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COMPUTER PROGRAM FOR THE ANALYSIS OF ANNULAR COMBUSTORS

VOLUME II: OPERATING MANUAL

Prepared for the
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This work was performed under the direction of Dr. D. M. Dix. The initial portion was carried out by M. R. Bewsher, R. G. Croissant, P. N. Hoggett, and J. A. Monahan. The final portion, consisting of obtaining satisfactory operation of the computer program and revising the final report, was carried out by W. L. Brassert and Dr. P. L. Duffield.

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SUMMARY

This is the second of two volumes devoted to a computer program for predicting the performance of an annular combustor. It is intended to form a self-contained operating manual allowing the program to be operated without reference to Volume I.

INTRODUCTION

In this volume the computer program, which incorporates the methods discussed in Volume I, is described and presented.

Arrangement of Report

First, there is a brief description of each of the subroutines, and the complete set of flow charts is presented. Then the procedures for setting up the program input are described, and samples of input data -- for library data and for the overall test case described in Volume I - are shown. The output format is illustrated by the computer printout for the same test case.

The Fortran listing of the program, a compilation of program messages, and a guide to the Fortran nomenclature, are presented as appendices.

A copy of the program can be obtained by anyone interested in using it by writing to Mr. Jack S. Grobman, NASA-Lewis Research Center, 21000 Brookpark Road, Cleveland, Ohio 44135.

PROGRAM DESCRIPTION

This section shows how the calculation methods described in Volume I are fitted into the program.

As explained in Volume I, the program consists of four independent subprograms, each of which contains a family of subroutines. A brief discussion of the purpose and content of each subroutine is given here, together with a set of flow charts. Numerical techniques used in the program are also discussed. A complete Fortran listing of the program is given in Appendix IV, and the Fortran nomenclature is defined in Appendix VI.

Control Subprogram

The control subprogram sets up starting values for the whole calculation. The action taken depends on the values of the indices NCASE and INPUT. NCASE is the number of cases to be considered in the run; if NCASE > 1 the control subprogram prepares starting values for the second case at the conclusion of the first. INPUT indicates which variables are to be altered from one case to the next.

If NCASE = 0, the input data are read in and written out, but none of the main calculations are carried out.

The main program and subroutines will now be described in turn.

Program CLARE

This is the main program. It calls subroutines INPUT1 and INPUT2 and the control subroutines for each of the subprograms. The flow chart is shown on Figure 1.

Subroutine INPUT1

In this subroutine, all run data (i.e. data that do not change from one case to the next) are read in. Units are converted where necessary, subroutine TAPE is called to obtain the data required from the library tape, and subroutine GEOM is called to set up geometric parameters required later in the program. The data are then written out in a convenient format. INPUT1 is only called once in each run, at the beginning of the first case.

The flow chart for subroutine INPUT1 is shown on Figure 2.

Subroutine INPUT2

This subroutine is called by CLARE at the beginning of each case of a run. It reads in the case data (i.e. the data that alter from one case of a run to the next) and writes them out.

The flow chart for Subroutine INPUT2 is shown on Figure 3.

Subroutine TAPE

Subroutine TAPE selects from the library tape the data that are required for use in the program. The library tape is designated KTAPE in the program, and Subroutine TAPE is the only subroutine that refers to it.

The discharge-coefficient and initial-jet-angle data are taken from the library tape as follows. The first set of hole data is read into core storage. Then the set of indices denoting hole types in the flame tube is searched to see whether hole type "1" is required. If so, these data are preserved in core storage; otherwise, the data are overwritten by the set of data for the next hole type on the library tape. In this way, a "short list" of data for the hole types that are to be used in the combustor is assembled.

The generalized empirical diffuser data and the flame-emissivity data are treated in a similar way. The flow chart is given on Figure 4.

Subroutine GEOM

This subroutine calculates various geometric quantities, such as reference area, total hole areas, and cross-sectional areas, that are of interest or required elsewhere in the program. It also fixes the axial locations of the calculation points as follows:

1. One calculation point for each axial position at which holes are located. There may be more than one row of holes at a given axial position; the calculation point for all these hole rows is located at the upstream edge of the holes in the first row specified on the input data.
2. Calculation points at specified intervals downstream of all cooling slots (up to a maximum of five per cooling slot).
3. Calculation points as specified in the input. (These are specified as rows of holes with hole type zero).
4. A calculation point at the very end of the combustor.

Linear or parabolic interpolation is used to provide the values of quantities that are required at each calculation point. (Input quantities are provided at each geometric input point or at each hole-row centerline).

The flow chart for subroutine GEOM is shown on Figure 5.

Subroutine BLOCKDATA

This subroutine consists of a series of data statements providing recommended starting values for a number of variables, including "optional" input quantities.

Diffuser Subprogram

The diffuser subprogram calculates the flow properties in the diffuser from the compressor outlet to the first calculation point in each annulus. Subroutine DIFLOW contains the entry points to the diffuser subprogram, and organizes the internal calculation procedure. The methods of calculation used are:

1. The streamtube method
2. The empirical-data method
3. The mixing-equation method

The streamtube method is organized in subroutines TUBCTS, TUBSTA, and TUBSA1, and the analysis is carried out in subroutine TUBFW1, TUBEIN, TUBANL, and NEWRAD. The empirical-data method is organized in subroutines EMPTCS and EMPSTA, and the analysis is carried out in EMPANL and PROFL. The mixing-equation method is contained in subroutine DIFLOW. The diffuser subprogram also calls subroutines DCUTPT, GASTBL, SLOPE, I1AP1, and INTPL8.

An overall flow chart for the diffuser subprogram is shown on Figure 6. The function of each subroutine will now be discussed in more detail.

Subroutine DIFLOW

Subroutine DIFLOW has three main functions:

1. To organize the calculation procedure used in the diffuser subprogram depending on the input variable NDIFF
2. To calculate the flow properties in the two annuli between the snout and the outer casing if the mixing equation is being used
3. To calculate the flow properties beyond Station 2 if the diffuser does not have a snout

Station numbers for the diffuser are defined on pages 14-16 of Volume I. The subroutine has three entry points splitting the program into three separate parts. The three parts perform the following functions:

1. The first part organizes the calculation procedure between Stations 1 and 2. If the mixing equation is to be used between Stations 2 and 4, a corrective term for the curvature of the passages is calculated.
2. Following Entry DIFLW the calculation procedure between Stations 2 and 4 is organized. If the diffuser does not have a snout, or if the mixing equation is being used between Stations 2 and 4, the flow properties at Station 4 are calculated.
3. The third part, following Entry DIFLW2, calculates the flow in the diffuser with a given mass-flow split using the streamtube method throughout.

A flow chart for subroutihe DIFLOW is shown on Figure 7.

Subroutine TUBCTS

Subroutine TUBCTS is called by DIFLOW if the streamtube method is to be used between Stations 1 and 2. The subroutine:

1. Calls subroutine TUBEIN to calculate the inlet static pressure and the inlet streamtube properties
2. Calculates the reference velocity, Mach number, and dynamic head
3. Sets up an iteration loop calling TUBANL and NEWRAD to calculate the flow properties and the boundary-layer characteristics
4. Calculates the outlet velocity profile and the diffuser performance
5. Calls DOUTPT to print out the diffuser performance, and NEWRAD to print out the boundary-layer characteristics

A flow chart for subroutine TUBCTS is shown on Figure 8.

Subroutine TUBSTA

Subroutine TUBSTA is called by DIFLOW if the streamtube method is to be used between Stations 2 and 3. This subroutine is called before the iteration on the mass flow commences, and its function is to set up the geometric data in a form that can be used by subroutine TUBSA1. The flow chart for subroutine TUBSTA is shown on Figure 9.

Subroutine TUBSA1

Subroutine TUBSA1 is called by DIFLOW to perform a streamtube calculation between Stations 2 and 4. The subroutine is organized as a large DO loop for the two annular passages, with the following steps:

1. Call subroutine TUBEIN to calculate the streamtube properties
2. Set up an iteration loop calling TUBANL and NEWRAD to calculate the flow properties and the boundary-layer characteristics
3. Calculate the flow properties and diffuser performance up to Station 3
4. Calculate flow properties and diffuser performance up to Station 4, assuming the flow mixes between Stations 3 and 4
5. Call DOUTPT to print out the diffuser performance, and NEWRAD to print out the boundary-layer characteristics

The flow chart for subroutine TUBSA1 is shown on Figure 10.

Subroutine TUBFW1

Subroutine DIFLOW calls TUBFW1 during the iteration on the mass-flow split if the streamtube method is used between Stations 1 and 2. For a given flow split at Station 2, TUBFW1 calculates:

1. The geometric positions of the flow split
2. The area-mean velocity and weight-mean velocity for the flow streams into each annulus and the snout

The flow chart for subroutine TUBFW1 is shown on Figure 11.

Subroutine TUBEIN

Subroutine TUBEIN is called by TUBCTS and TUBSA1 to calculate the input quantities for the streamtube calculation. In TUBEIN the following calculations are performed:

1. If the static pressure is not given (i.e. if TUBEIN is called by TUBCTS), calculate the static pressure
2. Split the flow into a number of streamtubes and calculate the total pressure for each streamtube
3. Calculate the flow area for each streamtube when the flow is accelerated isentropically to Mach 1

The flow chart for subroutine TUBEIN is shown on Figure 12.

Subroutine TUBANL

Subroutine TUBANL is called by TUBCTS and TUBSA1, to calculate:

1. The pressure at each calculation point in the diffuser
2. The velocity and density of the wall streamtubes at each calculation point
3. The outlet velocity profile

TUBANL calculates the above properties by performing a one-dimensional analysis for each streamtube, and satisfying the continuity equation for the section at each calculation point. Its flow chart is shown on Figure 13.

Subroutine NEWRAD

Subroutine NEWRAD is called by TUBCTS and TUBSA1 to perform a boundary-layer calculation for each wall of the diffuser.

Subroutine NEWRAD also:

1. Calculates the position of separation, if it occurs
2. Checks the solution for convergence
3. Calculates a new guess for the boundary-layer displacement thickness
4. Following Entry NEWR1, prints out the boundary-layer properties

The flow chart for subroutine NEWRAD is shown on Figure 14.

Subroutine EMPCTS

Subroutine EMPCTS is called by DIFLOW if the empirical-data method is to be used between Stations 1 and 2. The subroutine is divided into two parts. The first part:

1. Calculates the static pressure at inlet
2. Calculates the reference velocity, Mach number, and dynamic head
3. Calls EMPANL to calculate the diffuser performance from empirical data
4. Calls PROFL to calculate the outlet velocity profile
5. Calls DOUTPT to print out the results

The second part following Entry EMPDT1 is called during the iteration on the mass-flow split, to:

1. Call PROFL to calculate the geometric position of the

flow split

2. Calculate the weight-mean, and area-mean velocities for the flow streams into each annulus and the snout

The flow chart for subroutine EMPCTS is shown on Figure 15.

Subroutine EMPSTA

Subroutine EMPSTA is called by DIFLOW to calculate the diffuser performance between Stations 2 and 3 using empirical data. The calculation is performed in the following steps:

1. Set up a DO loop for the two annular passages
2. Call EMPANL to calculate the diffuser performance between Stations 2 and 3
3. Call PROFL to calculate the flow properties at Station 3
4. Calculate the flow properties at Station 4 assuming the flow mixes between Stations 3 and 4
5. Call DOUTPT to print out the diffuser performance

The flow chart for subroutine EMPSTA is shown on Figure 16.

Subroutine EMPANL

Subroutine EMPANL is called by subroutines EMPCTS and EMPSTA to calculate the diffuser performance from empirical data. EMPANL calls INTPL8 to perform Langrangian interpolation from a table of data of diffuser effectiveness at various values of area ratio and a nondimensional length at a fixed value of inlet blockage. A correction is made to allow for variations in inlet blockage. The flow chart for subroutine EMPANL is shown on Figure 17.

Subroutine PROFL

Subroutine PROFL is called by EMPCTS and EMPSTA and it is in two parts. The subroutine assumes that the velocity distribution at any section is given by a top-hat profile, and the first section calculates this velocity. The second section, following Entry PROFL1, calculates for a given flow split:

1. The geometric positions of the flow split
2. The area-mean velocity, and weight-mean velocity for the flow stream into each annulus and the snout

The flow chart for subroutine PROFL is shown on Figure 18.

Subroutine DOUTPT

DOUTPT is called by EMPCTS, EMPSTA, DIFLOW, TUBCTS, and TUBSA1 to print out the diffuser performance for the various diffusing passages.

Subroutine GASTBL

Subroutine GASTBL is a general subroutine which calculates:

1. The Mach number
2. The ratio of static temperature to stagnation temperature
3. The ratio of static pressure to stagnation pressure
4. The ratio of flow area to flow area for the same mass flow expanded isentropically to Mach 1

Either of the last two ratios may be given. It is assumed in this subroutine that the flow behaves as a perfect gas with constant specific heats; the specific heat ratio, γ, is taken to be 1.4.

Subroutine SLOPE

From a tabulated set of variable x against y, subroutine SLOPE calculates the gradient dy/dx from the equation:

$$\left(\frac{dy}{dx}\right)_i = \frac{1}{2}\left(\frac{y_{i+1} - y_i}{x_{i+1} - x_i} + \frac{y_i - y_{i-1}}{x_i - x_{i-1}}\right)$$

Subroutine IIAP1

Subroutine IIAP1 performs parabolic interpolation for a single tabulated function.

Subroutine INTPL8

Subroutine INTPL8 is used to perform Lagrangian interpolation from a two-dimensional table of y tabulated against x and z. INTPL8 also calls upon its own subroutines, UNS, LAGRAN, and DISSER.

Air-Flow Subprogram

The air-flow subprogram calculates the flow properties in the flame tube and annuli from the first calculation point (which corresponds to the first hole row on the wall, as distinct from the dome) to the end of the combustor. It also organizes the mass-flow-split iteration.

The overall flow chart for the air-flow subprogram is shown on Figure 19. Each subroutine will now be described in turn.

Subroutine AIRFLO

This subroutine controls the air-flow calculation. It carries out the following operations:

1. An initial estimate of the mass-flow split is based on the

total hole areas in the dome and on each annulus.

2. Subroutine DIFLOW is called to obtain initial conditions on the dome and at the start of each annulus.
3. From the discharge characteristics of the holes in the dome, the primary-zone pressure is obtained.
4. The annulus equations are solved (Subroutine EQUAN) at each calculation point along the inner annulus to the secondary holes; then along the outer annulus to the secondary holes.
5. Subroutine PRTEMP is called to obtain the primary-zone temperature and initial conditions for the flame-tube calculations.
6. At each calculation point from the secondary holes to the end of the combustor:
    a. The annulus equations are solved for the inner annulus.
    b. The annulus equations are solved for the outer annulus.
    c. The flame-tube equations are solved (Subroutine EQUFT).
7. If the air mass flows remaining in the annuli are of opposite sign, the initial mass-flow split between the two annuli is adjusted and Steps 2 to 6 are repeated.
8. If the air mass flows remaining in the annuli are not approximately zero, the initial mass-flow split between dome holes and annuli is adjusted and Steps 2 to 7 are repeated.

The flow chart for Subroutine AIRFLO is shown on Figure 20. To avoid overflowing the computer memory, this subroutine has been divided into two sections (AIRFLO and BIRFLO) as noted on the flow chart.

Subroutine DISJET

Subroutine DISJET determines jet discharge parameters:

1. Jet information to be used by Subroutine JETMIX:
    a. Initial jet-air mass flow rate
    b. Jet angle of discharge
    c. Jet discharge coefficient
2. Jet information to be used by Subroutines EQUAN and EQUFT:
    a. Initial jet-air mass flow rate
    b. Initial jet momentum
    c. Initial axial jet momentum
    d. Initial jet enthalpy

This subroutine uses discharge-coefficient and jet-angle data that have been selected from the library tape and set up in COMMON by Subroutine TAPE.

Another function performed by this subroutine is to sense when unrealistic conditions are occurring in the combustor (due to an incorrect mass-flow-split estimate), and to set the residual annulus flows so as to ensure that the next estimate of mass-flow split is adjusted in the right direction. This is done in the following way:

1. When the flame-tube static pressure is higher than the annulus static pressure (or, in the case of scoops, the annulus total pressure), the annulus equations are not solved in the normal way. Instead, increments of mass

flow proportional to the local hole area are added to the annulus flow at all subsequent calculation points down to the end of the combustor. The positive mass flow at the end of the annulus ensures that in subsequent flow-split estimates the flow through the dome will be increased and the flame-tube pressure lowered.

2. When the pressure drop from annulus to flame tube is such that the required flow through the hole exceeds that available in the annulus, the annulus equations are not solved in the normal way. Instead, increments of mass flow proportional to the local hole area are subtracted from the annulus flow at all subsequent calculation points down to the end of the combustor. The negative mass flow at the end of the annulus ensures that in subsequent flow-split estimates the flow through the dome will be decreased and the flame-tube pressure increased.

An overall flow chart for Subroutine DISJET is shown on Figure 21.

Subroutine PRTEMP

This subroutine calculates conditions within the primary zone by solution of a simplified form of the flame-tube equations, assuming the primary zone acts as a stirred reactor. Flame-tube conditions are thus set up for the secondary-hole calculation point, so that from then on the flame-tube equations can be solved in the normal way.

This subroutine also calculates the fraction of air entering the secondary holes which recirculates upstream, if this fraction is not specified as input.

The flow chart is shown on Figure 22.

Subroutine EQUAN

This subroutine solves the equations for flow in the annuli. The main equation is a quadratic in $u_{an,2}$. The rest of the subroutine is concerned with evaluating the constants in this equation. The following effects are included:

1. A total-pressure loss due to expansion of the annulus air as it passes across the hole
2. The loss of air bled from the annulus for cooling purposes
3. The loss of air due to transpiration cooling, as well as air passing through penetration holes and cooling slots

The flow chart for subroutine EQUAN is shown on Figure 23.

Subroutine EQUFT

This subroutine solves the equations for flow in the flame tube downstream of the primary zone. As explained in Volume I, the solution follows an iterative procedure. For convenience, this procedure is summarized again here. Calculations are performed for a control volume bounded by two adjacent calculation stations (defined as Station 1 and 2 for this discussion).

1. Initial values are assumed for $u_{ft,2}$, c_{p2}, and $\dot{q}$ based on conditions at the upstream station (Station 1).
2. The energy equation is solved for $T_{ft,2}$.
3. Using this estimate of $T_{ft,2}$, improved estimates of c_{p2}

and $\dot{q}$ are obtained.

4. Steps 2 and 3 are repeated until the change in $T_{ft,2}$ between successive cycles is smaller than FIENTH (which is supplied as data).
5. The momentum, continuity, and state equations are solved for an improved estimate of $u_{ft,2}$.
6. Steps 2 to 5 are repeated until the changes in $u_{ft,2}$ and $T_{ft,2}$ between successive $u_{ft,2}$-cycles are smaller than $u_{ft,2}$.FIPHI and FIENTH respectively.

The flow chart for subroutine EQUFT is shown on Figure 24.

Subroutine HEATAD

This subroutine provides EQUFT with the heat-addition term in the energy equation. It makes use of:

1. The fuel-burning rate, supplied as input to the program.
2. The effective fuel calorific value, including a correction for dissociation.
3. Correlations for the specific heat of air and of a mixture of stoichiometric combustion products.

The flow chart is shown on Figure 25.

Subroutine JETMIX

This subroutine provides EQUFT with the characteristics of the residual jets (entering the flame tube through holes upstream of the point under consideration). Mixing is calculated using one of three models, according to the value of the index NEF:

1. Mass-loss model
2. Equivalent-entrainment model
3. Profile-substitution model
4. Instantaneous-mixing model

Wall jets and penetration jets are calculated separately using the same model but different values of the mixing constant. In each case, the calculation proceeds stepwise along the jet from the hole to the axial position of the current calculation point.

The flow chart for this subroutine is shown on Figure 26.

Heat-Transfer Subprogram

An overall flow chart for the heat-transfer subprogram is shown on Figure 27.

Subroutine HEAT1

This subroutine carries out a noniterative heat-transfer calculation. The route through the subroutine is controlled by the index NHT1, which takes the following values:

1	for one-dimensional radiation, uncooled wall
2	for one-dimensional radiation, cooled wall
3	for two-dimensional radiation, uncooled wall
4	for two-dimensional radiation, cooled wall

The coefficients in the heat-balance equation are evaluated, using subroutines EEFT, COOL, and PROP, and the results are put in a form suitable for output.

The flow chart for this subroutine is shown on Figure 28.

Subroutine HEAT2

This subroutine carries out an iterative heat-transfer calculation. The route through the subroutine is controlled by the index NHT2, which takes the following values:

2 for longitudinal wall conduction
3 for radiation interchange between walls
4 for longitudinal conduction and radiation interchange
1 if none of these options required

The subroutine also writes out the results for the heat-transfer subprogram (whether the calculation is iterative or noniterative). The flow chart is shown on Figure 29.

Subroutine TWALL

This subroutine uses Newton's approximation to solve the heat-balance equation, which is of the following form:

$$D_1 T_w^4 + D_2 T_w^{2.5} + D_3 T_w = D_4$$

The flow chart is shown on Figure 30.

Subroutine EEFT

This subroutine calculates the emissivity of the flame in one of six ways, according to the value of the index NLUM:

1 Non-luminous correlation for distillate fuels
2 Non-luminous correlation for residual fuels
3 Lefebvre correlation for luminous flames

4 NREC 1964 correlation for luminous flames

5 NREC 1966 correlation for luminous flames

6 Interpolation from a table of experimental data

Subroutine PROP

This subroutine obtains average values for the specific heat, thermal conductivity, and the dynamic viscosity of a gas mixture containing oxygen, nitrogen, carbon dioxide, and water vapor. The flow chart for this subroutine is shown on Figure 31.

Subroutine COOL

This subroutine calculates wall cooling parameters according to the value of the index NCOOL:

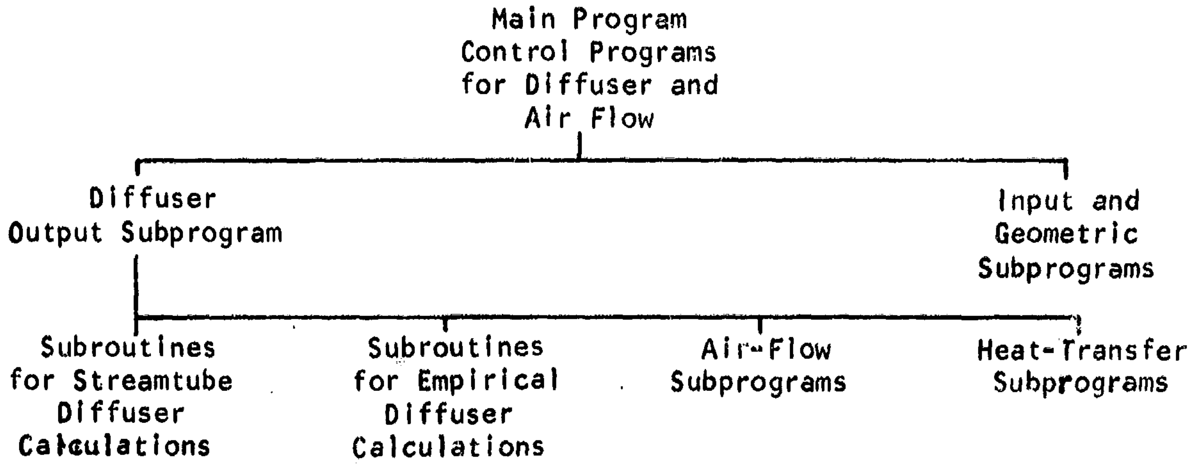
1 Film cooling

2 Transpiration cooling

The flow chart for this subroutine is shown on Figure 32.

Overlay Structure

In order to fit the whole program into the storage space available on the 7094, the program has been split into several links, which overwrite each other as the calculation proceeds. The sketch on the next page shows the overall arrangement, and the correct position for each subroutine is shown on Figure 33.



Numerical Techniques

The numerical techniques used in this program are quite simple, and need not be described in great detail. Most of them have been covered adequately in Volume I; only the iteration scheme on the overall mass-flow split will be discussed here.

Normal Iteration Procedure

As mentioned in Volume I, the iteration proceeds in two stages:

1. If the annulus flows at the end of the combustor, AFSTA and AFSTB, are of opposite sign, the mass flow through the dome is held constant and the ratio of the flows entering the two annuli is adjusted. The following ratio is used:

$$AFC = \frac{AFA}{AFA + AFB} \qquad (2)$$

where AFA = flow entering inner annulus

AFB = flow entering outer annulus

A running check is kept on AFCL, the highest value of AFC for which AFSTA is negative and AFSTB is positive, and AFCU, the lowest value of AFC for which AFSTA is positive and AFSTB is negative. At each step, the new value of AFC is taken to be (AFCL + AFCU)/2. At the start, values of AFCL and AFCU well outside the realistic range are chosen and the step size is limited to 1 per cent of AFC. In using this procedure it is assumed that the AFC corresponding to the converged solution will not lead to residual annulus flows of opposite sign at other values of AFS, the flow through the dome.

2. If AFSTA and AFSTB are of the same sign, AFS is adjusted in the following way. A running check is kept on AFSL, the highest value of AFS for which the residual flows are positive, and AFSU, the lowest value of AFS for which the residual flows are negative. At each step, the new value of AFS is taken to be (AFSL + AFSU)/2 and the change in AFS is split equally between AFA and AFB. At the start, values of AFSL and AFSU well outside the realistic range are chosen and the maximum step size is limited to 30 per cent of AFS.

Starting values of AFCL, AFCU, AFSL, and AFSU may be assigned as input; by judicious choice of these values the number of flow-split iterations may be substantially reduced. Likewise, starting values of AFS, AFA, and AFB may be assigned by supplying the input quantities DAFA and DAFB (fractions of total flow passing through inner and outer annuli, respectively). If no input values are supplied, starting values are assigned in Subroutines GEOM and INPUT2 on the basis of the total hole areas in the dome and the flame-tube walls.

Characteristics of the Method

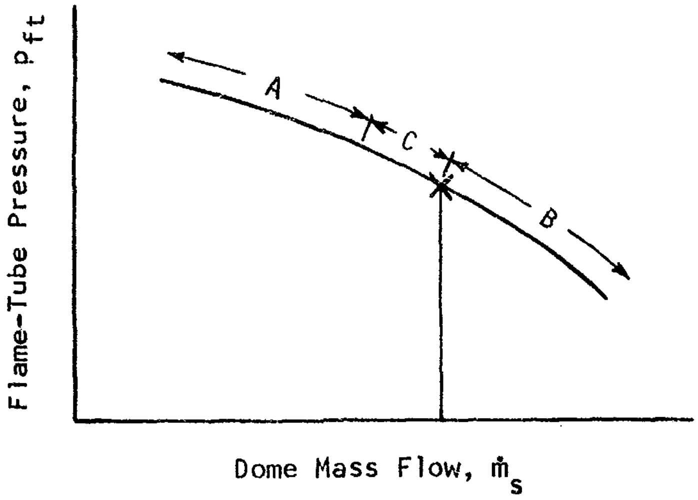
In a well-designed combustor (that is, one in which there is no flow out of the flame tube at the converged solution), the number of cycles to convergence depends on the accuracy required and the number of hole rows. To reduce AFSTA and AFSTB to 1 per cent of AF2 (the total mass flow) typically requires about 18 cycles. The number of cycles increases with the number of hole rows because the effect of small changes in upstream pressure builds up cumulatively down the combustor.

If the limit on the number of cycles permitted (LCANIL) is set too low, the program will print out an error message, "Increase LCANIL" when convergence fails to occur. However, there is no point in increasing LCANIL beyond about 50 because by that time the limit of accuracy of the machine has been reached - effectively:

AFSL = AFS = AFSU
and/or
AFCL = AFC = AFCU

If there is no convergence at 50 cycles and pressure reversal across the flame tube is still occurring, the program will print out an error message "Combustor poorly designed". This case will now be discussed more fully.

The relationship between the pressure at any point in the flame tube and the mass flow through the dome is of the form shown in the sketch.



By contrast, the pressures in the annuli are relatively unaffected by changes in the dome mass flow.

At low dome mass flows there will be a region (marked A in the sketch) in which pressure reversal across flame tube holes occurs. At high flows (B) the flame-tube pressure will be lowered, the hole pressure drop will be so high that more air will be called for than there is in the annulus, and the residual annulus flow will be negative.

Between A and B there will be a region C in which the residual flow is positive but no pressure reversal occurs.

In a badly designed combustor, region A may include the convergence point; there will then be no region C and the program will attempt to converge on the interface between A and B. Convergence will not be detected since the residual flows will not be near zero.

Decreasing the dome hole area will increase the flow resistance through the dome and may rectify the pressure reversal. Alternatively, the hole distribution along the flame-tube wall may be adjusted; the critical holes can easily be recognized since their discharge coefficients are zero when pressure reversal is just about to occur.

INPUT AND OUTPUT

This section contains the procedure for preparing the input data for program CLARE and a description of the types of output. Input and output sheets for the sample case discussed in Volume I of this report are shown.

Data required by the program are fed in via two input tapes, designated ITAPE and KTAPE. ITAPE refers to the normal input tape. KTAPE contains the library data which will only occasionally be altered between one run and the next; a deck of library data is supplied with the program.

Library Data

The library data consist of:

1. Hole-discharge-coefficient and jet-angle information. The data provided cover 100 different hole types, including all those mentioned in Reference 1 ; any number of additional hole types may be added. A key to these hole types is given in Table 1.
2. Diffuser-performance data for all straight-walled-annular and two-dimensional diffuser types shown in Figures 9 and 23 of Volume I. Space is available for further data (such as curved-wall-diffuser data) to be added as they become available.
3. Flame-emissivity data for particular combustor configurations. Initially, no data are provided for this table, but the option is available for inserting a set of values of

emissivity at various pressures and temperatures and using an emissivity obtained from this table in the heat-transfer calculation.

The method used to prepare the data-input sheet for this group is described below.

Line	Location	Input Item	Type of Number*	Fortran Name	Description
1	1-10		I	NMXTYP	Number of hole types for which discharge-coefficient data are to be given. There is no limit on this quantity.
2	1-10		I	NHTYP	Identification number indicating hole type. These numbers should run from 1 through NMXTYP. A key to the hole type numbers is given in Table 1.
2	11-20		R	DXH	Hole radius or distance from hole center-line to upstream edge, inches. For continuous cooling slots, this quantity should be zero.
2	21-30		R	HAA	Hole area, square inches. For continuous cooling slots this is the face area per inch width, i.e. the slot height, inches.
2	31-35		I	NSCOOQ	Index. 1 in tens position indicates that no initial-jet-angle data are available. 0 in units position indicates that the discharge coefficient is based on flush hole area, 1 indicates that it is based on hole face area, and 2 indicates that the hole type is a continuous cooling scoop.

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* R refers to real numbers. These should be written with decimal points; they may appear anywhere within their allotted fields. I refers to integers. These are written without decimal points on the right side of their fields.

Line	Location	Input Item	Type of Number	Fortran Name	Description
2	36-40		I	NSPA	Number of values of pressure-loss factor at which discharge coefficient is to be given (maximum value 15).
2	41-50	$1 + \frac{\Delta p_h}{q_{an}}$	R	DPHSA	First value of pressure-loss factor
2	51-60	C_d	R	CDSA	First value of corrected discharge coefficient.
2	61-70	ξ	R	GXISA	First value of initial jet angle
3	11-20	$1 + \frac{\Delta p_h}{q_{an}}$	R	DPHSA	Second value of pressure-loss factor
3	21-30	C_d	R	CDSA	Second value of corrected discharge coefficient
3	31-40	ξ	R	GXISA	Second value of initial jet angle
3	41-50	$1 + \frac{\Delta p_h}{q_{an}}$	R	DPHSA	Third value of pressure-loss factor
3	51-60	C_d	R	CDSA	Third value of corrected discharge coefficient
3	61-70	ξ	R	GXISA	Third value of initial jet angle
					The remaining values of $1 + \frac{\Delta p_h}{q_{an}}$, C_d, and ξ are listed on subsequent lines in the same format as Line 3 until all NSPA of the sets of values for this hole type have been given. The last set is on line N.
					Lines 2 through N are repeated until all NMXTYP hole types have been covered. The last values are on line N_A.

Line	Location	Input Item	Type of Number	Fortran Name	Description
N_A+1	72		I	INDEX	The program expects to find a 1 here, indicating that the correct number of hole-data cards have been read.
N_A+2	1-10		I	NWALMX	Number of diffuser types for which performance data are to be given. There is no limit on this quantity.[1]
N_A+3	1-10		I	NCARD(1)	Number of lines used for data for first diffuser type.
N_A+3	11-20		I	NCARD(2)	Number of lines used for data for second diffuser type.
					The remaining values of NCARD are entered on this line (and, if necessary, subsequent lines up to N_B) in the usual 7-column integer format until all NWALMX values are listed.
					The following lines N_B+1 through N_C relate to the first diffuser type.
N_B+1	1-10		I	NWALL	Identification number indicating diffuser type. These numbers should run from 1 through NWALMX.
N_B+1	11-20		I	NXDIFD	Number of values of ARDTA (area ratio A_2/A_1) that are to be given (maximum value 200).
N_B+1	21-30		I	NYDIFA	Number of values of EFDTA (diffuser effectiveness) that are to be given (maximum value 200).
N_B+1	31-40		I	NZDIFA	Number of values of XLNDTA (nondimensional length) that are to be given (maximum value 20).
N_B+1	41-50		I	NCDIFA	Index. Sign indicates the form in which the data are tabulated: positive sign

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[1] If NWALMX $\geq$ 10, the dimension of NCARD should be increased.

Line	Location	Input Item	Type of Number	Fortran Name	Description
					indicates that NXDIFD = NYDIFA/NZDIFA; negative sign indicates that NXDIFD = NYDIFA. Hundreds position should always contain 1. Number in tens position indicates degree of Langrangian interpolation in X direction that is to be used with these data. Number in units position indicates degree of interpolation in Z direction.
N_B+1	51-60	E_1	R	E1DTAA	Value of (1-inlet blockage) at which this set of data was taken.
N_B+2	1-10	ξ	R	EFDTA(1)	First value of diffuser effectiveness.
N_B+2	11-20	ξ	R	EFDTA(2)	Second value of diffuser effectiveness.
					The remaining values of diffuser effectiveness are entered on this and subsequent lines in the usual 7-column real format. The first set of values of EFDTA are for the first value of XLNDTA, the next set of values of EFDTA are for the second value of XLNDTA, and so on.
					Immediately following (not necessarily on a new card), the NXDIFD values of area ratio, ARDTA are listed, then the NZDIFA values of nondimensional length, XLNDTA. The last value is on line $N_C = N_B$ + NCARD(1).
					Data for the second diffuser type (NWALL = 2) are presented in the same way as for type 1, on line N_C+1 through line N_C+ NCARD(2).

Line	Location	Input Item	Type of Number	Fortran Name	Description
					Data for the remaining diffuser types are entered in the same way. The last data for diffuser type NWALMX are on line N_D.
N_D+1	72		I	INDEX	The program expects to find a 1 here, indicating that the correct number of diffuser-data cards have been read.
N_D+2	1-10		I	NTFT	Number of points at which flame temperature is to be specified in table of empirical flame-emissivity data.
N_D+2	11-20		I	NEFT	Number of points at which emissivity is to be given in table of empirical flame-emissivity data. Normally NEFT = NTFT x NPFT.
N_D+2	21-30		I	NPFT	Number of points at which pressure is to be given in table of empirical flame-emissivity data.
N_D+2	31-40		I	NFORM	Index. This refers to the way in which data are presented and interpolated; rules for assigning values to it were given above in connection with NCDIFA. It normally takes the value 133.
N_D+3	1-10		R	TABTFT(1)	First value of flame temperature (deg F) in table of empirical flame-emissivity data. Subsequent values of flame temperature are entered in the usual 7-column format, immediately followed by values of pressure, TABPFT (lbf/ft^2) and emissivity, TABEFT. The last value is on line N_E
N_E+1	72		I	INDEX	The program expects to find a 1 here, indicating that the correct

Line	Location	Input Item	Type of Number	Fortran Name	Description
					number of emissivity-data cards have been read.

This completes the library data.

Normal Input Data

The procedure used for setting up the normal input data is described below. There are a number of quantities that the user will only occasionally wish to specify; these are treated in the following way. Recommended values are automatically supplied to the program via a BLOCK DATA subroutine; any quantities that the user wishes to vary are then overwritten via the READ statement. In the list below, the word "optional" is given with these quantities, and the recommended values are shown in parentheses.

Run Identification

Line 1 of the normal input data contains a run identification message in columns 1-72. This message is later written out at the head of the output sheet.

Fixed Data - Integer

The first group of data is fed in via the namelist FIXEDI, using the normal format[1]. The variables in FIXEDI are as follows:

Name	Description
NCASE	No. of cases to be considered. If zero, major subroutines are not entered. Optional (0).

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[1] $FIXEDI beginning in column 2 of the first card, followed by the names of the variables and their input values in pairs, separated by commas, on this card and columns 2 to 80 of succeeding cards. The end of the list is marked by a $.

Name	Description
NRECT	Index. 1 for annular combustors, 2 for combustors of rectangular cross-section. Optional (1).
NG	No. of geometric input points. Maximum value 120.
NH	No. of hole rows. Maximum value 50.
NWH	No. of first hole row on the flame-tube wall (as distinct from the dome).
NSH	No. of hole row that marks the end of the primary zone. If there are hole rows on both annuli at this location, NSH must equal the hole row number on the inner annulus.
NSNOUT	Index. 1 if there is a snout. 0 otherwise.
NWALL1 NWALL2	Indices designating empirical diffuser data to be used in sections 1-2 and 2-4 respectively. Optional (1 for annular combustors, 2 for two-dimensional).
INPUT	Index. 0 if input flow conditions varied between cases. 1 if program routing varied. Optional (0).
K4	Index. 1 if flow split at secondary holes is specified. Otherwise 0. Optional (0).
K6	Index. 0 for no swirler 1 for specified swirler 2 for unspecified swirler Optional (0).
NCOOL	Index. 1 for film cooling 2 for transpiration cooling Optional (1).
NUMSW	Number of swirlers. Optional (0). NUMSW must be supplied if K6 = 1 or 2.
NBLADE	Number of swirler blades. Optional (8)
IPRINT	Index. 1 if intermediate results are to be printed.[1] 0 otherwise. Optional (0).

Combustor Geometry

The next set of cards contains the combustor geometry. The first and last cards define the beginning and end of the combustor. There should

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[1] This option is only available if output is on tape unit 6.

be NG cards in this group, each containing the following:

Location	Type of Number	Fortran Name	Description
1-10	R	XINCH	Axial location, measured from compressor discharge, inches. The XINCH values should increase monotonically; no two should be equal. It is advisable to specify the geometry at points a small distance downstream of each stepped cooling slot.
11-20	R	CA	Inner casing diameter, inches.
21-30	R	SA	Inner snout diameter,[1] inches. This field should be left blank if there is no snout at this location.
31-40	R	FTA	Inner flame-tube diameter,[1] inches. If XINCH coincides with the location of a cooling slot, the larger of the two FTA values should be given.
41-50	R	FTB	Outer flame-tube diameter,[1] inches. If there is a cooling slot at this point, the smaller of the two FTB values should be given.
51-60	R	SB	Outer snout diameter,[1] inches. If there is no snout at this location, the field should be left blank.
61-70	R	CB	Outer casing diameter,[1] inches.

The diffuser section should not occupy more than 50 geometric input points, and at least one geometric input point should lie upstream of the snout lip.

Hole and Miscellaneous Data

The next set of cards contains the hole data and fuel-burning-rate distribution. The casing temperature may also be specified on these cards. There should be NH cards in this group, each containing the following:

Location	Type of Number	Fortran Name	Description
1-10	R	XH	Axial location of hole-row center-

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[1] If the combustor is of rectangular cross section, "diameter" is replaced by "dimension from arbitrary datum".

Location	Type of Number	Fortran Name	Description
			line, inches. These values should lie between the first value of XINCH for which flame tube coordinates are given, and the last value of XINCH. Values of XH should generally increase, but there may be up to six rows of holes (i.e. six cards) corresponding to a single value of XH. For splash-ring cooling slots, the location specified should be that of the slot exit.
11-20	R	HAB	Hole area, square inches. In the case of continuous cooling slots, this is the height of the slot in inches. This field may be left blank if the hole area is the same as that used in the experiments on which the hole data are based (see Table I).
21-30	R	TCATA	Inner casing temperature, deg F.
31-40	R	TCATB	Outer casing temperature, deg F. These fields should be left blank if the casing temperature is not specified. To specify the casing temperature, it is only necessary to give a value on the first of each group of cards corresponding to a distinct value of XH.
41-50	R	FFB	Fraction of fuel burned up to this hole row. These values should increase from 0 to 1; it is only necessary to give a value on the first of each group of cards corresponding to a distinct XH.
51-55	I	NAB	Index indicating whether the hole row is on the inner or the outer wall. 1 for inner wall. 2 for outer wall.
56-60	I	NHH	Number of holes in this row. For continuous cooling slots this quantity should be made equal to 1.
61-65	I	NHTU	Index designating hole type. (Used to locate discharge-coefficient and jet-angle data on library tape). A zero indicates that calculations are to be performed at this point, although there are no holes. If NHTU = 0,

Location	Type of Number	Fortran Name	Description
			the following columns may be left blank: HAB, NAB, NHH. It is not permissible to set NHTU = 0 for the first hole row.

Fixed Data - Real

The next group of data is fed in via the namelist FIXEDR. The variables are as follows:

Name	Description
XINT	Interval downstream of cooling slot at which wall temperatures required, inches. Optional (100).
THIKFT	Flame-tube wall thickness, inches. Optional (a very small value).
FLCV	Fuel lower heating value, Btu per lbm. Optional (18540)
FHCR	Fuel hydrogen-carbon ratio. Optional (0.17).
SHAFST	Fraction of secondary air recirculating upstream. Optional (0.5).
AF23A	Fraction of inlet air bled from inner annulus. Optional (0). Up to three values may be provided, using the format shown in the example: AF23A = 0.02, 0.05, 0.03.
AF23B	Fraction of inlet air bled from outer annulus. Optional (0). Up to three values may be provided.
XAF23A	Axial location, inches, at which bleed air is removed from inner annulus. Optional (0). One value should be provided for each value of AF23A; it is not possible to bleed air from the diffuser.
XAF23B	Axial location, inches, at which bleed air is removed from outer annulus. Optional (0).
BETA	Swirler blade angle, degrees. Optional (50).
DSWLOU	Outer diameter of swirler, inches.

Name	Description
DSWLIN	Inner diameter of swirler, inches. DSWLOU and DSWLIN must be supplied if K6 = 1.
ABSW	Absorptivity of flame-tube wall. Optional (0.85)
EMW	Emissivity of wall. Optional (0.85).
EMC	Emissivity of casing. Optional (0.8).
CONDFT	Conductivity of flame-tube wall material, Btu per ft hr deg F. Optional (15.0).
XFILMZ	Constant in film-cooling correlation (X_0 in Equation 3-22 of Volume I). Optional (3.5).
DOMLOS	Number of velocity-heads of pressure lost inside the snout. Optional (0).
PERCO	Permeability coefficient of porous wall, sq ft. Optional (0).
WIDTH1	Width, inches, of rectangular-cross-section combustor. Optional (12).

Limits and Tolerances

The next group of data is fed in via the namelist LIMITS. The variables are as follows:

Name	Description
NXDIF	No. of geometric input point corresponding to station "2" (just upstream of snout) in diffuser analysis. Optional (if this value is not specified, NXDIF will be taken as the last geometric input point before the snout).
NXDIF1, NXDIF2	Nos. of geometric input points corresponding to Station 3 in inner and outer annulus respectively. These values must be specified if NDIFF = 11, 12, or 22. The annulus areas at Stations 3 and 4 (upstream edge of hole row NWH) must be equal.
LCANIL	Loop counter limit in the mass-flow-split interation. Optional (50).

Name	Description
STEP	Step size in jet-mixing calculation, inches. Optional (0.25).

This completes the data that are unchanged from case to case within a run.

Case Data

The set of cards required for the first case is described below. These continue straight on from the library-data cards, the last of which is on line L_A.

Line	Location	Type of Number	Fortran Name	Description
L_A+1	1-10	R	STAGT	Total temperature at compressor discharge, deg F.
L_A+1	11-20	R	STPREF	Weight-mean total pressure at compressor discharge, lbf per sq in
L_A+1	21-30	R	AF2	Air mass flow rate at compressor discharge, lbm per sec.
L_A+1	31-40	R	FAR	Overall fuel-air ratio based on airflow rate at compressor discharge.
L_A+1	41-50	R	ABLOCK	Fraction of inlet boundary-layer blockage that is on inner wall.
L_A+1	51-60	R	SHAPEI	Initial boundary-layer shape factor on inner wall. Optional (1.4)[1].
L_A+1	61-70	R	SHAPEO	Initial shape factor on outer wall. Optional (1.4)[1].
L_A+2	1-10	R	BLOCK(1)	Boundary-layer blockage at inlet. First estimates of the blockage at downstream geometric input points are given in the usual format (7 columns of 10) on this and subsequent lines. There should be NXDIF such values, including the first. The last value is on line L_B.

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[1] A method of calculating the initial shape factor more accurately is given on page 134 of Volume I.

Line	Location	Type of Number	Fortran Name	Description
$L_B + 1$	1-10	R	DAFA	Estimated fraction of total flow passing through inner annulus.[1]
$L_B + 1$	11-20	R	DAFB	Estimated fraction of total flow passing through outer annulus.[1]
$L_B + 1$	21-30	R	AFCL	Lower bound on the ratio of the flow through the inner annulus to the flow through both annuli.[1]
$L_B + 1$	31-40	R	AFCU	Upper bound on the ratio of the flow through the inner annulus to the flow through both annuli.[1]
$L_B + 1$	41-50	R	AFSL	Lower bound on the flow through the snout.[1]
$L_B + 1$	51-60	R	AFSU	Upper bound on the flow through the snout.[1]
$L_B + 2$	1-10	I	NTUBE	Number of streamtubes considered in diffuser calculation. Maximum value 15.
$L_B + 2$	11-20	I	NUPR	Number of points at which inlet velocity profile specified. Minimum value 2, maximum value 15.
$L_B + 3$	1-10	R	VPDATA	First value of velocity.
$L_B + 3$	11-20	R	RDATA	First value of annulus height.
				The other points on the velocity profile are entered on subsequent lines up to $L_C = L_B$ + NUPR + 2. RDATA should be made dimensionless so that all values lie between 0 (for the inner wall) and 1 (for the outer wall). VPDATA may consist of any set of numbers proportional to the velocity.
$L_C + 1$	1-10	I	NDIFF	Index for diffuser calculations. Tens position indicates method for Stations 1-2: 1 For streamtube analysis 2 For empirical data and units position for Stations 2-4:

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[1] These quantities can be estimated from information obtained from previous runs. If such information is not available, the quantities should all be set equal to 0.0 in which case they will be estimated within the program.

Line	Location	Type of Number	Fortran Name	Description
				1 For streamtube analysis 2 For empirical data 3 For mixing equation Note, however, that 1 in the units position cannot be specified with 2 in the tens position. 1 in hundreds position implies streamtube method to be carried out after empirical data method; negative sign implies no diffuser calculation: fixed effectivenesses supplied as input.
$L_C + 1$	11-20	I	NEF	Index indicating entrainment correlation to be used. 1 For mass-loss method 2 For equivalent-entrainment method 3 For profile-substitution method 4 For instantaneous mixing
$L_C + 1$	21-30	I	NLUM	Index indicating correlation to be used for flame emissivity. 1 For nonluminous flames, distillate fuels 2 For nonluminous flames, residual fuels 3 For Lefebvre correlation 4 For NREC 1964 correlation 5 For NREC 1966 correlation 6 For emissivity from table of experimental data
$L_C + 1$	31-40	I	LANHET	Index. 0 If heat transfer to annulus air ignored 1 If heat transfer to annulus air considered 2 If no heat transfer calculation required
$L_C + 1$	41-50	I	NHT1	Index indicating route through non-iterative heat-transfer calculation. 1 For uncooled wall, 1-dimensional radiation 2 For cooled wall, 1-dimensional radiation 3 For uncooled wall, 2-dimensional radiation 4 For cooled wall, 2-dimensional radiation

Line	Location	Type of Number	Fortran Name	Description
L_C+1	51-60	I	NHT2	Index indicating route through iterative heat-transfer calculation. 2 For longitudinal conduction 3 For radiation interchange between walls 4 For longitudinal conduction and radiation interchange 1 Otherwise
L_C+2	1-10	R	EFC(1)	Constant used to specify rate of mixing of penetration jets.
L_C+2	11-20	R	EFC(2)	Constant used to specify rate of mixing of wall jets.
L_C+2	21-30	R	EFDT(1)	Effectiveness of diffuser between Stations 1 and 2 (i.e. between geometric input points no. 1 and NXDIF).
L_C+2	31-40	R	EFDT(2)	Effectiveness of inner diffusing passage between Stations 2 and 4.
L_C+2	41-50	R	EFDT(3)	Effectiveness of outer diffusing passage between Stations 2 and 4. The three values of EFDT are required for the model in which no diffuser calculation is required, but experimental data for a diffuser of similar geometry operating under similar flow conditions are specified as input. For this case, NDIFF takes a value of -22. If this option is not required, the last three columns may be left blank.

This completes the data for the first case. Subsequent cases are specified in one of two ways:

1. Input Flow Conditions Varied

   If INPUT = 0, only the first part of the case data (lines L_A+1 to L_C) is given for subsequent cases.

2. Program Routing and Correlations Varied

   If INPUT = 1, only the second part of the case data (lines L_C+1 and L_C+2) is given for subsequent cases.

Sample Input Data

Appendix I contains samples to illustrate the preparation of library data input. In Appendix II the input data for Overall Test Case 3 are listed. Appendix II illustrates the instructions given above for the preparation of input data and also shows where the library data should be placed if ITAPE = KTAPE.

Output Data

The format for the computer output is self-explanatory and need not be discussed here. If problems arise, intermediate results may be printed out by setting IPRINT = 1. (This option is only available when output is on tape unit No. 6.) The format for these intermediate results is rudimentary, and the program user must refer to the individual WRITE statement for details. Condensed output is obtained on tape unit JTAPE (JTAPE = 8 in the present BLOCKDATA) by setting IPRINT = 0. With IPRINT= 1 under the present arrangement, intermediate results are written on tape unit 6 and condensed results on unit JTAPE (8).

Appendix III contains the condensed computer output from Test Case 3, and illustrates the format for this output.

Output of computer test-case input only may be obtained by setting NCASE = 0.

Program Messages

A number of messages are printed out by the program, either as part of the normal output or as indications of errors in program operation. A list of these program messages is included as Appendix V, with explanatory notes.

1. Dittrich, R. T. and Graves, C. C., Discharge Coefficients for Combustor-Liner Air-Entry Holes, I - Circular Holes (NACA TN 3663), National Advisory Committee for Aeronautics, 1965.

2. Kaddah, K. Sh., Discharge Coefficient and Jet Deflection Studies for Combustor-Liner Air-Entry Holes, Thesis No. 17/10, College of Aeronautics, Cranfield, England, June, 1964.

3. Venneman, W. F., Flow Coefficients and Jet Deflection Angles for Combustor-Liner Air-Entry Holes, Part I, General Electric Company, Schenectady, New York, 1959.

4. Dittrich, R. T., Discharge Coefficients for Combustor-Liner Air-Entry Holes, II - Flush Rectangular Holes, Step Louvers, and Scoops (NACA TN 3924), National Advisory Committee for Aeronautics, 1958.

5. Marshall, L. A., Aerodynamic Characteristics of Combustor-Liner Air-Entry Passages (Rep. R58 AGT 558), Aircraft Gas Turbine Division, General Electric Company, Cincinnati, 1958.

6. Venneman, W. F., Flow Coefficients and Jet Deflection Angles for Combustor-Liner Air-Entry Holes, Part II, General Electric Company, Schenectady, New York, 1960.

TABLES

TABLE I - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
	Flush Circular Holes			
1	Flush hole 0.125 in dia	1	6(a)	
2	Flush hole 0.25 in dia	1	6(b)	
3	Flush hole 0.328 in dia	2	42	
4	Flush hole 0.472 in dia	2	43	
5	Flush hole 0.75 in dia with 45 degree bevel	3	7	
6	Flush hole 0.75 in dia	1	6(e)	
7	Flush hole 0.75 in dia	4	14	E-1
8	Flush hole 0.75 in dia	5	3	
9	Flush hole 0.759 in dia	3	6	
10	Flush hole 0.807 in dia	2	44	
11	Flush hole 0.985 in dia	2	45	
12	Flush hole 1.5 in dia	1	6(k)	
13	Flush hole 1.59 in dia	2	46	
14	Flush hole 1.809 in dia	3	13	
	Flush Rectangular Holes			
15	Flush hole 0.5 in square	4	14	A-1
16	Flush hole 0.708 in square	2	90	
17	Flush hole 0.412 in long and 0.206 in wide	2	83	

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
18	Flush hole 0.436 in long and 0.218 in wide with semicircular ends	2	60	
19	Flush hole 0.591 in long and 0.295 in wide	2	84	
20	Flush hole 0.624 in long and 0.312 in wide with semicircular ends	2	61	
21	Flush hole 1.0 in long and 0.5 in wide	2	85	
22	Flush hole 1.0 in long and 0.5 in wide	4	14	A-2
23	Flush hole 1.062 in long and 0.531 in wide with semicircular ends	2	62	
24	Flush hole 1.24 in long and 0.62 in wide	2	86	
25	Flush hole 1.312 in long and 0.656 in wide with semicircular ends	2	63	
26	Flush hole 2.0 in long and 1.0 in wide	2	87	
27	Flush hole 2.0 in long and 1.0 in wide	4	14	A-4
28	Flush hole 2.124 in long and 1.062 in wide	2	64	
29	Flush hole 1.42 in long and 0.355 in wide	2	91	
30	Flush hole 1.497 in long and 0.375 in wide with semicircular ends	2	67	
31	Flush hole 4.0 in long and 0.5 in wide	4	14	A-3
32	Flush hole 2.0 in long and 0.25 in wide	2	92	

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
33	Flush hole 2.1 in long and 0.25 in wide with semicircular ends	2	68	
34	Flush hole 4.0 in long and 0.25 in wide	4	14	A-5
	Thimbled (Plunged) Holes without Scoops			
35	Thimbled hole 0.475 in dia with tapered skirt	5	4	
36	Thimbled hole 0.625 in dia with tapered skirt	5	5	
37	Thimbled hole 0.792 in dia with tapered skirt	5	6	
38	Thimbled hole 1.286 in dia with full tapered skirt	3	9	
39	Thimbled hole 1.82 in dia with tapered skirt	3	10	
40	Thimbled hole 1.828 in dia with full skirt	3	3	
41	Thimbled hole 1.832 in dia with half tapered skirt	3	11	
42	Thimbled hole 2.281 in long and 1.281 in wide with semicircular ends and full skirt	3	8	
	Step Louvers (For continuous cooling films)			
43	Step louver 0.095 in high with overlap	4	16(a)	B-4
44	Step louver 0.095 in high with wiggle strip	4	16(a)	B-6
45	Step louver 0.104 in high	4	15	B-1

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
46	Step louver 0.168 in high	4	15	B-10
47	Step louver 0.25 in high with overlap	4	16(b)	B-5
48	Step louver 0.25 in high with wiggle strip	4	16(b)	B-7
49	Step louver 0.255 in high (without sidewall extension)	4	17	B-2
50	Step louver 0.26 in high	4	15	B-3
51	Step louver 0.38 in high	4	15	B-9
52	Step louver 0.623 in high	4	15	B-8
	Holes with Scoops			
53	Thimbled hole 1.843 in dia with scoop 0.31 in high and 2.5 in wide	3	2	
54	Hole 2.0 in long and 1.63 in wide with scoop 0.5 in high and projecting 0.43 in into flame tube	3	4	
55	Hole 2.0 in long and 2.87 in wide tapering to 1.5 in wide at rear with scoop 0.437 in high and projecting 0.375 in into flame tube	3	5	
56	Half thimbled hole 1.286 in dia with scoop 0.437 in high and 2.83 in wide	3	12	
57	Triangular hole assumed 2.0 in long and 2.87 in wide with scoop assumed 0.437 in high and 2.87 in wide	3	16	
58	Hole 2.3 in long and 1.3 in wide with semicircular ends, scoop, and turning vane	6	8	

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
59	Thimbled hole 1.05 in square with 0.3 in radius at leading edge corners, trailing edge raised 0.112 in, and tapered skirt	6	10	
60	Thimbled hole 1.05 in square with 0.3 in radius at leading edge corners, trailing edge raised 0.112 in, scoop projecting into flame tube, and tapered skirt	6	11	
61	Thimbled hole 1.05 in square with 0.3 in radius at leading edge corners, trailing edge raised 0.112 in, 90 degree vane projecting into flame tube, and tapered skirt	6	12	
62	Thimbled hole 1.05 in square with 0.3 in radius at leading edge corners, trailing edge raised 0.075 in, vane projecting into flame tube, and tapered skirt	6	13	
63	Hole assumed 0.75 in long and 0.65 in wide with 0.26 in radius at leading edge corners and raised trailing edge	6	14	
64	Hole assumed 0.75 in long and 0.65 in wide with 0.26 in radius at leading edge corners, raised trailing edge, and vane projecting into flame tube	6	16	
65	Hole assumed 0.75 in long and 0.65 in wide with 0.26 in radius at leading edge corners, raised trailing edge, and 50 degree vane projecting into annulus and flame tube	6	18	

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
66	Hole assumed 0.75 in long and 0.65 in wide with 0.26 in radius at leading edge corners, raised trailing edge, and 70 degree vane projecting into annulus and flame tube	6	19	
67	Hole 2.3 in long and 1.3 in wide with semicircular ends, scoop, and turning vane	6	20	
68	Hole 2.3 in long and 1.3 in wide with semicircular ends, scoop raised 0.125 in, and turning vane	6	21	
69	Hole 2.3 in long and 1.3 in wide with semicircular ends, scoop raised 0.25 in, and turning vane	6	22	
70	Hole 2.3 in long and 1.3 in wide with semicircular ends, scoop, and turning vane with rounded corners	6	23	
71	Hole 2.3 in long and 1.3 in wide with semicircular ends, scoop with leading edge raised 0.125 in, and turning vane	6	24	
72	Semicircular hole assumed 0.295 in radius with thumbnail scoop 0.15 in high	4	18	C-1
73	Semicircular hole assumed 0.373 in radius with thumbnail scoop 0.265 in high	4	18	C-2
74	Hole 0.75 in dia with scoop 0.75 in wide and 0.427 in high	4	19	D-1
75	Hole 0.75 in dia with scoop 0.75 in wide and 0.636 in high	4	19	D-2

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
76	Hole 0.75 in dia with scoop 0.753 in wide and 0.891 in high	4	19	D-3
77	Hole 0.75 in dia with scoop 1.461 in wide and 0.585 in high	4	19	D-4
78	Thimbled hole 2.155 in long and 1.27 in wide with semicircular leading end, trailing edge raised 0.19 in, and tapered skirt	6	9	
79	Thimbled hole 2.155 in long and 1.27 in wide with semicircular leading end, trailing edge raised 0.19 in, scoop 0.7 in behind leading edge, and tapered skirt	6	9	
80	Thimbled hole 2.155 in long and 1.27 in wide with semicircular leading end, trailing edge raised 0.19 in, scoop 0.32 in behind leading edge, and tapered skirt	6	9	
81	Thimbled hole 0.815 in dia with scoop 0.312 in high and full skirt	5	7	
82	Hole 1.0 in dia with scoop 0.312 in high and long tube in place of skirt	5	10	
83	Thimbled hole 0.8 in dia with scoop 0.312 in high	5	11	
84	Thimbled hole 0.815 in dia with scoop 0.312 in high placed at 20 degrees to annulus flow direction and full skirt	5	12	

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
85	Hole 0.49 in long and 1.012 in wide with scoop 0.21 in high and turning vane	5	13	"Rear Hole Closed"
86	Hole 0.7 in long and 1.012 in wide with scoop 0.21 in high and turning vane	5	13	"Rear Hole Open"
87	Hole 0.123 in wide with scoop 0.47 in high	5	15	
88	Thimbled hole 0.75 in long and 0.745 in wide with scoop 0.506 in high and 0.765 in wide and full skirt	5	16	4a
89	Thimbled hole 0.48 in long and 0.745 in wide with scoop 0.506 in high and 0.765 in wide and full skirt	5	16	4b
90	Thimbled hole 0.24 in long and 0.745 in wide with scoop 0.506 in high and 0.765 in wide and full skirt	5	16	4c
91	Thimbled hole 0.57 in long and 0.51 in wide with scoop 0.5 in high and 0.555 in wide and full skirt	5	17	
92	Thimbled hole 0.325 in long and 0.74 in wide with scoop 0.53 in high and 0.76 in wide and full skirt	5	18	"Based on Exit Area"
93	Thimbled hole 0.325 in long and 0.74 in wide with scoop 0.53 in high and 0.76 in wide and full skirt	5	18	"Based on Inlet Area"
94	Hole 0.75 in long and 0.765 in wide with scoop 0.545 in high placed 0.75 in in front of hole leading edge	5	19	

TABLE I (CONTINUED) - KEY TO HOLE-DISCHARGE-COEFFICIENT AND JET-ANGLE DATA

Number	Hole Description	Reference	Figure	Curve
95	Thimbled hole 0.875 in long and 0.8 in wide with scoop 0.507 in high and 0.76 in wide and half skirt	5	20	
96	Hole 0.375 in dia fitted with elbow scoop 0.385 in dia with entrance centre-line 0.528 in from wall	5	22	
97	Hole 0.68 in long and 0.65 in wide with scoop 0.165 in high and 0.63 in wide projecting into flame tube	5	22	
98	Hole 0.69 in long and 0.65 in wide with scoop 0.205 in high and 0.63 in wide projecting into flame tube	5	23	
99	Hole 0.69 in long and 0.65 in wide with scoop 0.305 in high and 0.642 in wide projecting into flame tube	5	24	
100	Hole 0.92 in long and 0.89 in wide with scoop 0.273 in high and 1.02 in wide projecting into flame tube	5	25	

FIGURES

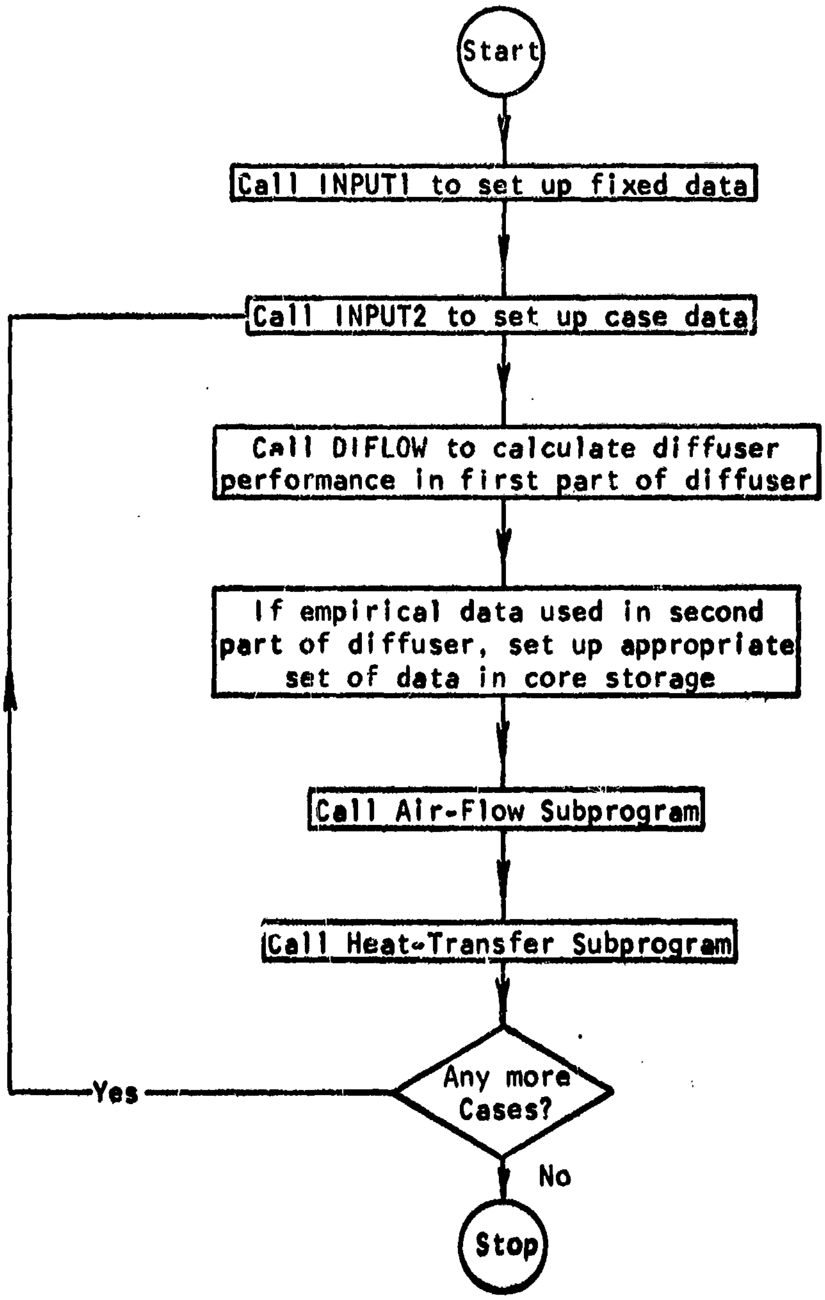


FIGURE 1 - FLOW CHART FOR MAIN PROGRAM CLARE

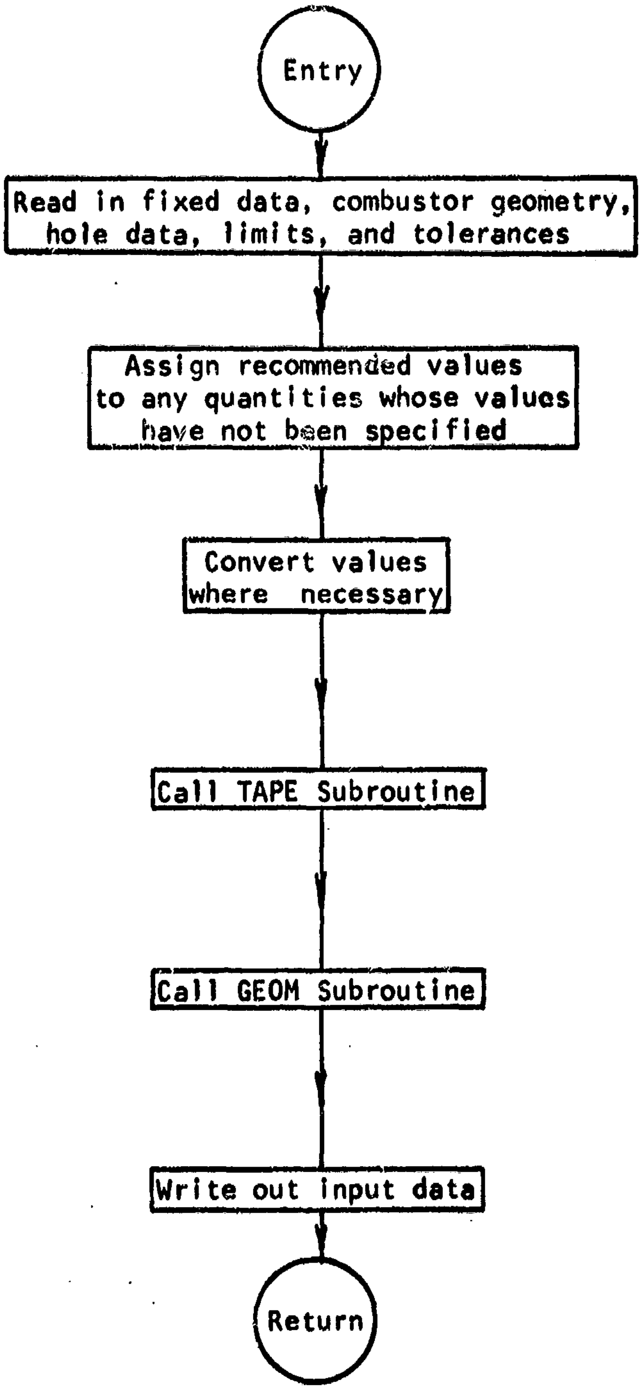


FIGURE 2 - FLOW CHART FOR SUBROUTINE INPUT1

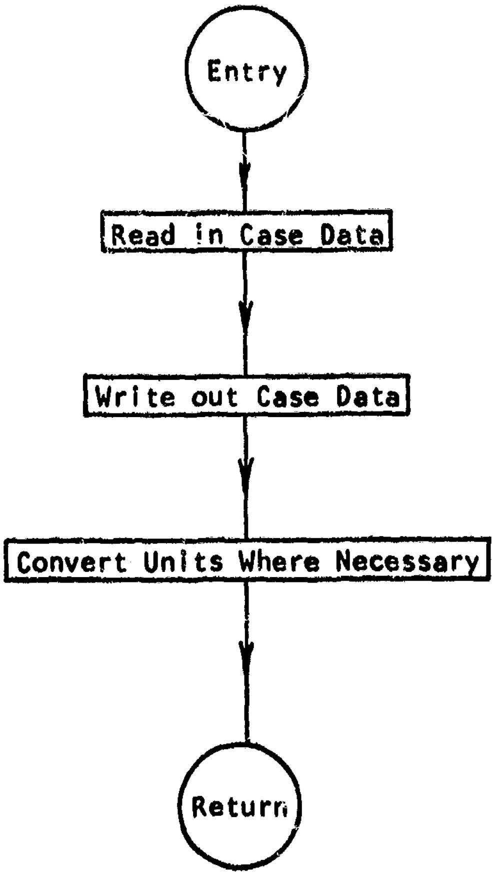


FIGURE 3 - FLOW CHART FOR SUBROUTINE INPUT2

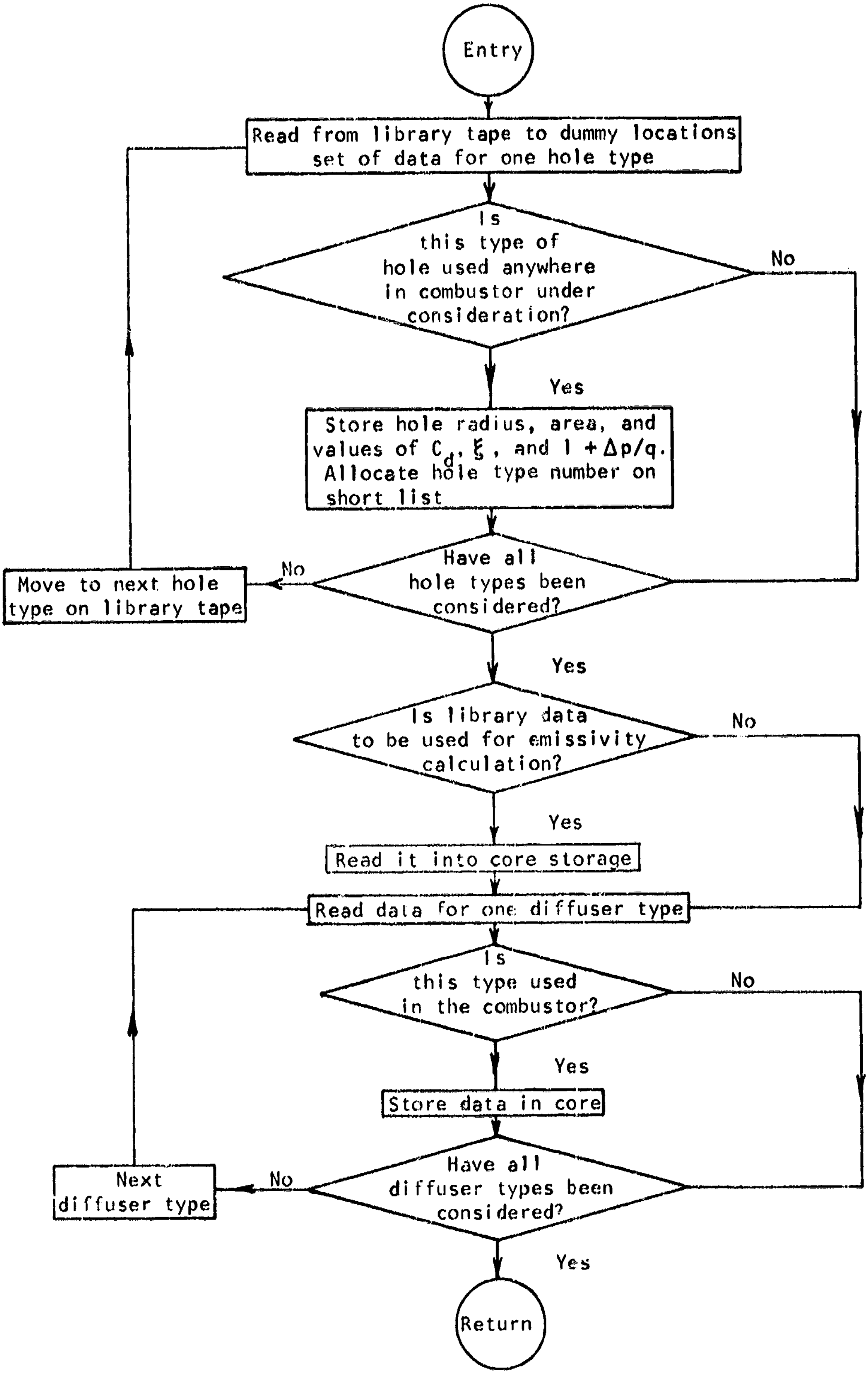


FIGURE 4 - FLOW CHART FOR SUBROUTINE TAPE

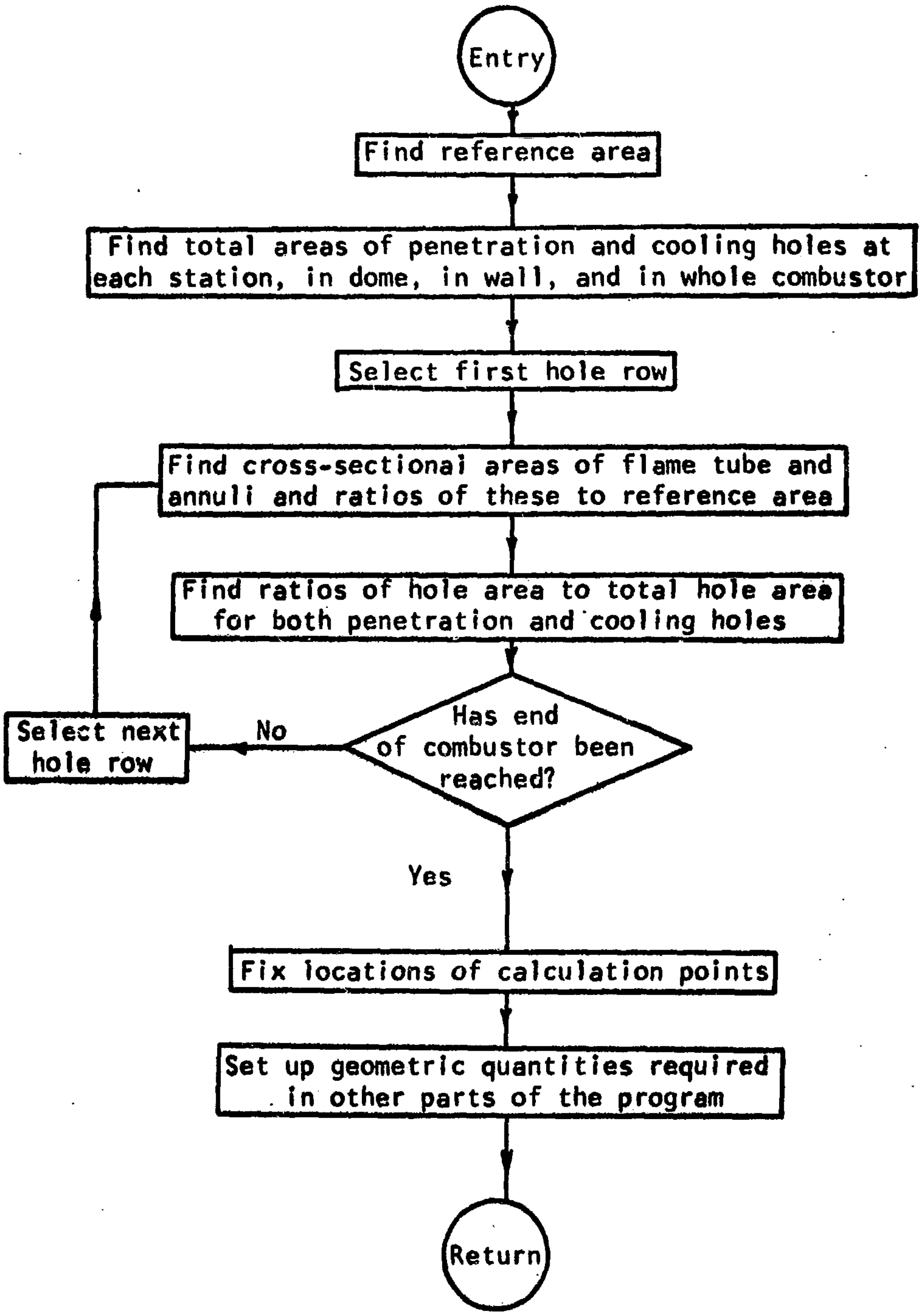


FIGURE 5 - FLOW CHART FOR SUBROUTINE GEOM

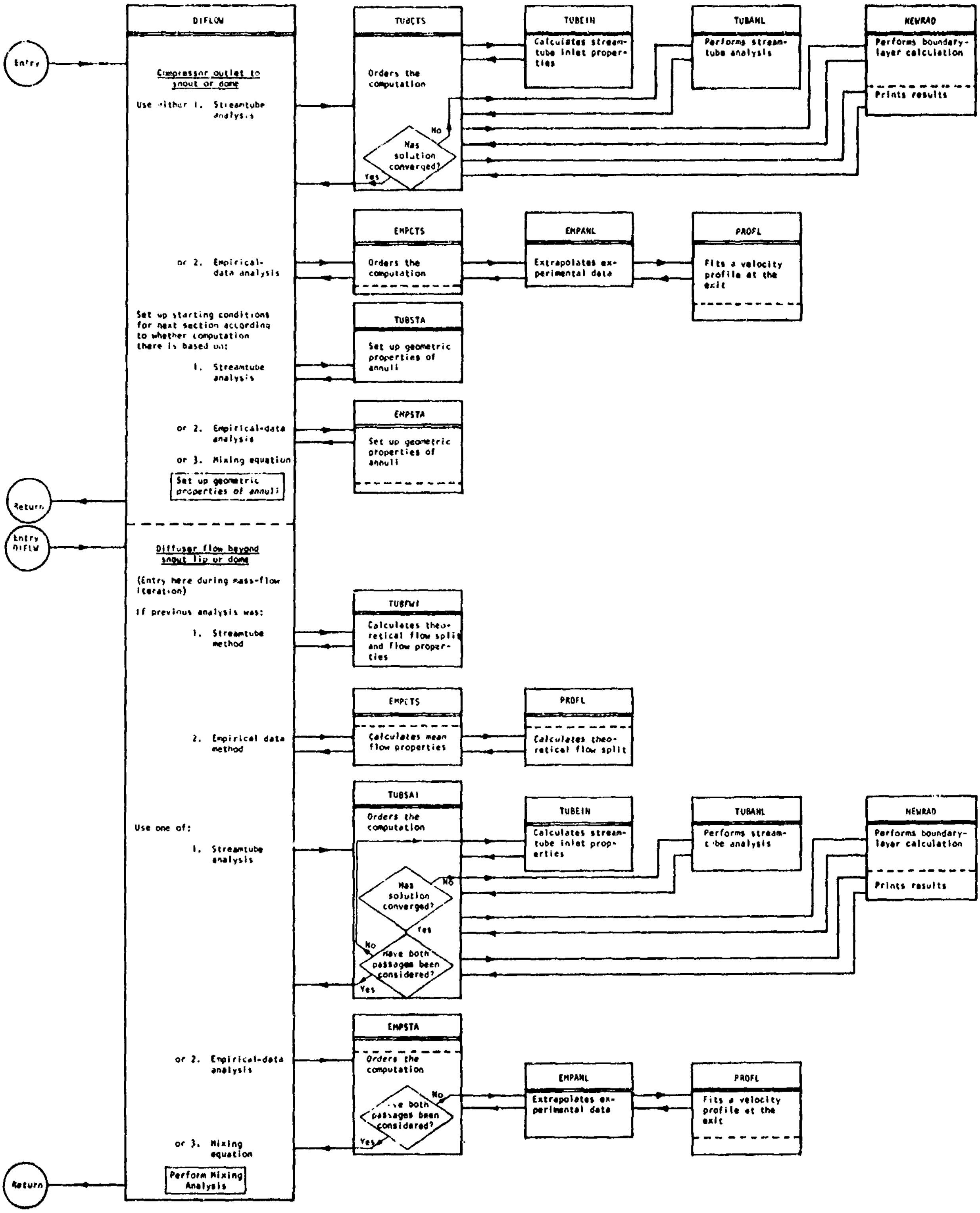


FIGURE 6 - OVERALL FLOW CHART FOR DIFFUSER SUBPROGRAM

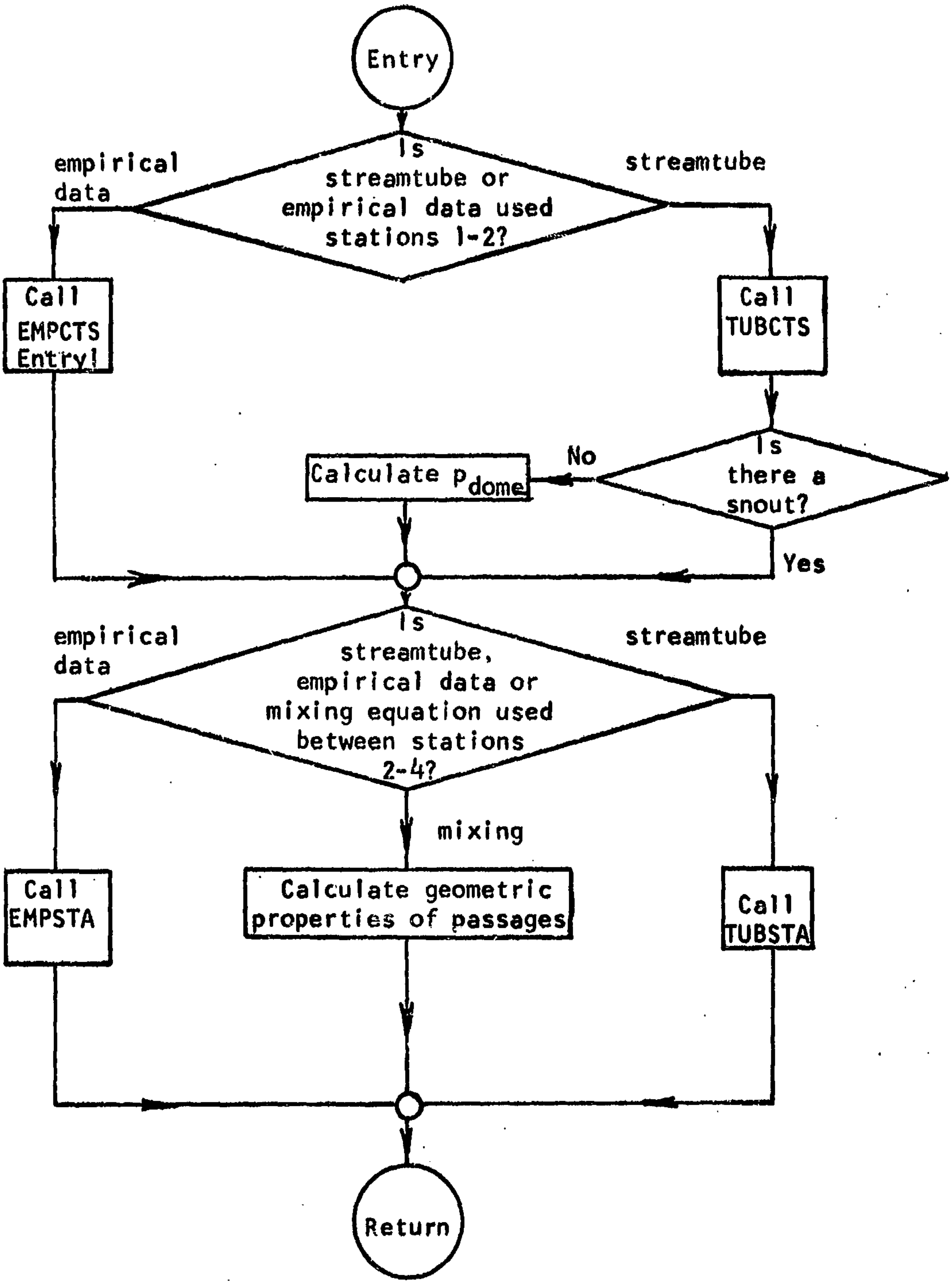
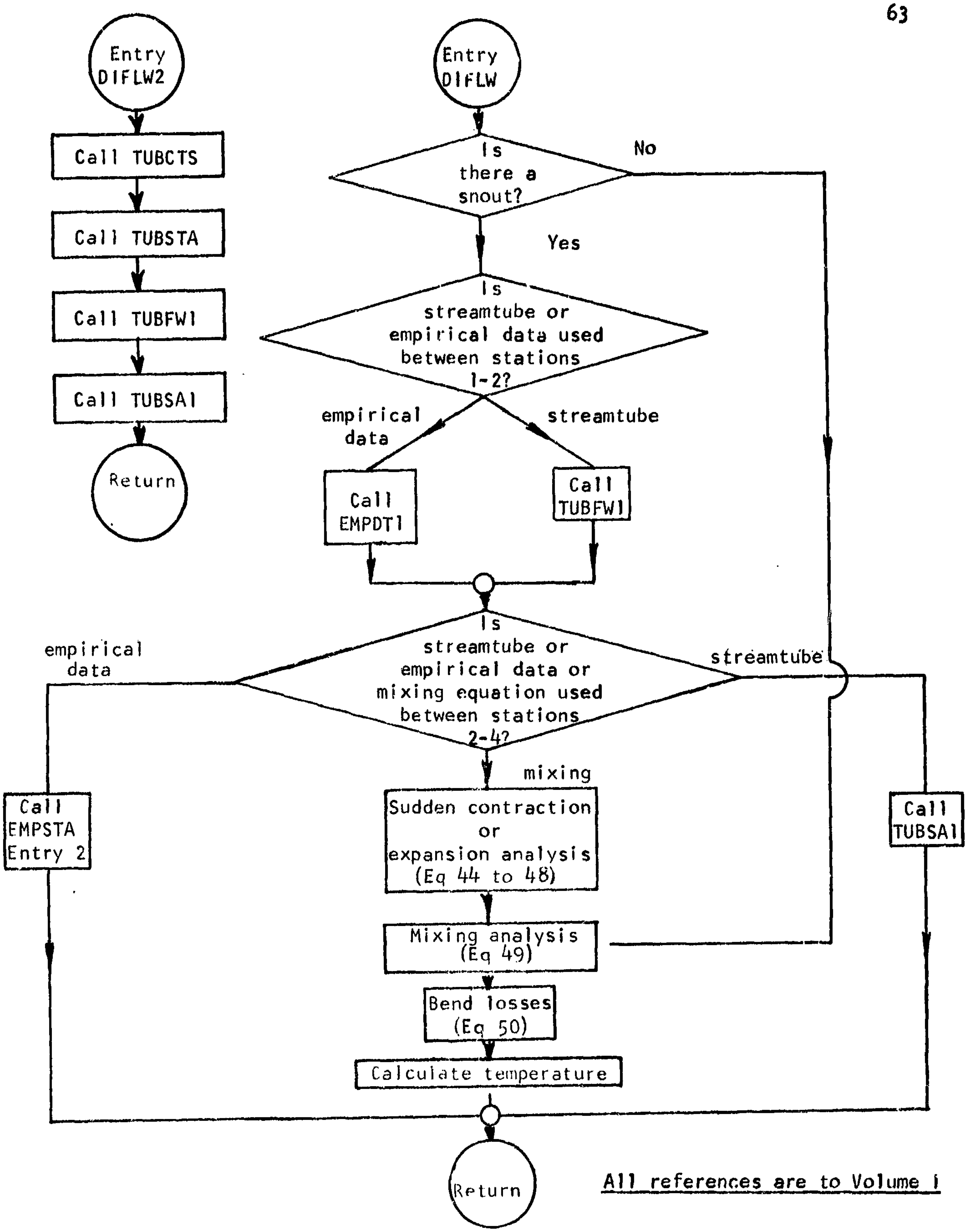
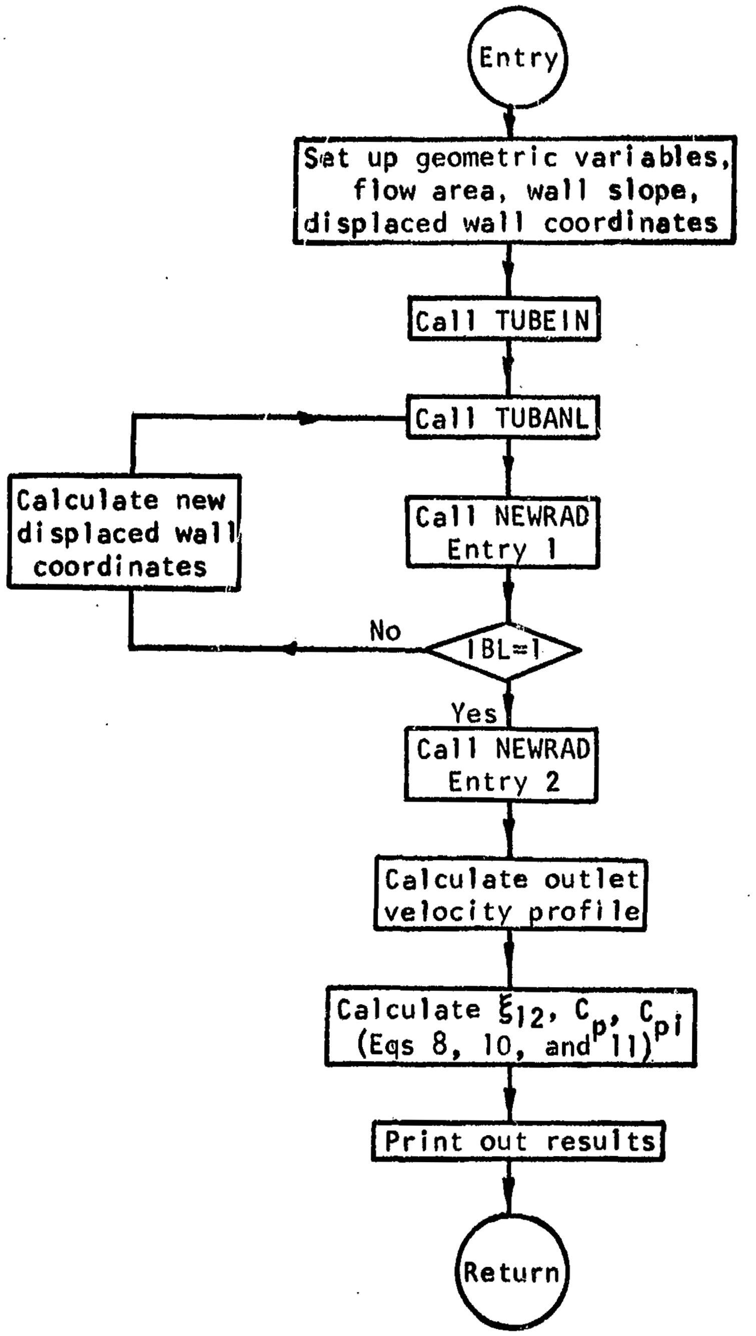


