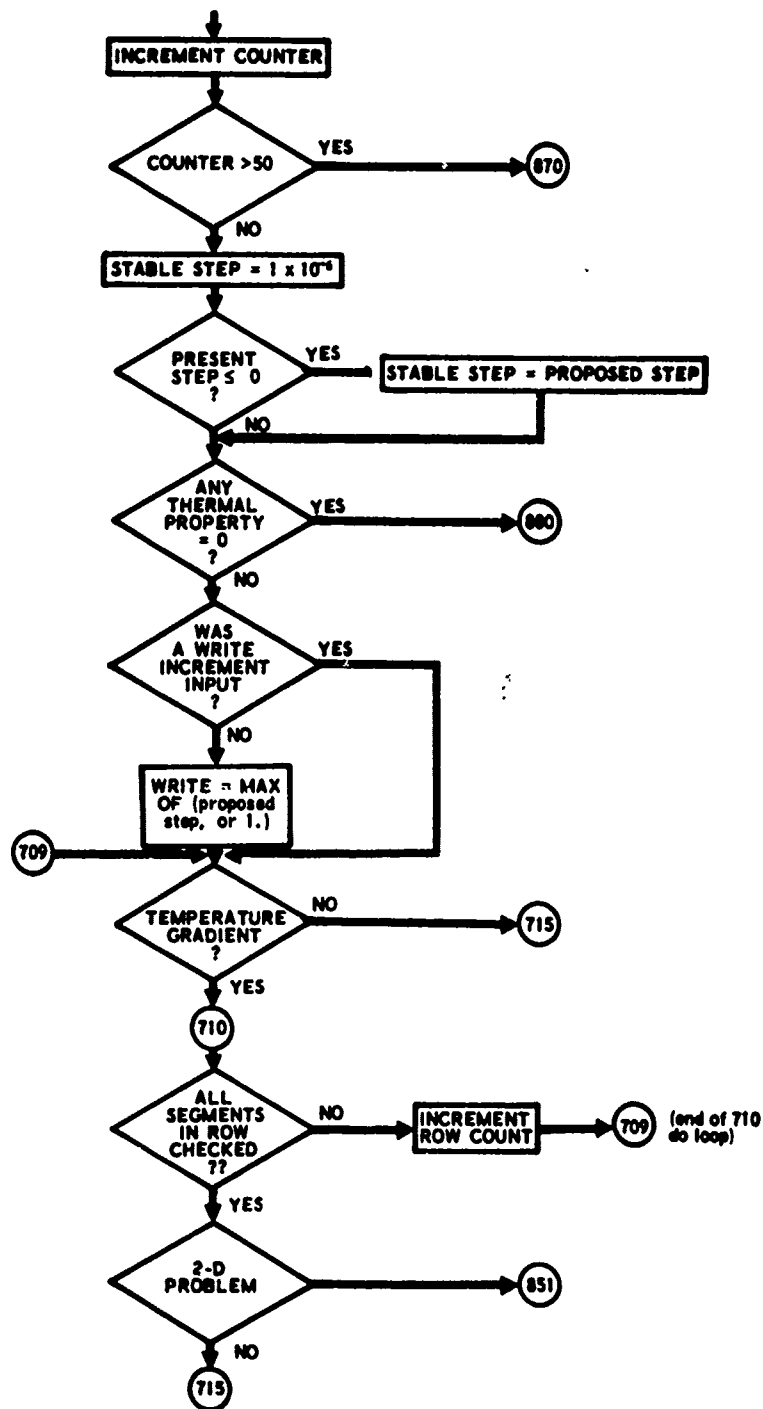


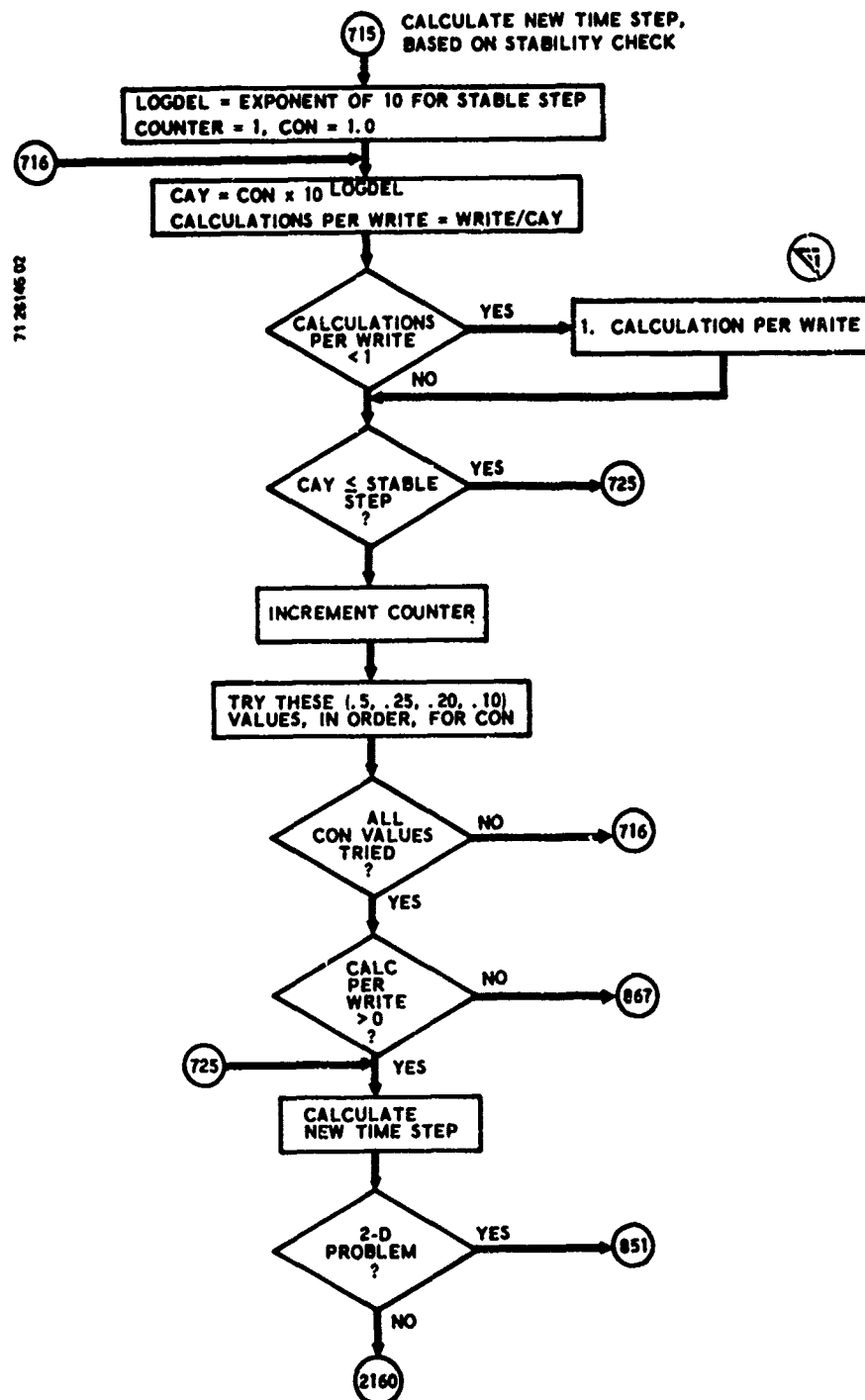
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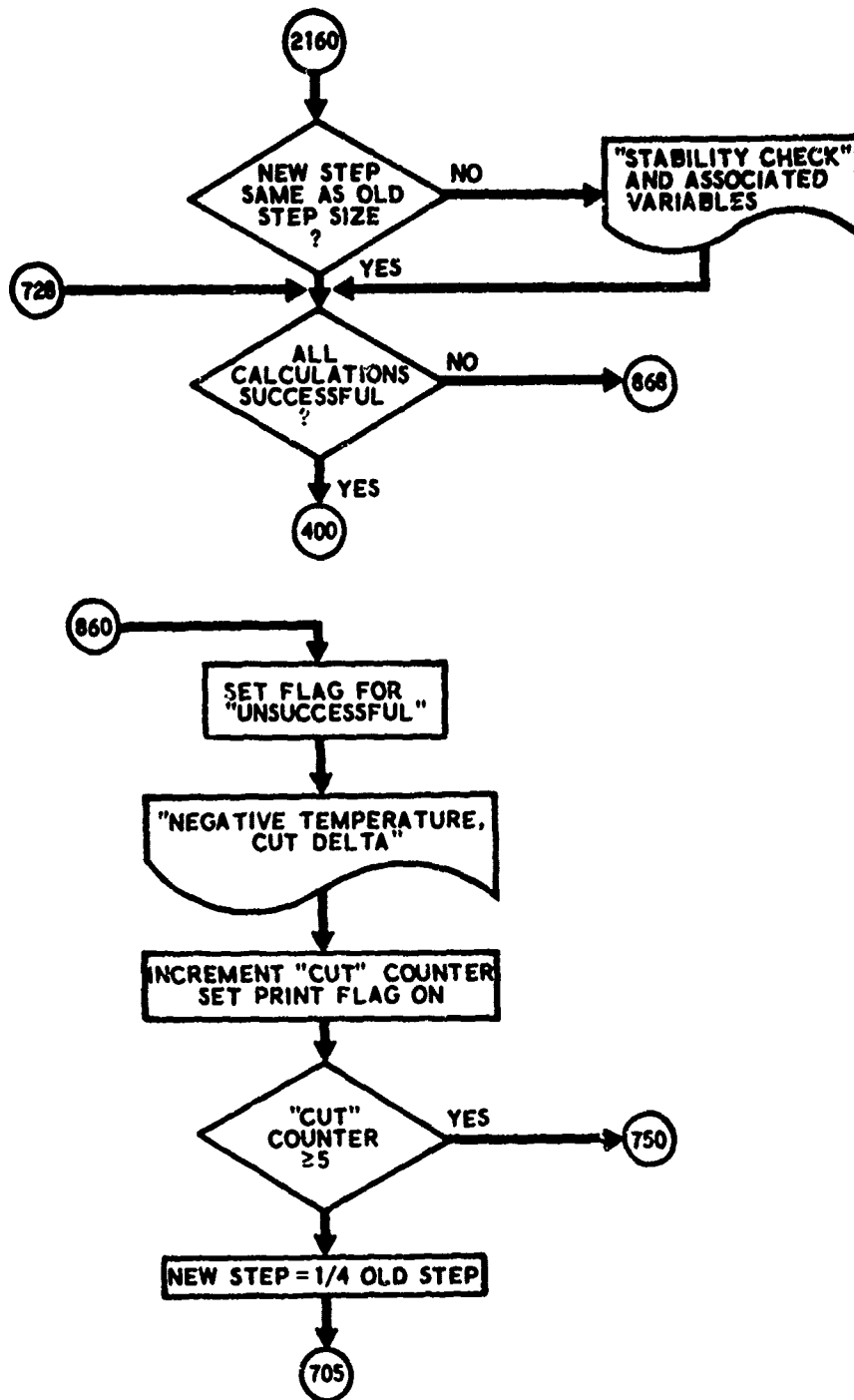
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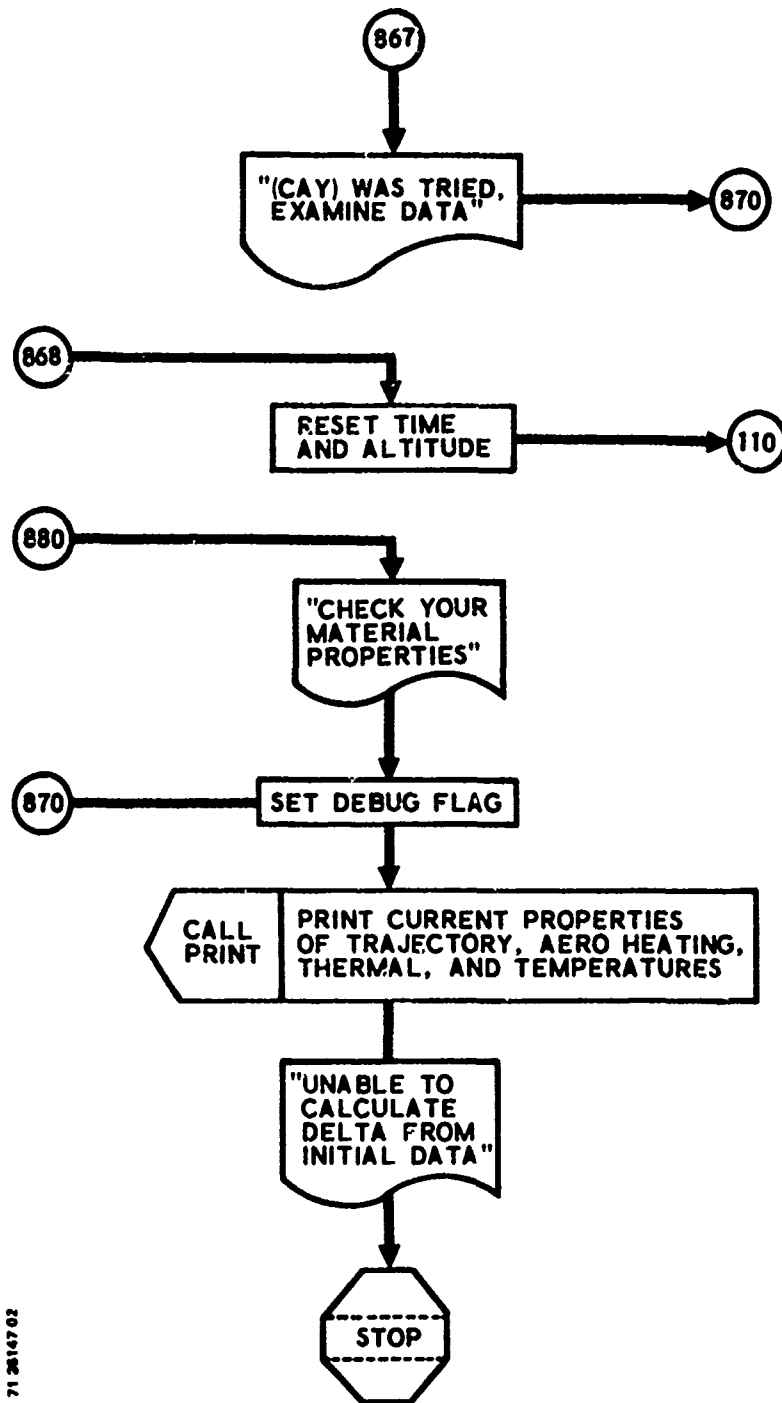
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APPENDIX B

Program Listing

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1  C NSRDC6 DECK MAIN PROG. FOR AFROSPACE AERO-HEATING BD06 0
2  C COMPILATIONS HAVE BEEN MADE UNDER FORTRAN (3. AND. H*2)
3  C CARD DECK FOR THIS PROGRAM RESIDES ON AFROSPACE TAPE = 06932
4  C
5  C CAUTION - ALTHOUGH ALL DESCRIPTIONS AND CODING IS BELIEVED TO BE CORRECT
6  C AT THIS TIME, COMPLETE ACCURACY CANNOT BE GUARANTEED. ALSO,
7  C THIS PROGRAM IS SUBJECT TO CHANGE AT ANY TIME, (AFTER 4/15/71)
8  C AS TO SPECIFICATIONS, OPTIONS, ETC., WITHOUT NOTICE
9  C OR OBLIGATION. (IT IS VERY HARD TO CHECK EACH, AND EVERY,
10 C OPTION) THIS HAS JUST BEEN A WARNING OF CAUTION, SINCE IT WORKS.
11 C
12 C COMMENT - LATEST -OPUS- LOAD MODULE (4/15/71) A422.ASAH --4/15/71
13 C A REFERENCE ENTHALPY/ SPACE PLANE METHOD , AUG 1967 BD06 1
14 C AA SEE- G.D.A. REPORT AF-62-0497 BY L.FISHER (5-24-62) BD06 2
15 C AAA PROGRAMMED BY J.KOHLBERGER -MATH AND COMPUTATIONS CENTER BD06 3
16 C A A RE-ENGINEERED BY M.GYFTVAY -FLUID MECHANICS DEPT. BD06 4
17 C A A AFROSPACE CORPORATION - SAN BERNARDINO OPERATIONS - CALIF. BD06 5
18 C DIMENSION TIME1(100),ALTI(100),VINFL(100),AQFAL(100),HINSDI(100)BD06E 5
19 C 1 , TINSOI(100),QCONS1(100),VAPRES(100),CPG(100),TEMPW(100) BD06E 6
20 C 2 , QI(100),QADI(100), CP(40),EK(40),EL(40),RHO(40),TEMP(40) BD06E 7
21 C 3 , A(4,40),R(4,40) BD06E 8
22 C 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10) BD06E 9
23 C COMMON A,ALTI,AQFAL,B, CP,CPG, EK,EL, HINSDI, QADI,QCONS1,QI BD06E 10
24 C 1 , RHO, TEMP,TEMPW,TIME1,TINSOI, VAPRES,VINFL BD06E 11
25 C 2 , AA, BB, CC,CP2, DK, T2 BD06E 12
26 C COMMON ALT,AMINF,AQFA,ANGLE, CCYPR, DELTA,DQSAV BD06E 13
27 C 1 , EMIS,ETAL,ETA2, HINSD,HQABL,HSURI,HV BD06E 14
28 C 2 , ICHK,ICK,ICONF,IGO,INB4,IN342,IREF, KASE,KFUNT, NPQ8DC6E 15
29 C 3 , NRCOL,NDRUG,NDIM,NOSR,NPGAS,NQI,NPREST,NPU,NSEG,NSEGI,NSEF2 BD06E 16
30 C 4 , NTRAJ, PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,OSUBI BD06E 17
31 C 5 , RADIUS,RECI,REFI,REFMU,REFPHQ,REFRM,QFY,N,RHOINF,RHOSL,RHOSL BD06E 18
32 C 6 , SHKI,SHKMU, STOP,SWEPT,STAL, TABL,TIME,TINE,TINSD,TRANR BD06E 19
33 C 7 , TSHK,TWALL,TWNB, VINFL,VSHK, W,WAB,WABDOT,WALLI,WRITE BD06E 20
34 C 8 , XX,XDIST BD06E 21
35 C 9 , FTATP,ETALP,HVPSTM,PSTMX,NT
36 C EQUIVALENCE (NSEG,NAROW),(QCALT,TRANLT)
37 C COMMON /BLK1/ TITLE(20)
38 C COMMON /CHARAB/ NTME,TSTOR(50),QN(50),PO(50),HSTAB(50),HLTAB(50), BD06E 23
39 C 1 UETAB(50) BD06E 24
40 C COMMON / SWALLOW/ QINT(50),HEDGE(50),PEDEGE(50),UEDGE(50),HRECONV(50)BD06E 25
41 C 1) , INPCW ,ISET BD06E 26
42 C FOR ARCHIE OSSIN - COLD WALL INPUTS FROM ENTROPY SWALLOWING BD06E 28
43 C COMMON / MIKE / HV2,ETAL2,ETAT2,XI, FVLP(10),FVIS(10),FV2P(10), BD06E 29
44 C BD06E 30

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44      FV2S(10),STGTBL(10),SHRTBL(10),NOPSTG,NOPSHR      BD06E 31
45      , QSONIC,SHEAR,H0ARL4,HF,ISTETS, NOCHEK,      INPT 34
46      , RHO7BL(10,40),CPTBL(10,40),EKTBL(10,40),TENTBL(10,40)      BD06E 33
47      COMMON /WERNER/ TRVRSI,TFB(100),RHOFB(100),PFB(100),ALTCM(100)
48      JOURLE PRECISION FLOW(3)
49      DATA FLOW/8HLAMINAR ,8HTURBULNT,8HUNKNOWN /
50      DATA ALTOLD,RADOLD,TIMOLD,VINGLD,MTRANS/3*0.,.1E-8,0/
51      NAMELIST /TRAJLT/ NTKAJ,TIME,ALT,VINF,AQFA, DELTA,WRITE,STOP,
52      IICK,TINF,PINF,RHONIF, ICONF,ANGLE
53      NAMELIST /TRJURL/ A,ALT1,AQFA1,VAPRES ,ALTIO
54      NAMELIST/RNFING/ QNET,HQABL,QSUBI,DELTA ,WRITE,STOP,HSUBI,ICONF,I
55      IGT,RADOLD,RADIOUS,HF,XX,XDIST,WAB, XI,NDRUG,ISFT,ISTETS,TIME,ALT
56      T(SR) = 17.899 + 4.0675*SR -.33984E-4*(SR*SR) -.3495E-6*SR*(SR*SR)BD06E 34
57      CALL TO ABCLDS SETS UP ERROR TRAPS FOR ADDRESSING TYPE ERRORS, ECT.
58      CALL ABCLDS
59      TO INITIALIZE BLANK COMMON
60      CALL ZEROLK
61      TO INITIALIZE BLANK COMMON
62      TRVRSI=C.0
63      IGT = -1
64      110 VSHOLD = 0.
65      RSHOLD = 0.
66      SMUOLD = 0.
67      SHOLD = 0.
68      QVOLD = 0.
69      PSHOLD = 0.
70      RCOLD = 0.
71      QCCOLD = QCCOLD
72      TEGOLD = TWALL
73      XDOLD = XDIST
74      XJOLD = XX
75
76      1100 CAL INPUT INPUT
77      C INPUT
78      DELATH=.1E-8
79      IF ((VSEG.EQ.1).OR.(VDIM.EQ.2)) DELATH=.00001
80      DELRPT = -.2.
81      HQABLM = 0.
82      HSUBI=0.
83      IDELER = 0
84      TRCOLD = 3
85      IREC = 3
86      ISET = 0
87      MTRANS = 0
88      NDRUG2 = NDRUG
89      QCCOLD = QCCOLD

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BD06E 71
BD06E 62
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BD06E 66
BD06E 68

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QNET = 0.
QSONIC = 0.
QSURI = 0.0
RADOLD = RADIUS
RECT = 0.
RFFI = 0.
REYN = C.
SCON = NDIM
SCON = SCON*12.5
SHEAR = 0.
SHKI = 0.
VSHK = 0.
IF (ALT) 111,112,111
111 TIME = ALT
GO TO 113
112 TIME = TIME1(1)
113 NDIM = NDIM
C INITIALIZE PARAMETERS
INB4 = C
120 QSUM = 0.0
125 QINSO = 0.0
QSAV = 0.0
IGD = 0
WAB = C.0
WARDNT = 0.0
NSEG1 = 1
NSEG2 = 1
GO TO (140, 180), NDIM
140 TWALL = TEMP(1)
GO TO 300
180 TWALL = T2(1,1)
300 DELSAV = DELTA
IF (NDBUG) 396,400,396
C 395 ALT = ALTOLD
WRITE (6,RNFIND)
PSHK = PSHOLD
QCONS = QCOLD
QSURI = QVOLD
RADIUS = RADOLD
RECT = RCIGLD
RHOSHK = RHSOLD
SHKI = SHIOLD
SHK4U = SMUOLD
IF (TSET.GT.0) TIME = TIMOLD
TWALL = TEGOLD

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BD06E 61
BD06E 69

BD06E 63
BD06E 60

BD06E 70
BD06E 65
BD06E 64
BD06E 72
BD06E 73
BD06E 74
BD06E 75
BD06E 76
BD06E 77
BD06E 78
BD06E 79
BD06E 80
BD06E 81
BD06E 82
BD06E 83
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BD06E 93

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BD06E128
BD06E129

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136 VINP = VINOLD
137 VSHK = VSHOLD
138 XDIST = XDOLD
139 XX = XDOLD
140 IF (NDBUG.GT.1)
141   WRITE(6,TRDUBL)
142   IF (NDBUG.EQ.1)
143     IF (NDBUG.EQ.2)
144       WRITE(6,399)
145   FORMAT(' INITIAL CONDITIONS')
146   CALL PRINT
147   WRITE(6,399)
148   CALL TRAJ
149   CALL ATMOS
150   TRANSF = 0.
151   ICK = 1
152   OR ICK = 0, IF OUTSIDE ATMOSPHERE (.GT. 297000.-FT.)
153   IF (INPCW.GE.1) GO TO 500
154   IF (NDBUG.GE.1) WRITE(6,TRAJLT)
155   IF (ICK) 410, 405, 410
156   CALL CONSTQ
157   GO TO 500
158   IREC = 1
159   IREC = 3
160   IF (ICNF-3) 420, 420, 450
161   ICNF = FLAT PLATE, WEDGE, OR CONE
162   IF (ANFA+ANGLE) 422,423,423
163   CALL PME
164   GO TO 425
165   CALL SHOCK
166   IF (IGO) 599,424,599
167   CALL THERMO
168   IF (NDBUG.LL.) GO TO 4250
169   HYPERSONIC FLOW NOSE BLUNTING CORRECTIONS 5/13/67 MJG
170   PSTAG = PINF*(1.2*(AMINF**2))**3.5 *(6./17.*(AMINF**2)-1.))**2.5
171   / 2116.
172   PSHK = 1160. *PSTAG
173   VSHK = .301 * VINP
174   RHOSHK = 7.24 *RHOFINP
175   SHKMU = 1.511E-10 * VINP
176   SHKI = STAGI - VSHK**2/5.01E+4
177   XDIST = RADIUS
178   REYN = VSHK*RHOSHK*XDIST / SHKMU
179   IF (PEYN.LT.0.) WRITE(6,4252) VSHK,PHDOSHK,XDIST,SHKMU
180   FORMAT(' REYN ERROR, ' 4F16.8)
181   C G.E. CRITERIA TRANSITION

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BD06E136

182 IF (MTRANS.GT.0) GO TO 430
 183 REYNOLDS NO. TRANSITION
 184 IF (TRANR.GT.0.) GO TO 427
 185 ALTITUDE DEPENDANT TRANSITION
 186 IF (TRANLT.GT.0.) GO TO 426
 187 MTRANS = 1
 188 FT = 1.0
 189 GO TO 430
 190 IF ((ALT-TRANLT).GT.0.) GO TO 428
 191 TRANR = FEYN
 192 GO TO 429
 193 IF (REYN-TRANR) 428,428,429
 194 IREC = 1
 195 GO TO 440
 196 IREC = 2
 197 GO TO 440
 198
 199 430 HIGH = SHKI / 33.86
 200 PEXP = ALOG10(PSHK/2116.)
 201 TEA = 230.63/(10.-PEXP) + .18304*(PEXP+3.00)
 202 THETA = 2.1965 + .31961*(PEXP+4.1)**2
 203 D = (TEA-TEA)/(2.*TEA-THETA-79.4)
 204 SMALR = 79.4 + (1.+D)*(TEA-79.4)
 205 SMALA = D*(79.4-SMAL3)
 206 C = -SMALA*D
 207 F = -2.1965 + 1.46434/(EXP(-2.*PEXP)+1.)
 208 GMEN = .0065 - .012096/(PEXP+9.6)
 209 SMALM = PEXP*(-1.6)*(1.-.5*PEXP) - 94.2
 210 TAU1 = (5.4913-.56743*(PEXP+1.75)**2) *EXP(BIGH/50.-10.)
 211 TAW = F*EXP(GMEN*(H+SMAL4)**2)
 212 TRAT = SMAL A+SMALB*(BIGH/250.)+C/((BIGH/250.)+D)+TAU1+TAW
 213 TSHK = 492.* TRAT
 214
 215 CHANGE - *H* WAS FOUND TO BE UNDEFINED (4/21/70), SO THE FOLLOWING IS
 216 CHANGE - A TEMPORARY FIX (4/29/70)
 217
 218 CHANGE - DAN NJWAN CLAIMS, *THIS IS GOOD TO ABOUT 5000*
 219 NAMELIST /TSHOCK/ TSHK,TRAT,TAW,TAU1,SMALM,GMEN,F,C,SMALA,SMALR,
 220 * D,THETA,TEA,PEXP,BIGH,PSHK,SHKI
 221 IF((TSHK.LF.0.).OR.(NDEBUG.EQ.1)) WRITE (6,TSHOCK)
 222 AMLQC = VSHK / (49.07*SQRT(TSHK))
 223 IF (WABDNT.GT.0.) GO TO 431
 224 TRANR = 220000.* AMLQC**1.90/FT
 225 GO TO 427
 226 431 TRANR = 75400. * AMLQC**1.891/FT
 227 GO TO 427
 228 440 IF (IREC .EQ. IPC7LD)GO TO 442

BD06E137
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228      C      CALL PRINT
229      TRANSF = 1.
230      WRITE (6,441) FLOW(IRCOLD),FLOW(IREC),TRANLT
231      441 FORMAT (54H- TRANSITION HAS OCCUPREC * * * * * CONDITIONS BELOW,
232      1', FROM 'A8,' TO 'A8,' TRANLT='F13.5)
233      IRCOLD = IREC
234      442 IF ((ANGLE +AOFA) .GE. 0.) GO TO 450
235      445 CALL PMF
236      GO TO 455
237      C      ICONF = SPHERE OR CYLINDER
238      450 CALL THERMO
239      455 CALL DIST
240      460 IC = ICONF
241      IF (NDSR) 462,462,461
242      462 IF (ICONF-3) 470,470,495
243      FLAT PLATE, WEDGE, CONE USE -ECKERT-
244      470 IF (NPGAS) 471,471,472
245      471 CALL ECKERT
246      GO TO 500
247      472 CALL CONSTQ
248      GO TO 500
249      C      ICONF IS 4 WHEN SPHERICAL (BLUNT) NOSE IS USED
250      461 ICONF = 4
251      405 IF (IREC-2) 467,467,496
252      496 IF (ICLK) 467,467,464
253      SPHERE , CYLINDER
254      464 CALL HANKEY
255      GO TO 468
256      C      SPHERE , CYLINDER
257      467 IF (NPGAS) 476,476,477
258      475 CALL KEMP
259      GO TO 468
260      477 CALL CONSTQ
261      468 IF(NDSB) 500,500,469
262      469 ICONF = IC
263      500 IF (NPGAS) 501,501,505
264      IF NPGAS + , Q1 FOUND IN CONSTQ AND SKIP ENERGY
265      501 CALL ENERGY
266      505 GO TO (550,600), NDI4
267      550 IF ( TAHL ) 560, 560, 570
268      560 CALL PNFD
269      GO TO 650
270      C      ABLATION - STANDARD OR NOSE BLUNTING
271      570 IF (NDSR.LF.0) GO TO 573
272      571 CALL ABLUNT
273      IF (NDSB.GT.0) WRITE (6,RNFIND)

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BD06E179
BD06E181
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BD06E223
BD06E224
BD06E225

BD06E226
BD06E227

IF (ISET .GE. 1) GO TO 395
GO TO 575
573 CALL A9LATE
IF (NSEG2.GT.NSEG) IGN=1
575 IF (IGO) 599,650,599
599 NDSUG = 1
WRITE (6,598) TIME
598 FORMAT (1- A PROBLEM HAS DEVELOPED',/ ' IT WAS DETECTED AT TIME='
1 516.8/)- CHECK YOUR DATA')
TIME = STOP + DELTA
GO TO 750

C*****BD06E229
600 CALL TWDD
C*****BD06E230
650 DELSAV = DELSAV + DELTA
C*****BD06E231
ALTD = ALT
C*****BD06E232
TIME = TIME
C*****BD06E233
VINLD = VINL
C*****BD06E234
VSHLD = VSHK
C*****BD06E235
RHSOLD = RHOSHK
C*****BD06E236
XDIOLD = XOIST
C*****BD06E237
XDIOLD = XX
C*****BD06E238
SMUOLD = SHKMU
C*****BD06E239
SHIOLD = SHKI
C*****BD06E240
QVIOLD = QSUBI
C*****BD06E241
PSHOLD = PSHK
C*****BD06E242
RCIOLD = RFCI
C*****BD06E243
QCCOLD = QCONS
C*****BD06E244
TFGOLD = TWALL
C*****BD06E245
RADOLD = RADIUS
C*****BD06E246
IF (NSEG2.LT.NSEG) GO TO 660
C*****BD06E247
IF (NSEG.EQ.1) GO TO 660
C*****BD06E248
CALL PRINT
TRANSF = 1.
GO TO 750

BD06E250
BD06E252

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BD06E255

BD06E256
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320 C      CHECK STOP
321 750 IF (TIME.GF.STOP) TRANSF = 1.
322 IF (TRANSF.GT.0.) CALL PRINT
323 NDRUG = NDRUG2
324 IF (TIME.LT. STOP) GO TO 950
325 IF (NPU.LE. 0) GO TO 804
326 NTME = NTME - 1
327 PUNCH 900, NTME,NTME,NTME,NTME,NTME
328 PUNCH 901, (QO(I), I=1,NTME)
329 PUNCH 902, (TSTOR(I),I=1,NTME)
330 PUNCH 903, (PO(I), I=1,NTME)
331 PUNCH 904, (TSTOR(I),I=1,NTME)
332 PUNCH 905, (HSTAB(I),I=1,NTME)
333 PUNCH 906, (TSTOR(I), I=1,NTME)
334 PUNCH 907, (HLTAB(I), I=1,NTME)
335 PUNCH 908, (TSTOR(I), I=1,NTME)
336 PUNCH 909, (UETAB(I), I=1,NTME)
337 PUNCH 910, (TSTOR(I), I=1,NTME)
338 900 FFORMAT (13H NTMP=1,NTME= 12, 6H, NPC=,12, 6H, NHS=,12,6H, NUF= 12,BD06E275
339 1 RH, NHLQC= 12, 1H, )
340 901 FFORMAT (8H QO = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
341 1( E18.8,2H, ,E18.8,2H, ,E18.8,2H, ,F18.8,1H, ) )
342 902 FFORMAT (8H TQO = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
343 1( E18.8,2H, ,F18.8,2H, ,E18.8,2H, ,F18.8,1H, ) )
344 903 FFORMAT (8H PO = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
345 1( E18.8,2H, ,F18.8,2H, ,E18.8,2H, ,F18.8,1H, ) )
346 904 FFORMAT (8H TPO = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
347 1( E18.8,2H, ,F18.8,2H, ,E18.8,2H, ,E18.8,1H, ) )
348 905 FFORMAT (8H HSTAB = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
349 1( E18.8,2H, ,E18.8,2H, ,E18.8,2H, ,F18.8,1H, ) )
350 906 FFORMAT (8H THS = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
351 1( E18.8,2H, ,F18.8,2H, ,E18.8,2H, ,F18.8,1H, ) )
352 907 FFORMAT (8H HLTAB = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
353 1( E18.8,2H, ,F18.8,2H, ,F18.8,2H, ,F18.8,1H, ) )
354 908 FFORMAT (8H THLOC = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
355 1( E18.8,2H, ,E18.8,2H, ,E18.8,2H, ,E18.8,1H, ) )
356 909 FFORMAT (8H UETAB = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
357 1( E18.8,2H, ,F18.8,2H, ,E18.8,2H, ,E18.8,1H, ) )
358 910 FFORMAT (8H TUE = E18.8,2H, ,E18.8,2H, ,E18.8,1H, /
359 1( E18.8,2H, ,E18.8,2H, ,E18.8,2H, ,E18.8,1H, ) )
360 WRITE(6,920) NTME,(TSTOP(I),I=1,NTME)
361 920 FFORMAT (1H- 16,31H VALUES PUNCHED, AT TIMES BELOW /(5E16.8) )
362 WRITE (6,921)
363 921 FFORMAT (13H-NOMENCLATURE/ 60H QO=QSURI, PO=PS, HSTAB=RECI,
364 1HLTAB=SHKI, UETAB=VSHK // )
365 WRITE (6,901) ( QO(I),I=1,NTME )

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8006E303
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8006E318
8006E319
8006E320
8006E321

WRITE (6,903) (PD(I) ,I=1,NTME)
WRITE (6,905) (HSTAB(I),I=1,NTME)
WRITE (6,907) (HLTAB(I),I=1,NTME)
WRITE (6,909) (UETAB(I),I=1,NTME)
804 IF (NDBUG.LE.0) GO TO 810
805 CALL OUTPUT
810 WRITE (6,811)
811 FORMAT (IH1)
ALT = 0.0
IGD = 0
IF (NOSH.GT.0) TWALL = 0.
IF (MTRANS.LE.0) GO TO 815
TRANR = 0.
TRANLT = 0.
GO TO 110
815 IF (TRANLT.LE.0.) GO TO 110
TRANR = 0.
GO TO 110

C NEGATIVE TEMPERATURE CHECK (EACH CALCULATION)
C 853 IF (NDIM.NE.2) GO TO 854
C NOCHECK = 0 , FOR CHECKING NEG. TEMP., AND STABILITY
C NOCHECK = 1 , FOR NEGATIVE TEMPERATURE CHECK ONLY
C , BUT STILL CHECKS FOR 2-D STABILITY (IN TWDD)
C NOCHECK = 2 , FOR NO CHECKS (FASTER RUNNING, BUT ERROR PRONE)
850 IF (NJCHECK.GT.1) GO TO 728
INDX2D=0
IF (NDIM.NE.2) GO TO 854
851 INDX2D= INDX2D + 1
IF (INDX2D.GT.NBCOL) GO TO 2160
ELB = 88(INDX2D)
DO 852 NA = 1,NAROW
TEMP(NA) = T2(NA,INDX2D)
RHO(NA) = RHO2(NA,INDX2D)
CP(NA) = CP2(NA,INDX2D)
EK(NA) = EK(NA,INDX2D)
852 EL(NA) = AMIN1(AA(NA),ELB)
DELBRT = 0.
854 DELTA1 = DELTA
DO 855 I=NSEG2,NSEG
IF (TFMP(I)) 860,855,855
855 CONTINUE
IF (NUCHECK.GT.0) GO TO 728
NOT = 0
IF (NT.LE.1) DELBRT=0
IF (INPCW.LE.0) GO TO 705

8006E323
8006E324
8006E325

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412 IF (DELVRT.GT.O.) GO TO 728
413 STABILITY CHECK OR IS THAT CZEK
414 DEL IS A STABLE DELTA
415 LOGDEL = EXPONENT (10) OF DEL
416 CAY = SCALED (BY CON, FOR EASE OF PRINTOUT) DELTA
417 NRI = NO. OF TIMES THROUGH FOR PRINT
418 WRI = SAME AS NRI, WRI*CAY SHOULD = WRITE
419 IF (INDX2D.LE.1) DEL = DELTA*2.
420 IF (KFUNT.NE.4) GO TO 706
421 IF (DELVRT.GT.O.) GO TO 728
422 DO 710 IRA = NSEG2,NSEG
423 ONLY IF 2D AND NO CONDUCTION - 709
424 IF (NDIM.EQ.1) GO TO 704
425 IF (CC(IRA,INDX2D).LE.O) GO TO 709
426 CHECKED ONLY FOR 2-DIM
427 704 DELVRT = SCON *RHO(IRA)*CP(IRA)*EL(IRA)*2 / FK(IRA)
428 DEL = AMIN1(DEL,DELVRT)
429 DALETH = DELATH*TEMP(IRA)
430 IF (DEL.GT.DALETH) GO TO 709
431 WRITE (6,707) IRA,RHO(IRA),CP(IRA),EL(IRA),EK(IRA),DELVRT,INDX2D
432 707 FORMAT (25H-POSSIBLE ERROR, SEGMENT I3,24H RHO, CP, EL, EK, DEL8BD06E340
433 FRT /5E16.3, COLUMN,I6)
434 IDELER = IDELER + 1
435 IF (IDELER.GT.50) GO TO 870
436 DEL = DALETH
437 WRITE (6,708) IRA,DEL,DELVRT,TEMP(IRA)
438 708 FORMAT (I FOR SEGMENT,I6, MINIMUM DELTA IS,E13.5, MAX=E13.
439 15, AT TEMP = ,E13.5)
440 IF (DELTA.LE.O.) DEL = DELVRT
441 IF (RHO(IRA)*CP(IRA)*EL(IRA)*EK(IRA).EQ.O.) GO TO 880
442 709 IF (TEMP(IRA).EQ.TEMP(IRA+1)) GO TO 715
443 710 CONTINUE
444 IF (NDIM.EQ.2) GO TO 851
445 715 LOGDEL = ALG10(DEL)
446 IRA = 1
447 CON = 1.0
448 716 CAY = CON*10.**LOGDEL
449 IF (WRITE.LE.O.) WRITE=AMAX1(.5,DELVRT)
450 NRI = WRITE/CAY
451 IF (NRI.LT.1) NRI = 1
452 IF (CAY.LE.OEL) GO TO 725
453 IRA = IRA + 1
454 GO TO (717,718,719,720,727) ,IRA
455 727 IF (NRI.GT.O) GO TO 725
456 GO TO 867
457 717 CON = .5

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GO TO 716
718 CON = .25
GO TO 716
719 CON = .20
GO TO 716
720 CON = .10
GO TO 716
725 WRI = NRI
DELTA = WRITE/WRI
C      SHOULD BE APPROX. SAME AS CAY
      IF (NDIM.EQ.2) GO TO 851
2160 IF (DELTA.EQ.DELTA1) GO TO 728
730 WRITE (6,726) DEL,CON,CAY,WRI,DELTA,LOGDEL
726 FORMAT ( 47H STABILITY CHECK, DEL, CON, CAY, WRI, DELTA /
1 5F20.8,18 )
C      END STABILITY CHECK
729 IF (IGO.GT. 0) GO TO 868
GO TO 400
860 IGO = 1
WRITE(6,866)
866 FORMAT (32H-NEGATIVE TEMPERATURE, CUT DELTA )
NOT = NOT + 1
C      CALL PRINT
TRANSF = 1.0
IF ((NOT.GT.5).AND.(DELBRT.LT.DEL)) IGO = 0
IF ( NOT.GE.5 ) GO TO 868
DELTA = DELTA / 4.
GO TO 705
867 WRITE (6,861) CAY
861 FORMAT ( 1H-E20.8,30H DELTA WAS TRIED, EXAMINE DATA )
868 TIME = TIME1(1)
ALT = 0
GO TO 110
880 WRITE (6,881)
981 FORMAT ( 1- CHECK YOUR MATERIAL PROPERTYS *)
980 NDRUG = 1
CALL PRINT
WRITE (6,888)
888 FORMAT (45H-UNABLE TO CALCULATE DELTA FROM INITIAL DATA )
STOP
END

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8D06E359
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500 SUBROUTINE A3LATE
501
502 C -- MARCH 27 1964 JOHN KOHLENBERGER
503 C --
504 C SOME COMMENTS - NSEG1= 1ST NON-ABLATING SEGMENT. NSFG2= 1ST
505 C SEGMENT PRESENT. HENCE NSEG2 LESS THAN OR EQUAL TO NSEG1.
506 C SET IGO = NONZERO TO INDICATE ONLY 1 SEGMENT LEFT.
507 C LEO BERGERS CHANGES TO ABLATE
508
509 DIMENSION TIME1(100),ALT1(100),VINFL(100),ADFA1(100),HINSD1(100)
510 1 , TINSO1(100),QCONS1(100),VAPRES(100),CP2(100),TFMPW(100)
511 2 , QI(100),QAD1(100),CP(40),EK(40),RH0(40),TEMP(40)
512 3 , A(4,40),B(4,40)
513 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
514 COMMON A,ALT1,ADFA1,R,CP,CPG,EK,FL,HINSD1,QAD1,QCONS1,QI
515 1 , RHO,TEMP,TEMPW,TIME1,TINSO1,VAPRES,VINFL
516 2 , AA,BB,CC,CP2,DK,T2
517 COMMON ALT,AMINF,ADFA,ANGLE,CONPR,DELTA,DQSAV
518 1 , EMIS,ETAL,ETA2,HINSD,H0A3L,HSU3I,HV
519 2 , ICHK,ICK,ICONF,IGN,INR4,INR42,IREC, KASE,KFUNT, NPQABLA
520 3 , NRCOL,NDRUG,NDIM,NOSB,NPGAS,NCI,NPREST,NPU,NSEG,NSFG1,NSFG2
521 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBI
522 5 , RADIUS,RECI,REFI,RFFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSLABLA
523 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSO,TRANR
524 7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE
525 8 , XX,XOIST
526 9 , ETATP,ETALP,HVPSTM,PSTMAX
527 EQUIVALENCE (NSEG,NAROW)
528 IF (NSEG.LT.NSEG2) GO TO 60
529 IF (WAB.LE.O.) WABSAV=O.
530 C ***** NOTE, USE QSUBI IN PLACE OF QNET WHEN NPU POSITIVE ***
531 IF (NOI.GE.1) GO TO 29
532 QUSE = QNET
533 GO TO 3
534 29 QUSE = QSUBI
535 IF (QUSE.EQ.O.) GO TO 3
536 QUSE = QUSE * QCONS
537 3 DQSAV = (TEMP(NSEG1)-TEMP(NSEG2))*DELTA/(150.*(EL(NSEG2)/EK(NSEG2)
538 1 +EL(NSEG1)/EK(NSEG1)))
539 IF (QUSE.NE.O.) DQSAV = QUSE *DELTA/3600.
540 IF (DQSAV.LE.O.) GO TO 15
541 2 IF (NPGAS.GE.O.) GO TO 6
542 IF (NPQ.LE.O.) GO TO 6
543 100 IF (STAGI-VAPRES(1))107,105,105
544 105 H0A3L = FINTRP (VAPRES,TEMPW,STAGI,NPQ,1)

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ABLA 31

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543 ISNANA = 105
544 GO TO 10
545
546 107 STAGI = VAPRES(1)
547 GO TO 10
548
549 4 IF (PSTMAX.LE.0.) GO TO 1
550 AMF2 = AMINF**2
551 IF (AMINF.GT. 1.09) GO TO 110
552 PSTAG = (PINF+RHOINF*VINP*VINP*.5)/2116.
553 GO TO 111
554
555 110 PSTAG=PINF*(1.2*AMF2)**3.5*(6./(7.*AMF2-1.))**2.5/2116.
556 111 IF (PSTAG.LE.PSTMAX) GO TO 1
557 HVT= HVPSTM
558 IF (IREC.EQ.2) GO TO 5
559 ETA = ETALP
560 GO TO 9
561
562 5 ETA = ETATP
563 GO TO 9
564
565 1 HVT = HV
566 IF (IREC.EQ.2) GO TO 7
567 ETA = ETAL
568 GO TO 9
569
570 7 ETA = ETA2
571 HOABL = HVT + ETA*(RFCI-WALLI)
572 ISNANA = 9
573
574 10 IF (NDRUG.GE.1) WRITE (6,11) ISNANA,HOABL,HV,HVT,HVPSTM,ETA,FTAI,ETA2,STA
575 11 ETAG,STAGI
576 11 FORMAT (' IN ABLATE , FROM' ,I6/((6E16.8))
577 IF (TEMP(NSEG2)-TABL)15,30,20
578
579 15 NSFG1 = NSEG2
580 WABDOT = 0.0
581 IF ((NSFG2.EQ.1).AND.(NSEG.EQ.1)) WABSAV=0.0
582 GO TO 45
583
584 20 TEMP(NSEG2) = TABL
585 30 NSEG1 = NSEG2+1
586 33 IF (NSEG2.GT.NSEG)GO TO 60
587 IF (NSEG1.GT.40) GO TO 60
588 IF (NSEG.EQ.1) GO TO 90
589 35 DQSAV =(TEMP(NSEG1)-TEMP(NSEG2))*DELTA/(150.*(EL(NSEG2)/FK(NSEG2)
590 1 +EL(NSFG1)/EK(NSEG1))) + QUSE*DELTA/3600.
591 QSAV = QSAV+DQSAV
592 WABDOT = DQSAV/HOABL
593 IF (WABDOT) 39,41,41
594
595 39 WABDOT = 0.0
596 41 WAB = WAB+WABDOT
597 WABSAV = WABSAV + WABDOT
598 FSEF = WABSAV/RHO(NSEG2)

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589 FDL = FSEG-FL(NSEG2)/12.
590 IF (NDBG.EQ.1) WRITE (6,44) DELTA,QUSF,WABSAV,FSEG,FDL,EL(NSFG2)
591 1, QSAV,QSAV
592 44 FORMAT (' DEBUG ABLATE *** , DELTA QUSE WABSAV FSEG FDL EL/ Q DQ
593 1 / (6F16.8)')
594 IF (FDL.GE.0.) GO TO 80
595 CALL ONED
596 55 RETURN
597 60 CALL PRINT
598 65 WRITE (6,66)
599 66 FORMAT( 77H0 IN ABLATION ROUTINE HAVE EXHAUSTED ALL BUT 1 SEGMENT
600 150 AM STOPPING.
601 PROBABLY PRINT SOME OTHER STUFF HERE TOO
602 IGN = 1
603 GO TO 55
604 80 WRITE (6,81) NSEG2
605 81 FORMAT( 42H0 HAVE COMPLETED ABLATION ON SEGMENT NO. 13 /55H
606 1TF THAT ON OUTPUT THERE IS NOW 1 LESS TEMPERATURE.
607 WABSAV= RHO(NSEG2)*FDL
608 NSEG2 = NSEG2+1
609 TEMP(NSEG2) = TABL
610 NSEG1 = NSEG2 + 1
611 IF (NSEG2.GT.40) GO TO 60
612 IF (NSEG1.GT.NSEG) GO TO 60
613 CALL PRINT
614 85 QSAV = 0.0
615 GO TO 45
616 90 WRITE (6,91)
617 91 FORMAT ('1 ADD MORE SEGMENTS ' / ' WHEN ABLATING, MORE THAN ONE SEG
618 1MENT IS REQUIRED ')
619 GO TO 60
620 END
ABLA 100

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621 SUBROUTINE ABLUNT
622 CABLUNT AEROSPACE NOSE BLUNTING ROUTINE (B0006C PROGRAM)
623 C ENGINEER GEYTVAY, PROGRAMMER KOHLENBERGER 02/07/64
624 C - - APRIL 14, 1964 JOHN KOHLENBERGER ** FORTRAN II **
625 C BASED ON STAGNATION POINT RECESSON AND HANKEY TYPE HEATING
626 C AT THE SPHERE JUNCTION. 4-14-64
627 C JULY 5 1967
628 C SOME COMMENTS - NSEG1 = FIRST NGN-ABLATING SEGMENT
629 C NSEG2 = FIRST SEGMENT PRESENT
630 C
631
632 DIMENSION TIME1(100),ALT1(100),VINFI(100),AQFAL(100),HINSD1(100),BLUNT 10
633 1 , TINSO1(100),QCONSI(100),VAPRES(100),CPG(100),TEMPW(100) BLUNT 1
634 2 , QI(100),QAD1(100),CP(40),EK(40),FL(40),RHD(40),TEMP(40) BLUNT 2
635 3 , A(4,40),R(4,40) BLUNT 3
636 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10) BLUNT 4
637 COMMON A,ALT1,AQFAL,B,CP,CPG,EK,EL,HINSD1,QAD1,QCONSI,QI BLUNT 5
638 1 , RHD,TEMP,TEMPW,TIME1,TINSO1,VAPRES,VINFI BLUNT 6
639 2 , AA,BB,CC,CP2,DK,T2 BLUNT 7
640 COMMON ALT,AMINF,AQFA,ANGLE,CONPR,DELTA,DQSAV BLUNT 8
641 1 , EMIS,ETAL,ETA2,HINSD,HQABL,HSURI,HV BLUNT 9
642 2 , ICHK,ICK,ICONF,IGO,INR4,INR42,IRFC, KASE,KFUNT, NPQBLUNT 20
643 3 , NRCOL,NDBG,NDIM,NDSB,NPGAS,NQI,NPREST,NPU,NSEG,NSEG1,NSEG2 BLUNT 21
644 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBI BLUNT 22
645 5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSL BLUNT 23
646 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSO,TRANR BLUNT 24
647 7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE BLUNT 25
648 8 , XX,XDIST BLUNT 26
649 9 , ETATP,ETALP,HVPST4,PSTMAX BLUNT 27
650 COMMON / SWALOW / QINT(50),HEDGE(50),PEDGE(50),UEDGE(50),HRECONV(50) BLUNT 28
651 1 , INPCW,ISET BLUNT 29
652 COMMON / MIKE / HV2,ETAL2,ETAT2,XI,FV1P(10),FV1S(10),FV2P(10), BLUNT 30
653 * FV2S(10),STGTBL(10),SHRTBL(10),NPPSTG,NPPSHR BLUNT 31
654 2 , QSONIC,SHEAR,HQABL4,HF,ISTETS BLUNT 32
655 DIMENSION THETAC(11),OJQQS(11) BLUNT 33
656 DATA FV1/1.0,FV2/0./ BLUNT 34
657 DATA COSPHI / .74/ BLUNT 35
658 DATA THETAC / 0.0,2.5, 5.0,7.5,10.0,12.5,15.0,20.0,25.0,30.0,35.0/ BLUNT 36
659 1 ,QJQQS / 0.0,0.04,0.016,0.035,0.057,0.085,0.115,0.18,0.255,0.335, BLUNT 37
660 2 .42 / BLUNT 38
661 EQUIVALENCE (NSEG,NAROW) BLUNT 39
662 AMINF = VINF/(49.07*SQRT (TINF)) BLUNT 40
663 A1 = .894*AMINF**(-1.768) BLUNT 41
664 RHOSL = 0.0023769 BLUNT 42
665 BLUNT 43

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664 C
665 C
666 AS PER ECKERT
667 EQU 25 , PG. 7 (AF 62-0497)
668 QDSRD = 176.00.*SQRT (RHOINF/RHOSL)* (VINP/26000.0)**3.15
669 1 * (STAGI-WALLI)/(STAGI-129.5)
670 QDOT = QDSRD / SQRT (RADIUS)
671 HSURI = QDSRD*3600./(SQRT (RADIUS)*(RECI-WALLI))
672 AMF2 = AMINF**2
673 9 IF (PSTMAX.LE.C.) GO TO 13
674 IF (AMINF.GT.1.09) GO TO 1
675 PSTAG =(PINF + RHOINF*VINP**2 *.5)/2115.8
676 GO TO 11
677 1 PSTAG = PINF* (1.2*AMF2)**3.5 *(6./(7.*AMF2-1.))**2.5 / 2116.
678 11 IF (PSTAG.LE.PSTMAX) GO TO 13
679 HVT = HVPSTM
680 FTA = FTALP
681 GO TO 14
682 13 HVT = HV
683 ETA = ETAL
684 IF (AMINF.GT.1.09) GO TO 12
685 PSTAG =(PINF + RHOINF*VINP**2 *.5)/2115.8
686 GO TO 14
687 12 PSTAG = PINF* (1.2*AMF2)**3.5 *(6./(7.*AMF2-1.))**2.5 / 2116.
688 14 XIM1 = 1.-XI
689 IF (INR4.LE.0) FV1=1.0
690 IF (INR4.LE.0) FV2=0.0
691 IF (XI.FU.1.0) GO TO 16
692 IF (N)PSIG.LE.0) GO TO 155
693 FV1 = FINTP(STGTBL,FV1P,PSTAG,NOPSTG,1)
694 FV2 = FINTRP(STGTBL,FV2P,PSTAG,NOPSTG,1)
695 155 ETA = ETAL
696 16 DELTAI = RECI-WALLI
697 XIHV1 = XI *(HVT +ETA *DELTAI)
698 XIHV2 = XIM1*(HV2+ETAL2*DELTAI)
699 HFDI = XI*(HF+FTA*DELTAI)
700 HQABL = FV1 * XIHV1 + FV2 * XIHV2 + (1.-FV1) * HFDI
701 IF (NORUG.GE.1)
702 WRITE (6,14922) HQABL,FV1,XIHV1,FV2,XIHV2,HFDI,HVT,ETA,XI,DELTAI
703 14922 FORMAT (1 FROM ABLUNT AT FN 14922*(5E16.8))
704 C
705 INITIALIZE CONSTANTS AT 8 (BELOW)
706 IF (INR4-1) 8,8,10
707 8 INR4 = ?
708 F = 0.0
709 FSAV = 0.0
710 IF (ANGLE-10.0) 7,7,6
711 7 A2 = 1.00