FIGURE 7 - FLOW CHART FOR SUBROUTINE DIFLOW



All references are to Volume I

FIGURE 7 (CONTINUED) - FLOW CHART FOR SUBROUTINE DIFLOW



All references are to Volume I

FIGURE 8 - FLOW CHART FOR SUBROUTINE TUBCTS

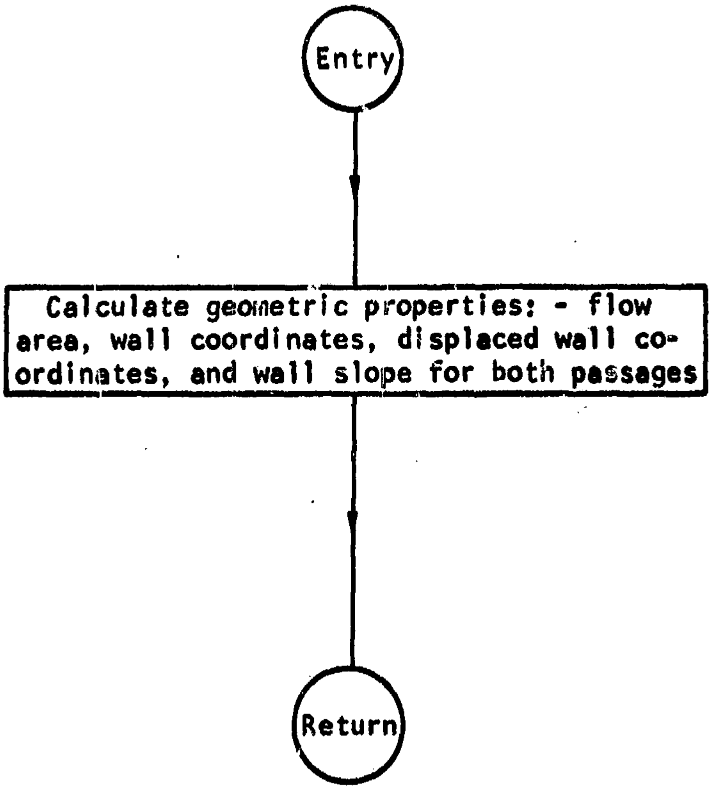
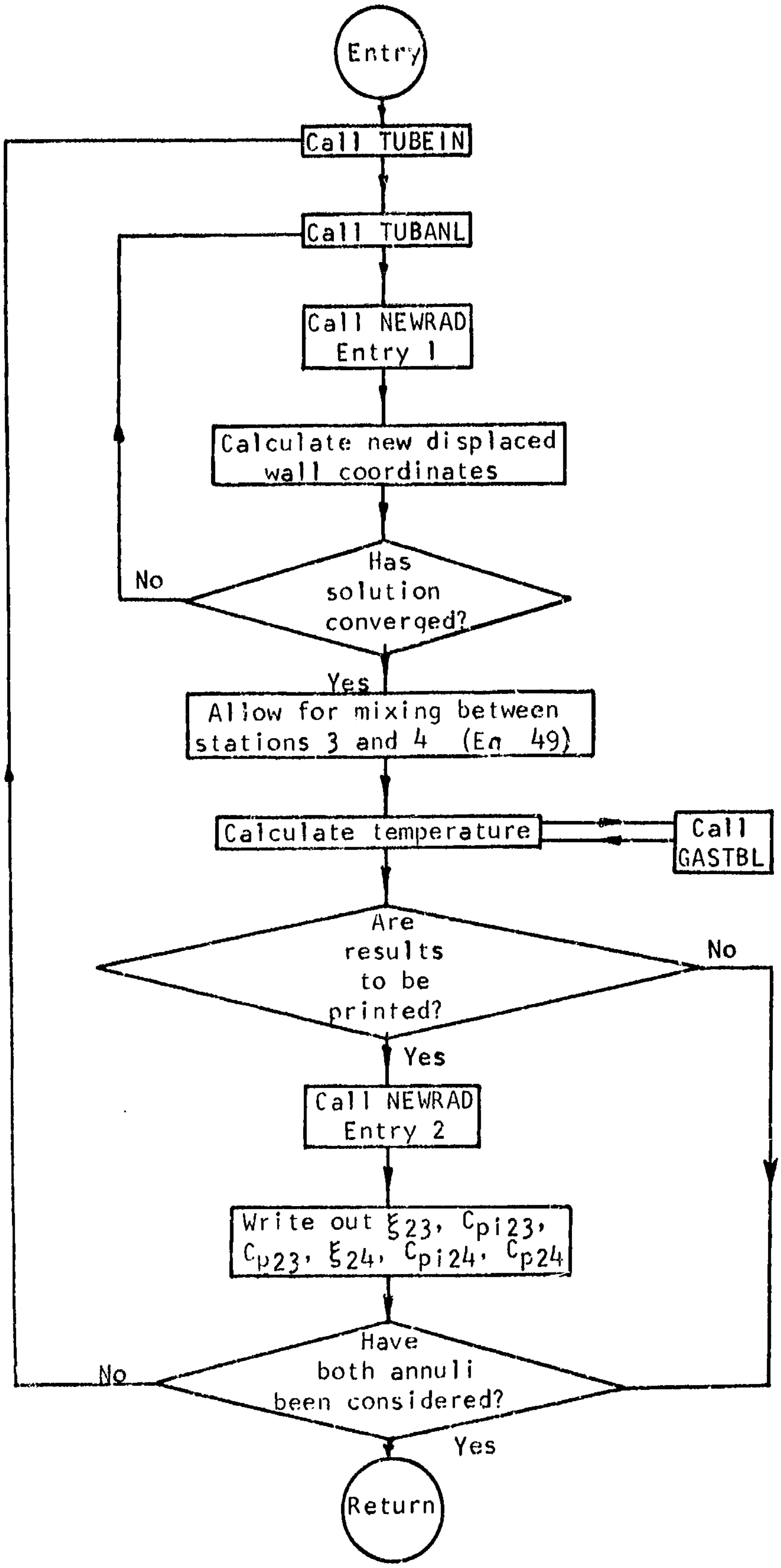


FIGURE 9 - FLOW CHART FOR SUBROUTINE TUBSTA



All references are to Volume I

FIGURE 10 - FLOW CHART FOR SUBROUTINE TUBSA1

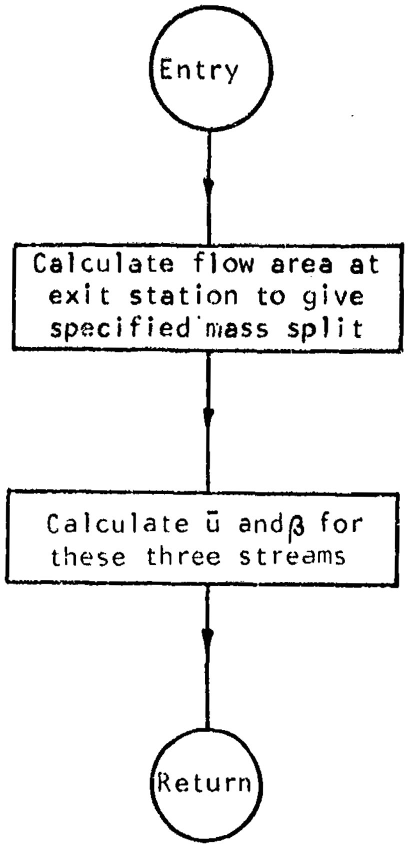
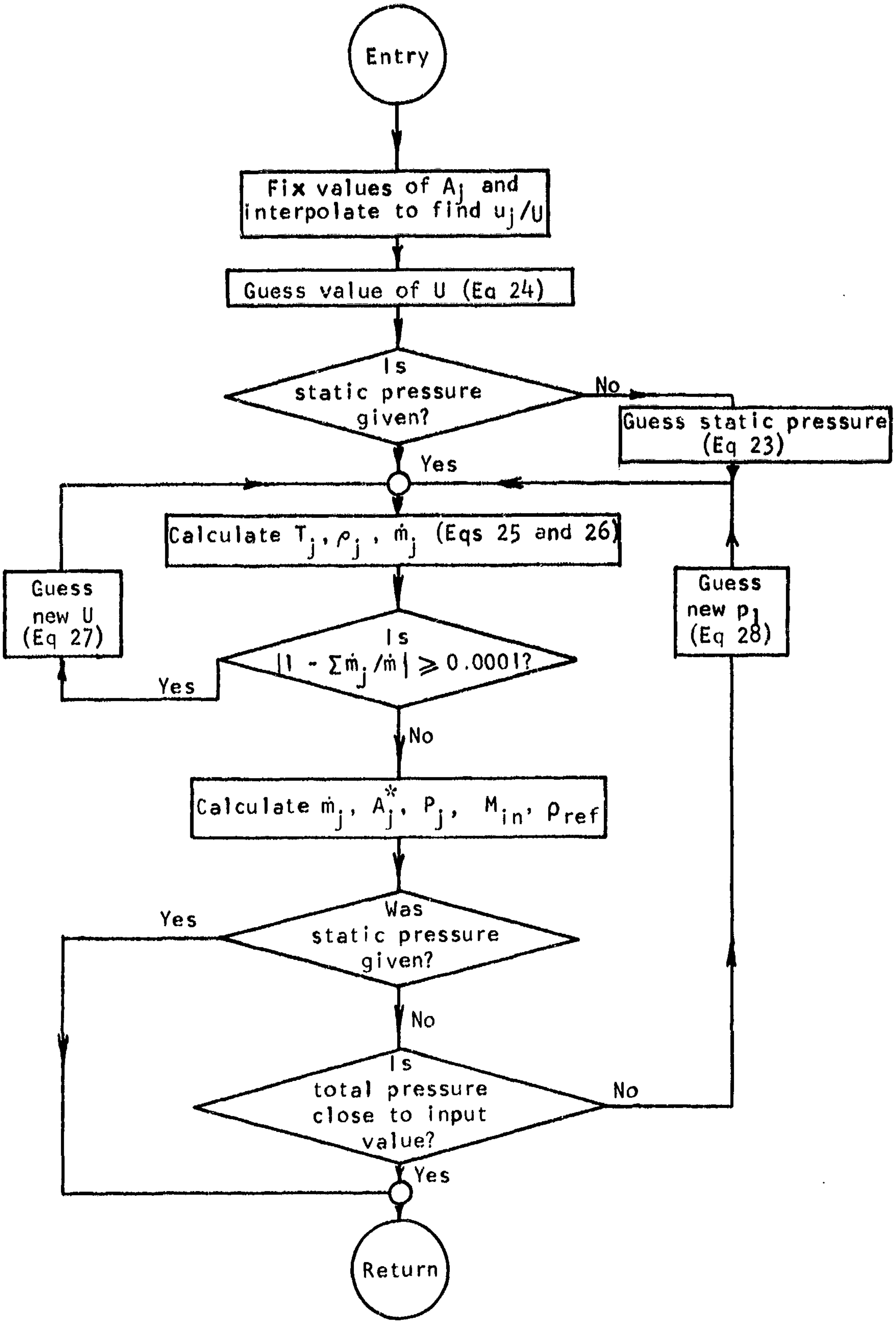
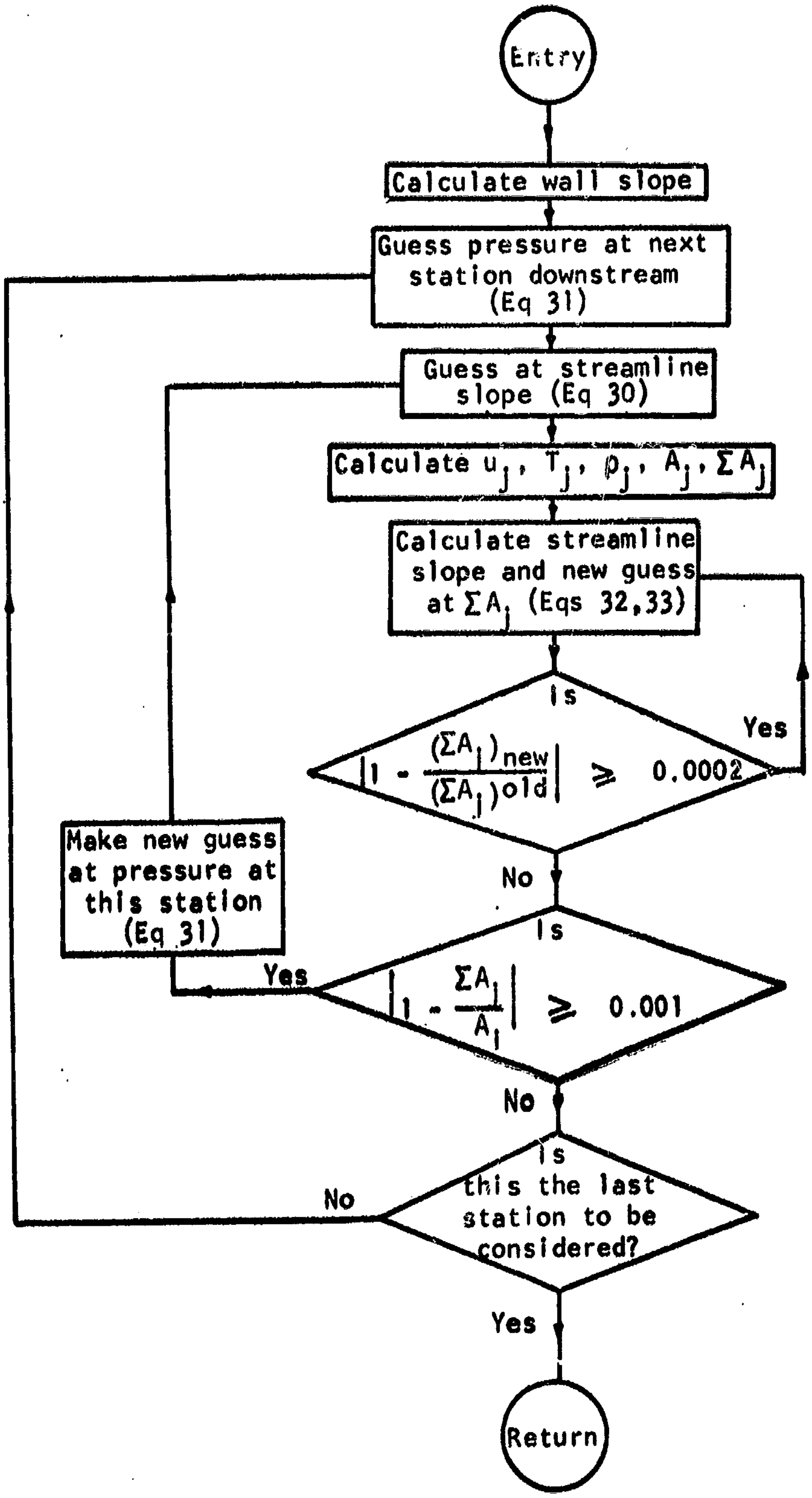


FIGURE 11 - FLOW CHART FOR SUBROUTINE TUBFW1



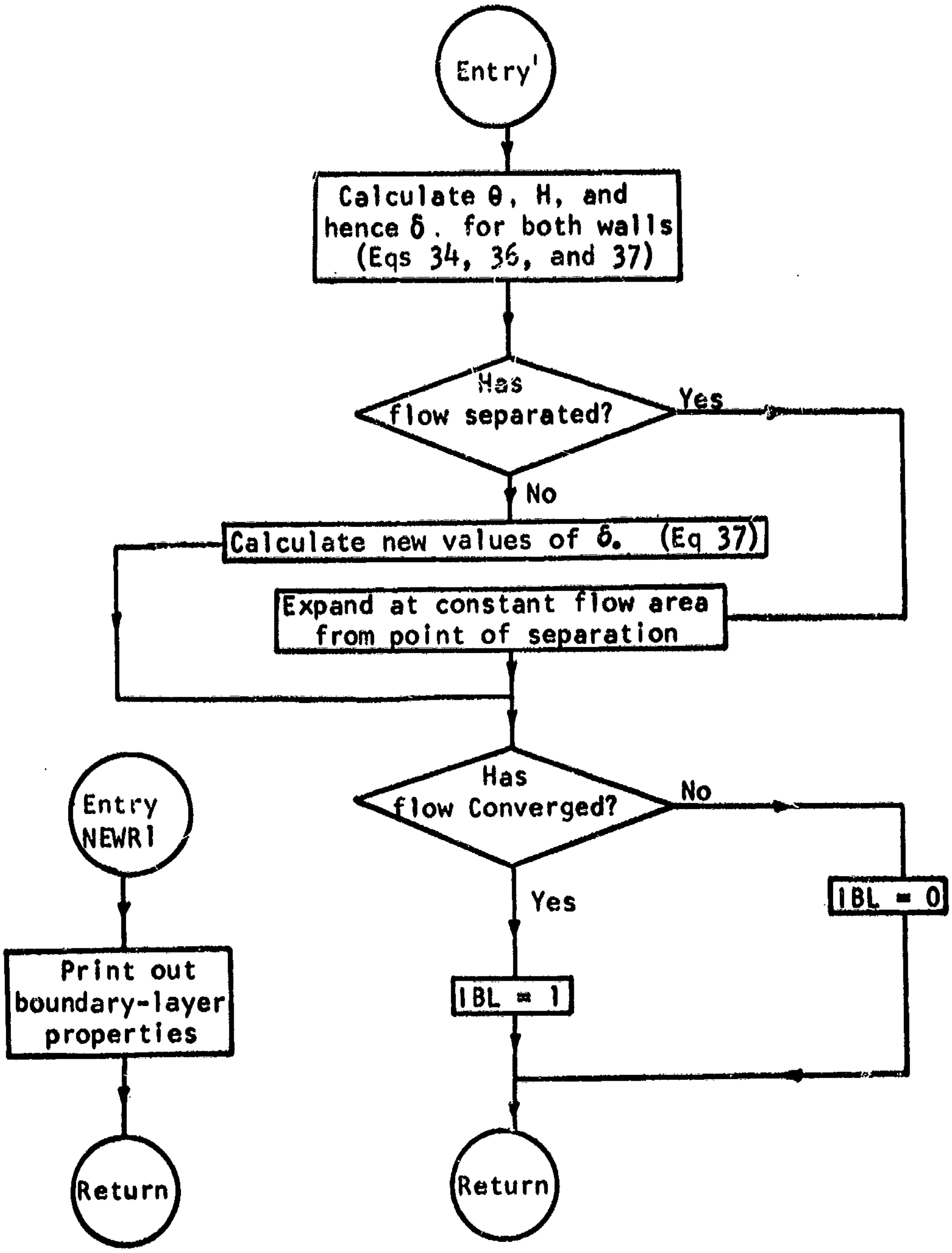
All references are to Volume I

FIGURE 12 - FLOW CHART FOR SUBROUTINE TUBEIN



All references are to Volume I

FIGURE 13 - FLOW CHART FOR SUBROUTINE TUBANL



All references are to Volume I

FIGURE 14 - FLOW CHART FOR SUBROUTINE NEWRAD

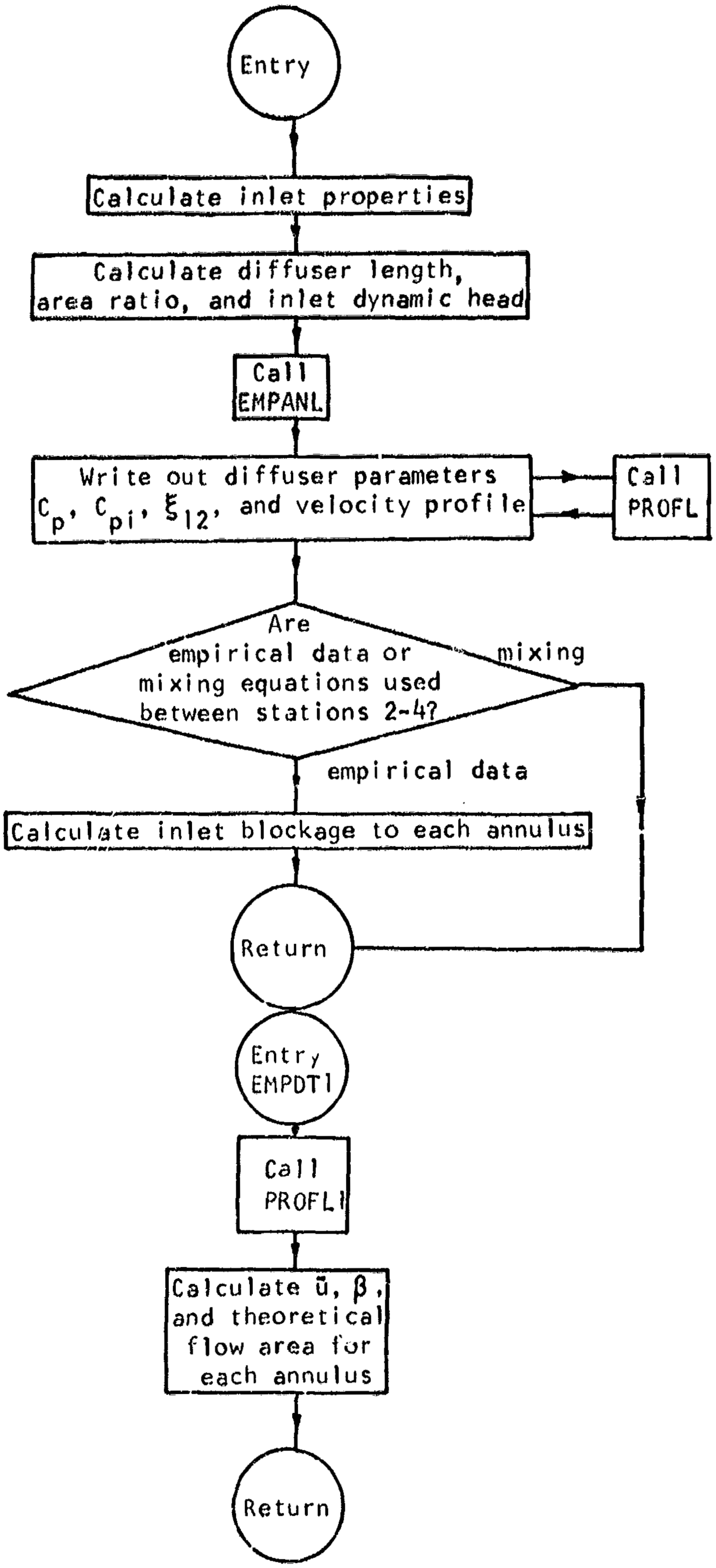
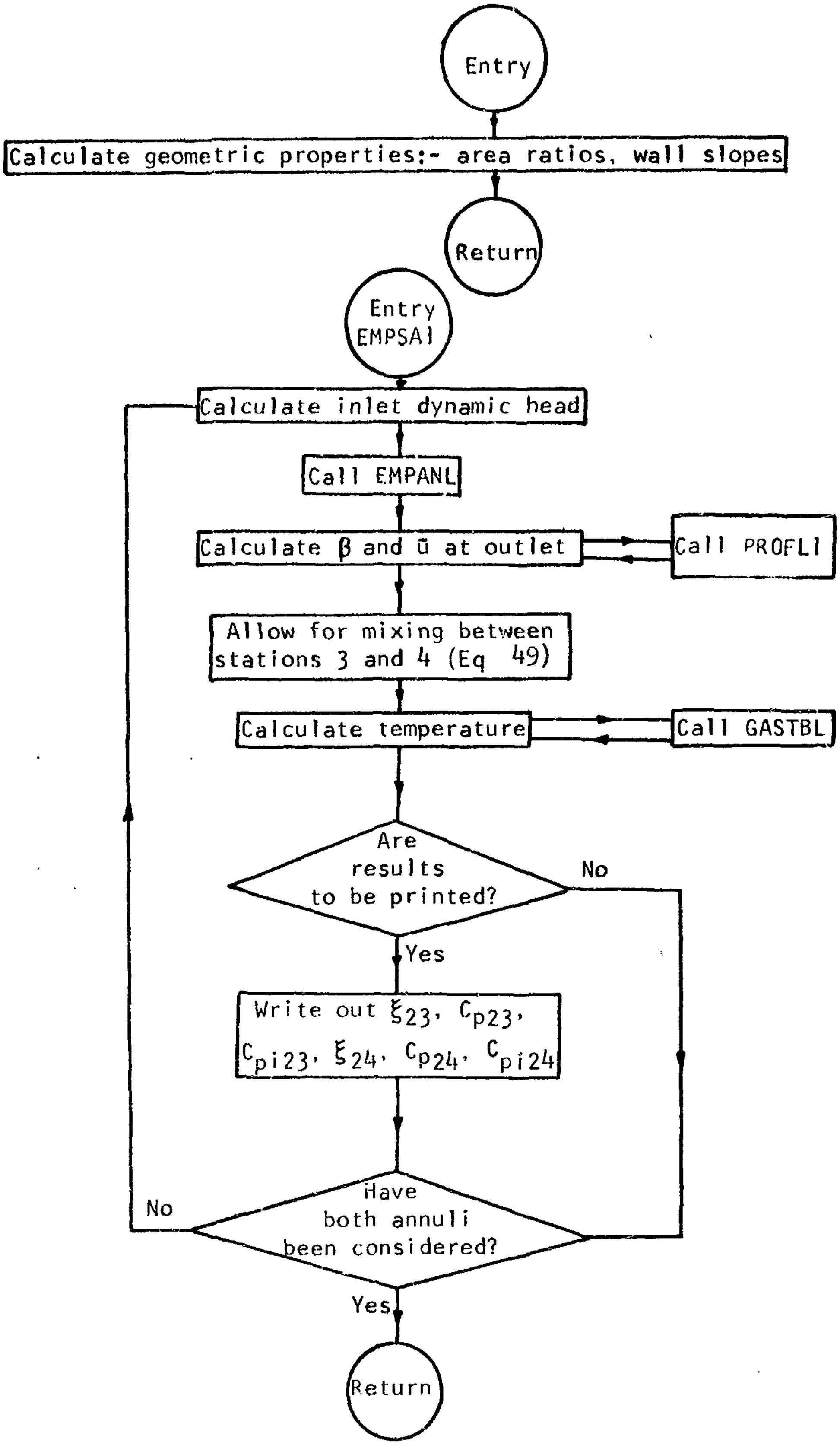
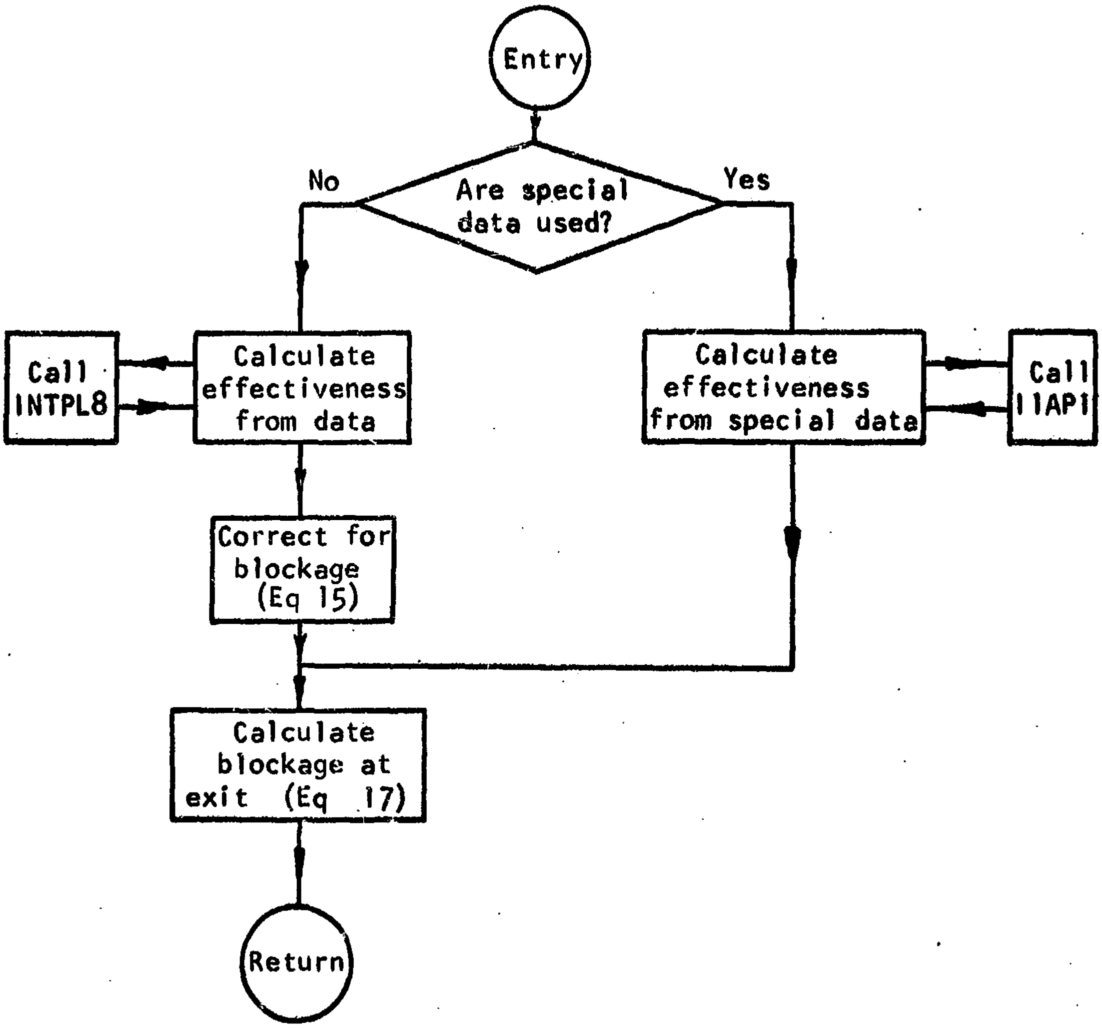


FIGURE 15 - FLOW CHART FOR SUBROUTINE EMPCTS



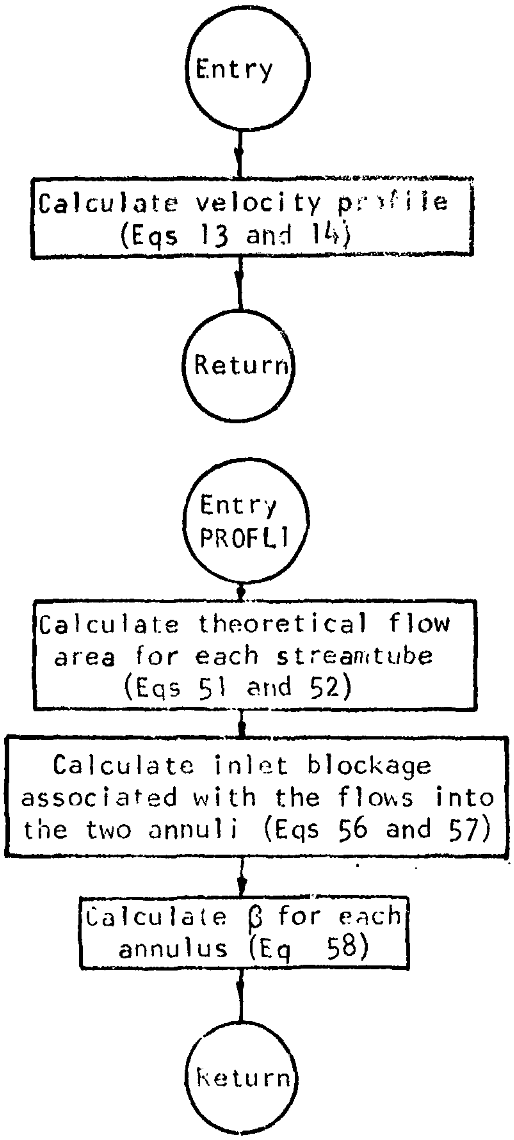
All references are to Volume I

FIGURE 16 - FLOW CHART FOR SUBROUTINE EMPSTA



All references are to Volume I

FIGURE 17 - FLOW CHART FOR SUBROUTINE EMPANL



All references are to Volume I

FIGURE 18 - FLOW CHART FOR SUBROUTINE PROFL

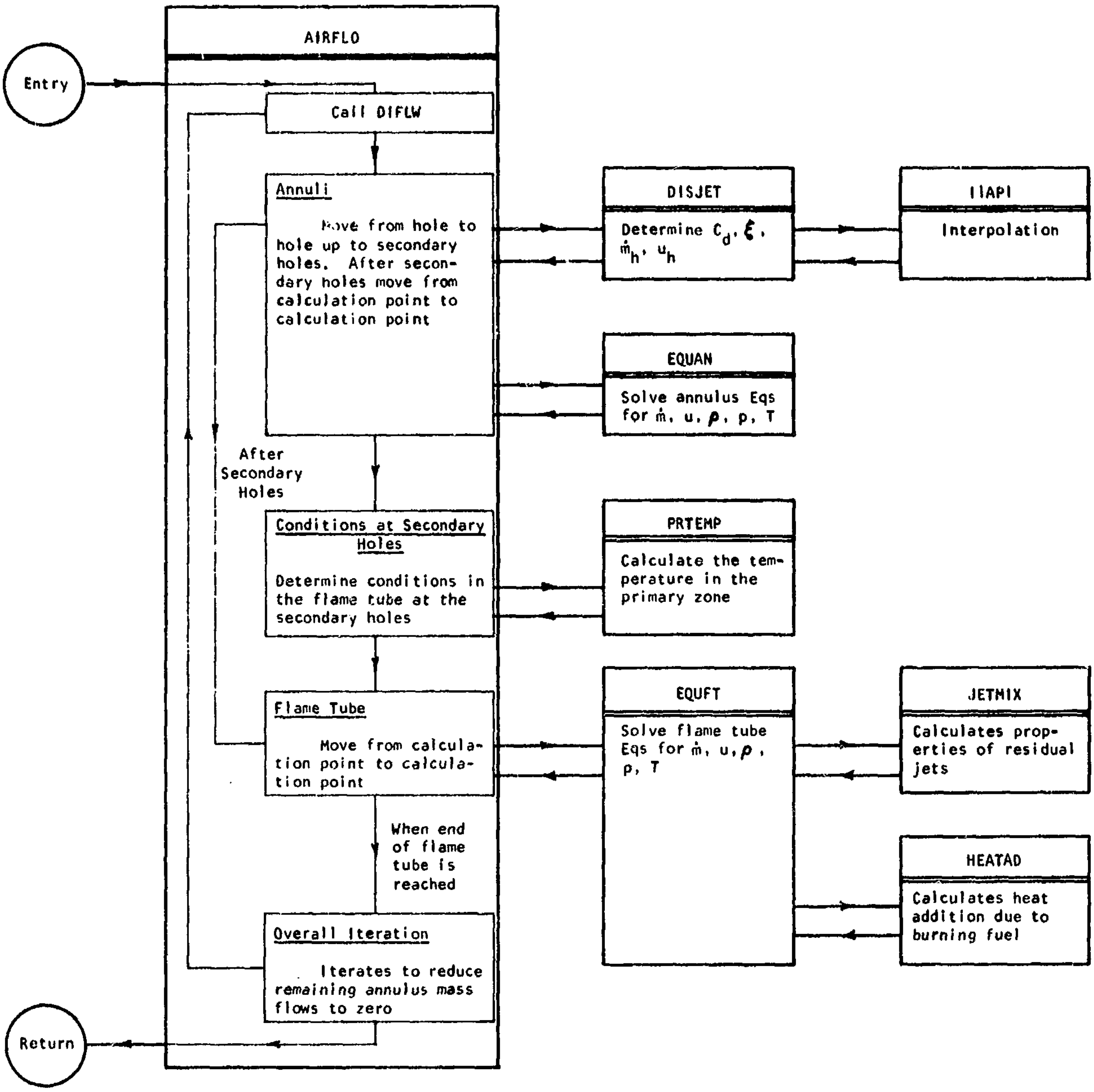


FIGURE 19 - OVERALL FLOW CHART FOR AIR-FLOW SUBPROGRAM

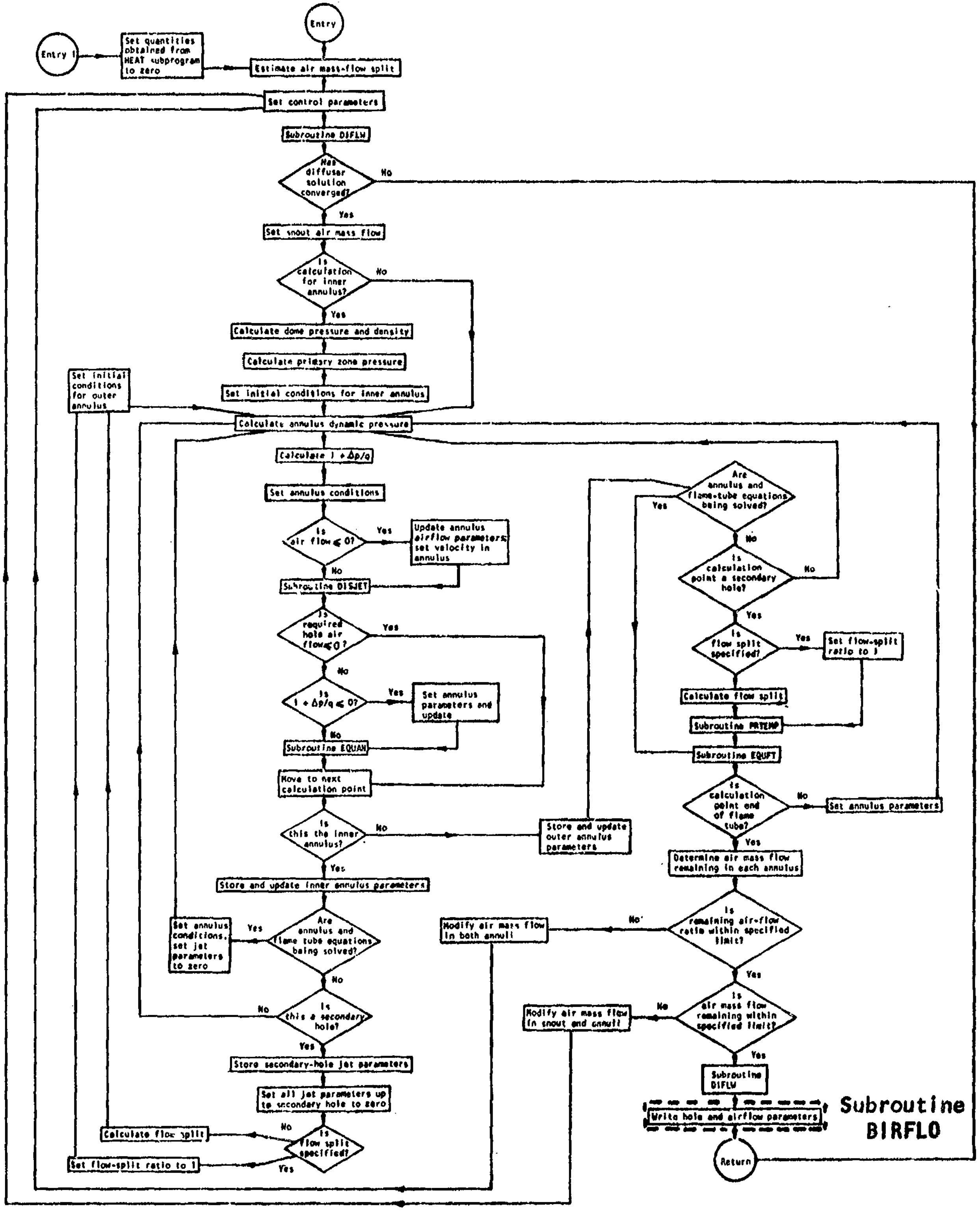


FIGURE 20 - FLOW CHART FOR SUBROUTINE AIRFLO

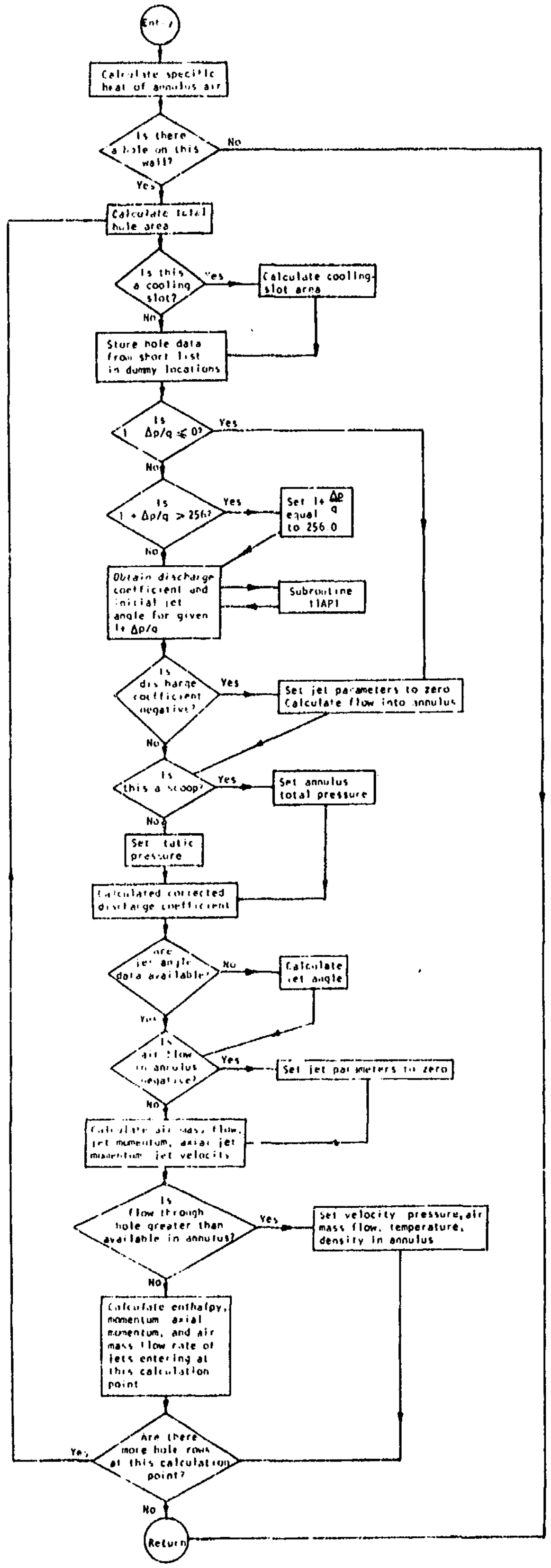


FIGURE 21 - FLOW CHART FOR SUBROUTINE DISJET

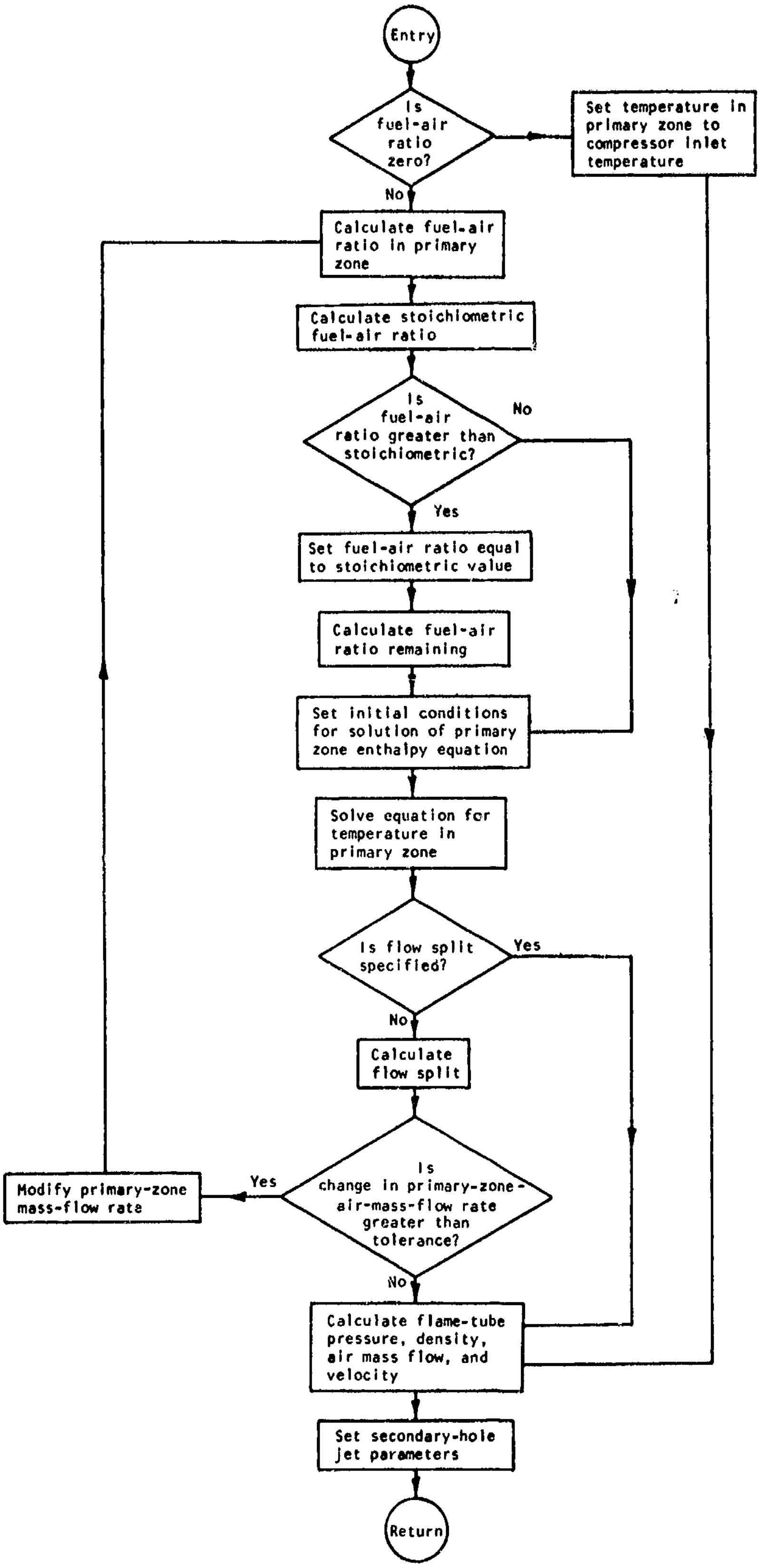


FIGURE 22 - FLOW CHART FOR SUBROUTINE PRTEMP

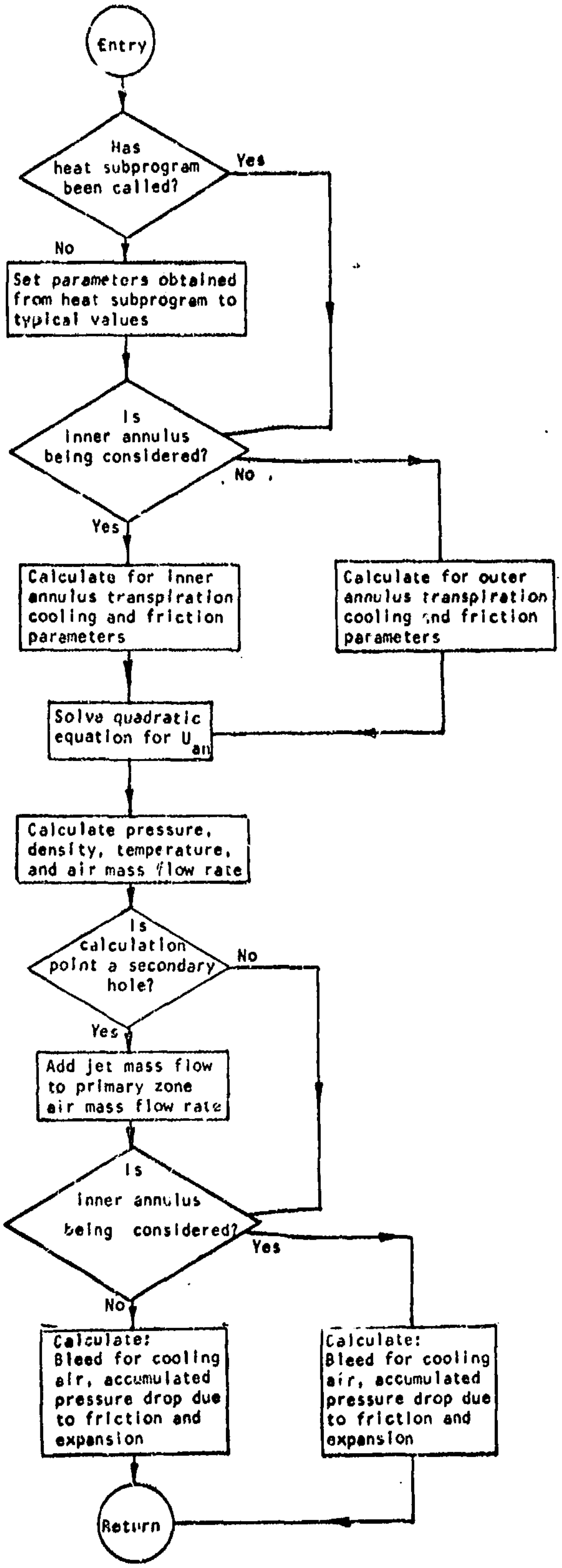


FIGURE 23 - FLOW CHART FOR SUBROUTINE EQUAN

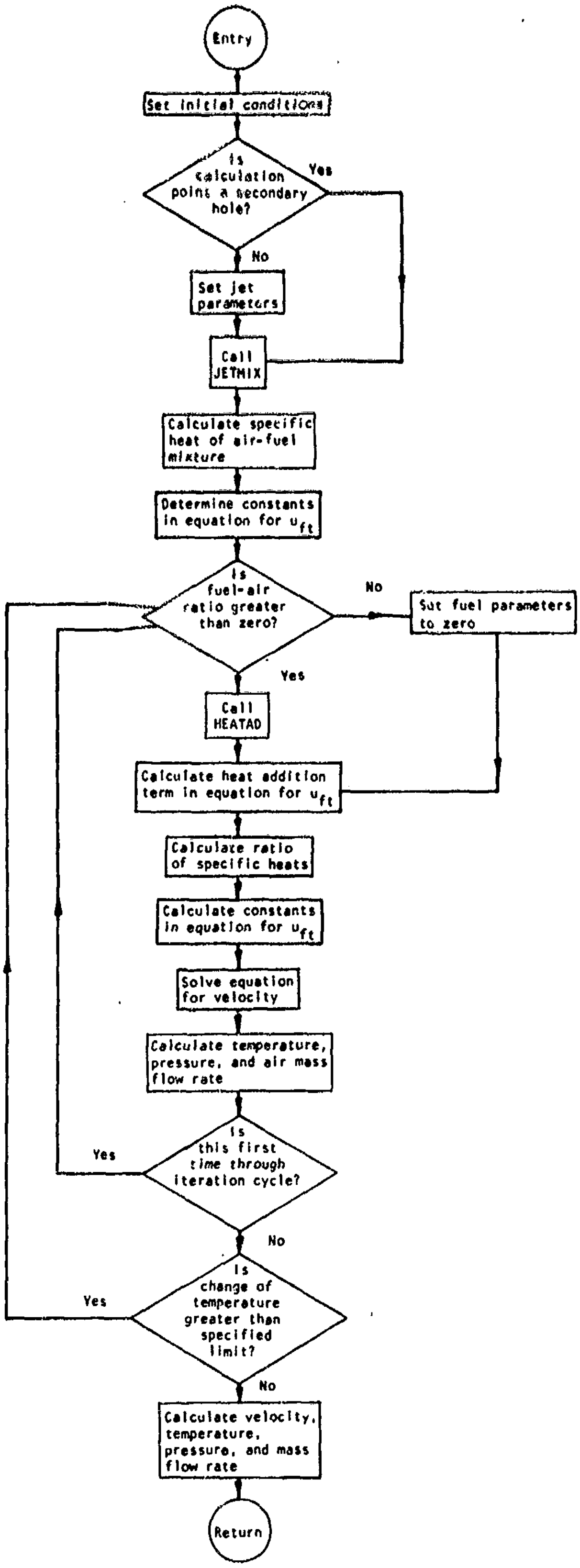
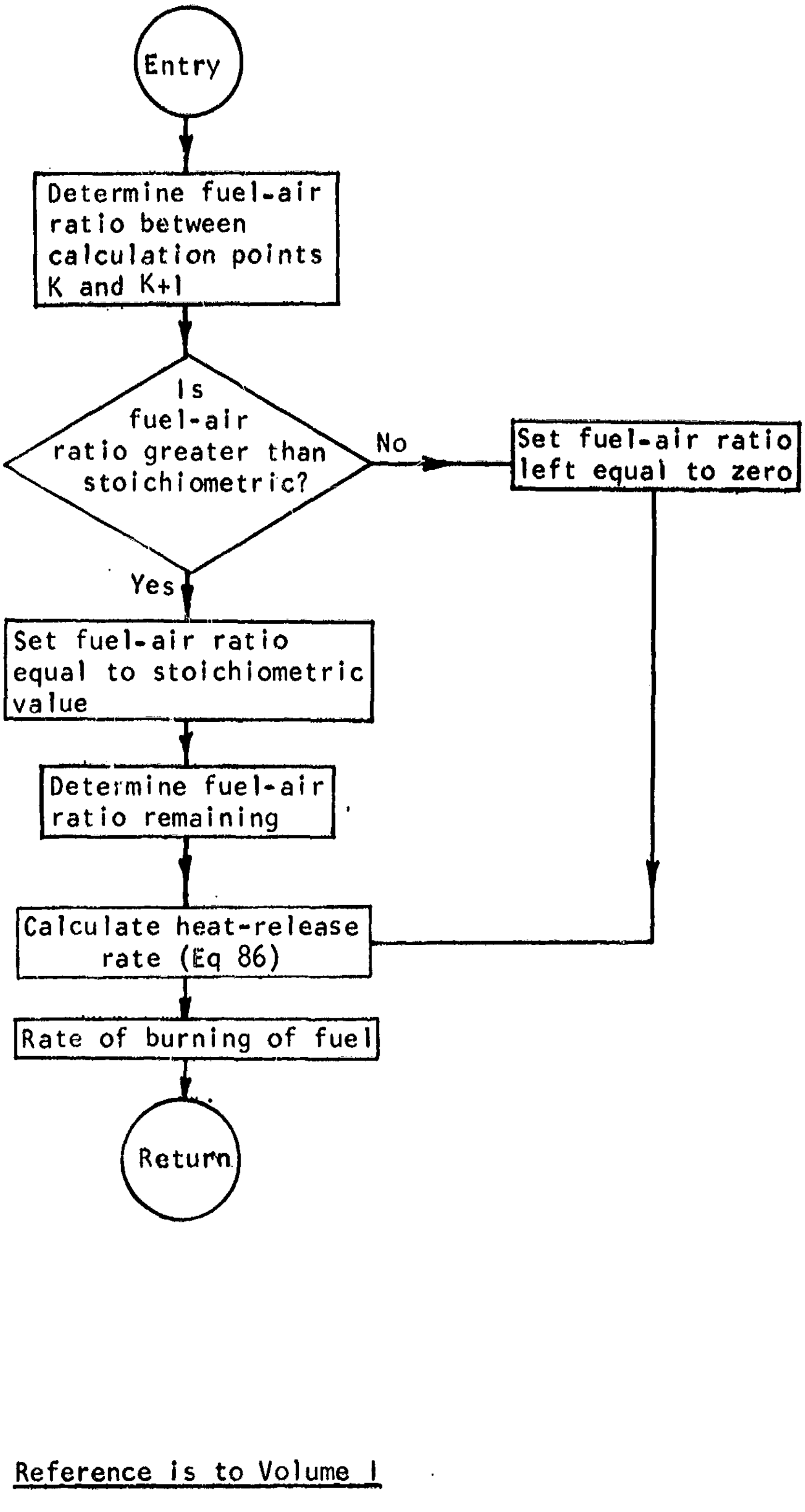
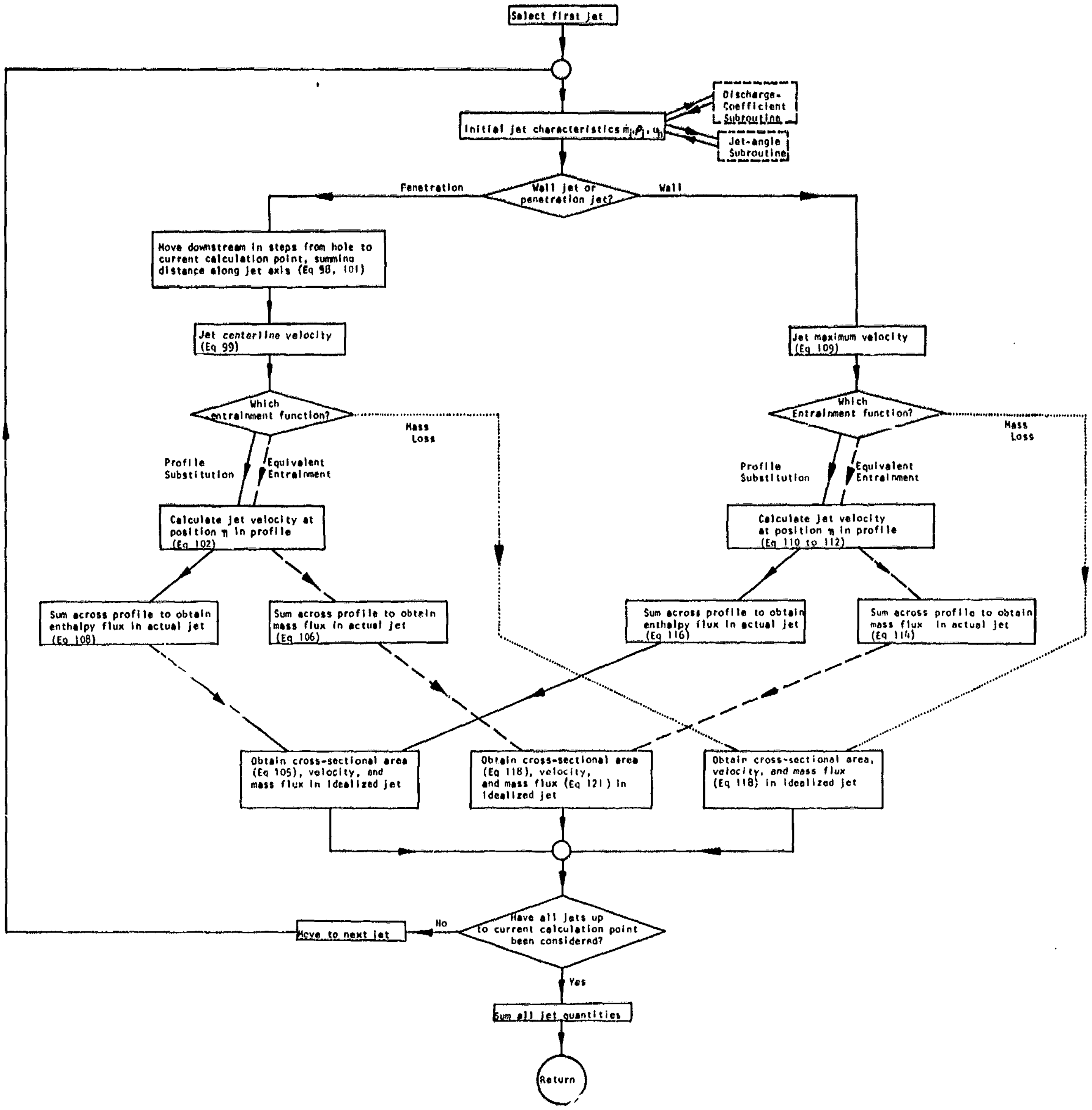


FIGURE 24 - FLOW CHART FOR SUBROUTINE EQUFT



Reference is to Volume I

FIGURE 25 - FLOW CHART FOR SUBROUTINE HEATAD



All References Are to Volume I

FIGURE 26 - FLOW CHART FOR SUBROUTINE JETMIX

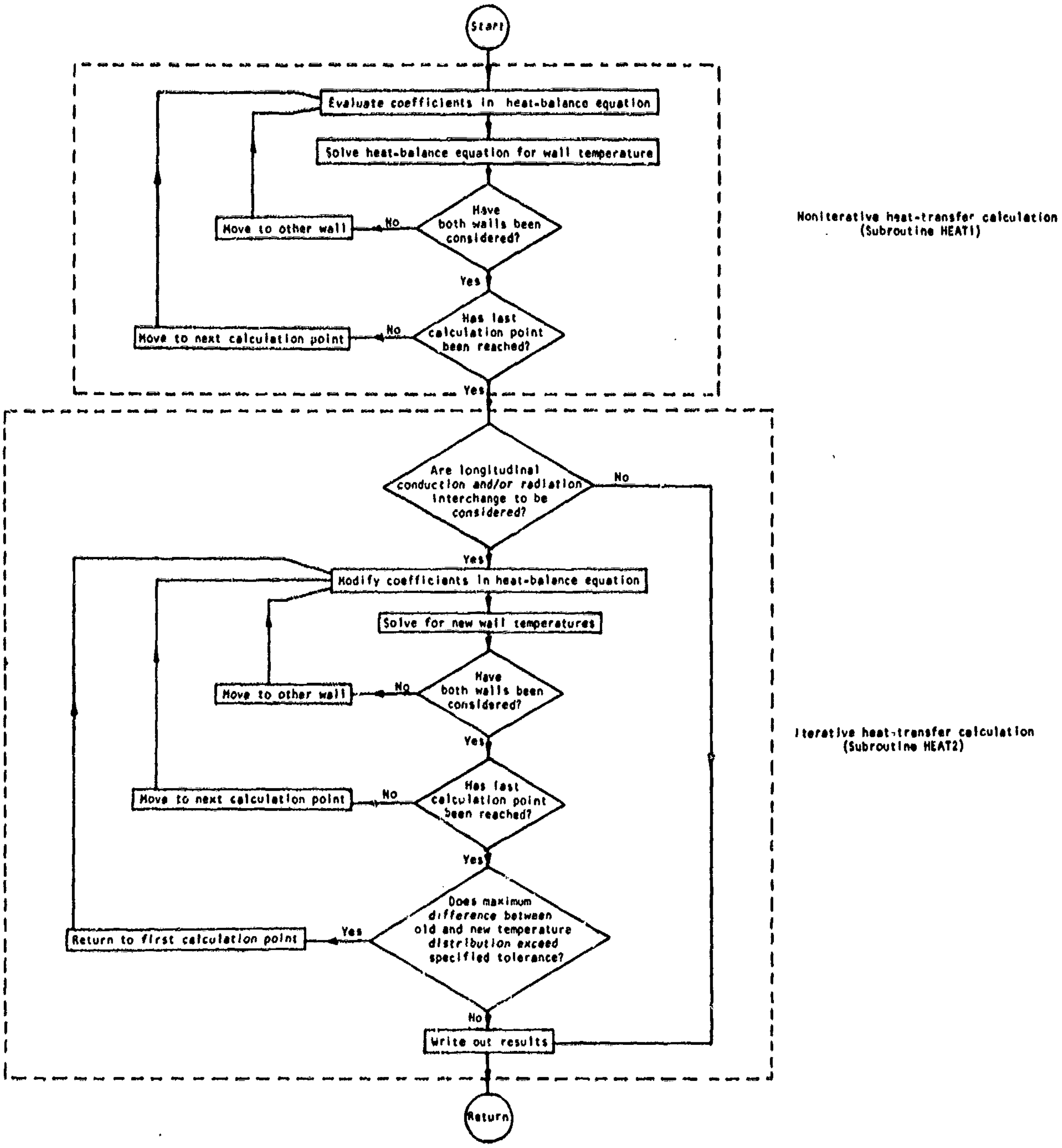
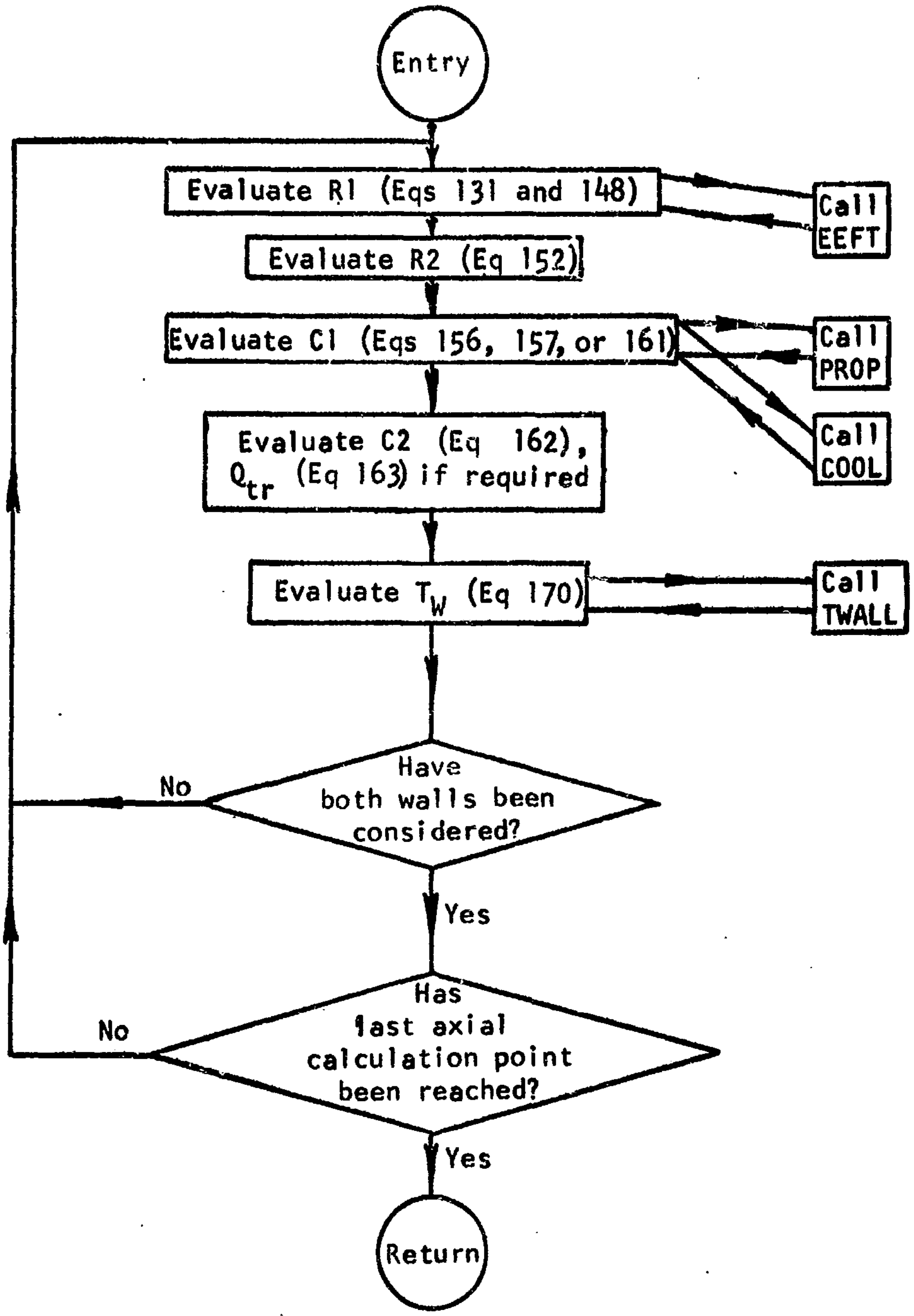
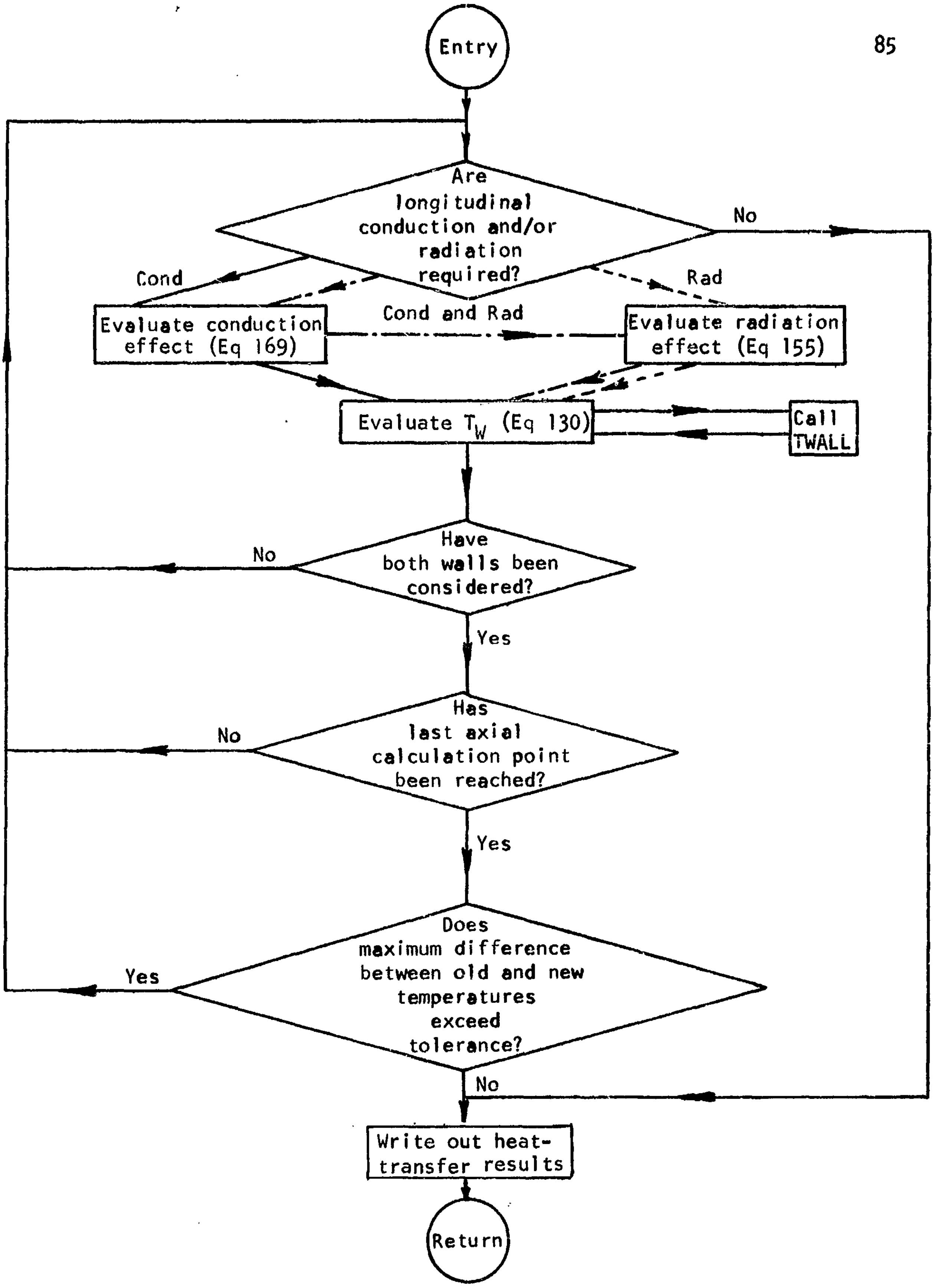