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GO TO 5
6 A2 = .70*(COS (.03925*(ANGLE-10.0)))*.3.74 + .30
5 R0 = RADIUS
F = 0.0
THETA = ANGLE / 57.2957795
SITHET = SIN (THETA)
IF (ANGLE-20.0) 3,3,4
4 B2 = SITHET*.1.50
GO TO 2
3 B2 = 1.480*SITHET*.1.943
2 B3 = 1.047*COS (THETA)/SITHET
F = 0.0
Z = 0.0
THMACH = 90. - ANGLE
ANGLP = THMACH/57.2957795
ANNE = 1.047*SIN (ANGLR)/COS (ANGLR) -2.095
10 IF (QNET) 19,19,15
15 IF (TEMP(NSEG2)-TWNB)20,45,30
30 TEMP(NSEG2) = TWNB
4-14-64 BASIC EQUINS. BELOW
45 DF = QDSPD * DELTA / (SQRT (RADIUS)*RHO(NSEG2)*H0ABL)
F = F + DF
NSEG1 = NSEG2 + 1
B1 = (SITHET - B2 - A1*A2) / (1. - SITHET)
PR = .76
IF ((ISTETS.GT.0) .AND. (IREC.NE.2)) GO TO 100
FACTOR = .637
IF (IREC.EQ.2) FACTOR = 4.68*(RHOINF/PHDSL)**.3 *RADIUS**.3
SONIC POINT JAZZ -REPLACES(FDF=FACTOR*DF)
QSONIC = QDSRD/SQRT(RADIUS) * FACTOR
SHEAR = QSONIC*VSHK/ (DELTA* PR**(-.667))/32.2
IF (X1.EQ.1.) GO TO 449
PS = PSHK/2116.
IF (NOPSTG.LE.0) GO TO 446
FV1 = FINTRP(STGTBL,FV1P,PS ,NOPSTG,1)
FV2 = FINTRP(STGTBL,FV2P,PS ,NOPSTG,1)
446 IF (NOPSHR.LE.0) GO TO 447
FV1SHR = FINTRP(SHRTBL,FV1S,SHEAR,NOPSHR,1)
FV2SHR = FINTRP(SHRTBL,FV2S,SHEAR,NOPSHR,1)
447 IF (IREC.NE.2) GO TO 448
XIHV1 = XI *(HVT +ETA2 *DELTAI)
XIHV2 = XI*1*(HV2 +ETAT2*DELTAI)
HFDI = XI*(HF+ETA2*DELTAI)
449 H0A9LP= FV1 * XIHV1+ FV2 * XIHV2 + HFDI * (1.-FV1)
CHANGED 0.29.69
IF (NOPSHR .GT. 0) GO TO 443

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756 HOABL = HOABLP
757 GO TO 444
758 HOABLS = FV1SHR*XIHV1 + FV2SHR*XIHV2 + HFDI * (1.-FV1SHR)
759 HOABLY = AMINI(HOABLP,HOABLS)
760 444 FDF = QSONIC/HOABLM*DELTA/RHO(NSEG2)
761 CHANGED = 0.29.69
762 GO TO 450
763 449 FDF = FACTOR * DF
764 HOABLY = HOABL
765 ISET = 0
766 IF (NDBG.CE.1) WRITE(6,451) PS,SHEAR,FV1,FV2,FV1SHR,FV2SHR,
767 1 XIHV1,XIHV2,HFDI,HOABLP,HOABLS,HOABLM, FDF,IREC,NOPSTG,NOPSHR
768 451 FORMAT (' IN ABLUNT, AT 450 PS,SHEAR,FV1-2,FV1-2SHR :/6E16.8/
769 1 , XIHV1-2,HFDI,HOABLP-S-M :/ 6E16.8/ : FDF,IREC,NOPSTG-SHR :/
770 2 5E16.8,3E16 )
771 IF ( (AMAX1(DF,FDF)).LT.((.999-COSPHI)*RADIUS)) GO TO 36
772 ISET = 1
773 DELTA = DELTA / 2.
774 WRITE(6,35) DF,FDF,RADIUS,DELTA
775 35 FORMAT ( ' 54H- DF OR FDF .GT. RADIUS*.05, DF,FDF,RADIUS,DELTA
776 * / 4E16.8)
777 WRITE(6,6666)IFEC,RN,FDFACC,DIFFAC,FDFAC,FDF,HOABLS,
778 * HOABLP,FACTOR,XIHV1,XIHV2,FV1,FV2 , PSTAG,PSHK,SHEAR,QSONIC
779 IF (DELTA.LT. .1E-8) STOP
780 RETURN
781 C ERROR RETURN DELTA HAS BEEN CUT
782 36 DIFFAC = 1.-DF/RADIUS
783 FDFAC = 1.-FDF/RADIUS
784 FDFACC = FDFAC *COSPHI
785 RN = RADIUS * (FDFAC**2 -2.*DIFFAC*FDFACC +DIFFAC**2) *.5 /
786 * (-FDFACC+DIFFAC)
787 1776 IF (NDBG.NE.2) GO TO 1967
788 WRITE(6,6666)IREC,RN,FDFACC,DIFFAC,FDFAC,FDF,HOABLS,
789 * HOABLP,FACTOR,XIHV1,XIHV2,FV1,FV2 , PSTAG,PSHK,SHEAR,QSONIC
790 6666 FORMAT ( ' 24H BLUNT,DEBUT=2, IREC = I3/34H RN, FDFACC, DIFFAC, FDFABLUNT151
791 *C, HOABLS /6E16.8/ 31H HOABLP, FACTOR, XIHV1,2, FV1,2 /(6E16.8)BLUNT152
792 1967 84 = R2 + A1*A2
793 DDR = B4*DF
794 VA = 93*(RN+DDR)**3-2.095*RN**3-RADIUS*RADIUS*RADIUS*AONE
795 RADIUS = RN
796 VTOTAL = VTOTAL + VA
797 WABDNT = DF*RHO(NSEG2)
798 WAB = WAB + WABDNT
799 VAPRES(100) = F
800 FSAV = FSAV +DF
801 FOL=FSAV-EL(NSEG2)/12.

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802 IF (FOL) 20,40,40
803 FSAV = FOL
804 NSFG2 = NSEG2 + 1
805 NSEG1 = NSEG2 + 1
806 TEMP(NSFG2) = TWNB
807 WRITE (6,81) NSEG2
808 81 FORMAT (42H0 HAVE COMPLETED ABLATION OF SEGMENT NO. 13 / 54H COMRLUNT169
809 10ITIONS JUST PREVIOUS TO ABLATION ARE AS FOLLOWS )
810 IF (NSEG1.GT.NSEG) GO TO 90
811 CALL PRINT
812 GO TO 20
813 19 NSEG1 = NSFG2
814 20 CALL ONED
815 48 IF (NDRUG-2) 50,46,50
816 NOTE/ DQSAV AND QSAV NOT USED
817 46 DQSAV = DDK
818 QSAV = VA
819 NOTE/ SO DEBUG WILL PRINT DDR AND VA
820 (6,47)QDSRD,DQSAV,QSAV,WABDOT,ETA,RADIUS,ANGLR
821 ,VTOTAL,DF,F, WAB,A1,A2,B2,B4, AMINF
822 47 FORMAT ( 7H0APLUNT/7X,6H QDSRD 15X,5HDQSAV 15X,4HQSAV 16X,
823 1 6HWABDOT 14X,3HETA / 5F20.8 / 7X,7H RADIUS 14X,5HANGLR
824 2 15X,6HVTOTAL 14X,2HDF 18X,1HF / 5F20.8 / 7X,4H WAB 16X,2HA1 18X,
825 3 2HA2 18X,2HB2 18X,2HB4 / 5E20.8 / 7X,6H AMINF /E20.8 )
826 50 IF (RADIUS) 60,60,80
827 80 IF (RADIUS - 1.E5) 55,60,60
828 55 RETURN
829 67 CALL PRINT
830 65 WRITE (6,66)
831 66 FORMAT (77 H0USE BLUNTING ROUTINE HAS NEGATIVE OR LARGE RADIUS,
832 150 AM STOPPING.
833 PROBABLY PRINT SOME OTHER STUFF HERE TOO
834 90 ISN = 1
835 GO TO 55
836 ----- SETSON -----
837 100 QTANGS = FINTRP (THETAC,QJOQS,ANGLE, 11,1)
838 QTAN = QTANGS * QDOT
839 QSONIC = QTAN
840 PTOPS = SIN(ANGLE)**2 + COS(ANGLE)**2/(1.2*AMINF)
841 PTAN = PTOPS * PSTAG
842 VTAN = VINP* SQRT (1.-PTOPS**16667
843 SHFAP = QTAN*VTAN *PR**(-.6667) / (32.2 *VEL(1))
844 REPRODUCED FROM IFN.78 TO IFN.79, OR THERE ABOUTS
845 IF (XI.EQ.1.) GO TO 101
846 IF (NOPSTG.LE.0) GO TO 102
847 FV1 = FINTRP(SIGTRN,FVIP,PTAN,NOPSTG,1)

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848      FV2 = FINTPP(STGTRL,FV2P,PTAN,NOPSIG,1)
849      102 IF (NOPSHR.LE.0) GO TO 101
850      FV1SHR = FINTRP (SHRTRL,FV1S,SHEAR,NOPSIG,1)
851      FV2SHR = FINTRP (SHRTRL,FV2S,SHEAR,NOPSIG,1)
852      C      SKIPPED A FEW HERE, DOWN TO EFN.448
853      101 HQABLP = FV1 *XIHV1+FV2 *XIHV2 +HFDI*(1.-FV1 )
854      CHANGED 0.29.69
855      IF (NOPSHR.GT. 0) GO TO 103
856      HQABLM = HQABLP
857      GO TO 104
858      103 HQABLS = FV1SHR*XIHV1+FV2SHR*XIHV2 +HFDI*(1.-FV1SHR)
859      HQABLM = AMINI (HQABLP,HQABLS)
860      C      END OF DUPEO STUFF
861      104 RN=0.
862      CHANGED 0.29.69
863      IF (HQABLM.GT.C.)
864      1    IPN = RADIUS+ DE*( SITHET / (1.-SITHET )- 1./(1.-SITHET
865      1    * OTANQS*HQABL/HQABLM)
866      GO TO 1775
867      END

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BLUNT208

BLUNT211
BLUNT212

BLUNT213
BLUNT214
BLUNT215

BLUNT216
BLUNT217
BLUNT218
BLUNT219

868	SUBROUTINE AEROSP	1	SBO.
869	WRITE (6,1960)	2	SBO.
870	1960 FORMAT (1H1///25X,42H THE MATHEMATICS AND COMPUTATIONS CENTER	3	SBO.
871	1/// 45X,3H OF ///	4	SBO.
872	WRITE (6,1961)	5	SBO.
873	1961 FORMAT (45X,1H* / 38X,1H* / 13X,1H* / 50X,3H*** / 49X,4H*** / 30X,1H*	6	SBO.
874	1 16X, 6H***, 7X, 1H* / 29X,1H* / 16X,7H*** ***, 8X,1H* / 44X,3H***, SBO.	7	SBO.
875	2 3X,3H*** / 27X,1H*,15X,3H*** 10X,1H* / 41X,3H*** 3X,1H* SBO.	8	SBO.
876	3 2X,3H*** / 26X,1H* 13X,3H*** 3X,2H** SBO.	9	SBO.
877	4 2X,3H*** 11X,1H* / 38X,3H*** 3X,4H*** 2X,3H*** / 37X, 3H*** 3X, SBO.	10	SBO.
878	5 5H*** 2X,3H*** / 25X,1H* 9X,3H*** 3X,7H*** 2X,3H*** 12X,1H* / SBO.	11	SBO.
879	6 34X,3H*** 3X,8H*** 2X,3H*** / 32X,3H*** 15X,3H*** / 26X,1H*, 3X, SBO.	12	SBO.
880	7 3H*** 17X,3H*** 11X,1H* / 29X,3H*** 4X,12H*** 2X,3H*** / SBO.	13	SBO.
881	8 27X,4H***, 4X,13H*** 2X,3H*** 10X,1H* / 28X,2H*** 4X, SBO.	14	SBO.
882	9 14H***, 4X,13H*** 2X,50H*** AEROSPACE CORPORATION, SAN BERNARDINO OSBO.	15	SBO.
883	OPERATIONS / 29X,1H* 31X,1H* / 30X,1H*, 29X,1H* / /	16	SBO.
884	9 38X,1H* 13X,1H* / 45X,1H*)	17	SBO.
885	WRITE (6,1962)	18	SBO.
886	1962 FORMAT (1H- ,35X , 15H PRESENTS / /)	19	SBO.
887	RETURN	20	SBO.
888	END	21	SBO.

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889 SUBROUTINE ATMDS (ICK,ALT,TINF,PINF,RHOINF)
890
891 C - - - - - JOHN KOHLENBERGER
892 C - - - - -
893 C - - - - -
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895 C - - - - -
896 C - - - - -
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911 C - - - - -
912 C - - - - -
913 C - - - - -
914 C - - - - -
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916 C - - - - -
917 C - - - - -
918 C - - - - -
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921 C - - - - -
922 C - - - - -
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926 C - - - - -
927 C - - - - -
928 C - - - - -
929 C - - - - -
930 C - - - - -
931 C - - - - -

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SUBROUTINE ATMDS
 DIMENSION TIME(100),ALTI(100),VINFI(100),ADFA(100),HINSOI(100),ATMS
 1, TINSOI(100),QCONSI(100),VAPRES(100),CPG(100),TFMPW(100)
 2, QI(100),QADI(100),CP(40),EK(40),EL(40),RH(40),TEMP(40)
 3, A(4,40),B(4,40)
 4, AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
 COMMON A,ALTI,ADFA,B,CP,CPG,EK,EL,HINSOI,QADI,QCONSI,QI
 1, RHO,TEMP,TEMPW,TIMEI,TINSOI,VAPRES,VINFI
 2, AA,BB,CC,CP2,DK,T2
 COMMON ALT,AMINF,ADFA,ANGLE,CCNPR,DELTA,DQSAV
 1, EMIS,ETAI,ETA2,HINSO,HQABL,HSUBI,HV
 2, ICHK,ICK,ICONF,IGO,IN34,IN342,IRFC,
 3, NRCOL,NRBUG,NDIM,NOSB,VPAS,NQI,NPREST,NPU,NSEG,NSEGL,NSEG2
 4, NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSURI
 5, RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSL,ATMS
 6, SHKI,SHKMU,STOP,SWEET,STAGI,TABL,TIME,TINF,TINSO,TRANR
 7, TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE
 8, XX,XDIST
 9, ETATP,ETALP,HVPSTM,PSTMAX
 COMMON /WERNER/ TRVRSI,TF3(100),RHOFB(100),PFB(100),ALTCM(100)
 EQUIVALENCE (NSEG,NAROW)
 ADD
 DIMENSION HB(7),ALN(6),P9(6),TMB(6)
 C ***** 1959 A.R.D.C. ATMOSPHERE *****
 DATA HR/O.,11000.,25000.,47000.,53000.,79000.,90000./,
 1 ALM/-0.0065,0.0000,0.0030,0.0000,-0.0045,0.0/, RHOSL/.0023796/,
 2 PR/760.0,169.76,18.668,0.90342,0.43749,0.007573/,TSL/287.51/,
 3 TMA/288.16,216.66,216.66,282.66,282.66,165.56/,PSEALV/760.0/,
 4 AK/.3048/,CL/.034164794/,RE/6356776./
 C ***** 1950 A.R.D.C. A1 'OSPHERE *****
 DATA XEDEL/O./
 ADD
 IF (XEDEL.E.O.) GO TO 90999
 PSL = PSEALV
 RHOSL = RHOSL
 BEGIN REPLACEMENT
 90999 ICK = 1
 IF (TRVPSL.GT.O.) GO TO 400
 1 HK = AK*ALT
 RH = RF*HK/(RE+HK)

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C      RE = RADIUS OF EARTH METERS = 20850000.FT
DO 5 J=1,7
IF (PH.GE. HB(J)) GO TO 5
FOR NEGATIVE ALTITUDES
IF (J.EQ.1) GO TO 300
I = J - 1
BHB = BH-HB(I)
GO TO 6
5 CONTINUE
FOR ALTITUDES ABOVE 295278 FT.
GO TO 300
6 TMPB = TMB(I)+ALM(I)*RHB
TAKES PLACE OF JSWA = 2, AND TEST
IF ((I/2)*2.EQ. I ) GO TO 280
260 E = CI/ALM(I)
P = PB(I)* (TMB(I)/TMPB) **E
GO TO 290
280 E = -CI* RHB/ TMB(I)
P = PB(I) * EXP(E)
C      END REPLACEMENT
290 DELT = P/PS:
THETA = TMPB/TSL
PINF = 2116.2*DELT
TINF = 518.69*THETA
RHOINF = (0.0023769*DELT)/THETA
SIGMA = RHOINF/RHOSL
IF (NDBG.EQ.3) WRITE (6,295) I,BHB,E,P, DELT,THETA,PINF,TINF,
1 RHOINF,SIGMA
205 FORMAT (' DEBUG-ATMOS-', I',I6,' BHB=',E13.5,' E=',E13.5,' P=',E13
1.5/,' DELT, THETA, PINF, TINF, RHOINF, RHOINF/RHOSL' / 6E13.5)
GO TO 310
300 ICK = 0
IF ( (XEDE.EQ.0.) .OR. (SIGN(1.,ALT).NE.SIGN(1.,XEDE)) .OR.
1 (NDBG.EQ.3) ) WRITE(6,305) ALT
XEDE = SIGN(1.,ALT)
305 FORMAT ('- OUTSIDE ATMOS TABLES, ALTITUDE=', E16.8)
310 RETURN
400 NTRAV = TRVRSL
SLOPE = 1.
IF (ALTCM(2).LT.ALTCM(1)) SLOPE = -1.
DO 410 I=1,NTRAV
J=I-1
IF ( I.GF.2 ) SLOPE=1.
IF ((I.GE.2).AND.(ALTCM(I+1).LT.ALTCM(I))) SLOPE =-1.
ALFTT = ALTCM(I)/30.48010
IF (SLOPE.GT.0.) GO TO 405

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ATMS 79
ATMS 80
ATMS 81
ATMS 82
ATMS 83
ATMS 84

ATMS 85
ATMS 86

ATMS 87
ATMS5989
ATMS5990
ATMS5991
ATMS5992
ATMS59
ATMS59
ATMS5995
ATMS5996

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978 IF (ALT,GT,ALTFT) GO TO 415
979 GO TO 410
980
981 IF (ALT,LT,ALTFT) GO TO 415
982
983 CONTINUE
984
985 WRITE (6,411) J,ALT,ALTFT,NTRAV,SLOPE
986
987 FORMAT (' IN-ATMOS-N7 F.R. FOUND. AT END OF LOOP WITH-J,ALT,ALTFTATMS-102
988 1,NTRAV, / 16,2E16.8,16, F16.8)
989
990 GO TO 1
991
992 IF (NDBUC.EQ.3) WRITE (5,416) NTRAV,SLOPE,J,I,ALTCM(J),ALTFT,ALTCMATMS-105
993 1(J+1),ALT,TFB(J),TFB(J+1)
994
995 FORMAT (' IN-ATMOS,F.R.- NTRAV,SLOPE,J,I' /15,E16.8,2I6/' ALTCM,ALATMS-107
996 1,TFB,ALTCM(J+1),ALT,TFB,TFB(J+1),/ 5E16.8)
997
998 IF ((TFB(J).LE.0.)OR.(TFB(J+1).LE.0.)) GO TO 1
999
1000 FACTOR = (ALT#30.4801-ALTCM(J)) / (ALTCM(J+1)-ALTCM(J))
1001
1002 TINF = ((TFB(J+1)- TFB(J) ) * ACTOR + TFB(J)) * 1.9
1003
1004 RHOINF = ((RHOFR(J+1) -RHOFR(J)) * FACTOR + RHOFR(J)) * 1.94057
1005
1006 PINF = ((PFR(J+1)- PFR(J) ) * FACTOR + PFR(J)) * 2.0886E-3
1007
1008 GO TO 310
1009
1010 END

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ATMS5997
 ATMS5998
 ATMS5999
 ATMS-100
 ATMS-101
 ATMS-102
 ATMS-103
 ATMS-104
 ATMS-105
 ATMS-106
 ATMS-107
 ATMS-108

 ATMS 92
 ATMS 93
 ATMS 94

 ATMS 95
 ATMS 97

997	BLK1	1
998		
999		
1000		
1001	BLK1	4
1002	BLK1	5
1003		
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BLOCK DATA
COMMON /BLK1/ TITLE(20)
DATA TITLE/20*0./
COMMON / MIKE / HV2,ETAL2,ETAT2,XI, FV1P(10),FVIS(10),FV2P(10),
* FV2S(10),STGTBL(10),SHRTBL(10),NOPSTG,NOPSHR
2 * QSONIC,SHEAR,HJABLM,HF, ISTETS, NOCHECK,
3 PHOTBL(10,40),CPTBL(10,40),EKTBL(10,40),TENT9L(10,40)
COMMON / SWALLOW/ QIT(50),HEDGE(50),PEDGE(50),HRECOV(50)
1) * INPCW,ISFT
FOR ARCHIE USSIN - COLD WALL INPUTS FROM ENTROPY SWALLOWING
COMMON /CHARAB/ NTF,PROPTY(300)
COMMON /WFFNER/ TRVRSL,FIRBAL(400)
COMMON /RALPH/ TWTAB(20),EMTAB(20),NEMIS,NQCOR,QABSF(20),TWA(20)
FOR DR. RALPH GILBERT 10/17/70-10/29/70
9 ,ETATP,ETALP,HVPSTH,PSTMX,NT
11/25/70

DATA FIRBAL/400*0./, RHOTBL/400*0./,CPTBL,EKTBL,TENTBL/1200*0./
1 , NTF/C/,PROPTY/300*0./, QSONIC,SHEAR,HJABLM,HF/4*0./
DATA XI/1.0/, INPCW/C/, ISET/C/,ISTETS/O/,NOCHEK/O/
1,NOPSTG,NOPSHR/2*0/
DATA TWTAB,EMTAB,NEMIS,NQCOR,QABSF,TWA /40*0.,2*0,40*0./
END

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	BLK1	10
	BLK1	11

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1019 SUBROUTINE CONSTQ
1020 - CALCULATES QSUBI ON BASIS OF ALT. OR TIME
1021 - OCTOBER 14 1970 JOHN KOHLENBERGER
1022 DIMENSION TIME1(100),ALT1(100),VINFL(100),AQFAL(100),HINSDI(100)
1023 1 , TINSDI(100),QCONSI(100),VAPRES(100),CPG(100),TEMPW(100)
1024 2 , QI(100),QADI(100),CP(40),EK(40),EL(40),RHQ(40),TEMP(40)
1025 3 , A(4,40),B(4,40)
1026 4 , AA(10),BB(10),CC(10,10),CP2(10,10),CK(10,10),T2(10,10)
1027
1028 COMMON A,ALT1,AQFAL,B,CP,CPG,EK,EL,HINSDI,QADI,QCONSI,QI
1029 1 , RHC,TEMP,TEMPW,TIME1,TINSDI,VAPRES,VINFL
1030 2 , AA,BB,CC,CP2,CK,T2
1031 COMMON ALT,AMINF,AQFA,ANGLE,CNPR,DELTA,QQSAV
1032 1 , EMIS,ETAL,ETA2,HINSD,HQABL,HSUBI,HV
1033 2 , IC4K,ICK,ICONF,IG7,INR4,INR42,IRFC, KASE,KFIINT,NPQCRVQ
1034 3 , NRCOL,NDRUG,NDIM,NDSB,NPGAS,NGI,NPREST,NPU,NSEGI,NSEG2 CRVQ
1035 4 , NTHAJ,PINF,P2,PSHK,PSL,OCALT,QCONS,QINS),QNET,OSAV,QSUBI CRVQ
1036 5 , RADIUS,KECI,KEFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSLK,RHOSLCRVQ
1037 6 , SHKI,SHKMU,STOP,SWEET,STAGI,TABL,TIME,TINF,TINSD,TRANR CRVQ
1038 7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE CPVQ
1039 8 , XX,XDIST CRVQ
1040 9 , ETATP,ETALP,HVPSTM,PSTMAX CRVQ
1041
1042 COMMON /RALPH/ TWTAB(20),EMTAB(20),NEMIS,NQCTR,QABS(20),TWA(20)
1043 EQUIVALENCE (NSEG,NAROW)
1044 100 IF (NPQ.GE.2) GO TO 160
1045 C OTHERWISE USE QSOLAR
1046 110 QSUBI = QI(100)
1047 C (QI(100) = 3600 QADI(100) = QSOLAR )
1048 GO TO 200
1049 160 IF (TIME-TIME1(1)) 7,5,5
1050 5 QSUBI = FINTRP (TIME1,QI,TIME,NPGAS,1)
1051 GO TO 200
1052 7 QSUBI = CPG(1)
1053 C VARIABLE EMIS - ADDED 10/14/70
1054 200 IF (NEMIS.GT.0) EMIS = FINTRP(TWTAB,EMTAB,TWALL,NEMIS,1)
1055 IF (NQCTR.GT.0) QCONS = QCONS * FINTRP(TWA,QABSF,TWALL,NQCTR,1)
1056 QNET = QSUBI*QCONS - (.174*EMIS* (TWALL/100.))**.4)
1057 C TAKEN FROM -ENERGY-
1058 RETURN
1059 END

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1060 SUBROUTINE DIST
1061 C -- - MARCH 27 1964 JOHN KOHLENBERGER
1062 C SURROUTINE DIST (ICONF, REYN, TRANR, XDIST, XX)
1063 C DIMENSION TIME1(100), ALTI(100), VINFI(100), AQFAL(100), HINSDI(100), HINSDI(100), HINSDI(100)
1064 C TINSOI(100), QCONSI(100), VAPRES(100), CPG(100), TEMPW(100)
1065 C QI(100), QAD(100), CP(40), EK(40), EL(40), RHO(40), TEMP(40)
1066 C A(4,40), B(4,40)
1067 C AA(10), RH(10), CC(10,10), CP2(10,10), DK(10,10), T2(10,10)
1068 C COMMON A, ALTI, AQFAL, B, CP, CPG, EK, EL, HINSDI, QAD, QCONSI, QI
1069 C 1, RHU, TEMP, TEMPW, TIME1, TINSOI, VAPRES, VINFI
1070 C 2, AA, BB, CC, CP2, DK, T2
1071 C COMMON ALT, AMINF, AQFA, ANGLE, CONPR, DFLTA, DQSAV
1072 C 1, EMIS, ETAL, ETA2, HINSD, HOARL, HSURI, HV
1073 C 2, ICHK, ICK, ICONF, IGO, INR4, INB42, IREC, KASE, KFUNT, NPQDISTX
1074 C 3, NBCOL, NDRUG, NDIM, NOSB, NPGAS, NQI, NPREST, NPU, NSEG, NSEGI, NSFG2
1075 C 4, NTRAJ, PINF, PR, PSHK, PSL, QCALT, QCONS, QINSD, QNET, QSAV, QSUBI
1076 C 5, RADIUS, RECI, REFI, RFFMU, REFRHC, REFRM, REYN, RHOINF, RHOSHK, RHOSLD
1077 C 6, SHKI, SHKMU, STOP, SWEEP, STAGI, TABL, TIME, TINF, TINSO, TRANR
1078 C 7, TSHK, TWALL, TWNB, VINFI, VSHK, W, WAB, WABDOT, WALLI, WRITE
1079 C 8, XX, XDIST
1080 C 9, FTATP, ETALP, HVPSTM, PSTIMAX
1081 C EQUIVALENCE (NSEG, NAROW)
1082 C GO TO (100, 100, 5, 110, 110), ICONF
1083 C 5 IF (NOSB) 100, 100, 120
1084 C 10-13-64 BYPASS OLD XX CALCULATION
1085 C 100 XX = XDIST
1086 C GO TO 200
1087 C 110 IF (RADIUS) 100, 100, 120
1088 C 120 XX = RADIUS * 2.
1089 C NAMELIST/XXDIST/ XX, XDIST, RADIUS, ICONF, NDSB
1090 C 200 IF (NDEBUG.GE.2) WRITE (5, XXDIST)
1091 C RETURN
1092 C END
1093
DISTX 3
DISTX 1
DISTX 2
DISTX 4
DISTX 5
DISTX 6
DISTX 7
DISTX 8
DISTX 9
DISTX 10
DISTX 11
DISTX 12
DISTX 13
DISTX 14
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DISTX 25
DISTX 26
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DISTX 28
DISTX 29
DISTX 30
DISTX 32