FIGURE 27 - OVERALL FLOW CHART FOR HEAT-TRANSFER SUBPROGRAM



All references are to Volume I

FIGURE 28 - FLOW CHART FOR SUBROUTINE HEAT1



All references are to Volume I

FIGURE 29 - FLOW CHART FOR SUBROUTINE HEAT2

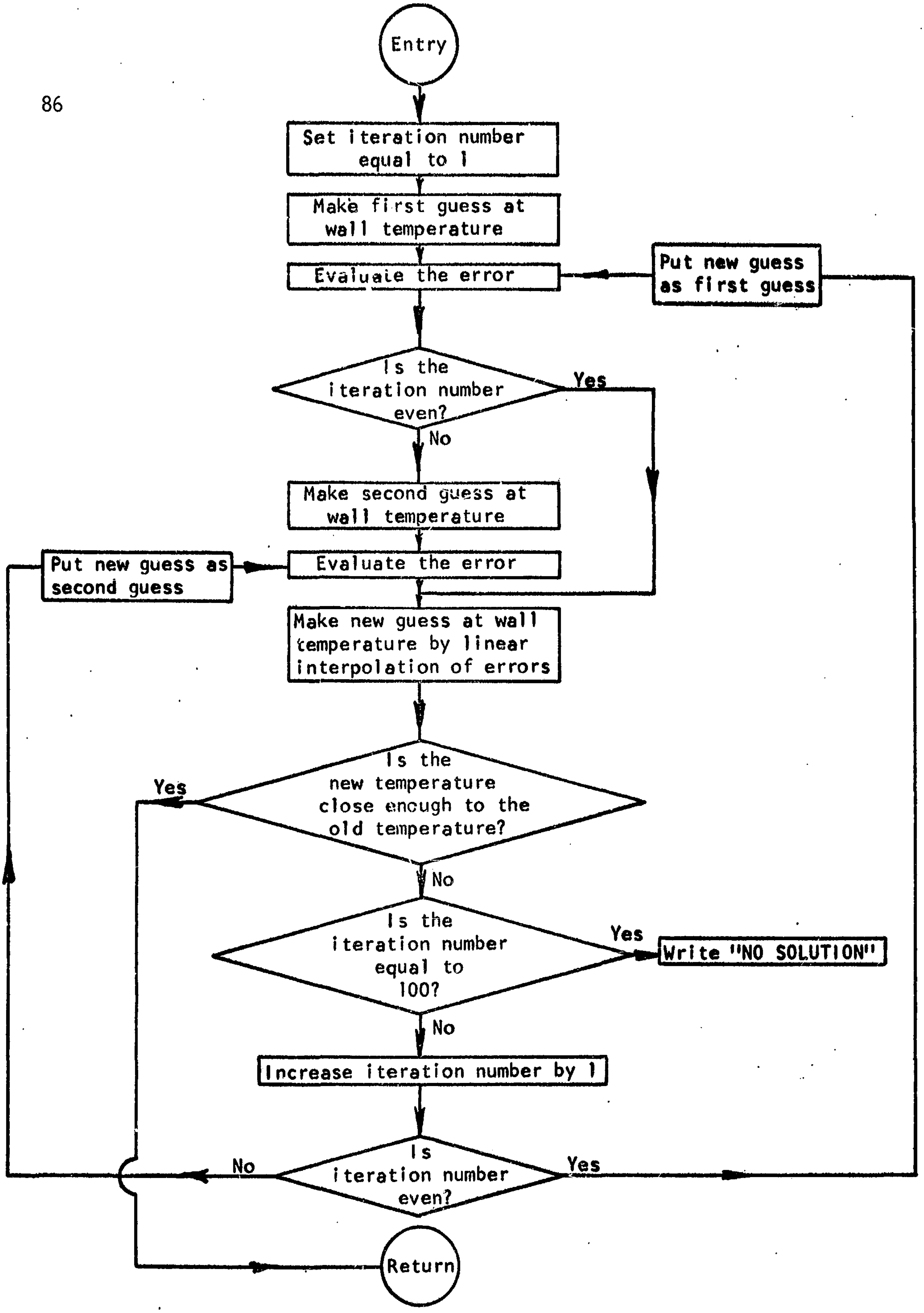
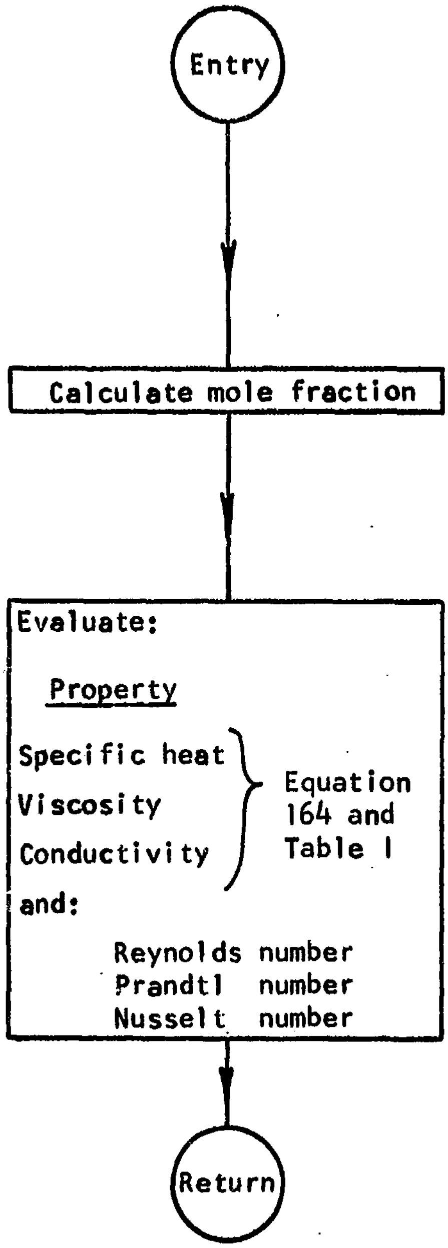
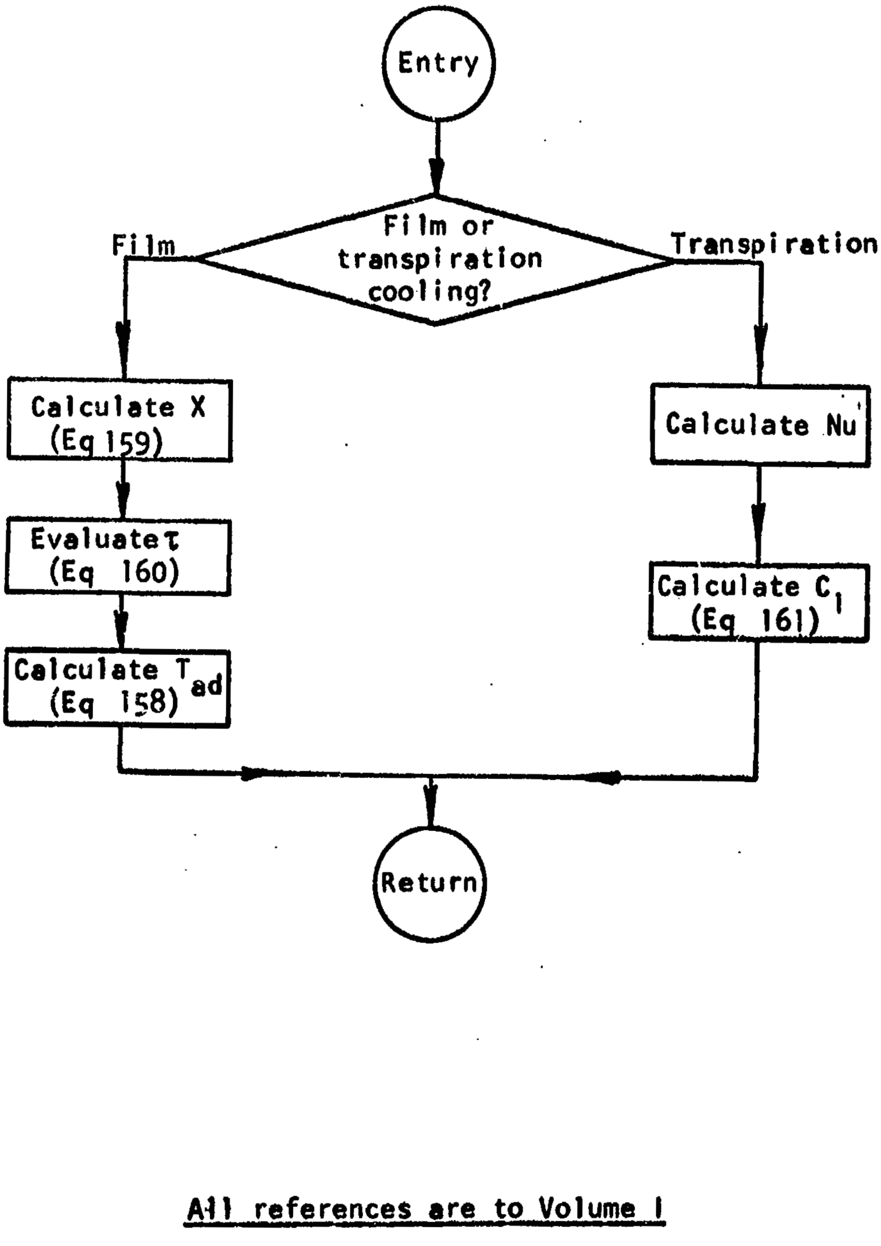


FIGURE 30 - FLOW CHART FOR SUBROUTINE TWALL



All references are to Volume I

FIGURE 31 - FLOW CHART FOR SUBROUTINE PROP



All references are to Volume I

FIGURE 32 - FLOW CHART FOR SUBROUTINE COOL

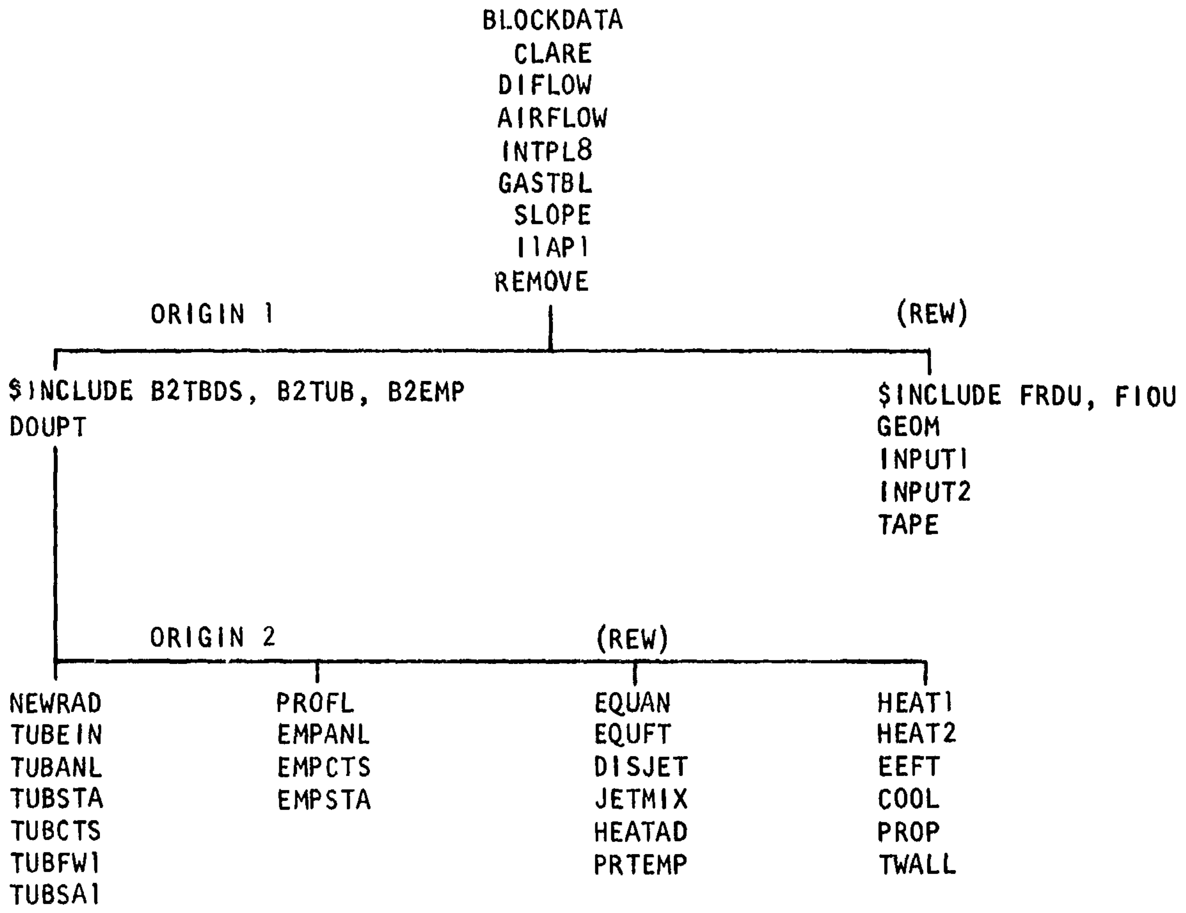


FIGURE 33 - OVERLAY STRUCTURE OF THE PROGRAM
]

APPENDICES

APPENDIX I

SAMPLE LIBRARY-DATA INPUT

The following three sample input-data sheets illustrate the computer card format used for the library data. The numbers at the tops of the input data sheets correspond to the 80 columns in a computer card; each line of data represents the content of one computer card. Beneath each input data sheet is a tabulated version of the data. For a verbal description of the library data-format the reader should refer to pages 27 to 33 of this volume.

Flame Emissivity

1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
4	12	3	133				
540.	1540.	2540.	3540.	4230.	846.	211.5	
.17	.185	.16	.092	.11	.13	.085	
.054	.07	.076	.05	.03			
							1

Data* Employed in Above Example

Pressure lbf/ft^2	Temperature deg F	Flame Emissivity
4230	540	.17
	1540	.185
	2540	.16
	3540	.092
846	540	.11
	1540	.13
	2540	.085
	3540	.054
211.5	540	.07
	1540	.076
	2540	.05
	3540	.03

*Purely Illustrative

Diffuser Effectiveness of Two Diffuser Types

1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
2							
5	4						
1	14	14	2	-133	0.98		
0.85	0.75	0.3	0.2	0.2	0.2	0.2	
0.73	0.85	0.85	0.78	0.6	0.4	0.2	
1.1	1.2	1.3	1.4	1.5	1.6	1.7	
1.1	1.2	1.3	1.4	1.52	1.62	1.75	
1.0	2.0						
2	8	16	2	133	0.98		
0.9	0.9	0.88	0.87	0.86	0.8	0.67	
0.58	0.88	0.9	0.9	0.88	0.86	0.85	
0.8	0.7	1.1	1.2	1.3	1.4	1.5	
1.6	1.7	1.8	1.0	2.0			
							1

Data Employed in the Above Example

Dimensionless Length	Area Ratio	Diffuser Effectiveness
1.0	1.1	0.85
	1.2	0.75
	1.3	0.3
	1.4	0.2
	1.5	0.2
	1.6	0.2
	1.7	0.2
2.0	1.1	0.73
	1.2	0.85
	1.3	0.85
	1.4	0.78
	1.52	0.6
	1.62	0.4
	1.75	0.2

Dimensionless Length	Area Ratio	Diffuser Effectiveness
1.0	1.1	0.9
	1.2	0.9
	1.3	0.88
	1.4	0.87
	1.5	0.86
	1.6	0.8
	1.7	0.67
	1.8	0.58
2.0	1.1	0.88
	1.2	0.9
	1.3	0.9
	1.4	0.88
	1.5	0.86
	1.6	0.85
	1.7	0.8
	1.8	0.7

Discharge Coefficient and Initial Jet Angle

1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
2							
1	0.0625	0.01227	10 9	1.	0.	0.	
	2.	0.33		4.	0.477		
	8.	0.555		16.	0.597		
	32.	0.623		64.	0.642		
	128.	0.65		256.	0.656		
2	0.164	0.0845	0 7	1.	0.	0.	
	2.	0.475	62.	4.	0.525	66.	
	8.	0.565	69.	16.	0.602	72.	
	32.	0.635	75.	64.	0.655	77.	
							1

Data Employed in the Above Example

Hole Number	Radius Inches	Area Square Inches	Pressure Loss Factor	Discharge Coefficient	Initial Jet Angle Deg.
1	0.0625	0.01227	1	0	0
			2	0.33	-
			4	0.477	-
			8	0.555	-
			16	0.597	-
			32	0.623	-
			64	0.642	-
			128	0.65	-
			256	0.656	-
2	0.164	0.0845	1	0	0
			2	0.475	62
			4	0.525	66
			8	0.565	69
			16	0.602	72
			32	0.635	75
			64	0.655	77

APPENDIX II

SAMPLE INPUT DATA (OVERALL TEST CASE NUMBER 3)

1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
$DATA							
TEST CASE	NO. 3						
$FIXED1 N	CASE=1, NG	=29, NH=19	, NWH=1, N	SH=3, NSNO	UT=1, K6=1	, NUMSW=24	$
0.	32.5					35.7	
0.5	32.3					35.9	
1.	32.					36.2	
1.5	31.8					36.4	
2.	31.5					36.7	
2.5	31.3					36.9	
2.8	31.1	33.1			35.1	37.1	
3.	31.	33.			35.2	37.2	
4.	30.5	32.5			35.7	37.7	
5.	30.1	32.1			36.1	38.1	
6.	29.6	31.6			36.6	38.6	
7.	29.1	31.1	34.1	34.1	37.1	39.1	
8.	28.6	30.6	31.1	37.1	37.6	39.6	
8.8	28.2	30.2	30.2	38.	38.	40.	
9.	28.2	30.2	30.2	38.	38.	40.	
9.1	28.2	29.9	29.9	38.3	38.3	40.	
14.	28.2	29.9	29.9	38.3	38.3	40.	
15.	28.2	29.9	29.9	38.3	38.3	40.	
15.1	28.2	29.6	29.6	38.6	38.6	40.	
20.	28.2	29.6	29.6	38.6	38.6	40.	
21.	28.2	29.6	29.6	38.6	38.6	40.	
21.1	28.2	29.3	29.3	38.9	38.9	40.	
26.	28.2	29.3	29.3	38.9	38.9	40.	
27.	28.2	29.3	29.3	38.9	38.9	40.	
27.1	28.2	29.	29.	39.2	39.2	40.	
29.	28.2	29.	29.	39.2	39.2	40.	
30.	28.2	29.	29.	38.2	38.2	40.	
31.	28.2	29.	29.	37.2	37.2	40.	
32.8	28.2	29.	29.	37.2	37.2	40.	

1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
9.				0.1	1 1	44	
9.				0.1	2 1	44	
12.				0.6	1 50	75	
12.				0.6	2 50	75	
13.5				0.7		0	
15.				0.8	1 1	44	
15.				0.8	2 1	44	
16.5				0.85		0	
18.				0.9	1 40	27	
18.				0.9	2 40	27	
19.5				0.95		0	
21.				0.95	1 1	44	
21.				0.95	2 1	44	
22.5				0.95		0	
24.				0.95	1 75	27	
24.				0.95	2 75	27	
27.				0.95	1 1	44	
27.				0.95	2 1	44	
32.7				0.95		0	
$FIXEDR XINT=0.5, THIKFT=0.06, FLCV=18560., AF23A=0.01, AF23B=0.03,							
XAF23A=32.8, XAF23B=32.8, DSWLOU=1.5, BETA=45., DSWLIN=1.$							
$LIMITS LCANIL=30, NXDIF1=14, NXDIF2=14, NXDIF=7$							
THE LIBRARY DATA CARDS ARE INSERTED HERE							
THE FORMAT FOR THESE DATA IS DESCRIBED ON PAGE 27							

1 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
1150.	90.	96.	0.018	0.5			
0.00625	0.01	0.01	0.01	0.01	0.01	0.01	
0.0	0.0	0.0	0.0	0.0	0.0		
7	7						
0.85	0.1						
0.9	0.2						
1.	0.4						
0.9	0.5						
0.9	0.6						
0.9	0.8						
0.85	0.9						
13	2	3	0	2	1		
1.	0.2						

APPENDIX III

SAMPLE COMPUTER OUTPUT

(RESULTS OF OVERALL TEST CASE NO. 3)

```
                    A N A L Y S I S   O F   A N   A N N U L A R   C O M B U S T O R

TEST CASE NO. 3


                    * * * * * * * * * * * * * * INPUT DATA * * * * * * * * * * * * * *


GEOMETRIC CONFIGURATION OF COMBUSTOR
------------------------------------
THE GEOMETRY IS DEFINED AT 29 GEOMETRIC INPUT POINTS
 AXIAL       - - - - - - - - - - - - - - DIAMETER INCHES - - - - - - - - - - - - - -
 POSITION
 FROM                                                                                  GEOMETRIC
 COMPRESSOR  INNER       INNER       INNER DOME  OUTER DOME  OUTER       OUTER        INPUT
 DISCHARGE   CASING      SNOUT       OR FLAME    OR FLAME    SNOUT       CASING       POINT
 INCHES                              TUBE WALL   TUBE WALL                            NUMBER

     0.       32.500      -0.          -0.         -0.         -0.       35.700         1
     0.500    32.300      -0.          -0.         -0.         -0.       35.900         2
     1.000    32.000      -0.          -0.         -0.         -0.       36.200         3
     1.500    31.800      -0.          -0.         -0.         -0.       36.400         4
     2.000    31.500      -0.          -0.         -0.         -0.       36.700         5
     2.500    31.300      -0.          -0.         -0.         -0.       36.900         6
     2.800    31.100      33.100       -0.         -0.       35.100      37.100         7
     3.000    31.000      33.000       -0.         -0.       35.200      37.200         8
     4.000    30.500      32.500       -0.         -0.       35.700      37.700         9
     5.000    30.100      32.100       -0.         -0.       36.100      38.100        10
     6.000    29.600      31.600       -0.         -0.       36.600      38.600        11
     7.000    29.100      31.100       34.100      34.100    37.100      39.100        12
     8.000    28.600      30.600       31.100      37.100    37.600      39.600        13
     8.800    28.200      30.200       30.200      38.000    38.000      40.000        14
     9.000    28.200      30.200       30.200      38.000    38.000      40.000        15
     9.100    28.200      29.900       29.900      38.300    38.300      40.000        16
    14.000    28.200      29.900       29.900      38.300    38.300      40.000        17
    15.000    28.200      29.900       29.900      38.300    38.300      40.000        18
    15.100    28.200      29.600       29.600      38.600    38.600      40.000        19
    20.000    28.200      29.600       29.600      38.600    38.600      40.000        20
    21.000    28.200      29.600       29.600      38.600    38.600      40.000        21
    21.100    28.200      29.300       29.300      38.900    38.900      40.000        22
    26.000    28.200      29.300       29.300      38.900    39.900      40.000        23
    27.000    28.200      29.300       29.300      38.900    38.900      40.000        24
    27.100    28.200      29.000       29.000      39.200    39.200      40.000        25
    29.000    28.200      29.000       29.000      39.200    39.200      40.000        26
    30.000    28.200      29.000       29.000      38.200    38.200      40.000        27
    31.000    28.200      29.000       29.000      37.200    37.200      40.000        28
    32.800    28.200      29.000       29.000      37.200    37.200      40.000        29
```

```
SWIRLER DESIGN
--------------

(SPECIFIED AS INPUT)

NUMBER OF SWIRLERS     =       24
NUMBER OF BLADES       =        8
BLADE STAGGER ANGLE    =    45.00  DEGREES
INNER DIAMETER         =     1.00  INCHES
OUTER DIAMETER         =     1.50  INCHES
AREA PER SWIRLER       =     0.98  SQUARE INCHES (IGNORING BLOCKAGE DUE TO VANES)



DETAILS OF AIR ENTRY PORTS AND GEOMETRY AT EACH HOLE ROW
--------------------------------------------------------
THERE ARE 19 HOLE ROWS

HOLE   AXIAL     HOLE  INNER  NUMBER    TOTAL PORT AREA   RATIO TOTAL PORT  CUMULATIVE SUM    RATIO    RATIO    RATIO
ROW    POSITION  TYPE  OR     OF HOLES  AT THIS HOLE ROW  AREA THIS ROW     OF AREA RATIO     FLAME    INNER    OUTER
NUMBER OF HOLE         OUTER  IN THIS   SQUARE FEET       TO GRAND TOTAL    (LAST COLUMN)     TUBE     ANNULUS  ANNULUS
       CENTER-         WALL   ROW                                                             C S AREA C S AREA C S AREA
       LINE                             PENETRAT COOLING  PENETRAT COOLING  PENETRAT COOLING  TO REF   TO REF   TO REF
       INCHES                           -ION     SLOTS    -ION     SLOTS    -ION     SLOTS    AREA     AREA     AREA
                                        HOLES             HOLES             HOLES
                                            - - - - - - - - - - - DOME - - - - - - - - - -

TOTAL COOLING AIR ENTRY PORT AREA IN THE DOME     = 0.    SQ FT
TOTAL PENETRATION AIR ENTRY PORT AREA IN THE DOME = 0.164 SQ FT (INCLUDING TOTAL SWIRLER AREA)

                                            - - - - - - - FLAME TUBE WALL- - - - - - -
   1     9.000   44    INNER     1      0.       0.063    0.       0.111    0.045    0.111    0.651    0.145    0.194
   2     9.000   44    OUTER     1      0.       0.079    0.       0.139    0.045    0.250    0.661    0.145    0.194
   3    12.000   75    INNER    50      0.153    0.       0.042    0.       0.087    0.250    0.712    0.123    0.165
   4    12.000   75    OUTER    50      0.153    0.       0.042    0.       0.128    0.250    0.712    0.123    0.165
   5    13.500    0             -0      0.       0.       0.       0.       0.128    0.250    0.712    0.123    0.165
   6    15.000   44    INNER     1      0.       0.062    0.       0.110    0.128    0.360    0.712    0.123    0.165
   7    15.000   44    OUTER     1      0.       0.079    0.       0.140    0.128    0.500    0.712    0.123    0.165
   8    16.500    0             -0      0.       0.       0.       0.       0.128    0.500    0.763    0.101    0.137
   9    18.000   27    INNER    40      0.556    0.       0.152    0.       0.280    0.500    0.763    0.101    0.137
  10    18.000   27    OUTER    40      0.556    0.       0.152    0.       0.432    0.500    0.763    0.101    0.137
  11    19.500    0             -0      0.       0.       0.       0.       0.432    0.500    0.763    0.101    0.137
  12    21.000   44    INNER     1      0.       0.061    0.       0.109    0.432    0.609    0.763    0.101    0.137
  13    21.000   44    OUTER     1      0.       0.080    0.       0.141    0.432    0.750    0.763    0.101    0.137
  14    22.500    0             -0      0.       0.       0.       0.       0.432    0.750    0.814    0.079    0.108
  15    24.000   27    INNER    75      1.042    0.       0.284    0.       0.716    0.750    0.814    0.079    0.108
  16    24.000   27    OUTER    75      1.042    0.       0.284    0.       1.000    0.750    0.814    0.079    0.108
  17    27.000   44    INNER     1      0.       0.061    0.       0.107    1.000    0.857    0.814    0.079    0.108
  18    27.000   44    OUTER     1      0.       0.081    0.       0.143    1.000    1.000    0.814    0.079    0.103
  19    32.700    0             -0      0.       0.       0.       0.       1.000    1.000    0.675    0.057    0.269

TOTAL COOLING PORT AREA IN THE FLAME-TUBE WALL     = 0.565 SQ FT
TOTAL PENETRATION PORT AREA IN THE FLAME-TUBE WALL = 3.501 SQ FT
```

```
RATIO OF TOTAL HOLE AREA (INCLUDING SWIRLER, DOME HOLES,
COOLING SLOTS, AND PENETRATION HOLES) TO REFERENCE AREA  =  .964

THERE ARE NO JET-ANGLE DATA FOR HOLE TYPE NO.  75.  THE INITIAL JET-ANGLE ESTIMATE USED IN THE PROGRAM IS NOT AT ALL
ACCURATE FOR SCOOPS.




MISCELLANEOUS DATA - DIFFUSER SECTION
-------------------------------------
THE DIFFUSER SECTION CONTAINS A SNOUT
INPUT POINT  7 IS THE LAST STATION BEFORE THE SNOUT
DIFFUSION IS CONSIDERED TO END AT INPUT POINT NUMBER 14 IN THE INNER ANNULUS
DIFFUSION IS CONSIDERED TO END AT INPUT POINT NUMBER 14 IN THE OUTER ANNULUS
THE EMPIRICAL DATA TO BE USED BEFORE THE SNOUT IS SET NUMBER  1
THE EMPIRICAL DATA TO BE USED  AFTER THE SNOUT IS SET NUMBER  1




MISCELLANEOUS DATA - AIRFLOW SECTION
------------------------------------
HOLE ROW NUMBER  1 IS THE FIRST HOLE ROW IN THE FLAME-TUBE WALL, AS DISTINCT FROM THE DOME
HOLE ROW NUMBER  3 IS CONSIDERED TO MARK THE END OF THE PRIMARY ZONE (WHICH IS CONSIDERED AS A STIRRED REACTOR)
THE FRACTION OF AIR FLOWING THROUGH THE SECONDARY HOLES THAT RECIRCULATES
INTO THE PRIMARY ZONE IS WORKED OUT IN THE PROGRAM
THE FLOW RESISTANCE IN THE SNOUT IS  0.    VELOCITY HEADS (BASED ON CONDITIONS IN THE SNOUT LIP)
FRACTION OF INLET AIR BYPASSING COMBUSTOR
                                          INNER ANNULUS  0.010
                                          OUTER ANNULUS  0.030
AXIAL POSITION AT WHICH THIS OCCURS
                                          INNER ANNULUS 32.800 IN
                                          OUTER ANNULUS 32.800 IN
FUEL DATA
      LOWER HEATING VALUE    18560.0 BTU PER LBM
      HYDROGEN/CARBON RATIO    0.170




MISCELLANEOUS DATA - HEAT TRANSFER SECTION
------------------------------------------
FLAME TUBE WALL THICKNESS................  0.060 IN
THERMAL CONDUCTIVITY OF WALL MATERIAL...  15.00 BTU PER FT HR DEG F
ABSORPTIVITY OF FLAMETUBE WALL..........  0.350
EMISSIVITY OF FLAMETUBE WALL............  0.850
EMISSIVITY OF OUTER CASING..............  0.800
THE CASING TEMPERATURE IS NOT SPECIFIED
FILM COOLING CAN BE USED
TRANSPIRATION COOLING IS NOT USED
```

```
CASES CONSIDERED IN THIS RUN
----------------------------
 1 CASES ARE TO BE CONSIDERED
PROGRAM ROUTING IS  ALTERED FROM CASE TO CASE
```

```
                    * * * * * * * * * * * * * * CASE NO. 1 * * * * * * * * * * * * * *


INLET FLOW CONDITIONS
---------------------

TOTAL TEMPERATURE AT COMPRESSOR DISCHARGE =  1150.000 DEG F
TOTAL PRESSURE AT COMPRESSOR DISCHARGE    =    90.000 PSIA
AIR FLOW RATE AT COMPRESSOR DISCHARGE     =    96.000 LBM PER SEC
OVERALL FUEL-AIR RATIO                    =     0.018




DIFFUSER INPUT DATA
-------------------

INITIAL SHAPE FACTORS
        INNER WALL                            1.400
        OUTER WALL                            1.400
INLET BOUNDARY LAYER BLOCKAGE              =  0.006
FRACTION OF INLET BLOCKAGE ON INNER WALL   =  0.500
NUMBER OF STREAM TUBES TO BE CONSIDERED    =    7


                         FIRST ESTIMATE OF BLOCKAGE AT DOWNSTREAM POINTS

                            AXIAL DISTANCE INCHES          BLOCKAGE

                                    0.                      0.006
                                    0.500                   0.010
                                    1.000                   0.010
                                    1.500                   0.010
                                    2.000                   0.010
                                    2.500                   0.010
                                    2.800                   0.010


                                     INLET VELOCITY PROFILE

              FRACTIONAL DISTANCE ACROSS INLET PLANE          VELOCITY (NONDIMENSIONALIZED
                  (MEASURED FROM INNER WALL)                  WITH AN ARBITRARY VELOCITY)

                          0.100                                        0.850
                          0.200                                        0.900
                          0.300                                        1.000
                          0.500                                        0.900
                          0.600                                        0.900
                          0.800                                        0.900
                          0.900                                        0.850
```

```
FUEL BURNING RATE AND CASING TEMPERATURE AT CALCULATION POINTS
--------------------------------------------------------------

CALCULATION    AXIAL       CUMULATIVE   FUEL BURNING    CASING TEMPERATURE
POINT          POSITION    FRACTION     RATE                  DEG F
NUMBER         IN          FUEL BURNT   LBM PER SEC      INNER     OUTER
    1            9.000       0.100         0.173         1150.0    1150.0
    2            9.500       0.183         0.144         1150.0    1150.0
    3           10.000       0.267         0.144         1150.0    1150.0
    4           10.500       0.350         0.144         1150.0    1150.0
    5           11.000       0.433         0.144         1150.0    1150.0
    6           11.625       0.537         0.160         1150.0    1150.0
    7           13.500       0.700         0.281         1150.0    1150.0
    8           15.000       0.800         0.173         1150.0    1150.0
    9           15.500       0.817         0.029         1150.0    1150.0
   10           16.000       0.833         0.029         1150.0    1150.0
   11           16.500       0.850         0.029         1150.0    1150.0
   12           17.000       0.867         0.029         1150.0    1150.0
   13           19.500       0.950         0.144         1150.0    1150.0
   14           21.000       0.950         0.            1150.0    1150.0
   15           21.500       0.950         0.            1150.0    1150.0
   16           22.000       0.950         0.            1150.0    1150.0
   17           22.500       0.950         0.            1150.0    1150.0
   18           23.000       0.950         0.            1150.0    1150.0
   19           27.000       0.950         0.            1150.0    1150.0
   20           27.500       0.950         0.            1150.0    1150.0
   21           28.000       0.950         0.            1150.0    1150.0
   22           28.500       0.950         0.            1150.0    1150.0
   23           29.000       0.950         0.            1150.0    1150.0
   24           32.700       0.950         0.            1150.0    1150.0
   25           32.800       0.950         0.            1150.0    1150.0



ROUTING THROUGH THE PROGRAM
---------------------------

THE EQUIVALENT ENTRAINMENT MODEL IS USED TO REPRESENT JET MIXING WITH A CONSTANT OF 1.000 FOR PENETRATION JETS
AND 0.200 FOR WALL JETS
HEAT TRANSFER TO ANNULUS AIR IS NOT CONSIDERED
THE FLAME IS ASSUMED TO BE LUMINOUS.            THE LEFEBVRE CORRELATION IS USED
THE BASIC HEAT TRANSFER CALCULATION SOLVES FOR A MODEL WITH  COOLED  FLAME-TUBE WALLS AND 1-DIMENSIONAL
RADIATION TRANSFER FROM THE FLAME
NO CORRECTIONS ARE MADE TO THE BASIC HEAT TRANSFER CALCULATION
THE    STREAMTUBE    METHOD IS USED TO CALCULATE DIFFUSER PERFORMANCE FROM THE DIFFUSER INLET TO THE SNOUT
THEMIXING EQUATION METHOD IS USED TO CALCULATE THE DIFFUSER PERFORMANCE IN THE PASSAGES BETWEEN SNOUT AND OUTER CASING
IF EMPIRICAL DATA ARE USED TO CALCULATE THE DIFFUSER  EFFECTIVENESS, THESE DATA ARE TAKEN FROM THE LIBRARY TAPE
```

```
REFERENCE CONDITIONS
--------------------

REFERENCE AREA               =     4.389 SQ FT
REFERENCE VELOCITY           =     145.2 FT PER SEC
INLET MACH NUMBER            =     0.287
REFERENCE MACH NUMBER        =     0.074
REFERENCE DYNAMIC PRESSURE   =      0.34 PSI




DIFFUSER PARAMETERS - COMPRESSOR OUTLET TO THE LIP OF THE SNOUT
----------------------------------------------------------------
IN THIS PART OF THE DIFFUSER A STREAMTUBE ANALYSIS IS USED


                                                DIFFUSER PERFORMANCE

NO MIXING AT OUTLET
          IDEAL PRESSURE RECOVERY COEFF. = 0.716
          PRESSURE RECOVERY COEFF.       = 0.540
          DIFFUSER EFFECTIVENESS         = 0.755
          FRACTIONAL TOTAL PRESSURE LOSS = 0.000


                                            VELOCITY PROFILE AT EXIT OF DIFFUSER

FRACTIONAL ANNULUS HEIGHT......  0.114   0.191   0.268   0.345   0.423   0.500   0.577   0.655   0.732   0.809   0.886
HEIGHT ALLOWING FOR BLOCKAGE...  0.      0.100   0.200   0.300   0.400   0.500   0.600   0.700   0.800   0.900   1.000
VELOCITY, FT PER SEC...........  284.40  328.59  373.06  429.31  472.42  375.84  380.03  382.61  380.20  336.13  285.03


                                       BOUNDARY LAYER PROPERTIES - SOLUTION HAS CONVERGED

                                           INNER WALL                      OUTER WALL
STATION    X(I)     PRESSURE       DELTA   THETA    H            DELTA   THETA    H          AN. AREA    FRACTIONAL    STATION
NUMBER     IN       PSIA           IN      IN                    IN      IN                  SQ IN       BLOCKAGE      NUMBER

   1       0.       84.902         0.005   0.004   1.400         0.005   0.003   1.400       171.495     0.0062          1
   2       0.500    85.994         0.012   0.008   1.587         0.011   0.007   1.575       192.831     0.0174          2
   3       1.000    87.006         0.029   0.016   1.812         0.027   0.015   1.735       224.969     0.0256          3
   4       1.500    87.413         0.042   0.024   1.780         0.040   0.023   1.769       246.355     0.0342          4
   5       2.000    87.440     **  0.083   0.039   2.151**   **  0.080   0.038   2.137**     278.533     0.0605          5
   6       2.500    87.531         0.253   0.030   3.500         0.252   0.029   3.500       299.955     0.1734          6
   7       2.800    87.585         0.358   0.030   3.500         0.357   0.029   3.500       321.395     0.2274          7
SEPARATION IF IT OCCURS IS INDICATED BY **......**
```

```
DIFFUSER PARAMETERS - INNER DIFFUSING PASSAGE BETWEEN SNOUT AND CASING
----------------------------------------------------------------------
IN THIS PART OF THE DIFFUSER THE PERFORMANCE IS CALCULATED USING THE MIXING EQUATION


                                                      DIFFUSER PERFORMANCE

FLOW ALLOWED TO MIX AT OUTLET
          IDEAL PRESSURE RECOVERY COEFF. =-0.190  (INCLUDING MIXING EFFECTS)
          PRESSURE RECOVERY COEFF.       =-0.275
          DIFFUSER EFFECTIVENESS         = 1.445
          FRACTIONAL TOTAL PRESSURE LOSS = 0.007  (BASED ON MEAN CONDITIONS AT COMPRESSOR OUTLET)
THIS SECTION HAS AN AREA RATIO LESS THAN ONE AND ACTS AS A NOZZLE AND NOT AS A DIFFUSER
THE VALUE PRINTED OUT AS THE DIFFUSER EFFECTIVENESS IS NOT AN INDICATION OF HOW WELL THE SECTION PERFORMS
MISMATCH AT THE SNOUT IS CHARACTERISED BY THE RATIO -
(TOTAL STREAMTUBE AREA JUST BEFORE THE SNOUT)/(FLOW AREA JUST INSIDE THE SNOUT). THIS RATIO IS  1.356
AS THIS RATIO IS OUTSIDE THE RANGE 0.85-1.15 THE FLOW SPLIT ON THE SNOUT IS NOT WELL MATCHED




DIFFUSER PARAMETERS - OUTER DIFFUSING PASSAGE BETWEEN SNOUT AND CASING
----------------------------------------------------------------------
IN THIS PART OF THE DIFFUSER THE PERFORMANCE IS CALCULATED USING THE MIXING EQUATION


                                                      DIFFUSER PERFORMANCE

FLOW ALLOWED TO MIX AT OUTLET
          IDEAL PRESSURE RECOVERY COEFF. =-0.114  (INCLUDING MIXING EFFECTS)
          PRESSURE RECOVERY COEFF.       =-0.364
          DIFFUSER EFFECTIVENESS         = 3.191
          FRACTIONAL TOTAL PRESSURE LOSS = 0.015  (BASED ON MEAN CONDITIONS AT COMPRESSOR OUTLET)
THIS SECTION HAS AN AREA RATIO LESS THAN ONE AND ACTS AS A NOZZLE AND NOT AS A DIFFUSER
THE VALUE PRINTED OUT AS THE DIFFUSER EFFECTIVENESS IS NOT AN INDICATION OF HOW WELL THE SECTION PERFORMS
MISMATCH AT THE SNOUT IS CHARACTERISED BY THE RATIO -
(TOTAL STREAMTUBE AREA JUST BEFORE THE SNOUT)/(FLOW AREA JUST INSIDE THE SNOUT). THIS RATIO IS  1.496
AS THIS RATIO IS OUTSIDE THE RANGE 0.85-1.15 THE FLOW SPLIT ON THE SNOUT IS NOT WELL MATCHED




AERODYNAMIC PARAMETERS AT EACH CALCULATION POINT
------------------------------------------------

AXIAL       TOTAL    TOTAL PRESSURE        STATIC PRESSURE        BULK VELOCITY        MACH NUMBER       ACCUMULATED PRESSURE
POSITION    TEMPER        PSIA                  PSIA               FT PER SEC                            LOSS IN ANNULI PSI
FROM        -ATURE
COMPRESSOR  IN        ANNULI      FLAME     ANNULI      FLAME     ANNULI    FLAME    ANNULI     FLAME    DUE TO       DUE TO
```

```
DISCHARGE  FLAME                      TUBE                    TUBE                    TUBE                 TUBE  FRICTION AND EXPANSION
INCHES     TUBE   INNER  OUTER                INNER  OUTER               INNER OUTER            INNER OUTER      HEAT ADDITION
           DEG F                                                                                                INNER OUTER INNER OUTER
           STATIC
           TEMP IN
           ANNULUS
           DEG F
       INNER OUTER

   9.000   3758.7  89.36  88.66  85.56  86.23  86.21  85.49 443.1 392.8 111.7 0.227 0.201 0.036  0.    0.    0.    0.
       1133.6 1137.1
   9.500   3758.7  89.35  88.65  85.56  86.12  86.15  85.49 445.7 396.9 111.7 0.230 0.203 0.036  0.01  0.01  0.    0.
       1133.1 1136.8
  10.000   3758.7  89.31  88.64  85.56  86.01  86.08  85.49 456.3 401.1 111.7 0.233 0.205 0.036  0.03  0.02  0.    0.
       1132.6 1136.6
  10.500   3758.7  89.32  88.63  85.56  85.90  86.02  85.49 462.9 405.3 111.7 0.237 0.207 0.036  0.04  0.03  0.    0.
       1132.2 1136.3
  11.000   3758.7  89.31  88.62  85.56  85.80  85.96  85.49 469.5 409.4 111.7 0.240 0.209 0.036  0.05  0.04  0.    0.
       1131.7 1136.1
  11.625   3758.6  89.30  88.61  85.56  85.66  85.88  85.49 477.7 414.6 111.7 0.244 0.212 0.036  0.06  0.05  0.    0.
       1131.2 1135.8
  13.500   4027.3  89.15  88.52  85.38  86.58  86.42  85.27 401.5 363.8 139.9 0.205 0.186 0.044  0.12  0.10  0.09  0.04
       1136.8 1139.1
  15.000   3852.3  89.11  88.48  85.49  86.51  86.38  85.34 401.7 363.9 162.6 0.205 0.186 0.052  0.16  0.13  0.09  0.04
       1136.8 1139.1
  15.500   3861.4  89.12  88.49  85.50  86.07  86.09  85.36 437.4 389.0 155.5 0.224 0.199 0.051  0.15  0.13  0.09  0.04
       1134.5 1137.7
  16.000   3898.4  89.09  88.47  85.50  86.05  86.07  85.35 437.5 389.0 161.7 0.224 0.199 0.051  0.17  0.15  0.09  0.04
       1134.5 1137.6
  16.500   3934.3  89.07  88.45  85.50  86.03  86.05  85.35 437.6 389.1 163.4 0.224 0.199 0.052  0.20  0.16  0.09  0.04
       1134.5 1137.6
  17.000   3994.3  89.05  88.44  85.50  86.00  86.04  85.34 437.7 389.2 164.4 0.224 0.199 0.052  0.22  0.18  0.09  0.04
       1134.5 1137.6
  19.500   3984.4  88.85  88.30  85.50  86.89  86.71  85.30 351.6 316.5 188.5 0.175 0.161 0.059  0.28  0.24  0.21  0.12
       1140.2 1141.9
  21.000   3649.1  88.87  88.26  85.61  86.85  86.67  85.37 351.7 316.6 199.8 0.179 0.161 0.065  0.33  0.27  0.21  0.12
       1140.2 1141.9
  21.500   3366.4  88.83  88.27  85.72  86.48  86.45  85.45 384.2 338.4 203.9 0.196 0.173 0.069  0.32  0.27  0.21  0.12
       1138.4 1140.8
  22.000   3343.1  88.81  88.25  85.73  86.46  86.43  85.46 384.3 338.5 206.4 0.196 0.173 0.069  0.34  0.29  0.21  0.12
       1138.4 1140.8
  22.500   3335.3  88.79  88.23  85.74  86.44  86.42  85.46 384.4 338.6 204.7 0.196 0.173 0.070  0.36  0.30  0.21  0.12
       1138.4 1140.8
  23.000   3333.9  88.77  88.21  85.74  86.42  86.40  85.46 384.5 338.7 204.8 0.196 0.173 0.070  0.38  0.32  0.21  0.12
       1138.4 1140.8
  27.000   2662.1  87.20  87.24  85.91  87.12  87.11  85.32  71.3  92.7 272.8 0.036 0.047 0.107  0.39  0.33  1.78  1.09
       1150.3 1149.7
  27.500   2387.3  87.17  87.22  86.13  87.15  87.16  85.44  35.2  61.0 275.4 0.018 0.031 0.110  0.41  0.35  1.79  1.09
       1150.5 1150.0
  28.000   2367.0  87.17  87.22  86.15  87.15  87.16  85.45  35.2  61.0 280.7 0.018 0.031 0.111  0.41  0.36  1.79  1.09
       1150.5 1150.0
  28.500   2364.2  87.17  87.22  86.15  87.15  87.16  85.45  35.2  61.0 280.9 0.018 0.031 0.111  0.41  0.36  1.78  1.09
       1150.6 1150.0
  29.000   2362.9  87.17  87.21  86.15  87.15  87.16  85.45  35.2  61.0 281.0 0.018 0.031 0.111  0.42  0.36  1.78  1.09
       1150.6 1150.0
  32.700   2321.6  87.16  87.21  86.22  87.15  87.20  85.00  35.2  17.9 368.9 0.018 0.009 0.147  0.42  0.36  1.78  1.09
       1150.6 1150.3
  32.800   2311.1  87.15  87.21  86.22  87.15  87.21  85.00   8.9   1.2 368.8 0.005 0.001 0.147  0.43  0.37  1.78  1.09
       1150.7 1173.9
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COMBUSTOR TOTAL-PRESSURE LOSS COEFFT FOR INNER ANNULUS  = 5.1507 (RELATIVE TO REFERENCE DYNAMIC PRESSURE)

COMBUSTOR TOTAL-PRESSURE LOSS COEFFT FOR OUTER ANNULUS  = 7.1072

TOTAL-PRESSURE LOSS FACTOR FOR COMBINED DIFFUSER AND COMBUSTOR  = 0.0420 (RELATIVE TO COMPRESSOR DELIVERY PRESSURE)

COMBUSTOR TOTAL-PRESSURE LOSS FACTOR FOR INNER ANNULUS  = 0.0349

COMBUSTOR TOTAL-PRESSURE LOSS FACTOR FOR OUTER ANNULUS  = 0.0271

EXPANSION TOTAL-PRESSURE LOSS FACTOR FOR INNER ANNULUS  = 0.0198

EXPANSION TOTAL-PRESSURE LOSS FACTOR FOR OUTER ANNULUS  = 0.0121

PRESSURE-LOSS FACTOR DUE TO FRICTION AND HEAT ADDITION FOR INNER ANNULUS  = 0.0048

PRESSURE-LOSS FACTOR DUE TO FRICTION AND HEAT ADDITION FOR OUTER ANNULUS  = 0.0041



MISCELLANEOUS QUANTITIES
------------------------

 AXIAL POSITION      RATE OF BURNING      FRICTION FACTOR
FROM COMPRESSOR         OF FUEL              IN ANNULI
   DISCHARGE         LBM PER SEC PER
     INCHES        FT AXIAL DISTANCE      INNER     OUTER

     9.000              3.456           0.00466   0.00472
     9.500              3.456           0.00466   0.00472
    10.000              3.456           0.00466   0.00472
    10.500              3.456           0.00466   0.00472
    11.000              3.456           0.00466   0.00472
    11.625              1.797           0.00470   0.00478
    13.500              1.382           0.00479   0.00485
    15.000              0.691           0.00479   0.00485
    15.500              0.691           0.00485   0.00492
    16.000              0.691           0.00485   0.00492
    16.500              0.691           0.00485   0.00492
    17.000              0.691           0.00495   0.00492
    19.500              0.              0.00498   0.00505
    21.000              0.              0.00498   0.00505
    21.500              0.              0.00508   0.00517
    22.000              0.              0.00508   0.00517
    22.500              0.              0.00508   0.00517
    23.000              0.              0.00508   0.00517
    27.000              0.              0.00671   0.00637
    27.500              0.              0.00843   0.00741
    28.000              0.              0.00843   0.00741
    28.500              0.              0.00843   0.00741
    29.000              0.              0.00843   0.00741
    32.750              0.              0.00843   0.00737
    32.800              0.              0.00843   0.00737
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QUANTITIES RELATED TO FLOW THROUGH HOLES
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HOLE ROW  AXIAL      HOLE  INNER  NUMBER  HOLE    DISCHARGE COEFFICIENTS   EFFECT  INITIAL  INITIAL  FRACTION  ACCUM-
NUMBER    POSITION   TYPE  OR     IN      PRESS                             -IVE    JET      JET VEL  OF        ULATED
          FROM COM         OUTER  THIS    -URE    CORRECT RATIO    ACTUAL   HOLE    ANGLE    -OCITY   CURRENT   FRACTION
          -PRESSOR         WALL   HOLE    LOSS    -ED     OF                AREA    DEGREES  FT PER   ANNULUS   OF INLET
          DISCHARGE               ROW     FACTOR          ACTUAL            SQ FT            SEC      AIR FLOW  AIR IN
          INCHES                                          TO COR                                      THROUGH   FLAME
                                                          RECTED                                      HOLES     TUBE

    1       9.000     44    1        1     1.25   0.921   1.002    0.923    0.575   -0.       486.22   0.093     0.102
    2       9.000     44    2        1     1.25   0.932   1.002    0.934    0.581   -0.       439.73   0.102     0.154
    3      12.000     75    1       50     1.11   0.534   1.000    0.534    0.092   90.00     487.19   0.154     0.214
    4      12.000     75    2       50     1.11   0.535   1.001    0.536    0.082   90.00     436.09   0.119     0.268
    5      13.500      0   -0       -0     0.     0.      -0.      -0.000   0.      -0.         0.     -0.000     0.268
    6      15.000     44    1        1     1.53   0.836   1.004    0.839    0.521    0.       477.75   0.111     0.305
    7      15.000     44    2        1     1.53   0.836   1.003    0.839    0.521    0.       459.90   0.119     0.353
    8      16.500      0   -0       -0     0.     0.      -0.      -0.000   0.      -0.         0.     -0.000     0.353
    9      18.000     27    1       40     1.29   0.136   1.011    0.138    0.077   28.27     442.75   0.121     0.405
   10      18.000     27    2       40     1.29   0.172   1.009    0.174    0.097   32.18     441.72   0.183     0.473
   11      19.500      0   -0       -0     0.     0.      -0.      -0.000   0.      -0.         0.     -0.000     0.473
   12      21.000     44    1        1     1.87   0.836   1.005    0.840    0.521    0.       457.67   0.149     0.509
   13      21.000     44    2        1     1.87   0.836   1.004    0.840    0.520    0.       465.00   0.158     0.555
   14      22.500      0   -0       -0     0.     0.      -0.      -0.000   0.      -0.         0.     -0.000     0.555
   15      24.000     27    1       75     1.52   0.225   1.010    0.227    0.237   37.48     456.43   0.914     0.719
   16      24.000     27    2       75     1.52   0.265   1.008    0.268    0.279   41.36     417.28   0.726     0.896
   17      27.000     44    1        1    13.14   0.812   1.005    0.816    0.505   -0.       322.33   0.643     0.920
   18      27.000     44    2        1    13.14   0.814   1.005    0.818    0.506    0.       361.23   0.519     0.954
   19      32.700      0   -0       -0     0.     0.      -0.      -0.000   0.      -0.         0.     -0.000     0.954



SECONDARY HOLE FLOW SPLIT
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FRACTION OF SECONDARY HOLE AIR RECIRCULATING UPSTREAM FOR INNER WALL =.3071

FRACTION OF SECONDARY HOLE AIR RECIRCULATING UPSTREAM FOR OUTER WALL =.3075



AIR MASS FLOW SPLIT
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FRACTION OF INLET AIR PASSING THROUGH SNOUT AND/OR DOME = 0.06231
FRACTION OF INLET AIR PASSING INTO INNER ANNULUS        = 0.42994
FRACTION OF INLET AIR PASSING INTO OUTER ANNULUS        = 0.50775
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DIMENSIONLESS GROUPS ASSOCIATED WITH HEAT TRANSFER
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AXIAL               REYNOLDS NUMBER                      PRANDTL NUMBER            NUSSELT NUMBER
POSITION
FROM                ANNULI                  FLAME          ANNULI     FLAME          ANNULI      FLAME
COMPRESSOR                                  TUBE                      TUBE                       TUBE
DISCHARGE     INNER          OUTER                     INNER  OUTER             INNER   OUTER
INCHES

   9.000   0.41[illegible]E 06   0.365E 06   0.206E 06     0.691  0.691  0.689     617.11  558.69  353.82
   9.500   0.419E 06   0.363E 06   0.206E 06     0.691  0.691  0.689     619.73  557.02  353.82
  10.000   0.419E 06   0.365E 06   0.206E 06     0.691  0.691  0.689     619.81  557.06  353.82
  10.500   0.4[illegible]5E 06   0.364E 06   0.206E 06     0.691  0.691  0.689     619.85  557.10  353.82
  11.000   0.416E 06   0.364E 06   0.206E 06     0.691  0.691  0.689     619.97  557.14  353.82
  11.625   0.377E 06   0.327E 06   0.206E 06     0.691  0.691  0.689     573.54  511.30  353.82
  13.500   0.318E 06   0.287E 06   0.118E 06     0.691  0.691  0.685     501.08  461.56  226.20
  15.000   0.318E 06   0.287E 06   0.122E 06     0.691  0.691  0.688     501.08  461.56  231.60
  15.500   0.285E 06   0.252E 06   0.160E 06     0.691  0.691  0.689     458.11  416.11  287.92
  16.000   0.285E 06   0.252E 06   0.159E 06     0.691  0.691  0.687     458.11  416.11  286.48
  16.500   0.285E 06   0.252E 06   0.158E 06     0.691  0.691  0.686     458.11  416.11  285.10
  1[illegible].000   0.209E 06   0.2[illegible]E 06   0.146E 06     0.691  0.691  0.685     458.11  416.11  282.81
  1[illegible].500   0.230E 06   0.2[illegible]E 06   0.2[illegible]E 06     0.691  0.691  0.685     385.88  353.64  [illegible]8.90
  21.000   0.230E 06   0.2[illegible]E 06   0.[illegible] 06     0.691  0.691  0.691     385.88  353.64  375.29
  21.500   0.197E 06   0.[illegible]73E 06   [illegible] 06     0.691  0.691  0.694     340.79  307.22  443.78
  22.000   0.197E 06   [illegible]73E [illegible]   [illegible] 06     0.691  0.691  0.694     340.79  307.22  444.77
  22.500   0.197E 06   [illegible]   [illegible] 06     0.691  0.691  0.694     340.79  307.22  445.77
  23.000   0.197E 06   [illegible]   [illegible] 06     0.691  0.691  0.694     340.79  307.22  445.36
  27.000   0.36[illegible] 05   0.[illegible] [illegible]   0.[illegible] [illegible]     0.691  0.691  0.699      88.76  108.92  724.19
  27.500   0.13[illegible] 05   0.[illegible] [illegible]   0.[illegible] [illegible]     0.691  0.691  0.700      38.89   60.45  797.51
  28.000   0.13[illegible] 05   0.[illegible] 06   0.5[illegible] [illegible]     0.691  0.691  0.700      38.89   60.45  800.29
  28.500   0.130E 05   0.2[illegible] 05   0.56[illegible] [illegible]     0.691  0.691  0.700      38.89   60.45  800.67
  29.000   0.130E 05   0.226E 05   0.568E 06     0.691  0.691  0.700      38.89   60.45  800.85
  [illegible].700   0.130E 05   0.237E 05   0.598E 06     0.691  0.691  0.700      38.89   61.69  826.56
  [illegible].800   0.[illegible]E 04   0.19[illegible] [illegible]   0.59[illegible] [illegible]     0.[illegible]  0.692  0.700      12.92    7.01  828.06


HEAT TRANSFER RATES
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AXIAL            HEAT TRANSFER RATE              HEAT TRANSFER RATE             RADIATION        HEAT TRANSFERRED
POSITION         FROM FLAME TO WALL              FROM WALL TO ANNULI            INTERCHANGE      TO TRANSPIRATION
FROM             BTU PER SQ FT SEC               BTU PER SQ FT SEC              FROM OPPOSITE    AIR IN THE WALL
COMPRESSOR                                                                      WALL BTU PER     BTU PER SEC PER
DISCHARGE      RADIATION      CONVECTION       RADIATION      CONVECTION         SQ FT SEC      SQ FT WALL SURFACE
INCHES
             INNER   OUTER   INNER   OUTER    INNER   OUTER   INNER   OUTER     INNER   OUTER     INNER   OUTER

   9.000    36.086  35.461  19.200  18.676   15.264  16.483  40.306  37.551     0.      0.        0.      0.
   9.500    42.241  41.779  -1.766  -2.314    7.922   8.681  32.777  31.031     0.      0.        0.      0.
  10.000    41.962  41.476  -0.213  -0.767    8.285   9.082  33.693  31.888     0.      0.        0.      0.
  10.500    41.697  41.188   1.248   0.724    8.632   9.475  34.547  32.703     0.      0.        0.      0.
  11.000    41.291  40.711   3.689   3.152    9.279  10.131  35.960  34.015     0.      0.        0.      0.
  11.625    40.414  39.913   5.314   4.790   10.379  11.401  35.632  33.413     0.      0.        0.      0.
  13.500    49.317  48.920   5.637   5.340   15.937  17.016  39.340  37.479     0.      0.        0.      0.
  15.000    42.545  42.170   6.551   6.274   13.465  14.426  35.912  34.309     0.      0.        0.      0.
  15.500    46.529  46.146  -2.644  -3.039   10.155  11.020  34.048  32.347     0.      0.        0.      0.
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   16.000        47.727 47.302   -1.409 -1.819      10.976 11.927   35.604 33.831       0.        0.           0.        0.
   16.500        49.011 48.564   -0.755 -1.170      11.669 12.675   36.861 35.004       0.        0.           0.        0.
   17.000        51.031 50.525    1.143  0.750      13.120 14.250   39.350 37.334       0.        0.           0.        0.
   19.500        47.872 47.493    6.829  6.420      17.013 18.195   38.077 36.072       0.        0.           0.        0.
   21.000        35.657 35.414    8.043  7.684      12.217 13.118   31.746 30.245       0.        0.           0.        0.
   21.500        30.259 30.152   -1.958 -2.402       5.770  6.313   22.709 21.632       0.        0.           0.        0.
   22.000        29.322 29.207   -0.507 -0.943       5.915  6.474   23.078 21.584       0.        0.           0.        0.
   22.500        28.958 28.836    0.267 -0.166       6.033  6.604   23.373 22.263       0.        0.           0.        0.
   23.000        28.682 28.545    1.545  1.109       6.324  6.922   24.089 22.935       0.        0.           0.        0.
   27.000        10.035 10.564    4.316  4.029       7.586  7.240    6.914  8.290       0.        0.           0.        0.
   27.500         8.494  8.981   -4.041 -4.050       2.571  2.259    1.968  2.770       0.        0.           0.        0.
   28.000         7.942  8.428   -2.944 -2.858       2.920  2.593    2.168  3.083       0.        0.           0.        0.
   28.500         7.749  8.238   -2.390 -2.253       3.154  2.815    2.297  3.282       0.        0.           0.        0.
   29.000         7.623  8.115   -2.013 -1.841       3.318  2.971    2.385  3.418       0.        0.           0.        0.
   32.700         6.074  6.371    0.834 -0.706       4.710  4.429    2.830  1.330       0.        0.           0.        0.
   32.800         5.636  6.027    0.069 -1.198       4.775  4.812    1.027  0.155       0.        0.           0.        0.
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HEAT TRANSFER PARAMETERS
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AXIAL         EMISSIVITY    FLAME             FILM-COOLING                      WALL TEMPERATURES
POSITION      OF FLAME      INTENSITY         EFFECTIVENESS                          DEG F
FROM                        BTU PER
COMPRESSOR                  SQ FT SEC                                       ADIABATIC          ACTUAL
DISCHARGE
INCHES                                    INNER WALL  OUTER WALL        INNER   OUTER     INNER   OUTER

   9.000         0.379        57.506      0.          0.                3761.6  3765.2    2226.6  2272.2
   9.500         0.390        59.186      0.789       0.788             1733.6  1729.0    1885.6  1928.2
  10.000         0.390        59.186      0.729       0.728             1887.9  1883.7    1906.3  1949.8
  10.500         0.390        59.186      0.672       0.671             2033.0  2032.7    1925.5  1970.4
  11.000         0.390        59.186      0.578       0.577             2275.1  2275.0    1957.5  2003.6
  11.625         0.390        59.186      0.501       0.500             2473.4  2473.5    2015.9  2064.5
  13.500         0.381        74.144      0.377       0.376             2961.5  2963.5    2252.0  2291.4
  15.000         0.387        64.064      0.323       0.323             2996.3  2999.8    2154.8  2193.9
  15.500         0.397        66.322      0.803       0.802             1712.8  1711.0    2004.8  2046.7
  16.000         0.396        68.443      0.741       0.740             1889.7  1888.5    2044.6  2088.4
  16.500         0.395        70.547      0.706       0.706             1994.1  1993.3    2076.7  2121.4
  17.000         0.393        74.167      0.616       0.615             2264.7  2268.4    2140.4  2186.9
  19.500         0.393        73.509      0.397       0.396             2878.7  2884.7    2291.3  2332.5
  21.000         0.403        55.067      0.339       0.338             2820.6  2827.7    2101.1  2140.3
  21.500         0.423        43.391      0.816       0.816             1580.2  1578.0    1750.4  1786.9
  22.000         0.424        42.424      0.752       0.752             1716.1  1715.1    1760.4  1797.4
  22.500         0.424        42.103      0.716       0.716             1791.6  1791.2    1768.3  1805.7
  23.000         0.424        42.042      0.656       0.656             1922.5  1922.6    1787.6  1825.8
  27.000         0.446        20.217      0.355       0.355             2145.3  2157.2    1866.1  1845.3
  27.500         0.464        14.532      0.951       0.978             1213.2  1180.3    1486.8  1454.5
  28.000         0.465        14.137      0.863       0.886             1321.1  1294.5    1521.0  1489.0
  28.500         0.465        14.078      0.814       0.836             1380.6  1357.9    1543.0  1510.9
  29.000         0.465        14.051      0.781       0.801             1421.2  1400.8    1558.0  1525.9
  32.700         0.429        12.153      0.561       0.628             1679.0  1613.8    1634.2  1651.7
  32.800         0.429        11.974      0.554       0.620             1682.3  1619.2    1678.6  1681.4
```