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1094 SUBROUTINE ECKERT
1095
1096   C -- FLAT PLATE, WEDGE, CONE CALCULATIONS
1097   C -- MARCH 27 1969 JOHN KOHLFENBECKER
1098   C SUBROUTINE ECKERT (ICONE, IREFC, XX, REFMU, REFRHO, VSHK, RECI, WALLI,
1099   C IQSUBI, HSURI)
1100   DIMENSION TIME1(100), ALTI(100), VINFI(100), ADFAL(100), HINSOI(100)
1101   1, TINSI(100), QCONSI(100), VAPRES(100), CPS(100), TEMPW(100)
1102   2, QI(100), QADI(100), CP(40), EK(40), FL(40), RH(40), TEMP(40)
1103   3, A(4,40), B(4,40)
1104   4, AA(10), BR(10), CC(10,10), CP2(10,10), DK(10,10), T2(10,10)
1105   COMMON A, ALTI, ADFAL, B, CP, CPG, EK, EL, HINSOI, QADI, QCONSI, QI
1106   1, RHO, TEMP, TEMPW, TIME1, TINSOI, VAPRES, VINFI
1107   2, AA, BB, CC, CP2, DK, T2
1108   COMMON ALT, AMINF, ADF, ANGLE, CCNPR, DELTA, DQSAV
1109   1, FMIS, ETAL, ETA2, HINSO, HJABL, HSURI, HV
1110   2, ICHK, ICK, ICONE, IGH, INB4, INB42, IREFC, KASF, KFUNT, NPQECRT
1111   3, NRCOL, NRCUG, NOIM, NQSB, NPGAS, NCI, NPRES, NPU, VSFG, NSEGI, NSFG2
1112   4, NTRAJ, PINF, PR, PSHK, PSL, QCALT, QCONS, QINSO, QNET, QSAV, QSURI
1113   5, RADIUS, RECI, REFI, REFMU, REFRHO, REFRM, REYN, RHJINE, RHOSHK, RHOSLECKRT
1114   6, SHKI, SHKMU, STOP, SWEEP, STAGI, TABL, TIME, TINF, TINSO, TRANR
1115   7, TSHK, TWALL, TWB3, VINFI, VSHK, W, WAB, WADOOT, WALLI, WPIE
1116   8, XX, XDIST
1117   9, ETATP, ETALP, HVPSTM, PSTMAX
1118   EQUIVALENCE (NSEG, NAROW)
1119   DIMENSION YCC(20), Z(20)
1120   DATA Z/.043, .045, .05, .07, .1, .2, .3, .5, .1, .2, .3, .5, .6, .8, .10, .20, .
1121   1 100, 1000, /, YCC/.3, .2, .3, .2, .7, .2, .1, .6, .94, .8, .73, .7, .6999, .5, .4, .32,
1122   2 .29, .26, .25, .22, .16, .07, .01/
1123   5 GO TO (10, 10, 10, 200, 200), ICONE
1124   10 GC = 32.2
1125   GO TO (20, 30), IREFC
1126   C -- LAMINAR EQUATIONS --
1127   20 ALPHA = ANGLE/57.3
1128   IF (RADIUS, LE, C.) GO TO 1009
1129   ZE = ALPHA**2 * COS(ALPHA) / (.802 * RADIUS) * XDIST
1130   1000 IF (ZE) 1009, 1009, 1001
1131   1001 YCV = FINTRP(Z, YCC, ZE, ZC, 2)
1132   C NORMAL SHOCK -- GRIFFITH AND LEWIS SOLUTION
1133   AINF = .24 * TINF
1134   AISTAR = STAGI/6. * (1. + 3. * WALLI/STAGI)
1135   CS2 = 2.58 * AINF**2.53 / AISTAR**3.86
1136   UINF = .173E-5 + .00933E-5 * AINF

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1137 REINF= RHOINF*VINF/ UINF *RADIUS*64.4
1138 IF(ZE-1.5) 1007,1007,1006
1139 1006 CSURP = 2.46 * ALPHA**2
1140 GO TO 1008
1141 1007 CSURP=2.*ALPHA**2*((( (-6.3*ZE+29.3)*ZE-52.2)*ZE+43.15)*ZE-15.5)
1142 1 *ZE +2.67)
1143 1008 CH = YCV*AMINF*ALPHA**2*(1.+1.428/(AMINF**2*CSURP))*CS2/
1144 1 (SQRT(REINF))*6320)
1145 HSUBI = CH*1.4*PINF*AMINF**2*115920./VINF
1146 QSUBI = HSUBI*(STAGI-WALLI)
1147 GO TO 200
1148 C BLASIUS SOLUTION
1149 1009 REFRN = (REFRHO*VSHK**XX)/REFMU
1150 CF = .664/(SQRT (REFRN))
1151 ST = (CF/2.0)*(PR**(-2./3.))
1152 HSUBW = ST*REFRHO*VSHK*GC*3600.
1153 GO TO 100
1154 C - TURBULENT EQUATIONS -
1155 CHANGED FOR OS/360 - NO DIVIDE BY ZERO
1156 30 IF (REFMU.NE.0.) GO TO 31
1157 HSURW = 0.
1158 GO TO 100
1159 31 REFRV = (REFRHO*VSHK**XX)/REFMU
1160 C SCHULTZ-GRUNOW
1161 CF = .370/(((ALOG(REFRN))/2.303)**2.594)
1162 ST = (CF/2.)*(PR**(-2./3.))
1163 HSUBW = ST*VSHK*REFRHO*GC*3600.
1164 100 GO TO (110,110,120),ICONF
1165 110 HSURI = HSURW
1166 GO TO 150
1167 120 GO TO (130,140),IREC
1168 130 HSUBI = 1.73*HSURW
1169 GO TO 150
1170 140 HSUBI = 1.176*HSURW
1171 150 QSUBI = HSUBI*(RECI-WALLI)
1172 200 RETURN
1173 END
ECKRT 83
ECKRT 84
ECKRT 85
ECKRT 86
ECKRT 87
ECKRT 88
ECKRT 89
ECKRT 90
ECKRT 91
ECKRT 92
ECKRT 93
ECKRT 94
ECKRT 95
ECKRT 96
ECKRT 97
ECKRT 98
ECKRT 99
ECKRT100
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ECKRT113
ECKRT114
ECKRT115

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1174 SURROUTINE ENERGY
1175 MAPCH 27 1969 JOHN KOHLENBERGER FORTRAN IV
1176 SURROUTINE ENERGY (QCONS,QSUBI,EMIS,TWALL,QNET)
1177 CFENERGY
1178 ENCO DECK,LIST ENERGY CONVERSION ROUTINE 2/21/67
1179 DIMENSION TIME1(100),ALTI(100),VINFL(100),AOFAL(100),HINSD1(100)ENCO
1180 1 , TINSO1(100),QCONS1(100),VAPRES(100),CPG(100),TEMPW(100) ENCO
1181 2 , QI(100),QADI(100),CP(40),EK(40),EL(40),RHQ(40),TEMP(40) ENCO
1182 3 , A(4,40),B(4,40) ENCO
1183 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10) ENCO
1184 COMMON A,ALTI,AOFAL,B,CP,CPG,EK,EL,HINSD1,QADI,QCONS1,QI ENCO
1185 1 , RHO,TEMP,TEMPW,TIME1,TINSO1,VAPRES,VINFL ENCO
1186 2 , AA,BB,CC,CP2,DK,T2 ENCO
1187 COMMON ALT,AMINF,AJFA,ANGLE,CONPR,DELTA,DQSAV ENCO
1188 1 , EMIS,ETAL,ETA2,HINSD,HQABL,HSURI,HV ENCO
1189 2 , ICHK,ICK,ICONF,IGO,INR4,INR42,IREF, KASE,KFUNT, NPQENCO
1190 3 , NBZOL,NDBJG,NJIM,NJSR,NPGAS,NCI,NPREST,NPU,NSEG,NSEG1,NSEG2 ENCO
1191 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSO,QNET,QSAV,QSUBI ENCO
1192 5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,PEYN,RHOINF,RHOSHK,RHOSLENCO
1193 6 , SHKI,SHKMU,STOP,SWEET,STAGI,TABL,TIME,TINF,TINSO,TRANR ENCO
1194 7 , TSHK,TWALL,TWNR,VINF,VSHK,W,WAB,WABDNT,WALLI,WRITE ENCO
1195 8 , XX,XOIST ENCO
1196 9 , FTATP,ETALP,HVPSTM,PSTMAX ENCO
1197 COMMON /PHIL/ NPQS,QSTAR(10),PSTAGN(10) ENCO
1198 COMMON / SWALLOW / JINT(50),HEDGE(50),PEDGE(50),UEDGE(50),HRECOV(50)ENCO
1199 1) , INPCW
1200 FOR ARCHIF QSSIN - COLD WALL INPUTS FROM ENTROPY SWALLOWING ENCO
1201 EQUIVALENCE (NSEG,NAROW) ENCO
1202 EQUIVALENCE (QCALT,TRANLT) ENCO
1203 ENTHLP(WA) = ((.23676E-9*WA +.11571E-4)*WA +.2272)*WA +2.2864 ENCO
1204 1 IF (INPCW.LE.0) GO TO 100 ENCO
1205 QICLO = QSUBI ENCO
1206 AATNF = ENTHLP(TINF) ENCO
1207 WALLI = ENTHLP(TWALL) ENCO
1208 AMINF = VINF / (49.01* SORT(TINF)) ENCO
1209 AMSA = AMINF *SIN ((AOFAL+ANGLE)/57.2958) ENCO
1210 2 IF (SHKI.GE.1300.) GO TO 3 ENCO
1211 SHKMU = .42642E-7* SHKI**4.93 ENCO
1212 RHOSHK =.576E-4 * SHKI**(-.849) *PSHK ENCO
1213 CQ TO 4 ENCO
1214 3 SHKMU = .28428E-6* SHKI**2.29 ENCO
1215 RHOSHK = .865E-5 * SHKI**(-.584) *PSHK ENCO
1216 4 IF (TRANR.GT.0.) GO TO 6 ENCO

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1217 IF (TRANLT.LT.O.)WRITE(6,5)
1218 5 FORMAT ('-TRANR AND TRANLT BOTH LESS THAN ZERO, NO G.E. TRANSITION' 42
1219 1//, *** LAMINAR ASSUMED ***)
1220 IF (ALT.GT.TRANLT) GO TO 8
1221 6 CALL DIST
1222 REYN = VSHK *RHOSPK*XDIST/ SHKMU
1223 IF (RFYN.GT.TRANR) GO TO 9
1224 8 IREC = 1
1225 GO TO 7734
1226 9 IRC = 2
1227 7734 IF (IREC.EQ.IRCOLD) GO TO 442
1228 WRITE (6,427) IRCOLD,IREC
1229 IRCOLD = IREC
1230 427 FORMAT ( ' 37H- TRANSITION (COLD WALL) HAS OCCURRED / 6H FROM 13,
1231 1 6H TO 13 )
1232 442 PR = .76
1233 GO TO (50,60,120) ,IREC
1234 50 REC = SQRT(PR)
1235 GO TO 70
1236 60 REC = PR **(.33333)
1237 GO TO 70
1238 C
1239 ENTRY FNCO
1240 WALLI = ENTHLP(TWALL)
1241 C
1242 3-28-69
1243 70 RECI = SHKI + REC* VSHK**2 / 50061.5
1244 REFI = SHKI + 0.5* (WALLI-SHKI) + .22*(RECI-SHKI)
1245 120 HQ = RECI
1246 HW = WALLI
1247 HEDG = SHKI
1248 QCOLD = QIOLD
1249 STARI = .28*HEDG +.22*HR +.5*HW
1250 IF (I*EC.NF.2) GO TO 30
1251 IF (STARI.GE.1300.) GO TO 10
1252 EKIM = .493
1253 DEN = .849
1254 ONEK = 5.76E-5
1255 TWOK = 4.264E-4
1256 GO TO 20
1257 10 EKIM = .288
1258 DFN = .584
1259 ONEK = 8.65E-6
1260 TWOK = 2.84E-7
1261 20 CONSTC = ONEK/TWOK *PSHK*VSHK**X
1262 UPPER = ALJG10(CONSTC*(REFI-.5*HW)**(-EKIM-DEN))
1263 QWERL = ALJG10(CONSTC*(REFI) **(-EKIM-DEN))

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1263 OWL = ALG10(CNSTC*(1.28*HEDG+.22*HR+.65.)*2.584) **(-FKIM-DEN))
1264 SECOND= (UPPER/OWFL)**2.584
1265 THIRD = (UPPER/OWL)**2.584
1266 GO TO 35
1267 DEN = .178
1268 SECOND = 1.
1269 THIRD = 1.
1270 CPF = ( 1.+ 2.27*HW/HR /(1.+1.27*HEDG/HR) ) **(-DEN) *SECOND
1271 CR2 = ( 1.+ 2.95.1 /HR /(1.+1.27*HEDG/HR) ) **(-DEN) *THIRD
1272 QSUBI = QCOLD * CRE*(1.-HW/HR)
1273 QSUBI = QSUBI/(CR2*(1.-130./HR))
1274 IF (QCONS.NE.O.) GO TO 190
1275 IF (NPQS.LE.O.) GO TO 150
1276 IF (AMINF.GT.1.09) GO TO 130
1277 PSTAG =(PINF + RHDINF*VINP**2 *.5 1/2116.
1278 GO TO 131
1279 PSTAG = PINF*(1.2*(AMINF**2)**3.5 *(6./(7.*(AMINF**2)-1.))**2.5
1280 1 / 2115.
1281 STARO = WARDOT/QNET
1282 HV = FINTRP (JSTAR,PSTAG,STARQ,NPQS,1)
1283 HV = FINTRP (PSTAG,QSTAR,PSTAG,NPQS,1)
1284 IF (QCONS) 151,180,190
1285 GETS 'QNET' AT THIS POINT
1286 CALL CONSTQ
1287 GO TO 200
1288 USE 'QNET' BELOW IF 'QCONS'=0.0
1289 COMMENTED CARDS DELETED
1290 APR. 15, '71
1291 QNET = QSUBI-(.174*EMIS*(TWALL/100.))**4)
1292 GO TO 200
1293 QNET = QCONS*QSUBI - .174*EMIS*(TWALL/100.))**4
1294 IF (NDRUG.NE.14) GO TO 250
1295 WRITE (6,201) TIME,ALT,VINF,IPEG, QCONS,QSUBI,EMIS,TWALL,QNET
1296 FORMAT (14H DEBUG-ENERGY- /23H TIME, ALT, VINF, IREC /3E16.8,16/
1297 1 32H QCONS, QSUBI, EMIS, TWALL, QNET /6E16.8 )
1298 IF (INPCW.GT.O) WRITE (6,205) INPCW,HR,HW,HEDG,QCOLD,STAR1,
1299 1 EKIM,DFN,CNFK,TWOK,SECOND, CCNSTC,UPPER,OWFL, CRE
1300 FORMAT ( 8H INPCW = 16 / 30H HR, HW, HEDG, QCOLD, STAR1 /5E16.8ENCO 104
1301 18 /304 EKIM, DFN, UNFK, TWOK, SECOND/ 5E16.8/ 3E16.8/ 5H CRE=E16.8ENCO 107
1302 2 ) ENCO 108
1303 RETURN ENCO 109
1304 END ENCO 110

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1305      FUNCTION      FINTRP (XA,YA,X,N,M)
1306      M = 1 LINEAR . . . . . M = 2 PARABOLIC . . . M = 3 STEP
1307      DIMENSION XA(2),YA(2)
1308      I = 1
1309      IF ( X-XA(1) )
1310      DO 10 I=2,N
1311      IF ( XA(I)-X )
1312      CONTINUE
1313      GO WRITE (6,96) X,XA(1),XA(I),I,N
1314      96 FORMAT ( 16H-ERROR IN FINTRP / 7X,1HX 19X,5HXA(1) 15X,5HXA(I)
1315      1 15X,1H1 7X,24N / 3E20.8,2I7 )
1316      FINTRP = YA(I)
1317      GO TO
1318      20 IF (M-2) 30,40,15
1319      30 IF (XA(I).EQ.XA(I-1)) GO TO 35
1320      FINTRP = YA(I) - (YA(I-1)-YA(I))*(XA(I)-X)/(XA(I-1)-XA(I))
1321      GO TO 100
1322      35 FINTRP = YA(I)
1323      GO TO
1324      IF ( N-2 )
1325      IF ( I-N )
1326      I=I-1
1327      S2 = XA(I-1)**2
1328      S1 = S2-XA(I)**2
1329      S2 = S2-XA(I+1)**2
1330      X1 = XA(I-1)-XA(I)
1331      X2 = XA(I-1)-XA(I+1)
1332      Y1 = YA(I-1)-YA(I)
1333      Y2 = YA(I-1)-YA(I+1)
1334      FINTRP = ((Y1, . . . 2/X2)/(S1/X1-S2/X2))*X+((Y1/S1-Y2/S2)/
1335      1 (X1/S1-X2/S2))*X+YA(I)-((Y1/X1-Y2/X2)/(S1/X1-S2/X2))*
1336      2 XA(I)+(Y1/S1-Y2/S2)/(X1/S1-X2/S2))*XA(I)
1337      100 RETURN
1338      END

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SUBROUTINE GECPK2

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CGFCPK2
C      THIS ROUTINE GETS CP2(I,K), DK(I,K) I=1,NAROW K=1,NBCOL FOR TWO
C      - - - APRIL 8 1964      JOHN KOEHLERBERGER
C      DIMENSION TIME1(100),ALTI(100),VINFI(100),AQFAL(100),HINSOI(100)CPKK
1      TINSOI(100),QCONS1(100),VAPRES(100),CPG(100),TEMPW(100)CPKK
2      QI(100),QADI(100),CP(40),FK(40),FL(40),RHO(40),TEMP(40)CPKK
3      A(4,40),B(4,40)CPKK
4      AA(10),BB(10),CC(10,10),CP2(10,10),OK(10,10),T2(10,10)CPKK
COMMON A,ALTI,AQFAL,B,CP,CPG,EK,EL,HINSOI,QADI,QCONS1,QI
1      PHO,TEMP,TEMPW,TIME1,TINSOI,VAPRES,VINFI
2      AA,BB,CC,CP2,DK,T2
COMMON ALT,AMIN,AQFA,ANGLE,CONPR,DELTA,DQSAV
1      EMIS,ETAL,ETA2,HINSO,H7ABL,HSURI,HV
2      TCHK,ICK,ICONE,IGD,INR4,INR42,IREC,KASF,KFUNT,NPQCCK
3      NRCOL,NOBUS,NOIM,NOSB,NPGAS,NGI,NPREST,NPU,NSEG,NSEGI,NSEG2CPKK
4      NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBICPKK
5      RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSLCPKK
6      SHKI,SHKMU,STOP,SHEEP,STAGI,TABL,TIME,TINF,TINSO,TRANRCPKK
7      TSHK,TWALL,TWN3,VINF,VSHK,W,WAB,WABDJI,WALLI,WPIECPKK
8      XX,XOIST
9      FTATP,ETALP,HVPSTM,PSTMAX
EQUIVALENCE (NSEG,NAROW)
KFUNT = 0,DK AND CP2 ENTERED DIRECTLY, OFBUG RETAINED
KFUNT = 1 EK(I) AND CP(I) ARE BGT.I FCNS OF TEMP(I)
KFUNT = 2 EK(I) IS FCN OF TEMP(I), CP(I) ARE CONSTANT
KFUNT = 3 EK(I) ARE CONSTANT, CP(I) ARE FCNS OF TEMP(I)
KFUNT = 4 BOTH EK(I) AND CP(I) ARE CONSTANT
COMMON /MIKE/ STUFF(71),RHOI(10,40),CPTBL(10,40),EKTBL(10,40),
1      TEMTBL(10,40)
DO 510 I = 1,NAROW
IF (KFUNT.EQ. 0) GO TO 504
IF (KFUNT.GT.4) GO TO 501
10 GO TO (100,200,300,400),KFUNT
100 DO 125 K = 1,NBCOL
105 IF (CC(I,K))110,125,110
110 DK(I,K) = A(1,I)+T2(I,K)*(A(2,I)+T2(I,K)*(A(3,I)+A(4,I)*T2(I,
1K)))
120 CP2(I,K) = B(1,I)+T2(I,K)*(B(2,I)+T2(I,K)*(B(3,I)+B(4,I)*
1T2(I,K)))
125 CONTINUE
130 GO TO 504
200 DO 225 K = 1,NBCOL

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CPKK 39
CPKK 40
CPKK 41
CPKK 42
CPKK 43
CPKK 44
CPKK 46
CPKK 47
CPKK 48
CPKK 49
CPKK 50
CPKK 51
CPKK 52
CPKK 54
CPKK 55
CPKK 56
CPKK 57
CPKK 58

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205 IF (CC(I,K)) 210,225,210
210 CP2(I,K) = B(1,I)
220 DK(I,K) = A(1,I)+T2(I,K)*(A(2,I)+T2(I,K)*(A(3,I)+A(4,I)*
    T2(I,K)))
225 CONTINUE
230 GO TO 504
300 DO 325 K = 1,NBCOL
305 IF (CC(I,K)) 310,325,310
310 DK(I,K) = A(1,I)
320 CP2(I,K) = B(1,I)+T2(I,K)*(B(2,I)+T2(I,K)*(B(3,I)+B(4,I)*
    T2(I,K)))
325 CONTINUE
330 GO TO 504
400 DO 425 K = 1,NBCOL
405 IF (CC(I,K)) 410,425,410
410 DK(I,K) = A(1,I)
420 CP2(I,K) = B(1,I)
425 CONTINUE
    GO TO 504

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C THIS IS NOW IN FINAL FORM, RHO2(I,KE SHOULD BE FORMED

```

501 K=NSEG1
C A ROUGH ESTIMATION FOR T2
RHO(I) = FINTRP (TEMTBL(1,I),RHCTBL(1,I),T2(I,K),KFUNT,1)
DO 502 K=1,NBCOL
IF (CC(I,K).EQ.0.) GO TO 504
CP2(I,K) = FINTRP(TEMTBL(1,I),CPTBL(1,I),T2(I,K),KFUNT,1)
DK (I,K) = FINTRP(TEMTBL(1,I),EKTBL(1,I),T2(I,K),KFUNT,1)
502 CONTINUE
504 IF (N8BUG.EQ.2) WRITE (6,505) I,RHO(I),(K,CP2(I,K),DK(I,K)
    1, K=1,NBCOL)
505 FORMAT ( I6, E16.8/(I6,6E16.8))
510 CONTINUE
500 RETURN
END

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CPKK 59
CPKK 60

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1416 SUBROUTINE GETCPK
1417 C - - - MARCH 27 1964 JOHN KÄHLENBERGER FORTRAN IV
1418 DIMENSION TIME1(100),ALTI(100),VINFI(100),AOFAL(100),HINSOI(100)
1419 1, TINSOI(100),QCONS1(100),VAPRES(100),CPG(100),TFMPW(100)
1420 2, QI(100),QADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
1421 3, A(4,40),B(4,40)
1422 4, AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
1423 COMMON A,ALTI,AOFAL,B,CP,CPG,EK,EL,HINSOI,QADI,QCONS1,QI
1424 1, RHO,TEMP,TFMPW,TIMF1,TINSOI,VAPRES,VIMF1
1425 2, AA,BB,CC,CP2,DK,T2
1426 COMMON ALTI,AMINF,AOFAL,ANGLE,CONPR,DELTA,DQSAV
1427 1, FMIS,ETAI,ETA2,HINSOI,HQABL,HSUBI,HV KASE,KFUNT,NPQC
1428 2, ICHK,ICK,ICUNF,IGQ,INR4,INR42,IRFC, NPU,NSEG,NSEGI,NSEGP
1429 3, NBCUL,NBRUG,NDIM,NDSB,NPGAS,NCI,NPPEST,NPU,NSEG,NSEGI,NSEGP
1430 4, NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,INSD,QNET,QSAV,QSUBI
1431 5, DADJUS,RECI,REFI,RTFMU,REFRM,REYN,RHOINF,RHOSLK,RHOSLC
1432 6, SHKI,SHKMU,STOP,SWEET,STAGI,TABL,TIME,TINF,TINSOI,TRANR
1433 7, TSHK,TWALL,TWNR,VINF,VSHK,W,WAB,WABOJT,WALLI,WRITE
1434 8, XX,XOIST
1435 9, ETATP,ETALP,HVPSTM,PSIMAX
1436 COMMON /MIKE/ STUFF(64),JUNK(2),SOMF(4),JAZZ(2),
1437 RHJTL(10,40),CPTBL(10,40),EKTRL(10,40),TEMTBL(10,40)
1438 EQUIVALENCE (NSEG,NROW)
1439 KFUNT = 1 FK(I) AND CP(I) ARE BOTH FCNS OF TEMP(I)
1440 KFUNT = 2 EK(I) IS FCN OF TEMP(I), CP(I) ARE CONSTANT
1441 KFUNT = 3 EK(I) ARE CONSTANT, CP(I) ARE FCNS OF TEMP(I)
1442 KFUNT = 4 BOTH EK(I) AND CP(I) ARE CONSTANT
1443 IF (KFUNT.GT.4) GO TO 5678
1444 TABLE LOOK-UP - TEMP DEPENDANT RHO,CP,EK AT 5678
1445 GO TO (100,200,300,400),KFUNT
1446 NOTE - POSSIBLY BYPASS COMPUTING OF CONSTANTS AFTER 1ST STEP
1447 DO 120 I = NSEG2,NSEG
1448 FK(I) = A(1,I)+TEMP(I)*(A(2,I)+TEMP(I)*A(3,I)+A(4,I)*TEMP(I))
1449 CP(I) = B(1,I)+TEMP(I)*(B(2,I)+TEMP(I)*B(3,I)+B(4,I)*TEMP(I))
1450 GO TO 500
1451 DO 220 I = NSEG2,NSEG
1452 CP(I) = B(1,I)
1453 EK(I) = A(1,I)+TEMP(I)*(A(2,I)+TEMP(I)*A(3,I)+A(4,I)*TEMP(I))
1454 GO TO 500
1455 DO 320 I = NSEG2,NSEG
1456 FK(I) = A(1,I)
1457 CP(I) = B(1,I)+TEMP(I)*(B(2,I)+TEMP(I)*B(3,I)+B(4,I)*TEMP(I))
1458

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CPAND 44
CPAND 45
CPAND 46
CPAND 47
CPAND 48
CPAND 49
CPAND 50
CPAND 51
CPAND 52
CPAND 53
CPAND 54
CPAND 55
CPAND 56
CPAND 57

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1459      GO TO 500
1460      DO 420 I = NSEG2,NSEG
1461          EK(I) = A(I,I)
1462          CP(I) = B(I,I)
1463      420 RETURN
1464      DO 5680 I=NSEG2,NSEG
1465          RHO(I) = FINTRP(TEMPBL(1,I),RHOBL(1,I),TEMP(I),KFUNT,1)
1466          EK(I) = FINTRP(TEMPBL(1,I), EKTR(1,I),TEMP(I),KFUNT,1)
1467          CP(I) = FINTRP(TEMPBL(1,I), CPTBL(1,I),TEMP(I),KFUNT,1)
1468          IF (NOBUG.EQ.1) WRITE(6,5679) I,RHO(I),EK(I),CP(I)
1469          5679 FORMAT ( 28H RHO,K,CP INTERPOLATED,SEG= I3,3E16.9 )
1470      5680 CONTINUE
1471      GO TO 500
1472      END

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1473 SURBOUNTNE HANKEY
1474 CHANKEY - SONIC POINT HEAT FLUX SUBROUTINE - AFROSPACE CORP. (580)
1475 C COMPOSED BY JOHN BERGER
1476 C WRITTEN BY JOHN KOHLFENBERGER
1477 C TO THE TUNE OF SMITH-FISHER (3006A)
1478 C
1479 AS DIRECTED BY Z. GYETVAY
1480 DIMENSION TIME(100),ALT(100),VINF(100),ADFAI(100),HINSDI(100)
1481 1, TINSO(100),QCONS(100),VAPRES(100),CPG(100),TEMPW(100)
1482 2, OI(100),OADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
1483 3, A(4,40),R(4,40)
1484 4, AAI(5),RRI(1),FC(1,10),CD(10,10),OK(10,10),T2(10,10)
1485 COMMON A,ALT1,ADFAI,CP,CPG,FK,FL, HINSDI, OADI,QCONS,OI
1486 1, PHC, TEMP,TEMPW,TIME1,TINSO1, VAPRES,VINF1
1487 2, AA, BB, CC,CP2, OK, T2
1488 COMMON ALT,AMIN,ADFA,ANGLE, CONPR, DELTA, DQSAV
1489 1, FMIS,ETAI,ETA2, HINSD,HDAB,HSUBI,HV
1490 2, TCHK,ICK,ICOF,IG,INR4,INR42,IRCC, KASE,KFINT, NPQFLUX
1491 3, NACU,NOFUC,NDIM,NDSB,NPGAS,NJ,NPREST,NPU,NSEG,NSFG1,NSFG2 FLUX
1492 4, NTRAJ,PIJ,PR,PSHK,PSL,QCALT,QCONS,INSD,INFT,QSAV,CSUBI FLUX
1493 5, RADIUS,RECI,PEFI,RTFMU,REFRHO,REFRM,REYI,RHOINE,RHOSL FLUX
1494 6, SHKI,SHKMU,STOP,SWEPT,STAGI,TABL,TIME,TINF,TINSD,TRANR FLUX
1495 7, TSHK,TWALL,TWNP,VINF,VSHK,W,WAB,WABDT,WALLI,WR TE FLUX
1496 8, XX,XDIST FLUX
1497 9, FTATO,FTALP,HVOSTM,PSIMAX FLUX
1498 EQUIVALENCE (NSEG,MAQW),(QCALT,TRANLT) FLUX
1499 RN = XX/2. FLUX
1500 IF (RADIUS.GT.C.) GO TO 300 FLUX
1501 PADIUS = PV FLUX
1502 300 IF (ICOF.LT.3) GO TO 400 FLUX
1503 BFLUF, SHKMU IS REALLY MU-INFINITY FLUX
1504 XX = RADIUS * 2. FLUX
1505 AINF = ((.23675E-9*TINF+.11571E-4)*TINF+.2272)*TINF+.2864 FLUX
1506 SHKMU = .42842E-7 *(AINF#.493) FLUX
1507 REYN = VINF#RHOINE#RADIUS/SHKMU FLUX
1508 VSHK = .301#VINF FLUX
1509 IF (TRANP) 426,426,429 FLUX
1510 426 IF (ALT-TRANLT) 427,428,430 FLUX
1511 427 IF (TRANP) 423,428,429 FLUX
1512 429 CALL PRINT FLUX
1513 WRITE (6,556) FLUX
1514 TRANR = REYN FLUX
1515 GO TO 435 FLUX
1516 429 IF (REYN-TRANP) 430,430,435 FLUX

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1516 C          CHANGED 8-4-67 TO GUARD AGAINST OS/360 DIVIDE BY 0.
1517 430 IF (RADIUS.LE.0.) GO TO 436
1518 QDOT = 10800.*SQRT(RHOINF/RHOSL)*((VINP/26000.)**3.15)
1519 1 *((STAGI-WALLI)/(STAGI-129.5))/SQRT(RADIUS)
1520 GO TO 440
1521 435 IF ((STAGI.EQ.0.).OR.(RN.LE.0.)) GO TO 436
1522 QDOT = 5.*(RHOINF/RHOSL)**.8*(VINP/1000.)**3*(1.-WALLI/STAGI)
1523 1 / (RN**.2)
1524 GO TO 440
1525 434 QDOT = 0.
1526 440 QSUBI = QDOT*3600.
1527 666 FORMAT ( 53H-* * * * * HANKEY TRANSITION HAS OCCURRED * * * *)
1528 GO TO 600
1529 C 500 CALL KEMP
1530 600 IF (NDEBUG-8) 700,610,700
1531 610 WRITE (6,612) QDOT,QSUBI,RHOINF,'INF,RN,RHOSL
1532 612 FORMAT (61H-.HANKEY. DEBUG, INCLUDES QDOT,QSUBI,RHOINF,VINF,RN,
1533 1 RHOSL / 6F16.8 )
1534 700 RETURN
1535 END
FLUXG 43
FLUXG 44
FLUXG 45
FLUXG 46
FLUXG 47
FLUXG 48
FLUXG 49
FLUXG 50
FLUXG 51
FLUXG 52
FLUX 49
FLUX 50
FLUX 51
FLUX 52
FLUX 53
FLUX 54
FLUX 55
FLUX 56
FLUX 57
FLUX 58

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1536 SUBROUTINE INPUT
1537 C - - - OCTOBER 14 1970 JOHN KOHLENBERGER FORTAN IV
1538 C INPUT B006F, USING I.B.M. NAMELIST FORTAN IV (7094, 360 FMJLATOR)
1539 C MODIFIED FOR FORTAN IV-G, VERSION 14 COMPILER
1540 C - - - JANUARY 20, 1968 JOHN KOHLENBERGER AEROSPACE CORP. SAN BERINPU
1541 C UP-DATED JUNF 11, 1968
1542 C DIMENSION TIME(100),ALTI(100),VINFL(100),ADFA(100),HINSOI(100)INPU
1543 C 1, TINS(100),QCONS(100),VAPRES(100),CPG(100),TEMPW(100)INPU
1544 C 2, QI(100),QAOI(100),CP(40),EK(40),FL(40),RHU(40),TEMP(40)INPU
1545 C 3, A(4,40),B(4,40)INPU
1546 C 4, AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)INPU
1547 C DIMENSION TIME(100),ALT(100),VINF(100),ADFA(100),INPU
1548 C 1 QCONS(100),STAGEN(100),TEMPER(40)INPU
1549 C DIMENSION AL(40),A2(40),A3(40),A4(40),B1(40),B2(40),B3(40),B4(40)INPU
1550 C DIMENSION GARHIJ(20)INPU
1551 C DIMENSION DATA(20)INPU
1552 C
1553 C COMMON A,ALTI,ADFAI,B,CP,CPG,FK,FL,HINSOI,QAOI,QCONS,I,QI
1554 C 1, RHG, TEMP,TEMPW,TIMF1,TINSOI,VAPRES,VINF
1555 C 2, AA,BB,CC,CP2,DK,T2
1556 C COMMON ALTI,AMIN,ANGDFA,ANGLE,CONPR,DELTA,DOSAV
1557 C 1,FMIS,ETAL,ETAP,HINSO,HQABL,HSURI,HV
1558 C 2,ICLK,ICK,ICINF,IG-1,INB4,INB42,IRFC,KASE,KFUNT,NPQINPU
1559 C 3,MRCOL,NB303,NDIM,NOS3,NPGAS,NQI,NPREST,NPJ,NSEF,NSFGL,NSEG2INPU
1560 C 4,NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONST,QINSD,QNET,QSAV,QSURIINPU
1561 C 5,RADIUS,RFCL,REFI,REFFWJ,REFRHQ,REFRM,RFYN,RHDIINF,RHOSHK,RHOSL,INPU
1562 C 6,TSHKI,SWFMJ,STUP,SWFEP,STAGI,TABL,TIM,TINF,TINSO,TRANRINPU
1563 C 7,TSHK,TWALL,TWNB,VFLINE,VSHK,W,WAAB,WABDNT,WALLI,WRITEINPU
1564 C 8,XX,XOISTINPU
1565 C 9,ETATP,ETALP,HVPST,PTMX,NT
1566 C COMMON /BLCK1/ TITLE(20)INPU
1567 C COMMON /SWALLOW/ QINT(50),HEDGE(50),PEDEGE(50),HPECON(50)INPU
1568 C 1, INDCINPU
1569 C
1570 C FOR ARCHIE USSIN - GOLD WALL INPUTS FROM ENTROPY SWALLOWING
1571 C COMMON /MIKE/ HV2,ETAL2,ETAT2,XI,FVIP(10),FVIS(10),FV2P(10),INPU
1572 C * FV2S(10),STGTB(10),SHRTBL(10),NDPSTG,NDPSHRINPU
1573 C 2, QSUNIC,SHFAR,HQABL,MHF,ISTETS,NDCHF,K,INPU
1574 C 3, RHOTBL(10,40),CPH(10,40),EKTRBL(10,40),TEMT9L(10,40)INPU
1575 C COMMON /WERNER/ TRVRSI,TFB(100),RHDFR(100),PFB(100),ALTCM(100)INPU
1576 C COMMON /CHARAB/ NIME,TSTOR(50),QO(50),PO(50),HSTAB(50),HLTAB(50),INPU
1577 C 1, HETAB(50)INPU
1578 C COMMON /PHIL/ NPQS,QSTAR(10),PSTAGN(10)INPU
1579 C COMMON /RALPH/ TWTAB(20),EMTAB(20),NEVIS,NQCJR,QABSF(20),TWA(20)INPU

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1579 C EQUIVALENCE (NSEG,NAROW),(QCALT,TRANLT)
1580
1581 C
1582 NAMELIST/BDOG/IS/ KASE,ICQNF,NDIM,NTRAJ,KFUNT,NSEG,NBCOL,NPU,ICLK,INPU
1583 1 CONPR,TRANR,TRANLT,ANGLF,SWEPP,XDIST,EMIS,DELTA,WRITE,STOP,STARTINPU
1584 2 ,TABL,HOABL,HV,ETAL,ETAT,NOSB,RADIUS,TWALL,RHD,A,B,TIME,ALT,VINF,INPU
1585 3 ANFA,HINSD1,TINSD1,OCQNS,NPQ,STAGEN,TEMPW,TEMP,EL,QI,QSOLAR,INPU
1586 4 NDRUG,ISTFIS,TEMTBL,CPTBL,EKTB1,RHCTBL INPU
1587 4 ,A1,B1,A2,B2,A3,B3,A4,B4,NQ1,THANK,NPGAS,PSTMAX,HVPSTM,ETATP INPU
1588 5 ,ETALP, INPCW,QINT,HFDGE,PEDGE,UEDGE,HRECOV INPU
1589 6 , HV2,ETAL2,ETAT2,XI,FVIP,FVIS,FV2P,FV2S,STGTBL,SHRTRL,NOPSTG INPU
1590 7 , NOPSRR,HF,TITLE,TRVRSL,TFB,RHCFB,PF8,ALTCM , NOCHECK INPU
1591 8 ,NPQS,QSTAR,PSTAGN,TWTAR,EMTAB,NEMIS,NQCOR,QABSF,TWA INPU
1592 NAMELIST /TWODIM/ AA,BB,CC,T2, NAROW,NBCOL ,OK,CP2 INPU
1593
1594 C DATA THANK/O/
1595 DATA A1/40*0./,A2/40*0./,A3/40*0./,A4/40*0./
1596 1 ,B1/40*0./,B2/40*0./,B3/40*0./,B4/40*0./
1597 DATA CKEND,WRONG,END /' $','060S',. END'/
1598 DATA TERM/' &EN',JAY/O/
1599 DATA TEMPER/40*540./,START/O./
1600
1601 C 10000 IF (IGD.GT.0) GO TO 28
1602 C IGD = - , FIRST TIME THROUGH
1603 C IGD = -0, TO READ A NEW CASE
1604 C IGD = + , TO RESTART SAME CASE
1605 CALL AEROSP
1606 WRITE (6,1067)
1607 1967 FORMAT(19X,' &&&& BBBB DDDO 000 665 000 SSSS'//
1608 1 19X,' & R R D D 0 0 6 0 0 0 S '//'
1609 2 19X,' &&&& BBBB D D 0 0 0 6 66 0 0 0 SSS '//'
1610 3 19X,' & R B D D 0 0 6 5 0 0 0 S'//
1611 4 19X,' &&&& BBBB DDDD 000 666 000 SSSS '//'
1612 5 19X,' AFRUSPACE SYNTHESIZED AERODYNAMIC HEATING - ASAH',5X,
1613 6 , FOR IBM 360-65(FORTRAN H-2) 4/15/71.)
1614 NDBUG1 = NDBUG
1615 DELTA = DELTSV
1616 NSEG1 = 1
1617 NSEG2 = 1
1618 WRITE OUT CARD IMAGES 5/19/66 J.M.K
1619 IF (JAY.GE.1) GO TO 8
1620 JAY = NO. CARDS FROM 5 TO 9
1621 1776 RETURN 9
1622 NCARD=0
1623 ICASE=0
1624 66 FORMAT (1H1,' COMPLETE LIST OF ALL INPUT CARDS TO BE PROCESSED '//)INPU

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1625 WRITE (6,66)
1626 JAY = 1
1627 4444 READ (5,5555) DATA
1628 4445 FORMAT (20A4)
1629 5555
1630 WRITE (6,5555) DATA
1631 IF (DATA(1).NE.TERM) GO TO 7730
1632 ICASE = ICASE + 1
1633 WRITE (6,7731) ICASE
1634 FORMAT ( 85X, 'END CASE',16)
1635 7731 IF ((DATA(20).EQ.CKEND) .OR. (DATA(1).EQ.EN)) GO TO 888
1636 C SINGLE 'ENDDATA' WILL TERMINATE DATA CASE GROUP
1637 C ' $' AT END NOW TERMINATES ALL READING, OR 'END' AT FIRST
1638 JAY = JAY + 1
1639 IF (DATA(2) .EQ. WRONG) GO TO 7734
1640 WRITE (9,5555) DATA
1641 GO TO 4445
1642 7734 WRITE (6,7735)
1643 7735 FORMAT ('BAD NAMELIST NAME, SHOULD BE 800605, NOT 800605 ')
1644 888 WRITE (6,9) N88UG
1645 ICASE = 0
1646 JAY = JAY-1
1647 END FILE 9
1648 WRITE (6,889) JAY
1649 889 FORMAT ( 16, ' CARDS READ')
1650 IF (JAY.LE.0) STOP
1651 C DOUBLE 'ENDDATA' WILL TERMINATE JOB
1652 NCARD = JAY
1653 REWIND 9
1654 9 IF (NCARD.LT. 1 ) GO TO 883
1655 C NCARD = NUMBER OF CARDS LEFT ON 9
1656 ICASE = ICASE + 1
1657 WRITE (6,6) ICASE
1658 6 FORMAT (1H1, ' INPUT CARDS READ, DATA SFT' 16)
1659 KARD=0
1660 887 READ (9,5555) DATA
1661 KARD =KARD+1
1662 WRITE (6,5555) DATA
1663 IF (DATA(1).EQ.TERM) GO TO 886
1664 GO TO 887
1665 883 WRITE (6,884)
1666 884 FORMAT ('ALL INPUT CARDS HAVE BEEN PROCESSED ')
1667 CALL AEPDSP
1668 GO TO 1776
1669 985 DO 885 I=1,KARD
1670 985 BACKSPACE 9

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INPU 91
INPU 92
INPU 83
INPU 84
INPU 85
INPU 96
INPU 87
INPU 88
INPU 89
INPU 90
INPU 91
INPU 92
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INPU 94
INPU 95
INPU 96
INPU 97
INPU 98
INPU 99
INPU 100
INPU 101
INPU 102
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INPU 112
INPU 113
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INPU 117
INPU 118
INPU 119
INPU 120
INPU 121
INPU 122
INPU 123
INPU 124
INPU 125

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1671      1671 CONTINUE
1672      NCARD = NCARD - KARD
1673      WRITE (6,881) KARD,NCARD
1674      1674 FORMAT (' KARD = ',I6,' TO GC = ',I6)
1675      1675      5/19/66 J.M.K.
1676      1676      END OF CARD IMAGES
1677      1677      FOR ONE DIM. ONLY
1678      1678      2R INR4 = 0
1679      1679      1 DIM INPUT
1680      1680      ICONF = 1 FLAT PLATE
1681      1681      = 2 WEDGF
1682      1682      = 3 CONE
1683      1683      = 4 SPHERE
1684      1684      = 5 CYLINDER
1685      1685      NTRAJ = NO. OF TRAJECTORY CARDS (MAXIMUM OF 100 )
1686      1686      KFUNT = 1 EK(I) AND CP(I) ARE BOTH FCNS OF TEMPERATURE
1687      1687      = 2 EK(I) IS A FCN OF TEMPERATURE, CP(I) IS CONSTANT
1688      1688      = 3 EK(I) IS CONSTANT, CP(I) IS A FCN OF TEMPERATURE
1689      1689      = 4 BOTH ARE CONSTANT
1690      1690      NSEG = NAROW = NUMBER OF SEGMENTS (MAXIMUM OF 20 IN 1D, 10 IN 2D )
1691      1691      NO. SEGMENTS - OR SLABS IN THIS PROBLEM
1692      1692      NPOINT = NO. POINTS IN THOSE INDIVIDUAL SLABS
1693      1693      NDRUG = 0 NO DRUG PRINT
1694      1694      NDRUG VALUES FOR ROUTINES, ARE LISTED BELOW
1695      1695      .EQ.1 ABLATE
1696      1696      .EQ.1 GETCPK
1697      1697      .GE.1 MAIN
1698      1698      .GE.1 ABLUNT
1699      1699      .GE.1 KFMP
1700      1700      .EQ.2 DIST
1701      1701      .EQ.2 GECPK2
1702      1702      .EQ.3 ATMDS
1703      1703      .EQ.3 TRAJ
1704      1704      .EQ.3 PME
1705      1705      .EQ.5 THERMO
1706      1706      .EQ.4 SHOCK
1707      1707      .EQ.8 HANKEY
1708      1708      .EQ.10 JNFD
1709      1709      .EQ.14 ENERGY/CONSTO
1710      1710      .GE.14 TWND
1711      1711      11/22/70 THESE MAY BE ADDED TO, OR CHANGED, WITHOUT NOTICE AT ANY TIME
1712      1712      IF (IGO) 1,2,3
1713      1713      NPU = 1 FOR PUNCH OPTION - USED FOR CHARRING ABLATOR INPUTS
1714      1714      NQI = 01 CALC. IN -ABLATE- WHERE, DOSAV=F(QUSE,EL,EK,TEMP,DELTA)
1715      1715      = - OR 0, QUSE = QNET
1716      1716      = +, QUSE = QSUFI*QCONS
1717      1717      INPU 126
1718      1718      INPU 127
1719      1719      INPU 128
1720      1720      INPU 129
1721      1721      INPU 130
1722      1722      INPU 131
1723      1723      INPU 132
1724      1724      INPU 133
1725      1725      INPU 134
1726      1726      INPU 135
1727      1727      INPU 136
1728      1728      INPU 137
1729      1729      INPU 138
1730      1730      INPU 139
1731      1731      INPU 140
1732      1732      INPU 141
1733      1733      INPU 142
1734      1734      INPU 143
1735      1735      INPU 144
1736      1736      INPU 145
1737      1737      INPU 146
1738      1738      INPU 147
1739      1739      INPU 148
1740      1740      INPU 150
1741      1741      INPU 151
1742      1742      INPU 152
1743      1743      INPU 153
1744      1744      INPU 154

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1717 C ICHK = 0 , FOR REGULAR PROX AM FLOW INPU 155
1718 C = + FOR HANKEY CALC. INPU 156
1719 C CONPR = CONE PRESSURE AS USED IN *PME# 10/23/63 INPU 157
1720 C TRANR = TRANSITION REYNOLDS NO. INPU 158
1721 C TRANLT IS TURB.-LAV. ALTITUDE INPU 159
1722 C ANGLE = WEDGE OR CONE HALF ANGLE INPU 160
1723 C SWEEP = SWEEP ANGLE INPU 161
1724 C XDIST = DISTANCE FROM LEADING EDGE FOR FLAT PLATE, WEDGE OR CONE (FEET) INPU 162
1725 C = DIAMETER FOR SPHERE OR CYLINDER INPU 163
1726 C EMIS = SURFACE EMISSIVITY INPU 164
1727 C DELTA = TIME STEP SIZE ( SECONDS ) INPU 165
1728 C WRITE = PRINT OUT TIME INTERVAL ( SECONDS ) INPU 166
1729 C STOP = END OF FLITE TIME INPU 167
1730 C START = ALT = START TIME , IF OTHER THAN ZERO INPU 168
1731 C TABL = ABLATION TEMPERATURE ( DEGREES R ) INPU 169
1732 C H2ABL = HEAT OF ABLATION ( BTU/LB ) INPU 170
1733 C OLD H2ABL NOW = HV + STA(10R2)* (RECI - WALLI) INPU 171
1734 C H2ABL CAN - HV ,IF A CONSTANT VALUE IS DESIRE. INPU 172
1735 C NDSR = IF POSITIVE, USE NOSE BLUNTING ROUTINE (A9LUNT) INPU 173
1736 C RADIUS = INITIAL RADIUS OF BLUNT NOSE INPU 174
1737 C TWALL = CONSTANT WALL TEMP USED IN NOSE BLUNTING ROUTINE (DEG R) INPU 175
1738 C PHN(1) = SPECIFIC WT. OF SEGMENT 1 ( LBS/FT**3 ) INPU 176
1739 C A(1,J) = COEFFICIENTS OF JTH SEGMENT FOR COMPUTING EK(J) THUSLY INPU 177
1740 C FK(J) = A(1,J) + A(2,J)*T + A(3,J)*T**2 + A(4,J)*T**3 INPU 178
1741 C B(1,J) = ARE TO CP(J) AS THE A S ARE TO EK(J) INPU 179
1742 C 1 NDRUG1 = 0 INPU 180
1743 C TRAJECTORY INPUT INPU 181
1744 C TIME = TIME ( SECONDS ) INPU 182
1745 C ALT = ALTITUDE ( FEET ) INPU 183
1746 C VINF = VELOCITY (FT/SEC ) INPU 184
1747 C ANFA = ANGLE OF ATTACK ( DEGREES ) INPU 185
1748 C HINSO = INSIDE HEAT TRANSFER ( BTU/HR FT**2 DEGREE P ) INPU 186
1749 C TINSO = INSIDE TEMPERATURE ( DEGREES R ) INPU 187
1750 C IF THE QCONS(1) ARE NOT READ IN THEY SHOULD ALL = 1 INPU 188
1751 C IF NPQ = -NO.,HV IS FOUND FROM STAGEN VS. TEMPW CURVE, INPU 189
1752 C WHERE C, STAGEN = STAGNATION ENTHALPY INPU 190
1753 C AND TEMPW = HEAT OF VAPORIZATION (HV) INPU 191
1754 C TEMP(1) = TEMPERATURE OF 1TH SEGMENT ( DEGREES R ) INPU 192
1755 C EL(1) = THICKNESS OF 1TH SEGMENT ( INCHES ) INPU 193
1756 C NOTE . . . QI STORED IN QAD1 , .OUTPUT. STORES QI*3600=QI INPU 194
1757 C NOCHECK = 0, TO CHECK NEG. TEMPS. AND STABILITY INPU 195
1758 C = 1, FOR NEGATIVE TEMPERATURE CHECK ONLY INPU 196
1759 C = 2, FOR NO CHECKS INPU 197
1760 C 2 DIM INPUT INPU 198
1761 C NAROW = NUMBER OF ROWS IN 2-D MESH (MAX.=10) INPU 199
1762 C INPU 200

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INPU 201
INPU 202
INPU 203
INPU 204
INPU 205
INPU 206
INPU 207
INPU 208
INPU 209
INPU 210
INPU 211
INPU 212
INPU 213
INPU 214
INPU 215
INPU 216

(INCHES)

NBCOL = IN 2 DIMENSIONS IS NO. CFCOLUMNS (MMAX.=10)
AA(J) = THICKNESS OF J-TH SEGMENT (INCHES)
BB(I) = WIDTH OF ITH SEGMENT IN 2D.
T2(J,I) = TEMPERATURE (ROW,COLUMN)
CP2(J,I) = SPECIFIC HEAT (ONLY IF KFUNT=0)
CK(J,I) = CONDUCTIVITY (ONLY IF KFUNT=0)

IHANK = 0
START = 0.0
NPQ = 0
NDSR = C
RADIUS = C.
RAD1 = RADIUS
TWALL = 0.
TRANR = 0.
NPGAS = 0
NPQS = 0

DO 396 I=1,10
QSTAR(I) = 0.0
396 PSTAGN(I) = 0.0
DO 96 I=1,100
IF (NPQ.LE.1) GO TO 96

QI(I) = QAD1(I)
IF (I.GT.4C) GO TO 96
TEMPER(I) = TEMP(I)
TIME(I) = TIME1(I)
ALT(I) = ALT1(I)
VINFI(I) = VINFI(I)
QCONS(I) = 1.0

2 DO 99 I=1,100

STAGEN(I) = VAPRES (I)
AOFAL(I) = AOFAL(I)
ALT(I) = ALT1(I)
TIME(I) = TIME1(I)
QCONS(I) = QCONS1(I)
QI(I) = QAD1(I)
IF (I.GT.4C) GO TO 99
TEMP(I) = TEMP(I)
VINFI(I) = VINFI(I)
IF (NPQ.LE.1) GO TO 98

DO 97 JETHRO = 1,NPQ
97 QI(JETHRO) = QAD1(JETHRO)
98 IF (NPQ.LT.0) NPGAS = NPQ
NIME = 0

QSOLAR=QAD1(100)
ETAL =ETAL

INPU 217
INPU 218
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1809      ETAT = FTA2
1810      RADIUS=RADI
1811      NDBUG =NDBUG1
1812
1813      READ (9,BDC60S)
1814
1815      DELTSV = DELTA
1816      TCHK = IHANK
1817      NDBUG1=NDBUG
1818      IF (NPGAS.GE.0)
1819          INPGAS =NPQ
1820      RADI =RADIUS
1821      FTA2 =FTAT
1822      ETAT =ETAL
1823      QADI(100)=QSOLAP
1824      TWRB = TWALL
1825      IF ((TWRB.LE.0.).AND.(NDSR.GT.0.)) TWRB = TABL
1826
1827      DO 100 JMK=1,100
1828          VAPRES(JMK) = STAGEN(JMK)
1829          TIME1 (JMK) = TIME (JMK)
1830          ALT1 (JMK) = ALT (JMK)
1831          VINFI (JMK) = VINFI (JMK)
1832          AOFAL (JMK) = AOFAL (JMK)
1833          QCONS1(JMK) = QCONS(JMK)
1834          QADI (JMK) = QI (JMK)
1835          IF (VINFI(1).EQ.0.) WRITE(6,1359)
1836          1359 FORMAT ('- VINFI(1)=0., MAY NOT WORK'////)
1837
1838          QADI(100) = QSOLAR
1839          DO 101 I =1,40
1840              A(1,I) = A1(I)
1841              A(2,I) = A2(I)
1842              A(3,I) = A3(I)
1843              A(4,I) = A4(I)
1844              B(1,I) = B1(I)
1845              B(2,I) = B2(I)
1846              B(3,I) = B3(I)
1847              B(4,I) = B4(I)
1848              101 TEMPER(I) = TEMP(I)
1849              WRITE (6,9) NDBUG
1850              9 FORMAT (15HEND OF INPUT. 75X I2 )
1851              CAPDS MOVED FROM OUTINT - FOR BETTER VIEW, ALSO NPGAS TEST CHANGED NOV70
1852              IF (IGO.GT.0)GO TO 55
1853              IF (NPGAS-1) 55, 49, 50
1854              IF (NPGAS.GT.1) GO TO 50
1855              49 QI(100) = QADI(100) * 3600.
1856              GO TO 55
1857
1858      INPU 243
1859      INPU 244
1860      INPU 245
1861      INPU 246
1862      INPU 247
1863      INPU 248
1864      INPU 249
1865      INPU 250
1866      INPU 251
1867      INPU 252
1868      INPU 253
1869      INPU 254
1870      INPU 255
1871      INPU 256
1872      INPU 257
1873      INPU 258
1874      INPU 259
1875      INPU 260
1876      INPU 261
1877      INPU 262
1878      INPU 263
1879      INPU 264
1880      INPU 265
1881      INPU 266
1882      INPU 267
1883      INPU 268
1884      INPU 269
1885      INPU 270
1886      INPU 271
1887      INPU 272
1888      INPU 273
1889      INPU 274
1890      INPU 275
1891      INPU 276
1892      INPU 277
1893      INPU 278
1894      INPU 279
1895      INPU 290
1896      INPU 281
1897      INPU 282
1898      OUTPT 41
1899      OUTPT 42
1900      OUTPT 43
1901      OUTPT 44

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1855 50 NPGAS=NTRAJ
1856 DO 51 I=1,NPGAS
1857 51 QI(I) = 3600.*QAD1(I)
1858 55 CONTINUE
1859 C
1860 CALL OUTINT (INPCW)
1861 C
1862 IF (NSEG.EQ.1) GO TO 3
1863 IF (KFUNT.LT.5) GO TO 3
1864 DO 260 I=1,KFUNT
1865 DO 260 J=2,NSEG
1866 IF (RHOTBL(I,J).LE.0.) RHOTBL(I,J)=RHOTBL(I,J-1)
1867 IF (TEMTBL(I,J).LE.0.) TEMTBL(I,J)=TEMTBL(I,J-1)
1868 IF (EKTRL(I,J).LE.0.) EKTRL(I,J)=EKTRL(I,J-1)
1869 IF (CPTBL(I,J).LE.0.) CPTBL(I,J)=CPTBL(I,J-1)
1870 260 IF (CPTBL(I,J).LE.0.) CPTBL(I,J)=CPTBL(I,J-1)
1871 C ENTER TABLES FOR FIRST SEGMENT
1872 C PROG. WILL FILL IN FOR YOU UNTILL IT FINDS MORE ENTRIES
1873 C AT WHICH TIME ALL SUCCEEDING SEGMENTS WILL HAVE THOSE PROPER
1874 C NOTE TO CHANGE, ZERO OUT THOSE TO BE CHANGED I.E.
1875 CPTBL(2,1)=40*0,CPTBL(3,1)=40*0,CPTBL(1,1)=NEW VALUES
1876 WILL CHANGE ONLY FIRST 3 ROWS (SEGMENTS) IN CP TABLE
1877 3 IGD = 0
1878 C INITIALIZE TEMPS.
1879 DO 16 I=1,NSEG
1880 16 TEMP(I) = TEMPER(I)
1881 IF (START) 4,5,4
1882 C START TIME, IF OTHER THAN 0.
1883 4 ALTUD = START
1884 5 IF (HV.NE. 0.) GO TO 22
1885 HV= HDABL
1886 22 IF (QCONS1(NTRAJ).NE.0.) GO TO 7
1887 245 DO 255 I = 1,NTRAJ
1888 255 QCONS1(I) = 1.0
1889 C
1890 7 IF (NDBG.EQ.0) GO TO 102
1891 WRITE (6,BD062S)
1892 102 IF (NDIM.LT.2) GO TO 15
1893 C
1894 WRITE (6,200)
1895 200 FORMAT ('--TWO-DIMENSIONAL OPTION BEING USED ')
1896 READ (9,TWO DIM)
1897 WRITE (6,201) NAROW,NBCOL,NDIM,(AA(I),I=1,NAROW)
1898 WRITE (6,202) (BB(I),I=1,NBCOL)
1899 WRITE (6,203) ((CC(I,J),J=1,10),I=1,NAROW)
1900 WRITE (6,204) ((T2(I,J),J=1,10),I=1,NAROW)

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OUTPT 45
 OUTPT 46
 OUTPT 47

INPU 283
 INPU 284
 INPU 285
 INPU 286
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201 FORMAT ( ' -NARROW NBCOL NDIM ' / 316 / ' THICKNESS Y,AA' / (5E16.8) ) INPU 325
202 FORMAT ( ' WIDTH X,RB' / (5E16.8) ) INPU 326
203 FORMAT ( ' COND. CONST. ' / (10E12.5) ) INPU 327
204 FORMAT ( ' TEMPERATURE (°),T2 ' / (10E12.5) ) INPU 328
INPU 329
INPU 330
INPU 331
INPU 332
INPU 333
INPU 334
INPU 335
INPU 336
INPU 337
INPU 338
INPU 339
INPU 340
INPU 341
INPU 342
INPU 343
INPU 344

C
15 CALL OUTPUT
C
NT = 0
12 IF (INPCW.LE.0) GO TO 18
IF (INPCW.LT.NTRAJ) INPCW = NTRAJ
WRITE (6,17) INPCW, (QINT(I),HEDGE(I),PEDGF(I),UEDGE(I),HRECONV(I)) INPU 335
1 ,TIME1(I), I=1,INPCW ) INPU 336
17 FORMAT ( 48H- COLD WALL INPUTS - AS PER ENTROPY SWALLOWING / INPU 337
1 27H NO. OF INPUTS = INPCW = I3 / 7X,4HQINT,11X,5HHEDGE,11X, INPU 338
2 5HPEDGE,11X,5HUEDGE,10X,6HHRECONV,11X,5HTIME / (6E16.8) ) INPU 339
18 IF (PSTMAX.LE.0.) GO TO 120 INPU 340
WRITE (6,119) PSTMAX,HVPSTM INPU 341
119 FORMAT (7X,'PSTMAX',10X,'HVPSTM' / 2E16.8) INPU 342
120 RETURN INPU 343
END INPU 344

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1922 SUBROUTINE KEMP
1923 C -- - MARCH 27 1964 JOHN KOHLENBERGER
1924 CKEMP
1925 C
1926 C
1927 C
1928 C
1929 C
1930 C
1931 C
1932 C
1933 C
1934 C
1935 C
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1937 C
1938 C
1939 C
1940 C
1941 C
1942 C
1943 C
1944 C
1945 C
1946 C
1947 C
1948 C
1949 C
1950 C
1951 C
1952 C
1953 C
1954 C
1955 C
1956 C
1957 C
1958 C
1959 C
1960 C
1961 C
1962 C
1963 C
1964 C

SUBROUTINE KEMP (ICONF,VINF,TINF,RHOINF,STAGI,WALLI,XX,SWEEP,AOFA,KMP
1QSUBI
DIMENSION TIME1(100),ALTI(100),VINFI(100),AOFAI(100),HINSDI(100)KMP
1 , TINSDI(100),QCONSI(100),VAPRES(100),CPG(100),TFMPW(100) KMP
2 , QI(100),QADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40) KMP
3 , A(4,40),B(4,40) KMP
4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10) KMP
COMMON A,ALTI,AOFAI,B,CP,CPG,EK,EL,HINSDI,QADI,QCONSI,QI KMP
1 , RHO,TEMP,TEMPW,TIME1,TINSDI,VAPRES,VINFI KMP
2 , AA,BB,CC,CP2,DK,T2 KMP
COMMON ALTI,AMINF,AOFA,ANGLE,CNPR,DELTA,DQSAV KMP
1 , EMIS,ETAL,ETA2,HINSD,HOA8L,HSUBI,HV KMP
2 , ICHK,ICK,ICONF,IGO,INB4,INB42,IREF, KASE,KFUNT,NPQKMP
3 , NBCOL,NDBUG,NDIM,NDSB,NPGAS,NCI,NPREST,NPU,NSEG,NSEGI,NSEG2 KMP
4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBI KMP
5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSLKMP
6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSD,TRANR KMP
7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE KMP
8 , XX,XDIST KMP
9 , ETATP,ETALP,HVPSTM,PSTMAX KMP
EQUIVALENCE (NSEG,NAROW) KMP
NAMELIST /KEMPR/ RHOINF,RHONOT,VINF,VORR,STAGI,WALLI,STAGI,BASEI KMP
1 ,XX,RADIUS,AMINF,QSPH,ICONF,TINF,QSUBI,ANG,AOFS,QCYL KMP
AMINF = VINF/(49.01*(SQRT(TINF))) KMP
IF (AMINF.LE.1.01) GO TO 5 KMP
IF (AMINF-3.0)10,20,20 KMP
SIBULKIN EQU. KMP
3220. CHANGED TO 174.0 C.B.A. 1/2/66 KMP
5 STAGI = SHKI + VINF**2/50061.5 KMP
WHERE SHKI IS AINF (FROM THERMO) KMP
RECI = STAGI KMP
10 QSPH = 174.0*(SQRT((RHOINF*VINF)/XX))*(STAGI-WALLI) KMP
GO TO (300,300,300,100,200),ICONF KMP
KEMP AND RIDDLE EQU. KMP
20 RHONOT = .C023769 KMP
VORR = 2600. KMP
BASEI = 129.5 KMP
QSPH=24900.*SQRT (RHOINF/RHONOT)*((VINF/VORR)**3.15)*((STAGI-WALLI KMP
1)/((STAGI-BASEI)**3600./SQRT(XX) KMP

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1965
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C      GO TO (300,300,300,100,200),ICONF
      SPHERF
      100 QSUBI = QSPH
      GO TO 300
C      CYLINDER
      200 ANG = (COS (AOFA/57.2958))*(SIN (SWEEP/57.2958))
      AFES = ATAN (ANG/(SQRT (1.0--(ANG**2))))
      QCYL = .931*QSPH*((COS (AFES))*1.5)
      QSUBI = QCYL
      GO TO 300
      300 IF (NDRUG.GE.1) WRITE(6,KEMPR)
      RETURN
      END