APPENDIX IV

PROGRAM LISTING

```
$IBFTC CLAR    LIST
C                                                                       CLAR0010
C       P R O G R A M   F O R   T H E   A N A L Y S I S   O F   A N     CLAR0020
C                   A N N U L A R   C O M B U S T O R                   CLAR0030
C                                                                       CLAR0040
C PROGRAM CLARE. THIS IS THE MAIN PROGRAM. IT READS IN DATA, WORKS OUT  CLAR0050
C      REFERENCE QUANTITIES, AND DIRECTS CONTROL THROUGH THE SUBROUTINES CLAR0060
C      IN THE APPROPRIATE SEQUENCE.                                     CLAR0070
C                                                                       CLAR0080
C      THIS PROGRAM CONTAINS THE FOLLOWING COMMON BLOCKS                 CLAR0090
C      B3, B12, B13, B126, B168, B178, B12678                           CLAR0100
                                                                        CLAR0110
      COMMON/B3/M,NCASE,INPUT,ITAPE,FGIZ(45)                            CLAR0120
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 CLAR0130
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       CLAR0140
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),                       CLAR0150
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  CLAR0160
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                CLAR0170
     5XMACH,RHOREF,EFDT(3)                                              CLAR0180
      COMMON/B13/     AREA1,NXDIFC,NYDIFB,NZDIFB,NCDIFB,E1DTAB          CLAR0190
     1,XLNDTB(20),EFDTAB(200),ARDTAB(200) ,                             CLAR0200
     1NWALL1,NWALL2                                                     CLAR0210
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,         NABX(45)       CLAR0220
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   CLAR0230
     2,SHAFST,                            FIFTPR,        LCMFL,LCANILCLAR0240
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)    CLAR0250
     4,LCPTAL,PAFRZ,NHTU(50)                                            CLAR0260
     5,AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)                            CLAR0270
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,        AFA,AFB,PREDM,STAGTCLAR0280
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS                             CLAR0290
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          CLAR0300
     1,KANHET,LANHET,PERCO,THIKFT                                       CLAR0310
     2,DANA(45),DANB(45)                                                CLAR0320
      COMMON/B178/DFT(45)                                               CLAR0330
      COMMON/B12678/JTAPE ,IPRINT                                       CLAR0340
                                                                        CLAR0350
C       FORMAT STATEMENTS                                               CLAR0360
                                                                        CLAR0370
    1 FORMAT(2X7E10.3)                                                  CLAR0380
                                                                        CLAR0390
      M=1                                                               CLAR0400
      CALL INPUT1                                                       CLAR0410
      CALL INPUT2                                                       CLAR0420
      ICHNGE=0                                                          CLAR0430
      IDFLOW=1                                                          CLAR0440
      NDIFF=NDIFF-100                                                   CLAR0450
      IF(NDIFF.GE.0) GO TO 200                                          CLAR0460
      IDFLOW=0                                                          CLAR0470
      NDIFF=NDIFF+100                                                   CLAR0480
  200 IPRINU=IPRINT                                                     CLAR0490
      CALL DIFLOW                                                       CLAR0500
      IPRINT=IPRINU                                                     CLAR0510
      IF(IBL.EQ.0) GO TO 500                                            CLAR0520
C EMPIRICAL CATA REQUIRED TO CALCULATE DIFFUSER PERFORMANCE STATIONS 2-4CLAR0530
      IF(MOD(NDIFF,10).NE.2.OR.NWALL1.EQ.NWALL2)GOTO105                 CLAR0540
      I=NXDIFC                                                          CLAR0550
      IF(NXDF.GE.I) I=NXDF                                              CLAR0560
      DUM=NXDF                                                          CLAR0570
      NXDF=NXDIFC                                                       CLAR0580
      NXDIFC=DUM                                                        CLAR0590
```

```
      DO 106 J=1,I                                                      CLAR0600
      DUM=ARDTA(J)                                                      CLAR0610
      ARDTA(J)=ARDTAB(J)                                                CLAR0620
  106 ARDTAB(J)=DUM                                                     CLAR0630
      I=NYDIFB                                                          CLAR0640
      IF(NYDF.GE.I) I=NYDF                                              CLAR0650
      DUM=NYDF                                                          CLAR0660
      NYDF=NYDIFB                                                       CLAR0670
      NYDIFB=DUM                                                        CLAR0680
      DO 107 J=1,I                                                      CLAR0690
      DUM=EFDTA(J)                                                      CLAR0700
      EFDTA(J)=EFDTAB(J)                                                CLAR0710
  107 EFDTAB(J)=DUM                                                     CLAR0720
      I=NZDIFB                                                          CLAR0730
      IF(NZDF.GE.I) I=NZDF                                              CLAR0740
      DUM=NZDF                                                          CLAR0750
      NZDF=NZDIFB                                                       CLAR0760
      NZDIFB=DUM                                                        CLAR0770
      DO 108 J=1,I                                                      CLAR0780
      DUM=XLNDTA(J)                                                     CLAR0790
      XLNDTA(J)=XLNDTB(J)                                               CLAR0800
  108 XLNDTB(J)=DUM                                                     CLAR0810
      DUM=NCDF                                                          CLAR0820
      NCDF=NCDIFB                                                       CLAR0830
      NCDIFB=DUM                                                        CLAR0840
      ICHNGE=1                                                          CLAR0850
  105 KANHET=0                                                          CLAR0860
      LCMFL=0                                                           CLAR0870
      CALL AIR1                                                         CLAR0880
      FITAU=.05                                                         CLAR0890
      IF(IBL.EQ.0) GO TO 500                                            CLAR0900
      IF(LANHET.EQ.2) GO TO 400                                         CLAR0910
      CALLHEAT1                                                         CLAR0920
C                                                                       CLAR0930
C     LANHET = 1 IF HEAT TRANSFER TO ANNULUS AIR IS TO BE CONSIDERED    CLAR0940
C                                                                       CLAR0950
      IF(LANHET.NE.1)GOTO112                                            CLAR0960
      CALLAIRFLO                                                        CLAR0970
      IF(IBL.EQ.0) GO TO 500                                            CLAR0980
      CALLHEAT1                                                         CLAR0990
  112 CALLHEAT2                                                         CLAR1000
  400 IF(IDFLOW.EQ.1) CALL DIFLW2                                       CLAR1010
  500 IF(M.EQ.NCASE) STOP                                               CLAR1020
      M=M+1                                                             CLAR1030
      IF(ICHNGE.EQ.0) GO TO 600                                         CLAR1040
      I=NXDIFC                                                          CLAR1050
      IF(NXDF.GE.I) I=NXDF                                              CLAR1060
      DUM=NXDF                                                          CLAR1070
      NXDF=NXDIFC                                                       CLAR1080
      NXDIFC=DUM                                                        CLAR1090
      DO 606 J=1,I                                                      CLAR1100
      DUM=ARDTA(J)                                                      CLAR1110
      ARDTA(J)=ARDTAB(J)                                                CLAR1120
  606 ARDTAB(J)=DUM                                                     CLAR1130
      I=NYDIFB                                                          CLAR1140
      IF(NYDF.GE.I) I=NYDF                                              CLAR1150
      DUM=NYDF                                                          CLAR1160
      NYDF=NYDIFB                                                       CLAR1170
      NYDIFB=DUM                                                        CLAR1180
      DO 607 J=1,I                                                      CLAR1190
      DUM=EFDTA(J)                                                      CLAR1200
```

```
      EFDTA(J)=EFDTAB(J)                                                CLAR1210
  607 EFDTAB(J)=DUM                                                     CLAR1220
      I=NZDIFB                                                          CLAR1230
      IF(NZDF.GE.I) I=NZDF                                              CLAR1240
      DUM=NZDF                                                          CLAR1250
      NZDF=NZDIFB                                                       CLAR1260
      NZDIFB=DUM                                                        CLAR1270
      DO 608 J=1,I                                                      CLAR1280
      DUM=XLNDTA(J)                                                     CLAR1290
      XLNDTA(J)=XLNDTB(J)                                               CLAR1300
  608 XLNDTB(J)=DUM                                                     CLAR1310
      DUM=NCDF                                                          CLAR1320
      NCDF=NCDIFB                                                       CLAR1330
      NCDIFB=DUM                                                        CLAR1340
      ICHNGE=0                                                          CLAR1350
  600 CONTINUE                                                          CLAR1360
      CALL INPUT2                                                       CLAR1370
      GO TO 200                                                         CLAR1380
       END                                                              CLAR1390
```

```
$IBFTC BKDA    LIST
      BLOCK DATA
C               S U B R O U T I N E   B L O C K   D A T A
C
C          THIS SUBROUTINE FILLS IN RECOMMENDED STARTING VALUES FOR A
C          NUCBER OF VARIABLES. SOME OF THESE MAY BE OVER-WRITTEN,
C          IF DESIRED, VIA NAMELIST INPUTS.
C
C THIS SUPRFUTHNE USES COMMON BLOCKS B1,B3,B12,B16,B17,B18,B68,B167,
C      B168,B1678,B12678
C COMMON STATEMENTS
      COMMON/B18/ABSW,EMW,EMC,NLUM,                           NHT1,NHT2
     1,        X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,        TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,       NUMAX1,NUMAX2
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B12678/JTAPE ,IPRINT
      COMMON/B1/KTAPE,                   XINT,PI4,NWH,NG,FFB(50),FTA(120)
     1,FTB(120),NBLADE,NUMSW,        DSWLOU,DSWLIN,
     1TCATA(50),TCATB(50),HAB(50)
      COMMON/B67/DENFT(45).EK17,EK19,EK20,            EK16
     1,          C(50),GXIA(50),K,WUJ(50)
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),
     1NGO,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,      ZZCP,IDIF
     1,HSEP   ,FLAREA(50),AREA(50)
      COMMON/B13/       AREA1,NXDIFC,NYDIFB,NZDIFB,NCDIFB,E1DTAB
     1,XLNDTB(20),EFDTAB(200),ARDTAB(200) ,
     1NWALL1,NWALL2
      COMMON/B3/M,NCASE,INPUT,ITAPE,FGIZ(45)
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),
     1NRECT,NXDIF,NDIFF,NSNCUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,
     2PRESIN,        BLOCK(50),ABLOCK,SHAPEH(2,50),
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,
     5XMACH,RHOREF,EFDT(3)
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,          NABX(45)
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH
     2,SHAFST,                                 FIFTPR,        LCMFL,LCANIL
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)
     4,LCPTAL,PAFRZ,NHTU(50)
     5,AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)
      COMMON/B17/ XHU(50),DXHU(50),EFC(2),    NEF,STEP,JKSN(50),NSH
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,         AFA,AFB,PREDM,STAGT
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS
C DATA STATEMENTS
      DATA ITAPE,JTAPE,KTAPE,PI,PI4,GASC,GRAVC,GJOULE,TZ/5,8,5,3.14159,
     10.7854,53.3,32.18,778.,459.7/
      DATA K4,K6,NCASE,NCOOL,NG,NH,NLUM,NRECT,NSH,NSNOUT,NWALL1,NWALL2,
     1NWH,NXDIF,INPUT/3*0,1,3*0,1,7*0/
      DATA ABSW,                CONDFT,EMC,EMW,FHCR,FLCV,SHAFST,STEP,THIKFT,
```

```
1TOLTW1,TOLTW2,XFILMZ,XINT/.85,       15.,.8,.85,.17,18540.,.5,.25, BKDA0060
2.1E-6,1.,1.,3.5,100./                                               BKDA0061
 DATA SHAPEH(1,1),SHAPEH(2,1)/1.4,1.4/,(BLOCK(I),I=2,50)/49*0./     BKDA0062
 DATA (TWA(I),TWB(I),I=1,45)/90*2500./                               BKDA0063
 DATA NUMAX1,NUMAX2,LCANIL,LCFTL,FID,FIA,FITAU,LCPTAL;LCPRTL,FIT,    BKDA0064
1       LCFTEL,FIENTH,LCANL,FIPSI,FIFTPR/                            BKDA0065
1 20, 20, 50, 50, .01, .5, .3, 5, 25, .01,     25, 1., 100, .01,1./BKDA0066
1,LCMFL/0/                                                           BKDA0067
1,FIPHI/.01/                                                         BKDA0068
 DATA KANHET/0/                           ,(NAB(J),J=1,50)/50*0/,    BKDA0069
1BETA,ASW/50.,0./,AREF/0./,                                          BKDA0070
 DATA IDIF/0/                                                        BKDA0071
 DATA ((KJSN(K,IX),IX=1,6),K=1,45)/270*0/                            BKDA0072
 DATA (NCODEA(K),NCODEB(K),K=1,45)/90*0/,(NHH(J),J=1,50)/50*1/      BKDA0073
1,NSHCP/0/                                                           BKDA0074
 DATA (C(K),K=1,50)/50*0./                                           BKDA0075
 DATA (QTRA(K),QTRB(K),K=1,45)/90*0./                                BKDA0076
 DATA (SAFTRA(K),SAFTRB(K),K=1,45)/90*0./                            BKDA0077
 DATA(AF23A(I),AF23B(I),XAF23A(I),XAF23B(I),I=1,3)/12*0./           BKDA0078
 DATA(HAB(J),J=1,50)/50*0./                                          BKDA0079
 DATA EK16,WIDTH1,STAGT/0.,12.,1./                                   BKDA0080
 DATA (EFDT(J),J=1,3)/3*1./                                          BKDA0081
 DATA NUMSW,NBLADE,DOMLOS,PERCO/0,8,0.,0./                           BKDA0082
 DATA HSEP/1.9/                                                      BKDA0083
 DATA PAFRZ/.1/                                                      BKDA0084
 DATAAF2/1./                                                         BKDA0085
 DATAIBL/1/                                                          BKDA0086
1,IPRINT/0/                                                          BKDA0087
 END                                                                 BKDA0088
```

```
$IBMAP REMOV
       ENTRY    .UN01.                                                    REM 0001
       ENTRY    .UN02.                                                    REM 0002
       ENTRY    .UN03.                                                    REM 0003
       ENTRY    .UN04.                                                    REM 0004
       ENTRY    .UN07.                                                    REM 0005
       ENTRY    .UN09.                                                    REM 0007
       ENTRY    .UN10.                                                    REM 0008
       ENTRY    .UN11.                                                    REM 0009
       ENTRY    .UN12.                                                    REM 0010
       ENTRY    .UN13.                                                    REM 0011
       ENTRY    .UN14.                                                    REM 0012
       ENTRY    .UN19.                                                    REM 0013
       ENTRY    .UN20.                                                    REM 0014
       ENTRY    .UN21.                                                    REM 0015
       ENTRY    .UN22.                                                    REM 0016
       ENTRY    .UN23.                                                    REM 0017
       ENTRY    .UN24.                                                    REM 0018
.UN01. PZE      0                                                         REM 0019
.UN02. PZE      0                                                         REM 0020
.UN03. PZE      0                                                         REM 0021
.UN04. PZE      0                                                         REM 0022
.UN07. PZE      0                                                         REM 0023
.UN09. PZE      0                                                         REM 0025
.UN10. PZE      0                                                         REM 0026
.UN11. PZE      0                                                         REM 0027
.UN12. PZE      0                                                         REM 0028
.UN13. PZE      0                                                         REM 0029
.UN14. PZE      0                                                         REM 0030
.UN19. PZE      0                                                         REM 0031
.UN20. PZE      0                                                         REM 0032
.UN21. PZE      0                                                         REM 0033
.UN22. PZE      0                                                         REM 0034
.UN23. PZE      0                                                         REM 0035
.UN24. PZE      0                                                         REM 0036
       END                                                                REM 0037
```

```
$IBFTC INP1     LIST

      SUBROUTINE INPUT1

C                 S U B R O U T I N E     I N P U T 1

C     THIS SUBROUTINE READS AND WRITES OUT THE FIXED RUN DATA

C     THIS SUBROUTINE USES THE FOLLOWING COMMON BLOCKS
C     B1,B12,B13,B16,B17,B18,B126,B167,B168,B178,B1678,B12678
C     ALSO B3 (SHARED WITH CLARE)

      COMMON/B1/KTAPE,                 XINT,PI4,NWH,NG,FFB(50),FTA(120)
     1,FTB(120),NBLADE,NUMSW,      DSWLOU,DSWLIN,
     1TCATA(50),TCATB(50),HAB(50)
      COMMON/B3/M,NCASE,INPUT,ITAPE,FGIZ(45)
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,
     5XMACH,RHOREF,EFDT(3)
      COMMON/B13/      AREA1,NXDIFC,NYDIFB,NZDIFB,NCDIFB,E1DTAB
     1,XLNDTB(20),EFDTAB(200),ARDTAB(200) ,
     1NWALL1,NWALL2
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,          NABX(45)
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH
     2,SHAFST,                                FIFTPR,      LCMFL,LCANIL
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)
     4,LCPTAL,PAFRZ,NHTU(50)
     5,AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)
      COMMON/B17/ XHU(50),DXHU(50),EFC(2),    NEF,STEP,JKSN(50),NSH
      COMMON/B18/ABSW,EMW,EMC,NLUM,                          NHT1,NHT2
     1,        X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,         TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,        NUMAX1,NUMAX2
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,         AFA,AFB,PREDM,STAGT
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),CANB(45)
      COMMON/B178/DFT(45            )
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT

      DIMENSION CA(60),DC(20),XINCH(120)
C
C NAMELIST DECLARATIONS
C
      NAMELIST/FIXEDI/NCASE,NRECT,NG,NH,NWH,NSH,NSNOUT,NWALL1,NWALL2
     1,INPUT,K4,K6,NUMSW,NBLADE
     1,IPRINT,NCOOL
      NAMELIST/FIXEDR/XINT,THIKFT,FLCV,FHCR,SHAFST,AF23A,AF23B,XAF23A,XA
     1F23B,ABSW,EMW,EMC,     DOMLOS,CONDFT,XFILMZ,PERCO
     1, WIDTH1,EFDT
     2,DSWLOU,DSWLIN,BETA
      NAMELIST/LIMITS/ LCANIL,STEP,NXDIF1,NXDIF2,NXDIF
```

```

C      FORMAT STATEMENTS

    1 FORMAT(7E10.3)
    4 FORMAT(12A6)
    5 FORMAT(1X,12A6//////)
    8 FORMAT(5E10.3,3I5)
   14 FORMAT(               29X13(2H* ),10HINPUT DATA13(2H *)//////37HOGEO
     2METRIC CONFIGURATION OF COMBUSTOR/1X36(1H-))
   16 FORMAT(1H125X69HA N A L Y S I S   O F   A   R E C T A N G U L A R
     1  C O M B U S T O R//////)
   17 FORMAT(1H128X63HA N A L Y S I S   O F   A N   A N N U L A R   C O
     1M B U S T O R//////)
   18 FORMAT(8HO  AXIAL9X13(2H- ),15HDIAMETER INCHES13(2H -))
   19 FORMAT(8HO  AXIAL9X7(2H- ),37HDIMENSION FROM ARBITRARY DATUM INCHE
     1S7(2H -))
   20 FORMAT(11H   POSITION/7H   FROM,81X9HGEOMETRIC/
     1                                13H   COMPRESSOR4X5HINNER7X5HINNER
     15X22HINNER DOME  OUTER DOME4X5HOUTER7X5HOUTER, 6X5HINPUT/
     1                                               12H   DISCHARGE5X6HC
     2ASING6X5HSNOUT2X2(3X9HOR FLAME ),5X5HSNOUT7X6HCASING,5X,5HPOINT/
     1                                                     9H   INCHES27
     3X2(3X9HTUBE WALL),28X,6HNUMBER//)
   21 FORMAT(1XF10.3,6F12.3,6X,I3)
   25 FORMAT(39HOTHE COMBUSTOR HAS A CONSTANT WIDTH OF ,F7.3,3H IN)
   27 FORMAT(/////19HOMISCELLANEOUS DATA/1X18(1H-)//16H HOLE ROW NUMBER
     1I3,90H IS CONSIDERED TO MARK THE END OF THE PRIMARY ZONE (WHICH IS
     2 TREATED AS A STIRRED REACTOR)/54H THE FIRST HOLES ON THE FLAME-TU
     3BE WALL ARE IN ROW NO.I3/10H FUEL DATA/11X19HLOWER HEATING VALUE9X
     41H=F10.3,12H BTU PER LBM/11X21HHYDROGEN-CARBON RATIO7X1H=F10.3/46H
     5 FRACTION OF INLET AIRFLOW BYPASSING COMBUSTOR/11X13HINNER ANNULUS
     616XF10.3/11X13HOUTER ANNULUS16XF10.3/36H AXIAL POSITION AT WHICH T
     7HIS OCCURS/11X13HINNER ANNULUS16XF10.3,7H INCHES/11X13HOUTER ANNUL
     8US16XF10.3,7H INCHES/26H FLAME-TUBE WALL THICKNESS13X1H=F10.3,7H I
     9NCHES/40H THERMAL CONDUCTIVITY OF WALL MATERIAL =F10.3,20H BTU PER
     1 FT HR DEG F/21H ABSORPTIVITY OF WALL18X1H=F10.3/19H EMISSIVITY OF
     2 WALL20X1H=F10.3/27H EMISSIVITY OF OUTER CASING12X1H=F10.3)
   37 FORMAT(63H SINCE NCASE IS ZERO, NONE OF THE MAJOR SUBROUTINES ARE
     1ENTERED)
   50 FORMAT(1X//////29H CASES CONSIDERED IN THIS RUN/1X, 29(1H-))
   51 FORMAT(1X//////38H MISCELLANEOUS DATA - DIFFUSER SECTION/
     11X,38(1H-))
   52 FORMAT(1X//////37H MISCELLANEOUS DATA - AIRFLOW SECTION/
     11X,37(1H-))
   53 FORMAT(1X//////43H MISCELLANEOUS DATA - HEAT TRANSFER SECTION/
     11X,43(1H-))
   61 FORMAT(1X,I2,27H CASES ARE TO BE CONSIDERED)
   62 FORMAT(1X,26HTHE GEOMETRY IS DEFINED AT,I3
     1,23H GEOMETRIC INPUT POINTS)
   64 FORMAT(1X,3A6,A1,26H ALTERED FROM CASE TO CASE)
   65 FORMAT(38H THE DIFFUSER SECTION CONTAINS A SNOUT)
   66 FORMAT(46H THE DIFFUSER SECTION DOES NOT CONTAIN A SNOUT)
   67 FORMAT(12H INPUT POINT,  I3,32H IS THE LAST STATION BEFORE THE ,A5
     1)
   68 FORMAT(53H DIFFUSION IS CONSIDERED TO END AT INPUT POINT NUMBER,
     1I3,
     18H IN THE ,A5, 8H ANNULUS)
   69 FORMAT(19H INPUT POINT NUMBER,  I3,47H MARKS THE END OF THE DIFFUS
     1ING SECTION IN THE ,A5,8H ANNULUS)
   70 FORMAT(31H THE EMPIRICAL DATA TO BE USED ,A6,5H THE , A5,14H IS SE
     1T NUMBER,I3)
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 71 FORMAT(16H HOLE ROW NUMBER,I3,72H IS THE FIRST HOLE ROW IN THE FLAINP10121
   1ME-TUBE WALL, AS DISTINCT FROM THE DOME)                          INP10122
 72 FORMAT(16H HOLE ROW NUMBER,I3,93H IS CONSIDERED TO MARK THE END OFINP10123
   1 THE PRIMARY ZONE (WHICH IS CONSIDERED AS A STIRRED REACTOR)     ) INP10124
 73 FORMAT(81H THE FRACTION OF AIR FLOWING THROUGH THE SECONDARY HOLESINP10125
   1 INTO THE PRIMARY ZONE IS, F7.3)                                   INP10126
 74 FORMAT(36H THE FLOW RESISTANCE IN THE SNOUT IS, F7.3,54H VELOCITY INP10127
   1HEADS (BASEL ON CONDITIONS IN THE SNOUT LIP))                      INP10128
 75 FORMAT  (42H FRACTION OF INLET AIR BYPASSING COMBUSTOR,            INP10129
   1  1X/ 36X,                                            13HINNER INP10130
   1ANNULUS,F7.3/36X,13HCUTER ANNULUS,F7.3/36H AXIAL POSITION AT WHICHINP10131
   2 THIS CCCURS/35X,14H INNER ANNULUS,F7.3, 5H IN  / 35X,14H OUTER ANINP10132
   3NULUS,F7.3, 5H IN  /  )                                            INP10133
 76 FORMAT(10H FUEL DATA/10X,20H LOWER HEATING VALUE,3X,F8.1,12H BTU PINP10134
   1ER LBM/10X,23H HYDROGEN/CARBON RATIO ,F8.3)                        INP10135
 77 FORMAT(41H FLAME TUBE WALL THICKNESS...............,F7.3,5H IN  / INP10136
   1 41H THERMAL CONDUCTIVITY OF WALL MATERIAL...,F7.2,20H BTU PER FT INP10137
   2HR DEG F/ 41H ABSORPTIVITY OF FLAMETUBE WALL...........,F7.3/     INP10138
   3           41H EMISSIVITY OF FLAMETUBE WALL.............,F7.3/     INP10139
   4           41H EMISSIVITY OF OUTER CASING...............,F7.3)     INP10140
 78 FORMAT(24H THE CASINf TEMPERATURE ,A6, 10H SPECIFIED)              INP10141
 79 FORMAT(14H FILM COOLING ,A6, 5H USED)                              INP10142
 80 FORMAT(23H TRANSPIRATION COOLING ,A6, 5H USED)                     INP10143
 81 FORMAT(51H THE PERMEABILITY COEFFICIENT OF THE POROUS WALL IS,     INP10144
   1E10.3, 6H SQ FT)                                                   INP10145
 87 FORMAT(74H THE FRACTION OF AIR FLOWING THROUGH THE SECONDARY HOLESINP10146
   1 THAT RECIRCULATES/51H INTO THE PRIMARY ZONE IS WORKED OUT IN THE INP10147
   2PROGRAM)                                                           INP10148
 90 FORMAT(19H1***  ERROR MESSAGE/38H0X(I) WAS FOUND TO BE LESS THAN XINP10149
   1(I-1),                                                             INP10150
   1     F7.3,50H INCHES ALONG THE COMBUSTOR.  THIS IS NOT ALLOWED.)   INP10151
 97 FORMAT(46H1IF THERE IS NO SNOUT, NXDIF MUST BE SPECIFIED)          INP10152
 98 FORMAT(43H1NG, NH, NWH, AND NSH MUST ALL BE SPECIFIED)             INP10153
                                                                       INP10154
: DATA DECLARATION                                                     INP10155
:                                                                      INP10156
      DATA DC(1),DC(5) /19HPROGRAM ROUTING IS ,19HFLOW CONDITIONS ARE/ INP10157
      DATA (CA(I),I=7,8)/5HSNOUT,5HDOME /                              INP10158
      DATA (CA(I),I=9,10)/5HOUTER,5HINNER/                             INP10159
      DATA (DA(I),I=11,12)/6HBEFORE,6H AFTER/                          INP10160
      DATA (CA(I),I=13,15)/6H  IS  ,6HIS NOT,6HCAN BE/                 INP10161
       DATA NTEMP/0/                                                   INP10162
:                                                                      INP10163
:     READ RUN IDENTIFICATION CARD                                     INP10164
:                                                                      INP10165
      READ(ITAPE,4) (DC(I),I=9,20)                                     INP10166
:                                                                      INP10167
: READ IN FIXED DATA, COMBUSTOR GEOMETRY, HOLE SPECIFICATIONS, LIMITS, INP10168
:     AND TOLERANCES                                                   INP10169
:                                                                      INP10170
      READ(ITAPE,FIXEDI)                                               INP10171
      IF(NG*NH*NWH*NSH        .EQ.0)GOTO198                            INP10172
      IF(NWALL1.EQ.0)NWALL1=NRECT                                      INP10173
      IF(NWALL2.EQ.0)NWALL2=NRECT                                      INP10174
      READ(ITAPE,1)(XINCH(I),CA(I),SA(I),FTA(I),FTB(I),SB(I),CB(I),I=1,NINP10175
     1G)                                                               INP10176
      READ(ITAPE,8)(XH(J',HAB(J),TCATA(J),TCATB(J),FFB(J),NAB(J),NHH(J),INP10177
     1NHTU(J),J=1,NH)                                                  INP10178
      IF(TCATA(1).NE.0.) NTEMP=1                                       INP10179
      READ(ITAPE,FIXEDR)                                               INP10180
      READ(ITAPE,LIMITS)                                               INP10181
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C                                                                       INP1018
C FILL IN DUMMY SNOUT COORDINATES                                       INP1018
C                                                                       INP1018
      IF(NXDIF.NE.0)GOTO0102                                            INP1018
      DO104I=1,NG                                                       INP1018
      IF(SA(I).EQ.0.)GOTO0104                                           INP1018
      NXDIF=I-1                                                         INP1018
      GOTO0102                                                          INP1018
  104 CONTINUE                                                          INP1019
      WRITE(JTAPE,97)                                                   INP1019
  102 NXZ=NXDIF+1                                                       INP1019
      DO103I=NXZ,50                                                     INP1019
      IF(SA(I).EQ.0.)SA(I)=FTA(I)                                       INP1019
      IF(SB(I).EQ.0.)SB(I)=FTB(I)                                       INP1019
  103 CONTINUE                                                          INP1019
C                                                                       INP1019
C WRITE OUT GEOMETRIC CONFIGURATION OF COMBUSTOR                        INP1019
C                                                                       INP1019
      IF(NRECT.EQ.1)   WRITE(JTAPE,17)                                  INP1020
      IF(NRECT.EQ.2)   WRITE(JTAPE,16)                                  INP1020
      WRITE(JTAPE,5) (DC(I),I=9,20)                                     INP1020
      WRITE(JTAPE,14)                                                   INP1020
      WRITE(JTAPE,62) NG                                                INP1020
      IF(NRECT.EQ.1)WRITE(JTAPE,18)                                     INP1020
      IF(NRECT.EQ.2)WRITE(JTAPE,19)                                     INP1020
      WRITE(JTAPE,20)                                                   INP1020
      WRITE(JTAPE,21)(XINCH(I),CA(I),SA(I),FTA(I),FTB(I),SB(I),CB(I),I, INP1020
     1I=1,NG)                                                           INP1020
      IF(NRECT.EQ.2) WRITE(JTAPE,25) WIDTH1                             INP1021
C                                                                       INP1021
C CONVERT UNITS                                                         INP1021
C                                                                       INP1021
      WIDTH1=WIDTH1/12.                                                 INP1021
      DO109I=1,NG                                                       INP1021
      X(I)=XINCH(I)/12.                                                 INP1021
      IF(I.EQ.1)GO TO 1085                                              INP1021
      IF(X(I).LE.X(I-1))GO TO 190                                       INP1021
 1085 CONTINUE                                                          INP1021
      CA(I)=CA(I)/12.0                                                  INP1022
      SA(I)=SA(I)/12.0                                                  INP1022
      FTA(I)=FTA(I)/12.0                                                INP1022
      FTB(I)=FTB(I)/12.0                                                INP1022
      SB(I)=SB(I)/12.0                                                  INP1022
  109 CB(I)=CB(I)/12.0                                                  INP1022
      DO130J=1,NH                                                       INP1022
  130 XH(J)=XH(J)/12.0                                                  INP1022
      XINT=XINT/12.0                                                    INP1022
      THIKFT=THIKFT/12.                                                 INP1023
      STEP=STEP/12.                                                     INP1023
                                                                        INP1023
C SELECT APPROPRIATE DATA FROM LIBRARY TAPE                             INP1023
C                                                                       INP1023
      CALLTAPE                                                          INP1023
                                                                        INP1023
C CALCULATE GEOMETRIC PARAMETERS AND SELECT CALCULATION POINTS          INP1023
C                                                                       INP1024
      CALLGEOM                                                          INP1024
      DO1316K=1,NLAST                                                   INP1024
 1316 FGIZ(K)=FFIZ(K)                                                   INP1024
                                                                        INP1024
C WRITE OUT MISCELLANEOUS DATA                                          INP1024
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                                                                        INP10246
                                                                        INP10247
                                                                        INP10248
      WRITE(JTAPE,51)                                                   INP10249
      IF(NSNCUT.EQ.1) WRITE(JTAPE,65)                                   INP10250
      IF(NSNCUT.NE.1) WRITE(JTAPE,66)                                   INP10251
      IF(NSNCUT.EQ.1) WRITE(JTAPE,67) NXDIF,DA(7)                       INP10252
      IF(NSNCUT.NE.1) WRITE(JTAPE,67) NXDIF,DA(8)                       INP10253
      IF(NSNCUT.EQ.1) WRITE(JTAPE,68) NXDIF1,DA(10)                     INP10254
      IF(NSNCUT.EQ.1) WRITE(JTAPE,68) NXDIF2,DA(9)                      INP10255
      IF(NSNCUT.NE.1) GO TO 990                                         INP10256
      WRITE(JTAPE,70) DA(11),DA(7),NWALL1                               INP10257
      WRITE(JTAPE,70) DA(12),DA(7),NWALL2                               INP10258
      GO TO 991                                                         INP10259
  990 WRITE(JTAPE,70) DA(11),DA(8),NWALL1                               INP10260
  991 CONTINUE                                                          INP10261
                                                                        INP10262
      WRITE(JTAPE,52)                                                   INP10263
      WRITE(JTAPE,71) NWH                                               INP10264
      WRITE(JTAPE,72) NSH                                               INP10265
      IF(K4.EQ.0)WRITE(JTAPE,87)                                        INP10266
      IF(K4.EQ.1)WRITE(JTAPE,73)SHAFST                                  INP10267
      WRITE(JTAPE,74) DOMLOS                                            INP10268
      DO 1995 JL=1,3                                                    INP10269
                                                                        INP10270
                                                                        INP10271
      IF(AF23A(JL)*AF23B(JL).GT.0.)WRITE(JTAPE,75)AF23A(JL),AF23B(JL),  INP1 272
     1XAF23A(JL),XAF23B(JL)                                             INP1 273
      XAF23A(JL)=XAF23A(JL)/12.                                         INP10274
 1995 XAF23B(JL)=XAF23B(JL)/12.                                         INP10275
      WRITE(JTAPE,76) FLCV,FHCR                                         INP10276
                                                                        INP10277
      WRITE(JTAPE,53)                                                   INP10278
      THIKFT=THIKFT*12.                                                 INP10279
      WRITE(JTAPE,77) THIKFT,CONDFT,ABSW,EMW,EMC                        INP10280
      THIKFT=THIKFT/12.                                                 INP10281
      IF(NTEMP.EQ.1) GO TO 992                                          INP10282
      WRITE(JTAPE,78) DA(14)                                            INP10283
      GO TO 993                                                         INP10284
  992 WRITE(JTAPE,78) DA(13)                                            INP10285
  993 IF(NCOOL.EQ.1) GO TO 1990                                         INP10286
      WRITE(JTAPE,79) DA(14)                                            INP10287
      GO TO 1991                                                        INP10288
 1990 WRITE(JTAPE,79) DA(15)                                            INP10289
 1991 IF(NCOOL.EQ.2) GO TO 1992                                         INP10290
      WRITE(JTAPE,80) DA(14)                                            INP10291
      GO TO 1993                                                        INP10292
 1992 WRITE(JTAPE,80) DA(15)                                            INP10293
      WRITE(JTAPE,81) PERCO                                             INP10294
 1993 CONTINUE                                                          INP10295
                                                                        INP10296
      IF(IPRINT.EQ.1)                                                   INP10297
     1WRITE(6,FIXEDI)                                                   INP10298
      IF(IPRINT.EQ.1)                                                   INP10299
     1WRITE(6,FIXEDR)                                                   INP10300
      IF(IPRINT.EQ.1)                                                   INP10301
     1WRITE(JTAPE,LIMITS)                                               INP10302
      WRITE(JTAPE,50)                                                   INP10303
      WRITE(JTAPE,61) NCASE                                             INP10304
      IF(NCASE.EQ.0) WRITE(JTAPE,37)                                    INP10305
      IF(INPUT.EQ.1) WRITE(JTAPE,64) (DC(I),I=1,4)                      INP10306
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      IF(INPUT.EQ.0) WRITE(JTAPE,64) (DC(I),I=5,8)                      INP10307
                                                                        INP10308
      RETURN                                                            INP10309
  190 WRITE(JTAPE,90)X(I)                                               INP10310
      STOP                                                              INP10311
  198 WRITE(JTAPE,98)                                                   INP10312
  199 STOP                                                              INP10313
      END                                                               INP1 314
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.........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC INP2     LIST
      SUBROUTINE INPUT2
C
C                 S U B R O U T I N E   I N P U T 2
C
C     THIS SUBROUTINE READS AND WRITES OUT THE CASE DATA
C
C COMMON STATEMENTS
C
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 1
C     B1,B12,B13,B16,B17,B18,B126,B167,B168,B178,B1678,B12678
C     ALSO B3 (SHARED WITH CLARE)
C
      COMMON/B1/KTAPE,             XINT,PI4,NWH,NG,FFB(50),FTA(120)
     1,FTB(120),NBLADE,NUMSW,     DSWLOU,DSWLIN,
     1TCATA(50),TCATB(50),HAB(50)
      COMMON/B3/M,NCASE,INPUT,ITAPE,FGIZ(45)
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,
     5XMACH,RHOREF,EFDT(3)
      COMMON/B13/      AREA1,NXDIFC,NYDIFB,NZDIFB,NCDIFB,E1DTAB
     1,XLNDTB(20),EFDTAB(200),ARDTAB(200) ,
     1NWALL1,NWALL2
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,          NABX(45)
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH
     2,SHAFST,                                FIFTPR,        LCPFL,LCANIL
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOCP(20)
     4,LCPTAL,PAFRZ,NHTU(50)
     5,AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)
      COMMON/B17/ XHU(50),DXHU(50),EFC(2),    NEF,STEP,JKSN(50),NSH
      COMMON/B18/ABSW,EMW,EMC,NLUM,                        NHT1,NHT2
     1,     X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,       TABTFT(10),TABEFT(10),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,       NUMAX1,NUMAX2
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,        AFA,AFB,PREDM,STAGT
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLCS
      COMMON/B167/GASC,GRAVC,GJOULF,IHJ(50),XH(50),NH
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B178/DFT(45          )
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT
      COMMON/B126D/AFCL,AFCU,AFSL,AFSU
C
C DIMENSION STATEMENT
C
      DIMENSION DA(60),DB(40),DUMF(46),WORD(2),WORE(6,5),XINCH(120)
C
C FORMAT STATEMENTS
C
    1 FORMAT(7E10.3)
    2 FORMAT(7I10)
    3 FORMAT(2E10.3)
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*.........*.........*.........*.........*.........*.........*.........*.........*
   11 FORMAT(/////22HCINLET FLOW CONDITIONS/1X21(1H-)/44HCTOTAL TEMPERATINP20600
     1URE AT COMPRESSOR DISCHARGE =F10.3,6H DEG F/44H TOTAL PRESSURE AT INP20610
     1COMPRESSOR DISCHARGE    =F10.3,5H PSIA/44H AIR FLOW RATE AT COMPREINP20620
     3SSOR DISCHARGE     =F10.3,12H LBM PER SEC/23H OVERALL FUEL-AIR RATINP20630
     4IO20X1H=F10.3//////20H0DIFFUSER INPUT DATA/1X19(1H-)/22H0INITIAL SINP20640
     5HAPE FACTORS/11X10HINNER WALL22XF7.3/11X10HOUTER WALL22XF7.3/30H IINP20650
     6NLET BOUNDARY LAYER BLOCKAGE12X1H=F7.3/43H FRACTION OF INLET BLOCKINP20660
     7AGE ON INNER WALL =F7.3/43H NUMBER OF STREAM TUBES TO BE CONSIDEREINP20670
     8D  =I4////36X47HFIRST ESTIMATE OF BLOCKAGE AT DOWNSTREAM POINTS///INP20680
     940X21HAXIAL DISTANCE INCHES10X8HBLOCKAGE//(30X2(14XF10.3)))       INP20690
   22 FORMAT(60H EMPIRICAL DATA ON LIBRARY TAPE IS USED FOR FLAME EMISSIINP20700
     1VITY)                                                             INP20710
   28 FORMAT(1X,4A6,A2,38H MODEL IS USED TO REPRESENT JET MIXING)       INP20720
   29 FORMAT(1X,4A6,A2,39H MODEL IS USED TO REPRESENT JET MIXING ,      INP20730
     1                                                          3A6,F6.INP20740
     13,3A6,A3/1X,A3,F6.3,3A6,A2)                                       INP20750
  311 FORMAT(30H HEAT TRANSFER TO ANNULUS AIR A6,11H CONSIDERED)        INP20760
  312 FORMAT(47H THE HEAT TRANSFER CALCULATION IS NOT PERFORMED)        INP20770
   32 FORMAT(///49X22HINLET VELOCITY PROFILE///22X38HFRACTIONAL DISTANCEINP20780
     1 ACROSS INLET PLANE10X28HVELOCITY (NONDIMENSIONALIZED/28X26H(MEASUINP20790
     2RED FROM INNER WALL)16X27HWITH AN ARBITRARY VELOCITY)//(2X2(32XF10INP20800
     3.3)))                                                             INP20810
   33 FORMAT(27H THE FLAME IS ASSUMED TO BE6A6,20H CORRELATION IS USED) INP20820
   34 FORMAT(1H128X13(2H* ),8HCASE NO.I3,13(2H *))                      INP20830
   35 FORMAT(/////28HORCUTING THROUGH THE PROGRAM/1X27(1H-)//)          INP20840
   36 FORMAT(/////50H0ALL THE OTHER VARIABLES ARE THE SAME AS FOR CASE ,INP20850
     1I3,                                                               INP20860
     1/1X50(1H-))                                                       INP20870
   38 FORMAT(112H IF EMPIRICAL DATA ARE USED TO CALCULATE THE DIFFUSER  INP20880
     1EFFECTIVENESS, THESE DATA ARE TAKEN FROM THE LIBRARY TAPE)        INP20890
   39 FORMAT( 85H DIFFUSSER EFFECTIVENESSES FOR THE DIFFUSING PASSAGES AINP20900
     1RE READ IN WITH THE FIXED DATA)                                   INP20910
   40 FORMAT( 61H THE BASIC HEAT TRANSFER CALCULATION SOLVES FOR A MODELINP20920
     1 WITH ,A6,A2,22H FLAME-TUBE WALLS AND ,A1,12H-DIMENSIONAL/        INP20930
     134H RADIATION TRANSFER FROM THE FLAME)                            INP20940
   41 FORMAT(26H CORRECTIONS ARE MADE FOR ,5A6,A5)                      INP20950
   42 FORMAT(26H CORRECTIONS ARE MADE FOR ,5A6,A5,A5,5A6,A5)            INP20960
   43 FORMAT(63H NO CORRECTIONS ARE MADE TO THE BASIC HEAT TRANSFER CALCINP20970
     1ULATION)                                                          INP20980
   45 FORMAT(5H THE ,2A6,A3,80H METHOD IS USED TO CALCULATE DIFFUSER PERINP20990
     1FORMANCE FROM THE DIFFUSER INLET TO THE,1X,A5)                    INP21000
   46 FORMAT(4H THE,2A6,A3,77H METHOD IS USED TO CALCULATE THE DIFFUSER INP21010
     1PERFORMANCE IN THE PASSAGES BETWEEN,1X,                           INP21020
     1                                   A5,17H AND OUTER CASING)       INP21030
   47 FORMAT(111H SEPARATION IN THE DIFFUSER IS PREDICTED USING THE STREINP21040
     1AMTUBE METHOD AND THE MASS FLOW SPLIT OBTAINED USING THE/         INP21050
     239H  CALCULATION PROCEDURE AS GIVEN ABOVE )                       INP21060
   82 FORMAT(73H0CALCULATION   AXIAL       CUMULATIVE  FUEL BURNING   CASINP21070
     1ING TEMPERATURE  /                                                INP21080
     2      73H POINT          POSITION   FRACTION    RATE              INP21090
     3    DEG F         /                                               INP21100
     4      73H NUMBER          IN         FUEL BURNT  LBM PER SEC    ININP21110
     5NER    OUTER      /)                                              INP21120
   83 FORMAT(2X,I3,9X,F7.3,6X,F6.3,6X,F7.3,7X,F7.1,2X,F7.1   )          INP21130
   84 FORMAT(1X//////63H FUEL BURNING RATE AND CASING TEMPERATURE AT CALINP21140
     1CULATION POINTS/1X,63(1H-))                                       INP21150
   85 FORMAT(117H THE TWO-DIMENSIONAL-RADIATION OPTION CANNOT BE USED ININP21160
     1 A COMBUSTOR OF RECTANGULAR CROSS SECTION. THE FLAME RADIATION/38HINP21170
     2 WILL BE CALCULATED ONE-DIMENSIONALLY.)                           INP21180
   86 FORMAT(98H0THE TWO-DIMENSIONAL-RADIATION OPTION CANNOT BE USED WITINP21190
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......*.........*.........*.........*.........*.........*.........*.........*
     1H TABULATED EMISSIVITY DATA                    /30H NLUM HAS BEEN SET EINP21200
     2QUAL TO 4 )                                                          INP21210
                                                                           INP21220
      DATA STATEMENTS                                                      INP21230
                                                                           INP21240
      DATA (DA(I),I=7,8)/5HSNOUT,5HDOME /                                  INP21250
      DATA DA(20),DA(22) /8HUNCOOLED,8H COOLED /,DA(24),DA(25)/1H1,1H2/  INP21260
      DATA DA(26),DA(32),DA(38)/35HLONGITUDINAL WALL CONDUCTION          , INP21270
     1 35HRADIATION INTERCHANGE BETWEEN WALLS,5H AND /                     INP21280
      DATA DA(50),DA(53),DA(56)/15H EMPIRICAL DATA,15H  STREAMTUBE    ,    INP21290
     115HMIXING EQUATION/                                                  INP21300
      DATA DB(6),DB(1),DB(11),DB(16)/ 26HTHE EQUIVALENT ENTRAINMENT,       INP21310
     126HTHE        MASS  LOSS      ,26HTHE PROFILE  SUBSTITUTION ,        INP21320
     226HTHE INSTANTANEOUS  MIXING /                                       INP21330
      DATA DB(21),DB(24),DB(28),DB(29)/ 18HWITH A CONSTANT OF,21H FOR PEINP21340
     1NETRATION JETS, 3HAND,14H FOR WALL JETS/                             INP21350
      DATA(WORD(I),I=1,2)/12H  IS  IS NOT/,((WORD(I,J),I=1,6),J=1,5)/180INP21360
     1H NONLUMINOUS. REEVES DISTILLATE-FUEL NONLUMINOUS.   REEVES RESIDUINP21370
     2AL-FUEL LUMINOUS.             THE LEFEBVRE LUMINOUS.                 INP21380
     3THE NREC 1964 LUMINOUS.            THE NREC 1966/                    INP21390
                                                                           INP21400
      DO1313I=1,NG                                                         INP21410
 1313 XINCH(I)=X(I)*12.                                                    INP21420
 1314 WRITE(JTAPE,34)M                                                     INP21430
      IF(M.NE.1.AND.INPUT.EQ.1)GOTO110                                     INP21440
                                                                           INP21450
      CHANGE UNITS IF INPUT=0                                              INP21460
                                                                           INP21470
      IF(M.EQ.1)AF2=1.0                                                    INP21480
      AFA=AFA/AF2                                                          INP21490
      AFB=AFB/AF2                                                          INP21500
      DO 136 JL=1,3                                                        INP21510
      AF23A(JL)=AF23A(JL)/AF2                                              INP21520
  136 AF23B(JL)=AF23B(JL)/AF2                                              INP21530
      IF(TCASA(1).EQ.STAGT) TCASA(1)=0.                                    INP21540
           ** THERE ARE NO CARDS INP21560, 1570, AND 1580  **              INP21550
 1354 CONTINUE                                                             INP21590
                                                                           INP21600
      READ NEW CASE DATA TO CHANGE FLOW VARIABLES                          INP21610
                                                                           INP21620
      DUM1=SHAPEH(1,1)                                                     INP21630
      DUM2=SHAPEH(2,1)                                                     INP21640
      READ(ITAPE,1)STAGT,STPREF,AF2,FAR,ABLOCK,SHAPEH(1,1),SHAPEH(2,1),  INP21650
     1(BLOCK(I),I=1,NXDIF)                                                 INP21660
      READ(ITAPE,1)DAFA,DAFB,AFCL,AFCU,AFSL,AFSU                           INP21670
      IF(DAFA.GT.0.)AFA=DAFA                                               INP21680
      IF(DAFB.GT.0.)AFB=DAFB                                               INP21690
      IF(AFCL.LE.0.)AFCL=0.1                                               INP21700
      IF(AFCU.LE.0.)AFCU=0.9                                               INP21710
      IF(AFSU.LE.0.)AFSU=AF2                                               INP21720
      IF(AFSL.LE.0.)AFSL=0.0                                               INP21730
      IF(SHAPEH(1,1).EQ.0.) SHAPEH(1,1)=DUM1                               INP21740
      IF(SHAPEH(2,1).EQ.0.) SHAPEH(2,1)=DUM2                               INP21750
      READ(ITAPE,2)NTUBE,NUPR                                              INP21760
      READ(ITAPE,3)(VPDATA(I5),RDATA(I5),I5=1,NUPR)                        INP21770
      AFA=AFA*AF2                                                          INP21780
      AFB=AFB*AF2                                                          INP21790
      FFPRZ=FAR*AF2                                                        INP21800
      DO 132 JL=1,3                                                        INP21810
      AF23A(JL)=AF23A(JL)*AF2                                              INP21820
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*........*........*........*........*........*........*........*........*........*
  132 AF23B(JL)=AF23B(JL)*AF2                                           INP21830
      IF(TCASA(1).NE.0.) GO TO 1361                                     INP21840
      DO 1360 K=1,NLAST                                                 INP21850
      TCASA(K)=STAGT                                                    INP21860
 1360 TCASB(K)=STAGT                                                    INP21870
 1361 CONTINUE                                                          INP21880
      DUMF(1)=0.                                                        INP21890
      DO 133 K=1,NLAST                                                  INP21900
      DUMF(K+1)=DUMF(K)+FFIZ(K)                                         INP21910
  133 FFIZ(K)=FGIZ(K)*AF2*FAR                                           INP21920
C                                                                       INP21930
C                                                                       INP21940
      DO 1341 K=1,NLAST                                                 INP21950
 1341 XCP(K)=XCP(K)*12.                                                 INP21960
C                                                                       INP21970
      WRITE(JTAPE,11)STAGT,STPREF,AF2,FAR,SHAPEH(1,1),SHAPEH(2,1),BLOCK(INP21980
     11),ABLOCK,NTUBE,(XINCH(I),BLOCK(I),I=1,NXDIF)                     INP21990
      WRITE(JTAPE,32)(RDATA(I),VPDATA(I),I=1,NUPR)                      INP22000
      WRITE(JTAPE,84)                                                   INP22010
      WRITE(JTAPE,82)                                                   INP22020
      WRITE(JTAPE,83) (K,XCP(K),DUMF(K+1),FFIZ(K),TCASA(K),TCASB(K),K=1,INP22030
     1NLAST)                                                            INP22040
C                                                                       INP22050
C     CONVERT UNITS                                                     INP22060
C                                                                       INP22070
      DO 1342 K=1,NLAST                                                 INP22080
      TCASA(K)=TCASA(K)+TZ                                              INP22090
      TCASB(K)=TCASB(K)+TZ                                              INP22100
 1342 XCP(K)=XCP(K)/12.                                                 INP22110
      STAGT=STAGT+TZ                                                    INP22120
      STPREF=STPREF*144.                                                INP22130
      IF(M.NE.1)GOTO111                                                 INP22140
C                                                                       INP22150
C     READ NEW CASE DATA TO CHANGE PROGRAM ROUTING                      INP22160
C                                                                       INP22170
C         ** INCLUDE CARDS INP22181 THROUGH 2186 **                     INP22180
  110 IF(M.EQ.1)GOTO109                                                 INP22181
      AFCL=0.1                                                          INP22182
      AFCU=0.9                                                          INP22183
      AFSU=AF2                                                          INP22184
      AFSL=0.0                                                          INP22185
  109 WRITE(JTAPE,35)                                                   INP22186
      READ(ITAPE,2)NDIFF,NEF,NLUM,LANHET,NHT1,NHT2                      INP22190
      READ(ITAPE,1)EFC(1),EFC(2),EFDT(1),EFDT(2),EFDT(3)                INP22200
 1105 IF(NEF.EQ.4) WRITE(JTAPE,28) (DB(IL),IL=16,20)                    INP22210
      IF (NEF.EQ.4) GO TO 1106                                          INP22220
      NFD=NEF*5                                                         INP22230
      NFE=NFD-4                                                         INP22240
      WRITE(JTAPE,29) (DB(IL),IL=NFE,NFD),(DB( IL), IL=21,23),EFC(1),(DB(IINP22250
     1L),IL=24,28),EFC(2),(DB( IL ), IL=29,31)                          INP22260
 1106 CONTINUE                                                          INP22270
      LANHT=LANHET+2                                                    INP22280
      IF(LANHT.EQ.3) LANHT=1                                            INP22290
      IF(LANHT.EQ.4) WRITE(JTAPE,312)                                   INP22300
      IF(LANHT.NE.4) WRITE(JTAPE,311) WORD(LANHT)                       INP22310
      IF(NLUM.EQ.6)WRITE(JTAPE,22)                                      INP22320
      IF(NRECT*NHT1.LT.6)GOTO1103                                       INP22330
      WRITE(JTAPE,85)                                                   INP22340
      NHT1=NHT1-2                                                       INP22350
 1103 IF(NHT1.LE.2.OR.NLUM.LE.5)GOTO1104                                INP22360
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........*.........*.........*.........*.........*.........*.........*.........*
      WRITE(JTAPE,86)                                                   INP22370
      NLUM=4                                                            INP22380
 1104 CCNTINUE                                                          INP2239C
      IF(NLUM.NE.6)WRITE(JTAPE,33)(WORE(IB,NLUM),IB=1,6)                INP22400
      IF (LANHT.EC.4) GO TO 1107                                        INP22410
      IF(NHT1.EC.1) WRITE(JTAPE,40) DA(20),CA(21),DA(24)                INP22420
      IF(NHT1.EQ.2) WRITE(JTAPE,40) DA(22),CA(23),DA(24)                INP22430
      IF(NHT1.EC.3) WRITE(JTAPE,4C) DA(20),DA(21),DA(25)                INP22440
      IF(NHT1.EC.4) WRITE(JTAPE,40) DA(22),DA(23),DA(25)                INP22450
      IF(NHT2.EC.1) WRITE(JTAPE,43)                                     INP22460
      IF(NHT2.EC.2) WRITE(JTAPE,41) (DA(JL),JL=26,31)                   INP22470
      IF(NHT2.EQ.3) WRITE(JTAPE,41) (DA(JL),JL=32,37)                   INP22480
      IF(NHT2.EC.4) WRITE(JTAPE,42) (DA(JL),JL=32,37),DA(38),(DA(JL),   INP22490
     1JL=26,31)                                                         INP22500
 1107 CCNTINUE                                                          INP22510
      NDIF=1                                                            INP22520
      NDIG=0                                                            INP22530
      IF(NDIFF.GE.0) GO TC 1109                                         INP22540
      NDIF=-1                                                           INP2255C
      NDIFF=-NDIFF                                                      INP22560
 1109 IF(NDIFF.LE.100) GO TO 1110                                       INP22570
      NDIFF=NCIFF-100                                                   INP22580
      NDIG=1                                                            INP22590
 1110 CCNTINUE                                                          INP226C0
      NWAY=NDIFF/10                                                     INP22610
      NGO=NDIFF-NWAY*10                                                 INP22620
      NDIFF=(NDIFF+100*NCIG)*NDIF                                       INP22630
      IF(NSNOUT.EC.1) IJ=7                                              INP22640
      IF(NSNCUT.EC.0) IJ=8                                              INP22650
      IF(NWAY.EC.1)WRITE(JTAPE,45) (DA(JK),JK=53,55),DA(IJ)             INP22660
      IF(NWAY.EC.2)WRITE(JTAPE,45) (DA(JK),JK=50,52),CA(IJ)             INP22670
      IF(NGC .EC.1)  WRITE(JTAPE,46)(DA(JK),JK=53,55),DA(IJ)            INP22680
      IF(NGC .EC.2)  WRITE(JTAPE,46)(DA(JK),JK=50,52),DA(IJ)            INP22690
      IF(NGO .EC.3)  WRITE(JTAPE,46)(DA(JK),JK=56,58),DA(IJ)            INP22700
      IF(NDIF.EC.1)  WRITE(JTAPE,38)                                    INP22710
      IF(NDIF.EQ.-1) WRITE(JTAPE,39)                                    INP22720
      IF(NDIG.EC.1) WRITE(JTAPE,47)                                     INP22730
  111 MN=1                                                              INP22740
      IF(M.NE.1)WRITE(JTAPE,36)    MN                                   INP22750
      IF(NCASE.EQ.0)GOTO 1315                                           INP22760
      RETURN                                                            INP22770
 1315 M=M+1                                                             INP22780
      GO TC 1314                                                        INP22790
      END                                                               INP22800

YOUR CARD TCTAL IS ---          285
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*........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC TAP
C                                                                       TAPE0001
      SUBROUTINETAPE                                                    TAPE0002
C                                                                       TAPE0003
C READS DATA FROM LIBRARY TAPE AND ASSEMBLES SHORT LIST OF RELEVANT     TAPE0004
C     DATA IN CORE                                                      TAPE0005
C                                                                       TAPE0006
C COMMON STATEMENTS                                                     TAPE0007
C                                                                       TAPE0008
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 1   TAPE0009
C     VIZ- B1,B12,B13,B16,B17,B18,B167,B168,B178,B1234,B1678,B12346     TAPE0010
C                                                                       TAPE0011
      COMMON/B1/KTAPE,              XINT,PI4,NWH,NG,FFB(50),FTA(120)    TAPE0012
     1,FTB(120),NBLADE,NUMSW,      CSWLOU,DSWLIN,                       TAPE0013
     1TCATA(50),TCATB(50),HAB(50)                                       TAPE0014
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 TAPE0015
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       TAPE0016
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),                       TAPE0017
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  TAPE0018
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                TAPE0019
     5XMACH,RHOREF,EFCT(3)                                              TAPE0020
      COMMON/B16/CDS(20,15),DPHS(20,15),FLOW,IH,        NABX(45)        TAPE0021
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   TAPE0022
     2,SHAFST,                              FIFTPR,       LCMFL,LCANILTAPE0023
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOCP(20)    TAPE0024
     4,LCPTAL,PAFRZ,NHTU(50)                                            TAPE0025
     5,AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)                            TAPE0026
      COMMON/B13/     AREA1,NXDIFC,NYDIFB,NZDIFB,NCDIFB,E1DTAB          TAPE0027
     1,XLNDTB(20),EFDTAB(200),ARDTAB(200) ,                             TAPE0028
     1NWALL1,NWALL2                                                     TAPE0029
      COMMON/B17/ XHU(50),DXHU(50),EFC(2),   NEF,STEP,JKSN(50),NSH      TAPE0030
      COMMON/B18/ABSW,EMW,EMC,NLUM,                      NHT1,NHT2      TAPE0031
     1,      X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLTTAPE0032
     2W2,XFILMZ,       TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORMTAPE0033
     3,NCOOL,      NUMAX1,NUMAX2                                        TAPE0034
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,         AFA,AFB,PREDM,STAGTTAPE0035
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS                             TAPE0036
      COMMON/B167/GASC,GRAVC,GJOULE,IMJ(50),XH(50),NH                   TAPE0037
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FMCR,NLAST          TAPE0038
     1,KANHET,LANHET,PERCO,THIKFT                                       TAPE0039
     2,DANA(45),DANB(45)                                                TAPE0040
      COMMON/B178/DFT(45)                                               TAPE0041
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             TAPE0042
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  TAPE0043
     2,NCODEB(45),TZ                                                    TAPE0044
      COMMON/B12678/JTAPE ,IPRINT                                       TAPE0045
C                                                                       TAPE0046
C DIMENSION STATEMENTS                                                  TAPE0047
C                                                                       TAPE0048
      DIMENSIONCDSA(25),DPHSA(25),GXISA(25),       NCARD(10),IDX(60)    TAPE0049
C                                                                       TAPE0050
C FORMAT STATEMENTS                                                     TAPE0051
C                                                                       TAPE0052
    1 FORMAT(7E10.3)                                                    TAPE0053
    2 FORMAT(7I10)                                                      TAPE0054
    5 FORMAT(5I10,E10.3)                                                TAPE0055
    6 FORMAT(70XI2)                                                     TAPE0056
    7 FORMAT(I10,2E10.3,2I5,3E10.3/(10X6E10.3))                         TAPE0057
   96 FORMAT(65H EMPIRICAL FLAME-EMISSIVITY DATA INCORRECTLY WRITTEN ON TAPE0058
     1DATA TAPE)                                                        TAPE0059
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*........*.........*.........*.........*.........*.........*.........*.........*
   97 FORMAT(47H DIFFUSER DATA INCORRECTLY WRITTEN ON DATA TAPE)           TAPE0060
   98 FORMAT(65H HOLE DISCHARGE COEFFICIENT DATA INCORRECTLY WRITTEN ON TAPE0061
     1DATA TAPE)                                                           TAPE0062
   99 FORMAT(/////37H0***  ERROR MESSAGE - PROGRAM STOPPED)                TAPE0063
                                                                           TAPE0064
      DO110J=1,NH                                                          TAPE0065
  110 IHJ(J)=0                                                             TAPE0066
C                                                                          TAPE0067
C HOLE DISCHARGE COEFFICIENT AND JET ANGLE DATA                            TAPE0068
C                                                                          TAPE0069
      IH=1                                                                 TAPE0070
      READ(KTAPE,2)NMXTYP                                                  TAPE0071
  102 READ(KTAPE,7)NHTYP,DXH,HAA,NSCOOQ,NSPA,(DPHSA(I),CDSA(I),GXISA(I),TAPE0072
     1I=1,NSPA)                                                            TAPE0073
      NEND=0                                                               TAPE0074
      DO101J=1,NH                                                          TAPE0075
      IF(NHTYP.NE.NHTU(J))GOTO101                                          TAPE0076
      IF(HAB(J).NE.0.) HAA=HAB(J)                                          TAPE0077
      DXHU(J)=DXH/12.                                                      TAPE0078
      HAU(J)=HAA/144.                                                      TAPE0079
      IF(MOD(NSCOOQ,10).NE.2)GOTO1025                                      TAPE0080
      HAU(J)=HAA/12.                                                       TAPE0081
      NHH(J)=1                                                             TAPE0082
 1025 IHJ(J)=IH                                                            TAPE0083
      IF(NEND.NE.0)GOTO101                                                 TAPE0084
      NEND=1                                                               TAPE0085
      DO103I4=1,NSPA                                                       TAPE0086
      DPHS(IH,I4)=ALOG(DPHSA(I4))                                          TAPE0087
      CDS(IH,I4)=CDSA(I4)                                                  TAPE0088
  103 GXIS(IH,I4)=GXISA(I4)*PI/180.                                        TAPE0089
      NSP(IH)=NSPA                                                         TAPE0090
      NSCOOP(IH)=NSCOOQ                                                    TAPE0091
  101 CONTINUE                                                             TAPE0092
      IF(NEND.EQ.1)IH=IH+1                                                 TAPE0093
  109 CONTINUE                                                             TAPE0094
      IF(NHTYP.LT.NMXTYP)GOTO102                                           TAPE0095
      READ(KTAPE,6)INDEX                                                   TAPE0096
      IF(INDEX.NE.1)GOTO198                                                TAPE0097
      INDEX=0                                                              TAPE0098
C                                                                          TAPE0099
C     EMPIRICAL GENERALIZED DIFFUSER DATA                                  TAPE0100
C                                                                          TAPE0101
      READ(KTAPE,2)NWALMX                                                  TAPE0102
      READ(KTAPE,?)(NCARD(I7),I7=1,NWALMX)                                 TAPE0103
      DO105I7=1,NWALMX                                                     TAPE0104
  104 READ(KTAPE,5)NWALL,NXDIFD,NYDIFA,NZDIFA,NCDIFA,E1DTAA                 TAPE0105
      IF(NWALL.NE.NWALL1)GOTO100                                           TAPE0106
      NXDF=NXDIFD                                                          TAPE0107
      NYDF=NYDIFA                                                          TAPE0108
      NZDF=NZDIFA                                                          TAPE0109
      NCDF=NCDIFA                                                          TAPE0110
      E1DTA=E1DTAA                                                         TAPE0111
      READ(KTAPE,1)(EFDTA(I),I=1,NYDF),(ARDTA(I),I=1,NXDF),(XLNDTA(I),I=TAPE0112
     11,NZDF)                                                              TAPE0113
      GOTO105                                                              TAPE0114
  100 IF(NWALL.NE.NWALL2)GOTO106                                           TAPE0115
      NXDIFC=NXDIFD                                                        TAPE0116
      NYDIFB=NYDIFA                                                        TAPE0117
      NZDIFB=NZDIFA                                                        TAPE0118
      NCDIFB=NCDIFA                                                        TAPE0119
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*.........*.........*.........*.........*.........*.........*.........*.........*
      E1DTAB=E1DTAA                                                     TAPE0120
      READ(KTAPE,1)(EFDTAB(I),I=1,NYDIFB),(ARDTAB(I),I=1,NXDIFC),       TAPE0121
     1(XLNDTB(I),I=1,NZDIFB)                                            TAPE0122
      GCTO105                                                           TAPE0123
  106 NCRD=NCARD(NWALL)                                                 TAPE0124
      READ(KTAPE,6)(ICX(I11),I11=1,NCRD)                                TAPE0125
  105 CCNTINUE                                                          TAPE0126
      READ(KTAPE,6)INDEX                                                TAPE0127
      IF(INDEX.NE.1)GOTO197                                             TAPE0128
      INDEX=0                                                           TAPE0129
C                                                                       TAPE0130
C EMPIRICAL FLAME-EMISSIVITY DATA                                       TAPE0131
C                                                                       TAPE0132
C     WHEN THIS TABLE IS SET UP CN THE DATA TAPE, NLUM IN BLOCK DATA    TAPE0133
C     SHOULD BE CHANGED TO 6.                                           TAPE0134
                                                                        TAPE0135
      IF(NLUM.NE.6)GOTO107                                              TAPE0136
      READ(KTAPE,2)      NTFT,NEFT,NPFT,NFORM                           TAPE0137
      READ(KTAPE,1) (TABTFT(I2),I2=1,NTFT),(TABPFT(I2),I2=1,NPFT),      TAPE0138
     1(TABEFT(I2),I2=1,NEFT)                                            TAPE0139
      DC 1055 I2=1,NTFT                                                 TAPE0140
 1055 TABTFT(I2)=TABTFT(I2)+TZ                                          TAPE0141
      READ(KTAPE,6)INDEX                                                TAPE0142
      IF(INDEX.NE.1)GOTO196                                             TAPE0143
      INDEX=0                                                           TAPE0144
  107 RETURN                                                            TAPE0145
  196 WRITE(JTAPE,99)                                                   TAPE0146
      WRITE(JTAPE,96)                                                   TAPE0147
      STCP                                                              TAPE0148
  197 WRITE(JTAPE,99)                                                   TAPE0149
      WRITE(JTAPE,97)                                                   TAPE0150
      STOP                                                              TAPE0151
  198 WRITE(JTAPE,99)                                                   TAPE0152
      WRITE(JTAPE,98)                                                   TAPE0153
      STOP                                                              TAPE0154
      END                                                               TAPE0155

 YOUR CARD TCTAL IS ---           157
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$IBFTC GEO     LIST                                                         0010
      SUBROUTINEGEOM                                                    GEOM0020
C                                                                       GEOM0030
C CALCULATES GEOMETRIC QUANTITIES AND FIXES LOCATIONS OF CALCULATION    GEOM0040
C     POINTS                                                            GEOM0050
C                                                                       GEOM0060
C COMMON STATEMENTS                                                     GEOM0070
                                                                        GEOM0080
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 1   GEOM0090
C     VIZ- B1,B12,B13,B16,B17,B18,B167,B168,B178,B1234,B1678,B12346     GEOM0100
                                                                        GEOM0110
      COMMON/B1/KTAPE,               XINT,PI4,NWH,NG,FFB(50),FTA(120)   GEOM0120
     1,FTB(120),NBLADE,NUMSW,     DSWLOU,DSWLIN,                        GEOM0130
     1TCATA(50),TCATB(50),HAB(50)                                       GEOM0140
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 GEOM0150
     1NRECT,NXDIF,NDIFF,NSNCUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       GEOM0160
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),                       GEOM0170
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  GEOM0180
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                GEOM0190
     5XMACH,RHOREF,EFDT(3)                                              GEOM0200
      COMMON/B16/COS(20,15),DPHS(20,15),FLCV,IH,        NABX(45)        GEOM0210
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   GEOM0220
     2,SHAFST,                                FIFTPR,       LCMFL,LCANILGEOM0230
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)    GEOM0240
     4,LCPTAL,PAFRZ,NHTU(50)                                            GEOM0250
     5,AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)                            GEOM0260
      COMMON/B13/      AREA1,NXDIFC,NYDIFB,NZDIFB,NCDIFB,E1DTAB         GEOM0270
     1,XLNDTB(20),EFDTAB(200),ARDTAB(200) ,                             GEOM0280
     1NWALL1,NWALL2                                                     GEOM0290
      COMMON/B17/ XHU(50),DXHU(50),EFC(2),   NEF,STEP,JKSN(50),NSH      GEOM0300
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH                   GEOM0310
      COMMON/B178/DFT(45)                                               GEOM0320
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             GEOM0330
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  GEOM0340
     2,NCODEB(45),TZ                                                    GEOM0350
      COMMON/B12678/JTAPE ,IPRINT                                       GEOM0360
      COMMON/B18/ABSW,EMW,EMC,NLUM,                         NHT1,NHT2   GEOM0370
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLTGEOM0380
     2W2,XFILMZ,       TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORMGEOM0390
     3,NCOOL,      NUMAX1,NUMAX2                                        GEOM0400
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,       AFA,AFB,PREDM,STAGTGEOM0410
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS                             GEOM0420
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          GEOM0430
     1,KANHET,LANHET,PERCO,THIKFT                                       GEOM0440
     2,DANA(45),DANB(45)                                                GEOM0450
                                                                        GEOM0460
C DIMENSION STATEMENTS                                                  GEOM0470
                                                                        GEOM0480
      DIMENSION HAT(50),XFC(51,5),AR(2),NAME(3)                         GEOM0490
                                                                        GEOM0500
C FUNCTION DEFINITIONS                                                  GEOM0510
                                                                        GEOM0520
      FINTRP(X,X1,X2,X3,Y1,Y2,Y3)=Y1*(X-X2)*(X-X3)/((X1-X2)*(X1-X3))+Y2*GEOM0530
     1(X-X1)*(X-X3)/((X2-X1)*(X2-X3))+Y3*(X-X1)*(X-X2)/((X3-X1)*(X3-X2))GEOM0540
      FINTL(X,X1,X2,Y1,Y2)=Y1+(X-X1)*(Y2-Y1)/(X2-X1)                    GEOM0550
                                                                        GEOM0560
C DATA DECLARATION                                                      GEOM0570
                                                                        GEOM0580
      DATA NAME(1)/18H INNER OUTER      /                               GEOM0590
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      DATANER,KMAX,  AHFCT,FBLAST,K2,K,       LA,LB/C,45  ,C.,0.,2*0,2*1/GEOM0600
      DATA AHTA,AHTB/2*0./                                              GEOM0610
                                                                        GEOM0620
C FORMAT STATEMENTS                                                      GEOM0630
                                                                        GEOM0640
  1   FORMAT(1H010F11.3)                                                GEOM0650
  2   FORMAT(1H010I11)                                                  GEOM0660
   12 FORMAT(52H0TOTAL COOLING AIR ENTRY PORT AREA IN THE DOME     =F6.3GEOM0670
     1,6H SQ FT/52H TOTAL PENETRATION AIR ENTRY PORT AREA IN THE DOME =FGEOM0680
     26.3,6H SQ FT,31H (INCLUDING TOTAL SWIRLER AREA)//45X7(2H- ),      GEOM0690
     315HFLAME TUBE WALL,7(2H- ))                                       GEOM0700
   13 FORMAT(53H0TOTAL COOLING PORT AREA IN THE FLAME-TUBE WALL     =F6.GEOM0710
     13,6H SQ FT/53H TOTAL PENETRATION PORT AREA IN THE FLAME-TUBE WALL GEOM0720
     2=F6.3,6H SQ FT)                                                   GEOM0730
   14 FORMAT(1XI4,F11.3,I5,2XA6,I7,2X3(2X2F8.3),3(F8.3,1X))             GEOM0740
   15 FORMAT(8H0REACHEDI3)                                              GEOM0750
   16 FORMAT(/////57H0DETAILS OF AIR ENTRY PORTS AND GEOMETRY AT EACH HOGEOM0760
     1LE ROW/1X56(1H-))                                                 GEOM0770
  17  FORMAT(//////30H THIS COMBUSTOR HAS NO SWIRLER/1X29(1H-))         GEOM0780
  18  FORMAT(//////15H SWIRLER DESIGN/1X14(1H-))                        GEOM0790
  19  FORMAT(21H0(SPECIFIED AS INPUT))                                  GEOM0800
  20  FORMAT(31H0(DESIGNED FROM EMPIRICAL DATA))                        GEOM0810
  21  FORMAT(28H0NUMBER OF SWIRLERS      =     I4,/28H NUMBER OF BLADES     GEOM0820
     1 =      I4,/26H BLADE STAGGER ANGLE    =  F6.2,9H  DEGREES/26H INNERGEOM0830
     2 DIAMETER          =  F6.2,8H  INCHES/26H OUTER DIAMETER        =  FGEOM0840
     36.2,8H  INCHES/25H AREA PER SWIRLER        = F7.2,48H  SQUARE INCHESGEOM0850
     4 (IGNORING BLOCKAGE DUE TO VANES))                                GEOM0860
   22 FORMAT(57H0RATIO OF TOTAL HOLE AREA (INCLUDING SWIRLER, DOME HOLESGEOM0870
     1,/59H COOLING SLOTS, AND PENETRATION HOLES) TO REFERENCE AREA  =F7GEOM0880
     2.3)                                                               GEOM0890
   61 FORMAT(           13H0HOLE   AXIAL5X81HHOLE  INNER  NUMBER    TOTALGEOM0900
     2 PORT AREA   RATIO TOTAL PORT  CUMULATIVE SUM   RATIO2(4X5HRATIO)/GEOM0910
     34H ROW4X18HPOSITION  TYPE  OR5X41HOF HOLES  AT THIS HOLE ROW  AREAGEOM0920
     4 THIS ROW5X13HOF AREA RATIO4X5HFLAME4X5HINNER4X5HOUTER/16H NUMBER GEOM0930
     5OF HOLE 8X28HOUTER  IN THIS   SQUARE FEET7X14HTO GRAND TOTAL4X13H(GEOM0940
     6LAST COLUMN)4X4HTUBE3X2(2X7HANNULUS)/8X8HCENTER- 8X10HWALL   ROW59GEOM0950
     7X3(9H C S AREA)/8X9HLINE      22X3(18H  PENETRAT COOLING),3(9H TO RGEOM0960
     8EF  )/8X6HINCHES25X3(6H  -ION5X7HSLOTS  ),3(5H AREA4X)/ 28X3(13X5HGEOM0970
     9HOLES)/,45X10(2H- ),4HDOME,10(2H -))                              GEOM0980
   63 FORMAT(1X,9HTHERE ARE,I3,10H HOLE ROWS)                           GEOM0990
  89  FORMAT(46H0THERE ARE NO JET-ANGLE DATA FOR HOLE TYPE NO.I4,67H.  TGEOM1000
     1HE INITIAL JET-ANGLE ESTIMATE USED IN THE PROGRAM IS NOT AT ALL/21GEOM1010
     2H ACCURATE FOR SCOOPS.)                                           GEOM1020
   91 FORMAT(19H1*** ERROR MESSAGE/22H NABX(1)=4 NOT ALLOWED)           GEOM1030
   93 FORMAT(42H1IX HAS EXCEEDED ITS LIMIT IN HOLE ROW NO.I3)           GEOM1040
   95 FORMAT(41H1K HAS EXCEEDED ITS LIMIT IN HOLE ROW NO.I3)            GEOM1050
                                                                        GEOM1060
C FIND REFERENCE AREA                                                    GEOM1070
                                                                        GEOM1080
      DO114I=1,NG                                                       GEOM1090
                                                                        GEOM1100
C --- TRUE ANNULUS                                                      GEOM1110
                                                                        GEOM1120
      IF(NRECT.EQ.1)A=(CB(I)**2-CA(I)**2)*PI4                           GEOM1130
                                                                        GEOM1140
C --- RECTANGULAR                                                       GEOM1150
                                                                        GEOM1160
      IF(NRECT.EQ.2) A=(CB(I)-CA(I))*WIDTH1                             GEOM1170
      D=CB(I)-CA(I)                                                     GEOM1180
      IF(I.EQ.1)AREA1=A                                                 GEOM1190
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*.........*.........*.........*.........*.........*.........*.........*.........*
  133 IF(AREF.GE.A)GOTO114                                              GEOM1200
      AREF=A                                                            GEOM1210
      DREF=D                                                            GEOM1220
  114 CONTINUE                                                          GEOM1230
                                                                        GEOM1240
C     SWIRLER DESIGN                                                    GEOM1250
                                                                        GEOM1260
      IF(K6)300,300,301                                                 GEOM1270
  300 WRITE(JTAPE,17)                                                   GEOM1280
      GO TO 305                                                         GEOM1290
  301 WRITE(JTAPE,18)                                                   GEOM1300
      IF(K6-1)302,302,303                                               GEOM1310
  302 WRITE(JTAPE,19)                                                   GEOM1320
      GO TO 304                                                         GEOM1330
  303 WRITE(JTAPE,20)                                                   GEOM1340
      DSWLOU=0.225*0.67*DREF+0.75                                       GEOM1350
      DSWLIN=0.1*0.67*DREF+0.25                                         GEOM1360
  304 ASW=PI*(DSWLOU**2-DSWLIN**2)/4.0                                  GEOM1370
      WRITE(JTAPE,21)NUMSW,NBLADE, BETA,DSWLIN,DSWLOU,ASW               GEOM1380
  305 CONTINUE                                                          GEOM1390
      BETA=BETA*PI/180.                                                 GEOM1400
      ASW=ASW/144.0                                                     GEOM1410
      ASW=ASW*FLOAT(NUMSW)                                              GEOM1420
      AHPT=ASW                                                          GEOM1430
  108 AHFCT=0.0                                                         GEOM1440
      I=1                                                               GEOM1450
      IF(NWH.NE.1) GO TO 1080                                           GEOM1460
      AHPTS=ASW                                                         GEOM1470
      AHFCTS=0.                                                         GEOM1480
      AHDOME=0.                                                         GEOM1490
 1080 DO122J=1,NH                                                       GEOM1500
      IF(J.GT.1.AND.FFB(J).LT.FFB(J-1)) FFB(J)=FFB(J-1)                 GEOM1510
      IF(J.GT.1.AND.TCATA(J).EQ.0.) TCATA(J)=TCATA(J-1)                 GEOM1520
      IF(J.GT.1.AND.TCATB(J).EQ.0.) TCATB(J)=TCATB(J-1)                 GEOM1530
      IF(NHTU(J).EQ.0)GOTO122                                           GEOM1540
C                    ** INCLUDE CARDS GEOM1551 AND 1555 ***             GEOM1550
      IF(DXHU(J).NE.0.)GOTO157                                          GEOM1551
      IF(NRECT.EQ.2)GO TO 1581                                          GEOM1555
  156 IF(X(I).GE.XH(J))GOTO158                                          GEOM1560
      I=I+1                                                             GEOM1570
      GOTO156                                                           GEOM1580
  158 IF(NAB(J).EQ.1)HAT(J)=HAU(J)*FINTL(XH(J),X(I-1),X(I),FTA(I-1),FTA(GEOM1590
     1I))*PI                                                            GEOM1600
      IF(NAB(J).EQ.2)HAT(J)=HAU(J)*FINTL(XH(J),X(I-1),X(I),FTB(I-1),FTB(GEOM1610
     1I))*PI                                                            GEOM1620
      GO TO 1582                                                        GEOM1623
 1581 HAT(J)=HAU(J)*WIDTH1                                              GEOM1627
 1582 AHFCT=AHFCT+HAT(J)                                                GEOM1629
C                    ** INCLUDE CARDS GEOM1623, 1627, AND 1629 **       GEOM1630
      GOTO162                                                           GEOM1640
  157 HAT(J)=HAU(J)*FLOAT(NHH(J))                                       GEOM1650
      AHPT=AHPT+HAT(J)                                                  GEOM1660
  162 IF(J.LT.NWH)GOTO1625                                              GEOM1670
      IF(NAB(J).EQ.1)AHTA=AHTA+HAT(J)                                   GEOM1680
      IF(NAB(J).EQ.2)AHTB=AHTB+HAT(J)                                   GEOM1690
      GOTO122                                                           GEOM1700
 1625 IF(J.NE.NWH-1)GOTO122                                             GEOM1710
      AHPTS=AHPT                                                        GEOM1720
      AHFCTS=AHFCT                                                      GEOM1730
      AHDOME=AHPTS+AHFCTS -ASW                                          GEOM1740
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*.........*.........*.........*.........*.........*.........*.........*.........*
  122 CONTINUE
      AHPTU=AHPT
      AHFCTU=AHFCT
      AHPTT=AHPTU-AHPTS
      AHFCTT=AHFCTU-AHFCTS

C MOVE DOWN FLAME TUBE WORKING OUT GEOMETRIC PARAMETERS AT HOLE
C      POSITIONS

      AHPT=ASW
      WHATT=ASW/AHPTU
      XHATT=0.
      AHFCT=0.
      I=1
      DO100J=1,NH
      IH=IHJ(J)
      IF(NSCOOP(IH).EQ.11)NER=NHTU(J)
  106 IF(X(I).GE.XH(J))GOTO118
      I=I+1
      GOTO106

C --- INTERPOLATE FOR GEOMETRY AT HOLE POSITION

  118 IF(DXHU(J).EQ.0.)GOTO110
      FTAHI=FINTL(XH(J),X(I-1),X(I),FTA(I-1),FTA(I))
      FTBHI=FINTL(XH(J),X(I-1),X(I),FTB(I-1),FTB(I))
      GOTO115
  110 FTAHI=FTA(I)
      FTBHI=FTB(I)
  115 CAHI=FINTRP(XH(J),X(I-2),X(I-1),X(I),CA(I-2),CA(I-1),CA(I))
      CBHI=FINTRP(XH(J),X(I-2),X(I-1),X(I),CB(I-2),CB(I-1),CB(I))
      IF(NRECT.EQ.2)GOTO121
  120 AFTAR=PI4*(FTBHI*FTBHI-FTAHI*FTAHI)/AREF
      AR(1)=PI4*(FTAHI**2-CAHI**2)/AREF
      AR(2)=PI4*(CBHI**2-FTBHI**2)/AREF
      GOTO117
  121 AFTAR=(FTBHI-FTAHI)/AREF *WIDTH1
      AR(1)=(FTAHI-CAHI)/AREF    *WIDTH1
      AR(2)=(CBHI-FTBHI)/AREF   *WIDTH1
  117 IF(NHTU(J).NE.0) GO TO 1170
      WHAT=0.
      XHAT=0.
      YHAT=0.
      ZHAT=0.
 1170 IF(NHTU(J).EQ.0)GOTO127

C FIND TOTAL HOLE AREAS IN COME AND FLAME TUBE WALL

      IF(DXHU(J).GT.0.0)GOTO123
      YHAT=0.
      ZHAT=HAT(J)
      AHFCT=AHFCT+HAT(J)
      GOTO124
  123 AHPT=AHPT+HAT(J)
      YHAT=HAT(J)
      ZHAT=0.
  124 WHAT=YHAT/AHPTU
      XHAT=ZHAT/AHFCTU
      WHATT=WHATT+WHAT
      XHATT=XHATT+XHAT
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*.........*.........*.........*.........*.........*.........*.........*.........*
  127 IF(J.NE.1) GO TO 1270                                             GEOM2350
      WRITE(JTAPE,16)                                                   GEOM2360
      WRITE(JTAPE,63) NH                                                GEOM2370
      WRITE(JTAPE,61)                                                   GEOM2380
      IF(NWH.EQ.1) WRITE(JTAPE,12) AHFCTS,AHPTS                         GEOM2390
 1270 CONTINUE                                                          GEOM2400
      XH(J)=12.*XH(J)                                                   GEOM2410
      IDUM=NAB(J)                                                       GEOM2420
      IF(NHTU(J).EQ.0) IDUM=3                                           GEOM2430
      WRITE(JTAPE,14)J,XH(J),NHTU(J),NAME(IDUM),NHH(J),YHAT,ZHAT,WHAT,XHGEOM2440
     1AT,WHATT,XHATT,AFTAR,AR(1),AR(2)                                  GEOM2450
      XH(J)=XH(J)/12.                                                   GEOM2460
      IF(J.EQ.NWH-1)WRITE(JTAPE,12)AHFCTS,AHPTS                         GEOM2470
      XHU(J)=XH(J)-DXHU(J)                                              GEOM2480
      XFC(J,1)=XHU(J)                                                   GEOM2490
      IF(DXHU(J).GT.0.0.OR.NHTU(J).EQ.0) GO TO 104                      GEOM2500
C                                                                       GEOM2510
C --- DUMMY LOCATIONS DOWNSTREAM OF COOLING SLOT, USED IN SELECTING     GEOM2520
C     CALCULATION POINTS                                                GEOM2530
C                                                                       GEOM2540
      DO126L=2,5                                                        GEOM2550
  126 XFC(J,L)=XFC(J,L-1)+XINT                                          GEOM2560
      GOTO100                                                           GEOM2570
  104 DO 131 L=2,5                                                      GEOM2580
      XFC(J,L)=999.9                                                    GEOM2590
  131 CONTINUE                                                          GEOM2600
  100 CONTINUE                                                          GEOM2610
      WRITE(JTAPE,13)AHFCTT,AHPTT                                       GEOM2620
      IF(AHDOME+ASW.LE.0.)AHDOME=.0001                                  GEOM2630
      AHT=AHTA+AHTB+AHDOME+ASW                                          GEOM2640
      AFA=AHTA/AHT                                                      GEOM2650
      AFB=AHTB/AHT                                                      GEOM2660
      AHRAT=AHT/AREF                                                    GEOM2670
      WRITE(JTAPE,22)AHRAT                                              GEOM2680
      IF(NER.NE.0)WRITE(JTAPE,89)NER                                    GEOM2690
      XFC(NH+1,1)=X(NG)                                                 GEOM2700
                                                                        GEOM2710
C FIX CALCULATION POINTS                                                GEOM2720
                                                                        GEOM2730
C     K IS THE INDEX ON CALCULATION POINTS. IT RUNS FROM 1 TO NLAST, WHIGEOM2740
C         IS AT THE VERY END OF THE COMBUSTOR.                          GEOM2750
C     J IS THE INDEX ON HOLE ROWS. IT EQUALS NWH FOR THE FIRST CALCULATIGEOM2760
C         POINT ( K = 1 ).                                              GEOM2770
C     I IS THE INDEX ON GEOMETRIC INPUT POINTS.                         GEOM2780
C     K2 = 1 WHEN THERE ARE HOLES ON BOTH WALLS AT THIS CALCULATION POINGEOM2790
C     JA IS THE VALUE OF J AT THE MOST RECENT HOLE ROW ON THE INNER WALLGEOM2800
C     JB IS THE VALUE OF J AT THE MOST RECENT HOLE ROW ON THE OUTER WALLGEOM2810
C     LA APPLIES MAINLY TO CONTINUOUS COOLING SLOTS. IT RUNS FROM 2 TO 6GEOM2820
C         INTERVALS OF XINT DOWNSTREAM OF EACH SLOT ON THE INNER WALL   GEOM2830
C     LB DOES THE SAME ON THE OUTER WALL                                GEOM2840
C     L = 1 IF THERE IS A FRESH HOLE AT THE CURRENT CALCULATION POINT   GEOM2850
C     NCODEA(K) = 1 WHEN THERE IS A COOLING SLOT ON THE INNER WALL  AT  GEOM2860
C         THE CURRENT CALCULATION POINT.                                GEOM2870
C     IX RUNS FROM 1 TO 6 FOR THE VARIOUS HOLE ROWS AT EACH CALCULATION GEOM2880
C     NABX(K) = 1 IF THERE ARE HOLES ON THE INNER WALL AT THIS CALCULATIGEOM2890
C     NABX(K) = 2 IF THERE ARE HOLES ON THE OUTER WALL AT THIS CALCULATIGEOM2900
C     NABX(K) = 3 IF THERE ARE HOLES ON BOTH WALLS AT THIS CALCULATION PGEOM2910
C     NABX(K) = 4 IF THERE ARE NO HOLES AT THIS CALCULATION POINT       GEOM2920
                                                                        GEOM2930
      I=1                                                               GEOM2940
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*.........*.........*.........*.........*.........*.........*.........*.........*
      J=NWH-1                                                           GEOM2950
      JLAST=J                                                           GEOM2960
      K2=0                                                              GEOM2970
      NSHCP=0                                                           GEOM2980
      JA=NH                                                             GEOM2990
      JB=NH                                                             GEOM3000
  112 K=K+1                                                             GEOM3010
      IX=1                                                              GEOM3020
      IF(K.GT.KMAX)GOTO199                                              GEOM3030
      IF(JA.EQ.JB.AND.NAB(JA).EQ.1.AND.JA.LE.NH) JB=JA+1                GEOM3040
      IF(JA.EQ.JB.AND.NAB(JA).EQ.2.AND.JA.LE.NH) JA=JB+1                GEOM3050
      XCP(K)=AMIN1(XFC(JA,LA),XFC(JB,LB),XFC(J+1,1))                    GEOM3060
      IF(ABS(XCP(K)-XFC(J+1,1))/XCP(K).LE.0.00001) XCP(K)=XFC(J+1,1)    GEOM3070
      IF(XCP(K).EQ.XFC(J+1,1))GOTO125                                   GEOM3080
      IF(XCP(K).EQ.XFC(JA,LA))GOTO152                                   GEOM3090
  154 IF(DXHU(J).NE.0..OR.LB.NE.1)GOTO109                               GEOM3100
      NCODEB(K)=1                                                       GEOM3110
      NABX(K)=2                                                         GEOM3120
  109 L=LB                                                              GEOM3130
      LB=LB+1                                                           GEOM3140
      IF(K2.EQ.1)LA=LB                                                  GEOM3150
      IF(LB.LE.5)GOTO153                                                GEOM3160
      LB=1                                                              GEOM3170
      JB=NH+1                                                           GEOM3180
      GOTO153                                                           GEOM3190
  125 J=J+1                                                             GEOM3200
      IF(J.EQ.NH+1) GO TO 150                                           GEOM3210
      IF(J.EQ.NSH)NSHCP=K                                               GEOM3220
      JKSN(J)=K                                                         GEOM3230
      IF(NHTU(J).EQ.0) GO TO 1250                                       GEOM3240
      IF(NAB(J).NE.1)GOTO128                                            GEOM3250
      IF(DXHU(J).EQ.0.)NCODEA(K)=1                                      GEOM3260
      JA=J                                                              GEOM3270
      LA=2                                                              GEOM3280
  128 IF(NAB(J).NE.2)GOTO130                                            GEOM3290
      IF(DXHU(J).EQ.0.)NCODEB(K)=1                                      GEOM3300
      JB=J                                                              GEOM3310
      LB=2                                                              GEOM3320
  130 L=1                                                               GEOM3330
      NABX(K)=NAB(J)                                                    GEOM3340
      K2=0                                                              GEOM3350
      GOTO153                                                           GEOM3360
 1250 IF(ABS(XH(J)-XFC(JA,LA))/XH(J).LE.0.00001) LA=LA+1                GEOM3370
      IF(ABS(XH(J)-XFC(JB,LB))/XH(J).LE.0.00001) LB=LB+1                GEOM3380
       NABX(K)=4                                                        GEOM3390
      KJSN(K,1)=J                                                       GEOM3400
      IF(LA.LE.5) GO TO 1251                                            GEOM3410
      LA=1                                                              GEOM3420
      JA=NH+1                                                           GEOM3430
 1251 IF(LB.LE.5) GO TO 153                                             GEOM3440
      LB=1                                                              GEOM3450
      JB=NH+1                                                           GEOM3460
      GO TO 153                                                         GEOM3470
  150 NLAST=K                                                           GEOM3480
      XCP(K)=X(NG)                                                      GEOM3490
      FFIZ(K)=0.                                                        GEOM3500
      FTACPI=FTA(NG)                                                    GEOM3510
      FTBCPI=FTB(NG)                                                    GEOM3520
      CACPI=CA(NG)                                                      GEOM3530
      CBCPI=CB(NG)                                                      GEOM3540
```