```

KMP	38
KMP	39
KMP	40
KMP	41
KMP	42
KMP	43
KMP	44
KMP	45
KMP	46
KMP	47
KMP	49

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1078 SUBROUTINE ONED
1079
1080 C
1081 C -- -- APRIL 8 1964 JOHN KOHLENBERGER FORTRAN IV
1082 C
1083
1084 DIMENSION TIME1(100),ALTI(100),VINFL(100),AQFAL(100),HINSD1(100)
1085 1 , TINSO1(100),QCONS1(100),VAPRES(100),CPG(100),TEMPW(100)
1086 2 , QI(100),QADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
1087 3 , AI(40),B(4,40)
1088 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
1089 COMMON A,ALTI,AQFAL,B,CP,CPG,EK,EL,HINSD1,QADI,QCONS1,QI
1090 1 , RHO,TEMP,TEMPW,TIMF1,TINSO1,VAPRES,VINFL
1091 2 , AA,BB,CC,CP2,DK,T2
1092 COMMON ALI,AMINF,AQFA,ANGLE,CNPR,DELTA,DQSAV
1093 1 , EMIS,ETAL,ETA2,HINSO,HOABL,HSURI,HV
1094 2 , ICHK,ICK,ICONF,IGD,INB4,INB42,IREF, KASE,KFUNT, NPQCOND
1095 3 , NBCOL,NDRUG,NDIM,NQSB,NPGAS,NCI,NPREST,NPU,NSEG,NSEGI,NSFG2 COND
1096 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALI,QCCNS,QINSO,QNET,QSAV,QSUBI COND
1097 5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRY,REYN,RHOINF,RHOSHK,RHOSLCOND
1098 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSO,TRANR COND
1099 7 , TSHK,TWALL,TWNR,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE COND
1100 8 , XX,XDIST COND
1101 9 , ETATP,ETALP,HVPSTY,PSTMX,NT COND
1102
1103 EQUIVALENCE (NSEG,VAROW)
1104
1105 C
1106 DOUBLE PRECISION TNEW(40),AI,TOLD(40)
1107
1108 C
1109 DATA TIMB4/100000./
1110
1111 C
1112 11/20/73 DOUBLE PRECISION (12 DIGITS) CONDUCTION ROUTINE
1113 ESPECIALLY FOR SMALL TIME STEPS
1114
1115 C
1116 10 CALL GETCPK
1117 11 IF (NSEG-1)12,12,14
1118 12 TEMP(1) = (DELTA/(RHO(1)*EL(1)*CP(1)*25.0))*((QNET/12.0+HINSD*
1119 1 (TINSO-TEMP(1))/12.0)+TEMP(1)
1120 GO TO 63
1121
1122 14 DO 50 I=NSEGI,NSEG
1123 15 AI = DELTA/(RHO(I)*EL(I)*CP(I)*25.0)
1124 IF (I-NSEG2)25,25,30
1125 IF (NT.GT. 1) GO TO 27
1126 CAPDS BELOW ARE FOR FIRST TIME THROUGH
1127 DO 26 J= NSEGI,NSEG
1128
1129 C
1130 COND 2
1131 COND 1
1132 COND 3
1133 COND 4
1134 COND 5
1135 COND 6
1136 COND 7
1137 COND 8
1138 COND 9
1139 COND 10
1140 COND 11
1141 COND 12
1142 COND 13
1143 COND 14
1144 COND 15
1145 COND 16
1146 COND 17
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1148 COND 19
1149 COND 20
1150 COND 21
1151 COND 22
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1153 COND 24
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1155 COND 26
1156 COND 27
1157 COND 28
1158 COND 29
1159 COND 30
1160 COND 31
1161 COND 32
1162 COND 33

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2021      TOLD(J) = TEMP(J)
2022      25 CONTINUE
2023      NS1R4 = NSEG1
2024      NSEGR4 = NSEG
2025      NS2R4 = NSEG2
2026      TIMB4 = TIME
2027      27 IF (NSEG2.EQ.NSEG1) GO TO 28
2028      TOLD(NSEG2) = TEMP(NSEG2)
2029      CARD ABOVE, USED IN CASE OF ABLATION
2030      28 TNEW(I) = A1*(QNET/12.0 + (TOLD(I+1) - TOLD(I)) / (.5*(EL(I)/EK(I) +
2031      1 EL(I+1)/EK(I+1))) + TOLD(I)
2032      GO TO 50
2033      30 IF (I-NSEG) 35,40,40
2034      35 TNEW(I) = A1*((TOLD(I-1) - TEMP(I)) / (.5*(EL(I-1)/EK(I-1) + FL(I)
2035      1 /EK(I))) + (TOLD(I+1) - TOLD(I)) / (.5*(EL(I+1)/EK(I+1) + EL(I+1)
2036      2 /EK(I+1))) + TOLD(I)
2037      GO TO 50
2038      40 TNEW(I) = A1*((TOLD(I-1) - TOLD(I)) / (.5*(EL(I-1)/EK(I-1) + FL(I)
2039      1 /EK(I))) + HINSD*(TINSD - TOLD(NSEG)) / 12.0) + TOLD(I)
2040      50 CONTINUE
2041      ON 60 I = NSEG1, NSEG
2042      IF (NDRUG.NF.10) GO TO 59
2043      WRITE(6,1970) TIMB4, TOLD
2044      WRITE(6,1970) TIME, TNEW
2045      1970 FORMAT(' DE 3 EG -UNED-, TIME AND TEMPERATURE',-16.8/(8016.8))
2046      59 CONTINUE
2047      TOLD(I) = TNEW(I)
2048      TEMP(I) = TNEW(I)
2049      63 DQINSD = HINSD*(TEMP(NSEG) - TINSD) * DELTA / 3600.
2050      QINSD = QINSD + DQINSD
2051      65 TWALL = TEMP(NSEG2)
2052      IF (NDRUG.NF.10) GO TO 69
2053      WRITE(6,1971) NSEG, NSEG1, NSEG2, A1, CNET, HINSD, TINSD, QINSD, TWALL
2054      1971 FORMAT(' NSEG NSEG1 NSEG2',14X,'A1',12X,'QNET',/316,2E16.8/
2055      111X,'HINSD',11X,'TINSD',11X,'QINSD',11X,'TWALL',/4E16.8)
2056      69 TIMB4 = TIME
2057      70 RETURN
2058      END

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COND 36
COND 37
COND 41
COND 44
COND 45
COND 46
COND 47
COND 48
COND 49
COND 50
COND 51

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2059 SUBROUTINE OUTINT (INPCW)
2060 COUNTINT INTEGERS FOR BDO6DS
2061 C - - - JANUARY 17, 1968 JOHN KOHLENBERGER
2062 DIMENSION TIME1(100),ALT1(100),VINFL(100),ANFAL(100),HINSD1(100)
2063 1 , TINSO1(100),QCONS1(100),VAPRES(100),CPG(100),TEMPW(100)
2064 2 , QI(100),QAD1(100),CP(40),FK(40),EL(40),RH(40),TEMP(40)
2065 3 , A(4,40),B(4,40)
2066 4 , AA(10),BB(10),CC(10,10),CP2(10,10),D(10,10),T2(10,10)
2067 COMMON A,ALT1,ANFAL,B,CP,CPG,EK,EL,HINSD1,QAD1,QCONS1,QI
2068 1 , RHO,TEMP,TEMPW,TIME1,TINSO1,VAPRES,VINFL
2069 2 , AA,AB,CC,CP2,DK,T2
2070 COMMON ALT,AMINF,AJFA,ANGLE,CONPR,DELTA,DQSAV
2071 1 , EMIS,ETAL,ETA2,HINSD,HQABL,HSU3I,HV
2072 2 , ICHK,ICK,ICOF,IGN,INR4,INB42,IRFC,
2073 3 , NBCOL,NBBUG,NJIM,NQSB,NPGAS,NQI,NPREST,NPU,NSEG,NSFG2
2074 4 , NTPAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSO,QNET,QSAV,QSUBI
2075 5 , RADIUS,RFCI,REFI,REFMU,REFRHO,REFRM,REYN,RHJINF,RHOSLK,RHOSLO
2076 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSO,TRANR
2077 7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABOOT,WALLI,WRITE
2078 8 , XX,XDIST
2079 9 , ETATP,ETALP,HVPSTM,PSTMAX
2080 COMMON / MIKE / HV2,ETAL2,ETAT2,XI,FVIP(10),FVIS(10),FV2P(10),
2081 * FV2S(10),STGTBL(10),SHRTBL(10),NOPSTG,NOPSHR
2082 2 , QSONIC,SHEAR,HQABL,M,HF,ISTETS,NOCHK,
2083 3 , RHCTBL(10,40),CPTBL(10,40),EKTBL(10,40),TENTBL(10,40)
2084 COMMON /LOOK1/ TITLE(20)
2085 COMMON /WERNER/ TRVRSI,TFB(100),RHOFB(100),PFB(100),ALTCM(100)
2086 DIMENSION WORD(24)
2087 DATA WORD/'PLAT','WEDG','CONE','SPHR','CYLN','BLVT',18*
2088 EQUIVALENCE (NSEG,NAROW)
2089 WRITE (6,6) TITLE
2090 6 FORMAT (1H1,20A4)
2091 55 WRITE (6,56) KASE
2092 56 FORMAT (3H IDENTIFICATION = 8800605 / 5H KASE 14 )
2093 78 IF (NOSB) 60,60,58
2094 78 CALL PRINTH (WORD(6))
2095 60 CALL PRINTH (WORD(ICONF))
2096 IF (ALT) 300,300,301
2097 300 TIME = START , INITIALLY
2098 301 TIME = TIME 1(1)
2099 GO TO 105
2100 TIME = ALT
2101 WRITE (6,302) ALT

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2102      302 FORMAT (9H0 START = E20.9 ///)
2103      105 WRITE (6,106) ICONF,ICLK,ICLK, INPCW,ISTETS,KASE,KFUNT,NBCOL,OUTIT 50
2104      1 N0BUG,NDIM, N0PSHR,N0PSTG, N0SB,NPGAS,NPQ,NPU,NQI,NSEF,NTRAJ OUTIT 60
2105      2 ,NOCHEK, IGO OUTIT 61
2106      106 FORMAT ( 9H INTEGERS / 5X,5HICCNF,6X,4HICLK,5X,5HSHANK, OUTIT 62
2107      1 5X,5HINPCW,4X,6HISTETS,6X,4HKASE,5X,5HKFUNT,5X,5HNBCOL,5X, OUTIT 63
2108      2 5HNDBUG,6X,4HNDIM /10I10/ 4X,6HNOPSHR,4X,6HNOPSTG,6X,4HNQSB, OUTIT 64
2109      3 5X,5HNPGAS,7X,3HNPU,7X,3HNQI,6X,4HNSEF,5X,5HNTRAJ OUTIT 65
2110      4 ,4X,6HNOCHK/10I10/ 110) 66
2111      ICONF = 1 FLAT PLATE OUTPT 65
2112      = 2 WEDGE OUTPT 66
2113      = 3 CONE OUTPT 67
2114      = 4 SPHERE OUTPT 68
2115      = 5 CYLINDER OUTPT 69
2116      NQIM = NO. OF DIMENSIONS ( 1 OR 2 ) OUTPT 70
2117      NTRAJ = NO. OF TRAJECTORY CARDS (MAXIMUM OF 100 ) OUTPT 71
2118      KFUNT = 1 F(K(I) AND CP(I) ARE BOTH FCNS OF TEMPERATURE OUTPT 72
2119      = 2 F(K(I) IS A FCN OF TEMPERATURE, CP(I) IS CONSTANT OUTPT 73
2120      = 3 F(K(I) IS CONSTANT, CP(I) IS A FCN OF TEMPERATURE OUTPT 74
2121      = 4 BOTH ARE CONSTANT OUTPT 75
2122      NSEG =NARCW = NUMBER OF SEGMENTS (MAXIMUM OF 20 IN 10, 10 IN 10 ) OUTPT 76
2123      NBCOL = IN ? DIMENSIONS IS NO. OF COLUMNS (MAX. PRESENT FOR GIVE OUTPT 77
2124      N SLAB, NOT TO EXCEED 10) OUTPT 78
2125      RETURN OUTIT 99
2126      END

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2127 SUBROUTINE OUTPUT
2128 ROUTINE FOR BDC6E
2129 OCTOBER 14 1970 JOHN KOHLEBERGER
2130 AERODYNAMIC HEATING PROGRAM 1967
2131 FORTAN IV
2132
2133 DIMENSION TIME(100),ALTI(100),VINFL(100),AQFAL(100),HINSD1(100),OUTPT 3
2134 QI(100),QAD1(100),CP(40),FK(40),EL(40),RHO(40),TEMP(40) 1
2135 A(4,40),B(4,40) 2
2136 AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10) 4
2137
2138 COMMON A,ALTI,AQFAL,B,CP,CPG,EK,EL,HINSD1,QAD1,QCONSL,QI 5
2139 RHO,TEMP,TEMPW,TIME1,TINSD1,VAPRES,VINFL 6
2140 AA,BB,CC,CP2,DK,T2 7
2141
2142 COMMON ALT,AMINF,AQFA,ANGLE,CONPR,DELTA,DQSAV 8
2143 EMIS,ETAL,ETA2,HINSD,HQABL,HSUHI,HV 9
2144 ICHK,ICK,ICONF,IGO,INB4,INB42,IREFC, 10
2145 NRCOL,NRBUG,NRDI,NRNB,NRNGAS,NRPREST,NPU,NSEG,NSEG1,NSEG2 11
2146 NTPAJ,ONF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUHI 12
2147 RADIUS,RECI,REFI,CMU,REFRHO,REFRM,REYN,RHCINF,RHOSHK,RHOSL 13
2148 SHKI,SHKMU,STOP,SJEEP,STAGI,TABL,TIME,TINF,TINSD,TRANR 14
2149 TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDCT,WALLI,WRITE 15
2150 XX,XDIST 16
2151
2152 ETATP,ETALP,HVPSTM,PSIMAX 17
2153
2154 COMMON /MIKE/ HV2,ETAL2,ETAT2,XI,FV1P(10),FVIS(10),FV2P(10), 18
2155 FV2S(10),STGTBL(10),SHRTBL(10),NOPSTG,NOPSHR 19
2156
2157 QSONIC,SHEAR,HQABLM,HF,ISTETS,NOCHKEK, 20
2158
2159 RHOABL(10,40),CPTBL(10,40),EKTBL(10,40),TEMTBL(10,40) 21
2160
2161 COMMON /BLOCK1/ TITLE(20) 22
2162
2163 COMMON /WERNER/ TRVRSI,TFB(100),RHOFB(100),PFB(100),ALTCM(100) 23
2164
2165 COMMON /PHIL/ NPQS,QSTAR(10),PSTAGN(10) 24
2166
2167 COMMON /PALPH/ TWTAB(20),FMTAB(20),NEMIS,NQCOR,QABSF(20),TWA(20) 25
2168
2169
2170 EQUIVALENCE (NSEG,NAROW) 28
2171 EQUIVALENCE (OCALT,TRANLT)
2172
2173 WRITE (6,6) TITLE
2174
2175 FORMAT (1H1,20A4 ) 32
2176
2177 FORMAT (14I5 ) 33
2178
2179 FORMAT (50F10.0 ) 34
2180
2181 FORMAT (4F14.0) 35
2182
2183 FORMAT (5E14.0) 36
2184
2185 FORMAT (7E10.0) 37
2186
2187 FORMAT (10F7.0 ) 38
2188
2189 FORMAT (12A6 ) 39
2190
2191

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2170 125 WRITE (6,126) TRANR,TRANLT,ANGLE,SWEEP,XDIST,CONPR
2171 126 FORMAT (10CHO
2172 1 SWEEP
2173 C TRANR = TRANSITION REYNOLDS NO.
2174 C ANGLE = WEDGE OR CONE HALF ANGLE
2175 C SWEEP = SWEEP ANGLE
2176 C XDIST = DISTANCE FROM LEADING EDGE FOR FLAT PLATE, WEDGE OR CONE
2177 C = DIAMETER FOR SPHERE OR CYLINDER
2178 C EMIS = SURFACE EMISSIVITY
2179 145 WRITE (6,146) DELTA,WRITE,STOP,TARL,HV,FTAL,FTA2,EMIS
2180 146 FORMAT (10C7X,5HDELTA,15X,5HWRITE,15X,4HSTOP/3F20.8//
2181 1 7X,5H TARL,15X,2HHV,18X,4HETAL,16X,4HETAT,15X,5HEMIS / 5F20.8)
2182 IF (ISTEPS.GT.0) WRITE (6,1775)
2183 1775 FORMAT (31H-WIYH STETSON LAMINAR ABLATION )
2184 C FTAL,FTA2 = USED IN HOARL EQUATION -SEE HV-
2185 C DELTA = TIME STEP SIZE ( SECONDS )
2186 C WRITE = PRINT OUT TIME INTERVAL ( SECONDS )
2187 C STOP = END OF FLITE TIME
2188 C TARL = ABLATION TEMPERATURE ( DEGREES P )
2189 C HV = USED IN HOARL EQU. (HOARL=HV+ETA*(PFCI-WALLI))
2190 C CONPR = CONE PRESSURE AS USED IN *PMF*
2191 IF (KFUNT.GT.4) GO TO 2665
2192 IF (KFUNT.GT.0) GO TO 159
2193 151 FORMAT (' KFUNT = 0, DK AND CP2 LISTED BELOW')
2194 WRITE (6,151)
2195 DO 155 I=1,NAROW
2196 WRITE (6,152) I, (DK(I,K), K=1,NRCOL)
2197 152 FORMAT(' ROW',I6, ' DK',/10E13.5)
2198 WRITE (6,153) (CP2(I,K), K=1,NRCOL)
2199 153 FORMAT(9X
2200 , 'CP2',/10E13.5)
2201 WRITE(6,154) RHO(I)
2202 154 FORMAT (9X, 'RHO'=',F13.5)
2203 155 CONTINUE
2204 GO TO 260
2205 159 WRITE (6,217) (J,A(1,J),A(2,J),A(3,J),A(4,J) ,J=1,NSEG)
2206 217 FORMAT (3HC J,10X, 5HAI(J),11X,5HA2(J),11X,5HA3(J),11X,5HA4(J)
2207 1 / (13,4F16.8) )
2208 WRITE (6,227) (J,R(1,J),R(2,J),R(3,J),R(4,J) ,J=1,NSEG)
2209 227 FORMAT (3HC J,10X, 5HBI(J),11X,5HB2(J),11X,5HB3(J),11X,5HB4(J)
2210 1 / (13,4F16.8) )
2211 C A(I,J) = COEFFICIENTS OF JTH SEGMENT FOR COMPUTING EK(J) THUSLY
2212 EK(J) = A(1,J) + A(2,J)*T + A(3,J)*T**2 + A(4,J)*T**3
2213 C R(I,J) = ARE TO CP(J) AS THE A S ARE TO EK(J)
2214 165 WRITE (6,166) NSEG,(RHO(I),I=1,NSEG)
2215 166 FORMAT ( 26H0 RHO(I), I=1, 12 / (5E20.8) )
2216 C RHO(I) = SPECIFIC WT. OF SEGMENT I ( LBS/FT**3 )
2217