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*.........*.........*.........*.........*.........*.........*.........*.........*
      NABX(K)=4                                                         GEOM3550
      TCASA(K)=TCASA(K-1)                                               GEOM3560
      TCASB(K)=TCASB(K-1)                                               GEOM3570
      GOTO1345                                                          GEOM3580
  152 IF(DXHU(J).NE.0..OR.LA.NE.1)GOTO102                               GEOM3590
      NCODEA(K)=1                                                       GEOM3600
      NABX(K)=1                                                         GEOM3610
  102 L=LA                                                              GEOM3620
      LA=LA+1                                                           GEOM3630
      IF(K2.EQ.1)LB=LA                                                  GEOM3640
      IF(LA.LE.5)GOTO153                                                GEOM3650
      LA=1                                                              GEOM3660
      JA=NH+1                                                           GEOM3670
      IF(K2.NE.1)GOTO153                                                GEOM3680
      JB=NH+1                                                           GEOM3690
      LB=1                                                              GEOM3700
                                                                        GEOM3710
C QUANTITIES REQUIRED AT EACH CALCULATION POINT                         GEOM3720
                                                                        GEOM3730
  153 IF(JLAST.NE.0) GO TO 1530                                         GEOM3740
      TCASA(1)=TCATA(1)                                                 GEOM3750
      TCASB(1)=TCATB(1)                                                 GEOM3760
      FBTOT=FFB(1)                                                      GEOM3770
      GO TO 1540                                                        GEOM3780
 1530 IF(JLAST.NE.NH) GO TO 1541                                        GEOM3790
      TCASA(K)=TCASA(K-1)                                               GEOM3800
      TCASB(K)=TCASB(K-1)                                               GEOM3810
      FBTOT=FBLAST                                                      GEOM3820
      GO TO 1540                                                        GEOM3830
 1541 FBTOT=FINTL(XCP(K),XH(JLAST),XH(JLAST+1),FFB(JLAST),FFB(JLAST+1)) GEOM3840
      TCASA(K)=FINTL(XCP(K),XH(JLAST),XH(JLAST+1),TCATA(JLAST),TCATA(JLAGEOM3850
     1ST+1))                                                            GEOM3860
      TCASB(K)=FINTL(XCP(K),XH(JLAST),XH(JLAST+1),TCATB(JLAST),TCATB(JLAGEOM3870
     1ST+1))                                                            GEOM3880
 1540 FFIZ(K)=FBTOT-FBLAST                                              GEOM3890
      FBLAST=FBTOT                                                      GEOM3900
  113 IF(X(I).GE.XCP(K))GOTO134                                         GEOM3910
      I=I+1                                                             GEOM3920
      GOTO113                                                           GEOM3930
  134 FTACPI=FINTL(XCP(K),X(I-1),X(I),FTA(I-1),FTA(I))                  GEOM3940
      FTBCPI=FINTL(XCP(K),X(I-1),X(I),FTB(I-1),FTB(I))                  GEOM3950
      CACPI=FINTRP(XCP(K),X(I-2),X(I-1),X(I),CA(I-2),CA(I-1),CA(I))     GEOM3960
      CBCPI=FINTRP(XCP(K),X(I-2),X(I-1),X(I),CB(I-2),CB(I-1),CB(I))     GEOM3970
 1345 IF(NRFCT.EQ.2)GOTO136                                             GEOM3980
  135 AFT(K)=PI4*(FTBCPI*FTBCPI-FTACPI*FTACPI)                          GEOM3990
      AANA(K)=PI4*(FTACPI*FTACPI-CACPI*CACPI)                           GEOM4000
      AANB(K)=PI4*(CBCPI*CBCPI-FTBCPI*FTBCPI)                           GEOM4010
      CCA(K)=PI*CACPI                                                   GEOM4020
      CCB(K)=PI*CBCPI                                                   GEOM4030
      CFTA(K)=PI*FTACPI                                                 GEOM4040
      CFTB(K)=PI*FTBCPI                                                 GEOM4050
      DFT(K)=FTBCPI-FTACPI                                              GEOM4060
      DANA(K)=FTACPI-CACPI                                              GEOM4070
      DANB(K)=CBCPI-FTBCPI                                              GEOM4080
      GOTO116                                                           GEOM4090
  136 AFT(K)=(FTBCPI-FTACPI)*WIDTH1                                     GEOM4100
      AANA(K)=(FTACPI-CACPI)*WIDTH1                                     GEOM4110
      AANB(K)=(CBCPI-FTBCPI)*WIDTH1                                     GEOM4120
      CCA(K)=WIDTH1                                                     GEOM4130
      CCB(K)=WIDTH1                                                     GEOM4140
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*.........*.........*.........*.........*.........*.........*.........*.........*
      CFTA(K)=WIDTH1                                                    GEOM4150
      CFTB(K)=WIDTH1                                                    GEOM4160
      DFT(K)=2.*(FTBCPI-FTACPI)                                         GEOM4170
      DANA(K)=2.*(FTACPI-CACPI)                                         GEOM4180
      DANB(K)=2.*(CBCPI-FTBCPI)                                         GEOM4190
  116 AANA(K)=AANA(K)*COS(ATAN((CA(I)+FTA(I)-CA(I-1)-FTA(I-1))/         GEOM4200
     1                                      (2.*(X(I)-X(I-1)))))        GEOM4210
      AANB(K)=AANB(K)*COS(ATAN((CB(I)+FTB(I)-CB(I-1)-FTB(I-1))/         GEOM4220
     1                                      (2.*(X(I)-X(I-1)))))        GEOM4230
      IF(K.EQ.NLAST)GO TO 111                                           GEOM4240
      IF(L.EQ.1)GOTO151                                                 GEOM4250
      NABX(K)=4                                                         GEOM4260
      GOTO112                                                           GEOM4270
  151 KJSN(K,IX)=J                                                      GEOM4280
      IF(J.EQ.NH)GOTO1030                                               GEOM4290
  103 IF(XH(J+1).LE.XH(J)) GO TO 1310                                   GEOM4300
 1030 JLAST=J                                                           GEOM4310
      GOTO112                                                           GEOM4320
                                                                        GEOM4330
C --- ADVANCE J UNTIL ALL HOLE ROWS AT THIS CALCULATION POINT COMPLETED GEOM4340
                                                                        GEOM4350
 1310 J=J+1                                                             GEOM4360
      JKSN(J)=K                                                         GEOM4370
      IF(NAB(J).NE.1)GOTO132                                            GEOM4380
      JA=J                                                              GEOM4390
      LA=2                                                              GEOM4400
  132 IF(NAB(J).NE.2)GOTO149                                            GEOM4410
      JB=J                                                              GEOM4420
      LB=2                                                              GEOM4430
  149 IX=IX+1                                                           GEOM4440
      IF(IX.GE.7)GOTO193                                                GEOM4450
      IF(K2.EQ.1.OR.NAB(J-1).EQ.NAB(J))GOTO151                          GEOM4460
      NABX(K)=3                                                         GEOM4470
      IF(NAB(J).EQ.1.AND.CXHU(J).EQ.0.)NCODEA(K)=1                      GEOM4480
      IF(NAB(J).EQ.2.AND.CXHU(J).EQ.0.)NCODEB(K)=1                      GEOM4490
      K2=1                                                              GEOM4500
      GOTO151                                                           GEOM4510
                                                                        GEOM4520
C      CHANGE DIAMETERS OF ANNULAR COMBUSTOR TO RADII                   GEOM4530
                                                                        GEOM4540
  111 IF(NRECT.EQ.2)GOTO163                                             GEOM4550
      DO 164 I=1,NG                                                     GEOM4560
      CA(I)=CA(I)/2.                                                    GEOM4570
      SA(I)=SA(I)/2.                                                    GEOM4580
      FTA(I)=FTA(I)/2.                                                  GEOM4590
      FTB(I)=FTB(I)/2.                                                  GEOM4600
      SB(I)=SB(I)/2.                                                    GEOM4610
  164 CB(I)=CB(I)/2.                                                    GEOM4620
                                                                        GEOM4630
C SET INDICES REQUIRED IN DIFFUSER SUBPROGRAM                           GEOM4640
                                                                        GEOM4650
  163 I=0                                                               GEOM4660
                                                                        GEOM4670
C --- MOVE TO FIRST ROW ON WALL                                         GEOM4680
                                                                        GEOM4690
  138 I=I+1                                                             GEOM4700
      IF(X(I).LE.XCP(1))GO TO 138                                       GEOM4710
      JJ=NABX(1)                                                        GEOM4720
      GO TO (139,140,141,142),JJ                                        GEOM4730
                                                                        GEOM4740
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*........*.........*.........*.........*.........*.........*.........*.........*
C --- FIRST RCW ON INNER WALL                                           GECM4750
                                                                        GECM4760
  139 NXDIFA=I-1                                                        GEOM4770
  143 K=K+1                                                             GECM4780
      IF(NABX(K).NE.2.AND.NABX(K).NE.3)GO TC 143                        GEOM4790
  145 IF(X(I).GT.XCP(K))GC TO 144                                       GEOM4800
      I=I+1                                                             GEOM4810
      GO TO 145                                                         GECM4820
  141 NXDIFA=I-1                                                        GECM4830
  144 NXDIFB=I-1                                                        GEOM4840
      GC TO 146                                                         GEOM4850
                                                                        GECM4860
C --- FIRST RCW CN CUTER WALL                                            GECM4870
  140 NXDIFB=I-1                                                        GECM4880
  148 K=K+1                                                             GEOM4890
      IF(NABX(K).NE.1.ANC.NABX(K).NE.3)GO TO 148                        GEOM4900
  159 IF(X(I).GT.XCP(K))GC TO 160                                       GECM4910
      I=I+1                                                             GECM4920
      GC TO 159                                                         GEOM4930
  160 NXDIFA=I-1                                                        GEOM4940
  146 CCNTINUE                                                          GEOM4950
      RETURN                                                            GEOM4960
  193 WRITE(JTAPE,93)J                                                  GEOM4970
      GCTO200                                                           GEOM4980
  199 WRITE(JTAPE,95)J                                                  GECM4990
      GC TO 200                                                         GEOM5000
  142 WRITE(JTAPE,91)                                                   GEOM5010
  200 STCP                                                              GEOM5020
C                                                                       GEOM5030
      END                                                               GEOM5040
  YOUR CARD TCTAL IS ---               510
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$IBFTC DIFL
      SUBROUTINE DIFLOW                                                 DIFL0010
C                                                                       DIFL0020
C     THIS SUBROUTINE CONTROLS THE DIFFUSER CALCULATION                 DIFL0030
C                                                                       DIFL0040
C                                                                       DIFL0050
C     NDIFF CONTROLS  THE METHOD OF CALCULATING THE DIFFUSER            DIFL0060
C     PERFORMANCE                                                       DIFL0070
C     1 IN TEN POSITION  = USE STREAMTUBE ANALYSIS UP TO SNOUT          DIFL0080
C     2 IN TEN POSITION  = USE EMPIRICAL DATA UP TO SNOUT               DIFL0090
C     1 IN UNIT POSITION = USE STREAMTUBE ANALYSIS AFTER SNOUT LIP      DIFL0100
C     2 IN UNIT POSITION = USE EMPIRICAL DATA AFTER SNOUT LIP           DIFL0110
C     3 IN UNIT POSITION = USE MIXING EQUATION AFTER SNOUT LIP          DIFL0120
C     POSITIVE SIGN      = USE EFFECTIVENESS PLOT                       DIFL0130
C     NEGATIVE SIGN      = USE SPECIFIC DIFFUSER DATA                   DIFL0140
C                                                                       DIFL0150
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),DIFL0160
     1NGO,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,    ZZCP,IDIF      DIFL0170
     2,HSEP  ,FLAREA(50),AREA(50)                                       DIFL0180
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 DIFL0190
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       DIFL0200
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),                       DIFL0210
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  DIFL0220
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                DIFL0230
     5XMACH,RHOREF,EFDT(3)                                              DIFL0240
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,        AFA,AFB,PREDM,STAGTDIFL0250
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS                             DIFL0260
      COMMON/B12678/JTAPE ,IPRINT                                       DIFL0270
      COMMON/BZERO/ALPHA1(50),ALPHA2(50),ALPHA3(50),ALPHA4(50),DMY(400) DIFL0280
      COMMON/BPLOS/PLOSS(2)                                             DIFL0290
      DIMENSION ASTAR(2),ARAT(3),AFUN(3),DPT(3),AR(2),CPID(2),CPAC(2),  DIFL0300
     1AF(2),PDLS(3)                                                     DIFL0310
C                                                                       DIFL0320
 8765 FORMAT(7H0DIFLOW10F11.3/(7X10F11.3))                              DIFL0330
C                                                                       DIFL0340
C     CALCULATE GAS PROPERTIES AND CHOOSE ROUTING THROUGH DIFFUSER      DIFL0350
C     SUBPROGRAM                                                        DIFL0360
C                                                                       DIFL0370
      IBL=1                                                             DIFL0380
      IDIF=0                                                            DIFL0390
      IF(NRECT.EQ.2) AF2=AF2/WIDTH1                                     DIFL0400
      CALL GASTBL(D1,D2,D3,D4,-1,D6,ZZR,ZZGAMA)                         DIFL0410
      ZZCP=ZZR*ZZGAMA/(ZZGAMA-1.)                                       DIFL0420
      IF(NDIFF) 90,99,98                                                DIFL0430
   90 IDIF=1                                                            DIFL0440
      NDIFF=-NDIFF                                                      DIFL0450
      GO TO 99                                                          DIFL0460
   98 IDIF=0                                                            DIFL0470
   99 NWAY=NDIFF/10                                                     DIFL0480
      NGO =NDIFF - NWAY*10                                              DIFL0490
      IF(IDIF.EQ.1) NDIFF=-NDIFF                                        DIFL0500
C                                                                       DIFL0510
C     CALCULATE DIFFUSER PERFORMANCE FROM COMPRESSOR EXIT TO THE LIP OF DIFL0520
C     SNOUT OR TO THE DOME                                              DIFL0530
C                                                                       DIFL0540
      GO TO (100,140),NWAY                                              DIFL0550
  100 CALL TUBCIS                                                       DIFL0560
      IF(IBL) 140,140,1401                                              DIFL0570
  140 NWAY=2                                                            DIFL0580
      IF(NGO) 1400,141,1400                                             DIFL0590
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  141 NGO=2                                                              DIFL0600
      IBL=1                                                              DIFL0610
 1400 CALL EMPCTS                                                        DIFL0620
      IF(IBL) 1401,900,1401                                              DIFL0630
 1401 IF(NSNCUT.EQ.1) GO TO 150                                          DIFL0640
  102 PREDM=PRES(NXDIF)                                                  DIFL0650
  111 A1=0.                                                              DIFL0660
      B1=0.                                                              DIFL0670
      GO TO (1570,1580),NRECT                                            DIFL0680
C                                                                        DIFL0690
C     CALCULATE VARIOUS GEOMETRIC PROPERTIES OF THE ANNULUS DIFFUSER     DIFL0700
C                                                                        DIFL0710
  150 CALL SLOPE(X,CA,NXDIF  ,NXDIFA,ALPHA1,NXDIFA+1)                    DIFL0720
      CALL SLOPE(X,SA,NXDIF+2,NXDIFA,ALPHA2,NXDIFA+1)                    DIFL0730
      CALL SLOPE(X,CB,NXDIF  ,NXDIFB,ALPHA3,NXDIFB+1)                    DIFL0740
      CALL SLOPE(X,SB,NXDIF+2,NXDIFB,ALPHA4,NXDIFB+1)                    DIFL0750
      NXDF1=NXDIF+1                                                      DIFL0760
      NXDF2=NXDIF+2                                                      DIFL0770
      NXDFA1=NXDIFA-1                                                    DIFL0780
      NXDFB1=NXDIFB-1                                                    DIFL0790
      DO 1500 I=NXDIF,NXDF1                                              DIFL0800
      ALPHA2(I)=ALPHA1(I)                                                DIFL0810
 1500 ALPHA4(I)=ALPHA3(I)                                                DIFL0820
      DO 151 I=NXDIF,NXDIFA                                              DIFL0830
      DD=1.                                                              DIFL0840
      DE=1.                                                              DIFL0850
      IF(ALPHA1(I).LT.0.) DD=-1.                                         DIFL0860
      IF(ALPHA2(I).LT.0.) DE=-1.                                         DIFL0870
      ALPHA1(I)=DD*ATAN(DD*ALPHA1(I))                                    DIFL0880
  151 ALPHA2(I)=DE*ATAN(DE*ALPHA2(I))                                    DIFL0890
      DO 152 I=NXDIF,NXDIFB                                              DIFL0900
      DD=1.                                                              DIFL0910
      DE=1.                                                              DIFL0920
      IF(ALPHA3(I).LT.0.) DD=-1                                          DIFL0930
      IF(ALPHA4(I).LT.0.) DE=-1.                                         DIFL0940
      ALPHA3(I)=DD*ATAN(DD*ALPHA3(I))                                    DIFL0950
  152 ALPHA4(I)=DE*ATAN(DE*ALPHA4(I))                                    DIFL0960
  156 A=(ALPHA1(NXDIF+1)+ALPHA2(NXDIF+1))/2.                             DIFL0970
      B=(ALPHA3(NXDIF+1)+ALPHA4(NXDIF+1))/2.                             DIFL0980
      A1=(ALPHA1(NXDIFA)+ALPHA2(NXDIFA))/2.                              DIFL0990
      B1=(ALPHA3(NXDIFB)+ALPHA4(NXDIFB))/2.                              DIFL1000
      GO TO (157,158),NRECT                                              DIFL1010
  157 THA1=(SA(NXDIF+1)**2-CA(NXDIF+1)**2)*3.141593 *COS(A)              DIFL1020
      THB1=(CB(NXDIF+1)**2-SB(NXDIF+1)**2)*3.141593 *COS(B)              DIFL1030
      THS1=(SB(NXDIF+1)**2-SA(NXDIF+1)**2)*3.141593                      DIFL1040
 1570 SUMA=( SA(NXDIFA)**2-CA(NXDIFA)**2)*3.141593                       DIFL1050
      SUMB=(CB(NXDIFB)**2- SB(NXDIFB)**2)*3.141593                       DIFL1060
      GO TO 159                                                          DIFL1070
  158 THA1=(SA(NXDIF+1)-CA(NXDIF+1))*COS(A)                              DIFL1080
      THB1=(CB(NXDIF+1)-SB(NXDIF+1))*COS(B)                              DIFL1090
      THS1=SB(NXDIF+1)-SA(NXDIF+1)                                       DIFL1100
 1580 SUMA=( SA(NXDIFA)-CA(NXDIFA))                                      DIFL1110
      SUMB=(CB(NXDIFB)- SB(NXDIFB))                                      DIFL1120
  159 CONTINUE                                                           DIFL1130
      GO TO (1590,1591,1592),NGO                                         DIFL1140
 1590 CALL TUBSTA                                                        DIFL1150
      GO TO 1600                                                         DIFL1160
 1591 CALL EMPSTA                                                        DIFL1170
      GO TO 1600                                                         DIFL1180
 1592 COR1=0.                                                            DIFL1190
      COR2=0.                                                            DIFL1200
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      DO 240 I=NXDF2,NXDFA1                                             DIFL1210
      TURN=ABS(ALPHA1(I)-ALPHA1(I-1)+ALPHA2(I)-ALPHA2(I-1))/2.          DIFL1220
      RADC=(X(I)-X(I-1))/COS((ALPHA1(I)+ALPHA2(I))/2.)/TURN             DIFL1230
      C=(SA(I)-CA(I))*COS((ALPHA1(I)+ALPHA2(I))/2.)                     DIFL1240
      DHY=1.      /32./2.*((SA(NXDIF+1)-CA(NXDIF+1))*COS(A )/C)**2      DIFL1250
  240 COR1 =COR1 +DHY*(0.124+3.1*SQRT(C/2./RADC))*TURN/3.14159          DIFL1260
      DO 241 I=NXDF2,NXDFB1                                             DIFL1270
      TURN=ABS(ALPHA3(I)-ALPHA3(I-1)+ALPHA4(I)-ALPHA4(I-1))/2.          DIFL1280
      RADC=(X(I)-X(I-1))/COS((ALPHA3(I)+ALPHA4(I))/2.)/TURN             DIFL1290
      C=(CB(I)-SB(I))*COS((ALPHA3(I)+ALPHA4(I))/2.)                     DIFL1300
      DHY=1.      /32./2.*((CB(NXDIF+1)-SB(NXDIF+1))*COS(B )/C)**2      DIFL1310
  241 COR2 =COR2 +DHY*(0.124+3.1*SQRT(C/2./RADC))*TURN/3.14159          DIFL1320
 1600 IF(NRECT.EQ.2) AF2=AF2*WIDTH1                                     DIFL1330
      DPHSNT=STPREF-PREDM                                               DIFL1340
      AG=A                                                              DIFL1350
      BG=B                                                              DIFL1360
      RETURN                                                            DIFL1370
C                                                                       DIFL1380
C     DIFFUSER CALCULATION ENTERED HERE DURING MASS FLOW ITERATION      DIFL1390
C                                                                       DIFL1400
      ENTRY DIFLW                                                       DIFL1410
      IF(NRECT.EQ.2) AF2=AF2/WIDTH1                                     DIFL1420
      AF(1)=AFA                                                         DIFL1430
      AF(2)=AFB                                                         DIFL1440
      IF(NSNOUT.EQ.1) GO TO 200                                         DIFL1450
C                                                                       DIFL1460
C     PRESSURE DOWN STREAM OF DIFFUSER CALCULATED AS AN ISENTROPIC      DIFL1470
C     EXPANSION FROM PRESSURE(DOME) AND TSTAG.                          DIFL1480
C                                                                       DIFL1490
  165 PREM=STPREF-DOMLOS*(STPREF-PREDM)                                 DIFL1500
      PNRTA=STPREF-DOMLOS*DPHSNT                                        DIFL1510
      PNRTB=PNRTA                                                       DIFL1520
      ASTAR(1)=AFA*SQRT(ZZCP*STAGT*(ZZGAMA-1.)*32.)*(1.+(ZZGAMA-1.)/2.) DIFL1530
     1**((ZZGAMA+1.)/(ZZGAMA-1.)/2.)/(PREM *32.)/(ZZGAMA)               DIFL1540
      ASTAR(2)=ASTAR(1)*AFB/AFA                                         DIFL1550
      AAS=SUMA/ASTAR(1)                                                 DIFL1560
      CALL GASTBL(AAS,TTO,Z,D4,1,IBL,D7,D8)                             DIFL1570
      IF(IBL) 900,900,166                                               DIFL1580
  166 PAN1A= Z *PREM                                                    DIFL1590
      TAN1A=TTO*STAGT                                                   DIFL1600
      AAS=SUMB/ASTAR(2)                                                 DIFL1610
      CALL GASTBL(AAS,TTO,Z,D4,1,IBL,D7,D8)                             DIFL1620
      IF(IBL) 900,900,169                                               DIFL1630
  169 PAN1B=Z*PREM                                                      DIFL1640
      TAN1B=TTO*STAGT                                                   DIFL1650
      DP=(STPREF-PREM )/STPREF                                          DIFL1660
      IF(IPRINT)190,190,170                                             DIFL1670
  170 CALL DOUTP1(NSNOUT,PREM ,PAN1A,D4,D5,D6,D7,3,1,D8,DP)             DIFL1680
      CALL DOUTP1(NSNOUT,PREM ,PAN1B,D4,D5,D6,D7,3,2,D8,DP)             DIFL1690
  190 GO TO 900                                                         DIFL1700
  200 GO TO (210,220),NWAY                                              DIFL1710
C                                                                       DIFL1720
                                                                        DIFL1730
C     USE STREAM TUBE ANALYSIS                                          DIFL1740
C                                                                       DIFL1750
  210 CALL TUBFW1                                                       DIFL1760
      GO TO 230                                                         DIFL1770
C                                                                       DIFL1780
C     USE EMPIRICAL DATA                                                DIFL1790
C                                                                       DIFL1800
  220 CALL EMPDT1                                                       DIFL1810
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C                                                                       DIFL1820
C     MIXING EQUATION USED IN DIFFUSING PASSAGE BEYOND THE SNOUT LIP    DIFL1830
C     USE SUDDEN EXPANSION OR CONTRACTION ANALYSIS                      DIFL1840
C                                                                       DIFL1850
  230 THA=THA*COS(AG)                                                   DIFL1860
      THB=THB*COS(BG)                                                   DIFL1870
      BETAS=1.                                                          DIFL1880
      ARAT(1)=THA/THA1                                                  DIFL1890
      ARAT(2)=THB/THB1                                                  DIFL1900
      ARAT(3)=THS/THS1                                                  DIFL1910
      DO 235 I=1,3                                                      DIFL1920
      IF(ARAT(I)-1.)232,232,231                                         DIFL1930
  231 AFUN(I)=(3.*ARAT(I)**2.-2.-ARAT(I))/4.                            DIFL1940
      HDLS(I)=0.5*(1.-1./ARAT(I))                                       DIFL1950
      GO TO 235                                                         DIFL1960
  232 AFUN(I)=ARAT(I)**2-ARAT(I)                                        DIFL1970
      HDLS(I)=(1.-ARAT(I))**2                                           DIFL1980
  235 CONTINUE                                                          DIFL1990
      RHA =AFA/THA/XMVA                                                 DIFL2000
      RHB =AFB/THB/XMVB                                                 DIFL2010
      RHS =(AF2-AFA-AFB)/THS/XMVS                                       DIFL2020
      XV2S=(BETAS*XMVS)**2                                              DIFL2030
      XV2A=(BETA1*XMVA)**2                                              DIFL2040
      XV2B=(BETA2*XMVB)**2                                              DIFL2050
      PANDA=PRES(NXDIF)-RHA*XV2A*AFUN(1)/32.                            DIFL2060
      PANDB=PRES(NXDIF)-RHB*XV2B*AFUN(2)/32.                            DIFL2070
      PREDM=PRES(NXDIF)-RHS*XV2S*AFUN(3)/32.                            DIFL2080
      A=(AFA*ZZR/PANDA/THA1)**2/(2.*32.18*ZZCP)                         DIFL2090
      TSTAT=(-1.+SQRT(1.+4.*A*STAGT))/2./A                              DIFL2100
      PLOSS(1)=HDLS(1)*RHA*XV2A/64.36                                   DIFL2110
      RH2PA=PANDA/ZZR/TSTAT                                             DIFL2120
      V2PRA=AFA/THA1/RH2PA                                              DIFL2130
      A=(AFB*ZZR/PANDB/THB1)**2/(2.*32.18*ZZCP)                         DIFL2140
      TSTAT=(-1.+SQRT(1.+4.*A*STAGT))/2./A                              DIFL2150
      PLOSS(2)=HDLS(2)*RHB*XV2B/64.36                                   DIFL2160
      RH2PB=PANDB/ZZR/TSTAT                                             DIFL2170
      V2PRB=AFB/THB1/RH2PB                                              DIFL2180
      THA=THA/COS(AG)                                                   DIFL2190
      THB=THB/COS(BG)                                                   DIFL2200
      DPHSNT=RHS*(XMVS*ARAT(3))**2/2./32.                               DIFL2210
      GO TO (300,310,2300),NGO                                          DIFL2220
C                                                                       DIFL2230
C     MIXING EQUATION IS USED TO GIVE PRESSURE IN ANNULUS               DIFL2240
C                                                                       DIFL2250
 2300 THA=THA*COS(AG)                                                   DIFL2260
      THB=THB*COS(BG)                                                   DIFL2270
      ARAT(1)=SUMA/THA1                                                 DIFL2280
      ARAT(2)=SUMB/THB1                                                 DIFL2290
      BLN=0.                                                            DIFL2300
      PAN1A=PANDA+(1.+1./ARAT(1))*(BETA1-1./ARAT(1))*RH2PA*V2PRA**2/64.4DIFL2310
      PAN1B=PANDB+(1.+1./ARAT(2))*(BETA2-1./ARAT(2))*RH2PB*V2PRB**2/64.4DIFL2320
C                                                                       DIFL2330
C     ALLOW FOR LOSSES DUE TO BENDS                                     DIFL2340
C                                                                       DIFL2350
      PAN1A=PAN1A-COR1*RHA*XV2A*(THA/THA1)**2                           DIFL2360
      PAN1B=PAN1B-COR2*RHB*XV2B*(THB/THB1)**2                           DIFL2370
C                                                                       DIFL2380
C     CALCULATE TEMPERATURE AND TOTAL PRESSURE LOSS                     DIFL2390
C                                                                       DIFL2400
      B=1.                                                              DIFL2410
      C=-STAGT                                                          DIFL2420
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      A=(AF(1)*ZZR/SUMA/PAN1A)**2/(2.*ZZCP*32.)                         DIFL2430
      TAN1A=(-B+SQRT(B*B-4.*A*C))/2./A                                  DIFL2440
      PNRTA=PAN1A*(STAGT/TAN1A)**(ZZGAMA/(ZZGAMA-1.))                   DIFL2450
      DPT(1)=(STPREF-PNRTA)/STPREF                                      DIFL2460
      A=(AF(2)*ZZR/SUMB/PAN1B)**2/(2.*ZZCP*32.)                         DIFL2470
      TAN1B=(-B+SQRT(B*B-4.*A*C))/2./A                                  DIFL2480
      PNRTB=PAN1B*(STAGT/TAN1B)**(ZZGAMA/(ZZGAMA-1.))                   DIFL2490
      DPT(2)=(STPREF-PNRTB)/STPREF                                      DIFL2500
C                                                                       DIFL2510
C     PRINT CUT RESULTS                                                 DIFL2520
C                                                                       DIFL2530
      IF(IPRINT) 900,900,250                                            DIFL2540
  250 AR(1)=THA/THA1                                                    DIFL2550
      AR(2)=THB/THB1                                                    DIFL2560
      ARZ=(SUMA/THA)**2                                                 DIFL2570
      CPID(1)=(2.*(BETA1-1.)+1.-1./ARZ)/BETA1**2                        DIFL2580
      ARZ=(SUMB/THB)**2                                                 DIFL2590
      CPID(2)=(2.*(BETA2-1.)+1.-1./ARZ)/BETA2**2                        DIFL2600
      CPAC(1)=(PAN1A-PRES(NXDIF))/(RHA*XV2A/2./32.)                     DIFL2610
     1/BETA1**2                                                         DIFL2620
      CPAC(2)=(PAN1B-PRES(NXDIF))/(RHB*XV2B/2./32.)                     DIFL2630
     1/BETA2**2                                                         DIFL2640
      DO 255 K=1,2                                                      DIFL2650
      CALL DCUTP1(NSNOUT,D2,D3,D4,CPID(K),CPAC(K),CPAC(K)/CPID(K),3,K,  DIFL2660
     1AR(K),CPT(K))                                                     DIFL2670
  255 CONTINUE                                                          DIFL2680
      GO TO 900                                                         DIFL2690
C                                                                       DIFL2700
C     USE STREAMTUBE ANALYSIS IN DIFFUSING PASSAGES BEYOND THE SNOUT LIPDIFL2710
C                                                                       DIFL2720
  300 CALL TUBSA1                                                       DIFL2730
      GO TO 900                                                         DIFL2740
C                                                                       DIFL2750
C     USE EMPIRICAL DATA IN THE DIFFUSING PASSAGES BEYOND THE SNOUT LIP DIFL2760
C                                                                       DIFL2770
  310 CALL EMPSA1                                                       DIFL2780
  900 IF(NRECT.EQ.2) AF2=AF2*WIDTH1                                     DIFL2790
      RETURN                                                            DIFL2800
C                                                                       DIFL2810
      ENTRY CIFLW2                                                      DIFL2820
      IF(NRECT.EQ.2) AF2=AF2/WIDTH1                                     DIFL2830
      IPN=IPRINT                                                        DIFL2840
      IPRINT=3                                                          DIFL2850
      CALL TUBCTS                                                       DIFL2860
      IF(IBL) 1000,1000,910                                             DIFL2870
  910 CALL TUBSTA                                                       DIFL2880
      CALL TUBFW1                                                       DIFL2890
      IF(IBL) 1000,1000,920                                             DIFL2900
  920 CALL TUBSA1                                                       DIFL2910
 1000 IPRINT=IPN                                                        DIFL2920
      GO TO 900                                                         DIFL2930
      END                                                               DIFL2940
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*........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC TBCT    LIST
      SUBROUTINE TUBCTS                                                 TBCT0010
C                                                                       TBCT0020
C     THIS SUBROUTINE PERFORMS A STREAMTUBE ANALYSIS OF THE DIFFUSING   TBCT0030
C     SECTION IMMEDIATELY FOLLOWING THE COMPRESSOR OUTLET               TBCT0040
C                                                                       TBCT0050
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),TBCT0060
     1NGC,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,     ZZCP,IDIF     TBCT0070
     2,HSEP  ,FLAREA(50),AREA(50)                                       TBCT0080
      COMMON/B4/DPREF                                                   TBCT0090
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 TBCT0100
     1NRECT,NXDIF,NDIFF,NSNCUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       TBCT0110
     2PRESIN,       BLOCK(50),ABLOCK,SHAPEH(2,50),                      TBCT0120
     3VFDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  TBCT0130
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                TBCT0140
     5XMACH,RHOREF,EFCT(3)                                              TBCT0150
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,        AFA,AFB,PREDM,STAGTTBCT0160
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,COMLOS                             TBCT0170
      COMMON/B12678/JTAPE ,IPRINT                                       TBCT0180
      COMMON/BZERO/ ALFA(50),ALFB(50),ALFC(50),VEL(2,50),RO(2,50),      TBCT0190
     1ALFD(50),ASTAR(15),STAGP(15),RHO(15),Y(11),YY(11),UJY(11),AR(2),  TBCT0200
     2DUMMY(70),ALFG(50)                                                TBCT0210
      COMMON/B2TBCS/SHP(2),THET(2),ROJ(2),VELJ(2),SUMXJ(4)              TBCT0220
      COMMON/B2TUB/ XMTB(15),ATUBE(15),ALPHA(15),CAL(15),CBL(15)        TBCT0230
C                                                                       TBCT0240
    2 FORMAT(91H SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBEIN. SOLUTTBCT0250
     2ION CONTINUED USING EMPIRICAL DATA.)                              TBCT0260
    3 FORMAT(91H SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBANL. SOLUTTBCT0270
     1ION CONTINUED USING EMPIRICAL DATA.)                              TBCT0280
    7 FORMAT(86H SOLUTION FAILED TO CONVERGE AFTER 40 CYCLES. SOLUTION CTBCT0290
     1ONTINUED USING EMPIRICAL DATA./54H THE LAST CALCULATED BOUNDARY LATBCT0300
     2YER PARAMETERS ARE....)                                           TBCT0310
   10 FORMAT(18H1*** ERROR MESSAGE)                                     TBCT0320
   11 FORMAT(1X//////18H *** ERROR MESSAGE)                             TBCT0330
   21 FORMAT(1H149X3(2H- ),7HRESULTS3(2H -)//////21H0REFERENCE CONDITIONTBCT0340
     1S/1X20(1H-)/15H0REFERENCE AREA13X1H=F10.3,6H SQ FT/19H REFERENCE VTBCT0350
     2ELOCITY9X1H=F10.1,11H FT PER SEC/18H INLET MACH NUMBER10X1H=F10.3/TBCT0360
     322H REFERENCE MACH NUMBER6X1H=F10.3/29H REFERENCE DYNAMIC PRESSURETBCT0370
     4 =F10.2,4H PSI)                                                   TBCT0380
   22 FORMAT(115H0THE DIFFUSER TREATMENT USED IN THIS PROGRAM BECOMES INTBCT0390
     1CREASINGLY INACCURATE AT INLET MACH NUMBERS GREATER THAN 0.7)     TBCT0400
C                                                                       TBCT0410
C     SET UP GEOMETRIC VARIABLES                                        TBCT0420
C                                                                       TBCT0430
      LN=1                                                              TBCT0440
      IHLC=1                                                            TBCT0450
      GO TO (101,103),NRECT                                             TBCT0460
  101 DO 102 I=1,NXDIF                                                  TBCT0470
      AREA(I)=3.14159*(CB(I)**2-CA(I)**2)                               TBCT0480
      B=(1.-ABLOCK)*BLOCK(I)                                            TBCT0490
      DELTA(2,I)=CB(I)*(1.-SQRT(1.-B*(1.-(CA(I)/CB(I))**2)))            TBCT0500
  102 DELTA(1,I)=CA(I)*(-1.+SQRT(1.+(BLOCK(I)-B)*((CB(I)/CA(I))**2-1.)))TBCT0510
      AR(1)=3.14159*(SA(NXDIF+1)**2-CA(NXDIF+1)**2)                     TBCT0520
      AR(2)=3.14159*(CB(NXDIF+1)**2-SB(NXDIF+1)**2)                     TBCT0530
      GO TO 106                                                         TBCT0540
  103 DO 104 I=1,NXDIF                                                  TBCT0550
      AREA(I)=CB(I)-CA(I)                                               TBCT0560
      DELTA(2,I)=AREA(I)*BLOCK(I)*(1.-ABLOCK)                           TBCT0570
  104 DELTA(1,I)=AREA(I)*BLOCK(I)*ABLOCK                                TBCT0580
      AR(1)=SA(NXDIF+1)-CA(NXDIF+1)                                     TBCT0590
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*.........*.........*.........*.........*.........*.........*.........*.........*
      AR(2)=CB(NXDIF+1)-SB(NXDIF+1)                                     TBCT0600
  106 DO 108 I=1,NXDIF                                                  TBCT0610
      ALFC(I)=0.                                                        TBCT0620
      FLAREA(I)=AREA(I)*(1.-BLOCK(I))                                   TBCT0630
      CAL(I)=CA(I)+DELTA(1,I)                                           TBCT0640
  108 CBL(I)=CB(I)-DELTA(2,I)                                           TBCT0650
      CALL SLOPE(X,CA,1,NXDIF,ALFC,NXDIF+1)                             TBCT0660
      CALL SLOPE(X,CB,1,NXDIF,ALFD,NXDIF+1)                             TBCT0670
      DO 1080 I=2,NXDIF                                                 TBCT0680
      DD=1                                                              TBCT0690
      DE=1                                                              TBCT0700
      IF(ALFC(I).LE.0.) DD=-1                                           TBCT0710
      IF(ALFD(I).LE.0.)DE=-1                                            TBCT0720
      ALFC(I)=DD*ATAN(DD*ALFC(I))                                       TBCT0730
 1080 ALFD(I)=DE*ATAN(DE*ALFD(I))                                       TBCT0740
C                                                                       TBCT0750
C     CALCULATE INLET PROPERTIES                                        TBCT0760
C                                                                       TBCT0770
      DO 1060 J=1,NUPR                                                  TBCT0780
 1060 RDATA(J)=(RDATA(J)*(CB(1)-CA(1))+CA(1)-CAL(1))/(CBL(1)-CAL(1))    TBCT0790
      CALL TUBEIN(IBL,NRECT,FLAREA(1),CAL(1),CPL(1),NTUBE,AF2,PRESIN,STATBCT0800
     1GT,VPDATA,RDATA,NUPR,UJ,ASTAR,STAGP,RHO,XMTB,STPREF,1)            TBCT0810
      PRES(1)=PRESIN                                                    TBCT0820
      IF(IBL) 1081,1082,1081                                            TBCT0830
 1082 WRITE(JTAPE,11)                                                   TBCT0840
      WRITE(JTAPE,2)                                                    TBCT0850
      RETURN                                                            TBCT0860
 1081 DYHD=0.                                                           TBCT0870
      RH=0.                                                             TBCT0880
      DO 1084 J=1,NTUBE                                                 TBCT0890
      DYHD=DYHD+XMTB(J)/AF2*UJ(J)                                       TBCT0900
 1084 RH=RH+XMTB(J)/AF2*RHO(J)                                          TBCT0910
      DYHD=DYHD**2*RH/2./32.                                            TBCT0920
      VEL(2,1)=UJ(NTUBE)                                                TBCT0930
      VEL(1,1)=UJ(1)                                                    TBCT0940
      RO(2,1) = RHO(NTUBE)                                              TBCT0950
      RO(1,1) = RHO(1)                                                  TBCT0960
      ALFA(1)=0.                                                        TBCT0970
      ALFB(1)=0.                                                        TBCT0980
      DO 1085 J=1,2                                                     TBCT0990
      SUMXJ(J)=0.                                                       TBCT1000
      SHP(J)=SHAPEH(J,1)                                                TBCT1010
      THET(J)=DELTA(J,1)/SHAPEH(J,1)                                    TBCT1020
      ROJ(J)=RO(J,1)                                                    TBCT1030
 1085 VELJ(J)=VEL(J,1)                                                  TBCT1040
C                                                                       TBCT1050
C     CALCULATE REFERENCE PROPERTIES                                    TBCT1060
C                                                                       TBCT1070
      ASS=FLAREA(1)*0.532*STPREF/AF2/SQRT(STAGT)                        TBCT1080
      CALL GASTBL(ASS,TSS,PSS,YMACH,1,IBL,ZZR,ZZGAMA)                   TBCT1090
      ASS=AREF*ASS/FLAREA(1)                                            TBCT1100
      IF(NRECT.EQ.2) ASS=ASS/WIDTH1                                     TBCT1110
      CALL GASTBL(ASS,TSS,PSS,XMACH,1,IBL,ZZK,ZZGAMA)                   TBCT1120
      DPREF=STPREF*(1.0-PSS)/144.                                       TBCT1130
      UREF=XMACH*SQRT(ZZGAMA*ZZR*32.2*STAGT*TSS)                        TBCT1140
      IF(IPRINT.EQ.3) GO TO 1083                                        TBCT1150
C     WRITE OUT REFERENCE CONDITIONS                                    TBCT1160
C                                                                       TBCT1170
      WRITE(JTAPE,21)AREF,UREF,YMACH,XMACH,DPREF                        TBCT1180
      IF(YMACH.GE..7)WRITE(JTAPE,22)                                    TBCT1190
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*........*.........*.........*.........*.........*.........*.........*.........*.........*
 1083 DPREF=DPREF*144.                                                  TBCT1200
C                                                                       TBCT1210
      IF(NXDIF-1) 5000,5000,109                                         TBCT1220
C                                                                       TBCT1230
C     ITERATION LOOP STARTS HERE                                        TBCT1240
C                                                                       TBCT1250
  109 ALFA(1)=0.                                                        TBCT1260
      ALFB(1)=0.                                                        TBCT1270
      DO 110 I=2,NXDIF                                                  TBCT1280
      ALFA(I)=(CAL(I)-CAL(I-1))/(X(I)-X(I-1))                           TBCT1290
      ALFB(I)=(CBL(I)-CBL(I-1))/(X(I)-X(I-1))                           TBCT1300
      DD=1                                                              TBCT1310
      DE=1                                                              TBCT1320
      IF(ALFA(I).LE.0.) DD=-1                                           TBCT1330
      IF(ALFB(I).LE.0.) DE=-1                                           TBCT1340
      ALFA(I)=DD*ATAN(DD*ALFA(I))                                       TBCT1350
  110 ALFB(I)=DE*ATAN(DE*ALFB(I))                                       TBCT1360
  115 CALL TUBANL(IBL,LN,ALFA,ALFB,IHLD,NXDIF,PRES,ASTAR,RHO,           TBCT1370
     1STAGP,UJ,VEL,RO,FLAREA,ATUBE,STAGT,ALPHA,NTUBE)                   TBCT1380
      IF(IBL) 120,120,130                                               TBCT1390
  120 WRITE(JTAPE,11)                                                   TBCT1400
      WRITE(JTAPE,3)                                                    TBCT1410
      RETURN                                                            TBCT1420
  130 CALL NEWRAD (IBL,X,VEL,RO,DELTA,SHAPEH,1,NXDIF,IHLD,CB,CA,        TBCT1430
     1ALFC,ALFD,HSEP,NRECT,ALFG)                                        TBCT1440
      IF(IBL) 135,135,5000                                              TBCT1450
  135 LN=LN+1                                                           TBCT1460
      IF(LN-40) 140,140,137                                             TBCT1470
  137 WRITE(JTAPE,10)                                                   TBCT1480
      WRITE(JTAPE,7)                                                    TBCT1490
      GO TO 200                                                         TBCT1500
  140 DO 145 I=2,NXDIF                                                  TBCT1510
      CAL(I)=CA(I)+DELTA(1,I)*COS(ALFC(I))                              TBCT1520
      CBL(I)=CB(I)-DELTA(2,I)*COS(ALFD(I))                              TBCT1530
      GO TO (141,144),NRECT                                             TBCT1540
  141 BLOCK(I)=1.-(CBL(I)**2-CAL(I)**2)/(CB(I)**2-CA(I)**2)             TBCT1550
      GO TO 145                                                         TBCT1560
  144 BLOCK(I)=1.-(CBL(I)-CAL(I))/(CB(I)-CA(I))                         TBCT1570
  145 FLAREA(I)=AREA(I)*(1.-BLOCK(I))                                   TBCT1580
      GO TO 109                                                         TBCT1590
C                                                                       TBCT1600
C     CALCULATE OUTLET VELOCITY PROFILE                                 TBCT1610
C                                                                       TBCT1620
 5000 RAD(1)=CAL(NXDIF)                                                 TBCT1630
      GO TO (510,515),NRECT                                             TBCT1640
  510 DO 512 J=1,NTUBE                                                  TBCT1650
  512 RAD(J+1)=SQRT(RAD(J)**2.+ATUBE(J)*COS(ALPHA(J))/3.14159)          TBCT1660
      GO TO 518                                                         TBCT1670
  515 DO 517 J=1,NTUBE                                                  TBCT1680
  517 RAD(J+1)=RAD(J)+ATUBE(J)*COS(ALPHA(J))                            TBCT1690
  518 DO 520 J=1,NTUBE                                                  TBCT1700
  520 RAD(J)=(RAD(J)+RAD(J+1))/2.                                       TBCT1710
      Y(1)=CAL(NXDIF)                                                   TBCT1720
      DO 525 I=2,11                                                     TBCT1730
  525 Y(I)=CAL(NXDIF)+(CBL(NXDIF)-CAL(NXDIF))*0.1*(FLOAT(I)-1.)         TBCT1740
      DO 530 I=1,11                                                     TBCT1750
      YI=Y(I)                                                           TBCT1760
      CALL I1AP1(YI,ANS,RAD,UJ,NTUBE)                                   TBCT1770
      UJY(I)=ANS                                                        TBCT1780
      YY(I)=(Y(I)-CA(NXDIF))/(CB (NXDIF)-CA (NXDIF))                    TBCT1790
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*.........*.........*.........*.........*.........*.........*.........*.........*
  530 Y(I)=(Y(I)-CAL(NXDIF))/(CEL(NXDIF)-CAL(NXDIF))                     TBCT1800
C                                                                        TBCT1810
C      PRINT OUT SCLUTION                                                TBCT1820
C                                                                        TBCT1830
      AR2=(AREA(NXDIF)/AREA(1))**2.                                      TBCT1840
      CPIDL=1.-1./AR2                                                    TBCT1850
      CPACT=(PRES(NXDIF)-PRES(1))/CYHD                                   TBCT1860
      EFECTN=CPACT/CPICL                                                 TBCT1870
      CALL DOUTPT(NSNCUT,CPIDL,CPACT,EFECTN,UJY,YY,Y,1)                  TBCT1880
  200 IF(NRECT.NE.2) GO TC 202                                           TBCT1890
      DC 201 I=1,NXCIF                                                   TBCT1900
  201 AREA(I)=AREA(I)*WIDTH1                                             TBCT1910
  202 CALL NEWR1(PRES,AREA,BLOCK)                                        TBCT1920
      IF(NRECT.NE.2) GO TO 204                                           TBCT1930
      DC 203 I=1,NXDIF                                                   TBCT1940
  203 AREA(I)=AREA(I)/WIDTH1                                             TBCT1950
  204 CCNTINUE                                                           TBCT1960
      DO 210 K=1,2                                                       TBCT1970
      EE1(K)=BLOCK(NXDIF)*DELTA(K,NXDIF)/(DELTA(2,NXDIF)+DELTA(1,NXDIF))TBCT1980
  210 EE1(K)=1.-EE1(K)*AREA(NXDIF)/AR(K)                                 TBCT1990
  900 RETURN                                                             TBCT2000
      END                                                                TBCT2010

  YOUR CARD TCTAL IS ---              203
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*........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC TBST
      SUBROUTINE TUBSTA                                                 TBST0001
C                                                                       TBST0002
C                                                                       TBST0003
C     THIS SUBROUTINE PREPARES DATA FOR SUBROUTINE TUBSTA               TBST0004
C                                                                       TBST0005
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),TBST0006
     1NGC,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,     ZZCP,IDIF     TBST0007
     2,HSEP  ,FLAREA(50),AREA(50)                                       TBST0008
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 TBST0009
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       TBST0010
     2PRESIN,       BLOCK(50),ABLOCK,SHAPEH(2,50),                      TBST0011
     3VFDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  TBST0012
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                TBST0013
     5XMACH,RHOREF,EFDT(3)                                              TBST0014
      COMMON/BZERO/ ALPA(50),ALPB(50),ALPC(50),ALPD(50),DUMMY(400)      TBST0015
      COMMON/B2TBDS/ALFA(2,50),AL(2,2,50),WIL(2,50),WCL(2,50),WI(2,50), TBST0016
     1WC(2,50),ARR(2,50),DELT(2,2),SHAPH(2,2),NX(2),NXDD(2),ARF(2,50),  TBST0017
     1SHPP(2,2),THETT(2,2),SUMXJJ(2,2),ROJJ(2  ),VELJJ(2)               TBST0018
      COMMON/B2TBCS/SHP(2),THET(2),ROJ(2),VELJ(2),SUMXJ(4)              TBST0019
C                                                                       TBST0020
C     CALCULATE GEOMETRIC VARIABLES AND INPUT PARAMETERS                TBST0021
C                                                                       TBST0022
      NX(1)=NXDIF1                                                      TBST0023
      NX(2)=NXDIF2                                                      TBST0024
      NXDD(1)=NXDIFA                                                    TBST0025
      NXDD(2)=NXDIFB                                                    TBST0026
      DELT(1,1)=DELTA(1,NXDIF)                                          TBST0027
      DELT(1,2)=0.                                                      TBST0028
      DELT(2,1)=0.                                                      TBST0029
      DELT(2,2)=DELTA(2,NXDIF)                                          TBST0030
      SHAPH(1,1)=SHAPEH(1,NXDIF)                                        TBST0031
      SHAPH(1,2)=1.4                                                    TBST0032
      SHAPH(2,1)=1.4                                                    TBST0033
      SHAPH(2,2)=SHAPEH(2,NXDIF)                                        TBST0034
      SHPP(1,1)=SHAPEH(1,1)                                             TBST0035
      SHPP(1,2)=1.4                                                     TBST0036
      SHPP(2,1)=1.4                                                     TBST0037
      SHPP(2,2)=SHAPEH(2,1)                                             TBST0038
      THETT(1,1)=DELTA(1,1)/SHAPEH(1,1)                                 TBST0039
      THETT(1,2)=0.                                                     TBST0040
      THETT(2,1)=0.                                                     TBST0041
      THETT(2,2)=DELTA(2,1)/SHAPEH(2,1)                                 TBST0042
      SUMXJJ(1,1)=SUMXJ(3)                                              TBST0043
      SUMXJJ(1,2)=0.                                                    TBST0044
      SUMXJJ(2,1)=0.                                                    TBST0045
      SUMXJJ(2,2)=SUMXJ(4)                                              TBST0046
      ROJJ(1)=ROJ(1)                                                    TBST0047
      ROJJ(2)=ROJ(2)                                                    TBST0048
      VELJJ(1)=VELJ(1)                                                  TBST0049
      VELJJ(2)=VELJ(2)                                                  TBST0050
      CALL SLOPE(X,CA,NXDIF,NXDIFA,ALPA,NXDIFA+1)                       TBST0051
      CALL SLOPE(X,CB,NXDIF,NXDIFB,ALPB,NXDIFB+1)                       TBST0052
      CALL SLOPE(X,SA,NXDIF+2,NXDIFA,ALPC,NXDIFA+1)                     TBST0053
      CALL SLOPE(X,SB,NXDIF+2,NXDIFB,ALPD,NXDIFB+1)                     TBST0054
      NXDF1=NXDIF+1                                                     TBST0055
      DO 119 I=NXDIF,NXDF1                                              TBST0056
      ALPC(I)=ALPA(I)                                                   TBST0057
  119 ALPD(I)=ALPB(I)                                                   TBST0058
      SA(NXDIF)=CA(NXDIF)+SA(NXDIF+1)-CA(NXDIF+1)                       TBST0059
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*.........*.........*.........*.........*.........*.........*.........*.........*
      SB(NXDIF)=SB(NXDIF+1)-CB(NXDIF+1)+CB(NXDIF)                       TBST0060
      DO 120 I=NXDIF,NXDIFA                                             TBST0061
      DD=1                                                              TBST0062
      DE=1                                                              TBST0063
      IF(ALPA(I).LE.0.) DD=-1                                           TBST0064
      IF(ALPC(I).LE.0.) DE=-1                                           TBST0065
      ALFA(1,I)=(DD*ATAN(DD*ALPA(I))+DE*ATAN(DE*ALPC(I)))/2.            TBST0066
      WI(1,I)=CA(I)                                                     TBST0067
      WC(1,I)=SA(I)                                                     TBST0068
      WIL(1,I)=WI(1,I)+DELTA(1,NXDIF)/COS(ALFA(1,I))                    TBST0069
      WOL(1,I)=WC(1,I)                                                  TBST0070
      AL(1,1,I)=DD*ATAN(DD*ALPA(I))-ALFA(1,I)                           TBST0071
  120 AL(1,2,I)=DE*ATAN(DE*ALPC(I))-ALFA(1,I)                           TBST0072
      DO 121 I=NXDIF,NXDIFB                                             TBST0073
      DD=1                                                              TBST0074
      DE=1                                                              TBST0075
      IF(ALPB(I).LE.0.) DD=-1                                           TBST0076
      IF(ALPD(I).LE.0.) DE=-1                                           TBST0077
      ALFA(2,I)=(DD*ATAN(DD*ALPB(I))+DE*ATAN(DE*ALPD(I)))/2.            TBST0078
      WI(2,I)=SB(I)                                                     TBST0079
      WC(2,I)=CB(I)                                                     TBST0080
      WIL(2,I)=WI(2,I)                                                  TBST0081
      WOL(2,I)=WC(2,I)-DELTA(2,NXDIF)/COS(ALFA(2,I))                    TBST0082
      AL(2,2,I)=DD*ATAN(DD*ALPB(I))-ALFA(2,I)                           TBST0083
  121 AL(2,1,I)=DE*ATAN(DE*ALPD(I))-ALFA(2,I)                           TBST0084
      DO 130 K=1,2                                                      TBST0085
      NXD=NXDD(K)                                                       TBST0086
      DO 130 I=NXDIF,NXD                                                TBST0087
      GO TO (125,127),NRECT                                             TBST0088
  125 ARR(K,I)=3.14159*(WC(K,I)**2 -WI(K,I)**2 )*COS(ALFA(K,I))         TBST0089
      ARF(K,I)=3.14159*(WOL(K,I)**2-WIL(K,I)**2)*COS(ALFA(K,I))         TBST0090
      GO TO 130                                                         TBST0091
  127 ARR(K,I)=(WO(K,I) -WI(K,I) )*COS(ALFA(K,I))                       TBST0092
      ARF(K,I)=(WOL(K,I)-WIL(K,I))*COS(ALFA(K,I))                       TBST0093
  130 CONTINUE                                                          TBST0094
      GO TO (131,132),NRECT                                             TBST0095
  131 ARR(1,NXDIFA)=3.14159*(SA(NXDIFA)**2-CA(NXDIFA)**2)               TBST0096
      ARR(2,NXDIFB)=3.14159*(CB(NXDIFB)**2-SB(NXDIFB)**2)               TBST0097
      GO TO 133                                                         TBST0098
  132 ARR(1,NXDIFA)=SA(NXDIFA)-CA(NXDIFA)                               TBST0099
      ARR(2,NXDIFB)=CB(NXDIFB)-SB(NXDIFB)                               TBST0100
  133 CONTINUE                                                          TBST0101
      RETURN                                                            TBST0102
      END                                                               TBST0103

 YOUR CARD TOTAL IS ---          105
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*.........*.........*.........*.........*.........*.........*.........*.........*1
$IBFTC TBA1
      SUBROUTINE TUBSA1                                                 TBA10010
C                                                                       TBA10020
C     THIS SUBROUTINE PERFORMS A STREATUBE ANALYSIS IN THE DIFFUSING    TBA10030
C     PASSAGES BETWEEN THE SNOUT AND THE OUTER CASING                   TBA10040
C                                                                       TBA10050
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),TBA10060
     1NGO,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,    ZZCP,IDIF      TBA10070
     2,HSEP  ,FLAREA(50),AREA(50)                                       TBA10080
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 TBA10090
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       TBA10100
     2PRESIN,       BLOCK(50),ABLOCK,SHAPEH(2,50),                      TBA10110
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  TBA10120
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                TBA10130
     5XMACH,RHOREF,EFCT(3)                                              TBA10140
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,        AFA,AFB,PREDM,STAGTTBA10150
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS                             TBA10160
      COMMON/B12678/JTAPE ,IPRINT                                       TBA10170
      COMMON/B2TBCS/SHP(2),THET(2),ROJ(2),VELJ(2),SUMXJ(4)              TBA10180
      COMMON/BZERO/ARK(50),YBL(50),ALA(50),ALB(50),VEL(2,50),           TBA10190
     2RC(2,50),XX(50),RD(15),UJK(15),ASTAR(15),STAGP(15),XMTB(15),RHO(15TBA10200
     3),ALPHA(15),ATUBE(15),DUMMY(30)                                   TBA10210
      COMMON/B2TBDS/ALFA(2,50),AL(2,2,50),WIL(2,50),WOL(2,50),WI(2,50), TBA10220
     1WO(2,50),ARR(2,50),DELT(2,2),SHAPH(2,2),NX(2),NXDD(2),ARF(2,50),  TBA10230
     1SHPP(2,2),THETT(2,2),SUMXJJ(2,2),ROJJ(2  ),VELJJ(2)               TBA10240
      COMMON/BPLOS/PLOSS(2)                                             TBA10250
      DIMENSION AF(2),YAL(50),ARRK(50)                                  TBA10260
      EQUIVALENCE (ARRK(1),YAL(1))                                      TBA10270
C                                                                       TBA10280
    1 FORMAT(71H SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBEIN. SOLUTTBA10290
     1ION TERMINATED.)                                                  TBA10300
    2 FORMAT(71H SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBANL. SOLUTTBA10310
     1ION TERMINATED.)                                                  TBA10320
    7 FORMAT(105H THE STREAMTURE ANALYSIS IN THE DIFFUSING PASSAGES BETWTBA10330
     1EEN SNOUT AND OUTER CASING HAS FAILED TO CONVERGE./21H SOLUTION TETBA10340
     2RMINATED.//54H THE LAST CALCULATED BOUNDARY LAYER PARAMETERS ARE..TBA10350
     3..)                                                               TBA10360
   10 FORMAT(18H1*** ERROR MESSAGE)                                     TBA10370
C                                                                       TBA10380
C     SET UP VALUES NEEDED IN THE DO LOOP                               TBA10390
C                                                                       TBA10400
      NXDF1=NXDIF+1                                                     TBA10410
      AF(1)=AFA                                                         TBA10420
      AF(2)=AFB                                                         TBA10430
      XX(NXDIF)=X(NXDIF)                                                TBA10440
      GO TO (190,195),NRECT                                             TBA10450
  190 WOL(1,NXDIF)=SQRT(CA(NXDIF)**2+THA/3.14159)                       TBA10460
      WIL(2,NXDIF)=SQRT(CB(NXDIF)**2-THB/3.14159)                       TBA10470
      GO TO 197                                                         TBA10480
  195 WOL(1,NXDIF)=CA(NXDIF)+THA                                        TBA10490
      WIL(2,NXDIF)=CB(NXDIF)-THB                                        TBA10500
  197 ARR(1,NXDIF)=THA*COS(ALFA(1,NXDIF))                               TBA10510
      ARR(2,NXDIF)=THB*COS(ALFA(2,NXDIF))                               TBA10520
      WO(1,NXDIF)=WOL(1,NXDIF)                                          TBA10530
      WI(2,NXDIF)=WIL(2,NXDIF)                                          TBA10540
      GO TO (1970,1971),NRECT                                           TBA10550
 1970 ARF(1,NXDIF)=3.14159*(WOL(1,NXDIF)**2-WIL(1,NXDIF)**2)*COS(ALFA(1,TBA10560
     1NXDIF))                                                           TBA10570
      ARF(2,NXDIF)=3.14159*(WOL(2,NXDIF)**2-WIL(2,NXDIF)**2)*COS(ALFA(2,TBA10580
     1NXDIF))                                                           TBA10590
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*.........*.........*.........*.........*.........*.........*.........*.........*
      GO TO 200                                                         TBA10600
 1971 ARF(1,NXDIF)=(WOL(1,NXDIF)-WIL(1,NXDIF))*COS(ALFA(1,NXDIF))       TBA10610
      ARF(2,NXDIF)=(WOL(2,NXDIF)-WIL(2,NXDIF))*COS(ALFA(2,NXDIF))       TBA10620
C                                                                       TBA10630
C     START OF DO LOOP FOR TWO ANNULI                                   TBA10640
C                                                                       TBA10650
  200 DO 500 K=1,2                                                      TBA10660
      IHLD=NXDIF                                                        TBA10670
      NXX=NX(K)                                                         TBA10680
      NXD=NXDD(K)                                                       TBA10690
      DO 2000 I=NXDIF,NXX                                               TBA10700
      XX(I+1)=XX(I)+(X(I+1)-X(I))/COS(ALFA(K,I))                        TBA10710
      DELTA(1,I)    =DELT(K,1)                                          TBA10720
      DELTA(2,I)    =DELT(K,2)                                          TBA10730
 2000 CONTINUE                                                          TBA10740
      SHAPEH(1,NXDIF)=SHAPH(K,1)                                        TBA10750
      SHAPEH(2,NXDIF)=SHAPH(K,2)                                        TBA10760
      WILX=WIL(K,NXDIF)*COS(ALFA(K,NXDIF))                              TBA10770
      WOLX=WOL(K,NXDIF)*COS(ALFA(K,NXDIF))                              TBA10780
      LN=1                                                              TBA10790
      DO 210 J=1,NTUBE                                                  TBA10800
      RD(J)=RAD(J)*COS(ALFA(K,NXDIF))                                   TBA10810
  210 RD(J)=(RD(J)-WILX)/(WOLX-WILX)                                    TBA10820
      CALL TUBEIN(IBL,NRECT,ARF(K,NXDIF),WILX,WOLX,NTUBE                TBA10830
     1,AF(K),PRES(NXDIF),STAGT,UJ,RD,NTUBE,UJK,ASTAR,STAGP,RHO,XMTB,    TBA10840
     2PRES(NXDIF),0)                                                    TBA10850
      IF(IBL) 215,215,220                                               TBA10860
  215 WRITE(JTAPE,10)                                                   TBA10870
      WRITE(JTAPE,1)                                                    TBA10880
      RETURN                                                            TBA10890
  220 DO 225 I=NXDIF,NXX                                                TBA10900
      ARK(I)=ARF(K,I)                                                   TBA10910
      ALA(I)=AL(K,1,I)                                                  TBA10920
  225 ALB(I)=AL(K,2,I)                                                  TBA10930
      VEL (1,NXDIF)=UJK(1)                                              TBA10940
      VEL (2,NXDIF)=UJK(NTUBE)                                          TBA10950
      RO (1,NXDIF) = RHO(1)                                             TBA10960
      RO(2,NXDIF)=RHO(NTUBE)                                            TBA10970
      IF(K.EQ.2) GO TO 2250                                             TBA10980
      ROJ(1)=ROJJ(1)                                                    TBA10990
      ROJ(2)=RHO(NTUBE)                                                 TBA11000
      VELJ(1)=VELJJ(1)                                                  TBA11010
      VELJ(2)=UJ(NTUBE)                                                 TBA11020
      GO TO 2251                                                        TBA11030
 2250 ROJ(1)=RHO(1)                                                     TBA11040
      ROJ(2)=ROJJ(2)                                                    TBA11050
      VELJ(1)=UJ(1)                                                     TBA11060
      VELJ(2)=VELJJ(2)                                                  TBA11070
 2251 DO 2252 J=1,2                                                     TBA11080
      SUMXJ(J)=SUMXJJ(K,J)                                              TBA11090
      SHP(J)=SHPP(K,J)                                                  TBA11100
 2252 THET(J)=THETT(K,J)                                                TBA11110
      SUM=0.                                                            TBA11120
      SUMA=0.                                                           TBA11130
      DO 226 J=1,NTUBE                                                  TBA11140
      SUM=SUM+XMTB(J)/RHO(J)                                            TBA11150
  226 SUMA=SUMA+XMTB(J)*UJK(J)/RHO(J)                                   TBA11160
      RHR=AF(K)/SUM                                                     TBA11170
      BTA=SUMA*ARR(K,NXDIF)/SUM**2                                      TBA11180
      DYHD=(SUMA/SUM)**2*RHR/32./2.                                     TBA11190
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*.......*.........*.........*.........*.........*.........*.........*.........*
C                                                                       TBA11200
C     START OF ITERATION LOOP                                           TBA11210
C                                                                       TBA11220
  227 CALL TUBANL(IBL,LN,ALA,ALB,IHLD,NXX,PRES,ASTAR,RHO,               TBA11230
     1STAGP,UJK,VEL,RO,ARK,ATUBE,STAGT,ALPHA,NTUBE)                     TBA11240
      IF(IBL) 228,228,230                                               TBA11250
  228 WRITE(JTAPE,10)                                                   TBA11260
      WRITE(JTAPE,2)                                                    TBA11270
      RETURN                                                            TBA11280
  230 DO 2300 I=NXDIF,NXX                                               TBA11290
      ALA(I)=AL(K,1,I)                                                  TBA11300
      ALB(I)=AL(K,2,I)                                                  TBA11310
      ARK(I)=ALFA(K,I)                                                  TBA11320
      YAL(I)= WI(K,I)*COS(ALFA(K,I))                                    TBA11330
 2300 YBL(I)= WO(K,I)*COS(ALFA(K,I))                                    TBA11340
      CALL NEWRAD(IBL,XX,VEL,RO,DELTA,SHAPEF,NXDIF,NXX,IHLD,YBL,YAL,    TBA11350
     1ALA,ALB,HSEP,NRECT,ARK)                                           TBA11360
      IF(IBL) 250,250,320                                               TBA11370
  250 IF(LN-40)255,270,270                                              TBA11380
  255 LN=LN+1                                                           TBA11390
  257 DO 260 I=NXDF1,NXX                                                TBA11400
      WIL(K,I)=WI(K,I)+DELTA(1,I)*COS(AL(K,1,I))/COS(ALFA(K,I))         TBA11410
  260 WOL(K,I)=WO(K,I)-DELTA(2,I)*COS(AL(K,2,I))/COS(ALFA(K,I))         TBA11420
      GO TO (261,263),NRECT                                             TBA11430
  261 DO 262 I=NXDIF,NXX                                                TBA11440
      ARK(I)=3.14159*(WOL(K,I)**2-WIL(K,I)**2)*COS(ALFA(K,I))           TBA11450
  262 BLOCK(I)=1.-ARK(I)/ARR(K,I)                                       TBA11460
      GO TO 265                                                         TBA11470
  263 DO 264 I=NXDIF,NXX                                                TBA11480
      ARK(I)=(WOL(K,I)-WIL(K,I))*COS(ALFA(K,I))                         TBA11490
  264 BLOCK(I)=1.-ARK(I)/ARR(K,I)                                       TBA11500
  265 DO 266 I=NXDIF,NXX                                                TBA11510
      YAL(I)=WIL(K,I)                                                   TBA11520
  266 YBL(I)=WOL(K,I)                                                   TBA11530
      CALL SLOPE(XX,YAL,NXDIF+1,NXX,ALA,NXX)                            TBA11540
      CALL SLOPE(XX,YBL,NXDIF+1,NXX,ALB,NXX)                            TBA11550
      DO 267 I=NXDF1,NXX                                                TBA11560
      DD=1                                                              TBA11570
      DE=1                                                              TBA11580
      IF(ALA(I).LE.0.) DD=-1                                            TBA11590
      IF(ALB(I).LE.0.) DE=-1                                            TBA11600
      ALA(I)=DD*ATAN(DD*ALA(I))-ALFA(K,I)                               TBA11610
  267 ALB(I)=DE*ATAN(DE*ALB(I))-ALFA(K,I)                               TBA11620
      GO TO 227                                                         TBA11630
  270 WRITE(JTAPE,10)                                                   TBA11640
      WRITE(JTAPE,7)                                                    TBA11650
      GO TO 450                                                         TBA11660
C                                                                       TBA11670
C     CALCULATE OUTLET PROPERTIES                                       TBA11680
C                                                                       TBA11690
  320 RHM=0.                                                            TBA11700
      XMV2=0.                                                           TBA11710
      XAV=0.                                                            TBA11720
      DO 321 J=1,NTUBE                                                  TBA11730
      XMV2=XMV2+UJK(J)**2*ATUBE(J)*COS(ALPHA(J))                        TBA11740
  321 XAV=XAV+UJK(J)*ATUBE(J)*COS(ALPHA(J))                             TBA11750
      XMV2=XMV2/ARR(K,NXX)                                              TBA11760
      XAV=XAV/ARR(K,NXX)                                                TBA11770
      BT =XMV2/XAV**2                                                   TBA11780
      RHM=AF(K)/XAV/ARR(K,NXX)                                          TBA11790
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*.........*.........*.........*.........*.........*.........*.........*.........*
      ARAT= ARR(K,NXD)/ARR(K,NXX)                                       TBA11800
      PRES(NXD) = PRES(NXX)+    (1.+1./ARAT)*(BT-1./ARAT     )*RHM*XAV**2/TBA11810
     164.4                                                              TBA11820
C                                                                       TBA11830
C     CALCULATE TEMPERATURE AT INLET TO ANNULI AND TOTAL PRESSURE LOSS  TBA11840
C                                                                       TBA11850
      B=1.                                                              TBA11860
      C=-STAGT                                                          TBA11870
      A=(AF(K)*ZZR/ARR(K,NXD)/PRES(NXD))**2/(2.*ZZCP*32.)               TBA11880
      TANA=(-B+SQRT(B*B-4.*A*C))/2./A                                   TBA11890
      PNRT=PRES(NXD)*(STAGT/TANA)**(ZZGAMA/(ZZGAMA-1.))                 TBA11900
      PNRT=PNRT-PLOSS(K)                                                TBA11910
      ASS=AF(K)*SQRT(STAGT)/(0.532*PNRT)                                TBA11920
      ASS=ARR(K,NXD)/ASS                                                TBA11930
      CALL GASTBL(ASS,RAT,RAP,XMACH,1,IBL,ZZR,ZZGAMA)                   TBA11940
      PRES(NXD)=RAP*PNRT                                                TBA11950
      TANA=STAGT*RAT                                                    TBA11960
      DELTP=(STPREF-PNRT)/STPREF                                        TBA11970
C                                                                       TBA11980
      GO TO (323,324),K                                                 TBA11990
  323 PAN1A=PRES(NXD)                                                   TBA12000
      TAN1A=TANA                                                        TBA12010
      PNRTA=PNRT                                                        TBA12020
      GO TO 400                                                         TBA12030
  324 PAN1B=PRES(NXD)                                                   TBA12040
      TAN1B=TANA                                                        TBA12050
      PNRTB=PNRT                                                        TBA12060
  400 IF(IPRINT) 500,500,410                                            TBA12070
C                                                                       TBA12080
C     CALCULATE DIFFUSER PERFORMANCE                                    TBA12090
C                                                                       TBA12100
  410 CPACT=(PRES(NXX)-PRES(NXDIF))/DYHD                                TBA12110
      AR=ARR(K,NXX)/ARR(K,NXDIF)                                        TBA12120
      IF(AR-1.) 4100,4101,4100                                          TBA12130
 4101 CPIDL=0.                                                          TBA12140
      EFECTN=1.                                                         TBA12150
      GO TO 420                                                         TBA12160
 4100 CPIDL=1.-1./AR/AR                                                 TBA12170
      EFECTN=CPACT/CPIDL                                                TBA12180
C                                                                       TBA12190
C     CALCULATE DIFFUSER PERFORMANCE ALLOWING FOR MIXING                TBA12200
C                                                                       TBA12210
  420 CPCT=(PRES(NXD)-PRES(NXDIF))/DYHD                                 TBA12220
      AR=ARR(K,NXD)/ARR(K,NXDIF)                                        TBA12230
      BT=BTA                                                            TBA12240
 4200 CPID=(2.*(BT-1.)+1.-1./AR**2)/BT**2                               TBA12250
      EFECT=CPCT/CPID                                                   TBA12260
  430 CONTINUE                                                          TBA12270
C                                                                       TBA12280
C     PRINT OUT RESULTS                                                 TBA12290
C                                                                       TBA12300
      CALL DOUTP1(NSNOUT,CPIDL,CPACT,EFECTN,CPID,CPCT,EFECT,1,K,        TBA12310
     1ARR(K,NXDIF)/ARR(K,NXDIF+1),DELTP)                                TBA12320
  450 DO 460 I=NXDIF,NXX                                                TBA12330
      WID=1.                                                            TBA12340
      IF(NRECT.EQ.2) WID=WIDTH1                                         TBA12350
  460 ARRK(I)=ARR(K,I)*WID                                              TBA12360
  490 CALL NEWR1(PRES,ARRK,BLOCK)                                       TBA12370
      IF(IBL) 500,900,500                                               TBA12380
  500 CONTINUE                                                          TBA12390
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*.........*.........*.........*.........*.........*.........*.........*.........*
C                                                                         TBA12400
  900 RETURN                                                              TBA12410
      END                                                                 TBA12420

  YOUR CARD TCTAL IS ---                 244
```

```
$IBFTC TBFW
      SUBROUTINE TUBFW1
C
C     THIS SUBROUTINE CALCULATES THEORETICAL FLOW SPLITS
C     USING DATA FROM SUBROUTINE TUBCTS.
C
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),
     1NGO,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,     ZZCP,IDIF
     2,HSEP  ,FLAREA(50),AREA(50)
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,
     5XMACH,RHOREF,EFDT(3)
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,       AFA,AFB,PREDM,STAGT
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS
      COMMON/B12678/JTAPE ,IPRINT
      COMMON/B2TUB/ XMTB(15),ATUBE(15),ALPHA(15),CAL(15),CBL(15)
C
    4 FORMAT(96H SOLUTION FAILED TO CALCULATE THEORETICAL FLOW AREAS FOR
     1A GIVEN FLOW SPLIT. SOLUTION TERMINATED.)
   10 FORMAT(18H1*** ERROR MESSAGE)
C
      THA=0.
      THB=0.
      BETA1=0.
      BETA2=0.
      XMVA=0.
      XMVB=0.
      XMVS=0.
      SUM=0.
C
C     INNER ANNULUS
C
      DO 600 J=1,NTUBE
      THA=THA+ATUBE(J)*COS(ALPHA(J))
      BETA1=BETA1+ATUBE(J)*UJ(J)*UJ(J)*COS(ALPHA(J))
      XMVA=XMVA+UJ(J)*ATUBE(J)*COS(ALPHA(J))
      SUM=SUM+XMTB(J)
      JK=J
      IF(SUM-AFA) 600,610,604
  600 CONTINUE
      WRITE(JTAPE,10)
      WRITE(JTAPE,4)
      STOP
  604 J=JK
      THA=THA-((SUM-AFA)/XMTB(J))*ATUBE(J)*COS(ALPHA(J))
      BETA1=BETA1-((SUM-AFA)/XMTB(J))*ATUBE(J)*UJ(J)*UJ(J)*COS(ALPHA(J))
      XMVA=XMVA-((SUM-AFA)/XMTB(J))*ATUBE(J)*UJ(J)*COS(ALPHA(J))
C
C     OUTER ANNULUS
C
  610 SUM=0.
      DO 620 J=1,NTUBE
      JJ=NTUBE+1-J
      THB=THB+ATUBE(JJ)*COS(ALPHA(JJ))
      BETA2=BETA2+ATUBE(JJ)*UJ(JJ)*UJ(JJ)*COS(ALPHA(JJ))
      XMVB=XMVB+UJ(JJ)*ATUBE(JJ)*COS(ALPHA(JJ))
      SUM=SUM+XMTB(JJ)
```

```
      IF(SUM-AFB) 620,630,625                                           TBFW0060
  620 CONTINUE                                                          TBFW0061
      WRITE(JTAPE,10)                                                   TBFW0062
      WRITE(JTAPE,4)                                                    TBFW0063
      STOP                                                              TBFW0064
C                                                                       TBFW0065
  625 THB=THB-(SUM-AFB)/XMTB(JJ)*ATUBE(JJ)*COS(ALPHA(JJ))               TBFW0066
      BETA2=BETA2-(SUM-AFB)/XMTB(JJ)*ATUBE(JJ)*UJ(JJ)*UJ(JJ)*COS(ALPHA(JTBFW0067
     1J))                                                               TBFW0068
      XMVB=XMVB- (SUM-AFB)/XMTB(JJ)*ATUBE(JJ)*COS(ALPHA(JJ))*UJ(JJ)     TBFW0069
C                                                                       TBFW0070
C     FLOW INTO THE SNOUT                                               TBFW0071
C                                                                       TBFW0072
  630 THS=FLAREA(NXDIF)-THB-THA                                         TBFW0073
      IF(THS)635,635,640                                                TBFW0074
  635 THS=0.000001                                                      TBFW0075
  640 CONTINUE                                                          TBFW0076
C                                                                       TBFW0077
C     ALLOW FOR BOUNDARY LAYER BLOCKAGE                                 TBFW0078
C                                                                       TBFW0079
      GO TO (650,660),NRECT                                             TBFW0080
  650 THA=THA+(CAL(NXDIF)**2.-CA(NXDIF)**2.)*3.14159                    TBFW0081
      THB=THB+(CB(NXDIF)**2.-CBL(NXDIF)**2.)*3.14159                    TBFW0082
      GO TO 680                                                         TBFW0083
  660 THA=THA+ CAL(NXDIF)-CA(NXDIF)                                     TBFW0084
      THB=THB+ CB(NXDIF)-CBL(NXDIF)                                     TBFW0085
  680 CONTINUE                                                          TBFW0086
      XMVA=XMVA/THA                                                     TBFW0087
      XMVB=XMVB/THB                                                     TBFW0088
      BETA1=BETA1/THA/XMVA**2                                           TBFW0089
      BETA2=BETA2/THB/XMVB**2                                           TBFW0090
      DO 685 J=1,NTUBE                                                  TBFW0091
  685 XMVS=XMVS+UJ(J)*ATUBE(J)*COS(ALPHA(J))                            TBFW0092
      XMVS=(XMVS-XMVA*THA-XMVB*THB)/THS                                 TBFW0093
  900 RETURN                                                            TBFW0094
      END                                                               TBFW0095
```

```
$IBFTC TBIN
      SUBROUTINE TUBEIN(IBL,NRECT,AREA,YA,YB,NTUBE,XMDOT,PRES,STAGT,
     1VPDATA,RDATA,NUPR,UJ,ASTAR,STAGP,RHO,XMTB,STP,N)
C
C     THIS SUBROUTINE CALCULATES THE INPUT STREAMTUBE PROPERTIES
C     FOR THE STREAMTUBE CALCULATION
C
      COMMON/B12678/ JTAPE,IPRINT
      DIMENSION VPR(15) ,VPDATA(15),RDATA(15),UJ(15),ASTAR(15), STAGP(15
     1),ATUBE(15),RAD(16),RHO(15),TJ(15),XMTB(15) ,ATB(15)
C
    1 FORMAT(99H1SOLUTION FAILED TO FIND A CONVERGED VALUE OF U. PROBLEM
     1TERMINATED. THE LAST TWO VALVES OF U WERE..)
    2 FORMAT (1X,6(E12.5))
   10 FORMAT(1X//////18H *** ERROR MESSAGE)
   11 FORMAT(66H SOLUTION FAILED TO CALCULATE STATIC PRESSURE AT COMPRES
     1SOR OUTLET)
C
C
      CALL GASTBL(D1,D2,D3,D4,-1,D6,ZZR,ZZGAMA)
      ZZCP=ZZR*ZZGAMA/(ZZGAMA-1.)
      IBL=1
C
C     CALCULATE AREA OF EACH STREANTUBE AND NONDIMENSIONAL VELOCITY
C
      SUMA=0.
      RAD(1)=YA
      GO TO (103,106),NRECT
  103 AR=3.14159*(YB**2-YA**2)
      DO 104 J=1,NTUBE
      ATB(J)=AR/FLOAT(NTUBE)
      ATUBE(J)=AREA/FLOAT(NTUBE)
      SUMA=SUMA+ATB(J)
  104 RAD(J+1)=SQRT(SUMA/3.14159+YA**2)
      GO TO 110
  106 AR=YB-YA
      DO 108 J=1,NTUBE
      ATB(J)=AR/FLOAT(NTUBE)
      ATUBE(J)=AREA/FLOAT(NTUBE)
  108 RAD(J+1)=RAD(J)+ATB(J)
  110 DO 115 J=1,NTUBE
  115 RAD(J)=((RAD(J)+RAD(J+1))/2.-YA)/(YB-YA)
      DO 120 J=1,NTUBE
  120 CALL I1AP1(RAD(J),VPR(J),RDATA,VPDATA,NUPR)
      RHOR=STP/ZZR/STAGT
      SUM=0.
      DO 121 J=1,NTUBE
  121 SUM=SUM+VPR(J)*RHOR*ATUBE(J)
      U=XMDOT/SUM
      LC=0
C
C     IS STAGNATION PRESSURE GIVEN (N=1) OR STATIC PRESSURE (N=0)
C     IF TOTAL PRESSURE GIVEN (N=1) GUESS STATIC PRESSURE
C
      IF(N.EQ.0) GO TO 1210
      PRES=STP-U*U*RHOR/32./2.
      LD=0
 1210 SUM=0.
C
C     CALCULATE VELOCITY TEMPERATURE AND DENSITY FOR EACH STREAMTUBE
```

```
C                                                                       TBIN0060
      DO 122 J=1,NTUBE                                                  TBIN0061
      UJ(J)=VPR(J)*U                                                    TBIN0062
      TJ(J)=STAGT-UJ(J)**2/(2.*ZZCP*32.)                                TBIN0063
      RHO(J)=PRES/ZZR/TJ(J)                                             TBIN0064
  122 SUM=SUM+VPR(J)*RHO(J)*ATUBE(J)                                    TBIN0065
      UU=XMDCT/SUM                                                      TBIN0066
C                                                                       TBIN0067
C     IS GUESS AT VELOCITY GOOD ENOUGH                                  TBIN0068
C                                                                       TBIN0069
      IF(ABS((UU-U)/U)-0.00001) 130,130,123                             TBIN0070
  123 U=UU                                                              TBIN0071
      LC=LC+1                                                           TBIN0072
      IF(LC-40)1210,1210,124                                            TBIN0073
  124 WRITE(JTAPE,1)                                                    TBIN0074
      WRITE(JTAPE,2)UU,U                                                TBIN0075
      IBL=0                                                             TBIN0076
      RETURN                                                            TBIN0077
C                                                                       TBIN0078
C      CALCULATE TOTAL PROPERTIES FOR EACH STREAMTUBE                   TBIN0079
C                                                                       TBIN0080
  130 SUM=0.                                                            TBIN0081
      DO 135 J=1,NTUBE                                                  TBIN0082
      STAGP(J)=PRES*(STAGT/TJ(J))**(ZZGAMA/(ZZGAMA-1.))                 TBIN0083
      CALL GASTBL(AAS,D2,PRES/STAGP(J),D4,0,IBL,D7,D8)                  TBIN0084
      IF(IBL)900,900,133                                                TBIN0085
  133 XMTB(J)=RHO(J)*ATUBE(J)*UJ(J)                                     TBIN0086
  135 ASTAR(J)=ATUBE(J)/AAS                                             TBIN0087
      IF(N.EQ.0) GO TO 900                                              TBIN0088
      STPP=0.                                                           TBIN0089
C                                                                       TBIN0090
C     CALCULATE WEIGHT MEAN TOTAL PRESSURE                              TBIN0091
C                                                                       TBIN0092
      DO 140 J=1,NTUBE                                                  TBIN0093
  140 STPP=STPP+STAGP(J)*XMTB(J)/XMDOT                                  TBIN0094
C                                                                       TBIN0095
C     IS TOTAL PRESSURE NEAR ENOUGH TO INPUT VALUE                      TBIN0096
C                                                                       TBIN0097
      IF(ABS(STPP/STP-1.)-0.0001) 200,200,150                           TBIN0098
C                                                                       TBIN0099
C     GUESS NEW VALUE OF STATIC PRESSURE                                TBIN0100
C                                                                       TBIN0101
  150 PRES=PRES/STPP*STP                                                TBIN0102
      LD=LD+1                                                           TBIN0103
      IF(LD-40)1210,1210,160                                            TBIN0104
  160 WRITE(JTAPE,10)                                                   TBIN0105
      WRITE(JTAPE,11)                                                   TBIN0106
      IBL=0                                                             TBIN0107
      RETURN                                                            TBIN0108
  200 STP=STPP                                                          TBIN0109
  900 RETURN                                                            TBIN0110
      END                                                               TBIN0111
```