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OUTPUT112

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2262 399 FORMAT (1H-', TRVRSL = 'F6.1 / 8X, 'ALTCM',13X,'TFB',13X,'RHOFB',OUTP
2263 1 11X,'PFB' / (13,4E16.8) )
2264 IF(NOSR) 401,404,401
2265 401 TABL = TWRB
2266 WRITE (6,402) NOSB,RADIUS,ANGLE,TWRB
2267 402 FORMAT (35HONOSE BLUNTING ROUTINE WILL BE USED 7H ,NOSB= 13 //
2268 17X,7H RADIUS 14X,6HANGLE 14X,5HTWALL / 3E20.8)
2269 IF (PSTMAX.LE.C.) GO TO 404
2270 IF (HF.LT.1.E-8) HF = 0.0
2271 WRITE (6,406) PSTMAX,HVPSTM,HOBRLM
2272 406 FORMAT (10X,'HVPSTM',10X,'HOBRLM',/3E16.8)
2273 WRITE (6,1776) HF
2274 1776 FORMAT (6H HF = E16.8)
2275 PRCT = 1.-XI
2276 NOP = MAX0 (NOPSHR,NOPSTG)
2277 WRITE (6,403) HV,ETAL,ETA2,XI
2278 403 FORMAT (18H MATERIAL NO. 1 / 7X,2HVV,14X,4HETAL,12X,4HETA2,12X
2279 *,2HX1/ 4E16.8)
2280 IF (XI.EQ.1.) GO TO 404
2281 WRITE (6,405) HV2,ETAL2,ETA2,PRCT,NOPSTG,NOPSHR,
2282 *(FV1P(I),FV1S(I),STGTBL(I) ,SHRTBL(I),FV2P(I),FV2S(I), I=1,NOP)OUTPT165
2283 405 FORMAT (18H MATERIAL NO. 2 / 7X,3HVV2,14X,5HETAL2,11X,5HETA2,
2284 1 11X,5H1.-XI / 4E16.8 / 32X,9H NOPSTG = 13, 4X,9H NOPSHR = 13 /
2285 2 7X,5H FV1P,11X, 4HFV1S,12X,6HSTGTBL,10X,6HSHRTBL,10X,4HFV2P,12X
2286 3, 4HFV2S / (6E16.8))
2287 404 IF (NPGAS) 410,421,421
2288 410 NOP = IABS (NPGAS)
2289 WRITE (6,413) NOP,(VAPRFS(I),TEMPH(I),I=1,NOP)
2290 413 FORMAT (44H-STAGNATION ENTHALPY VS. HOABL, NO. OF PTS.= 13/
2291 1 (2E20.8))
2292 GO TO 424
2293 421 WRITE (6,422) QAD1(100)
2294 422 FORMAT (7X,7H QSOLAR / E20.8)
2295 424 IF (NPQS.LE.0) GO TO 430
2296 WRITE (6,426) NPQS,(QSTAR(I),PSTAGN(I),I=1,NPQS)
2297 426 FORMAT (1H- QSTAR VS. PSTAGN - TABLE TO COMPUTE HV, HAS',16,
2298 1, VALUES (N ,S)/(2E13.5))
2299 430 IF (NEMIS.LE.0) GO TO 440
2300 WRITE (6,428) (TWTAB(I),EMTAB(I),I=1,NEMIS)
2301 428 FORMAT (10X, VARIABLE EMISSIVITY, AS A FUNCTION OF TWALL, BEING USED
2302 1,7X,'TWTAB',10X,'EMTAB',10X,'TWTAB',10X,'TWTAB',10X,
2303 2 'EMTAB',/ (6E16.8))
2304 440 IF (NQCOR.LE.0) GO TO 500
2305 WRITE (6,431) (TWA(I),QABSF(I),I=1,NQCOR)
2306 431 FORMAT (10X, QCONS WILL BE MULTIPLIED BY QABSF AT TWA' / TWA (TWALL
2307 1) QABSF (Q FACTOR)' / (2E16.8))

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2313 SUBROUTINE PME
2314 PRANDLT MAYER EXPANSION
2315 APRIL 22 1964 JOHN KOHLENBERGER
2316 SURROUTINE PME (TINF,VINF,AQFA,RHOINF,PINF,IREF,RECI,WALLI,REFRHO,PRAND
2317 IVSHK,REFMU)
2318 DIMENSION
2319 1 , TINSOL(100),QCONS1(100),VAPRES(100),CPG(100),TFMPW(100)
2320 2 , QI(100),QADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
2321 3 , A(4,40),B(4,40)
2322 4 , AA(10),BA(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
2323 COMMON A,ALTI,AOFAL,B,CP,CPG,EK,EL,HINSDI,QADI,QCONS1,QI
2324 1 , RHO,TEMP,TEMPW,TIME1,TINSD1,VAPRES,VINF1
2325 2 , AA,BB,CC,CP2,DK,T2
2326 COMMON ALT,AMINF,AQFA,ANGLE,CNPR,DELTA,DQSAV
2327 1 , EMIS,ETAI,ETA2,HINSD,HQABL,HSURI,HV
2328 2 , ICHK,ICK,ICJNF,IGQ,INRG,INB42,IREF, KASE,KFUNT, NPQPRAND
2329 3 , NRCOL,NDBG,NDIM,NJSB,NPGAS,NQI,NPREST,NPU,NSEG,NSEGI,NSEGT,PRAND
2330 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSQ,QNFT,QSAV,QSUBI PRAND
2331 5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REFYN,RHOINF,PHOSHK,RHOSL PRAND
2332 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSD,TRANR PRAND
2333 7 , TSHK,TWALL,TWR3,VINF,VSHK,W,WAB,WABDQT,WALLI,WRITE PRAND
2334 8 , XX,XDIST PRAND
2335 9 , ETATP,ETALP,HVPSTM,PSTMAX PRAND
2336 EQUIVALENCE (NSEG,NAROW),(REFRM,REFRN) PRAND
2337 TRUANG = ANGLE + AQFA PRAND
2338 AMINF = VINF/(49.01*SQRT (TINF)) PRAND
2339 IF (AMINF - 1.0)20,20,10 PRAND
2340 10 RETAI = SQRT (AMINF*AMINF-1.0) PRAND
2341 UNI = 140.34601*ATAN (.40825*RETAI) - 57.29578*ATAN (RETAI) PRAND
2342 IF (TRUANG+.05) 30,30,20 PRAND
2343 PR = 1.0 PRAND
2344 TR = 1.0 PRAND
2345 VR = 1.0 PRAND
2346 RM = 1.0 PRAND
2347 DR = 1.0 PRAND
2348 GO TO 110 PRAND
2349 30 UNE = UNI - TRUANG PRAND
2350 IF (UNE-.00140,40,50 PRAND
2351 40 AME = -26.301065/(UNE-.81.77828)+.78959002+.02791663*UNE PRAND
2352 GO TO 90 PRAND
2353 50 IF (UNE - 102.32)60,60,70 PRAND
2354 60 AME = -280.09435/(UNE-130.19996)-.89411241+.8.2845071E-03*UNE PRAND
2355 GO TO 90 PRAND

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2356 70 AME = -284.84684/(UNE-130.43433)-1.0199074+8.6803698E-03*UNE PRAND 44
2357 90 PR = ((2.+.4*AMINF*AMINF)/(2.+.4*AME*AME))**.5 PRAND 45
2358 IF (CONPR.GT. 0.) GO TO 94 PRAND 46
2359 COMPR = 1.E-3 PRAND 47
2360 C COMPUTED PR (NOT TO OVER RIDE INPUT VALUE WHEN PR IS SMALL) PRAND 48
2361 IF (PR.GE. CONPR) GO TO 100 PRAND 49
2362 PR = CONPR PRAND 50
2363 GO TO 96 PRAND 51
2364 94 IF (PR.GE. CONPR) GO TO 100 PRAND 52
2365 PR = CONPR PRAND 53
2366 96 AME = SQRT( (2.+.4*AMINF**2)/(.4*PR**2.857143) -.5. ) PRAND 54
2367 100 TR = (2.+.4*AMINF*AMINF)/(2.+.4*AME*AME) PRAND 55
2368 VR = (AME/AMINF)*SQRT (TR) PRAND 56
2369 DR = PR/TR PRAND 57
2370 PSHK = PR*PINF PRAND 58
2371 TSHK = TR*TRINF PRAND 59
2372 RHOSHK = DR*RHOINF PRAND 60
2373 VSHK = VR*VINP PRAND 61
2374 SHKI = 2.2864+.2272*TSHK+.11571E-4*(TSHK**2)+.23676E-9*(TSHK**3) PRAND 62
2375 119 PR = .76 PRAND 63
2376 GO TO (120,130,180),IREC PRAND 64
2377 120 REC = SQRT(PR) PRAND 65
2378 GO TO 140 PRAND 66
2379 130 REC = PR**.33333 PRAND 67
2380 140 RECI = SHKI+(REC*(VSHK**2))/50061.5 PRAND 68
2381 WALLI=2.2864+.2272*TWALL+.11571E-4*(TWALL**2)+.23676E-9*(TWALL**3) PRAND 69
2382 REFI = SHKI+0.5*(WALLI-SHKI)+.22*(RECI-SHKI) PRAND 70
2383 IF (REFI - 1300.)150,160,160 PRAND 71
2384 150 REFMU = .42642E-7*(REFI**493) PRAND 72
2385 REFRHO = .576E-4*(REFI**(-.849))*PSHK PRAND 73
2386 GO TO 170 PRAND 74
2387 160 REFMU = .28428E-6*(REFI**.228) PRAND 75
2388 REFRHO = .865E-5*(REFI**(-.584))*PSHK PRAND 76
2389 170 REFRM = .2465E-11*(REFI**(-.356))*PSHK PRAND 77
2390 GO TO 200 PRAND 78
2391 180 IF (SHKI-1300.)185,190,190 PRAND 79
2392 185 SHKMU = .42642E-7*(SHKI**493) PRAND 80
2393 GO TO 200 PRAND 81
2394 190 SHKMU = .28428E-6*(SHKI**.228) PRAND 82
2395 C ***** CHANGES ***** PRAND 83
2396 200 IF (NDBUG-.J) 210,117,210 PRAND 84
2397 117 WRITE (6,118) PR,CONPR,PSHK,DR,AME,AMINF, PRAND 85
2398 1 TRUANG,UNE,REFRM,RHOSHK,I REC PRAND 86
2399 118 FORMAT (20H .PME. DEBUG PRINT /7X,27H PR,CONPR,PSHK,DR,AME,AMINF/PRAND 87
2400 1 6E18.8/7X,45H TRUANG(ANGLE-ACFA), UNE, REFRM, RHOSHK, IREC/PRAND 88
2401 2 4E18.8,18 ) PRAND 89

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PRAND 90
PRAND 91
PRAND 92

C ***** CHANGES *****

210 RETURN
END

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C - - - - - OCTOBER 14 1970      JOHN KOHLENBERGER      FORTRAN IV
SUBROUTINE PRINT
DIMENSION  TIME1(100),ALTI(100),VINFL(100),AOFAI(100),HINSDI(100)PRNT
1  ,  TINSDI(100),QCONSI(100),VAPRES(100),CPG(100),TEMPW(100)PRNT
2  ,  QI(100),QADI(100),  CP(40),EK(40),EL(40),RHO(40),TEMP(40)PRNT
3  ,  A(4,40),B(4,40)PRNT
4  ,  AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)PRNT
COMMON  A,ALTI,AOFAI,B,  CP,CPG,  EK,EL,  HINSDI,  QADI,QCONSI,QI
1  ,  RHO,  TEMP,TEMPW,TIME1,TINSDI,  VAPRES,VINFLPRNT
2  ,  AA,  BB,  CC,CP2,  DK,  T2PRNT
COMMON  ALT,AMINF,AOFA,ANGLE,  CONPR,  DELTA,DQSAV
1  ,  EMIS,ETAL,ETA2,  HINSD,HOABL,HSUBI,HVPRNT
2  ,  ICHK,ICK,ICONE,IGO,INR4,INR42,IREC,  KASE,KFUNT,  NPQPRNT
3  ,  NRCOL,NDRUG,NDIM,NOSB,NPGAS,NQI,NPREST,NPU,NSEG,NSEGI,NSEG2PRNT
4  ,  NTRAJ,  PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBIPRNT
5  ,  RADIUS,RECT,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSLPRNT
6  ,  SHKI,SHKMU,  STOP,SWEEP,STAGI,  TABL,TIME,TINF,TINSD,TRANRPRNT
7  ,  TSHK,TWALL,TWNB,  VINFL,VSHK,  W,WAB,WABDOT,WALLI,WRITEPRNT
8  ,  XX,XDISTPRNT
9  ,  ETATP,ETALP,HVPSTM,PSTMX,NTPRNT
COMMON /CHARAB/ NTME,TSTOR(50),CO(50),PO(50),HSTAB(50),HLTAR(50),PRNT
1 UETAB(50)PRNT
COMMON / SWALOW/  QINT(50),HEDGE(50),PEDGE(50),UEDGE(50),HRECOV(50)PRNT
1) ,  INPCWPRNT
COMMON / MIKE / HV2,ETAL2,ETAT2,XI,  FV1P(10),FVIS(10),FV2P(10),PRNT
*  FV2S(10),STGTBL(10),SHKTRBL(10),NOPSTG,NOPSHRPRNT
*  QSONIC,SHEAR,HOABLM
EQUIVALENC (NSEFG,NAROW)
NAMELIST /COMMON/
1  ALT,AMINF,AOFA,ANGLE,  CONPR,  DELTA,DQSAV
1  ,  EMIS,ETAL,ETA2,  HINSD,HOABL,HSUBI,HV
2  ,  ICHK,ICK,ICONE,IGO,INR4,INR42,IREC,  KASE,KFUNT,  NPQPRNT
3  ,  NRCOL,NDRUG,NDIM,NOSB,NPGAS,NQI,NPREST,NPU,NSEG,NSEGI,NSEG2PRNT
4  ,  NTRAJ,  PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBIP
5  ,  RADIUS,RECT,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSLPRNT
6  ,  SHKI,SHKMU,  STOP,SWEEP,STAGI,  TABL,TIME,TINF,TINSD,TRANR
7  ,  TSHK,TWALL,TWNB,  VINFL,VSHK,  W,WAB,WABDOT,WALLI,WRITE
8  ,  XX,XDIST
9  ,  ETATP,ETALP,HVPSTM,PSTMX
Q3600 = QSURI/3600.
H3500 = HSUBI/3600.
QN3500 = QNET/3600.

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20 IF (NT.GE.1) GO TO 40
30 QNSUM = 0.0
   QN = 0.0
   TIM1 = TIME1(1)
   TIM2 = TIME
   GO TO 45
40 TIM1 = TIME2
   TIM2 = TIME
45 IF (QN3600) 60,50,50
50 QNSUM = QNSUM + (QN3600+QN) / 2. * (TIM2 - TIM1)
60 QN = QN3600
   QNIP = RHOINF * VINI*VINI/2.
   IF (RECI.NE.WALLI) GO TO 64
   TIM1 = TIME-DELTA
   GO TO 65
64 SHEARS=.025 *QSUBI*VSHK / ((RECI-WALLI)*3600 * *QCONS
65 IF (AMINF.GT.1.00) GO TO 70
   PSTAG = (PINI + RHOINF*VINI**2 *.5 )/2116.
   GO TO 80
70 PSTAG = PINI*(1.2*(AMINF**2))**.5 *(6. / (7. *(AMINF**2)-1. ))**2.5
   / 2116.
80 PS = PSHK/ 2116.
   WABSEC = WABDOT/DELTA
   WRITE (6,105) TIME,ALT,VINI,AJFA,Q3600,H3600,QN3600,REYN,
1     DELTA,WABDOT,WA9,RECI,WALLI,QSAV,QINSD,TRANR,
2     -QABL,TABL,PSHK,QNIP,VSHK,SHKI,REFI,QNSUM,SHEARS,PS
3     ,PSTAG,FMIS,QCONS,WABSEC,NT
105 FORMAT (1H,7X,5H TIME,16X,3H ALT,14X,4H VINI,15X,4H AJFA,13X,
1     5H QSUBI,13X,5H QSUBI / 6E18.8 / 7X,5H QNFI,16X,4H REYN,13X,
2     5H DELTA,14X,6H WABDOT,13X,3H WAB,15X,4H RECI / 6E18.8 / 7X,
3     6H WALLI,14X,4H QSAV,14X,5H QINSD,13X,5H TRANR,13X,4H TABL,13X,
4     4H PSHK,14X,4H QNIP,14X,4H VSHK,14X,4H SHKI,14X,4H REFI,14X,
5     5H QNSUM / 6E18.8 / 7X,6H SHEAR,13X,2H PS,16X,5H PSTAG,13X,4H
6     ,QCONS,13X, WAB/SEC,14X,NT / 6E18.8,112)
   IF (QNSB) 106,110,106
106 RADIN = RADIUS * 12.
   F = VAPRES(100)
   WRITE
       (6,107) RADIUS,RADIN ,F,QSONIC,SHEAR,HOABL
107 FORMAT (11H RADIUS(FT) 10X,10H RADIUS(IN) 10X,1H F,16X,6H QSONIC,
1     10X,6H SHEAR,10X, 7H HOABL / 6E16.8 )
110 GO TO (120,140),NDIM
120 WRITE (6,121) NSEG2,(TEMP(1),I=NSEG2,NSEG)
121 FORMAT(30H 1ST SEGMENT PRES=NT=NSEG2 = 12.33H. TEMP(1), I=NSEG,
12,NSEG FOLLOW. / ( 5F12.1 ) )
   GO TO 200

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2494      140 WRITE (6,141)
2495      141 FORMAT ( 41H0 TEMPERATURES FOR 2D FCLLOW
2496      143 DO 145 I = 1,NAROW
2497      145 WRITE (6,146) (T2(I,J),J = 1,NBCOL)
2498      146 FORMAT (10F10.1 )
2499      200 IF (NDEBUG.EQ.0) GO TO 300
2500      IF (TINF.NE.0.) GO TO 210
2501      AMINF = 0.
2502      GO TO 215
2503      210 AMINF = VINF / (49.01 * SQRT(TINF))
2504      215 WRITE (6,COMMON)
2505      300 IF (NPU.LT.1) GO TO 400
2506      PREVENTS TSTOR(1)=0.
2507      IF (TIME.LT.TIME1(1)+DELTA) GO TO 400
2508      IF (NTMF.LT.1) GO TO 250
2509      PREVENTS DOUBLE TSTOR POINTS
2510      IF (TIME.EQ.TSTOR(NTME)) GO TO 400
2511      250 NTMF = NTME + 1
2512      IF (NTMF.LT.51) GO TO 260
2513      DO 255 I=1,49,2
2514      II = (I+1)/2
2515      TSTOR(II) = TSTOR(I)
2516      QO (II) = QO (I)
2517      PO (II) = PO (I)
2518      HSTAB(II) = HSTAB(I)
2519      HLTAB(II) = HLTAB(I)
2520      255 UETAB(II) = UETAB(I)
2521      NTMF = II+1
2522      260 TSTOR(NTME) = TIME
2523      TO PREVENT QO=0, SINCE CHAR DIVIDES BY IT
2524      IF (Q3600.LE.0.) Q3600 = 1.E-16
2525      QO (NTME) = Q3600
2526      PO (NTME) = PS
2527      HSTAB(NTME) = RECI
2528      HLTAB(NTME) = SHKI
2529      UETAB(NTME) = VSHK
2530      400 RETURN
2531      END

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B-66

8-11-69

PRNT 74
PRNT 75
PRNT 76
PRNT 77
PRNT 78

PRNT 80
PRNT 101

PRNT 103
PRNT 104
PRNT 105
PRNT 106
PRNT 107
PRNT 108
PRNT 109
PRNT 110
PRNT 111
PRNT 112
PRNT 113
PRNT 114

PRNT 115
PRNT 116
PRNT 117
PRNT 118
PRNT 119
PRNT 120
PRNT 121

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CPPNH SUBROUTINE PRINTH (ALPHA)
- SUBROUTINE TO PRINT HOLLERITH (ALPHA)
WRITE (6,6) ALPHA
6 FORMAT (1H A6)
RETURN
END

FNTRP 34
FNTRP 33
FNTRP 35
FNTRP 36
FNTRP 37
FNTRP 38

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2539      SUBROUTINE SHOCK
2539      CSHOCK
2539      C - - - APRIL 8 1964      JOHN KOHLBERGER      FORTRAN IV
2540      C
2541      SURROUTINE SHOCK (ICONF,PINF,TINF,VINF,AOFA,ANGLE,PSHK,TSHK,VSHK)
2542      DIMENSION TIME1(100),ALTI(100),VINFI(100),ADFAI(100),HINSOI(100)
2543      1 , TINSOI(100),QCONSI(100),VAPRES(100),CPG(100),TEMPW(100)
2544      2 , QI(100),QADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
2545      3 , A(4,40),B(4,40)
2546      4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
2547      COMMON A,ALTI,ADFAI,B,CP,CPG,EK,EL,HINSOI,QADI,QCONSI,QI
2548      1 , RHO,TEMP,TEMPW,TIMFI,TINSOI,VAPRES,VINF
2549      2 , AA,BB,CC,CP2,DK,T2
2550      COMMON ALT,AMINF,ADFA,ANGLE,CNPR,DELTA,DQSAV
2551      1 , EMIS,ETAL,ETA2,HINSO,HDABL,HSUBI,HV
2552      2 , ICHK,ICK,ICONF,IGO,INB4,INB42,IREC,
2553      3 , NBCOL,NDBUG,NDIM,NOSB,NPGAS,NGI,NPREST,NPU,NSEG,NSEGI,NSEG2
2554      4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSO,QNET,QSAV,QSUBI
2555      5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REFYN,RHOINF,RHOSH,RHOSL
2556      6 , SHKI,SHKMU,STOP,SWEET,STAGI,TABL,TIME,TINF,TINSO,TRANR
2557      7 , TSHK,TWALL,TWNA,VINF,VSHK,W,WAB,WABOBT,WALLI,WRITE
2558      8 , XX,XDIST
2559      9 , ETATP,ETALP,HVPSTM,PSTMAX
2560      EQUIVALENCE (NSEG,NAROW)
2561      5 VSHKS = C.O
2562      ALPHA = (AOFA+ANGLE)/57.2957795
2563      AMINF = VINF/ (49.01*SQRT(TINF))
2564      IF (AMINF.LE.1.01) GO TO 21
2565      10 GO TO (20,30,120,300,300),ICONF
2566      20 IF (ALPHA.GT.0.) GO TO 30
2567      21 PSHK = PINF
2568      VSHK = VINF
2569      TSHK = TINF
2570      GO TO 300
2571      30 AMSA = AMINF* SIN (ALPHA)
2572      IF (AMSA-1.8)40,50,50
2573      40 PRATIO = -.0661*(AMSA**3)+1.889*(AMSA**2)+.603*AMSA+1.041
2574      GO TO 60
2575      50 PRATIO = -2.320+4.045*AMSA+1.036*(AMSA**2)+.0161*(AMSA**3)
2576      60 PSHK = PRATIO*PINF
2577      RFFM = VINF/1086.
2578      RMSA = REFM* SIN (ALPHA)
2579      IF (RMSA-.6)70,80,80
2580      70 VPARA = (.1923+1.404*RMSA+1.147*(RMSA**2)+.8325*(RMSA**3))*1.0E+6
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2581 GO TO 200
2582 R0 IF (RMSA-6.0)90,100,100
2583 90 VPARA = (.5958+.4494*RMSA+1.938*(RMSA**2)-.0486*(RMSA**3))*1.0E6
2584 GO TO 200
2585 100 VPARA = (.78.03-19.58*RMSA+3.13*(RMSA**2)-.05054*(RMSA**3))*1.0E6
2586 110 GO TO 200
2587 113 IF (VSHKS)115,115,118
2588 115 WRITE (6,350)
2589 IGO = 1
2590 GO TO 300
2591 118 VSHK = SQRT (VSHKS)
2592 GO TO 300
2593 FOLLOWING 120 IN SHOCK *** GRIFFITH -- LEWIS ***
2594 120 IF ( (RADIUS.LE.0.).OR. (ALPHA.LE.0.).OR. (XDIST.LE.0.)) GO TO 127
2595 Z = ALPHA*ALPHA*COS(ALPHA)*XDIST/(.802*RADIUS)
2596 TEST ADDED 8-2-67 FOR OS/360 TO AVOID DIV.ORMULT.BY ZERO
2597 126 IF (Z-10.) 300,127,127
2598 127 AMSA = AMINF*SIN(ALPHA)
2599 128 IF (AMSA-1.5)130,140,140
2600 130 PRATIO = 1.007+.3816*AMSA+1.522*(AMSA**2)-.1593*(AMSA**3)
2601 GO TO 170
2602 140 IF (AMSA-5.0)150,160,160
2603 150 PRATIO = .2397+1.161*AMSA+1.06*(AMSA**2)+.0489*(AMSA**3)
2604 GO TO 170
2605 160 PRATIO = -3.182+4.177*AMSA+.8373*(AMSA**2)+.0216*(AMSA**3)
2606 170 PSHK = PRATIO*PINF
2607 REFM = VINP/1086.
2608 RMSA = REFM*SIN (ALPHA)
2609 IF (RMSA-4.0)180,190,190
2610 180 VPARA = (.157+.04*RMSA+1.91*(RMSA**2)-.107*(RMSA**3))*1.0E+6
2611 GO TO 200
2612 190 VPARA = (6.187-1.038*RMSA+1.414*(RMSA**2)-.0062*(RMSA**3))*1.0E+6
2613 200 VINFS = VINP**2
2614 VSHKS = VINFS-VPARA
2615 IF (VSHKS) 205,205,210
2616 205 VSHKS = VINFS
2617 210 IF (VINP-700.0) 118,118,113
2618 300 IF (NDRUG-4) 310,305,310
2619 305 WRITE (6,306) IGO,VINFS,VSHKS,VPARA,PRATIO
2620 306 FORMAT (15H-SHOCK, IGO= 13/(6E20.8))
2621 350 FORMAT(16H0 VSHKS NEGATIVE)
2622 310 RETURN
2623 END

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2624 SUBROUTINE THERMO
2625 C THERMO
2626 C SUBROUTINE THERMO (IREC,ICONF,TWALL,TINF,PINF,VINF,RHOINF,AOFA,
2627 C   IANGLE,TSHK,PSHK,RHOSHK,WALLI,RECI,REFMU,REFRHO,REFRM,STAGI)
2628 C   - - - - - AUG. 18 1964 JOHN KOHLENBERGER FOR3R+N I5
2629 C   DIMENSION TIME1(100),ALTI(100),VINFL(100),AQFAL(100),HINSOI(100)
2630 C   1 , TINSOI(100),QCONSI(100),VAPRES(100),CPG(100),TEMPW(100)
2631 C   2 , QI(100),QAOI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
2632 C   3 , A(4,40),B(4,40)
2633 C   4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
2634 C   COMMON A,ALTI,AQFAL,B,CP,CPG,EK,EL,HINSOI,QAD1,QCONSI,QI
2635 C   1 , RHO,TEMP,TEMPW,TIME1,TINSOI,VAPRES,VINFI
2636 C   2 , AA,BB,CC,CP2,DK,T2
2637 C   COMMON ALT,AMINF,AQFA,ANGLE,CNPR,DELTA,DQSAV
2638 C   1 , EMIS,ETA1,ETA2,HINSO,HOABL,HSUBI,HV
2639 C   2 , ICHK,ICK,ICONF,IGO,INB4,INB42,IREF, KASE,KFUNT, NPQ THERM 16
2640 C   3 , NBCOL,NDBUG,NDIM,NGSB,NPGAS,NGI,NPPEST,NPU,NSEG,NSEG2 THERM 17
2641 C   4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBI THERM 18
2642 C   5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSLT THERM 19
2643 C   6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSO,TRANR THERM 20
2644 C   7 , TSHK,TWALL,TWN8,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE THERM 21
2645 C   8 , XX,XDIST THERM 22
2646 C   9 , ETATP,ETALP,HVPSTM,PSTMAX THERM 23
2647 C   EQUIVALENCE (NSEG,NAROW) THERM 24
2648 C   ALPHA = (AOFA+ANGLE)/57.2957795 THERM 25
2649 C   WALLI=2.2864+.2272*TWALL+.11571E-4*(TWALL**2)+.23676E-9*(TWALL**3) THERM 26
2650 C   AIIINF = 2.2864+.2272*TINF+.11571E-4*(TINF**2)+.23676E-9*(TINF**3) THERM 27
2651 C   AMINF = VINF/(49.01*SQRT (TINF)) THERM 28
2652 C   IF (NJSB.GT.0) GO TO 212 THERM 29
2653 C   IF (AMINF.LE.1.01) GO TO 11 THERM 30
2654 C   GO TO (10,20,30,210,210),ICONF THERM 31
2655 C   10 IF (ALPHA.GT.0.) GO TO 20 THERM 32
2656 C   11 TSHK = TINF THERM 33
2657 C   PSHK = PINF THERM 34
2658 C   RHOSHK = RHOINF THERM 35
2659 C   SHKI = 2.2864+.2272*TSHK+.11571E-4*(TSHK**2)+.23676E-9*(TSHK**3) THERM 36
2660 C   FOR ASCENT TRAJECTORY . . . 11/4/68 PETE CROWL JMK
2661 C   VSHK = VINF
2662 C   SHKMU = .42642E-7*(SHKI**.493)
2663 C   FOR ASCENT TRAJECTORY . . . 3/14/69 MIKE GYETVAY JMK
2664 C   GO TO 4C
2665 C   20 AMSA = AMINF*SIN (ALPHA)
2666 C   IF (AMSA-8.0)25,25,28