```
$IBFTC TBAN
      SUBROUTINE TUBANL(IBL,LN,ALPHA1,ALPHA2,N,NX,PRES,ASTAR,RHO,
     1STAGP,UJ,VEL,RO,AREA,ATUBE,STAGT,ALPHA,NTUBE)
      COMMON/812678/ JTAPE,IPRINT
C
C     THIS SUBROUTINE PERFORMS A STREAM TUBE ANALYSIS FROM GIVEN
C     STARTING CONDITIONS
C
      DIMENSION ALPHA1(50),ALPHA2(50),PRES(50),ASTAR(15),
     1RHO(15),STAGP(15),VEL(2,50),RO(2,50),AREA(50),ATUBE(15),UJ(15),
     2 TJ(15),ALPHA(15),C1(15),C2(15),XMTB(15)
C
    2 FORMAT(1X,9(E12.5,1X))
    3 FORMAT(34H1ITERATION ON ALPHA AT STATION NO.,I3,10H CYCLE NO.,I3,5
     15H HAS NOT CONVERGED. THE LATEST VALUES OF ALPHA ARE.....)
    5 FORMAT(33H ITERATION ON AREA AT STATION NO.,I3,10H CYCLE NO.,I3,67
     1H HAS NOT CONVERGED. THE LATEST VALUES OF GUESSED AREA AND FLOW AR
     2EA)
    6 FORMAT(11H ARE.......,2(E12.5,2X))
   10 FORMAT(1X////// 18H *** ERROR MESSAGE)
C
      CALL GASTBL(D1,D2,D3,D4,-1,D6,ZZR,ZZGAMA)
      ZZCP=ZZR*ZZGAMA/(ZZGAMA-1.)
      IBL=1
      DO 125 J=1,NTUBE
      Z=PRES(N)/STAGP(J)
      CALL GASTBL(AAS,D2,Z,D4,0,IBL,D7,D8)
      IF(IBL) 900,900,121
  121 ATUBE(J)=AAS*ASTAR(J)
      TJ(J)=STAGT*D2
      RHO(J)=PRES(N)/ZZR/TJ(J)
      UJ(J)=SQRT(32.*ZZCP*(STAGT-TJ(J))*2.)
      XMTB(J)=ATUBE(J)*UJ(J)*RHO(J)
  125 ALPHA(J)=ALPHA1(N+1)+(ALPHA2(N+1)-ALPHA1(N+1))*FLOAT(J)/FLOAT(NTUB
     1E)
C
C     GUESS PRESSURE AT NEXT STATION DOWN STREAM
C
      N1=N+1
      DO 300 I=N1,NX
  150 PRR=PRES(I-1)
      LR=0
 2000 DP=10.**10.
      DO 201 J=1,NTUBE
      C1(J)=RHO(J)*(UJ(J)*ATUBE(J))**2/2./32.
      C2(J)=C1(J)/ATUBE(J)**2
  201 IF(DP.GE.C2(J))DP=C2(J)
      R=0.
      DO 202 J=1,NTUBE
  202 R=R+SQRT(C1(J)/C2(J))*COS(ALPHA(J))
      R=R-AREA(I)
      IF (R) 2020,2021,2022
 2021 PRES(I)=PRR
      GOTO 300
 2022 DP=-10.*DP
 2020 SUM=ABS(DP/4. )
      DP=DP/2.
      DO 206 KK=1,30
      R=0.
      DO 203 J=1,NTUBE
```

```
  203 R=R+SQRT(C1(J)/(C2(J)-DP))*COS(ALPHA(J))
      R=R-AREA(I)
      IF(ABS(R/AREA(I))-0.00001)207,207,2040
 2040 IF(R) 204,207,205
  204 DP=DP+SUM
      GO TO 206
  205 DP=DP-SUM
  206 SUM=SUM/2.
  207 PRES(I)=PRR+DP
      DO 212 J=1,NTUBE
      Z=PRES(I)/STAGP(J)
      CALL GASTBL(AAS,TTO,Z,D4,0,IBL,D7,D8)
      IF(IBL)900,900,211
  211 ATUBE(J)=AAS*ASTAR(J)
      TJ(J)=TTO*STAGT
      RHO(J)=PRES(I)/ZZR/TJ(J)
  212 UJ(J)=SQRT(2.*ZZCP*32.*(STAGT-TJ(J)))
C
C     CALCULATE STREAM-TUBE SLOPE
C
      LC=0
      SUMA=0.
      DO 215 J=1,NTUBE
  215 SUMA=SUMA+ATUBE(J)*COS(ALPHA(J))
 2150 SUMB=0.
      DO 2151 J=1,NTUBE
      SUMB=SUMB+ATUBE(J)*COS(ALPHA(J))
 2151 ALPHA(J)=ALPHA1(I)+(ALPHA2(I)-ALPHA1(I))*(SUMB-ATUBE(J)*COS(ALPHA(
     1J))/2.)/SUMA
      SUMC=0.
      DO 218 J=1,NTUBE
  218 SUMC=SUMC +ATUBE(J)*COS(ALPHA(J))
      IF(ABS((SUMA-SUMC)/SUMA)-0.000005)225,225,220
  220 LC=LC+1
      SUMA=SUMC
      IF(LC-40)2150,2150,221
  221 WRITE(JTAPE,10)
      WRITE(JTAPE,3)I,LN
      WRITE(JTAPE,2) (ALPHA(J),J=1,NTUBE)
      IBL=0
      RETURN
C
C     COMPARE COMPUTED FLOW AREA AT THIS GUESSED PRESSURE TO ACTUAL FLOW
C     AREA AT THIS STATION NUMBER
C
  225 IF(ABS((AREA(I)-SUMC)/AREA(I))-0.0001) 290,290,230
  230 LR=LR+1
      IF(LR-40)240,240,235
  235 WRITE(JTAPE,10)
      WRITE(JTAPE,5)I,LN
      SUMB=AREA(I)
      WRITE(JTAPE,6) SUMA,SUMB
      IBL=0
      RETURN
  240 PRR=PRES(I)
      GO TO 2000
  290 VEL(1,I)=UJ(1)
      VEL(2,I)=UJ(NTUBE)
      RO(1,I)=RHO(1)
      RO(2,I)=RHO(NTUBE)
  300 CONTINUE
```

```
900 RETURN                                                    TBAN0121
    END                                                       TBAN0122
```

```
$IBFTC NEWR    LIST
      SUBROUTINE NEWRAD (IBL,X,VEL,RO,DELTB,SHAPEH,N,NX,IHLD,CB,CA,
     1ALFA,ALFB,HSEP,NRECT,ALFC)
C
C     THIS SUBROUTINE CALCULATES THE BOUNDARY LAYER DISPLACEMENT
C     THICKNESS FOR A GIVEN VELOCITY DISTRIBUTION
C
      COMMON/B12678/ JTAPE,IPRINT
      COMMON/B2T8CS/SHP(2),THET(2),ROJ(2),VELJ(2),SUMXJ(4)
      DIMENSION VEL(2,50),            RO(2,50),            SHAPEH(2,50),
     1X(  1),CA(  1),CB(  1),ISEP(2),DELTB(2,50),
     2           DELTA(2,50),THETA(2,50),E(4),F(2),G(2),DT(2),
     3ALFA(1),ALFB(1)
     4,ALFC(1)
      DATA A,C/2H**,2H
C
    1 FORMAT(1X///  35X,50HBOUNDARY LAYER PROPERTIES - SOLUTION HAS CONV
     1ERGED)
    2 FORMAT(1X//)
    3 FORMAT(1X///  35X,54HBOUNDARY LAYER PROPERTIES - SOLUTION HAS NOT
     1CONVERGED)
    4 FORMAT(76H                                          INNER WALL
     1        OUTER WALL)
    5 FORMAT(116H STATION   X(I)    PRESSURE     DELTA   THETA    H
     1     DELTA   THETA    H        AN. AREA   FRACTIONAL    STATION)
    6 FORMAT(115H  NUMBER    IN        PSIA        IN      IN
     1      IN      IN              SQ IN      BLOCKAGE       NUMBER)
    7 FORMAT( 2X,I4,2X,F9.3,F9.3,3X,A2,3F7.3,A2,3X,A2,
     13F7.3,    A2,2X,F9.3,F11.4,5X,I4)
    8 FORMAT(51H SEPARATION IF IT OCCURS IS INDICATED BY **.......**)
   12 FORMAT(1X/)

      IBL=1
      THETA(1,N)=DELTB(1,N)/SHAPEH(1,N)
      THETA(2,N)=DELTB(2,N)/SHAPEH(2,N)
      DELTA(1,N)=DELTB(1,N)
      DELTA(2,N)=DELTB(2,N)

      CALCULATE THETA AND SHAPE FACTOR H FOR BOTH WALLS

      N1=N+1
      DO 140 J=1,2
      ISEP(J)=N +1
      SUMX=SUMXJ(J)
      DO 1050 I=N1,NX
      II=I-1
      SUMX=SUMX+(VEL(J,I)**4*RO(J,I)**(7./6.)+VEL(J,II)**4*RO(J,II)**(7.
     1/6.))/2.*(X(I)-X(II))
 1050 THETA(J,I)=(THET(J)**(7./6.)*(VELJ(J)/VEL(J,I))**(25./6.)*(ROJ(J)/
     1RO(J,I))**(7./6.)+SUMX*.0076*.23/VEL(J,I)**(25./6.)/RO(J,I)**
     2(7./6.))**(6./7.)
      SUMXJ(J+2)=SUMX
      DO 140 I=N1,NX
      TA   =(THETA(J,I)-THETA(J,I-1))/(X(I)-X(I-1))
      SHAPEH(J,I)=SHP(J)+70.*(SHP(J)-1.05)*TA
      IF(SHAPEH(J,I).LE.1.1) SHAPEH(J,I)=1.1
      IF(SHAPEH(J,I).GE.3.5) SHAPEH(J,I)=3.5
  106 IF(SHAPEH(J,I)-HSEP) 108,108,110
  108 ISEP(J)=ISEP(J)+1
      IF(ISEP(J).LE.I) ISEP(J)=ISEP(J)-1
```

```
  110 DELTA(J,I)=THETA(J,I)*SHAPEH(J,I)
  140 CONTINUE
C
C     CALCULATE NEW VALUES OF THE DISPLACEMENT THICKNESS FROM THE
C     PREVIOUS VALUES AND THE PREDICTED VALUES AT THE PREVIOUS BLOCKAGE
C
      ISP=NX+1
      JH=1
      IF(ISEP(1).GT.ISEP(2) ) JH=2
      IF(ISEP(JH).EQ.NX+1) GO TO 145
      ISP=ISEP(JH)
      JK=1
      IF(JH.EQ.1) JK=2
  145 DT(1)=0.
      DT(2)=0.
      E(3)=DELTB(1,N)
      E(4)=DELTB(2,N)
      DO 2000 I=N1,NX
      IF(I.GT.ISP) GO TO 250
      DO 2001 J=1,2
      D=240.*(SHP(J)-1.05)/SHAPEH(J,I)*THETA(J,I)/(X(I)-X(I-1))+3.3
      IF(SHAPEH(J,I)-3.5) 1501,1503,1501
 1501 IF(SHAPEH(J,I)-1.1) 1500,1503,1500
 1503 D=3.3
      DT(J)=0.
 1500 CONTINUE
      E(J)=DELTA(J,I)*(1.+D/(CB(I)-CA(I))*(DELTB(1,I)+DELTB(2,I)))
     1-70.*DT(J)*(SHP(J)-1.05)/SHAPEH(J,I)/(X(I)-X(I-1))
     2*DELTA(J,I)
      F(J)=DELTA(J,I)*D/(CB(I)-CA(I))
 2001 G(J)=F(J)
      F(1)=F(1)+1.
      G(2)=G(2)+1.
      G(1)=G(1)/F(1)
      E(1)=E(1)/F(1)
      E(2)=E(2)-E(1)*F(2)
      G(2)=G(2)-G(1)*F(2)
      E(2)=E(2)/G(2)
      E(1)=E(1)-E(2)*G(1)
      AB1=DELTB(1,I)
      AB2=DELTB(2,I)
      DO 2004 J=1,2
      IF(E(J).LE.0.) E(J)=0.
      IF(E(J).GT.0.5*(CB(I)-CA(I))) E(J)=0.5*(CB(I)-CA(I))
      IF(DELTB(J,I).LE.0.02*(CB(I)-CA(I))) GO TO 2002
      IF(ABS(E(J)-DELTB(J,I))/DELTB(J,I).LE.0.4) GO TO 2002
      DELTB(J,I)=DELTB(J,I)*(1.+0.2*SIGN(1.,E(J)/DELTB(J,I)-1.))
      GO TO 2004
 2002 DELTB(J,I)=(E(J)+DELTB(J,I))/2.
 2004 CONTINUE
      DO 2006 J=1,2
 2006 DT(J)=-3.3*THETA(J,I)*(E(1)+E(2)-AB1-AB2)/(CB(I)-CA(I))
      E(3)=E(1)
      E(4)=E(2)
      GO TO 220
C
C     IF FLOW HAS SEPERATED EXPAND AT CONSTANT PRESSURE  I.E. CONSTANT
C     FLOW AREA
C
  250 RT=(SHAPEH(JH,ISP)-HSEP)/(SHAPEH(JH,ISP)-SHAPEH(JH,ISP-1))
      IF(ISP.EQ.N1) RT=1.
```

```
      IF(RT.GT.1.)RT=1.                                                 NEWR0121
      ALF=(ABS(ALFA(ISP))+ABS(ALFB(ISP)))/4.                            NEWR0122
      IF(NRECT.EQ.1)GO TO 350                                           NEWR0123
      FL1=CB(ISP)-CA(ISP)-DELTB(1,ISP)*COS(ALFA(ISP))-DELTB(2,ISP)*     NEWR0124
     1COS(ALFB(ISP))                                                    NEWR0125
      FL2=CB(ISP-1)-CA(ISP-1)-DELTB(1,ISP-1)*COS(ALFA(ISP-1))-DELTB(2,  NEWR0126
     1ISP-1)*COS(ALFB(ISP-1))                                           NEWR0127
      FL=FL1*(1.-RT)+FL2*RT                                             NEWR0128
      FL=FL/COS(ALF)                                                    NEWR0129
      AL1=COS(ALFA(I))                                                  NEWR0130
      AL2=COS(ALFB(I))                                                  NEWR0131
      IF(ISEP(1).EQ.ISEP(2)) GO TO 270                                  NEWR0132
      IF(JH.EQ.2) AL1=AL2                                               NEWR0133
      IF(JH.EQ.2)  AL2=COS(ALFA(I))                                     NEWR0134
      E(JK)=DELTA(JK,I)                                                 NEWR0135
      E(JH)=(CB(I)-CA(I)-FL-DELTA(JK,I)*AL2)/AL1                        NEWR0136
      SHAPEH(JH,I) =3.5                                                 NEWR0137
      GO TO 2509                                                        NEWR0138
  270 E(1)=(CB(I)-CA(I)-FL)/AL1* E(3)/(E(3)+E(4))                       NEWR0139
      E(2)=(CB(I)-CA(I)-FL)/AL2* E(4)/(E(3)+E(4))                       NEWR0140
      DO 251 J=1,2                                                      NEWR0141
  251 SHAPEH(J,I)=3.5                                                   NEWR0142
      GO TO 2509                                                        NEWR0143
  350 DO 351 K=1,2                                                      NEWR0144
      IS=ISP+1-K                                                        NEWR0145
      AA=3.141593*((CB(IS)-DELTB(2,IS)*COS(ALFB(IS)))**2-(CA(IS)+DELTB(1NEWR0146
     1,IS)*COS(ALFA(IS)))**2)/COS(ALFC(IS))                             NEWR0147
      IF(K.EQ.1) FL1=AA                                                 NEWR0148
  351 IF(K.EQ.2) FL2=AA                                                 NEWR0149
      FL=FL1*(1.-RT)+FL2*RT                                             NEWR0150
       FL=FL/COS(ALF)                                                   NEWR0151
  360 AL1=COS(ALFA(I))                                                  NEWR0152
      AL2=COS(ALFB(I))                                                  NEWR0153
      IF(ISEP(1).EQ.ISEP(2)) GO TO 370                                  NEWR0154
      E(JK)=DELTA(JK,I)                                                 NEWR0155
      IF(JH.EQ.1) E(JH)=(SQRT((CB(I)-DELTB(2,I)*AL2      )**2-FL*COS(ALFCNEWR0156
     1(I))/3.141593) -CA(I))/AL1                                        NEWR0157
      IF(JH.EQ.2) E(JH)=(CB(I)-SQRT(FL*COS(ALFC(I))/3.141593+(CA(I)+DELTNEWR0158
     1B(1,I)*AL1)**2))/AL2                                              NEWR0159
      SHAPEH(JH,I)=3.5                                                  NEWR0160
      GO TO 2509                                                        NEWR0161
  370 E(1)=(CB(I)**2-CA(I)**2-FL*COS(ALFC(I))/3.141593)/2./(CB(I) +     NEWR0162
     1CA(I)     ) /AL1                                                  NEWR0163
      E(2)=E(1)/AL2*AL1                                                 NEWR0164
      SHAPEH(1,I)=3.5                                                   NEWR0165
      SHAPEH(2,I)=3.5                                                   NEWR0166
 2509 DO 2511 J=1,2                                                     NEWR0167
 2511 DELTB(J,I)=(DELTB(J,I)+E(J))/2.                                   NEWR0168
C                                                                       NEWR0169
C     FIND IF SOLUTION HAS CONVERGED (IBL=1) OR NOT (IBL=0)             NEWR0170
C                                                                       NEWR0171
  220 IF(IBL) 2008,2000,2008                                            NEWR0172
 2008 IF(ABS(DELTB(1,I)/E(1)-1.)-0.01 ) 200,200,210                     NEWR0173
  200 IF(ABS(DELTB(2,I)/E(2)-1.)-0.01 ) 205,205,210                     NEWR0174
  205 CONTINUE                                                          NEWR0175
      IBL=1                                                             NEWR0176
      GO TO 2000                                                        NEWR0177
 210  IBL=0                                                             NEWR0178
      IHLD=I-2                                                          NEWR0179
      IF(IHLD.LE.N) IHLD=N                                              NEWR0180
 2000 CONTINUE                                                          NEWR0181
```

```
      RETURN                                                            NEWR0182
C                                                                       NEWR0183
C     WRITE CUT BOUNDARY LAYER PARAMETERS                               NEWR0184
C                                                                       NEWR0185
      ENTRY NEWR1(PRES,AREA,BLOCK)                                      NEWR0186
      DIMENSION PRES(50),BLOCK(50),AREA(50)                             NEWR0187
      WRITE(JTAPE,12)                                                   NEWR0188
      IF(IBL) 490,490,491                                               NEWR0189
  490 WRITE(JTAPE,3)                                                    NEWR0190
      GO TO 500                                                         NEWR0191
  491 WRITE(JTAPE,1)                                                    NEWR0192
  500 DO 510 I=N,NX                                                     NEWR0193
      PRES(I)=PRES(I)/144.                                              NEWR0194
      X(I)=X(I)*12.                                                     NEWR0195
      DELTA(1,I)=DELTB(1,I)*12.                                         NEWR0196
      DELTA(2,I)=DELTB(2,I)*12.                                         NEWR0197
      THETA(1,I)=THETA(1,I)*12.                                         NEWR0198
      THETA(2,I)=THETA(2,I)*12.                                         NEWR0199
  510 AREA(I)=AREA(I)*144.                                              NEWR0200
      WRITE(JTAPE,2)                                                    NEWR0201
      WRITE(JTAPE,4)                                                    NEWR0202
      WRITE(JTAPE,5)                                                    NEWR0203
      WRITE(JTAPE,6)                                                    NEWR0204
      WRITE(JTAPE,12)                                                   NEWR0205
      DO 600 I=N,NX                                                     NEWR0206
      IF( ISEP(1)-I) 560,565,560                                        NEWR0207
  560 IF( ISEP(2)-I) 570,575,570                                        NEWR0208
  565 IF( ISEP(2)-I) 580,585,580                                        NEWR0209
  570 WRITE(JTAPE,7)                                                    NEWR0210
     1           I,X(I),PRES(I),C,DELTA(1,I),THETA(1,I),SHAPEH(1,I),C,C,NEWR0211
     1DELTA(2,I),THETA(2,I),SHAPEH(2,I),C,AREA(I),BLOCK(I),I            NEWR0212
      GO TO 600                                                         NEWR0213
  575 WRITE(JTAPE,7)                                                    NEWR0214
     1           I,X(I),PRES(I),C,DELTA(1,I),THETA(1,I),SHAPEH(1,I),C,A,NEWR0215
     1DELTA(2,I),THETA(2,I),SHAPEH(2,I),A,AREA(I),BLOCK(I),I            NEWR0216
      GO TO 600                                                         NEWR0217
  580 WRITE(JTAPE,7)                                                    NEWR0218
     1           I,X(I),PRES(I),A,DELTA(1,I),THETA(1,I),SHAPEH(1,I),A,C,NEWR0219
     1DELTA(2,I),THETA(2,I),SHAPEH(2,I),C,AREA(I),BLOCK(I),I            NEWR0220
      GO TO 600                                                         NEWR0221
  585 WRITE(JTAPE,7)                                                    NEWR0222
     1           I,X(I),PRES(I),A,DELTA(1,I),THETA(1,I),SHAPEH(1,I),A,A,NEWR0223
     1DELTA(2,I),THETA(2,I),SHAPEH(2,I),A,AREA(I),BLOCK(I),I            NEWR0224
  600 CONTINUE                                                          NEWR0225
      WRITE(JTAPE,8)                                                    NEWR0226
      DO 610 I=N,NX                                                     NEWR0227
      PRES(I)=PRES(I)*144.                                              NEWR0228
      X(I)=X(I)/12.                                                     NEWR0229
      THETA(1,I)=THETA(1,I)/12.                                         NEWR0230
      THETA(2,I)=THETA(2,I)/12.                                         NEWR0231
  610 AREA(I)=AREA(I)/144.                                              NEWR0232
      RETURN                                                            NEWR0233
      END                                                               NEWR0234
```

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$IBFTC EMPC    LIST
      SUBROUTINE EMPCTS
C
C
C     THIS SUBROUTINE USES EMPIRICAL DATA TO CALCULATE THE DIFFUSER
C     PERFORMANCE FROM THE COMPRESSOR OUTLET TO THE SNOUT LIP OR
C     TO THE DOME
C
C
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),
     1NGO,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,    ZZCP,IDIF
     2,HSEP  ,FLAREA(50),AREA(50)
      COMMON/B4/DPREF
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,
     5XMACH,RHOREF,EFDT(3)
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,       AFA,AFB,PREDM,STAGT
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS
      COMMON/B12678/JTAPE ,IPRINT
      COMMON/BZERO/ UJY(11),YY(11),F(2),D9(11),DUMMY(565)
      COMMON/B2EMP/ DUMMIE(135),UCL2
     1,ZCTS
C
    1 FORMAT(1X/////18H *** ERROR MESSAGE/64H SOLUTION FAILED TO CALCUL
     1ATE STATIC PRESSURE AT COMPRESSOR EXIT)
   21 FORMAT(1H149X3(2H- ),7HRESULTS3(2H -)/////21H0REFERENCE CONDITION
     1S/1X20(1H-)/15H0REFERENCE AREA13X1H=F10.3,6H SQ FT/19H REFERENCE V
     2ELOCITY9X1H=F10.1,11H FT PER SEC/18H INLET MACH NUMBER10X1H=F10.3/
     322H REFERENCE MACH NUMBER6X1H=F10.3/29H REFERENCE DYNAMIC PRESSURE
     4 =F10.2,4H PSI)
   22 FORMAT(115H0THE DIFFUSER TREATMENT USED IN THIS PROGRAM BECOMES IN
     1CREASINGLY INACCURATE AT INLET MACH NUMBERS GREATER THAN 0.7)
 8765 FORMAT(7H0EMPCTS10F11.3/(7X10F11.3))
C
      NXDF1=NXDIF-1
      GO TO (100,104),NRECT
  100 DO 102 I=1,NXDIF,NXDF1
  102 AREA(I)=(CB(I)**2-CA(I)**2)*3.141593
      GO TO 1505
  104 DO 105 I=1,NXDIF,NXDF1
  105 AREA(I)=CB(I)-CA(I)
C
C     CALCULATE STATIC PRESSURE AT INLET
C
 1505 LG=0
  106 FLAREA(1)=AREA(1)*(1.-BLOCK(1))
      PRESIN=STPREF
      A=1./(2.*ZZCP*32.)
      C=-STAGT
 1500 B=FLAREA(1)*PRESIN/(AF2*ZZR)
      U=(-B+SQRT(B*B-4.*A*C))/2./A
      TEMP=STAGT-U*U*A
      PRS=STPREF*(TEMP/STAGT)**(ZZGAMA/(ZZGAMA-1.))
      IF(ABS(PRS/PRESIN-1.)-0.0001) 1504,1504,1501
 1501 LG=LG+1
      PRESIN=PRS
      IF(LG-40) 1500,1500,1502
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```
 1502 WRITE(JTAPE,1)                                                        EMPC0600
      IBL=0.                                                                EMPC0610
      RETURN                                                                EMPC0620
 1504 PRESIN=PRS                                                            EMPC0630
C                                                                           EMPC0640
C     CALCULATE INLET AND REFERENCE PROPERTIES                              EMPC0650
C                                                                           EMPC0660
      ASS=FLAREA(1)*0.532*STPREF/AF2/SQRT(STAGT)                            EMPC0670
      CALL GASTBL(ASS,TSS,PSS,YMACH,1,IBL,ZZR,ZZGAMA)                       EMPC0680
      ASS=AREF*ASS/FLAREA(1)                                                EMPC0690
      IF(NRECT.EQ.2) ASS=ASS/WIDTH1                                         EMPC0700
      CALL GASTBL(ASS,TSS,PSS,XMACH,1,IBL,ZZK,ZZGAMA)                       EMPC0710
      DPREF=STPREF*(1.0-PSS)/144.                                           EMPC0720
      UREF=XMACH*SQRT(ZZGAMA*ZZR*32.2*STAGT*TSS)                            EMPC0730
      IF(IPRINT.EQ.3) GO TO 107                                             EMPC0740
C     WRITE OUT REFERENCE CONDITIONS                                        EMPC0750
C                                                                           EMPC0760
      WRITE(JTAPE,21)AREF,UREF,YMACH,XMACH,DPREF                            EMPC0770
      IF(YMACH.GE..7)WRITE(JTAPE,22)                                        EMPC0780
  107 DPREF=DPREF*144.                                                      EMPC0790
C                                                                           EMPC0800
C     CALCUTATE DIFFUSER PERFORMANCE                                        EMPC0810
C                                                                           EMPC0820
      AR=AREA(NXDIF)/AREA(1)                                                EMPC0830
      B=B*AREA(1)/FLAREA(1)                                                 EMPC0840
      U=(-B+SQRT(B*B-4.*A*C))/2./A                                          EMPC0850
      RH=PRESIN/ZZR/(STAGT-U*U*A)                                           EMPC0860
      DYHD=RH*U*U/2./32.                                                    EMPC0870
      CPIDL=1.-1./AR/AR                                                     EMPC0880
      XLNGTH=(X(NXDIF)-X(1))/(CB(1)-CA(1))                                  EMPC0890
      E1=FLAREA(1)/AREA(1)                                                  EMPC0900
      CALL EMPANL(AR,XLNGTH,ARDTA,XLNDTA,EFDTA,NCDF,NYDF,NZDF,E1,E1DTA,     EMPC0910
     1E2,EFECTN,IDIF,EFDT,1)                                                EMPC0920
      CPACT=CPIDL*EFECTN                                                    EMPC0930
      PRES(NXDIF)=PRESIN+DYHD*CPACT                                         EMPC0940
      B=E2*AREA(NXDIF)*PRES(NXDIF)/AF2/ZZR                                  EMPC0950
      U=(-B+SQRT(B*B-4.*A*C))/2./A                                          EMPC0960
      TEMP=STAGT-U*U*A                                                      EMPC0970
      RHO2=PRES(NXDIF)/ZZR/TEMP                                             EMPC0980
      UCL2=AF2/E2/AREA(NXDIF)/RHO2                                          EMPC0990
      SUM=0.                                                                EMPC1000
      CALL PROFL(E2,UJY,ZCTS)                                               EMPC1010
      DO 120 J=1,11                                                         EMPC1020
      UJY(J)=UJY(J)*UCL2                                                    EMPC1030
      YY(J)=SUM                                                             EMPC1040
  120 SUM=SUM+0.1                                                           EMPC1050
C                                                                           EMPC1060
C     PRINT OUT SOLUTION                                                    EMPC1070
C                                                                           EMPC1080
      CALL DOUTPT(ESNOUT,CPIDL,CPACT,EFECTN,UJY,YY,D9,2)                    EMPC1090
C                                                                           EMPC1100
      GO TO (150,1200,150),NGO                                              EMPC1110
 1200 GO TO (121,130),NRECT                                                 EMPC1120
  121 F(1)=(SA(NXDIF+1)**2-CA(NXDIF+1)**2)/(CB(NXDIF+1)**2-CA(NXDIF+1)**EMPC1130
     12)                                                                    EMPC1140
      F(2)=(CB(NXDIF+1)**2-SB(NXDIF+1)**2)/(CB(NXDIF+1)**2-CA(NXDIF+1)**EMPC1150
     12)                                                                    EMPC1160
      GO TO 131                                                             EMPC1170
  130 F(2)=(CB(NXDIF+1)-SB(NXDIF+1))/(CB(NXDIF+1)-CA(NXDIF+1))              EMPC1180
      F(1)=(SA(NXDIF+1)-CA(NXDIF+1))/(CB(NXDIF+1)-CA(NXDIF+1))              EMPC1190
  131 EE1(1)=1.-(1.-E2)/2./F(1)                                             EMPC1200
```

```
      EE1(2)=1.-(1.-E2)/2./F(2)                                         EMPC1210
  150 RETURN                                                            EMPC1220
C                                                                       EMPC1230
C     ENTRY HERE DURING MASS FLOW ITERATION WITH MIXING EQUATION BEING  EMPC1240
C     USED IN THE PASSAGE BETWEEN SNOUT AND OUTER CASING                EMPC1250
C                                                                       EMPC1260
      ENTRY EMPDT1                                                      EMPC1270
      XMA=AFA/AF2                                                       EMPC1280
      XMB=AFB/AF2                                                       EMPC1290
      CALL PROFL1(XMA,XMB,YA,YB,EA,EB,ES,BETA1,BETA2,ZCTS)              EMPC1300
      THA=AREA(NXDIF)*YA                                                EMPC1310
      THB=AREA(NXDIF)*(1.-YB)                                           EMPC1320
      THS=AREA(NXDIF)-THA-THB                                           EMPC1330
      XMVA=EA*UCL2                                                      EMPC1340
      XMVB=EB*UCL2                                                      EMPC1350
      XMVS=ES*UCL2                                                      EMPC1360
      BETA1=BETA1                                                       EMPC1370
      BETA2=BETA2                                                       EMPC1380
  900 RETURN                                                            EMPC1390
      END                                                               EMPC1400
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*.........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC EMPS
      SUBROUTINE EMPSTA                                                 EMPS0010
C                                                                       EMPS0020
C     THIS SUBROUTINE CALCULATES THE FLOW PROPERTIES IN THE TWO ANULII  EMPS0030
C     USING EMPIRICAL DATA                                              EMPS0040
C                                                                       EMPS0050
      COMMON/B2/ RAD(16),DELTA(2,50),EE1(2),UJ(15),THA,THB,THS,PRES(50),EMPS0060
     1NGO,NWAY,ZZR,ZZGAMA,BETA1,BETA2,XMVA,XMVB,XMVS,     ZZCP,IDIF      EMPS0070
     2,HSEP  ,FLAREA(50),AREA(50)                                       EMPS0080
      COMMON/B12/ X(120),CA(120),CB(120),SA(50),SB(50),                 EMPS0090
     1NRECT,NXDIF,NDIFF,NSNOUT,NXDIF1,NXDIF2,NXDIFA,NXDIFB,NTUBE,       EMPS0100
     2PRESIN,      BLOCK(50),ABLOCK,SHAPEH(2,50),                       EMPS0110
     3VPDATA(15),RDATA(15),NUPR,ARDTA(200),XLNDTA(20),EFDTA(200),NCDF,  EMPS0120
     4NYDF,NZDF,E1DTA, NXDF,AREF,WIDTH1,                                EMPS0130
     5XMACH,RHOREF,EFCT(3)                                              EMPS0140
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B,        AFA,AFB,PREDM,STAGTEMPS0150
     1,IBL,STPREF,PNRTA,PNRTB,DPHSNT,DOMLOS                             EMPS0160
      COMMON/B12678/JTAPE ,IPRINT                                       EMPS0170
      COMMON/BZERO/        ALPB(50),ALPC(50),ALPD(50),                  EMPS0180
     1DUMMY(400),ALPA(50)                                               EMPS0190
      COMMON/B2EMP/   NXD(2),AR(3,2),TH(2),R(2),T(2),ASTR(2),AF(2),     EMPS0200
     1UJY(11),XX(2),DYD(2) ,ALFA(2,50),NX(2),UCL2                       EMPS0210
     1,ZCTS                                                             EMPS0220
      COMMON/BPLOS/PLOSS(2)                                             EMPS0230
C                                                                       EMPS0240
 8765 FORMAT(7H0EMPSTA10F11.3/(7X10F11.3))                              EMPS0250
C                                                                       EMPS0260
C     SET UP VALUES NEEDED IN THE DO LOOP                               EMPS0270
C                                                                       EMPS0280
      NXDF1=NXDIF-1                                                     EMPS0290
      NX(1)=NXDIF1                                                      EMPS0300
      NX(2)=NXDIF2                                                      EMPS0310
      NXD(1)=NXDIFA                                                     EMPS0320
      NXD(2)=NXDIFB                                                     EMPS0330
      CALL SLOPE(X,CA,NXDIF,NXDIFA,ALPA,NXDIFA+1)                       EMPS0340
      CALL SLOPE(X,CB,NXDIF,NXDIFB,ALPB,NXDIFB+1)                       EMPS0350
      CALL SLOPE(X,SA,NXDIF+2,NXDIFA,ALPC,NXDIFA+1)                     EMPS0360
      CALL SLOPE(X,SB,NXDIF+2,NXDIFB,ALPD,NXDIFB+1)                     EMPS0370
      NXDF2=NXDIF+1                                                     EMPS0380
      DO 119 I=NXDIF,NXDF2                                              EMPS0390
      ALPC(I)=ALPA(I)                                                   EMPS0400
  119 ALPD(I)=ALPB(I)                                                   EMPS0410
      DO 120 I=NXDIF,NXDIFA                                             EMPS0420
      DD=1                                                              EMPS0430
      DE=1                                                              EMPS0440
      IF(ALPA(I).LE.0.) DD=-1                                           EMPS0450
      IF(ALPC(I).LE.0.) DE=-1                                           EMPS0460
  120 ALFA(1,I)=(DD*ATAN(DD*ALPA(I))+DE*ATAN(DE*ALPC(I)))/2.            EMPS0470
      DO 121 I=NXDIF,NXDIFB                                             EMPS0480
      DD=1                                                              EMPS0490
      DE=1                                                              EMPS0500
      IF(ALPB(I).LE.0.) DD=-1                                           EMPS0510
      IF(ALPD(I).LE.0.) DE=-1                                           EMPS0520
  121 ALFA(2,I)=(DD*ATAN(DD*ALPB(I))+DE*ATAN(DE*ALPD(I)))/2.            EMPS0530
      DO 130 K=1,2                                                      EMPS0540
      XX(K)=0.                                                          EMPS0550
      NXX=NX(K)-1                                                       EMPS0560
      DO 130 I=NXDIF,NXX                                                EMPS0570
  130 XX(K)=XX(K)+(X(I+1)-X(I))/COS((ALFA(K,I)+ALFA(K,I+1))/2.)         EMPS0580
      GO TO (140,145),NRECT                                             EMPS0590
```

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*.........*.........*.........*.........*.........*.........*.........*.........*
  140 AR(2,1)=3.14159*(SA(NXDIF1)**2-CA(NXDIF1)**2)*COS(ALFA(1,NXDIF1)) EMPS0600
      AR(3,1)=3.14159*(SA(NXDIFA)**2-CA(NXDIFA)**2)                     EMPS0610
      AR(2,2)=3.14159*(CB(NXDIF2)**2-SB(NXDIF2)**2)*COS(ALFA(2,NXDIF2)) EMPS0620
      AR(3,2)=3.14159*(CB(NXDIFB)**2-SB(NXDIFB)**2)                     EMPS0630
      AR(1,1)=3.14159*(SA(NXDIF+1)**2-CA(NXDIF+1)**2)                   EMPS0640
     1*COS(ALFA(1,NXDIF+1))                                             EMPS0650
      AR(1,2)=3.14159*(CB(NXDIF+1)**2-SB(NXDIF+1)**2)                   EMPS0660
     1*COS(ALFA(2,NXDIF+1))                                             EMPS0670
      GO TO 147                                                         EMPS0680
  145 AR(2,1)=(SA(NXDIF1)-CA(NXDIF1))*COS(ALFA(1,NXDIF1))               EMPS0690
      AR(3,1)=(SA(NXDIFA)-CA(NXDIFA))                                   EMPS0700
      AR(2,2)=(CB(NXDIF2)-SB(NXDIF2))*COS(ALFA(2,NXDIF2))               EMPS0710
      AR(3,2)=(CB(NXDIFB)-SB(NXDIFB))                                   EMPS0720
      AR(1,1)=(SA(NXDIF+1)-CA(NXDIF+1))   *COS(ALFA(1,NXDIF+1))         EMPS0730
      AR(1,2)=(CB(NXDIF+1)-SB(NXDIF+1)) *COS(ALFA(2,NXDIF+1))           EMPS0740
  147 R(1)=(SA(NXDIF+1)-CA(NXDIF+1))*COS(ALFA(1,NXDIF+1))               EMPS0750
      R(2)=(CB(NXDIF+1)-SB(NXDIF+1))*COS(ALFA(2,NXDIF+1))               EMPS0760
      RETURN                                                            EMPS0770
C                                                                       EMPS0780
C     ENTRY HERE DURING INTERATION ON MASS SPLIT                        EMPS0790
C                                                                       EMPS0800
      ENTRY EMPSA1                                                      EMPS0810
C                                                                       EMPS0820
C     CALCULATE DIFFUSER PERFORMANCE                                    EMPS0830
C                                                                       EMPS0840
      AF(1)=AFA                                                         EMPS0850
      AF(2)=AFB                                                         EMPS0860
      TH(1)=THA*COS(ALFA(1,NXDIF1))                                     EMPS0870
      TH(2)=THB*COS(ALFA(2,NXDIF2))                                     EMPS0880
      DYD(1)=XMVA**2                                                    EMPS0890
      DYD(2)=XMVB**2                                                    EMPS0900
      DO 500 K=1,2                                                      EMPS0910
      IF(K.EQ.1) BT=BETA1                                               EMPS0920
      IF(K.EQ.2) BT=BETA2                                               EMPS0930
      ARR=AR(2,K)/TH(K)                                                 EMPS0940
  200 E1=1.-(1.-EE1(K))*AR(1,K)/TH(K)                                   EMPS0950
      RHO=AF(K)/TH(K)/SQRT(DYD(K))                                      EMPS0960
      DYHD=RHO*DYD(K)/2./32.*BT**2                                      EMPS0970
      CPIDL=1.-1./ARR/ARR                                               EMPS0980
      XLN=XX(K)/R(K)                                                    EMPS0990
      IF(ARR-1.) 223,223,222                                            EMPS1000
  222 CALL EMPANL(ARR,XLN,ARDTA,XLNDTA,EFDTA,NCDF,NYDF,NZDF,E1,E1DTA,   EMPS1010
     1E2,EFECTN,IDIF,EFDT, K+1)                                         EMPS1020
      GO TO 224                                                         EMPS1030
                                                                        EMPS1040
C     ASSUME THAT FLOW MAINTAINS A SIMILAR PROFILE IF PASSAGE ACTS      EMPS1050
C     AS A NOZZLE                                                       EMPS1060
                                                                        EMPS1070
  223 EFECTN=1.                                                         EMPS1080
      E2=E1                                                             EMPS1090
  224 CPACT=CPIDL*EFECTN                                                EMPS1100
      PRSOUT=PRES(NXDIF)+CPACT*DYHD                                     EMPS1110
      A=1./(ZZCP*2.*32.)                                                EMPS1120
      B=E2*AR(2,K)*PRSOUT/(AF2*ZZR)                                     EMPS1130
      C=-STAGT                                                          EMPS1140
      UM=(-B+SQRT(B*B-4.*A*C))/2./A                                     EMPS1150
      RHO=PRSOUT/ZZR/(STAGT-UM*UM*A)                                    EMPS1160
      UCL3=AF(K)/E2/AR(2,K)/RHO                                         EMPS1170
C                                                                       EMPS1180
C     CALCULATE DIFFUSER PERFORMANCE ALLOWING FOR MIXING                EMPS1190
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*.........*.........*.........*.........*.........*.........*.........*.........*
C                                                                       EMPS1200
      CALL PRCFL(E2,UJY,ZAN)                                            EMPS1210
      CALL PRCFL1(1.,0.,C3,C4,D5,C6,D7,BT,D8,ZAN)                       EMPS1220
      ARR=AR(3,K)/AR(2,K)                                               EMPS1230
      DYH=RHC*UCL3**2/32./2.                                            EMPS1240
       BTA=1./E2                                                        EMPS1250
      PRR=PRSCUT+(1.+1./ARR)*(BTA-1./ARR)*DYH                           EMPS1260
     1/BTA**2                                                           EMPS1270
      AZ  =1.-1./(AR(3,K)/TH(K))**2                                     EMPS1280
      CPID=(2.*(BT-1.)+AZ)/BT**2                                        EMPS1290
C                                                                       EMPS1300
C     CALCULATE TEMPERATURE AT INLET TO ANNULII AND TOTAL PRESSURE LOSS EMPS1310
C                                                                       EMPS1320
      B=1.                                                              EMPS1330
      C=-STAGT                                                          EMPS1340
      A=(AF(K)* ZZR/AR(3,K)/PRR)**2/(2.*ZZCP*32.)                       EMPS1350
      TANA=(-B+SQRT(B*B-4.*A*C))/2./A                                   EMPS1360
      PNRT=PRR*(STAGT/TANA)**(ZZGAMA/(ZZGAMA-1.))                       EMPS1370
      PNRT=PNRT-PLOSS(K)                                                EMPS1380
      ASS=AF(K)*SQRT(STAGT)/(0.532*PNRT)                                EMPS1390
      ASS=AR(3,K)/ASS                                                   EMPS1400
      CALL GASTBL(ASS,RAT,RAP,XMACH,1,IBL,ZZR,ZZGAMA)                   EMPS1410
      PRR=RAP*PNRT                                                      EMPS1420
      TANA=STAGT*RAT                                                    EMPS1430
      CPCT=(PRR-PRES(NXDIF))/DYHD                                       EMPS1440
      EFECT=CPCT/CPID                                                   EMPS1450
      DELTP=(STPREF-PNRT)/STPREF                                        EMPS1460
      IF(IPRINT)300,300,250                                             EMPS1470
C                                                                       EMPS1480
C     PRINT CUT RESULTS                                                 EMPS1490
C                                                                       EMPS1500
  250 CALL CCUTP1(NSNCUT,CPIDL,CPACT,EFECTN,CPID,CPCT,EFECT,2,K,TH(K)/AREMPS1510
     1(1,K),DELTP)                                                      EMPS1520
  300 GO TO (323,324),K                                                 EMPS1530
  323 PAN1A=PRR                                                         EMPS1540
      IF(DELTP.LT.0.)PAN1A=PAN1A*(1.+DELTP)                             EMPS1550
      TAN1A=TANA                                                        EMPS1560
      PNRTA=PNRT                                                        EMPS1570
      GO TO 500                                                         EMPS1580
  324 PAN1B=PRR                                                         EMPS1590
      IF(DELTP.LT.0.)PAN1B=PAN1B*(1.+DELTP)                             EMPS1600
      TAN1B=TANA                                                        EMPS1610
      PNRTB=PNRT                                                        EMPS1620
      GO TO 500                                                         EMPS1630
  500 CONTINUE                                                          EMPS1640
  900 RETURN                                                            EMPS1650
      END                                                               EMPS1660

 YOUR CARD TOTAL IS ---           168
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$IBFTC EMPA
      SUBROUTINE EMPANL (AR,XLNGTH,ARDTA,XLNDTA,EFDTA,NCDF,NYDF,NZDF,E1,EMPA0001
     1E1DTA,E2,EFECTN,IDIF,EFDT,NUDF)                                   EMPA0002
      DIMENSION ARDTA(1),XLNDTA(1),EFDTA(1)                             EMPA0003
     1,EFDT(1)                                                          EMPA0004
C                                                                       EMPA0005
      IF(IDIF)200,100,200                                               EMPA0006
  100 CALL INTPL8( AR,XLNGTH,ARDTA,EFDTA,XLNDTA,NCDF,NYDF,NZDF,EFECT)   EMPA0007
  101 SUM=0.25                                                          EMPA0008
      EFB=0.5                                                           EMPA0009
      DO 120 J=1,14                                                     EMPA0010
      R=2./0.15*(0.85-E1DTA)**2*COS(3.141593*(EFB-0.5))+EFB-EFECT       EMPA0011
      IF(R) 110,130,117                                                 EMPA0012
  117 EFB=EFB-SUM                                                       EMPA0013
      GO TO 120                                                         EMPA0014
  110 EFB=EFB+SUM                                                       EMPA0015
  120 SUM=SUM/2.                                                        EMPA0016
  130 EFECTN=EFB+2./0.15*(0.85-E1)**2*COS(3.141593*(EFB-0.5))           EMPA0017
  135 E2=1./SQRT(AR**2*(1./E1**2-EFECTN*(1.-1./AR**2)))                 EMPA0018
      CPIDL=1.-1./AR**2                                                 EMPA0019
      GO TO 900                                                         EMPA0020
  200 EFECTN=EFDT(NUDF)                                                 EMPA0021
      GO TO 135                                                         EMPA0022
  900 RETURN                                                            EMPA0023
      END                                                               EMPA0024
```

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*.........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC PROF
      SUBRCUTINE PROFL(E2,UJ,Z)                                          PRCF0001
C                                                                        PROF0002
C     THIS SUBROUTINE ASSUMES A TOP HAT PROFILE                          PROF0003
C                                                                        PRCFCCC4
      DIMENSICN UJ(11)                                                   PRCF0005
C                                                                        PRCF0006
      Z=E2                                                               PROF0007
      DO 100 J=1,11                                                      PROFOC08
  100 UJ(J)=1.                                                           PROF0009
      EK=1.                                                              PROF0010
      DC 110 J=1,5                                                       PROF0011
      JJ=12-J                                                            PROF0012
      IF(EK.LT.E2) GO TO 105                                             PRCF0013
      UJ(J)=0.                                                           PROF0014
      UJ(JJ)=0.                                                          PROF00'5
  105 EK=EK-0.2                                                          PROF0016
  110 CCNTINUE                                                           PRCF0017
      RETURN                                                             PRCF0018
C                                                                        PROF0019
C     CALCULATE THEORETICAL FLOW SPLIT                                   PROF0020
C                                                                        PRCF0021
      ENTRY PROFL1 (XMA,XMB,YA,YB,EA,EB,ES,BA,BB,E2)                     PRCF0022
C                     ** THIS CARD BLANK **                              PROF0023
      YA=(1.-E2)/2.+XMA*E2                                               PROF0024
      YB=1.-((1.-E2)/2.+XMB*E2)                                          PRCF0025
      IF(XMA.EC.0.) YB=0.                                                PROF0026
      IF(XMB.EC.0.)YA=1.                                                 PROF0027
      EA=XMA*E2/(YA)                                                     PROF0028
      EB=XMB*E2/(1.-YB)                                                  PRCF0029
      ES=1.                                                              PRCF0030
      BA=1./EA                                                           PRCF0031
      BB=1./EB                                                           PRCF0032
      RETURN                                                             PRCF0033
      END                                                                PRCF0034

  YOUR CARD TCTAL IS ---              36
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*........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC DOPT    LIST
      SUBROUTINE DOUTPT (NSNOUT,CPIDL,CPACT,EFECT,UJ, Y ,YY,N)          DOPT0001
C                                                                       DOPT0002
C     THIS SUBROUTINE PRINTS OUT RESULTS FROM THE DIFFUSER SUBPROGRAM   DOPT0003
C                                                                       DOPT0004
      COMMON/B12678/ JTAPE,IPRINT                                       DOPT0005
      DIMENSION UJ(11), Y(11) ,YY(11)                                   DOPT0006
      DIMENSION DA(4)                                                   DOPT0007
      DATA DA(1),DA(2)/4H  IN,4H OUT/                                   DOPT0008
      DATA DA(3),DA(4)/6H  IS  ,6HIS NOT/                               DOPT0009
C                                                                       DOPT0010
    2 FORMAT(59H IN THIS PART OF THE DIFFUSER A STREAMTUBE ANALYSIS IS UDOPT0011
     1SED)                                                              DOPT0012
    3 FORMAT(52H IN THIS PART OF THE DIFFUSER EMPIRICAL DATA IS USED)   DOPT0013
    4 FORMAT(85H IN THIS PART OF THE DIFFUSER THE PERFORMANCE IS CALCULADOPT0014
     1TED USING THE MIXING EQUATION)                                    DOPT0015
    8 FORMAT(42X,36HVELOCITY PROFILE AT EXIT OF DIFFUSER)               DOPT0016
    9 FORMAT(32H FRACTIONAL ANNULUS HEIGHT......,11(2X,F6.3))           DOPT0017
   10 FORMAT(32H HEIGHT ALLOWING FOR BLOCKAGE...,11(2X,F6.3))           DOPT0018
   11 FORMAT(32H VELOCITY, FT PER SEC...........,11F8.2)                DOPT0019
   14 FORMAT(10X,32HIDEAL PRESSURE RECOVERY COEFF. =,F6.3/              DOPT0020
     1        10X,32HPRESSURE RECOVERY COEFF.       =,F6.3/             DOPT0021
     2        10X,32HDIFFUSER EFFECTIVENESS         =,F6.3/             DOPT0022
     3        10X,38HFRACTIONAL TOTAL PRESSURE LOSS = 0.000)            DOPT0023
   15 FORMAT(10X,32HIDEAL PRESSURE RECOVERY COEFF. =,F6.3,              DOPT0024
     128H  (INCLUDING MIXING EFFECTS)/                                  DOPT0025
     1        10X,32HPRESSURE RECOVERY COEFF.       =,F6.3/             DOPT0026
     2        10X,32HDIFFUSER EFFECTIVENESS         =,F6.3/             DOPT0027
     3        10X,32HFRACTIONAL TOTAL PRESSURE LOSS =,F6.3,49H  (BASED ONDOPT0028
     1 MEAN CONDITIONS AT COMPRESSOR OUTLET))                           DOPT0029
   20 FORMAT(1X/////64H DIFFUSER PARAMETERS - COMPRESSOR OUTLET TO THE DOPT0030
     1LIP OF THE SNOUT/64H ---------------------------------------------DOPT0031
     2------------------)                                               DOPT0032
   21 FORMAT(1X/////52H DIFFUSER PARAMETERS - COMPRESSOR OUTLET TO THE DOPT0033
     1DOME/52H ---------------------------------------------------)     DOPT0034
   22 FORMAT(1X/////23H DIFFUSER PARAMETERS - ,A5,27H DIFFUSING PASSAGEDOPT0035
     1 BETWEEN ,A5,11H AND CASING/71H ----------------------------------DOPT0036
     2------------------------------------)                             DOPT0037
   24 FORMAT(50X,21H DIFFUSER PERFORMANCE)                              DOPT0038
   25 FORMAT(30H FLOW ALLOWED TO MIX AT OUTLET)                         DOPT0039
   26 FORMAT(20H NO MIXING AT OUTLET)                                   DOPT0040
   41 FORMAT( 34H GAS EXPANDED ISENTROPICALLY FROM ,F8.3,9H PSIA TO ,F8.DOPT0041
     13, 5H PSIA)                                                       DOPT0042
   42 FORMAT(59H FRACTIONAL TOTAL PRESSURE LOSS DUE TO MIXING ON THE DOMDOPT0043
     1E =,F6.3 )                                                        DOPT0044
   40 FORMAT(54H MISMATCH AT THE SNOUT IS CHARACTERISED BY THE RATIO -/ DOPT0045
     1 96H (TOTAL STREAMTUBE AREA JUST BEFORE THE SNOUT)/(FLOW AREA JUSTDOPT0046
     2 INSIDE THE SNOUT). THIS RATIO IS ,F6.3/                          DOPT0047
     3 17H AS THIS RATIO IS,A4,53HSIDE THE RANGE 0.85-1.15 THE FLOW SPLIDOPT0048
     4T ON THE SNOUT ,A6,13H WELL MATCHED)                              DOPT0049
   43 FORMAT( 88H THIS SECTION HAS AN AREA RATIO LESS THAN ONE AND ACTS DOPT0050
     1AS A NOZZLE AND NOT AS A DIFFUSER/ 106H THE VALUE PRINTED OUT AS TDOPT0051
     2HE DIFFUSER EFFECTIVENESS IS NOT AN INDICATION OF HOW WELL THE SECDOPT0052
     3TION PERFORMS)                                                    DOPT0053
   52 FORMAT(1X/)                                                       DOPT0054
   53 FORMAT(1X///)                                                     DOPT0055
C                                                                       DOPT0056
C                                                                       DOPT0057
      IF(NSNOUT-1)101,100,101                                           DOPT0058
  100 WRITE(JTAPE,20)                                                   DOPT0059
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*.........*.........*.........*.........*.........*.........*.........*.........*
      GO TO 102                                                         DOPT0060
  101 WRITE(JTAPE,21)                                                   DOPT0061
  102 GO TO (103,104,120),N                                             DOPT0062
  103 WRITE(JTAPE,2)                                                    DOPT0063
      GO TO 110                                                         DOPT0064
  104 WRITE(JTAPE,3)                                                    DOPT0065
  110 WRITE(JTAPE,53)                                                   DOPT0066
      WRITE(JTAPE,24)                                                   DOPT0067
      WRITE(JTAPE,52)                                                   DOPT0068
      WRITE(JTAPE,26)                                                   DOPT0069
      WRITE(JTAPE,14) CPIDL,CPACT,EFECT                                 DOPT0070
      WRITE(JTAPE,53)                                                   DOPT0071
      GO TO (111,112,120),N                                             DOPT0072
  111 WRITE(JTAPE,8)                                                    DOPT0073
      WRITE(JTAPE,52)                                                   DOPT0074
      WRITE(JTAPE,9)  (Y(I),I=1,11)                                     DOPT0075
      WRITE(JTAPE,10)(YY(I),I=1,11)                                     DOPT0076
      WRITE(JTAPE,11)(UJ(I),I=1,11)                                     DOPT0077
      GO TO 120                                                         DOPT0078
  112 WRITE(JTAPE,8)                                                    DOPT0079
      WRITE(JTAPE,52)                                                   DOPT0080
      WRITE(JTAPE,9)  (Y(I),I=1,11)                                     DOPT0081
      WRITE(JTAPE,11)(UJ(I),I=1,11)                                     DOPT0082
  120 RETURN                                                            DOPT0083
C                                                                       DOPT0084
C     ENTRY HERE TO PRINT OUT PERFORMANCE OF FLOW IN ANNULII            DOPT0085
C                                                                       DOPT0086
      ENTRY DOUTP1(NSNOUT,CPIDL,CPACT,EFECT,CPID,CPAC,EFEC,N,K,AR,DP)   DOPT0087
C                                                                       DOPT0088
      DATA A,B,C,D/5HINNER,5HOUTER,5HSNOUT,5HDOME /                     DOPT0089
      GO TO (301,302),K                                                 DOPT0090
  301 WW=A                                                              DOPT0091
      GO TO 303                                                         DOPT0092
  302 WW=B                                                              DOPT0093
  303 IF(NSNOUT-1)600,310,600                                           DOPT0094
  310 WRITE(JTAPE,22)WW,C                                               DOPT0095
      GO TO(311,312,313),N                                              DOPT0096
  311 WRITE(JTAPE,2)                                                    DOPT0097
      GO TO 320                                                         DOPT0098
  312 WRITE(JTAPE,3)                                                    DOPT0099
      GO TO 320                                                         DOPT0100
  313 WRITE(JTAPE,4)                                                    DOPT0101
      GO TO 350                                                         DOPT0102
  320 WRITE(JTAPE,53)                                                   DOPT0103
      WRITE(JTAPE,24)                                                   DOPT0104
      WRITE(JTAPE,52)                                                   DOPT0105
      WRITE(JTAPE,26)                                                   DOPT0106
      WRITE(JTAPE,14) CPIDL,CPACT,EFECT                                 DOPT0107
      WRITE(JTAPE,25)                                                   DOPT0108
      WRITE(JTAPE,15)CPID,CPAC,EFEC,DP                                  DOPT0109
      GO TO 500                                                         DOPT0110
  350 WRITE(JTAPE,53)                                                   DOPT0111
      WRITE(JTAPE,24)                                                   DOPT0112
      WRITE(JTAPE,52)                                                   DOPT0113
      WRITE(JTAPE,25)                                                   DOPT0114
      WRITE(JTAPE,15) CPID,CPAC,EFEC,DP                                 DOPT0115
  500 IF(CPID.LE.0.0.OR.CPIDL.LE.0.0) WRITE(JTAPE,43)                   DOPT0116
      IA=1                                                              DOPT0117
      IB=3                                                              DOPT0118
      IF(ABS(1.-AR).LE.0.15) GO TO 501                                  DOPT0119
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*.........*.........*.........*.........*.........*.........*.........*.........*
      IA=2                                                              DCPT0120
      IB=4                                                              DCPT0121
  501 WRITE(JTAPE,40) AR,DA(IA),DA(IB)                                  DCPT0122
      RETURN                                                            DCPT0123
C                                                                       DCPT0124
  600 WRITE(JTAPE,22)WW,D                                               DCPT0125
      WRITE(JTAPE,4)                                                    DCPT0126
      WRITE(JTAPE,53)                                                   DCPT0127
      CPIDL=CPIDL/144.                                                  DCPT0128
      CPACT=CPACT/144.                                                  DCPT0129
      WRITE(JTAPE,41)CPIDL,CPACT                                        DCPT0130
      WRITE(JTAPE,42)DP                                                 DCPT0131
      CPIDL=CPIDL*144.                                                  DCPT0132
      CPACT=CPACT*144.                                                  DCPT0133
      RETURN                                                            DCPT0134
      END                                                               DCPT0135
  YOUR CARD TOTAL IS ---                136
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$IBFTC GAST
      SUBROUTINE GASTBL(X,Y,Z,XMACH,N,IBL,ZZR ,ZZGAMA)                  GAST0001
C                                                                       GAST0002
C     X=AREA(I)/AREA(MACH NO = 1.)                                      GAST0003
C     Y=TEMP(I)/STAGT                                                   GAST0004
C     Z=PRES(I)/STAGP                                                   GAST0005
C     XMACH=MACH NUMBER                                                 GAST0006
C     N=0    SUBROUTINE ACCEPTS A VALUE Z TO GIVE X,Y,AND XMACH         GAST0007
C     N=1    SUBROUTINE ACCEPTS A VALUE X TO GIVE Y,Z,AND XMACH         GAST0008
C     N=-1   SUBROUTINE RETURN THE VALUE OF R AND GAMMA                 GAST0009
C     IN THIS SUBROUTINE GAMMA=1.4 AND R=53.3 LBF FT SEC                GAST0010
C                                                                       GAST0011
      COMMON/B12678/ JTAPE,IPRINT                                       GAST0012
    1 FORMAT(42H NEGATIVE VALUE CALCULATED FOR MACH NUMBER/20H SOLUTION GAST0013
     1TERMINATED)                                                       GAST0014
   2  FORMAT(49H MACH NUMBER GREATER THAN ONE. SOLUTION CONTINUED)      GAST0015
 11   FORMAT(18H *** ERROR MESSAGE)                                     GAST0016
 12   FORMAT(1X//////)                                                  GAST0017
C                                                                       GAST0018
      IF(N)50,100,200                                                   GAST0019
   50 ZZGAMA=1.4                                                        GAST0020
      ZZR=53.3                                                          GAST0021
      RETURN                                                            GAST0022
  100 Y=Z**(2./7.)                                                      GAST0023
      IF(Z.LE.0..OR.Z.GT.1.) GO TO 101                                  GAST0024
      XMACH=SQRT(5.*((1./Z)**(2./7.)-1.))                               GAST0025
      IBL=1                                                             GAST0026
      IF(XMACH)101,101,102                                              GAST0027
  101 WRITE(JTAPE,12)                                                   GAST0028
      WRITE(JTAPE,11)                                                   GAST0029
      WRITE(JTAPE,1)                                                    GAST0030
      IBL=0                                                             GAST0031
      RETURN                                                            GAST0032
  102 IF(XMACH-1.)104,104,103                                           GAST0033
  103 WRITE(JTAPE,12)                                                   GAST0034
      WRITE(JTAPE,11)                                                   GAST0035
      WRITE(JTAPE,2)                                                    GAST0036
  104 ASTAR=1.2**3.                                                     GAST0037
      A   =((1.+0.2*XMACH**2.)**3.)/XMACH                               GAST0038
      X=A/ASTAR                                                         GAST0039
      RETURN                                                            GAST0040
 200  XMACH=1./X                                                        GAST0041
      IF(X.LT.1.) GO TO 101                                             GAST0042
      DO 210 J=1,20                                                     GAST0043
      R=(1.+0.2*XMACH**2.)**3./(1.2**3.*XMACH)-X                        GAST0044
      DRDM=(1.2*(1.+0.2*XMACH**2)**2-(1.+0.2*XMACH**2)**3/XMACH**2)/1.2*GAST0045
     1*3                                                                GAST0046
      DM=-R/DRDM                                                        GAST0047
      IF(ABS(DM/XMACH)-0.0001)220,205,205                               GAST0048
  205 XMACH=XMACH+DM                                                    GAST0049
  210 CONTINUE                                                          GAST0050
      IBL=0                                                             GAST0051
      RETURN                                                            GAST0052
  220 Z=1./(1.+0.2*XMACH**2.)**3.5                                      GAST0053
      Y=Z**(2./7.)                                                      GAST0054
  900 RETURN                                                            GAST0055
      END                                                               GAST0056
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```
$IBFTC SLOP
      SUBROUTINE SLOPE(X,Y,LS,LE,DYDX,NX)                               SLOP0001
C                                                                       SLOP0002
      DIMENSION X(1),Y(1),DYDX(1)                                       SLOP0003
C                                                                       SLOP0004
      NIS=0                                                             SLOP0005
      IS=LS                                                             SLOP0006
      IE=LE                                                             SLOP0007
      IF(IS-1)4,4,3                                                     SLOP0008
    3 IS=IS-1                                                           SLOP0009
      NIS=1                                                             SLOP0010
      HLD=DYDX(IS)                                                      SLOP0011
    4 NIE=0                                                             SLOP0012
      IF(NX-IE) 45,45,40                                                SLOP0013
   40 IE=IE+1                                                           SLOP0014
      NIE=1                                                             SLOP0015
      HLE=DYDX(IE)                                                      SLOP0016
   45 CONTINUE                                                          SLOP0017
      IF(IS-IE) 8,5,8                                                   SLOP0018
    5 DYDX(IS)=0.0                                                      SLOP0019
      GO TO 60                                                          SLOP0020
    8 DO 50 I=IS,IE                                                     SLOP0021
      IF(I-IS) 10,10,20                                                 SLOP0022
   10 DX1=X(IS+1)-X(IS)                                                 SLOP0023
      DY1=Y(IS+1)-Y(IS)                                                 SLOP0024
      DYDX(IS)=DY1/DX1                                                  SLOP0025
      GO TO 50                                                          SLOP0026
   20 IF(I-IE) 30,41,60                                                 SLOP0027
   30 DYDX(I)=((Y(I+1)-Y(I))/(X(I+1)-X(I))+(Y(I)-Y(I-1))/(X(I)-X(I-1)))/SLOP0028
     12.0                                                               SLOP0029
      GO TO 50                                                          SLOP0030
   41 DXIE=X(IE)-X(IE-1)                                                SLOP0031
      DYIE =Y(IE)-Y(IE-1)                                               SLOP0032
      DYDX(IE)=DYIE/DXIE                                                SLOP0033
   50 CONTINUE                                                          SLOP0034
   51 IF(NIS-1) 53,52,52                                                SLOP0035
   52 DYDX(IS)=HLD                                                      SLOP0036
   53 IF(NIE-1) 55,54,54                                                SLOP0037
   54 DYDX(IE)=HLE                                                      SLOP0038
   55 CONTINUE                                                          SLOP0039
   60 RETURN                                                            SLOP0040
      END                                                               SLOP0041
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$IBFTC I1AP
      SUBROUTINE I1AP1(X,Y,ARGX,ARGY,IMX)                               I1AP0001
C                                                                       I1AP0002
C   SUBROUTINE FOR THE PARABOLIC INTERPOLATILN OF A FUNCTION OF ONE     I1AP0003
C                              ARGUMENT                                 I1AP0004
      DIMENSION ARGX(1),ARGY(1)                                         I1AP0005
      DIMENSION DI(2)                                                   I1AP0006
C                                                                       I1AP0007
      IF (IMX-2)5,7,6                                                   I1AP0008
    5 Y=ARGY(1)                                                         I1AP0009
      GO TO 95                                                          I1AP0010
C LINEAR EXTRAPOLATIONS ARE PERFORMED                                   I1AP0011
    6 IF(X-ARGX(1))7,7,8                                                I1AP0012
    7 IE=1                                                              I1AP0013
      NE=2                                                              I1AP0014
      GO TO 10                                                          I1AP0015
    8 IF(X-ARGX(IMX))15,9,9                                             I1AP0016
    9 IE=IMX                                                            I1AP0017
      NE=IMX-1                                                          I1AP0018
   10 Y=ARGY(IE)+(ARGY(NE)-ARGY(IE))*(X-ARGX(IE))/(ARGX(NE)-ARGX(IE))   I1AP0019
      GO TO 95                                                          I1AP0020
   15 IM1=IMX-1                                                         I1AP0021
      IREF=2                                                            I1AP0022
      DI(2)=ABS(ARGX(2)-X)                                              I1AP0023
      DO 30 I=2,IM1                                                     I1AP0024
      DI(1)=ABS(ARGX(I)-X)                                              I1AP0025
      IF(DI(1)-DI(2))20,30,30                                           I1AP0026
   20 IREF=I                                                            I1AP0027
      DI(2)=DI(1)                                                       I1AP0028
   30 CONTINUE                                                          I1AP0029
      I=IREF                                                            I1AP0030
   40 X1=ARGX(I+1)                                                      I1AP0031
      X2=ARGX(I)                                                        I1AP0032
      X3=ARGX(I-1)                                                      I1AP0033
      Y1=ARGY(I+1)                                                      I1AP0034
      Y2=ARGY(I)                                                        I1AP0035
      Y3=ARGY(I-1)                                                      I1AP0036
   70 A=((Y1-Y2)*(X2-X3)-(Y2-Y3)*(X1-X2))/((X1**2-X2**2)*(X2-X3)        I1AP0037
     1 -(X2**2-X3**2)*(X1-X2))                                          I1AP0038
      B=((Y2-Y3)-A*(X2**2-X3**2))/(X2-X3)                               I1AP0039
      Y=A*(X**2-X2**2)+B*(X-X2)+Y2                                      I1AP0040
   95 RETURN                                                            I1AP0041
      END                                                               I1AP0042
```

```
      SUBROUTINE INTPL8 (XA,ZA,TABX,TABY,TABZ,NC,NY,NZ,ANS)             INT80001
      COMMON/B12678/ JTAPE,IPRINT                                       INT80002
      DIMENSION TABX(1),TABY(1),TABZ(1),NRX(8),NPY(8),YY(8),TABXN(8),   INT80003
     1TABYN(8),TABZN(8)                                                 INT80004
      IN=1                                                              INT80005
      CALL UNS (NC,IA,IDX,IDZ,IMS)                                      INT80006
      IF (NZ-1)   5,5,10                                                INT80007
    5 IF(XA.GT.TABX(NZ).OR.XA.LT.TABX(1)) IN=IN+2                       INT80008
      IF(XA.GT. TABX(NZ)) XA=TABX(NZ)                                   INT80009
      IF(XA.LT.TABX(1)) XA=TABX(1)                                      INT80010
      CALL DISSER(XA,TABX,1,NY,IDX,NN)                                  INT80011
      NNN=IDX+1                                                         INT80012
      NNM=NN-1                                                          INT80013
      DO 7  K=1,NNN                                                     INT80014
      NNMK=NNM+K                                                        INT80015
      TABXN(K)=TABX(NNMK)                                               INT80016
    7 TABYN(K)=TABY(NNMK)                                               INT80017
      CALL LAGRAN (XA,TABXN,TABYN,NNN,ANS)                              INT80018
      GO TO 615                                                         INT80019
   10 ZARG=ZA                                                           INT80020
      IP1X=IDX+1                                                        INT80021
      IP1Z=IDZ+1                                                        INT80022
   15 IF(ZARG.GT.TABZ(NZ).OR.ZARG.LT.TABZ(1)) IN=IN+1                   INT80023
      IF(ZARG.GT.TABZ(NZ)) ZARG=TABZ(NZ)                                INT80024
      IF(ZARG.LT.TABZ(1)) ZARG=TABZ(1)                                  INT80025
   25 CALL DISSER (ZARG,TABZ,1,NZ,IDZ,NPZ)                              INT80026
      NX=NY/NZ                                                          INT80027
      NPZL=NPZ+IDZ                                                      INT80028
      I=1                                                               INT80029
      IF (IMS)   30,30,40                                               INT80030
   30 CALL DISSER (XA,TABX,1,NX,IDX,NPX)                                INT80031
      DO 35  JJ=NPZ,NPZL                                                INT80032
      NPY(I)=(JJ-1)*NX+NPX                                              INT80033
      NRX(I)=NPX                                                        INT80034
   35 I=I+1                                                             INT80035
      GOTO 50                                                           INT80036
   40 DO 45  JJ=NPZ,NPZL                                                INT80037
      IS=(JJ-1)*NX+1                                                    INT80038
      CALL DISSER (XA,TABX,IS,NX,IDX,NPX)                               INT80039
      NPY(I)=NPX                                                        INT80040
      NRX(I)=NPX                                                        INT80041
   45 I=I+1                                                             INT80042
   50 INN=0                                                             INT80043
      DO 55  I=1,IP1Z                                                   INT80044
      XH=XA                                                             INT80045
      NLOC =NRX(I)-1                                                    INT80046
      NLOCY=NPY(I)-1                                                    INT80047
      DO 53  K=1,IP1X                                                   INT80048
      NLOCK=NLOC+K                                                      INT80049
      NLOCYK=NLOCY+K                                                    INT80050
      TABXN(K)=TABX(NLOCK)                                              INT80051
   53 TABYN(K)=TABY(NLOCYK)                                             INT80052
      IF(XA.GT.TABX(NLOCK).OR.XA.LT.TABX(NLOC+1)) INN=INN+1             INT80053
      IF(XA.GT.TABX(NLOCK)) XH=TABX(NLOCK)                              INT80054
      IF(XA.LT.TABX(NLOC+1)) XH=TABX(NLOC+1)                            INT80055
      CALL LAGRAN(XH,TABXN,TABYN,IP1X,AN)                               INT80056
   55 YY(I)=AN                                                          INT80057
      IF(INN.GT.0) IN=IN+2                                              INT80058
      NPZN=NPZ-1                                                        INT80059
      DO 60  K=1,IP1Z                                                   INT80060
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```
      NPZNK=NPZN+K                                                      INT80061
   60 TABZN(K)=TABZ(NPZNK)                                              INT80062
      CALL LAGRAN (ZARG,TABZN,YY,IP1Z,ANS)                              INT80063
  615 IF(IN.EQ.1) GO TO 70                                              INT80064
      WRITE(JTAPE,4)                                                    INT80065
      GO TO (70,620,621,622),IN                                         INT80066
  620 WRITE(JTAPE,1)                                                    INT80067
      RETURN                                                            INT80068
  621 WRITE(JTAPE,2)                                                    INT80069
      RETURN                                                            INT80070
  622 WRITE(JTAPE,3)                                                    INT80071
    1 FORMAT(33H DATA EXTRAPOLATED IN Z DIRECTION)                      INT80072
    2 FORMAT(33H DATA EXTRAPOLATED IN X DIRECTION)                      INT80073
    3 FORMAT(37H DATA EXTRAPOLATED IN BOTH DIRECTIONS)                  INT80074
    4 FORMAT(1X//////18H *** ERROR MESSAGE)                             INT80075
   70 RETURN                                                            INT80076
      END                                                               INT80077
$IBFTC UN
      SUBROUTINE UNS (IC,IA,IDX,IDZ,IMS)                                INT80078
      IF (IC)   5,5,10                                                  INT80079
    5 IMS=1                                                             INT80080
      NC=-IC                                                            INT80081
      GOTO 15                                                           INT80082
   10 IMS=0                                                             INT80083
      NC=IC                                                             INT80084
   15 IF (NC-100)   20,25,25                                            INT80085
   20 IA=0                                                              INT80086
      GOTO 30                                                           INT80087
   25 IA=1                                                              INT80088
      NC=NC-100                                                         INT80089
   30 IDX=NC/10                                                         INT80090
      IDZ=NC-IDX*10                                                     INT80091
      RETURN                                                            INT80092
      END                                                               INT80093
$IBFTC LAGR
      SUBROUTINE LAGRAN (XA,X,Y,N,ANS)                                  INT80094
      DIMENSION X(1),Y(1)                                               INT80095
      SUM=0.0                                                           INT80096
      DO 3 I=1,N                                                        INT80097
      PROD=Y(I)                                                         INT80098
      DO 2 J=1,N                                                        INT80099
      A=X(I)-X(J)                                                       INT80100
      IF (A)    1,2,1                                                   INT80101
    1 B=(XA-X(J))/A                                                     INT80102
      PROD=PROD*B                                                       INT80103
    2 CONTINUE                                                          INT80104
    3 SUM=SUM+PROD                                                      INT80105
      ANS=SUM                                                           INT80106
      RETURN                                                            INT80107
      END                                                               INT80108
$IBFTC DISS
                                                                        INT80109
      SUBROUTINE DISSER (XA,TAB,I,NX,ID,NPX)                            INT80110
      DIMENSION TAB(1 )                                                 INT80111
      NPT=ID+1                                                          INT80112
      NPB=NPT/2                                                         INT80113
      NPU=NPT-NPB                                                       INT80114
      IF (NX-NPT)   10,5,10                                             INT80115
    5 NPX=I                                                             INT80116
      RETURN                                                            INT80117
   10 NLOW=I+NPB                                                        INT80118
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      NUPP=I+NX-(NPU+1)                                                 INT80119
      DO 15 II=NLOW,NUPP                                                INT80120
      NLOC=II                                                           INT80121
      IF (TAB(II)-XA)   15,20,20                                        INT80122
   15 CONTINUE                                                          INT80123
      NPX=NUPP-NPB+1                                                    INT80124
      RETURN                                                            INT80125
   20 NL=NLOC-NPB                                                       INT80126
      NU=NL+ID                                                          INT80127
      DO 25 JJ=NL,NU                                                    INT80128
      NDIS=JJ                                                           INT80129
      IF (TAB(JJ)-TAB(JJ+1))   25,30,25                                 INT80130
   25 CONTINUE                                                          INT80131
      NPX=NL                                                            INT80132
      RETURN                                                            INT80133
   30 IF (TAB(NDIS)-XA)   40,35,35                                      INT80134
   35 NPX=NDIS-ID                                                       INT80135
      RETURN                                                            INT80136
   40 NPX=NDIS+1                                                        INT80137
      RETURN                                                            INT80138
      END                                                               INT80139
```

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*.......*.........*.........*.........*.........*.........*.........*.........*
$IBFTC AIRF    LIST
      SUBROUTINE AIRFLO                                                 AIRF0010
C                                                                       AIRF0020
C                                                                       AIRF0030
C                  S U B R O U T I N E   A I R F L O                    AIRF0040
C                                                                       AIRF0050
C        THIS SUBROUTINE CALCULATES AIRFLOW CONDITIONS IN THE           AIRF0060
C        FLAME TUBE AND ANNULUS  OF A COMBUSTION CHAMBER.               AIRF0070
C                                                                       AIRF0080
C        FOUR SUBROUTINES ARE CALLED BY AIRFLO                          AIRF0C90
C             1. EQUAN  - SOLUTICN TO ANNULUS  EQUATIONS                AIRF0100
C             2. DISJET - JET PARAMETERS RELATING TO FLOW               AIRF0110
C                         THROUGH HOLES IN THE FLAME TUBE               AIRF0120
C             3. EQUFT  - SOLUTION TO FLAME TUBE EQUATIONS              AIRF0130
C             4. PRTEMP - CALCULATION OF PRIMARY ZONE TEMP.             AIRF0140
C                                                                       AIRF0150
C        ONE SUBROUTINE CALLS AIRFLO                                    AIRF0160
C             1. CLARE                                                  AIRF0170
C                                                                       AIRF0180
C     CCMMON STATEMENTS                                                 AIRF0190
                                                                        AIRF0200
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6   AIRF0210
C     VIZ- B6, B16, B67, B68, B126, B167, B168, B678, B1678, B12678     AIRF0220
C     ALSO B4 (SHARED WITH EMPCTS AND TUBCTS)                           AIRF0230
C     BZERO IS A DUMMY BLOCK, USED INSTEAD OF A DIMENSICN STATEMENT     AIRF0240
                                                                        AIRF0250
      CCMMON/B4/DPREF                                                   AIRF0260
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,        NABX(45)        AIRF0270
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   AIRF0280
     2,SHAFST,                               FIFTPR,        LCMFL,LCANILAIRF0290
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)    AIRF0300
     4,LCPTAL,PAFRZ,NHTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)      AIRF031C
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)     AIRF0320
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)                            AIRF0330
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)      AIRF0340
     4,TWA(45),TWB(45)                                                  AIRF0350
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FMCR,NLAST          AIRF0360
     1,KANHET,LANHET,PERCO,THIKFT                                       AIRF0370
     2,DANA(45),DANB(45)                                                AIRF0380
      CCMMON/B67/DENFT(45),EK17,EK19,EK20,         EK16                 AIRF0390
     1          ,C(50),GXIA(50),K,WUJ(50)                               AIRF0400
      COMMON/B167/GASC,GRAVC,GJCULE,IHJ(50),XH(50),NH                   AIRF0410
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANAIRF0420
     1ANB(45),AFJ1(50),UFT(45)                                          AIRF0430
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             AIRF0440
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  AIRF0450
     2,NCODEB(45),TZ                                                    AIRF0460
      COMMON/B12678/JTAPE,IPRINT                                        AIRF0470
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B                           AIRF0480
     1,AFA,AFB,PREDM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,DOMLOS         AIRF0490
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,  AIRF0500
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,LANB(45),      AIRF0510
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,                     AIRF0520
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                  PREFT1,PREFT2,  AIRF0530
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,                   AIRF0540
     5FARFT2,ENTHAL,LCMF,LCANI,LCAN,LCFTE,LCFT,K7,K13,K12,              AIRF0550
     6AFSYPA,AFSYPB,AFSYIA,AFSYIB,LCPRT,LCPTA                           AIRF0560
     7,C2(45),            UANA(45),            ZMHA(2),GX1A,GX1B        AIRF0570
     8,DPH(50),WCD(50),WFFIZ(45),DPAFS,DPBFS,DPAES,DPBES                AIRF0580
     9,RC(50),A,B,D,E,K30,K40,K50,K60                                   AIRF0590
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*.........*.........*.........*.........*.........*.........*.........*.........*
      COMMON/B5867/XFSA,XFSB                                            AIRF0600
       COMMON/B126E/AF1,AF3,AF4,AFS,N,NSH,KK1                           AIRF0610
      COMMON/BZERO/DFFT(50),FRICFA(45),FRICFB(45),HAW(50),AFJZ(50),     AIRF0620
     1DUM(360)                                                          AIRF0630
      COMMON/BUNIK/DUMAE(45),DUMBE(45)                                  AIRF0640
      COMMON/B126D/ AFCL,AFCU,AFSL,AFSU                                 AIRF0650
      DIMENSION  DOOM(4),Q(9)                                           AIRF0660
                                                                        AIRF0670
C FORMAT STATEMENTS                                                     AIRF0680
                                                                        AIRF0690
  1   FORMAT(8H0REACHED I3)                                             AIRF0700
 20   FORMAT(/////49H0AERODYNAMIC PARAMETERS AT EACH CALCULATION POINT/1AIRF0710
     1X48(1H-)/6H0AXIAL6X23HTOTAL    TOTAL PRESSURE7X15HSTATIC PRESSURE6AIRF072
     2X55HBULK VELOCITY      MACH NUMBER    ACCUMULATED PRESSURE/18H POAIRF0730
     3SITION   TEMPER2(8X4HPSIA9X), 4X10HFT PER SEC25X18HLOSS IN ANNULI AIRF0740
     4PSI/5H FROM7X6H-ATURE/14H COMPRESSOR IN6X2(8H  ANNULI5X5HFLAME3X),AIRF0750
     52(18H ANNULI    FLAME  ),7H DUE TO6X6HDUE TO/17H DISCHARGE  FLAME2AIRF0760
     6(16X5HTUBE ),2(14X4HTUBE),24H  FRICTION AND EXPANSION/16H INCHES  AIRF0770
     7   TUBE2(15H   INNER  OUTER6X),2(3X11HINNER OUTER4X),2X13HHEAT ADDAIRF0780
     8ITION/12X5HDEG F79X2(12H INNER OUTER)/12X6HSTATIC/12X7HTEMP IN/12XAIRF0790
     97HANNULUS/12X5HDEG F/9X11HINNER OUTER//)                          AIRF0795
C              **INCLUDE CARDS AIRF0795 AND 0805 **                     AIRF0800
   21 FORMAT(58H0COMBUSTOR TOTAL-PRESSURE LOSS COEFFT FOR INNER ANNULUS AIRF080
     1 =F7.4,41H (RELATIVE TO REFERENCE DYNAMIC PRESSURE)/58H0COMBUSTOR AIRF0810
     2TOTAL-PRESSURE LOSS COEFFT FOR OUTER ANNULUS  =F7.4/66H0TOTAL-PRESAIRF0820
     3SURE LOSS FACTOR FOR COMBINED DIFFUSER AND COMBUSTOR  =F7.4,43H (RAIRF083
     4ELATIVE TO COMPRESSOR DELIVERY PRESSURE)/58H0COMBUSTOR TOTAL-PRESSAIRF084
     5URE LOSS FACTOR FOR INNER ANNULUS  =F7.4/58H0COMBUSTOR TOTAL-PRESSAIRF0850
     6URE LOSS FACTOR FOR OUTER ANNULUS  =F7.4/58H0EXPANSION TOTAL-PRESSAIRF086
     7URE LOSS FACTOR FOR INNER ANNULUS  =F7.4/58H0EXPANSION TOTAL-PRESSAIRF087
     8URE LOSS FACTOR FOR OUTER ANNULUS  =F7.4/76H0PRESSURE-LOSS FACTOR AIRF0880
     9DUE TO FRICTION AND HEAT ADDITION FOR INNER ANNULUS  =F7.4/76H0PREAIRF0890
     XSSURE-LOSS FACTOR DUE TO FRICTION AND HEAT ADDITION FOR OUTER ANNUAIRF090
     XLUS  =F7.4)                                                       AIRF0910
C             ** THERE ARE NO CARDS AIRF 0930,0940,0950,0960 **         AIRF0920
   38 FORMAT(/////20H0AIR MASS FLOW SPLIT/1X19(1H-)/58H0FRACTION OF INLEAIRF097
     1T AIR PASSING THROUGH SNOUT AND/OR DOME =F8.5/49H FRACTION OF INLEAIRF0980
     2T AIR PASSING INTO INNER ANNULUS8X1H=F8.5/49H FRACTION OF INLET AIAIRF0990
     3R PASSING INTO OUTER ANNULUS8X1H=F8.5)                            AIRF100
  42  FORMAT(1XF8.3,F9.1,6F7.2,3F6.1,3F6.3,4F6.2)                       AIRF101
   67 FORMAT(1XF13.1,F7.1)                                              AIRF1020
C                        ** THERE ARE NO CARDS AIRF 1040 THROUGH 1120  * AIRF1030
 1000 FORMAT(40H PROGRAMME STOPPED IN SUBROUTINE AIRFLO.,/31H LOOP COUNTAIRF113
     1ER *LCANL* EXCEEDED.,/31H MAX CALL FOR *EQUAN* EXCEEDED.)         AIRF1140
 1001 FORMAT(40H PROGRAMME STOPPED IN SUBROUTINE AIRFLO.,/31H LOOP COUNTAIRF1150
     1ER *LCFTL* EXCEEDED.,/31H MAX CALL FOR *EQUFT* EXCEEDED.)         AIRF116
 1002 FORMAT(90H IN SUBROUTINE AIRFLO THE MAXIMUM NUMBER OF ITERATIONS OAIRF1170
     1N THE AIR FLOW SPLIT WAS EXCEEDED.)                               AIRF1180
 1003 FORMAT(59H INCREASE ITERATION CYCLE LIMIT *LCANIL* OR TOLERANCE *FAIRF119
     1IO*)                                                              AIRF1200
 1004 FORMAT(88H THE COMBUSTOR IS BADLY DESIGNED - NEGATIVE PRESSURE DROAIRF1210
     1P IS OCCURRING ACROSS THE HOLES./80H TO REMEDY - 1. IF ANNULUS VELAIRF122
     2OCITIES GREATER THAN 300 FPS, OPEN UP THE ANNULUS./13X31H2. INCREAAIRF123
     3SE SIZE OF WALL HOLES./13X25H3. REDUCE DOME HOLE AREA./13X35H4. USAIRF1240
     4E MORE SCOOPS OVER WALL HOLES.)                                   AIRF1250
 1005 FORMAT(54H AIR FLOW RESULTS FOR THE LAST ITERATION CYCLE FOLLOW.) AIRF12
 3000 FORMAT(1X,//////19H ***  ERROR MESSAGE)                           AIRF1270
 8761 FORMAT(1H03F11.3)                                                 AIRF1280
 8762 FORMAT(1H04I10)                                                   AIRF129
 8763 FORMAT(1H03I10,10X6I10)                                           AIRF130
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*........*........*........*........*........*........*........*........*........*
 8764 FORMAT(7H0AIRCON3F9.1,7F11.7,I10)
 8765 FORMAT(1H010F11.3)

C     AIR FLOW PROGRAM

      GO TO 7
      ENTRY AIR1
      LD=IPRINT
      LDD=0
      IF(KANHET.NE.0)GOTO9999

C     QUANTITIES OBTAINED FROM SUBROUTINE HEAT,SET TO ZERO IF HEAT HAS
C     NOT BEEN CALLED

      DO9998K=1,NLAST
      C2A(K)=0.
      C2B(K)=0.
      WFFIZ(K)=0.
      REAAN(K)=1.E4
      REBAN(K)=1.E4
      QTRA(K)=0.0
      QTRB(K)=0.0
 9998 CONTINUE
 9999 CONTINUE
      DO 2012 J=1,NH
 2012 AFJ1(J)=0.
      IF(IPRINT.NE.1)GOTO8760
      WRITE(6,8765)(HAU(J),XH(J),J=1,20)
      WRITE(6,8765)FLCV,BETA,ASW,AHDOME
      WRITE(6,8762)(NHH(J),NHTU(J),NAB(J),IHJ(J),J=1,20)
      WRITE(6,8765)(FFIZ(K),CFTA(K),CFTB(K),AANA(K),AANB(K),CCA(K),CCB(K
     1),DANA(K),DANB(K),AFT(K),K=1,26)
      WRITE(6,8763)(NABX(K),NCODEA(K),NCODEB(K),(KJSN(K,I),I=1,6),K=1,26
     1)
      WRITE(6,8765)                                 ((DPHS(IH,I4),I4=1,10),
     1                                                (CDS(IH,I4),I4=1,10),
     2                                               (GXIS(IH,I4),I4=1,10),
     3IH=1,3)
       WRITE(6,8763)NLAST,MSHCP
 8760 CONTINUE

C     SETTING OF CONTROL PARAMETERS.

   7  CONTINUE
      NSTOP=0
      LCANI=0
      LCANJ=0
      FITAV=FITAU/2.
      DCOM(1)=AFCU
      DCOM(2)=AFCL
      DCOM(3)=AFSL
      DCOM(4)=AFSU

C     ITERATION LOOP COUNTERS SET TO ZERO

   97 LCAN=0
      LCFT=0

C     K1=0  INNER ANNULUS.
C     K1=1  OUTER ANNULUS.
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*.........*.........*.........*.........*.........*.........*.........*.........*
C      K2=0  ANNULUS EQUATIONS ONLY.                                     AIRF1910
C      K2=1  ANNULUS AND FLAMETUBE EQUATIONS.                            AIRF1920
C      K3=0  FOR FIRST SECONDARY HOLE.                                   AIRF1930
C      K3=1  FOR SECONDARY HOLE.                                         AIRF1940
C      K5=0  FOR ANNULUS A.                                              AIRF1950
C      K5=1  FOR ANNULUS B.                                              AIRF1960
C      K10=0  FIRST TIME THROUGH EACH ANNULUS                            AIRF1970
C      K20=0  FIRST TIME THROUGH EACH ANNULUS WITH FLAME TUBE EQUATIONS  AIRF1980
C      BEING SOLVED                                                      AIRF1990
                                                                         AIRF2000
       K1=0                                                              AIRF2010
       K2=0                                                              AIRF2020
       K3=0                                                              AIRF2030
       K5=0                                                              AIRF2040
       K10=0                                                             AIRF2050
       K20=0                                                             AIRF2060
                                                                         AIRF2070
C      SET JET PARAMETERS OBTAINED IN SUBROUTINE DISJET TO ZERO          AIRF2080
                                                                         AIRF2090
       EK16=0.0                                                          AIRF2100
       EK17=0.0                                                          AIRF2110
       EK19=0.0                                                          AIRF2120
       EK20=0.0                                                          AIRF2130
                                                                         AIRF2140
C      PRESSURE LOSS DUE TO EXPANSION AND FRICTIONAL EFFECTS IN ANNULI   AIRF2150
C      USED ONLY FOR PRINTING OUT RESULTS                                AIRF2160
                                                                         AIRF2170
       DPAES=0.0                                                         AIRF2180
       DPAFS=0.0                                                         AIRF2190
       DPBFS=0.0                                                         AIRF2200
       DPBES=0.0                                                         AIRF2210
                                                                         AIRF2220
C      INTEGERS USED IN SUBROUTINE DISJET TO FIX PRESSURE REVERSAL OR    AIRF2230
C      NEGATIVE AIR MASS FLOW IN THE ANNULI FOR THE WHOLE COMBUSTOR      AIRF2240
                                                                         AIRF2250
       K30=0                                                             AIRF2260
       K40=0                                                             AIRF2270
       K50=0                                                             AIRF2280
       K60=0                                                             AIRF2290
                                                                         AIRF2300
C      CONSTANT IN SWIRLER PRESSURE LOSS EQUATION                        AIRF2310
                                                                         AIRF2320
       ZZKSW=1.3                                                         AIRF2330
                                                                         AIRF2340
C      CLEARING SUMMATION LOCATIONS.                                     AIRF2350
                                                                         AIRF2360
       DO 99 K=1,NLAST                                                   AIRF2370
       ZPJET(K)=0.0                                                      AIRF2380
       ZAJM(K)=0.0                                                       AIRF2390
       ZMJUJ(K)=0.0                                                      AIRF2400
       ZMH(K)=0.0                                                        AIRF2410
 99    CONTINUE                                                          AIRF2420
                                                                         AIRF2430
C      AIR MASS FLOW IN PRIMARY ZONE                                     AIRF2440
                                                                         AIRF2450
       AFPRZ=0.0                                                         AIRF2460
                                                                         AIRF2470
C      AIR FLOW IN SNOUT.                                                AIRF2480
                                                                         AIRF2490
       IF(LCPFL.NE.1)CALLDIFLW                                           AIRF2500
```

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*.......*.........*.........*.........*.........*.........*.........*.........*
      IF(IPRINT.NE.1)GOTO8759                                           AIRF2510
      WRITE(6,8765)AF2,TAN1A,TAN1B,PAN1A,PAN1B,AFA,AFB,PREDM,STAGT,STPREAIRF2520
     1F,PNTRA,PNTRB,DPHSNT,COMLOS                                       AIRF2530
 8759 CONTINUE                                                          AIRF2540
      IF(IPRINT.GE.1.OR.LCMFL.EQ.1)WRITE(JTAPE,20)                      AIRF2550
                                                                        AIRF2560
C     TEST CONVERGENCE INDEX, SET IN SUBROUTINE DIFLW                   AIRF2570
                                                                        AIRF2580
      IF(IBL)100,900,100                                                AIRF2590
                                                                        AIRF2600
C     AIR MASS FLOW THROUGH DOME                                        AIRF2610
                                                                        AIRF2620
 100  AFS=AF2-AFA-AFB                                                   AIRF2630
      AFPRZ=AFS                                                         AIRF2640
                                                                        AIRF2650
C     PRESSURE IN THE PRIMARY ZONE.                                     AIRF2660
                                                                        AIRF2670
      K=1                                                               AIRF2680
      J=K                                                               AIRF2690
      GO TO 124                                                         AIRF2700
 145  K10=1                                                             AIRF2710
      IF(K1)90,90,105                                                   AIRF2720
                                                                        AIRF2730
C     PRESSURE IN THE DOME                                              AIRF2740
                                                                        AIRF2750
 90   PREDM=PREDM-COMLOS*DPHSNT                                         AIRF2760
      IF(PREDM.LE.0.)NSTOP=1                                            AIRF2770
      DENDM=PREDM/(GASC*STAGT)                                          AIRF2780
                                                                        AIRF2790
C     TEST  K6=0 NO SWIRLER.                                            AIRF2800
C           K6=1    SWIRLER.                                            AIRF2810
                                                                        AIRF2820
 80   IF(K6)102,102,101                                                 AIRF2830
                                                                        AIRF2840
C     PRESSURE IN PRIMARY ZONE BEFORE COMBUSTION                        AIRF2850
                                                                        AIRF2860
  101 PREFT(K)=PREDM-0.5*AFS**2/(GRAVC*DENDM*(0.6*AHDOME+ASW*AFT(K)/    AIRF2870
     1SQRT(ZZKSW*((AFT(K)/COS(BETA))**2-ASW**2)))**2)                   AIRF2880
      IF(PREFT(K).LT..2*PREDM)PREFT(K)=.2*PREDM                         AIRF2890
      PREFT1=PREFT(K)                                                   AIRF2900
      GO TO 103                                                         AIRF2910
 102  PREFT(K)=PREDM-AFS**2/(DENDM*.36*AHDOME**2*GRAVC)*0.5             AIRF2920
      IF(PREFT(K).LT..2*PREDM)PREFT(K)=.2*PREDM                         AIRF2930
      PREFT1=PREFT(K)                                                   AIRF2940
                                                                        AIRF2950
C     INITIAL CONDITIONS FOR ANNULUS A.                                 AIRF2960
                                                                        AIRF2970
  103 IF(NSHCP.EQ.1)GOTO1031                                            AIRF2980
      DO1030I=1,NSHCP                                                   AIRF2990
 1030 PREFT(I)=PREFT(1)                                                 AIRF3000
 1031 AFAN1=AFA                                                         AIRF3010
      DENAN1=PAN1A/(GASC*TAN1A)                                         AIRF3020
      TAN1=TAN1A                                                        AIRF3030
      UAN1=AFAN1/(DENAN1*AANA(K))                                       AIRF3040
      PREAN1=PAN1A                                                      AIRF3050
      K1=0                                                              AIRF3060
      DENANA(1)=DENAN1                                                  AIRF3070
      AFANA(1)=AFAN1                                                    AIRF3080
      PREANA(1)=PREAN1                                                  AIRF3090
      UANA(1)=UAN1                                                      AIRF3100
```

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*.......*.........*.........*.........*.........*.........*.........*.........*
      TANANA(1)=TAN1                                                    AIRF3110
      GO TO 105                                                         AIRF3120
                                                                        AIRF3130
C     INITIAL CONDITIONS FOR ANNULUS B.                                 AIRF314C
                                                                        AIRF3150
  104 AFAN1=AFB                                                         AIRF3160
      DENAN1=PAN1B/(GASC*TAN1B)                                         AIRF3170
      TAN1=TAN1B                                                        AIRF3180
      K=1                                                               AIRF3190
      UAN1=AFAN1/(DENAN1*AANB(K))                                       AIRF3200
      PREAN1=PAN1B                                                      AIRF3210
      DENANB(1)=DENAN1                                                  AIRF3220
      TANANB(1)=TAN1                                                    AIRF3230
      UANB(1)=UAN1                                                      AIRF3240
      PREANB(1)=PREAN1                                                  AIRF3250
      AFANB(1)=AFAN1                                                    AIRF3260
      K20=1                                                             AIRF3270
      K1=1                                                              AIRF3280
      J=K                                                               AIRF3290
                                                                        AIRF3300
C     TEST FOR ANNULUS AND FLAME-TUBE EQUATIONS.                        AIRF3310
                                                                        AIRF3320
      GO TO 124                                                         AIRF3330
  851 K20=0                                                             AIRF3340
                                                                        AIRF3350
C     DYNAMIC PRESSURE IN ANNULUS.                                      AIRF3360
                                                                        AIRF3370
  105 DYPAN1=0.5*DENAN1*UAN1**2/GRAVC                                   AIRF3380
      DPH1=1.0+(PREAN1-PREFT1)/DYPAN1                                   AIRF3390
                                                                        AIRF3400
C     LCCP CCUNTER INCEXED AND TESTED FOR ANNULUS ECUATION SOLUTIONS.   AIRF3410
                                                                        AIRF3420
      LCAN=LCAN+1                                                       AIRF3430
      IF(LCANL-LCAN)404,404,405                                         AIRF3440
  404 CCNTINUE                                                          AIRF3450
      WRITE(JTAPE,3000)                                                 AIRF3460
      WRITE(JTAPE,1000)                                                 AIRF3470
      RETURN                                                            AIRF3480
                                                                        AIRF3490
C     TEST FCR INNER OR OUTER ANNULUS                                   AIRF3500
                                                                        AIRF3510
  405 IF(K1)106,106,107                                                 AIRF3520
                                                                        AIRF3530
C     SET ANNULUS AREAS AND HEAT CONVECTION INNER ANNULUS               AIRF3540
                                                                        AIRF3550
  106 AAN1=AANA(K)                                                      AIRF3560
      AAN2=AANA(J)                                                      AIRF357C
      C2(K)=C2A(K)                                                      AIRF3580
      GC TO 108                                                         AIRF3590
                                                                        AIRF3600
C     SET ANNULUS AREAS AND HEAT CONVECTION, OUTER ANNULUS              AIRF3610
                                                                        AIRF3620
  107 AAN1=AANB(K)                                                      AIRF3630
      AAN2=AANB(J)                                                      AIRF3640
      C2(K)=C2B(K)                                                      AIRF3650
  108 CCNTINUE                                                          AIRF3660
                                                                        AIRF3670
C     TEST ANNULUS AIR MASS FLOW, IF NEGATIVE SET ANNULUS PARAMETERS ANDAIRF3680
C     DO NOT CALL SUBROUTINE EQUAN                                      AIRF3690
                                                                        AIRF3700
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*........*.........*.........*.........*.........*.........*.........*.........*
      IF(AFAN1)60,60,53                                                 AIRF3710
   60 PREAN2=PREAN1                                                     AIRF3720
      DENAN2=DENAN1                                                     AIRF3730
      TAN2=TAN1                                                         AIRF3740
      UAN2=0.01                                                         AIRF3750
   53 CALL DISJET                                                       AIRF376C
                                                                        AIRF3770
C     IF PRESSURE REVERSAL CCCURS OR AIR MASS FLOW IS NEGATIVE DO NOT CAAIRF378C
C     SUBRCUTINE EQUAN                                                  AIRF3790
                                                                        AIRF3800
      IF(ZMH(K)-AFAN1)59,56,56                                          AIRF381C
   59 IF(DPH1.LE.0.0)GO TO 56                                           AIRF3820
      CALL ECUAN                                                        AIRF3830
      GC TO 52                                                          AIRF3840
                                                                        AIRF3850
C     SET ANNULUS PARAMETERS                                            AIRF3860
                                                                        AIRF3870
   56 AFAN2=AFAN1                                                       AIRF3880
      PREAN2=PREAN1                                                     AIRF3890
      TAN2=TAN1                                                         AIRF3900
      UAN2=UAN1                                                         AIRF3910
      DENAN2=DENAN1                                                     AIRF3920
   52 KSH=K                                                             AIRF3930
                                                                        AIRF3940
C     TEST FCR SECONDARY HOLES                                          AIRF395C
                                                                        AIRF3960
      IF(KSH.EQ.NSHCP)GOTO1325                                          AIRF3970
      K=J                                                               AIRF3980
                                                                        AIRF3990
C     TEST IF ANNULUS ANC FLAME TUBE EQUATIONS ARE BEING SOLVED.        AIRF4000
                                                                        AIRF4C10
  701 IF(K2)124,124,95                                                  AIRF4020
 95   J=K+1                                                             AIRF4030
      GC TO 134                                                         AIRF4040
                                                                        AIRF4C50
C     TEST FCR HCLE AT NEXT CALCULATION POINT.                          AIRF4C60
C     NABX(K)=1 HCLES ON INNER WALL ONLY.                               AIRF4070
C     NABX(K)=2 HOLES ON OUTER WALL ONLY.                               AIRF4080
C     NABX(K)=3 HOLES ON BOTH WALLS.                                    AIRF4C90
C     NABX(K)=4 NO HOLES.                                               AIRF4100
                                                                        AIRF4110
 124  IF(NLAST-J+1)134,6,6                                              AIRF412C
    6 IF(J.EC.NSHCP  .OR.NABX(J+1).LE.3)GOTO126                         AIRF4130
  125 J=J+1                                                             AIRF4140
      GO TO 124                                                         AIRF4150
  126 IF(NABX(J+1)-2)127,127,133                                        AIRF4160
  127 IF(K1)128,128,131                                                 AIRF4170
 128  IF(NABX(J+1)-1)132,133,132                                        AIRF4180
  131 IF(NABX(J+1)-1)132,132,133                                        AIRF4190
  132 J=J+1                                                             AIRF4200
      GC TO 124                                                         AIRF4210
 1325 K=KSH+1                                                           AIRF4220
      J=K                                                               AIRF4230
  133 J=J+1                                                             AIRF4240
                                                                        AIRF4250
C     IS THIS THE FIRST TIME ANNULUS EQUATIONS HAVE BEEN SOLVED         AIRF4260
C     TCGETHER WITH FLAME TUBE EQUATIONS FOR THE CURRENT ANNULUS        AIRF4270
                                                                        AIRF4280
      IF(K20)850,850,851                                                AIRF4290
                                                                        AIRF4300
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*........*.........*.........*.........*.........*.........*.........*.........*
C     IS THIS THE FIRST TIME ANNULUS EQUATIONS HAVE BEEN SOLVED FOR THE AIRF4310
C     CURRENT ANNULUS                                                   AIRF432C
                                                                        AIRF4330
  850 IF(K10)145,145,134                                                AIRF4340
                                                                        AIRF4350
C     STCRAGE                                                           AIRF4360
C     TEST INNER OUTER ANNULUS.                                         AIRF4370
                                                                        AIRF4380
  134 IF(K1)135,135,137                                                 AIRF4390
                                                                        AIRF4400
C     STORAGE AND UPDATING OF INNER ANNULUS PARAMETERS.                 AIRF4410
                                                                        AIRF4420
 135  UANA(K)=UAN2                                                      AIRF4430
      PREANA(K)=PREAN2                                                  AIRF444C
      DENANA(K)=DENAN2                                                  AIRF4450
      TANANA(K)=TAN2                                                    AIRF4460
      AFANA(K)=AFAN2                                                    AIRF4470
      UAN1=UAN2                                                         AIRF4480
      PREAN1=PREAN2                                                     AIRF4490
      DENAN1=DENAN2                                                     AIRF4500
      TAN1=TAN2                                                         AIRF4510
      AFAN1=AFAN2                                                       AIRF452C
      GX1A=GXI                                                          AIRF4530
                                                                        AIRF454C
C     TEST IF ANNULUS AND FLAMETUBE EQUATIONS ARE BEING SOLVED.         AIRF4550
                                                                        AIRF4560
      IF(K2)136,136,150                                                 AIRF4570
                                                                        AIRF4580
C     TEST FCR SECONDARY HOLES.                                         AIRF4590
                                                                        AIRF4600
 136  IF(KSH-NSHCP)105,299,105                                          AIRF4610
                                                                        AIRF4620
C     STORAGE OF JET PARAMETERS FOR SECONDARY HOLES                     AIRF4630
                                                                        AIRF4640
 299  ZMHAS=ZMH(KSH)                                                    AIRF4650
      A=ZMJET(NSHCP)                                                    AIRF4660
      B=ZMJUJ(NSHCP)                                                    AIRF4670
      E=ZAJM(NSHCP)                                                     AIRF4680
      D=ZMH(NSHCP)                                                      AIRF4690
      DC 55 I =1,NSHCP                                                  AIRF4700
                                                                        AIRF4710
C     SET JET PARAMETERS FOR SECONDARY HOLES TO ZERO                    AIRF4720
                                                                        AIRF4730
      ZMJET(I)=0.0                                                      AIRF4740
      ZAJM(I)=0.0                                                       AIRF4750
      ZMJUJ(I)=0.0                                                      AIRF4760
      ZMH(I)=0.0                                                        AIRF477C
  55  CONTINUE                                                          AIRF4780
                                                                        AIRF4790
C     TEST FOR SPECIFICATION OF FLOW SPLIT.                             AIRF4800
                                                                        AIRF4810
      IF(K4)94,94,141                                                   AIRF4820
                                                                        AIRF4830
C     STORAGE AND UPDATING OF OUTER ANNULUS PARAMETERS.                 AIRF4840
                                                                        AIRF4850
  137 UANB(K)=UAN2                                                      AIRF4860
      PREANB(K)=PREAN2                                                  AIRF4870
      DENANB(K)=DENAN2                                                  AIRF4880
      TANANB(K)=TAN2                                                    AIRF4890
      AFANB(K)=AFAN2                                                    AIRF4900
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*........*.........*.........*.........*.........*.........*.........*.........*
      UAN1=UAN2                                                         AIRF4910
      PREAN1=PREAN2                                                     AIRF4920
      DENAN1=DENAN2                                                     AIRF4930
      TAN1=TAN2                                                         AIRF4940
      AFAN1=AFAN2                                                       AIRF4950
      GXIB=GXI                                                          AIRF4960
                                                                        AIRF4970
C     TEST IF ANNULUS AND FLAMETUBE EQUATIONS ARE BEING SOLVED.         AIRF4980
                                                                        AIRF4990
      IF(K2)138,138,151                                                 AIRF5000
                                                                        AIRF5010
C     TEST FOR SECONDARY HOLES.                                         AIRF5020
                                                                        AIRF5030
  138 IF(KSH-NSHCP)105,139,105                                          AIRF5040
                                                                        AIRF5050
C     TEST FOR SPECIFICATION OF FLOW SPLIT                              AIRF5060
                                                                        AIRF5070
  139 IF(K4)147,147,142                                                 AIRF5080
                                                                        AIRF5090
C     SPECIFICATION OF FLOW SPLIT.                                      AIRF5100
C     FLOW SPLIT FOR A SECONDARY HOLES.                                 AIRF5110
                                                                        AIRF5120
  141 AFSYPA=ZMHAS*SHAFST                                               AIRF5130
      AFSYIA=ZMHAS-AFSYPA                                               AIRF5140
      AFPRZ=AFPRZ+AFSYPA                                                AIRF5150
      GO TO 104                                                         AIRF5160
                                                                        AIRF5170
C     FLOW SPLIT FOR B SECONDARY HOLES.                                 AIRF5180
                                                                        AIRF5190
  142 AFSYPB=ZMH(KSH)*SHAFST                                            AIRF5200
      AFSYIB=ZMH(KSH)-AFSYPB                                            AIRF5210
      AFPRZ=AFPRZ+AFSYPB                                                AIRF5220
      CALL PRTEMP                                                       AIRF5230
      GO TO 151                                                         AIRF5240
                                                                        AIRF5250
C     SET FLOW SPLIT =0.5 FIRST ITERATION  A ANNULUS                    AIRF5260
   94 AFSYIA=0.5*ZMHAS                                                  AIRF5270
                                                                        AIRF5280
      AFSYPA=AFSYIA                                                     AIRF5290
      AFPRZ=AFPRZ+AFSYPA                                                AIRF5300
      ZMHA(1)=ZMHAS                                                     AIRF5310
      GO TO 104                                                         AIRF5320
                                                                        AIRF5330
C     SET FLOW SPLIT =0.5 FIRST ITERATION  B ANNULUS                    AIRF5340
                                                                        AIRF5350
  147 AFSYIB=0.5*ZMH(K-1)                                               AIRF5360
      AFSYPB=AFSYIB                                                     AIRF5370
      AFPRZ=AFPRZ+AFSYPB                                                AIRF5380
      ZMHA(2)=ZMH(KSH)                                                  AIRF5390
      CALL PRTEMP                                                       AIRF5400
      GO TO 151                                                         AIRF5410
                                                                        AIRF5420
C     SOLUTION OF FLAME TUBE EQUATIONS.                                 AIRF5430
                                                                        AIRF5440
  150 K2=1                                                              AIRF5450
      K1=1                                                              AIRF5460
      J=J-1                                                             AIRF5470
      K=K-1                                                             AIRF5480
                                                                        AIRF5490
C     SET ANNULUS PARAMETERS FOR USE IN SUBROUTINE EQUAN                AIRF5500
```

```
      UAN1=UANB(K)
      PREAN1=PREANB(K)
      DENAN1=DENANB(K)
      TAN1=TANANB(K)
      AFAN1=AFANB(K)

C     SECONDARY HOLE AIR MASS FLOW PASSING INTO PRIMARY ZONE

      AFSYP=AFSYPA+AFSYPB

C     STORAGE OF JET PARAMETERS FOR INNER ANNULUS

      A=ZMJET(K)
      B=ZMJUJ(K)
      C=ZMH(K)
      E=ZAJM(K)

C     SET JET PARAMETERS TO ZERO

      ZMJET(K)=0.0
      ZMJUJ(K)=0.
      ZMH(K)=0.
      ZAJM(K)=0.0
      GO TO 105
 151  K1=0
      K2=1
      K=K-1
      J=J-1

C     SET ITERATION LOOP COUNTER TO ZERO

      LCFTE=0

C     LOOP COUNTER INDEXED AND TESTED FOR NO. FLAME TUBE EQUATION SOL.

      LCFT=LCFT+1
      IF(LCFTL-LCFT)408,408,409
  408 CONTINUE
      WRITE(JTAPE,3000)
      WRITE(JTAPE,1001)
      RETURN
 409  CALL EQUFT
      IF(K-NSHCP)906,908,908
  908 IF(LD)906,906,907
  907 IF(K.EQ.NSHCP)K=1

C     SPECIFIC HEAT AT CONSTANT PRESSURE AS A FUNCTION OF FUEL-AIR RATIO

 9070 ZZCP=(.2121+.103*FARFT(K))+(5.06+22.6*FARFT(K))*1.0E-5*TFT(K)+
     1(-13.1-29.6*FARFT(K))*1.0E-9*TFT(K)**2+(2.10+.35*FARFT(K))
     2*1.0E-12*TFT(K)**3

C     TOTAL PRESSURE IN ANNULUS AND FLAME TUBE

      PSA=PREANA(K)*((TANANA(K)+0.5/(0.24*GJOULE*GRAVC)
     1*UANA(K)**2)/TANANA(K))**3.5
      PSB=PREANB(K)*((TANANB(K)+0.5/(0.24*GJOULE*GRAVC)
     1*UANB(K)**2)/TANANB(K))**3.5
      PSF=PREFT(K)+0.5*DENFT(K)*UFT(K)**2/GRAVC
```

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*.........*.........*.........*.........*.........*.........*.........*.........*
                                                                        AIRF6110
C     MACH NUMBER IN ANNULUS AND FLAME TUBE                             AIRF6120
                                                                        AIRF6130
      AA=UANA(K)/((SQRT(1.40*TANANA(K)*GASC*GRAVC)))                    AIRF6140
      AB=UANB(K)/(SCRT(1.40*TANANB(K)*GASC  *GRAVC))                    AIRF6150
      AF=UFT(K)/(SQRT(1.33*TFT(K)*GASC  *GRAVC))                        AIRF6160
                                                                        AIRF6170
C     TCTAL TEMPERATURE IN FLAME TUBE                                   AIRF6180
                                                                        AIRF6190
      TFTTOT=TFT(K)+0.5*UFT(K)**2/(GRAVC*ZZCP*GJOULE)-459.7             AIRF6200
                                                                        AIRF6210
C     UNITS CONVERSION                                                  AIRF6220
C            ** INCLUDE CARDS AIRF6233 AND 6237  **                     AIRF6230
      TANANA(K)=TANANA(K)-459.7                                         AIRF6233
      TANANB(K)=TANANB(K)-459.7                                         AIRF6237
      XCP(K)=XCP(K)*12.                                                 AIRF6240
      PREANA(K)=PREANA(K)/144.                                          AIRF6250
      PREANB(K)=PREANB(K)/144.                                          AIRF6260
      PREFT(K)=PREFT(K)/144.                                            AIRF6270
      PSA=PSA/144.                                                      AIRF6280
      PSB=PSB/144.                                                      AIRF6290
      PSF=PSF/144.                                                      AIRF6300
      IF(K.NE.1)GCTC 980                                                AIRF6310
      PSAIN=PSA                                                         AIRF6320
      PSBIN=PSB                                                         AIRF6330
 980  DPARS=PSAIN-PSA-DUMAE(K)                                          AIRF6340
      DPBRS=PSBIN-PSB-DUMBE(K)                                          AIRF6350
      WRITE(JTAPE,42)XCP(K),TFTTOT,PSA,PSB,PSF,PREANA(K),PREANB(K),     AIRF6360
     1PREFT(K),UANA(K),UANB(K),UFT(K),AA,AB,AF,DPARS,DPBRS,             AIRF6370
     2DUMAE(K),DUMBE(K)                                                 AIRF6380
      WRITE(JTAPE,67)TANANA(K),TANANB(K)                                AIRF6385
C                     ** INCLUDE CARD AIRF6385 **                       AIRF6390
C     UNITS CCNVERSICN                                                  AIRF6400
C                     ** INCLUDE CARDS AIRF6413 AND 6417 **             AIRF6410
      TANANA(K)=TANANA(K)+459.7                                         AIRF6413
      TANANB(K)=TANANB(K)+459.7                                         AIRF6417
      PREANA(K)=PREANA(K)*144.                                          AIRF6420
      PREANB(K)=PREANB(K)*144.                                          AIRF6430
      PREFT(K)=PREFT(K)*144.                                            AIRF6440
      IF(IPRINT,NE,1)GOTO8758                                           AIRF6450
      WRITE(6,8765)XCP(K),UANA(K),TANANA(K),AFANA(K),AFANB(K),          AIRF6460
     1PREAN1,PREFT1,ZZCP,GASC,GRAVC                                     AIRF6470
 8758 CCNTINUE                                                          AIRF6480
      IF(NSTCP.EQ.1)STOP                                                AIRF6490
      XCP(K)=XCP(K)/12.                                                 AIRF6500
      IF(K.GE.NSHCP)GCTO906                                             AIRF6510
      K=K+1                                                             AIRF6520
      GOTO9C70                                                          AIRF6530
 906  CCNTINUE                                                          AIRF6540
                                                                        AIRF6550
C     TEST FOR END OF FLAMETUBE.                                        AIRF6560
                                                                        AIRF6570
      IF(K+1-NLAST)157,9C60,158                                         AIRF6580
                                                                        AIRF6590
CC    INDEX TC NEXT CALCULATION POINT                                   AIRF6600
                                                                        AIRF6610
 9060 K=NLAST                                                           AIRF6620
      GCTO908                                                           AIRF6630
 157  K=K+1                                                             AIRF6640
      J=K+1                                                             AIRF6650
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.......*.........*.........*.........*.........*.........*.........*.........*..........*
                                                                         AIRF6660
     SET ANNULUS PARAMETERS FOR SUBROUTINE EQUAN                        AIRF6670
                                                                         AIRF6680
     UAN1=UANA(K)                                                        AIRF6690
     PREAN1=PREANA(K)                                                    AIRF6700
     DENAN1=DENANA(K)                                                    AIRF6710
     TAN1=TANANA(K)                                                      AIRF6720
     AFAN1=AFANA(K)                                                      AIRF6730
     GO TO 105                                                           AIRF6740
                                                                         AIRF6750
     ITERATION CONTROL TO ADJUST MASS FLOWS.                             AIRF6760
     AIR MASS FLOW REMAINING IN EACH ANNULUS                             AIRF6770
                                                                         AIRF6780
 158 AFSTA=AFANA(NLAST)                                                  AIRF6790
     AFSTB=AFANB(NLAST)                                                  AIRF6800
     D8=AFSTA/AFA                                                        AIRF6810
     D9=AFSTB/AFB                                                        AIRF6820
     IF(IPRINT.NE.1)GOTO8750                                             AIRF6830
     WRITE(6,8764)PREANA(NLAST),PREANB(NLAST),PREFT(NLAST),AFS,AFSTA,AFAIRF6840
    1STB,AFSL,AFSU                                                       AIRF6850
    2,AFCL,AFCU,LCANI                                                    AIRF6860
8750 IF(PSF.GT.1.E10)PSF=1.E10                                           AIRF6870
     STREFP=STPREF/144.                                                  AIRF6880
     Q(1)=(PSAIN-PSF)/DPREF*144.                                         AIRF6890
     Q(2)=(PSBIN-PSF)/DPREF*144.                                         AIRF6900
     Q(3)=(STREFP-PSF)/STREFP                                            AIRF6910
     Q(4) =(PSAIN-PSF)/STREFP                                            AIRF6920
     Q(5) =(PSBIN-PSF)/STREFP                                            AIRF6930
     Q(6)=DUMAE(NLAST )/STREFP                                           AIRF6940
     Q(7)=DUMBE(NLAST)/STREFP                                            AIRF6950
     Q(8)=DPARS/STREFP                                                   AIRF6960
     Q(9)=DPBRS/STREFP                                                   AIRF6970
     IF(IPRINT.GE.1.OR.LCMFL.EQ.1)                                       AIRF6980
    1WRITE(JTAPE,21)(Q(K),K=1,9)                                             6990
     AF1=AFS/AF2                                                         AIRF7000
     AF3=AFA/AF2                                                         AIRF7010
     AF4=AFB/AF2                                                         AIRF7020
     IF(IPRINT.GE.1)                                                     AIRF7030
    1WRITE(JTAPE,38)AF1,AF3, AF4                                         AIRF7040
     ZAFA=AFA                                                            AIRF7050
     ZAFB=AFB                                                            AIRF7060
     AFSS=AFS                                                            AIRF7070
                                                                         AIRF7080
     LOOP COUNTER INDEXED AND TESTED FOR MA*/MAMB*/MB ITERATION          AIRF7090
                                                                         AIRF7100
     LCANI=LCANI+1                                                       AIRF7110
     IF(K30+K40.GE.1)LCANJ=LCANI                                         AIRF7120
     IF(LCMFL.EQ.1)GOTO163                                               AIRF7130
     IF(LCANI.LE.LCANIL)GOTO403                                          AIRF7140
     WRITE(JTAPE,3000)                                                   AIRF7150
     WRITE(JTAPE,1002)                                                   AIRF7160
     IF(LCANIL.LE.45)WRITE(JTAPE,1003)                                   AIRF7170
     IF(LCANJ.GE.35)WRITE(JTAPE,1004)                                    AIRF7180
     WRITE(JTAPE,1005)                                                   AIRF7190
     LANHET=2                                                            AIRF7200
     GO TO 163                                                           AIRF7210
                                                                         AIRF7220
     TEST IF MA* IS APPROX. 0.                                           AIRF7230
                                                                         AIRF7240
 403 IF(AFSTA*AFSTB.LT.0.)GOTO160                                        AIRF7250
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*........*.........*.........*.........*.........*.........*.........*.........*.........*
      IF(ABS(AFSTA+AFSTB)/2./AF2.LE.FID)GOTO163                                 AIRF726C
                                                                                AIRF7270
C     MCDIFICATICN OF MA AND MB.                                                AIRF7280
                                                                                AIRF7290
      IF((AFSTA+AFSTB).GT.0.)GOTO1615                                           AIRF7300
      IF(AFS.LT.AFSU)AFSU=AFS                                                   AIRF7310
      AFS=AMAX1(AFS*(1.-FITAU),(AFSL+AFSU)/2.)                                  AIRF7320
      GOTO1616                                                                  AIRF7330
 1615 IF(AFS.GT.AFSL)AFSL=AFS                                                   AIRF7340
      AFS=AMIN1(AFS*(1.+FITAU),(AFSL+AFSU)/2.)                                  AIRF7350
                                                                                AIRF7360
C     NEW AIR MASS FLOW IN INNER ANNULUS                                        AIRF7370
                                                                                AIRF7380
 1616 AFA=AFA-(AFS-AFSS)/2.                                                     AIRF7390
                                                                                AIRF7400
C     NEW AIR MASS FLCW IN OUTER ANNULUS                                        AIRF7410
                                                                                AIRF7420
      AFB=AF2-AFA-AFS                                                           AIRF7430
      GC TO 97                                                                  AIRF744C
                                                                                AIRF7450
C     MODIFICATION CF MA ANC MB.                                                AIRF7460
                                                                                AIRF747C
  160 AFD=AFA+AFB                                                               AIRF7480
      AFC=AFA/AFD                                                               AIRF7490
      IF(AFSTA.GE.0.)GOTC159                                                    AIRF7500
      IF(AFC.GT.AFCL)AFCL=AFC                                                   AIRF7510
      AFC=AMIN1(AFC*(1.+FITAV),(AFCL+AFCU)/2.)                                  AIRF7520
      GOTO1590                                                                  AIRF7530
  159 IF(AFC.LT.AFCU)AFCU=AFC                                                   AIRF7540
      AFC=AMAX1(AFC*(1.-FITAV),(AFCL+AFCU)/2.)                                  AIRF7550
                                                                                AIRF7560
C     NEW AIR MASS FLOW IN INNER ANNULUS                                        AIRF7570
                                                                                AIRF7580
 1590 AFA=AFC*AFD                                                               AIRF7590
      AFB=AFD-AFA                                                               AIRF7600
      IF(AFB.LE.0.0)STOP                                                        AIRF7610
      GO TC 97                                                                  AIRF762C
  163 IF(LDD.EQ.1)GCTC911                                                       AIRF7630
      IF(KANHET.NE.0)GOTO909                                                    AIRF764C
      IF(LANHET.EQ.1)GOTO9000                                                   AIRF7650
  909 LDD=1                                                                     AIRF7660
      LD=1                                                                      AIRF7670
      LCMFL=1                                                                   AIRF7680
      IPN=IPRINT                                                                AIRF7690
      IPRINT=1                                                                  AIRF7700
      CALL CIFLW                                                                AIRF7710
      IPRINT=IPN                                                                AIRF7720
      GOTO97                                                                    AIRF7730
  911 CCNTINUE                                                                  AIRF7740
      CALL BIRFLO                                                               AIRF7750
  779 CCNTINUE                                                                  AIRF7760
 900  RETURN                                                                    AIRF7770
 9000 AFCU=DCCM(1)                                                              AIRF7780
      AFCL=DCCM(2)                                                              AIRF7790
      AFSL=DOOM(3)                                                              AIRF7800
      AFSU=DCCM(4)                                                              AIRF7810
      COTO 900                                                                  AIRF7820
      END                                                                       AIRF7830

  YOUR CARD TCTAL IS ---            779
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........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC BIRF    LIST
      SUBROUTINE BIRFLO                                                 BIRF0001
C                                                                       BIRF0002
C                   S U B R O U T I N E   B I R F L O                   BIRF0003
C                                                                       BIRF0004
C        THIS SUBROUTINE IS A CONTINUATION OF SUBROUTINE AIRFLO         BIRF0005
C                                                                       BIRF0006
C        NO SUBROUTINES ARE CALLED BY BIRFLO                            BIRF0007
C                                                                       BIRF0008
C        ONE SUBROUTINE CALLS BIRFLO                                    BIRF0009
C             1. AIRFLO                                                 BIRF0010
C                                                                       BIRF0011
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6.  BIRF0012
C BZERO IS A DUMMY BLOCK, USED INSTEAD OF A DIMENSION STATEMENT         BIRF0013
C                                                                       BIRF0014
      COMMON/B4/DPREF                                                   BIRF0015
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,          NABX(45)      BIRF0016
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAL,FID,FIENTH   BIRF0017
     2,SHAFST,                              FIFTPR,          LCPFL,LCANILBIRF0018
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHCOME,NSCOOP(20)    BIRF0019
     4,LCPTAL,PAFRZ,NHTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)      BIRF0020
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)     BIRF0021
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)                            BIRF0022
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)      BIRF0023
     4,TWA(45),TWB(45)                                                  BIRF0024
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          BIRF0025
     1,KANHET,LANHET,PERCC,THIKFT                                       BIRF0026
     2,DANA(45),DANB(45)                                                BIRF0027
      COMMON/B67/DENFT(45),EK17,EK19,EK20,            EK16              BIRF0028
     1          ,C(50),GXIA(50),K,WUJ(50)                               BIRF0029
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH                   BIRF0030
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANBIRF0031
     1ANB(45),AFJ1(50),UFT(45)                                          BIRF0032
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             BIRF0033
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  BIRF0034
     2,NCODEB(45),TZ                                                    BIRF0035
      COMMON/B12678/JTAPE,IPRINT                                        BIRF0036
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B                           BIRF0037
     1,AFA,AFB,PREOM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,DOPLOS         BIRF0038
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,  BIRF0039
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,UANB(45),      BIRF0040
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,                     BIRF0041
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                  PREFT1,PREFT2,  BIRF0042
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,                   BIRF0043
     5FARFT2,ENTHAL,LCMF,LCANI,LCAN,LCFTE,LCFT,K7,K13,K12,              BIRF0044
     6AFBYPA,AFBYPB,AFBYIA,AFBYIB,LCPRT,LCPTA                           BIRF0045
     7,C2(45),             UANA(45),             ZMHA(8),GXIA,GXIB      BIRF0046
     8,DPH(50),WCC(50),WFFIZ(45),DPAFS,DPBFS,DPABS,DPBBS                BIRF0047
     9,RC(50)                                                           BIRF0048
     1,A,B,D,E                                                          BIRF0049
     2,K30,K40,K50,K60                                                  BIRF0050
      COMMON/BZERO/CFFT(50),FRICFA(45),FRICFB(45),HAW(50),AFJZ(50),     BIRF0051
     1DUM(360)                                                          BIRF0052
      COMMON/BUNIK/DUMAE(45),DUMBE(45)                                  BIRF0053
      COMMON/B126D/AFCL,AFCU,AFSL,AFSU                                  BIRF0054
      COMMON/B5867/XFSA,XFSB                                            BIRF0055
      COMMON/B126E/AF1,AF3,AF4,AFS,N,NSH,KK1                            BIRF0056
   25 FORMAT(/////25HOMISCELLANEOUS QUANTITIES/1X24(1H-)/56H0  AXIAL POSBIRF0057
     1ITION     RATE OF BURNING    FRICTION FACTOR/18H   FROM COMPRESSORBIRF0058
     28X7HOF FUEL11X9HIN ANNULI/6X9HDISCHARGE7X15HLBM PER SEC PER/7X6HINBIRF0059
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*.........*.........*.........*.........*.........*.........*.........*.........*
     3CHES8X35HFT AXIAL DISTANCE    INNER    OUTER//(5XF8.3,11XF8.3,7X2FBIRF0060
     49.5))                                                             BIRF0061
   38 FORMAT(/////20H0AIR MASS FLOW SPLIT/1X19(1H-)/58H0FRACTION OF INLEBIRF0062
     1T AIR PASSING THROUGH SNOUT AND/OR DOME =F8.5/49H FRACTION OF INLEBIRF0063
     2T AIR PASSING INTO INNER ANNULUS8X1H=F8.5/49H FRACTION OF INLET AIBIRF0064
     3R PASSING INTO OUTER ANNULUS8X1H=F8.5)                            BIRF0065
   54 FORMAT(/////41H0QUANTITIES RELATED TO FLOW THROUGH HOLES/1X40(1H-)BIRF0066
     1/16H0HOLE ROW  AXIAL6X95HHOLE  INNER  NUMBER  HOLE   DISCHARGE COBIRF0067
     2EFFICIENTS  EFFECT  INITIAL  INITIAL  FRACTION  ACCUM-/37H NUMBER BIRF0068
     3   POSITION   TYPE  OR      IN6X5HPRESS27X11H-IVE    JET6X11HJET VEBIRF0069
     4L  OF8X6HULATED/11X8HFROM COM9X91HOUTER  THIS   -URE    CORRECT RBIRF0070
     5ATIO   ACTUAL  HOLE   ANGLE   -OCITY   CURRENT   FRACTION/11X8H-BIRF0071
     6PRESSOR9X33HWALL   HOLE    LOSS    -ED     OF14X44HAREA    DEGREESBIRF0072
     7  FT PER   ANNULUS   OF INLET/11X9HDISCHARGE15X14HROW     FACTOR10BIRF0073
     8X7HACTUAL 9X5HSQ FT12X3HSEC6X16HAIR FLOW  AIR IN/11X6HINCHES42X6HTBIRF0074
     90 COR36X15HTHROUGH   FLAME/59X6HRECTED36X5HHOLES5X4HTUBE//(1XI5,F1BIRF0075
     12.3,I7,I5,I9,F10.2,4F8.3,F8.2,F10.2,F8.3,F10.3))                  BIRF0076
   73 FORMAT(/////26HOSECONDARY HOLE FLOW SPLIT/1X24(1H-)/71H0FRACTION OBIRF0077
     1F SECONDARY HOLE AIR RECIRCULATING UPSTREAM FOR INNER WALL =F5.4/7BIRF0078
     21H0FRACTION OF SECONDARY HOLE AIR RECIRCULATING UPSTREAM FOR OUTERBIRF0079
     3 WALL =F5.4)                                                      BIRF0080
      DO 2 K=1,NLAST                                                    BIRF0081
      XCP(K)=XCP(K)*12.                                                 BIRF0082
                                                                        BIRF0083
C     FRICTION FACTOR                                                   BIRF0084
                                                                        BIRF0085
      FRICFA(K)=.0035+.264*REAAN(K)**(-.42)                             BIRF0086
      FRICFB(K)=.0035+.264*REBAN(K)**(-.42)                             BIRF0087
  2   CONTINUE                                                          BIRF0088
      WRITE(JTAPE,25)(XCP(K),WFFIZ(K),FRICFA(K),FRICFB(K),K=1,NLAST)    BIRF0089
      DO 3 K=1,NLAST                                                    BIRF0090
      XCP(K)=XCP(K)/12.                                                 BIRF0091
  3   CONTINUE                                                          BIRF0092
      NSH=KJSN(1,1)                                                     BIRF0093
      DO 901 K=1,NLAST                                                  BIRF0094
      DO 902 I=1,6                                                      BIRF0095
      IF(KJSN(K,I))902,902,903                                          BIRF0096
 903  KK1=KJSN(K,I)                                                     BIRF0097
      IF(NHTU(KK1).GE.1)GOTO57                                          BIRF0098
      AFJ1(KK1)=0.                                                      BIRF0099
      DPH(KK1)=0.                                                       BIRF0100
      WCD(KK1)=0.                                                       BIRF0101
      HAU(KK1)=0.                                                       BIRF0102
                                                                        BIRF0103
C     RATIO OF ACTUAL TO CORRECTED DISCHARGE COEFFICIENT  EFF HOLE AREA BIRF0104
                                                                        BIRF0105
   57 RC(KK1)=C(KK1)/WCD(KK1)                                           BIRF0106
                                                                        BIRF0107
      HAW(KK1)=HAU(KK1)*C(KK1)*FLOAT(NHH(KK1))                          BIRF0108
      IF(DXHU(KK1).NE.0.0) GO TO 631                                    BIRF0109
      IF(NAB(KK1).EQ 1) HAW(KK1)=HAW(KK1)*CFTA(K)                       BIRF0110
      IF(NAB(KK1).EQ.2) HAW(KK1)=HAW(KK1)*CFTB(K)                       BIRF0111
                                                                        BIRF0112
C     ACCUMULATED FRACTION OF INLET AIR IN FLAME TUBE                   BIRF0113
                                                                        BIRF0114
  631 IF(KK1.EQ.NSH)DFFT(KK1)=AF1 +AFJ1(KK1)/AF2                        BIRF0115
      IF(KK1.NE.NSH)DFFT(KK1)=DFFT(KK1-1)+AFJ1(KK1  )/AF2               BIRF0116
                                                                        BIRF0117
C     FRACTION OF ANNULUS AIR FLOW THROUGH HOLES                        BIRF0118
                                                                        BIRF0119
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      IF(NAB(KK1).EQ.1)AFJZ(KK1)=AFJ1(KK1)/AFANA(K)                     BIRF0120
      IF(NAB(KK1).EQ.2)AFJZ(KK1)=AFJ1(KK1)/AFANB(K)                     BIRF0121
  902 CONTINUE                                                          BIRF0122
      K1=(KJSN(K,1)-1)                                                  BIRF0123
      IF(K1.LT.1)K1=KK1                                                 BIRF0124
      IF(K.EQ.1)AFFT(K)=AFS                                             BIRF0125
  901 IF(K.NE.1)AFFT(K)=DFFT(K1)*AF2                                    BIRF0126
      DO 4 KK1=NSH,NH                                                   BIRF0127
                                                                        BIRF0128
C     INITIAL JET ANGLE                                                 BIRF0129
C     UNITS CONVERSION                                                  BIRF0130
                                                                        BIRF0131
      GXIA(KK1)=GXIA(KK1)*180./PI                                       BIRF0132
      XH(KK1)=XH(KK1)*12.                                               BIRF0133
    4 CONTINUE                                                          BIRF0134
      WRITE(JTAPE,54)(KK1,XH(KK1),NHTU(KK1),NAB(KK1),NHH(KK1),DPH(KK1),WBIRF0135
     1CD(KK1),RC(KK1),C(KK1),HAW(KK1),GXIA(KK1),WUJ(KK1),AFJZ(KK1),DFFT(BIRF0136
     2KK1),KK1=NSH,NH)                                                  BIRF0137
      DO 5 KK1=NSH,NH                                                   BIRF0138
C     UNITS CONVERSION                                                  BIRF0139
      GXIA(KK1)=GXIA(KK1)*PI/180.                                       BIRF0140
      XH(KK1)=XH(KK1)/12.                                               BIRF0141
    5 CONTINUE                                                          BIRF0142
  346 XFSAQ=1.0-XFSA                                                    BIRF0143
      XFSBQ=1.0-XFSB                                                    BIRF0144
      WRITE(JTAPE,73)XFSAQ,XFSBQ                                        BIRF0145
      WRITE(JTAPE,38)AF1,AF3,AF4                                        BIRF0146
      IF(NSHCP.EQ.1)GOTO779                                             BIRF0147
      N=NSHCP-1                                                         BIRF0148
      DO778K=1,N                                                        BIRF0149
  778 FARFT(K)=FARFT(NSHCP)                                             BIRF0150
  779 CONTINUE                                                          BIRF0151
  900 RETURN                                                            BIRF0152
      END                                                               BIRF0153

 YOUR CARD TOTAL IS ---                155
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*.......*.......*.......*.......*.......*.......*.......*.......*.......*
$IBFTC DISJ    LIST
      SUBROUTINE DISJET
C
C
C                 S U B R O U T I N E   D I S J E T
C
C        THIS SUBROUTINE CALCULATES THE FOLLOWING JET PARAMETERS
C              1. JET VELOCITY
C              2. JET MASS FLOW RATE
C              3. JET DISCHARGE ANGLE
C              4. JET ENTHALPY
C              5. JET MOMENTUM
C        FILM COOLING PARAMETERS ARE ALSO CALCULATED.
C
C        ONE SUBROUTINE IS CALLED BY DISJET
C              1. I1AP1 - 1D INTERPOLATION
C
C        ONE SUBROUTINE CALLS DISJET
C              1. AIRFLO
C
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6
C     VIZ- B6, B16, B67, B68, B126, B167, B168, B678, B1678, B12678

      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,          NABX(45)
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH
     2,SHAFST,                                FIFTPR,        LCMFL,LCANIL
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)
     4,LCPTAL,PAFRZ,NHTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B67/DENFT(45),EK17,EK19,EK20,          EK16
     1          ,C(50),GXIA(50),K,WUJ(50)
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE, IPRINT
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B
     1,AFA,AFB,PREDM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,COMLOS
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,LANB(45),
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                  PREFT1,PREFT2,
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,
     5FARFT2,ENTHAL,LCMF,LCAN1,LCAN,LCFTE,LCFT,K7,K13,K12,
     6AFSYPA,AFSYPB,AFSYIA,AFSYIB,LCPRT,LCPTA
     7,C2(45),             UANA(45),             ZMHA(2),GX1A,GX1B
     8,DPH(50),WCC(50),WFFIZ(45),DPAFS,DPBFS,DPAES,DPBES
     9,RC(50)
     1,A,B,D,E
     2,K30,K40,K50,K60
      COMMON/BZERO/UH(50),AFJ(50),DUMGXI(25),DUMDPH(25),DUMCD(25)
     1,DUM(425)
```

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*........*.........*.........*.........*.........*.........*.........*.........*.........*
                                                                        DISJ0600
 8765 FORMAT(7HODISJET3I11,7F11.3/(7X10F11.3))                          DISJ0610
                                                                        DISJ0620
C     DISCHARGE COEFFICIENT AND JET ANGLE                               DISJ0630
      F=NLAST                                                           DISJ0640
C     SET HOLE AREA TO ZERO                                             DISJ0650
                                                                        DISJ0660
      THA=0.0                                                           DISJ0670
                                                                        DISJ0680
C     SPECIFIC HEAT AT CONSTANT PRESSURE                                DISJ0690
                                                                        DISJ0700
      TA1=TAN1                                                          DISJ0710
      ZZCPT=.2419*TA1-.8181E-5*TA1**2/2.+17.91E-9*TA1**3/3.-2.742E-12*  DISJ0720
     1 TA1**4/4.-102.42                                                 DISJ0730
      DO 116 I=1,6                                                      DISJ0740
                                                                        DISJ0750
C     ARE THERE ANY MORE HOLES AT THIS CALCULATION POINT                DISJ0760
                                                                        DISJ0770
      IF(KJSN(K,I))117,117,109                                          DISJ0780
  109 KK1=KJSN(K,I)                                                     DISJ0790
      DPH(KK1)=DPH1                                                     DISJ0800
      IF(K1)110,110,111                                                 DISJ0810
                                                                        DISJ0820
C     ARE HOLES ON THE CURRENT ANNULUS                                  DISJ0830
                                                                        DISJ0840
  111 IF(NAB(KK1)-2)116,112,116                                         DISJ0850
  110 IF(NAB(KK1).NE.1)GOTO116                                          DISJ0860
  112 KKK=KK1                                                           DISJ0870
      HNHH=NHH(KKK)                                                     DISJ0880
      IH=IHJ(KK1)                                                       DISJ0890
      THA=HNHH*HAU(KKK)                                                 DISJ0900
      NSPN=NSP(IH)                                                      DISJ0910
      IF(MOD(NSCCCP(IH),10).NE.2)GOTO1125                               DISJ0920
                                                                        DISJ0930
C     HOLE AREA FOR COOLING SLOTS                                       DISJ0940
                                                                        DISJ0950
      IF(NAB(KKK).EQ.1)THA=HAU(KKK)*CCA(K)                              DISJ0960
      IF(NAB(KKK).EQ.2)THA=HAU(KKK)*CCB(K)                              DISJ0970
                                                                        DISJ0980
C     HAS PRESSURE REVERSAL OCCURRED PREVIOUSLY                         DISJ0990
                                                                        DISJ1000
 1125 IF(NAB(KK1).EQ.1.AND.K30.EQ.1)GOTO150                             DISJ1010
      IF(NAB(KK1).EQ.2.AND.K40.EQ.1) GOTO150                            DISJ1020
                                                                        DISJ1030
C     HAS ANNULUS AIR FLOW BEEN NEGATIVE PREVIOUSLY                     DISJ1040
                                                                        DISJ1050
      IF(NAB(KK1).EQ.1.AND.K50.EQ.1) GOTO500                            DISJ1060
      IF(NAB(KK1).EQ.2.AND.K60.EQ.1) GOTO500                            DISJ1070
                                                                        DISJ1080
C     TRANSFER HOLE DATA TO DUMMY STORE                                 DISJ1090
                                                                        DISJ1100
      DO 113 I3 = 1,NSPN                                                DISJ1110
      DUMDPH(I3)=DPHS(IH,I3)                                            DISJ1120
      DUMCD(I3)=CDS(IH,I3)                                              DISJ1130
      DUMGXI(I3)=GXIS(IH,I3)                                            DISJ1140
  113 CONTINUE                                                          DISJ1150
      IF(DPH1.LE.0.)GO TO 150                                           DISJ1160
      DUMNSP=NSP(IH)                                                    DISJ1170
      DPH1LG=ALOG(DPH1)                                                 DISJ1180
                                                                        DISJ1190
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*........*........*........*........*........*........*........*........*........*
C     IS PRESSURE RATIO OUTSIDE HOLE DATA TABLE RANGE                      DISJ1200
                                                                           DISJ1210
      IF(DPH1LG.GT.ALOG(256.0))DPH1LG=ALOG(256.0)                          DISJ1220
                                                                           DISJ1230
C     DETERMINE DISCHARGE COEFFICIENT BY INTERPOLATION                     DISJ1240
                                                                           DISJ1250
      CALLI1AP1(DPH1LG,CD,DUMDPH,DUMCD,NSPN)                               DISJ1260
                                                                           DISJ1270
C     DETERMINE INITIAL JET ANGLE BY INTERPOLATION                         DISJ1280
                                                                           DISJ1290
      CALLI1AP1(DPH1LG,GXI,DUMDPH,DUMGXI,NSPN)                             DISJ1300
                                                                           DISJ1310
C     STORE DISCHARGE COEFFICIENT FOR PRINTOUT IN AIRCON                   DISJ1320
                                                                           DISJ1330
      HCD(KK1)=CD                                                          DISJ1340
      IF(IPRINT.GE.1)                                                      DISJ1350
     1WRITE(6,8765)K,K1,KK1,DPH1,CD,AFAN1,THA,UAN1,PREAN1                  DISJ1360
                                                                           DISJ1370
C     TEST FOR CD OUTSIDE TABLE LOWER BOUNDARY                             DISJ1380
                                                                           DISJ1390
      IF(CD)150,160,160                                                    DISJ1400
  150 CD=0.6                                                               DISJ1410
      GXI=1.5708                                                           DISJ1420
      AFH=0.6*THA*AFAN1*SQRT(ABS(DPH1))/AAN1                               DISJ1430
      IF(AFH.GT.AF2/F/3.)AFH=AF2/F              /3.                        DISJ1440
 2    CONTINUE                                                             DISJ1450
                                                                           DISJ1460
C     SET AIR FLOW PARAMETERS                                              DISJ1470
                                                                           DISJ1480
      AFAN1=AFAN1+AFH                                                      DISJ1490
      AFAN2=AFAN1                                                          DISJ1500
      DENAN2=DENAN1                                                        DISJ1510
      UAN2=UAN1                                                            DISJ1520
      TAN2=TAN1                                                            DISJ1530
      PREAN2=PREAN1                                                        DISJ1540
                                                                           DISJ1550
C     SET JET PARAMETERS                                                   DISJ1560
                                                                           DISJ1570
      AFJ(KK1)=0.0                                                         DISJ1580
      GXIA(KK1)=0.0                                                        DISJ1590
      C(KK1)=0.0                                                           DISJ1600
      UH(KK1)=0.0                                                          DISJ1610
      ZMJET(K)=0.0                                                         DISJ1620
      ZMH(K)=0.0                                                           DISJ1630
      ZAJM(K)=0.0                                                          DISJ1640
      ZMJUJ(K)=0.0                                                         DISJ1650
      IF(NAB(KK1).EQ.1)K30=1                                               DISJ1660
      IF(NAB(KK1).EQ.2)K40=1                                               DISJ1670
      GO TO 116                                                            DISJ1680
                                                                           DISJ1690
C     DISCHARGE COEFFICIENT CORRECTION FOR PRESSURE RATIO.                 DISJ1700
C     NSCOOP(IH)= 0  FOR HOLE WITH NO SCOOP                                DISJ1710
C               = 1  FOR HOLE WITH SCOOP                                   DISJ1720
                                                                           DISJ1730
  160 IF(MOD(NSCOOP(IH),10).NE.0)GOTO182                                   DISJ1740
  180 DP=0.5*DENAN1*UAN1**2/GRAVC+PREAN1                                   DISJ1750
      GO TO 183                                                            DISJ1760
  182 DP=PREAN1                                                            DISJ1770
  183 CDC=CD*(0.25*DP/PREFT1+0.75)                                         DISJ1780
      IF(CDC.LT.CD)CDC=CD                                                  DISJ1790
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.......*.........*.........*.........*.........*.........*.........*.........*
      IF(CDC.GT.1.5*CD)CDC=1.5*CD                                       DISJ1800
                                                                        DISJ1810
      TEST FOR NO JET ANGLE DATA.                                       DISJ1820
                                                                        DISJ1830
      IF(NSCOOP(IH).NE.10.AND.NSCOOP(IH).NE.11)GOTO190                  DISJ1840
  191 DMAXL=ALOG(256.0)                                                 DISJ1850
      CALLI1AP1(DMAXL,CD,DUMDPH,DUMCD,NSPN)                             DISJ1860
      CDINF=CD                                                          DISJ1870
      CDINFC=CDINF*(0.25*DP/PREFT1+0.75)                                DISJ1880
      AA=CDC/CDINFC                                                     DISJ1890
      IF(AA.GT.1.0)AA=1.0                                               DISJ1900
      GXI=ARSIN(SQRT(AA))                                               DISJ1910
  190 CD=CDC                                                            DISJ1920
                                                                        DISJ1930
;     TEST ANNULUS AIR FLOW                                             DISJ1940
                                                                        DISJ1950
      IF(AFAN1.LE.0.0)GO TO 500                                         DISJ1960
      GO TO 115                                                         DISJ1970
                                                                        DISJ1980
C     SET JET PARAMETERS                                                DISJ1990
                                                                        DISJ2000
 500  ZAJM(K)=0.0                                                       DISJ2010
      ZMJET(K)=0.0                                                      DISJ2020
      ZMH(K)=0.0                                                        DISJ2030
      ZMJUJ(K)=0.0                                                      DISJ2040
      AFJ(KK1)=0.0                                                      DISJ2050
      GXIA(KK1)=0.0                                                     DISJ2060
      C(KK1)=0.0                                                        DISJ2070
      UH(KK1)=0.0                                                       DISJ2080
                                                                        DISJ2090
C     SET AIR FLOW PARAMETERS                                           DISJ2100
                                                                        DISJ2110
      AFHH=ABS(.6*THA*AFAN1*SQRT(ABS(DPH1))/AAN1)                       DISJ2120
      IF(AFHH.GT.AF2/F/4.)AFHH=AF2/F/4.                                 DISJ2130
   1  CONTINUE                                                          DISJ2140
      AFAN1=AFAN1-AFHH                                                  DISJ2150
      AFAN2=AFAN1                                                       DISJ2160
      PREAN2=PREAN1                                                     DISJ2170
      TAN2=TAN1                                                         DISJ2180
      UAN2=UAN1                                                         DISJ2190
      DENAN2=DENAN1                                                     DISJ2200
      IF(NAB(KK1).EQ.1)K50=1                                            DISJ2210
      IF(NAB(KK1).EQ.2)K60=1                                            DISJ2220
      GO TO 116                                                         DISJ2230
                                                                        DISJ2240
C     C       CALCULATE JET AIR MASS FLOW RATE                          DISJ2250
                                                                        DISJ2260
 115  AFJ(KK1)=CD*AFAN1*THA*DPH1**0.5/AAN1                              DISJ2270
      C(KK1)=CD                                                         DISJ2280
      GXIA(KK1)=GXI                                                     DISJ2290
      AFJ1(KK1)=AFJ(KK1)                                                DISJ2300
                                                                        DISJ2310
C     JET VELOCITY.                                                     DISJ2320
                                                                        DISJ2330
      AAA=2.*(PREAN1+.5*DENAN1*UAN1**2/GRAVC-PREFT1)*GRAVC/DENAN1       DISJ2340
      IF(AAA.LE.0.0)AAA=0.0                                             DISJ2350
      UH(KK1)=SQRT(AAA)                                                 DISJ2360
      WUJ(KK1)=UH(KK1)                                                  DISJ2370
                                                                        DISJ2380
C     AXIAL JET MOMENTUM.                                               DISJ2390
```

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*........*.........*.........*.........*.........*.........*.........*.........*
                                                                        DISJ2400
      AJM=AFJ(KK1)*UH(KK1)*COS(GXI)                                     DISJ2410
                                                                        DISJ2420
C     SUMMATION OF JET AIR FLOW.                                        DISJ2430
                                                                        DISJ2440
      ZMH(K)=ZMH(K)+AFJ(KK1)                                            DISJ2450
                                                                        DISJ2460
C     IS THE NET REMAINING ANNULUS FLOW NEGATIVE                        DISJ2470
                                                                        DISJ2480
      IF(IPRINT.GE.1)                                                   DISJ2490
     1WRITE(6,8765)K,K1,KK1,DPH(KK1),C(KK1),AFJ(KK1),ZMH(K)             DISJ2500
  305 IF(ZMH(K)-AFAN1)300,300,301                                       DISJ2510
  301 IF(K.LT.NSHCP)AFPRZ=AFPRZ+ABS(AFAN1)                              DISJ2520
      AFAN1=-AF2/F                                                      DISJ2530
      AFAN2=AFAN1                                                       DISJ2540
      AFJ(KK1)=0.0                                                      DISJ2550
      ZMH(K)=0.0                                                        DISJ2560
      ZMJUJ(K)=0.0                                                      DISJ2570
      ZMJET(K)=0.0                                                      DISJ2580
      ZAJM(K)=0.0                                                       DISJ2590
      DENAN2=DENAN1                                                     DISJ2600
      TAN2=TAN1                                                         DISJ2610
      UAN1=0.01                                                         DISJ2620
      PREAN2=PREAN1                                                     DISJ2630
      IF(NAB(KK1).EQ.1)K50=1                                            DISJ2640
      IF(NAB(KK1).EQ.2)K60=1                                            DISJ2650
      IF(K.LT.NSHCP)AFPRZ=AF2                                           DISJ2660
      GOTO116                                                           DISJ2670
                                                                        DISJ2680
C     SUMMATION OF JET ENTHALPY.                                        DISJ2690
                                                                        DISJ2700
  300 ZMJET(K)=AFJ(KK1)*(   ZZCPT      *GRAVC*GJOULE+UH(KK1)**2/2.)+    DISJ2710
     1ZMJET(K)                                                          DISJ2720
                                                                        DISJ2730
C     SUMMATION OF AXIAL JET MOMENTUM                                   DISJ2740
                                                                        DISJ2750
      ZAJM(K)=ZAJM(K)+AJM                                               DISJ2760
                                                                        DISJ2770
C     SUMMATION OF JET MOMENTUM.                                        DISJ2780
                                                                        DISJ2790
      ZMJUJ(K)=AFJ(KK1)*UH(KK1)+ZMJUJ(K)                                DISJ2800
 116  CONTINUE                                                          DISJ2810
 117  RETURN                                                            DISJ2820
      END                                                               DISJ2830

  YOUR CARD TOTAL IS ---            289 .
```

```
$IBFTC PRT      LIST
C
      SUBROUTINE PRTEMP
C
C
C                    S U B R O U T I N E   P R T E M P
C
C         THIS SUBROUTINE SOLVES THE EQUATIONS FOR A STIRRED REACTION
C         IN THE COMBUSTOR PRIMARY ZONE TO GIVE THE TEMPERATURE IN
C         THE PRIMARY ZONE.
C         IF THE SECONDARY HOLE FLOW SPLIT IS NOT SPECIFIED AN
C         ITERATION IS PERFORMED ON THE AIR FLOW IN THE PRIMARY
C         ZONE,SINCE THE FLOW SPLIT IS TAKEN TO BE A FUNCTION
C         OF THE PRIMARY ZONE TEMPERATURE.
C
C         NO SUBROUTINE IS CALLED BY PRTEMP
C
C         ONE SUBROUTINE CALLS PRTEMP
C              1. AIRFLO
C
C COMMON STATEMENTS

C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6
C      VIZ- B6, B16, B67, B68, B126, B167, B168, B678, B1678, B12678

      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,         NABX(45)
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH
     2,SHAFST,                                 FIFTPR,       LCMFL,LCANIL
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)
     4,LCPTAL,PAFRZ,NHTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B67/DENFT(45),EK17,EK19,EK20,         EK16
     1          ,C(50),GXIA(50),K,WUJ(50)
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE,IPRINT
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B
     1,AFA,AFB,PREDM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,DOMLOS
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,UANB(45),
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                      PREFT1,PREFT2,
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,
     5FARFT2,ENTHAL,LCMF,LCANI,LCAN,LCFTE,LCFT,K7,K13,K12,
     6AFSYPA,AFSYPB,AFSYIA,AFSYIB,LCPRT,LCPTA
     7,C2(45),              UANA(45),              ZMHA(2),GX1A,GX1B
     8,[illegible](50),WCD(50),WFFIZ(45),DPAFS,DPBFS,DPAES,DPBES
     9,RC(50)
     1,A,B,D,E
     2,K30,K40,K50,K60
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      COMMON/B5867/XFSA,XFSB

C     DATA STATEMENT

      DATA NTOTP,PLIMIT/20,.1/

C     FORMAT STATEMENTS

    1 FORMAT(7H PRTEMP10F11.3)
  100 FORMAT(40H PROGRAMME STOPPED IN SUBROUTINE PRTEMP.,/35H ITERATION
     1LIMIT *LCPRTL* EXCEEDED.)
  101 FORMAT(40H PROGRAMME STOPPED IN SUBROUTINE PRTEMP.,/35H ITERATION
     1LIMIT *LCPTAL* EXCEEDED.)
 3000 FORMAT(1X,//////19H ***  ERROR MESSAGE)
 3001 FORMAT(68H ITERATION LIMIT OM TOTAL PRESSURE LOSS DUE TO HEAT RELE
     1ASE EXCEEDED)

C     CALCULATION OF FLAME TUBE TEMPERATURE AT SECONDARY HOLES.
C     SET LOOP COUNTER TO ZERO FOR FLOW SPLIT ITERATION

      LCPTA=0

C     FUEL AIR RATIO IN THE PRIMARY ZONE.

 3005 FARPRZ=FFIZ(1)/AFPRZ
      IF(NSHCP.EQ.1)GOTO3007
      NSHCP1=NSHCP-1
      DO3006K=1,NSHCP1
      WFFIZ(K)=FFIZ(K+1)/(XCP(K+1)-XCP(K))
 3006 FARPRZ=FARPRZ+FFIZ(K+1)/AFPRZ

C     TEST IF FUEL IS AVAILABLE

 3007 ZSTOC=0.0867*(1.+FHCR)/(1.+3.*FHCR)
      IF(FARPRZ.GT.0.) GO TO 300
      TFT11=STAGT
      FARPRZ=0.0
      FARL=0.0
      GO TO 310

C     STOICHIOMETRIC FUEL AIR RATIO.

  300 CONTINUE

C     TEST FOR FUEL AIR RATIO GREATER THAN STOICHIOMETRIC.
C     YES PUT EQUAL TO STOICHIOMETRIC
C     NO CONTINUE.

      IF(ZSTOC-FARPRZ)301,302,302

C     CALCULATE FUEL AIR RATIO REMAINING.

  301 FARL=AMAX1(0.,FARPRZ-ZSTOC)
      FARPRZ=ZSTOC
      AFRPRZ=1.0/FARPRZ
      GO TO 400
 302  FARL=0.0
      AFRPRZ=1.0/FARPRZ
 400  TFT1=STAGT
      FARFT(NSHCP)=FARPRZ
C
```

```
     CONVERT FARL TO A FUEL-GAS RATIO                                    PRT 1210
                                                                         PRT 1220
     FARL=FARL/(1.+FARFT(NSHCP))                                         PRT 1230
                                                                         PRT 1240
     SET INITIAL GUESS AT TEMPERATURE TO BE 3000 DEG. R.                 PRT 1250
                                                                         PRT 1260
     DELT=3000.0                                                         PRT 1270
     TFT11=DELT                                                          PRT 1280
                                                                         PRT 1290
     SET LOOP COUNTER TO ZERO FOR TEMPERATURE ITERATION                  PRT 1300
                                                                         PRT 1310
     LCPRT=0                                                             PRT 1320
                                                                         PRT 1330
     CALCULATE HEAT ADDITION.                                            PRT 1340
                                                                         PRT 1350
 303 QB=AFRPRZ                                                           PRT 1360
     QD=1./AFRPRZ                                                        PRT 1370
     D11=QB*(.2419*(TFT1-459.4)-.8181E-5*(TFT1**2-459.4**2)/2.+17.9      PRT 1380
    1*1.E-9*(TFT1**3-459.4**3)/3.-2.743E-12*(TFT1**4-459.4**4)/4.)       PRT 1390
     D12=(QB+1.)*((.2419+0.103*QD)*(TFT11-459.4)-(.8181-22.6*QD)*1.E-5*PRT 1400
    1(TFT11**2-459.4**2)/2.+(17.91-29.6*QD)*1.E-9*(TFT11**3-459.4**3)/ PRT 1410
    13.+(-2.743+0.35*QD)*(TFT11**4-459.4**4)/4.*1.E-12)                 PRT 1420
     ERROR=FLCV+D11-D12-3.0*1.E-26*QB*TFT11**7.5                         PRT 1430
     DELT=0.5*DELT                                                       PRT 1440
     IF(IPRINT.EQ.1)WRITE(6,1)TFT11                                      PRT 1450
                                                                         PRT 1460
     TEST ERROR IN COMBUSTION EQUATION FOR CONVERGENCE OF TEMPERATURE    PRT 1470
                                                                         PRT 1480
305  IF(ABS(ERROR)-FIFTPR)307,307,306                                    PRT 1490
306  IF(ERROR)700,307,701                                                PRT 1500
                                                                         PRT 1510
     MODIFY TEMP. AND RETURN.                                            PRT 1520
                                                                         PRT 1530
700  TFT11=TFT11-DELT                                                    PRT 1540
     GO TO 500                                                           PRT 1550
701  TFT11=TFT11+DELT                                                    PRT 1560
                                                                         PRT 1570
     INDEX LOOP COUNTER                                                  PRT 1580
                                                                         PRT 1590
500  LCPRT=LCPRT+1                                                       PRT 1600
                                                                         PRT 1610
     TEST LOOP COUNT                                                     PRT 1620
                                                                         PRT 1630
     IF(LCPRT-LCPRTL)303,303,601                                         PRT 1640
 601 CONTINUE                                                            PRT 1650
     WRITE(JTAPE,3000)                                                   PRT 1660
     WRITE(JTAPE,100)                                                    PRT 1670
                                                                         PRT 1680
     TEST K4=0 FLOW SPLIT NOT SPECIFIED.                                 PRT 1690
          K4=1 FLOW SPLIT SPECIFIED.                                     PRT 1700
                                                                         PRT 1710
307  IF(K4)308,308,310                                                   PRT 1720
                                                                         PRT 1730
     CALCULATION OF FLOW SPLIT.                                          PRT 1740
                                                                         PRT 1750
308  AFPRZZ=AFPRZ                                                        PRT 1760
                                                                         PRT 1770
     INDEX LOOP COUNTER                                                  PRT 1780
                                                                         PRT 1790
     LCPTA=LCPTA+1                                                       PRT 1800
                                                                         PRT 1810
```

```
C     TEST LCOP COUNTER                                                 PRT 1820
                                                                        PRT 1830
      IF(LCPTA-LCPTAL)350,350,351                                       PRT 1840
  351 CONTINUE                                                          PRT 1850
      WRITE(JTAPE,3000)                                                 PRT 1860
      WRITE(JTAPE,101)                                                  PRT 1870
      GO TO 310                                                         PRT 1880
  350 AFPRZ=AFPRZ-AFSYPA-AFSYPB                                         PRT 1890
      AFSYPA=ZMHA(1)*0.5*SIN(GX1A)*SQRT(TANANA(NSHCP)/TFT11)            PRT 1900
      AFSYIA=ZMHA(1)-AFSYPA                                             PRT 1910
      AFSYPB=ZMHA(2)*0.5*SIN(GX1B)*SQRT(TANANB(NSHCP)/TFT11)            PRT 1920
      AFSYIB=ZMHA(2)-AFSYPB                                             PRT 1930
      AFPRZ=AFPRZ+AFSYPA+AFSYPB                                         PRT 1940
                                                                        PRT 1950
C     TEST CHANGE IN FLOW SPLIT THROUGH SECONDARY HOLES                 PRT 1960
                                                                        PRT 1970
      IF(ABS(AFPRZZ-AFPRZ)/AFPRZZ*100.0-PAFRZ)310,310,3005              PRT 1980
                                                                        PRT 1990
C     TOTAL PRESSURE LOSS DUE TO HEAT RELEASE IN THE PRIMARY ZONE       PRT 2000
                                                                        PRT 2010
  310 DENFT(1)=PREFT(1)/STAGT/GASC                                      PRT 2020
      UFT(1)=AFPRZ/AFT(NSHCP)/DENFT(1)                                  PRT 2030
      PREFT(2)=PREFT(1)                                                 PRT 2040
      PLAST=PREFT(2)                                                    PRT 2050
      DO3105I=1,NTOTP                                                   PRT 2060
      DENFT(2     )=PREFT(2)/(TFT11*(53.32+1.725*FARPRZ-1.49*FARPRZ**2)) PRT 2070
      UFT(2)=AFPRZ/AFT(NSHCP)/DENFT(2)                                  PRT 2080
     1*(1.+FARPRZ)                                                      PRT 2090
      PREFT(2)=PREFT(1)+AFRPRZ/AFT(NSHCP)/32.*(UFT(1)-UFT(2)*(1.+FARPRZ)PRT 2100
     1)                                                                 PRT 2110
      IF(ABS(PREFT(2)-PLAST).LT.PLIMIT)GOTO3106                         PRT 2120
      PLAST=PREFT(2)                                                    PRT 2130
      IF(IPRINT.EQ.1)WRITE(6,1)PREFT(2)                                 PRT 2140
 3105 CONTINUE                                                          PRT 2150
      WRITE(JTAPE,3000)                                                 PRT 2160
      WRITE(JTAPE,3001)                                                 PRT 2170
 3106 CONTINUE                                                          PRT 2180
                                                                        PRT 2190
C     FLOW PARAMETERS AT THE SECONDARY HOLES                            PRT 2200
C     SET FLCW PARAMETERS UP TO THE SECONDARY HOLES TO THE SAME VALUES  PRT 2210
                                                                        PRT 2220
      DO 20 I=1,NSHCP                                                   PRT 2230
      DENFT(I)=DENFT(2)                                                 PRT 2240
      UFT(I)=UFT(2)                                                     PRT 2250
      AFFT(I)=AFPRZ*(1.+FARFT(NSHCP))                                   PRT 2260
      TFT(I)=TFT11                                                      PRT 2270
      PREFT(I)=PREFT(2)                                                 PRT 2280
   20 CONTINUE                                                          PRT 2290
  502 TFT2=TFT11                                                        PRT 2300
                                                                        PRT 2310
C     PROPORTION JET PARAMETERS ACCORDING TO FLOW SPLIT                 PRT 2320
                                                                        PRT 2330
      X=AFSYIB/(AFSYIB+AFSYPB)                                          PRT 2340
      Y=AFSYIA/(AFSYIA+AFSYPA)                                          PRT 2350
C                                                                       PRT 2360
C     SET FLCW-SPLIT INDEX                                              PRT 2370
C                                                                       PRT 2380
      IF(K4)5001,5001,5002                                              PRT 2390
 5001 XFSA=Y                                                            PRT 2400
      XFSB=X                                                            PRT 2410
      GO TO 5003                                                        PRT 2420
```

```
5002 XFSA=1.-SHAFST                                                         PRT 2430
     XFSB=1.-SHAFST                                                         PRT 2440
5003 CONTINUE                                                               PRT 2450
     ZMH(NSHCP)=AFSYIA+AFSYIB                                               PRT 2460
     ZMJET(NSHCP)=A*Y+X*ZMJET(NSHCP)                                        PRT 2470
     ZAJM(NSHCP)=E*Y+X*ZAJM(NSHCP)                                          PRT 2480
     ZMJUJ(NSHCP)=B*Y+ZMJUJ(NSHCP)*X                                        PRT 2490
     IF(IPRINT.GE.1)WRITE(6,1)AFPRZ,FARPRZ,ZSTOC,FARL,(FFIZ(K),K=1,NSHCPRT 2500
    1P),(WFFIZ(K),K=1,NSHCP)                                                PRT 2510
     RETURN                                                                 PRT 2520
     END                                                                    PRT 2530
```