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2667 25 SHKI = AINIF*(.0167+.3203*AMSA+.224*(AMSA**2)-.4484E-3*(AMSA**3))
2668 GO TO 40
2669 28 SHKI = AINIF*(1.107-.22(9*AMSA+.3644*(AMSA**2)-.008452*(AMSA**3))
2670 GO TO 40
2671 C IN THERM, BELOW 30 *** GRIFFITH - LEWIS
2672 30 IF ((RADIUS.LE.O.)OR.(ALPHA.LE.O.))OR.(XDIST.LE.O.)) GO TO 31
2673 Z = ALPHA*ALPHA*COS(ALPHA)*XDIST/(.802*RADIUS)
2674 TEST ADDED 8-2-67 FOR OS/360 TO AVOID DIVIDING BY ZERO
2675 298 IF (Z-10.) 290,31,31
2676 299 IF (Z-1.5) 300,300,295
2677 295 CSURP = 2.46 * ALPHA**2
2678 GO TO 310
2679 300 CSURP = 2.*ALPHA**2*(((1-6.3*Z+29.3)*Z-52.2)*Z+.43.15)*Z
2680 1 +2.47)
2681 310 PSHK = PINF*(.7*AMINF**2*CSURP+1.)
2682 VSHK = SQRT(VINF*VINF*(1.-(PSHK/PINF)**.295 *.8333/(AMINF**2)
2683 *((1.168*(AMINF**2)-.1663)**.714))
2684 STAGI=AINIF+(VINF**2)/50061.5
2685 SHKI = STAGI - VSHK*VSHK/50061.5
2686 GO TO 40
2687 31 AMSA = AMINF*SIN(ALPHA)
2688 IF (AMSA-.0)35,35,33
2689 35 SHKI = AINIF*(1.03+.0827*AMSA+.2174*(AMSA**2)-.6956E-3*(AMSA**3))
2690 GO TO 40
2691 38 SHKI = AINIF*(1.106-.3695*AMSA+.3466*(AMSA**2)-.007766*(AMSA**3))
2692 GO TO 40
2693 40 PR = .76
2694 GO TO (50,60,120),IRFC
2695 50 REC = SQRT(PR)
2696 GO TO 70
2697 60 REC = PR**(.33333)
2698 ECKERTS REFERENCE ENTHALPY EQUONS.
2699 70 RECI = SHKI+(REC*(VSHK**2))/50061.5
2700 REFI = SHKI+C.5*(WALLI-SHKI)+.22*(RECI-SHKI)
2701 IF (REFI-1300.)80,90,90
2702 80 PEFMU = .42542E-7*(REFI**+.473)
2703 REFRHO = .576E-4*(REFI**(-.849))*PSHK
2704 GO TO 100
2705 90 REFMU = .28428E-6*(REFI**+.228)
2706 REFRHO = .865E-5*(REFI**(-.584))*PSHK
2707 100 REFMU = .2465E-11*(REFI**(-.356))*PSHK
2708 110 STAGI = AINIF+(VINF**2)/50061.5
2709 GO TO 200
2710 C SONIC POINT (WEDGE OR CONE)
2711 120 IF (SHKI-1300.)130,140,140
2712 130 SHKMU = .42642E-7*(SHKI**+.473)

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THERM 40
THERM 41
THERM 42
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 THERM 97
 THERM 98
 THERM 99
 THERM100
 THERM101
 THERM102

RHOSHK = .576E-4*(SHKI**(-.849))*PSHK
 GO TO 200
 140 SHKMU = .28428E-6*(SHKI**.228)
 RHOSHK = .865E-5*(SHKI**(-.584))*PSHK
 200 IF (VDRUG-5) 205,201,205
 201 WRITE (6,203) AINFR,REFI,RECI,REC, ALPHA,AMSA,WALLI,TWALL
 203 FORMAT (14H- THERMO DERUG / 5X,5HAINF 15X,4HREFI 16X,4HRECI 16X,
 1 3HREC / 4E20.8 / 5X,5HALPHA 15X,4HAMSA 16X,5HWALLI 15X,
 2 5HTWALL / 4E20.8)
 205 RETURN
 210 IF (ICLK.GT.0) GO TO 212
 211 PSHK = PINF*(1.20*AMINF**2)**3.5*(6./({7.*AMINF**2-1.}))**2.5
 C. ANDERSON MOD. 03/15/65
 212 STAGI = AINFR*(VINFR**2)/50061.5
 RFI = STAGI
 C. C.8.A. 8-19-64 CHANGE
 GO TO 200
 END

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2731 SUBROUTINE TRAJ
2732 C -- APRIL 22 1964 JOHN KOHLENBERGER FORTRAN IV
2733 C INCREASES TIME BY DELTA THEN LINEARLY INTERPOLATES TO GET ALT,
2734 C VINP, AQFA, HINSD, TINSO, AND QCONS AS FUNCTIONS OF TIME
2735 C DIMENSION TIME(100),ALT(100),VINP(100),AQFA(100),HINSD(100),ALTM
2736 1 , TINSO(100),QCONS(100),VAPRES(100),CPG(100),TEMPW(100)
2737 2 , Q(100),QADI(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
2738 3 , A(4,40),R(4,40)
2739 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
2740 COMMON A,ALT1,AQFA1,B,CP,CPG,EK,EL,HINSD1,QADI,QCONS1,QI
2741 1 , PHO,TEMP,TEMPW,TIME1,TINSO1,VAPRES,VINP1
2742 2 , AA,BB,CC,CP2,DK,T2
2743 COMMON ALT1,AQFA1,HINSD1,QADI,QCONS1,HV
2744 1 , FMIS,ETAL,ETA2,HINSD,HJABL,HSUBI,HV
2745 2 , ICHK,ICK,ICONF,IGO,INR4,INR42,IREF, KASE,KFUNT, NQALTM
2746 3 , NRCOL,NRBUG,NRIM,NOSB,NPGAS,NQI,NPREST,NPU,NSEG,NSEGI,NSFG2 ALTM
2747 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSO,QNFT,QSAV,QSUBI ALTM
2748 5 , RADIUS,REFCI,REFI,QFEMU,REFRHO,REFRM,RFYN,RHINF,RHDSHK,RHISLALTM
2749 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSO,TRANR ALTM
2750 7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WARDOT,WALLI,WRITE ALTM
2751 8 , XX,XOIST
2752 9 , ETATP,ETALP,HVPSTM,PSTMX,NT
2753 COMMON / SWALOW/ QINT(50),HEDGE(50),PEDGE(50),UEDGE(50),HRECOV(50)ALTM
2754 1) , INPCW
2755 EQUIVALENCE (NSEG,NAROW)
2756 10 TIME = TIME+DELTA
2757 NT = NT + 1
2758 15 IF(NTRAJ-2)105,55,20
2759 20 DO 30 I=1,NTRAJ
2760 25 IF(TIME-TIME1(I))50,110,30
2761 30 CONTINUE
2762 40 I = NTRAJ
2763 50 IF(I-1)55,55,60
2764 55 I = 2
2765 60 FACTOR = (TIME-TIME1(I-1))/(TIME1(I)-TIME1(I-1))
2766 70 ALT = (ALT1(I)-ALT1(I-1))*FACTOR + ALT1(I-1)
2767 VINP = (VINP1(I)-VINP1(I-1))*FACTOR + VINP1(I-1)
2768 AQFA = (AQFA1(I)-AQFA1(I-1))*FACTOR + AQFA1(I-1)
2769 HINSD = (HINSD1(I)-HINSD1(I-1))*FACTOR + HINSD1(I-1)
2770 TINSO = (TINSO1(I)-TINSO1(I-1))*FACTOR + TINSO1(I-1)
2771 QCONS = (QCONS1(I)-QCONS1(I-1))*FACTOR + QCONS1(I-1)
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2774 IF (INPCW.LE.0) GO TO 100
2775 QSUBI = (QINT(I-1) + FACTOR*(QINT(I)-QINT(I-1)))*3600.
2776 SHKI = HEDGE(I-1) + FACTOR*(HEDGE(I)-HEDGE(I-1))
2777 VSHK = UEDGE(I-1) + FACTOR*(UEDGE(I)-UEDGE(I-1))
2778 PSHK = (PEDGE(I-1) + FACTOR*(PEDGE(I)-PEDGE(I-1)))*116.8
2779 RECI = HRECOV(I-1) + FACTOR*(HRECOV(I)-HRECOV(I-1))
2780 IF (INPCW.NE.NTRAJ) INPCW = NTRAJ
2781 IF (VINP.LE.0.)AND.(INPCW.GT.0) VINP = VSHK
2782 IF (NDBUG.NE.3) RETURN
2783 WRITE (6,101) ALT,VINF,AOFA,HINSD,TINSD,QCONS
2784 101 FORMAT(' TRAJ- ALT',13X,'VINF',12X,'AOFA',12X,'HI',SD',11X,
2785 1 'TINSD',11X,'QCONS' / 6E16.8)
2786 IF (INPCW.LE.0) RETURN
2787 WRITE (6,102) QSUBI,SHKI,VSHK,PSHK,RECI
2788 102 FORMAT ('7X,'QSUBI',11X,'SHKI',12X,'VSHK',12X,'PSHK',12X,'RECI' /
2789 1 5E16.8)
2790 RETURN
2791 105 I=1
2792 110 ALT = ALT1(I)
2793 VINF = VINP1(I)
2794 AOFA = AOFA1(I)
2795 HINSD = HINSD1(I)
2796 TINSD = TINSD1(I)
2797 QCONS = QCONS1(I)
2798 IF (INPCW.LE.0) GO TO 100
2799 QSUBI = QINT(I) * 3600.
2800 SHKI = HEDGE(I)
2801 VSHK = UEDGE(I)
2802 PSHK = PEDGE(I) * 116.8
2803 RECI = HRECOV(I)
2804 IF (INPCW.NE.NTRAJ) INPCW = NTRAJ
2805 140 GO TO 100
2806 C MAYBE AT 100 CONVERT AOFA TO RACIANS
2807 END

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44 ALTM
45 ALTM
46 ALTM
47 ALTM
48 ALTM
49 ALTM
50 ALTM
51 ALTM
52 TRAJ
52I
52H
52G
52F
52E
52D
52C
52B
52A
53 ALTM
54 ALTM
55 ALTM
56 ALTM
57 ALTM
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2808 SUBROUTINE TMOO
2809 CTWOD
2810 C - - - MARCH 27 1969 JOHN KOHLENBERGER
2811 DIMENSION TIME1(100),ALTI(100),VINFI(100),ADFAI(100),HINSOI(100)
2812 1 , TINSOI(100),QCONS1(100),VAPRES(100),CPG(100),TEMPW(100)
2813 2 , QI(100),QAD1(100),CP(40),EK(40),EL(40),RHO(40),TEMP(40)
2814 3 , A(4,40),B(4,40)
2815 4 , AA(10),BB(10),CC(10,10),CP2(10,10),DK(10,10),T2(10,10)
2816 COMMON A,ALTI,ADFAI,B,CP,CPG,FK,EL,HINSOI,QAD1,QCONS1,QI
2817 1 , RHO,TEMP,TEMPW,TIME1,TINSOI,VAPRES,VINFI
2818 2 , AA,BB,CC,CP2,DK,T2
2819 COMMON ALT,AMINF,ADFA,ANGLE,CONPR,DELTA,DQSAV
2820 1 , FMIS,ETAL,ETA2,HINSOI,HJABL,HSUBI,HV
2821 2 , ICHK,ICK,ICONF,IGO,INB4,INB42,IREF,
2822 3 , NRCOL,NOBUG,NDIM,NOSB,NPGAS,NQI,NPREST,NPU,NSEG,NSEGI,NSEGI2,NSEGI3
2823 4 , NTRAJ,PINF,PR,PSHK,PSL,QCALT,QCONS,QINSD,QNET,QSAV,QSUBI
2824 5 , RADIUS,RECI,REFI,REFMU,REFRHO,REFRM,REYN,RHOINF,RHOSHK,RHOSL
2825 6 , SHKI,SHKMU,STOP,SWEEP,STAGI,TABL,TIME,TINF,TINSD,TRANR
2826 7 , TSHK,TWALL,TWNB,VINF,VSHK,W,WAB,WABDOT,WALLI,WRITE
2827 8 , XX,XDIST
2828 9 , ETATP,ETALP,HVPSTM,PSTMAX
2829 EQUIVALENCE (NSEG,NAROW)
2830 COMMON /MIKE/ ADAM(64),JESHUA(2),ENCCH(4),ISTETS,NOCHEK
2831 DIMENSION T2NEW(10,10)
2832 2D
2833 C MATERIALS MUST BE HOMOGENEOUS IN X (BUT NOT Y) DIRECTION
2834 C AA(I) = SEGMENT THICKNESS (Y DIRECTION) - INCHES = EL(I)
2835 C BB(K) = SEGMENT LENGTH (X DIRECTION) - INCHES
2836 C CC(I,K) = 1 FOR CONDUCTION INTO AND OUT-OF NODAL POINT I,K
2837 C = 0 FOR NO HEAT CONDUCTION TO OR FROM NODAL POINT (I,K)
2838 C CP2(I,K) = CP(I)
2839 C DK(I,K) = EK(I)
2840 C T2(I,K) = TEMP(I)
2841 C 5 CALL GECPK2
2842 C STARMX = 0.
2843 10 DO 125 I = 1,NAROW
2844 30 DO 125 K = 1,NBCOL
2845 50 IF (CC(I,K) .GT. 0.) GO TO 60
2846 55 T2NEW(I,K) = 0.0
2847 GO TO 125
2848 60 FACTOR = DELTA/(25.0*RHO(I)*CP2(I,K)*BB(K)*AA(I))
2849 IF (I.GT.1) GO TO 70
2850 CHANGED 3-4-69 FOR RIGILBERT

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2851	CHANGED	3-27-69	FOR R.GILBERT		
2852	65	IF (K.LE.1)	GO TO 66		
2853		IF (T2(I,K-1)-T2(I,K))*2.LE.100.)	GO TO 66		
2854		TWALL = T2(I,K)			
2855		CALL ENCO			
2856	66	TERM1 = QNET*88(K)/12.0		TERM	41
2857	CHANGED	3-27-69	FOR R.GILBERT		
2858		GO TO 75			
2859	70	TERM1 = 88(K)*CC(I-1,K)/(0.5*(AA(I-1)/DK(I-1,K)+AA(I)/DK(I,K)))		TERM	42
2860		1*(T2(I-1,K)-T2(I,K))		TERM	43
2861	75	IF (1.GE.NAROW)	GO TO 85	TERM	44
2862	80	TERM2 = 88(K)*CC(I+1,K)/(0.5*(AA(I+1)/DK(I+1,K)+AA(I)/DK(I,K)))		TERM	46
2863		1*(T2(I+1,K)-T2(I,K))		TERM	47
2864		GO TO 90		TERM	48
2865	85	TERM2 = HINSD*(TINSD-T2(I,K))/12.0*88(K)		TERM	49
2866	90	IF (K.GT.1)	GO TO 100		
2867	95	TERM3 = 0.0		TERM	51
2868		GO TO 105		TERM	52
2869	100	TERM3 = AA(I)*CC(I,K-1)/(0.5*(88(K-1)/DK(I,K-1)+88(K)/DK(I,K)))		TERM	53
2870		1)*(T2(I,K-1)-T2(I,K))		TERM	54
2871	105	IF (K.LT.NBCOL)	GO TO 115		
2872	110	TERM4 = 0.0		TERM	56
2873		GO TO 120		TERM	57
2874	115	TERM4 = AA(I)*CC(I,K+1)/(0.5*(88(K+1)/DK(I,K+1)+88(K)/DK(I,K)))		TERM	58
2875		1)*(T2(I,K+1)-T2(I,K))		TERM	59
2876	120	T2NEW(I,K) = FACTOR*(TERM1+TERM2+TERM3+TERM4)		TERM	60
2877		IF (NBUG.GE.14)	WRITE(6,1200) TIME,T2NEW(I,K),FACTOR,TERM1,TERM2,		
2878		TERM3,TERM4,AA(I),88(K),CP2(I,K),RHC(I),DK(I,K),QNET,I,K,STAB			
2879	1200	FORMAT (' DEBUG- TWOD - TIME=E16.8, T2NEW=E16.8, FACTOR=E16.8			
2880		1/ 7X, TERM1, 7X, TERM2, 7X, TERM3, 7X, TERM4, 7X, AA, IOX, 88, IOX			
2881		2, CP2, 9X, RHO, IOX, DK/9E12.4/			
2882		3 QNET=E16.8, I=, I6, K=, I6, STAB=E13.5)			
2883		IF (1.GT.1)	GO TO 121	TERM	610
2884		DTL = 0.0			
2885		GO TO 1210			
2886	121	DTL = T2(I-1,K)-T2(I,K)			
2887	1210	IF (1.LT.NAROW)	GO TO 122		
2888		DTR = 0.0			
2889		GO TO 1220			
2890	122	DTR = T2(I+1,K)-T2(I,K)		TERM	611
2891	1220	IF (K.GT.1)	GO TO 123		
2892		DTD = 0.0			
2893		GO TO 1230			
2894	123	DTD = T2(I,K-1)-T2(I,K)		TERM	612
2895	1230	IF (K.LT.NBCOL)	GO TO 124		
2896		DTU = 0.0			

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GO TO 1240
124 DTU = T2(I,K+1)-T2(I,K)
1240 CONTINUE
IF (DTL.EQ.0.) GO TO1121
TERM1 = TERM1/DTL
1121 IF (DTR.EQ.0.) GO TO1122
TERM2 = TERM2/DTK
1122 IF (D7D.EQ.0.) GO TO1123
TERM3 = TERM3/DTD
1123 IF (DTU.EQ.0.) GO TO1124
TERM4 = TERM4/DTU
1124 STAB = FACTOR *(TERM1+TERM2+TERM3+TERM4)
C STABMX = AMAX (STAB,STABMX)
IF (STAB.LE.1.) GO TO 125
IF (NOCHEK.GT.1) GO TO 125
WRITE (6,1200) TIME,T2NEW(I,K),FACTOR,TERM1,TERM2,
1 TERM3,TERM4,AA(I),BB(K),CP2(I,K),RHC(I),DK(I,K),QNET,I,K,STAB
WRITE (6,126) DTL,DTP,DTD,DTU, T2(I-1,K),T2(I+1,K),
1 T2(I,K-1),T2(I,K+1), HINSD,TINSD
126 FORMAT (20X,'LEFT',12X,'RIGHT',11X,'DOWN',12X,'UP',,D(T2)',4F16.
1 8,' T2 ',4F16.8/ 10X,
2)
HINSD='E13.5', TINSD='E13.5'
WRITE (6,127)
127 FORMAT (1H-,20X,' STABILITY ERROR .... AT ABOVE CONDITIONS',1H-)
125 CONTINUE
C SHOULD CUT TIME STEP (DELTA) HERE IF STABMX.GT.1.
C OR INCREASE DELTA IF STABMX.LT. .5
DO 150 I = 1,NAROW
DO 150 K = 1,NBCOL
150 T2(I,K) = T2NEW(I,K) +T2(I,K)
160 THALL = T2(1,1)
RETURN
C 50 IF (CC(I,K))55,55,60
C IF (I-1)65,65,70
C 75 IF (I-NAROW)80,85,85
C 90 IF (K-1)95,95,100
C 105 IF (K-NBCOL)115,110,110
END

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TERM 613
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TERM 619
TERM 620
TERM 621
TERM 622
TERM 63

TERM 67
TERM 68
TERM 69
TERM 70
TERM 71
TERM 72
TERM 36
TERM 40
TERM 45
TERM 50
TERM 55
TERM 73

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2935 SUBROUTINE ZERBLK
2936 / INITIALIZE
2937 TO INITIALIZE BLANK COMMON
2938 C - - - APR 1969
2939 COMMON A(2154) , ICHK(22), PINF(46)
2940 DIMENSION ALTIO(2154), ALT2(46), IZZAK(22)
2941 EQUIVALENCE (ALTIO(1), A(1) ), (PINF(1), ICHK(1)), IZZAK(1))
2942 DATA ALTIO/1740*0., 100*1., 100*10., 100*01, 114*0./
2943 1 , IZZAK/0., 1, 3, -1, 0, 0, 3, 5*0, 1, 5*0, 1, 0, 0, 0, 0/
2944 2 , ALT2/ 3*0., 760., 15*0., 0023796, 19*0., 1., 6*0./
2945 NAMELIST /BLANK/ ALTIO, IZZAK, ALT2
2946 DO 422 I=1, 2154
2947 IF (I.GT.46) GO TO 422
2948 PINF(I) = ALT2(I)
2949 IF (I.GT.22) GO TO 422
2950 ICHK(I) = IZZAK(I)
2951 422 A(I) = ALTIO(I)
2952 IF (A (I).EQ.A (1078)) GO TO 7
2953 WRITE (6,6)
2954 6 FORMAT (' BLANK COMMON NOT PROPERLY INITIALIZED')
2955 WRITE (6,BLANK)
2956 7 RETURN
2957 END

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2958 C      FND OF ASAH PROGRAM DECK
2959 C
2960 C
2961 C      BEGINNING OF ASAH SAMPLE DATA
2962 C      SAMPLE 1 AND 2 DIMENSIONAL PROBLEMS - FOR A.S.A.H. MAR.3,'71
2963 C      &RDO60S
2964 C      TITLE=' SAMPLE ONE DIMENSIONAL PROBLEM, ONE SEGMENT, AERO HEAT',
2965 C      ISTATS=0,AOFA=16*0,HVPSTM=0.,PSTMAX=0.,KASE=1,NDIM=1,
2966 C      ICJNF=3,ANGLE=8.,DELTA=.05,WRITE=10.,NSEG=1,KFUNT=4,NTRAJ=16
2967 C      FMIS=.85,TABL=10000.,HV=1000.,ETAL=1.,ETAT=1.,
2968 C      TIME=0.,22.,40.,54.,60.,70.,80.,96.,112.,118.,124.,130.,136.,
2969 C      140.,144.,148.,
2970 C      ALT=200.,4350.,15500.,19540.,37000.,51570.,69210.,104800.,151270.,
2971 C      172125.,195210.,220540.,245180.,261700.,277990.,294230.,
2972 C      VINP=10.,410.,915.,1410.,1690.,1950.,2000.,2630.,4000.,5850.,7550.,
2973 C      8690.,9350.,9750.,9970.,10110.,10270.,
2974 C      AJ=60., BI=.28., RHO=108., EL=.125, STNP=14.8, XDIST=.243,
2975 C      &FND
2976 C      ONE DIM., ONE SLAB, ONE MAT'L
2977 C      &RDO60S KASE=2,TITLE(9)=' - W',ITH ',COLD', WAL',L IN',PJTS',
2978 C      '5',SFC.,
2979 C      KFUNT=3,
2980 C      XDIST=.243,TRANLT=80000.,NTRAJ=17,INPCW=17,
2981 C      TIME=0.,22.,40.,54.,60.,67.,70.,80.,96.,112.,118.,124.,130.,136.,140.,
2982 C      144.,148.,
2983 C      QINT=.1.,28.,1.00,15.9,15.6,11.36,6.42,3.97,2.88,3.43,4.12,3.68,
2984 C      2.57,1.57,1.08,.711,.375,
2985 C      ALT=200.,4350.,15500.,19540.,37000.,47000.,51570.,69210.,104800.,
2986 C      151300.,172125.,195210.,220540.,245180.,261700.,277990.,295000.,
2987 C      PFDGF=.095,.94,.55,.35,.25,.15,.13,.062,.010,.0033,.00131,6.6E-4,
2988 C      2.65E-4,9.47E-5,4.23E-5,1.86E-5,7.69E-6,
2989 C      HRECOV=123.,123.,126.,140.,146.,160.,167.,221.,400.,700.,1093.,1393.,
2990 C      1574.,1683.,1753.,1800.,1907.,
2991 C      UFDGF=10.,400.,900.,1300.,1550.,1775.,1800.,2400.,3600.,5500.,7149.,
2992 C      8320.,9084.,9593.,9802.,9977.,10000.,
2993 C      HFDGF=123.,123.,120.,130.,165.,165.,165.,170.,190.,210.,242.,240.,
2994 C      199.,149.,153.,140.,127.,
2995 C      TFMP=8*540., TRANLT=47000.,
2996 C      NSEG=5,
2997 C      A1=60.,.25.,965,2*75.,
2998 C      R1=.0.,28.,125,2*.034,B2=.0003,4*.0,
2999 C      R40=103.,150.,334.,2*1192.,
3000 C      EL=.125,.010,.050,2*.25,
      WRITE=5.,

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3001      NOTE - VARIABLE THERMAL PROPERTIES
3002      &BD060S QCONS=5*.495,
3003      &END
3004      &BD060S TITLE(15)=' SI', 'X SE', 'GMEN', 'TS ', KASE=3,
3005      NSEG=6,
3006      QCONS=6*1.,
3007      TEMP=6*540.,
3008      A1=.14,60.,.25.,.965,2*75.,
3009      B1=.26,0.,.28.,.125,2*.034, B2=.0.,.0003,4*.0,
3010      RHO=136.,108.,150.,.334.,2*1192.,
3011      EL=.010.,.125.,.010.,.050,2*.25,
3012      EMIS=.15,HV=950.,ETAL=.43,ETAT=.17,TABL=1800.,
3013      &END      NOTE - CHANGED EMIS, HV, TABL, ECT.
3014      &BD060S TITLE=' TWO-DIMENSIONAL PROBLEM, BASED ON KASE 3 (1-0)'
3015      KASE=23, NDIM=2,
3016      WRITE=.02,
3017      START= 68.7,
3018      &END
3019      &TWO DIM
3020      AA=.125,.010,.050,2*.25,
3021      BB=.308,.308,
3022      CC=5*1,5*0,1,0,3*1,80*0.,
3023      T2=5*540.,5*0,540,0,3*540,85*0,
3024      NAROW=5,
3025      NRCOL=2,
3026      T2=657,632,577,546,545,5*0,665,C,3*544,85*0,
3027      &END
3028      &END DATA
3029      &BD060S TITLE=' SAMPLE PROBLEM OUTPUT (SECTION 6 )
3030      NTRAJ=9,
3031      ICONF =3, ANGLE=10, DELTA=.01, WRITE=1, STOP=9.0,
3032      EMIS=.55, TABL=4900, HV=5500, ETAL=.52, ETAL=.25, RHD=20*102,
3033      A1=20.*.29,B1=20*.26, TEMP=20*560,EL=20*.2, XDIST=.16667
3034      NOSR=1, RADIUS=.0833, TWALL=4500,
3035      XI=.75, HF=60,
3036      HV2=1000, ETAT2=.25, ETAL2=.52,
3037      NOPSTG=6, NOPSHR=6,
3038      STGTBL= 0,13.66, 20, 30, 44, 200,
3039      FV1S= .69, .50, .34, .20, 2*.125,
3040      FV2S= 6*.55,
3041      SHRTBL= 0, 150, 220, 280, 310, 500,
3042      FV1P= 2*.85, .74, .49, 2*.125,
3043      FV2P= 6*.55
3044      TIME=0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 9.0,
3045      ALT =299000,291470,283929,276378,268817,261246,253665,246075,230870,
3046      VINP=22000, 22009.,22018, 22026, 22035, 22041, 22047, 22052, 22057,

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3047      &END
3048      ENDDATA
3049      ENDDATA
3050      RHO=108,EL=.125,NPU=0,NSEG=1,STOP=148,KFUNT=3,
3051      C      FND OF TAPE 06932 (MADE APRIL 15, 1971)
      END OF FILE READ ON UNIT 11.
      DONE

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