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*........*.........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC EQAN    LIST
      SUBROUTINE EQUAN                                                  EQAN0010
C                                                                       EQAN0020
C                                                                       EQAN0030
C                   S U B R O U T I N E   E Q U A N                     EQAN0040
C                                                                       EQAN0050
C         THIS SUBROUTINE SOLVES THE EQUATIONS OF MOMENTUM,CONTINUITY,  EQAN0060
C         STATE,AND ENTHALPY FOR THE ANNULII OF A COMBUSTOR.            EQAN0070
C                                                                       EQAN0080
C         NO SUBROUTINES ARE CALLED BY EQUAN                            EQAN0090
C                                                                       EQAN0100
C         ONE SUBROUTINE CALLS EQUAN                                    EQAN0110
C              1. AIRFLO                                                EQAN0120
C                                                                       EQAN0130
C  THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6  EQAN0140
C      VIZ- B6, B16, B67, B68, B126, B167, B168, B678, B1678, B12678    EQAN0150
C                                                                       EQAN0160
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,          NABX(45)      EQAN0170
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   EQAN0180
     2,SHAFST,                             FIFTPR,       LCMFL,LCANILEQAN0190
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)    EQAN0200
     4,LCPTAL,PAFRZ,NMTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)      EQAN0210
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)     EQAN0220
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)                            EQAN0230
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)      EQAN0240
     4,TWA(45),TWB(45)                                                  EQAN0250
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          EQAN0260
     1,KANHET,LANHET,PERCO,THIKFT                                       EQAN0270
     2,DANA(45),DANB(45)                                                EQAN0280
      COMMON/B67/DENFT(45),EK17,EK19,EK20,          EK16                EQAN0290
     1          ,C(50),GXIA(50),K,WUJ(50)                               EQAN0300
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH                   EQAN0310
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANEQAN0320
     1ANB(45),AFJ1(50),UFT(45)                                          EQAN0330
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             EQAN0340
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCCDEA(45)  EQAN0350
     2,NCCDEB(45),TZ                                                    EQAN0360
      COMMON/B12678/JTAPE,IPRINT                                        EQAN0370
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B                           EQAN0380
     1,AFA,AFB,PREDM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,DOMLOS         EQAN0390
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,  EQAN0400
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,UANB(45),      EQAN0410
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,                     EQAN0420
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                   PREFT1,PREFT2, EQAN0430
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,                   EQAN0440
     5FARFT2,ENTHAL,LCMF,LCANI,LCAN,LCFTE,LCFT,K7,K13,K12,              EQAN0450
     6AFSYPA,AFSYPB,AFSYIA,AFSYIB,LCPRT,LCPTA                           EQAN0460
     7,C2(45),             UANA(45),             ZMHA(2),GX1A,GX1B      EQAN0470
     8,DPH(50),WCC(50),WFFIZ(45),CPAFS,DPBFS,DPAES,DPBES                EQAN0480
     9,RC(50)                                                           EQAN0490
     1,A,B,D,E                                                          EQAN0500
     2,K30,K40,K50,K60                                                  EQAN0510
      COMMON/BZERO/FRICFA(45),FRICFB(45),DUM(510)                       EQAN0520
      COMMON/BUNIK/CUMAE(45),CUMBE(45)                                  EQAN0530
                                                                        EQAN0540
C FORMAT STATEMENTS                                                     EQAN0550
                                                                        EQAN0560
   15 FORMAT(1H010F11.4)                                                EQAN0570
 3000 FORMAT(1X,//////19H ***  ERROR MESSAGE)                           EQAN0580
 8765 FORMAT(6H0EQUAN10F11.3/(6X10F11.3))                               EQAN0590
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*.........*.........*.........*.........*.........*.........*.........*.........*
C                                                                       EQAN0600
C     SOLUTION OF ANNULII EQUATIONS.                                    EQAN0610
C                                                                       EQAN0620
      AA23=0.0                                                          EQAN0630
                                                                        EQAN0640
C     TEST KANHET TO SEE IF HEAT SUBPROGRAM HAS BEEN CALLED             EQAN0650
C     IF IT HAS NOT, SET HEAT PARAMETERS TO EITHER TYPICAL VALUES OR ZEREQAN0660
                                                                        EQAN0670
      IF(KANHET.NE.0)GOTO600                                            EQAN0680
      TRAN=0.0                                                          EQAN0690
      PERCO=0.0                                                         EQAN0700
      V=3.057E-3+8.607E-5*TAN1-2.279E-8*TAN1**2+2.908E-12*TAN1**3       EQAN0710
      IF(K1.EQ.0)REAAN(K)=3600.*DANA(K)*AFANA(K)/V/AANA(K)              EQAN0720
      IF(K1.EQ.1)REBAN(K)=3600.*DANB(K)*AFANB(K)/V/AANB(K)              EQAN0730
      C2(K)=0.0                                                         EQAN0740
      TWA(K)=0.0                                                        EQAN0750
      TWB(K)=0.0                                                        EQAN0760
      QTRA(K)=0.0                                                       EQAN0770
      QTRB(K)=0.0                                                       EQAN0780
      AAN3=(AAN1+AAN2)/2.                                               EQAN0790
  600 CONTINUE                                                          EQAN0800
C                                                                       EQAN0810
C     TEST INNER OUTER ANNULUS.                                         EQAN0820
C                                                                       EQAN0830
      IF(K1)118,118,119                                                 EQAN0840
C                                                                       EQAN0850
C      INNER ANNULUS                                                    EQAN0860
C                                                                       EQAN0870
  118 CIR=CCA(K)+CFTA(K)                                                EQAN0880
      CIRFT=CFTA(K)                                                     EQAN0890
                                                                        EQAN0900
C     FRICTION FACTOR                                                   EQAN0910
                                                                        EQAN0920
      FRICF=.0035+.264*REAAN(K)**(-.42)                                 EQAN0930
      FRICFA(K)=FRICF                                                   EQAN0940
                                                                        EQAN0950
C     TRANSPIRATION COOLING                                             EQAN0960
                                                                        EQAN0970
      SAFTRA(K)=(PREANA(K)**2-PREFT(K)**2)*PERCO*3600./3.32/THIKFT/TWA(KEQAN0980
C                  ** INCLUDE CARDS EQAN0991 AND 0995 **                EQAN0990
     1)/(3.057E-3+8.607E-5*TWA(K)-2.279E-8*TWA(K)**2+2.908E-12*TWA(K)   EQAN0991
     2**3)                                                              EQAN0995
      TRAN=SAFTRA(K)*CFTA(K)*(XCP(J)-XCP(K))                            EQAN1000
      GO TO 200                                                         EQAN1010
                                                                        EQAN1020
C     OUTER ANNULUS                                                     EQAN1030
                                                                        EQAN1040
  119 CIR=CCB(K)+CFTB(K)                                                EQAN1050
      CIRFT=CFTB(K)                                                     EQAN1060
                                                                        EQAN1070
C     FRICTION FACTOR                                                   EQAN1080
                                                                        EQAN1090
      FRICF=.0035+.264*REBAN(K)**(-.42)                                 EQAN1100
      FRICFB(K)=FRICF                                                   EQAN1110
                                                                        EQAN1120
C     TRANSPIRATION COOLING                                             EQAN1130
                                                                        EQAN1140
      SAFTRB(K)=(PREANB(K)**2-PREFT(K)**2)*PERCO*3600./3.32/THIKFT/TWB(KEQAN1150
C                 ** INCLUDE CARDS EQAN1161 AND 1165 **                 EQAN1160
     1)/(3.057E-3+8.607E-5*TWB(K)-2.279E-8*TWB(K)**2+2.908E-12*TWB(K)   EQAN1161
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*.........*.........*.........*.........*.........*.........*.........*.........*
     2**3)                                                              EQAN1165
      TRAN=SAFTRB(K)*CFTB(K)*(XCP(J)-XCP(K))                            EQAN1170
      GO TO 201                                                         EQAN1180
 200  DO 202I=1,3                                                       EQAN1190
                                                                        EQAN1200
C     BLEED AIR FOR INNER ANNULUS                                       EQAN1210
                                                                        EQAN1220
      IF(XAF23A(I).GT.XCP(K).AND.XAF23A(I).LE.XCP(J)+1.E-3)AA23=AA23+AF2EQAN1230
     13A(I)                                                             EQAN1240
  202 CONTINUE                                                          EQAN1250
      GOTO203                                                           EQAN1260
 201  DO 204 I=1,3                                                      EQAN1270
                                                                        EQAN1280
C     BLEED AIR FOR OUTER ANNULUS                                       EQAN1290
                                                                        EQAN1300
      IF(XAF23B(I).GT.XCP(K).AND.XAF23B(I).LE.XCP(J)+1.E-3)AA23=AA23+AF2EQAN1310
     13B(I)                                                             EQAN1320
  204 CONTINUE                                                          EQAN1330
  203 CONTINUE                                                          EQAN1340
      F=NLAST                                                           EQAN1350
                                                                        EQAN1360
C     TEST TOTAL FLOW FROM ANNULUS                                      EQAN1370
                                                                        EQAN1380
 120  IF(AA23+TRAN+ZMH(K)-AFAN1)124,124,125                             EQAN1390
                                                                        EQAN1400
C     IF TOTAL FLOW IS NEGATIVE, SET ANNULUS PARAMETERS AT NEXT         EQAN1410
                                                                        EQAN1420
  125 AFAN1=-AF2/F                                                      EQAN1430
      AFAN2=AFAN1                                                       EQAN1440
      DENAN2=DENAN1                                                     EQAN1450
      TAN2=TAN1                                                         EQAN1460
      UAN2=0.001                                                        EQAN1470
      PREAN2=PREAN1                                                     EQAN1480
      CONTINUE                                                          EQAN1490
      GO TO 82                                                          EQAN1500
                                                                        EQAN1510
C     TOTAL-PRESSURE LOSS DUE TO SUDDEN EXPANSION OF ANNULUS AIR AS IT  EQAN1520
C     PASSES ACROSS AIR ENTRY HOLE                                      EQAN1530
                                                                        EQAN1540
  124 DPE=0.                                                            EQAN1550
      IF(K1.EQ.0.AND.NCODEA(K).EQ.1)GOTO1242                            EQAN1560
      IF(K1.EQ.1.AND.NCODEB(K).EQ.1)GOTO1242                            EQAN1570
      AA1=UAN1/SQRT(1.4*TAN1*GASC*GRAVC)                                EQAN1580
      IF(AA1.GT..85)AA1=.85                                             EQAN1590
      DPEXP=1.85*(ZMH(K)/AFAN1/1.36)**(1./(.5+.242*AA1**2.22))          EQAN1600
      IF(DPEXP.GT.1.2)DPEXP=1.2                                         EQAN1610
      DPE=DENAN1*UAN1**2/2./GRAVC*DPEXP                                 EQAN1620
      DPEXQ=DPE-DENAN1*UAN1**2/2./GRAVC*(1.-(1.-ZMH(K)/AFAN1)**2)       EQAN1630
      IF(IPRINT.NE.1)GOTO8755                                           EQAN1640
      WRITE(6,8765)PREAN1,AA1,DPEXP,DPAE,DPEXQ                          EQAN1650
 8755 CONTINUE                                                          EQAN1660
C                                                                       EQAN1670
C     CALCULATE GAS PROPERTIES DOWN-STREAM OF THE EXPANSION             EQAN1680
C                                                                       EQAN1690
      ZZCP=0.2121+5.06E-5*TAN1-13.1E-9*TAN1**2+2.1E-12*TAN1**3          EQAN1700
      AFZ=AFAN1-ZMH(K)                                                  EQAN1710
      DQ=53.3*1.4/0.4*GRAVC                                             EQAN1720
      TNRT=TAN1+UAN1**2/2./DQ                                           EQAN1730
      PNRT=PREAN1*(TNRT/TAN1)**(1.4/0.4)                                EQAN1740
      PNRT=PNRT-DPE                                                     EQAN1750
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........*.........*.........*.........*.........*.........*.........*.........*
      ASTAR=AFZ*SCRT(DQ*TNRT*0.4)*1.2**3/PNRT/GRAVC/1.4                 ECAN1760
      AAS=AAN1/ASTAR                                                    ECAN1770
      CALL GASTBL(AAS,TTC,PPO,MNZ,1,IBL,MNX,MNV)                        ECAN1780
      PREAN1=PPO*PNRT                                                   ECAN1790
      TAN1=TTC*TNRT                                                     EQAN1800
      DENAN1=PREAN1/GASC/TAN1                                           EQAN1810
      UAN1=AFZ/DENAN1/AAN1                                              ECAN1820
 1242 IF(K1.NE.0)GOTO1243                                               EQAN1830
      CPAE=DPE/144.                                                     ECAN1840
      DUMAE(K)=DPAES                                                    EQAN1850
      DPAES=CPAES+DPAE                                                  ECAN1860
      GCTC1245                                                          EQAN1870
 1243 DPBE=DPE/144.                                                     ECAN1880
      DUMBE(K)=DPBES                                                    ECAN1890
      DPBES=DPBES+DPBE                                                  ECAN1900
                                                                        ECAN191C
      CALCULATION OF CONSTANTS FOR ANNULUS EQUATIONS.                   ECAN192C
                                                                        ECAN1930
 1245 AFAN2=AFAN1-ZMH(K)-TRAN-AA23                                      ECAN1940
      EK2=AFAN2                                                         ECAN195C
      ARC=AAN2/AAN1                                                     ECAN1960
      ZZCP=0.2121+5.06E-5*TAN1-13.1E-9*TAN1**2+2.1E-12*TAN1**3          EQAN1970
      EK3=(TAN1*ZZCP*GRAVC*GJCULE+0.5*UAN1**2)*EK2                      ECAN198C
     1+C2(K)*CIRFT*GRAVC*GJOULE*(XCP(J)-XCP(K))                         ECAN1990
      AAN4=2.*AAN2/(ARC+1.)                                             EQAN2C00
      EK1=PREAN1*GRAVC*AAN4+UAN1*EK2                                    EQAN2010
      EK4=PREAN1/(DENAN1*TAN1)*GRAVC                                    ECAN2020
      D1=(FRICF*0.5*CIR*DENAN1*(XCP(J)-XCP(K))*     GRAVC*GJOULE*ZZCP)/(ECAN2030
     1EK2*EK4*1.   )*UAN1**2*(ARQ+1.)/2.                                EQAN2040
      C2=.5-ZZCP*GRAVC*GJOULE       /EK4*(ARQ+1.)/2.                    ECAN2050
      D3=ZZCP*GRAVC*GJOULE*      EK1/(      EK2*EK4)*(ARQ+1.)/2.-D1     ECAN2060
      D4=EK3/EK2                                                        EQAN2070
                                                                        ECAN2080
      ANNULUS VELCCITY AT NEXT CALCULATION POINT                        ECAN2090
                                                                        ECAN2100
      IF((D3**2+4.*D2*D4).LT.0.)UAN2=UAN1                               ECAN2110
      IF((D3**2+4.*D2*D4).GE.0.)                                        ECAN2120
     1UAN2=(-D3+SQRT(C3**2+4.*D2*D4))/(2.*D2)                           ECAN2130
                                                                        ECAN2140
      CALCULATE PRESSURE,CENSITY,TEMPERATURE ANC AIRFLOW.               EQAN2150
                                                                        ECAN216C
  123 PREAN2=(EK1-UAN2*EK2-FRICF*.5*CIR*CENAN1*(XCP(J)-XCP(K))*UAN1**2)/ECAN2170
     1GRAVC/AAN4                                                        ECAN2180
      DENAN2=AFAN2/(AAN2*UAN2)                                          ECAN2190
      TAN2=PREAN2*GRAVC/(DENAN2*EK4)                                    ECAN2200
      IF(IPRINT.EC.1)                                                   ECAN2210
     1WRITE(6,8765)UAN1,PPEAN1,DENAN1,AAN1,AAN2,AFAN1,ZMH(K),TRAN,      ECAN2220
     1AA23,TAN1,FRICF,CIR,ZZCP,C2(K),EK1,EK2,EK4,D1,D2,D3,D4            ECAN2230
     2               ,UAN2,PREAN2,AFAN2,DENAN2,TAN2                     EQAN224C
      CUMBE(K+1)=CPBES                                                  EQAN2250
      IF(K1.EC.1) GC TO 3654                                            EQAN2260
      DUMAE(K+1)=DPAES                                                  ECAN2270
                                                                        ECAN2280
      CALCULATION OF ANNULUS PARAMETERS AT CALCULATION POINTS HAVING NO EQAN2290
      HOLES                                                             EQAN2300
                                                                        ECAN2310
 3654 IF(K-NSHCP.GT.0)GCTC501                                           EQAN232C
      N=K+1                                                             ECAN2330
      DC502I=N,J                                                        EQAN2340
      X1=(XCP(I)-XCP(K))/(XCP(J)-XCP(K))                                EQAN2350
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*.........*.........*.........*.........*.........*.........*.........*.........
      IF(K1.EQ.1)GOTO503                                                EQAN236
      PREANA(I)=X1*(PREAN2-PREAN1)+PREAN1                               EQAN237
      UANA(I)=X1*(UAN2-UAN1)+UAN1                                       EQAN238
      TANANA(I)=X1*(TAN2-TAN1)+TAN1                                     EQAN239
      DENANA(I)=X1*(DENAN2-DENAN1)+DENAN1                               EQAN240
      AFANA(I)=AFANA(K)                                                 EQAN241
C                    ** INCLUDE CARDS EQAN2421 AND 2425 **              EQAN242
      DUMAE(I)=DPAES                                                    EQAN2421
      REAAN(I)=REAAN(K)                                                 EQAN242
      GOTO502                                                           EQAN243
  503 PREANB(I)=X1*(PREAN2-PREAN1)+PREAN1                               EQAN244
      UANB(I)=X1*(UAN2-UAN1)+UAN1                                       EQAN245
      TANANB(I)=X1*(TAN2-TAN1)+TAN1                                     EQAN246
      DENANB(I)=X1*(DENAN2-DENAN1)+DENAN1                               EQAN247
      AFANB(I)=AFANB(K)                                                 EQAN248
C                   ** INCLUDE EQAN2491 AND 2495  **                    EQAN249
      DUMBE(I)=DPBES                                                    EQAN249
      REBAN(I)=REBAN(K)                                                 EQAN249
  502 CONTINUE                                                          EQAN250
  501 CONTINUE                                                          EQAN251
      IF(K-NSHCP)300,301,301                                            EQAN252
 300  CONTINUE                                                          EQAN253
                                                                        EQAN254
C     FORM PRIMARY ZONE AIR FLOW                                        EQAN255
                                                                        EQAN256
      AFPRZ=AFPRZ+ZMH(K)                                                EQAN257
 301  CONTINUE                                                          EQAN258
C                   ** INCLUDE CARDS EQAN2591, 2593, AND 2597 **        EQAN259
 82   CONTINUE                                                          EQAN259
      REAAN(NLAST)=REAAN(K)                                             EQAN259
      REBAN(NLAST)=REBAN(K)                                             EQAN259
      RETURN                                                            EQAN260
      END                                                               EQAN261

  YOUR CARD TOTAL IS ---               274
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*.........*.........*.........*.........*.........*.........*.........*.........*
$IBFTC EQFT    LIST
      SUBROUTINE EQUFT                                                  EQFT0010
C                                                                       EQFT0020
C                 S U B R O U T I N E   E Q U F T .                     EQFT0030
C                                                                       EQFT0040
C        THIS SUBROUTINE SOLVES THE EQUATIONS OF MOMENTUM,CONTINUITY,   EQFT0050
C        STATE,AND ENTHALPY FOR A COMBUSTOR FLAME TUBE.                 EQFT0060
C                                                                       EQFT0070
C        TWO SUBROUTINES ARE CALLED BY EQUFT.                           EQFT0080
C             1. JETMIX - FOR JET PARAMETERS                            EQFT0090
C             2. HEATAD - FOR ENTHALPY ADDED TO FLAME                   EQFT0100
C                         TUBE AIR BY BURNING FUEL.                     EQFT0110
C                                                                       EQFT0120
C        ONE SUBROUTINE CALLS EQUFT                                     EQFT0130
C             1. AIRFLO                                                 EQFT0140
C                                                                       EQFT0150
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6   EQFT0160
C     VIZ- B6, B16, B67, B68, B126, B167, B168, B678, B1678, B12678     EQFT0170
C                                                                       EQFT0180
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,        NABX(45)        EQFT0190
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   EQFT0200
     2,SHAFST,                                   FIFTPR,      LCMFL,LCANILEQFT0210
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOCP(20)    EQFT0220
     4,LCPTAL,PAFRZ,NHTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)      EQFT0230
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)     EQFT0240
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)                            EQFT0250
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)      EQFT0260
     4,TWA(45),TWB(45)                                                  EQFT0270
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          EQFT0280
     1,KANHET,LANHET,PERCC,THIKFT                                       EQFT0290
     2,DANA(45),DANB(45)                                                EQFT0300
      COMMON/B67/DENFT(45),EK17,EK19,EK20,         EK16                 EQFT0310
     1         ,C(50),GXIA(50),K,WUJ(50)                                EQFT0320
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH                   EQFT0330
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANEQFT0340
     1ANB(45),AFJ1(50),UFT(45)                                          EQFT0350
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             EQFT0360
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  EQFT0370
     2,NCODEB(45),TZ                                                    EQFT0380
      COMMON/B12678/JTAPE,IPRINT                                        EQFT0390
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B                           EQFT0400
     1,AFA,AFB,PREDM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,COMLOS         EQFT0410
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,  EQFT0420
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,LANB(45),      EQFT0430
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,                     EQFT0440
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                  PREFT1,PREFT2,  EQFT0450
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,                   EQFT0460
     5FARFT2,ENTHAL,LCMF,LCANI,LCAN,LCFTE,LCFT,K7,K13,K12,              EQFT0470
     6AFSYPA,AFSYPB,AFSYIA,AFSYIB,LCPRT,LCPTA                           EQFT0480
     7,C2(45),           UANA(45),             ZMHA(2),GX1A,GX1B        EQFT0490
     8,DPH(50),WCD(50),WFFIZ(45),DPAFS,DPBFS,DPAES,DPBES                EQFT0500
     9,RC(50)                                                           EQFT0510
     1,A,B,D,E                                                          EQFT0520
     2,K30,K40,K50,K60                                                  EQFT0530
                                                                        EQFT0540
    2 FORMAT(6H EQUFT ,9E12.3/(6X,9E12.3))                              EQFT0550
    3 FORMAT(1H05F12.3)                                                 EQFT0560
    4 FORMAT(1H0I10,2F12.3)                                             EQFT0570
 3000 FORMAT(1X,//////19H ***  ERROR MESSAGE)                           EQFT0580
 4000 FORMAT(38H TEMPERATURE IN *EQUFT* LESS THAN ZERO)                 EQFT0590
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*.........*.........*.........*.........*.........*.........*.........*.........*

C     SET ITERATION LOOP COUNTER TO ZERO

      LCFTE=0
      K8=0
      K7=0
      D10=0.
      D7=0.0
C
C     SETTING OF FLAME TUBE EQUATION VARIABLES.
C
      AFT1=AFT(K)
      AFT2=AFT(K+1)
      PREFT1=PREFT(K)
      UFT1=UFT(K)
      UFT2=UFT1
      DENFT1=DENFT(K)
      TFT1=TFT(K)
      TFT2=TFT1
      AFFT1=AFFT(K)
      AFFTT1=AFFT1
      ENTHAL=1.0

C     UPDATE JET PARAMETERS FROM JETMIX

      EK160=EK16
      EK170=EK17
      EK190=EK19
      EK200=EK20
      IF(NSHCP.EQ.K)GO TO 1
      ZMJET(K)=A+ZMJET(K)
      ZMJUJ(K)=B+ZMJUJ(K)
      ZMH(K)=C+ZMH(K)
      ZAJM(K)=E+ZAJM(K)
    1 CONTINUE

C     CALCULATE UNBURNT-FUEL TO GAS RATIO

      FARL=FARL+FFIZ(K+1)/AFFT1
      IF(IPRINT.NE.1)GOTO8757
      WRITE(6,2)FARFT(K),ZAJM(K),ZMH(K),ZMJUJ(K),ZMJET(K),EK16,EK17
      WRITE(6,2)AFT1,PREFT1,UFT1,DENFT1,TFT1,AFFT1,EK19
 8757 CONTINUE
C
C     CALL SUBROUTINE JETMIX TO OBTAIN EK16,EK17,EK19,AND EK20
C
      IF(K30+K40+K50+K60.EQ.0)CALLJETMIX
C
C     SPECIFIC HEAT AT CONSTANT PRESSURE -FUNCTION OF FUEL-AIR RATIO
C
      F1=FARFT(K)
      ZZCP=(.2419+.103*F1)+(-.8181+22.6*F1)*1.E-5*TFT(K)+(17.91-29.6*F1)
     1*1.E-9*TFT(K)**2+(-2.743+.35*F1)*1.E-12*TFT(K)**3
C
C     DETERMINATION OF EQUATION CONSTANTS.
C
      EK15= PREFT1*GRAVC*(AFT2-AFT1)*0.5
      EK10=PREFT1*GRAVC*AFT1+AFFT1*UFT1+ZAJM(K)+EK160
      EK10=EK10-EK16+EK15
      EK14=(AFT2-AFT1)*0.5
```

```
*........*.........*.........*.........*.........*.........*.........*.........*
      EK11=CENFT1*UFT1*(AFT1-EK170)+EK190+ZMH(K)+(SAFTRA(K)*CFTA(K)+SAFTEQFT1200
     1RB(K)*CFTB(K))*(XCP(J)-XCP(K))                                    EQFT1210
      EK11=EK11-EK19                                                    EQFT1220
      AFFTT1=EK11+FARL*AFFT1                                            EQFT1230
C                                                                       EQFT1240
C     CALCULATE FUEL-AIR RATIO AT STATION (K+1)                         EQFT1250
C                                                                       EQFT1260
      FGR2=(FARFT(K)/(FARFT(K)+1.)+FARL)           *AFFT1/AFFTT1        EQFT1270
      FARFT2=FGR2/(1.-FGR2)                                             EQFT1280
      IF(FARFT2.GT.ZSTOC) GO TO 2001                                    EQFT1290
       FARR=0.                                                          EQFT1300
      GO TO 20                                                          EQFT1310
 2001 ZB=ZSTCC/(ZSTCC+1.)                                               EQFT1320
      FARR=AFFTT1*(FGR2-ZB)                                             EQFT1330
      AFFTT1=AFFTT1-FARR                                                EQFT1340
      FARFT2=ZSTCC                                                      EQFT1350
      FARL=FARL-FARR/AFFT1                                              EQFT1360
      IF(FARL.LE.0.) FARL=0.                                            EQFT1370
                                                                        EQFT1380
C     SET LOOP FOR ITERATION ON FLAME TUBE PARAMETERS                   EQFT1390
                                                                        EQFT1400
  20  DO 10 I=1,200                                                     EQFT1410
  205 CONTINUE                                                          EQFT1420
C                                                                       EQFT1430
C     CALL SUBROUTINE HEATAD TO OBTAIN HEAT RELEASE RATE                EQFT1440
C                                                                       EQFT1450
   51 CALL HEATAD                                                       EQFT1460
      FARFT1=FARFT(K)                                                   EQFT1470
  203 EK12=AFFT1*(((.2419+.103*F1)*TFT1+(-.8181+22.6*F1)*1.E-5*TFT1**2/2EQFT1480
     1.+(17.91-29.6*F1)*1.E-9*TFT1**3/3.+(-2.743+.35*F1)*1.E-12*TFT1**4/EQFT1490
     24.-102.42-70.15*F1)*GRAVC*GJOULE+UFT1**2/2.)+EK200-EK20+ZMJET(K)+HEQFT1500
     3RRATE*GJOULE*GRAVC+(QTRA(K)*(XCP(J)-XCP(K                         EQFT1510
     4))*CFTA(K)+QTRB(K)*(XCP(J)-XCP(K))*CFTB(K))*GRAVC*GJOULE          EQFT1520
      IF(K7)153,153,162                                                 EQFT1530
 153  EK13=PREFT1/(TFT1*CENFT1)*GRAVC                                   EQFT1540
  162 F2=FARFT2                                                         EQFT1550
      ENTHAL=(( .2419+.103*F2)*TFT2+(-.8181+22.6*F2)*1.E-5*TFT2**2/2.+(1EQFT1560
     17.91-29.6*F2)*1.E-9*TFT2**3/3.+(-2.742+.35*F2)*1.E-12*TFT2**4/4.-1EQFT1570
     202.42-70.15*F2)/ZZCP/(TFT2-459.4)                                 EQFT1580
                                                                        EQFT1590
C     DETERMINE FLAME TUBE TEMPERATURE                                  EQFT1600
                                                                        EQFT1610
  154 TFT2=459.4+(EK12/AFFTT1-UFT2**2/2.)/(ZZCP*ENTHAL*GRAVC*GJOULE)    EQFT1620
      IF(IPRINT.GE.1)WRITE(6,2)EK12,ENTHAL,TFT2,AFFT1,F1,TFT1,UFT1,     EQFT1630
     1EK200,EK20,ZMJET(K),HRRATE,QTRA(K),QTRB(K),F2,EK11,ZZCP,TZ        EQFT1640
                                                                        EQFT1650
C     IF TEMPERATURE IS NEGATIVE STOP ITERATION                         EQFT1660
                                                                        EQFT1670
      IF(TFT2.LE.0.0)GO TO 60                                           EQFT1680
      D6=D7                                                             EQFT1690
C                 ** INCLUDE CARDS EQFT1701 AND 1705 **                 EQFT1700
                                                                        EQFT1701
      IF(TFT2.GT.5000.)TFT2=5000.                                       EQFT1705
C     IS IT THE FIRST TIME THROUGH THE ITERATION CYCLE                  EQFT1710
                                                                        EQFT1720
      IF(K7.EQ.1)GO TO 11                                               EQFT1730
      K7=1                                                              EQFT1740
                                                                        EQFT1750
C     FORM NEW TEMPERATURE                                              EQFT1760
                                                                        EQFT1770
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+.........*.........*.........*.........*.........*.........*.........*.........*
      TFT2=.4*TFT2+.6*TFT1                                              ECFT1780
      D7=TFT2                                                           ECFT1790
      GC TO 10                                                          ECFT1800
   11 CONTINUE                                                          EQFT1810
      TFT2=.45*TFT2+.55*D6                                              ECFT1820
      D7=TFT2                                                           ECFT1830
                                                                        EQFT1840
C     TEST CHANGE IN TEMPERATURE AGAINST SPECIFIED LIMIT                ECFT1850
                                                                        ECFT1860
      IF(ABS(D7-D6)-FIENTH)155,155,10                                   ECFT1870
  155 X=EK13*TFT2*(AFT2-EK14)                                           ECFT1880
      Y=EK11**2/(AFT2-EK17)                                             ECFT1890
      IF(4.*X*Y.GE.EK10**2)GOTO1555                                     ECFT1900
      DENFT2=(EK10+SQRT(EK10**2-4.*X*Y))/(2.*X)                         EQFT1910
      GCTC1556                                                          EQFT1920
 1555 DENFT2=EK10/2./X                                                  EQFT1930
 1556 CCNTINUE                                                          EQFT1940
                                                                        ECFT1950
C     FLAME TUBE PRESSURE VELOCITY AND AIR MASS FLOW RATE               ECFT1960
                                                                        EQFT1970
      PREFT2=EK13*DENFT2*TFT2/GRAVC                                     ECFT1980
      UFT2=AFFTT1/(DENFT2*(AFT2-EK17))                                  ECFT1990
      AFFT2=AFFTT1                                                      ECFT2000
      D9=D10                                                            ECFT2010
      IF(K8.EQ.1)GO TO 12                                               EQFT2020
      K8=1                                                              ECFT2030
      D11=TFT2                                                          ECFT2040
      D10=UFT2                                                          ECFT2C50
      GC TC 10                                                          EQFT2C60
   12 CONTINUE                                                          ECFT2070
      D12=D11                                                           ECFT2080
      D10=UFT2                                                          ECFT2C90
      D11=TFT2                                                          EQFT2100
                                                                        ECFT2110
C     IS THE CHANGE IN VELOCITY LESS THAN ONE PERCENT OF PREVIOUS VELOCIECFT2120
                                                                        EQFT2130
      IF(ABS(D9-D10).LE.UFT2*FIPHI.AND.ABS(D11-D12).LE.FIENTH)GCTC156   ECFT2140
   10 IF(IPRINT.GE.1)WRITE(6,2)AFFTT1,AFFT1,FAR,FARL,AFR,HRRATE,FARFT2, ECFT2150
     1EK11,EK12,ENTHAL,TFT1,TFT2                                        ECFT2160
      GC TO 156                                                         EQFT2170
   60 WRITE(JTAPE,3000)                                                 ECFT2180
      WRITE(JTAPE,4000)                                                 ECFT2190
      TFT2=100.                                                         EQFT2200
                                                                        ECFT2210
C     STORE FLAME TUBE PARAMETERS                                       EQFT2220
                                                                        ECFT2230
  156 UFT(K+1)=UFT2                                                     ECFT2240
      PREFT(K+1)=PREFT2                                                 EQFT2250
      DENFT(K+1)=DENFT2                                                 ECFT2260
      TFT(K+1)=TFT2                                                     EQFT2270
      AFFT(K+1)=AFFT2                                                   ECFT2280
      FARFT(K+1)=FARFT2                                                 ECFT2290
C                                                                       ECFT2300
C     SET UNBURNT-FUEL TO GAS RATIO                                     EQFT2310
C                                                                       ECFT2320
      FARL=FARR/AFFTT1                                                  ECFT2330
      RETURN                                                            EQFT2340
      END                                                               EQFT2350

 YOUR CARD TCTAL IS ---           239
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 IBFTC HTAD    LIST
      SUBROUTINE HEATAD                                                 HTAD0010
                                                                        HTAD0020
                                                                        HTAD0030
                   S U B R O U T I N E   H E A T A D                    HTAD0040
                                                                        HTAD0050
          THIS SUBROUTINE CALCULATES THE HEAT PRODUCED BY               HTAD0060
          THE BURNING OF FUEL IN THE COMBUSTOR FLAME TUBE.              HTAD0070
                                                                        HTAD0080
          NO SUBROUTINE IS CALLED BY HEATAD                             HTAD0090
                                                                        HTAD0100
          ONE SUBROUTINE CALLS HEATAD                                   HTAD0110
               1. EQUFT                                                 HTAD0120
                                                                        HTAD0130
                                                                        HTAD0140
  THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 6   HTAD0150
      VIZ- B6, B16, B67, B68, B126, B167, B168, B678, B1678, B12678     HTAD0160
                                                                        HTAD0170
      COMMON/B16/CDS(20,15),DPHS(20,15),FLCV,IH,        NABX(45)        HTAD0180
     1,NSP(20),GXIS(20,15),K4,K6,FIT,FIPHI,FIPSI,FIA,FITAU,FID,FIENTH   HTAD0190
     2,SHAFST,                                FIFTPR,       LCMFL,LCANILHTAD0200
     3,LCANL,LCFTEL,LCFTL,LCPRTL,BETA,ASW,FFIZ(45),AHDOME,NSCOOP(20)    HTAD0210
     4,LCPTAL,PAFRZ,NHTU(50),AF23A(3),AF23B(3),XAF23A(3),XAF23B(3)      HTAD0220
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)     HTAD0230
     2,AFSYP,FARFT(45),DENANA(45),DENANB(45)                            HTAD0240
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)      HTAD0250
     4,TWA(45),TWB(45)                                                  HTAD0260
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          HTAD0270
     1,KANHET,LANHET,PERCO,THIKFT                                       HTAD0280
     2,DANA(45),DANB(45)                                                HTAD0290
      COMMON/B67/DENFT(45),EK17,EK19,EK20,        EK16                  HTAD0300
     1         ,C(50),GXIA(50),K,WUJ(50)                                HTAD0310
      COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XH(50),NH                   HTAD0320
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANHTAD0330
     1ANB(45),AFJ1(50),UFT(45)                                          HTAD0340
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             HTAD0350
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  HTAD0360
     2,NCODEB(45),TZ                                                    HTAD0370
      COMMON/B12678/JTAPE,IPRINT                                        HTAD0380
      COMMON/B126/AF2,TAN1A,TAN1B,PAN1A,PAN1B                           HTAD0390
     1,AFA,AFB,PREDM,STAGT,IBL,STPREF,PNTRA,PNTRB,DPHSNT,DOMLOS         HTAD0400
      COMMON/B6/PREAN1,PREAN2,DENAN1,DENAN2,TAN1,TAN2,AAN1,AAN2,AFAN1,  HTAD0410
     1AFAN2,UAN1,UAN2,ZAJM(45),ZMH(45),ZZCP,K1,K11,J,KSH,UANB(45),      HTAD0420
     2FARL,FAR,ZSTOC,AFFT1,AFFTT1,TFT1,TFT2,HRRATE,                     HTAD0430
     3ZMJUJ(45),ZMJET(45),CD,GXI,DPH1,                   PREFT1,PREFT2, HTAD0440
     4DENFT1,DENFT2,AFT1,AFT2,AFFT2,UFT1,UFT2,FARFT1,                   HTAD0450
     5FARFT2,ENTHAL,LCMF,LCANI,LCAN,LCFTE,LCFT,K7,K13,K12,              HTAD0460
     6AFSYPA,AFSYPB,AFSYIA,AFSYIB,LCPRT,LCPTA                           HTAD0470
     7,C2(45),           UANA(45),           ZMHA(2),GX1A,GX1B          HTAD0480
     8,DPH(50),WCD(50),WFFIZ(45),DPAFS,DPBFS,DPAES,DPBES                HTAD0490
     9,RC(50)                                                           HTAD0500
     1,A,B,D,E                                                          HTAD0510
     2,K30,K40,K50,K60                                                  HTAD0520
                                                                        HTAD0530
      CALCULATION OF FLAME TUBE HEAT ADDITION                           HTAD0540
                                                                        HTAD0550
                                                                        HTAD0560
      CALCULATE MASS OF FUEL BURNT BETWEEN CALCULATION POINTS K AND K+1 HTAD0570
                                                                        HTAD0580
      FARZ=FARL                                                         HTAD0590
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      IF(FARFT2.LE.ZSTOC) GO TO 200                                     HTAD0600
      FAL=FARFT2-ZSTOC                                                  HTAD0610
      FGL=FAL/(1.+FARFT2)                                               HTAD0620
      FARZ=FARL-FGL*AFFTT1/AFFT1                                        HTAD0630
      IF(FARZ.LE.0.) FARZ=0.                                            HTAD0640
  200 CONTINUE                                                          HTAD0650
      HRRATE=FLCV*FARZ*AFFT1+(3.0*1.E-26)*(TFT1**7.5*AFFT1/(1.+FARFT(K))HTAD0660
     1-TFT2**7.5*AFFTT1/(1.+FARFT2))                                    HTAD0670
      WFFIZ(K)=FARZ*AFFT1/(XCP(K+1)-XCP(K))                             HTAD0680
      RETURN                                                            HTAD0690
      END                                                               HTAD0700
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IBFTC JETM    LIST
                                                                       JETM0010
                                                                       JETM0020
     SUBROUTINE JETMIX                                                 JETM0030
                                                                       JETM0040
                                                                       JETM0050
                  S U B R O U T I N E   J E T M I X                    JETM0060
                                                                       JETM0070
     THIS SUBROUTINE CALCULATES RESIDUAL JET PARAMETERS                JETM0080
     THE METHOD OF CALCULATION IS GOVERNED BY THE VALUE OF THE         JETM0090
     VARIABLE - NEF                                                    JETM0100
               NEF=1  MASS LOSS                                        JETM0110
               NEF=2  EQUIVALENT ENTRAINMENT                           JETM0120
               NEF=3  PROFILE SUBSTITUTION                             JETM0130
               NEF=4  INSTANTANEOUS MIXING                             JETM0140
                                                                       JETM0150
                                                                       JETM0160
 THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 7   JETM0170
     VIZ- B17, B67, B167, B178, B678, B1678, B12678                    JETM0180
                                                                       JETM0190
     COMMON/BZERO/ A(430),EFCL(40),TJETA(40),UJCL(50),UJETA(40)        JETM0200
     COMMON/B17/ XHU(50),DXHU(50),EFC(2),    NEF,STEP,JKSN(50),NSH     JETM0210
     COMMON/B67/DENFT(45),EK17,EK19,EK20,         EK16                 JETM0220
    1         ,C(50),GXIA(50),K,WUJ(50)                                JETM0230
     COMMON/B167/GASC,GRAVC,GJOULE,IHJ(50),XM(50),NH                   JETM0240
     COMMON/B178/DFT(45)                                               JETM0250
     COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANJETM0260
    1ANB(45),AFJ1(50),UFT(45)                                          JETM0270
     COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             JETM0280
    1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  JETM0290
    2,NCODEB(45),TZ                                                    JETM0300
     COMMON/B12678/JTAPE ,IPRINT                                       JETM0310
     COMMON/B5867/XFSA,XFSB                                            JETM0320
                                                                       JETM0330
 DIMENSION STATEMENTS                                                  JETM0340
                                                                       JETM0350
     DIMENSION NDIS(50)                                                JETM0360
                                                                       JETM0370
 FORMAT STATEMENT                                                      JETM0380
                                                                       JETM0390
  1  FORMAT(1X//////18H *** ERROR MESSAGE)                             JETM0400
   2 FORMAT(7H JETMIX3I7, 9F10.3)                                      JETM0410
  10 FORMAT(1X   /120H      J   NDIS(J)      EK17       EK19      EK16JETM0420
    1      EK20      AJET     FLUXH     FLUXM      DENSJ        S      JETM0430
    2  UJ/2(5X,I5),10(E10.3)/ 40H        DJ   UJCL(J)     EFCLZ      ETJETM0440
    3AH/4(E10.3))                                                      JETM0450
  11 FORMAT(5X,I5,3(E10.3),5X,I5,4(E10.3),5X,I5)                       JETM0460
  12 FORMAT(5X,I5,2(E10.3),5X,I5,5(E10.3))                             JETM0470
  13 FORMAT(1X/  50H        IX         S         X   UJCL(J)    EFCLZ/JETM0480
    15X,I5,4(E10.3))                                                   JETM0490
  14 FORMAT(1X/  30H        IX          Y         S/5X,I5,2(E10.3))    JETM0500
  21 FORMAT(1X / 90H        J2      ETA       AJET  EFCL(J2)       J3 JETM0510
    1     TJET     FLUXU     FLUXH      FLUXM,10H       K2)            JETM0520
  22 FORMAT(1X/  90H        J2      AJET  EFCL(J2)        J3 TJETA(J2) JETM0530
    1    FLUXU     FLUXH     FLUXM       ETA)                          JETM0540
  23 FORMAT(26H SUBROUTINE JETMIX ENTERED)                             JETM0550
  24 FORMAT(25H SUBROUTINE JETMIX EXITED)                              JETM0560
  91 FORMAT(41H WHEN SUBROUTINE JETMIX WAS CALLED, K WASI3,20H, LESS THJETM0570
    1AN NSHCP+1.)                                                      JETM0580
  92 FORMAT(21H PECULIAR JET PROFILE/11H IN JET NO.I3,10H,EFCL(40)=F6.3JETM0590
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*.........*.........*.........*.........*.........*.........*.........*.........*
     1)                                                                 JETM0600
   98 FCRMAT(52H NEGATIVE QUANTITY IN EXPRESSION FOR JET PENETRATION6F11JETM0610
     1.3)                                                               JETM0620
   99 FCRMAT(26H THE JET FROM HOLE ROW NO.I4,36H IS SPREADING TOO FAR. IJETM0630
     1NCREASE EFC.)                                                     JETM0640
C                                                                       JETM0650
C     TO OBTAIN PRINTCUT OF INTERMEDIATE RESULTS IN THIS SUBROUTINE     JETM0660
C     SET IPRINT = 2                                                    JETM0670
C                                                                       JETM0680
      IPRINT=IPRINT-1                                                   JETM0690
      IF(IPRINT.EC.1) WRITE(6,23)                                       JETM0700
      DO 601 J=1,NH                                                     JETM071C
  601 AFJ1(J)=AFJ1(J)/FLOAT(NHH(J))                                     JETM0720
      EK16=0.                                                           JETM0730
      EK17=0.0                                                          JETM0740
      EK19=0.0                                                          JETM0750
      EK20=0.0                                                          JETM0760
      IF(NEF.EC.4) GO TO 900                                            JETM0770
      JS=KJSN(NSHCP,1)                                                  JETM0780
      IF(K-NSHCP  )191,124,150                                          JETM0790
C                                                                       JETM0800
C SET BACK NDIS(J), THE INDICATOR THAT SHOWS WHICH JETS HAVE DISAPPEAREDJETM0810
C                                                                       JETM0820
  124 NHCLAS=0                                                          JETM0830
      DO149J=JS,NH                                                      JETM0840
  149 NDIS(J)=0                                                         JETM0850
  150 K1=K                                                              JETM0860
      NHC= MAXO(KJSN(K,1),KJSN(K,2),KJSN(K,3),KJSN(K,4),KJSN(K,5),KJSN(KJETM0870
     1,6),NHCLAS)                                                       JETM0880
      NHCLAS=NHC                                                        JETM0890
      XHDUM=XCP(K+1)                                                    JETM0900
      DO1031J=JS,NHC                                                    JETM0910
      IF(NDIS(J).EQ.1.OR.NAB(J).LT.1) GO TO 1031                        JETM0920
      K=JKSN(J)                                                         JETM0930
      IF(NAB(J).EC.1)GOTO109                                            JETM0940
      TAN=TANANB(K)                                                     JETM0950
      DENSJ=PREANB(K)/(GASC*TAN)                                        JETM0960
      GOTO115                                                           JETM0970
  109 TAN=TANANA(K)                                                     JETM0980
      DENSJ=PREANA(K)/(GASC*TAN)                                        JETM0990
  115 VISJ=(3.057E-3+8.607E-5*TAN-2.279E-8*TAN*TAN+2.908E-12*TAN**3)    JETM1000
     1/3600.                                                            JETM1010
      CCNS =PREFT(K1)      *GRAVC*GJOULE/GASC                           JETM1020
      CONT=PREFT(K1)/GASC                                               JETM1030
      FLUXH=0.0                                                         JETM1040
      FLUXM=0.0                                                         JETM1050
      AJET=0.                                                           JETM1060
      FLUXU=0.                                                          JETM1070
      S=0.0                                                             JETM1080
      XLAST=0.                                                          JETM1090
      YLAST=0.0                                                         JETM1100
      IND=0                                                             JETM1110
      INE=0                                                             JETM1120
C                                                                       JETM1130
C SEPARATE WALL AND PENETRATION JETS                                    JETM1140
C                                                                       JETM1150
      IF(DXHU(J).EQ.0.0)GOTO100                                         JETM1160
C                                                                       JETM1170
C --- PENETRATION JETS                                                  JETM1180
C                                                                       JETM1190
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*........*.........*.........*.........*.........*.........*.........*.........*
      DJ=SQRT(C(J)*HAU(J)*4./PI)                                        JETM1200
      DJA=SQRT(C(J))*2.*DXHU(J)                                         JETM1210
      UJ=AFJ1(J)/DENSJ/C(J)/HAU(J)                                      JETM1220
      WUJ(J)=UJ                                                         JETM1230
      EFD=EFC(1)                                                        JETM1240
C                                                                       JETM1250
C     IS THIS A SECONDARY HOLE                                          JETM1260
C                                                                       JETM1270
      IF(JKSN(J).NE.NSHCP) GO TO 1100                                   JETM1280
      IF(NAB(J).EQ.1) SPL = XFSA                                        JETM1290
      IF(NAB(J).EQ.2) SPL =XFSB                                         JETM1300
      SQSPL = SQRT(SPL)                                                 JETM1310
      DJ = DJ*SQSPL                                                     JETM1320
      DJA=DJA*SQSPL                                                     JETM1330
      AFJ1(J) = AFJ1(J) * SPL                                           JETM1340
 1100 CONTINUE                                                          JETM1350
C                                                                       JETM1360
C --- FIND DISTANCE ALONG JET CENTRE LINE                               JETM1370
C                                                                       JETM1380
      DO102IX=1,100                                                     JETM1390
      IF(INE.EQ.1) GO TO 105                                            JETM1400
      AI=IX                                                             JETM1410
      X=AI*STEP                                                         JETM1420
      IF(X-XHDUM   +XH(J)) 103,206,106                                  JETM1430
  106 X=XHDUM   -XH(J)                                                  JETM1440
  206 INE=1                                                             JETM1450
  103 IF(IND.EQ.1)GOTO127                                               JETM1460
  128 IF(DENSJ.LE.0..OR.DENFT(K).LE.0..OR.UJ.LE.0..OR.UFT(K).LE.0..OR.X.JETM1470
     1LE.0..OR.DJA.LE.0.)GOTO198                                        JETM1480
      Y=0.87*DJA*(DENSJ/DENFT(K))**.47*(UJ/UFT(K))**.85*(X/DJA)**.3     JETM1490
     12*SIN(GXIA(J))                                                    JETM1500
      IF(Y.LT.0.37*DFT(K))GOTO101                                       JETM1510
      Y=0.37*DFT(K)                                                     JETM1520
      INC=1                                                             JETM1530
  101 S=S+SQRT((X-XLAST)**2+(Y-YLAST)**2)                               JETM1540
      YLAST=Y                                                           JETM1550
      XLAST=X                                                           JETM1560
      GOTO102                                                           JETM1570
  127 S=S+X-XLAST                                                       JETM1580
      XLAST = X                                                         JETM1590
  102 CONTINUE                                                          JETM1600
  105 COSETA=1./SQRT(1.+((Y-YLAST)/(X-XLAST))**2)                       JETM1610
      K=K1                                                              JETM1620
      S=S+(2.93-0.279*UJ/UFT(K))*DJ                                     JETM1630
      IF(S.LT..001)S=.001                                               JETM1640
C                                                                       JETM1650
C --- JET CENTRE-LINE VELOCITY                                          JETM1660
C                                                                       JETM1670
      IF(S/DJ.GT.3.45)GOTO107                                           JETM1680
      UJCL(J)=UJ                                                        JETM1690
      GO TO 129                                                         JETM1700
  107 IF(S/DJ.GT.5.2)GOTO110                                            JETM1710
      UJCL(J)=UFT(K)+(1.-.229*(S/DJ-3.45 ))*(UJ-UFT(K))                 JETM1720
      GO TO 129                                                         JETM1730
  110 IF(S/DJ.GT.100.)UJCL(J)=UFT(K)                                    JETM1740
      IF(S/DJ.LE.100.)                                                  JETM1750
     1UJCL(J)=UFT(K)+3.6/EXP(.344*S/DJ)*(UJ-UFT(K))                     JETM1760
  129 IF(NEF.EQ.1)GOTO111                                               JETM1770
C                                                                       JETM1780
C --- PROFILE-SUBSTITUTION OR EQUIVALENT ENTRAINMENT METHOD             JETM1790
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*.........*.........*.........*.........*.........*.........*.........*.........*
C                                                                       JETM1800
  113 ETAH=AMAX1(.215*S,DJ)                                             JETM1810
      IF (NEF.EQ.1) GO TO 143                                           JETM1820
      ETA=0.0                                                           JETM1830
C                                                                       JETM1840
C --- WORK ACROSS JET PROFILE, SUMMING HEAT OR MASS FLUX                JETM1850
C                                                                       JETM1860
      ETAINC=.1*ETAH                                                    JETM1870
      IF(IPRINT.EQ.1)                                                   JETM1880
     1WRITE(6,22)                                                       JETM1890
      DO114J2=1,40                                                      JETM1900
      ETA=ETA+ETAINC                                                    JETM1910
      IF(ETA.GT.ETAH)GOTO116                                            JETM1920
      UJETA(J2)=UFT(K)+(0.5*(COS(0.5*PI*ETA/ETAH))+0.5)*(UJCL(J)-UFT(K))JETM1930
      GOTO117                                                           JETM1940
  116 UJETA(J2)=UFT(K)+1.74*EXP(-1.25*ETA/ETAH)*(UJCL(J)-UFT(K))        JETM1950
  117 EFCL(J2)=(UJETA(J2)-UFT(K))/(UJ-UFT(K))                           JETM1960
      J3=.5+FLOAT(J2)/1.4                                               JETM1970
      IF(NEF.EQ.2) GO TO 1119                                           JETM1980
      IF(4.8/6.5*EFCL(J3).GE.EFD) GO TO 1119                            JETM1990
      IF(J2.GT.1) GO TO 143                                             JETM2000
      GO TO 1430                                                        JETM2010
 1119 TJETA(J2)=TFT(K)+(TAN-TFT(K))*EFCL(J3) *4.8/6.5                   JETM2020
      FLUXM=FLUXM+CONT /TJETA(J2)*UJETA(J2)*.12*1.8*ETA**.8*ETAINC      JETM2030
      IF(NEF.EQ.2) GO TO 114                                            JETM2040
      AJET=.12*ETA**1.8/COSETA                                          JETM2050
      FLUXU=FLUXU+CONT /TJETA(J2)*UJETA(J2)**2*.12*1.8*ETA**.8*ETAINC   JETM2060
     1 *COSETA                                                          JETM2070
      ZZCP1=.2419-.8181E-5*TJETA(J2)/2.+17.91E-9*TJETA(J2)**2/3.        JETM2080
     1 -2.742E-12*TJETA(J2)**3/4.-102.42/TJETA(J2)                      JETM2090
      CONST=CONS*ZZCP1                                                  JETM2100
      FLUXH=FLUXH+(CONST+CONT/TJETA(J2)*0.5*UJETA(J2)**2)*UJETA(J2)*    JETM2110
     1.12*1.8*ETA**.8*ETAINC                                            JETM2120
  114 IF(IPRINT.EQ.1)                                                   JETM2130
     1WRITE(6,12) J2, AJET,EFCL(J2),J3,TJETA(J2),FLUXU   ,FLUXH,FLUXM,  JETM2140
     1ETA                                                               JETM2150
      GO TO 143                                                         JETM2160
C                                                                       JETM2170
C --- WALL JETS                                                         JETM2180
C                                                                       JETM2190
  100 DJ=HAU(J)*C(J)                                                    JETM2200
      COSETA = 1.0                                                      JETM2210
      K2=K                                                              JETM2220
      K22=K                                                             JETM2230
      K=K1                                                              JETM2240
      EFD=EFC(2)                                                        JETM2250
      IF(NAB(J).EQ.2)GOTO132                                            JETM2260
      CFT=CFTA(K)                                                       JETM2270
      GOTO133                                                           JETM2280
  132 CFT=CFTB(K)                                                       JETM2290
  133 UJ=AFJ1(J)/(DENSJ*DJ*CFT)                                         JETM2300
      WUJ(J)=UJ                                                         JETM2310
      UJCL(J)=UJ                                                        JETM2320
C                                                                       JETM2330
C --- FIND DISTANCE PARAMETER ALONG WALL                                JETM2340
C                                                                       JETM2350
      DO122IX=1,100                                                     JETM2360
      AI=IX                                                             JETM2370
      XL=XCP(K2+1)-XCP(K22)                                             JETM2380
      X=AI*STEP                                                         JETM2390
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.........*.........*.........*.........*.........*.........*.........*.........*
      IF(X.LT.(XHDUM   -XH(J)))GOTO135                                  JETM2400
      X=XHDUM   -XH(J)                                                  JETM2410
      INE=1                                                             JETM2420
  135 IF(X.GE.XL) K2=K2+1                                               JETM2430
      S=S+ABS(1.-UFT(K2)/UJCL(J))*(X-XLAST)                             JETM2440
      IF(S.LE.0.)UJCL(J)=UJ                                             JETM2450
      IF(ABS(1.-UFT(K2)/UJ      ).LT..012) GO TO 3135                   JETM2460
      IF(S.GT.0.)                                                       JETM2470
     1UJCL(J)=UFT(K2)+0.0287*DJ*(UJ-UFT(K2))*DENSJ/(VISJ*(S*12.)        JETM2480
     2**((1.06/ABS(1.-UFT(K2)/UJ))-.5))                                 JETM2490
      IF(((UJCL(J).GE.UJ).AND.(UJCL(J).LE.UFT(K2))) .OR.                JETM2500
     1   ((UJCL(J).LE.UJ).AND.(UJCL(J).GE.UFT(K2)))) GO TO 148          JETM2510
      UJCL(J)=UJ                                                        JETM2520
      GO TO 148                                                         JETM2530
 3135 UJCL(J)=UFT(K2)                                                   JETM2540
  148 IF(INE.EQ.1)GOTO118                                               JETM2550
  134 XLAST=X                                                           JETM2560
  122 IF(IPRINT.EQ.1)                                                   JETM2570
     1WRITE(6,13) IX,S,X,UJCL(J),EFCLZ                                  JETM2580
C                                                                       JETM2590
C --- WORK ACROSS JET PROFILE, SUMMING HEAT OR MASS FLUX                JETM2600
C                                                                       JETM2610
  118 IF(NEF.EQ.1)GOTO143                                               JETM2620
      EFCLZ=(UJCL(J)-UFT(K))/(UJ-UFT(K))                                JETM2630
      IF(NEF.EQ.3.AND.4.8/6.5*EFCLZ.LE.EFD) GO TO 1430                  JETM2640
      ETAH=AMAX1(.065*S,DJ)                                             JETM2650
      DELTA1=0.0109*S                                                   JETM2660
      ETA=-0.6                                                          JETM2670
      TJCL=TFT(K)+(TAN-TFT(K))*EFCLZ  *4.8/6.5                          JETM2680
      ZZCP1=.2419-.8181E-5*TJCL      /2.+17.91E-9*TJCL      **2/3.      JETM2690
     1 -2.742E-12*TJCL      **3/4.-102.42/TJCL                          JETM2700
      CONST=CONS*ZZCP1                                                  JETM2710
      FLUXH=(CONST+CONT/TJCL*0.5*UJCL(J)**2*0.95   )*UJCL(J)            JETM2720
     1*CFT*DELTA1*0.95                                                  JETM2730
      FLUXM=CONT /TJCL*UJCL(J)*CFT*DELTA1                               JETM2740
      FLUXU=CONT /TJCL*UJCL(J)**2*CFT*DELTA1*0.95                       JETM2750
      AJET=DELTA1*CFT                                                   JETM2760
      IF(IPRINT.EQ.1)                                                   JETM2770
     1WRITE(6,21)                                                       JETM2780
      DO112J2=1,40                                                      JETM2790
      ETA=ETA+.12                                                       JETM2800
      UJETA(J2)=UFT(K )+(UJCL(J)-UFT(K))*EXP(-0.693*ETA*ETA)            JETM2810
      EFCL(J2)=(UJETA(J2)-UFT(K))/(UJ-UFT(K))                           JETM2820
      J3=.5+FLOAT(J2)/1.4                                               JETM2830
      TJET =TFT(K)+(TAN-TFT(K))*EFCL(J3)*4.8/6.5                        JETM2840
      ZZCP1=.2419-.8181E-5*TJET      /2.+17.91E-9*TJET      **2/3.      JETM2850
     1 -2.742E-12*TJET      **3/4.-102.42/TJET                          JETM2860
      CONST=CONS*ZZCP1                                                  JETM2870
      FLUXH=FLUXH+(CONST+CONT/TJET*0.5*UJETA(J2)**2)*.1*ETAH*CFT*UJETA(JJETM2880
     1 2)                                                               JETM2890
      FLUXM=FLUXM+CONT/TJET*.1*ETAH*CFT*UJETA(J2)                       JETM2900
      FLUXU=CONT/TJET*.1*ETAH*CFT*UJETA(J2)**2 + FLUXU                  JETM2910
      AJET=AJET+.1*ETAH*CFT                                             JETM2920
      GO TO (143,112,140),NEF                                           JETM2930
  140 IF(4.8/6.5*EFCL(J3).LE.EFD) GO TO 143                             JETM2940
  112 IF(IPRINT.EQ.1)                                                   JETM2950
     1WRITE(6,11) J2,ETA,     AJET,EFCL(J2),J3,TJET,FLUXU   ,FLUXH,FLUXMJETM2960
     1,K2                                                               JETM2970
C                                                                       JETM2980
C --- AREA OF IDEALIZED JET                                             JETM2990
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*.........*.........*.........*.........*.........*.........*.........*.........*
C                                                                       JETM3000
  143 IF(IPRINT.GE.0)WRITE(6,2)K1,J,NDIS(J),UJ,UFT(K),UJCL(J),EFCL(J3), JETM3010
     1FLUXM,AFJ1(J)                                                     JETM3020
      IF(NEF.EQ.1.AND.DXHU(J).EQ.0.0) GO TO 2111                        JETM3030
      GO TO (111,125,2130),NEF                                          JETM3040
  111 FLUXM=AFJ1(J)*(1.-EFD*S/(2.*DXHU(J)))                             JETM3050
      GO TO 126                                                         JETM3060
 2111 FLUXM = AFJ1(J)*(1.-EFD*S/HAU(J))                                 JETM3070
      GO TO 126                                                         JETM3080
  125 FLUXM=AMIN1(AFJ1(J)*(1.+EFD)-EFD*FLUXM),FLUXM)                    JETM3090
  126 IF(FLUXM.GT.0.) GO TO 2126                                        JETM3100
      AJET=0.                                                           JETM3110
      FLUXU=0.                                                          JETM3120
      FLUXH=0.                                                          JETM3130
 1131 FLUXM=0.                                                          JETM3140
 1430 NDIS(J) = 1                                                       JETM3150
      GO TO 1030                                                        JETM3160
 2126 AJET=FLUXM/UJ/DENSJ     /COSETA                                   JETM3170
      FLUXU=FLUXM*UJ  *COSETA                                           JETM3180
      ZZCPT=.2419*TAN-.8181E-5*TAN**2/2.+17.91E-9*TAN**3/3.-2.742E-12*  JETM3190
     1 TAN**4/4.-102.42                                                 JETM3200
      FLUXH=FLUXM*(     ZZCPT     *GRAVC*GJOULE+0.5*UJ**2)              JETM3210
 2130 IF(DXHU(J).EQ.0.0) GO TO 2131                                     JETM3220
  130 BB=4.*ETAH*DFT(K1)/2.                                             JETM3230
      IF(AJET.GT.BB) AJET=BB                                            JETM3240
      CC=FLOAT(NHH(J))                                                  JETM3250
      GO TO 2199                                                        JETM3260
 2131 CC=1.                                                             JETM3270
 2199 IF(AJET.LE.0.25*AFT(K1)/CC) GO TO 131                             JETM3280
  199 IF(IPRINT.LT.0.AND.LCMFL.NE.1)GOTO1030                            JETM3290
      WRITE(JTAPE,1)                                                    JETM3300
      WRITE(JTAPE,99) J                                                 JETM3310
      GO TO 1030                                                        JETM3320
  198 IF(IPRINT.LT.0.AND.LCMFL.NE.1)GOTO1030                            JETM3330
      WRITE(JTAPE,1)                                                    JETM3340
      WRITE(JTAPE,98) DENSJ,DENFT(K),UJ,UFT(K),X,DJA                    JETM3350
      GOTO1030                                                          JETM3360
  131 EK16=EK16+FLUXU*CC                                                JETM3370
      EK17=EK17+AJET*CC                                                 JETM3380
      EK19=EK19+FLUXM*CC                                                JETM3390
      EK20=EK20+FLUXH*CC                                                JETM3400
C                                                                       JETM3410
C     IF THIS IS A SECONDARY HOLE, RESET AFJ1(J)                        JETM3420
C                                                                       JETM3430
 1030 IF(JKSN(J).EQ.NSHCP) AFJ1(J)=AFJ1(J)/SPL                          JETM3440
 1031 IF(IPRINT.GE.0)                                                   JETM3450
     1WRITE(6,10) J,NDIS(J),EK17,EK19,EK16,EK20,AJET,FLUXH,FLUXM,DENSJ, JETM3460
     1S,UJ,DJ,UJCL(J),EFCLZ,ETAH                                        JETM3470
      K=K1                                                              JETM3480
      GO TO 900                                                         JETM3490
  191 WRITE(JTAPE,1)                                                    JETM3500
      WRITE(JTAPE,91)K                                                  JETM3510
  900 DO 901 J=1,NH                                                     JETM3520
  901 AFJ1(J)=AFJ1(J)*FLOAT(NHH(J))                                     JETM3530
      IF(IPRINT.EQ.1) WRITE(6,24)                                       JETM3540
      IPRINT=IPRINT+1                                                   JETM3550
      RETURN                                                            JETM3560
      END                                                               JETM3570

  YOUR CARD TOTAL IS ---          359
```

```
$IBFTC HT1     LIST

      SUBROUTINE HEAT1
C
C                    S U B R O U T I N E   H E A T 1
C
C         THIS SUBROUTINE CARRIES OUT A NONITERATIVE HEAT TRANSFER
C         CALCULATION.
C
C         THIS SUBROUTINE CALLS FOR FOUR SUBROUTINES
C                1. EEFT
C                2. PROP
C                3. COOL
C                4. TWSOLN
C
C         THIS SUBROUTINE IS USED BY THE MAIN PROGRAM CLARE
C
C     THE ROUTE THROUGH THIS PART OF THE PROGRAM IS CONTROLLED BY
C     THE INDEX NHT1
C
C                 NHT1 = 1 FOR 1-DIMENSIONAL RADIATION, UNCOOLED WALL
C                 NHT1 = 2 FOR 1-DIMENSIONAL RADIATION, COOLED WALL
C                 NHT1 = 3 FOR 2-DIMENSIONAL RADIATION, UNCOOLED WALL
C                 NHT1 = 4 FOR 2-DIMENSIONAL RADIATION, COOLED WALL
C
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 8
C     VIZ- B8, B18, B68, B168, B178, B678, B1678, B12678
C
C     COMMON STATEMENTS

      COMMON/B8/D1A(45),D2A(45),D3A(45),D4A(45),D1B(45),D2B(45),D3B(45)
     1,D4B(45),FMOCO2(45),FMOH2O(45),C1A(45),C1B(45),R1A(45),R1B(45),R2
     2A(45),R2B(45),R3A(45),R3B(45),TNUAAN(45),TNUBAN(45),TNUFT(45),
     3TWADA(45),TWADB(45),
     4EMFT(45),FILMFA(45),FILMFB(45),PRAAN(45),PRBAN(45),PRFT(45),REFT(4
     55),FINT(45),TCFA(45),TCFB(45),UFTA(45),UFTB(45),UJ1A(45),UJ1B(45),
     6AFJA(45),AFJB(45),YCFA(45),YCFB(45)
      COMMON/B18/ABSW,EMW,EMC,NLUM,                          NHT1,NHT2
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,         TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,      NUMAX1,NUMAX2
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     1          ,           AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B178/DFT(45)
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT

C     DATA STATEMENT

      DATA YA,YB/2*0./

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```
C     FORMAT STATEMENTS                                                 HT1 0600
C                                                                       HT1 0610
    1 FORMAT(6H0HEAT110F11.3/(6X10F11.3))                               HT1 0620
    2 FORMAT(1H010I5)                                                   HT1 0630
    3 FORMAT(6H0HEAT110F11.6/(6X10F11.6))                               HT1 0640
C                                                                       HT1 0650
C     QUANTITIES REQUIRED FOR FILM-COOLING CALCULATION                  HT1 0660
C                                                                       HT1 0670
      DO201K=1,NLAST                                                    HT1 0680
      TWADA(K)=0.                                                       HT1 0690
      TWADB(K)=0.                                                       HT1 0700
      R3A(K)=0.                                                         HT1 0710
      R3B(K)=0.                                                         HT1 0720
      FILMFA(K)=0.                                                      HT1 0730
      FILMFB(K)=0.                                                      HT1 0740
      IF(K.NE.1)GO TO 2004                                              HT1 0750
      X1FCA(K) = 100.                                                   HT1 0760
      X1FCB(K) = 100.                                                   HT1 0770
      GO TO 2005                                                        HT1 0780
 2004 XCPDIF = XCP(K) - XCP(K-1)                                        HT1 0790
      IF(NCODEA(K-1).EQ.1) X1FCA(K) = XCPDIF                            HT1 0800
      IF(NCODEA(K-1).NE.1) X1FCA(K) = XCPDIF + X1FCA(K-1)               HT1 0810
      IF(NCODEB(K-1).EQ.1) X1FCB(K) = XCPDIF                            HT1 0820
      IF(NCODEB(K-1).NE.1) X1FCB(K) = XCPDIF + X1FCB(K-1)               HT1 0830
 2005 AFJA(K)=FJA                                                       HT1 0840
      AFJB(K)=FJB                                                       HT1 0850
      TCFA(K)=TA                                                        HT1 0860
      TCFB(K)=TB                                                        HT1 0870
      UFTA(K)=UA                                                        HT1 0880
      UFTB(K)=UB                                                        HT1 0890
      UJ1A(K)=UJA                                                       HT1 0900
      UJ1B(K)=UJB                                                       HT1 0910
      YCFA(K)=YA                                                        HT1 0920
      YCFB(K)=YB                                                        HT1 0930
      IF(NCODEA(K).NE.1) GO TO 202                                      HT1 0940
      DO2001 L = 1,6                                                    HT1 0950
      J = KJSN(K,L)                                                     HT1 0960
      IF(NAB(J).NE.1) GO TO 2001                                        HT1 0970
      YA=HAU(J)                                                         HT1 0980
      FJA=AFJ1(J)                                                       HT1 0990
      UA=UFT(K)                                                         HT1 1000
      UJA=FJA/(YA*CFTA(K)*DENANA(K))                                    HT1 1010
      UAN=AFANA(K)/DENANA(K)/AANA(K)                                    HT1 1020
      TA=TANANA(K) +UAN**2/(2.*32.2*53.35)                              HT1 1030
      GO TO 202                                                         HT1 1040
 2001 CONTINUE                                                          HT1 1050
  202 IF(NCODEB(K).NE.1)GOTO201                                         HT1 1060
      DO2002 L = 1,6                                                    HT1 1070
      J = KJSN(K,L)                                                     HT1 1080
      IF(NAB(J).NE.2) GO TO 2002                                        HT1 1090
      YB=HAU(J)                                                         HT1 1100
      FJB=AFJ1(J)                                                       HT1 1110
      UB=UFT(K)                                                         HT1 1120
      UJB=FJB/(YB*CFTB(K)*DENANB(K))                                    HT1 1130
      UAN=AFANB(K)/DENANB(K)/AANB(K)                                    HT1 1140
      TB=TANANB(K)      +UAN**2/(2.*32.2*53.35)                         HT1 1150
      GO TO 201                                                         HT1 1160
 2002 CONTINUE                                                          HT1 1170
  201 CONTINUE                                                          HT1 1180
      IF(IPRINT.NE.1)GOTO8765                                           HT1 1190
      WRITE(6,1)(TFT(K),TANANA(K),TANANB(K),TCFA(K),TCFB(K),UFTA(K),    HT1 1200
```

```
     1UFTB(K),UJ1A(K),UJ1B(K),DFT(K),K=1,NLAST)                          HT1 1210
      WRITE(6,3)(AFT(K),DANA(K),AANA(K),AANB(K),DANB(K),CCA(K),CCB(K),   HT1 1220
     1X1FCA(K),X1FCB(K),YCFA(K),K=1,NLAST)                               HT1 1230
      WRITE(6,1)(YCFB(K),AFJA(K),AFJB(K),PREFT(K),PREANA(K),PREANB(K),   HT1 1240
     1FARFT(K),TCASA(K),TCASB(K),XCP(K),K=1,NLAST)                       HT1 1250
      WRITE(6,1)AFPRZ,AFSYP,ABSW,EMC,PI,CONDFT,THIKFT,XFILMZ,PERCO,      HT1 1260
     1FHCR,(AFANA(K),K=1,NLAST),(AFANB(K),K=1,NLAST),(AFFT(K),K=1,NLAST)HT1 1270
 8765 CONTINUE                                                           HT1 1280
C                                                                        HT1 1290
      KANHET=KANHET+1                                                    HT1 1300
      K=1                                                                HT1 1310
    5 CALL EEFT(K)                                                       HT1 1320
      FINT(K)=4.8E-13*EMFT(K)*TFT(K)**4                                  HT1 1330
C                                                                        HT1 1340
C******CALCULATE THE INTERNAL DIRECT RADIATION COEFFICIENT, A             HT1 1350
C                                                                        HT1 1360
      A=2.4E-13*(1.+ABSW)*EMFT(K)*TFT(K)**1.5                            HT1 1370
C                                                                        HT1 1380
C******CALCULATE THE EXTERNAL RADIATION COEFFICIENT, B                    HT1 1390
C                                                                        HT1 1400
      B=4.8E-13*(EMW*EMC)/(EMC+EMW*(1.-EMC))                             HT1 1410
      CALL PROP(K,CNDAV,FMCO2,FMH2O)                                     HT1 1420
C                                                                        HT1 1430
C******CALCULATE THE INTERNAL CONVECTION COEFFICIENT, CFT                 HT1 1440
C                                                                        HT1 1450
      CFT=TNUFT(K)*CNDAV/DFT(K)  /3600.                                  HT1 1460
C                                                                        HT1 1470
C******CALCULATE GAS PROPERTIES IN THE ANNULUS                            HT1 1480
C******SET CALCULATION TO INNER ANNULUS                                   HT1 1490
C                                                                        HT1 1500
      INXAN=1                                                            HT1 1510
      AAN =AANA(K)                                                       HT1 1520
      AFAN=AFANA(K)                                                      HT1 1530
      DAN=DANA(K)                                                        HT1 1540
      TAN=TANANA(K)                                                      HT1 1550
      TCAS=TCASA(K)                                                      HT1 1560
   10 CNDAN=-0.2853E-3+3.268E-5*TAN-0.825E-8*TAN**2+1.239E-12*TAN**3     HT1 1570
      VISAN=3.057E-3+8.607E-5*TAN-2.279E-8*TAN**2+2.908E-12*TAN**3       HT1 1580
      CPAN =0.2419-0.8181E-5*TAN+1.791E-8*TAN**2-0.2743E-11*TAN**3       HT1 1590
      REAN=3600.*DAN*AFAN/VISAN/AAN                                      HT1 1600
      IF(REAN.LT.1.)REAN=1.                                              HT1 1610
      PRAN=CPAN*VISAN/CNDAN                                              HT1 1620
      IF(PRAN.LT..01)PRAN=.01                                            HT1 1630
      TNUAN=.023*REAN**0.8*PRAN**0.4                                     HT1 1640
C                                                                        HT1 1650
C******CALCULATE CONVECTION COEFFICIENT IN ANNULUS                        HT1 1660
C                                                                        HT1 1670
      CAN = TNUAN*CNDAN/DAN/3600.                                        HT1 1680
      GO TO (50,40,20,20),NHT1                                           HT1 1690
C                                                                        HT1 1700
C******INCLUDE TOTAL RADIATION FROM FLAME                                 HT1 1710
C                                                                        HT1 1720
   20 GO TO(30,30,31,32,33),NLUM                                         HT1 1730
C     NLUM=1,2 NON LUMINOUS                                              HT1 1740
   30 DUMLUM=1.                                                          HT1 1750
      GO TO 35                                                           HT1 1760
C                                                                        HT1 1770
C     NLUM=3     LEVEBVE CORRELATION FOR LUMINOSITY                      HT1 1780
C                                                                        HT1 1790
   31 DUMLUM      =7.53*(1./FHCR-5.5)**0.85                              HT1 1800
      GO TO 35                                                           HT1 1810
```

```
C     NLUM=4     NREC 1964                                              HT1 1820
   32 DUMLUM=EXP((1.-4.4*FHCR)/(2.3*FHCR))                              HT1 1830
      GO TO 35                                                          HT1 1840
C     NLUM=5      NREC 1966                                             HT1 1850
   33 DUMLUM=((1.-FHCR*5.)/(FHCR*0.16))**0.74                           HT1 1860
   35 S1=0.                                                             HT1 1870
      S2=0.                                                             HT1 1880
      DO 1400 KK=1,NLAST                                                HT1 1890
C                                                                       HT1 1900
      DUMR3=(XCP(K)-XCP(KK))                                            HT1 1910
      IF(INXAN.EQ.1) GO TO 1000                                         HT1 1920
      DUMR1=((CCA(K)-CCA(KK))/PI+DANA(K)-DANA(KK)+DFT(K))/2.            HT1 1930
      DUMR2=DUMR1-DFT(KK)/2.                                            HT1 1940
      GO TO 1020                                                        HT1 1950
 1000 DUMR1=((CCA(KK)-CCA(K))/PI+DANA(KK)-DANA(K)+DFT(KK))/2.           HT1 1960
      DUMR2=DUMR1-DFT(KK)/2.                                            HT1 1970
 1020 TRANSM=0.                                                         HT1 1980
      DO37I=1,20                                                        HT1 1990
   37 TRANSM=TRANSM+14.82/20./(14.82+(FMCO2+FMH2O)*PREFT(KK)*SQRT       HT1 2000
     1(DUMR3**2+(DUMR1-(FLOAT(I)/20.-.025)*(DUMR1-DUMR2))**2))          HT1 2010
C                                                                       HT1 2020
C     VIEW FACTOR PER UNIT LENGTH OF RECEIVING SECTION                  HT1 2030
C                                                                       HT1 2040
      IF(DUMR2.LE.0.0001)GO TO 1040                                     HT1 2050
      VU=0.25/DUMR1*(1.-DUMR3/SQRT(DUMR3**2+DUMR1**2))                  HT1 2060
     1+0.25/DUMR2*(1.-DUMR3/SQRT(DUMR3**2+DUMR2**2))                    HT1 2070
      GOTO1060                                                          HT1 2080
 1040 VU=0.25/DUMR1*(1.-DUMR3/SQRT(DUMR3**2+DUMR1**2))                  HT1 2090
C                                                                       HT1 2100
C      EVALULATE WIDTH OF RADIATING SECTION                             HT1 2110
C                                                                       HT1 2120
 1060 IF(KK.EQ.1) GO TO 1080                                            HT1 2130
      IF(KK.EQ.NLAST) GO TO 1100                                        HT1 2140
      WIDTH=(XCP(KK+1)-XCP(KK-1))/2.                                    HT1 2150
      GO TO 1200                                                        HT1 2160
 1080 WIDTH=(XCP(KK+1)-XCP(KK))                                         HT1 2170
      GO TO 1200                                                        HT1 2180
 1100 WIDTH=(XCP(KK)-XCP(KK-1))                                         HT1 2190
C                                                                       HT1 2200
C      EVALULATE FLAME CROSS-SECTIONAL AREA                             HT1 2210
C                                                                       HT1 2220
 1200 FLAR=PI*((CCA(KK)/2./PI+DANA(KK)/2.+                              HT1 2230
     1 DFT(KK)/2.)**2-(CCA(KK)/2./PI+DANA(KK)/2.)**2)                   HT1 2240
      S1=S1+4.*4.8E-13*PREFT(KK)*(FMCO2+FMH2O)                          HT1 2250
     1 *3.6/TFT(KK)*WIDTH*FLAR*VU*TRANSM*DUMLUM                         HT1 2260
     2 *(1.0+ABSW)/2.0*TFT(KK)**4                                       HT1 2270
      S2=S2+4.*4.8E-13*PREFT(KK)*(FMCO2+FMH2O)                          HT1 2280
     1 *3.6/TFT(KK)*WIDTH*FLAR*VU*TRANSM*(1.+ABSW)/2.*DUMLUM            HT1 2290
 1400 IF(IPRINT.EQ.1) WRITE(6,1) TRANSM,VU,FLAR,S1,S2,DUMR1,DUMR2,DUMR3 HT1 2300
C                                                                       HT1 2310
C     FORM EQUIVALENT FLAME TEMPERATURE                                 HT1 2320
C                                                                       HT1 2330
      TSTAR1=S1/S2                                                      HT1 2340
 1700 IF(INXAN.EQ.1)GO TO 1800                                          HT1 2350
C                                                                       HT1 2360
C     FORM TOTAL RADIATION COMPONENT, AA                                HT1 2370
C                                                                       HT1 2380
      AA=S2/((CCB(K)-DANB(K)*PI))                                       HT1 2390
      GO TO 1900                                                        HT1 2400
 1800 AA=S2/((CCA(K)+DANA(K)*PI))                                       HT1 2410
 1900 IF(NHT1.EQ.3)GO TO 50                                             HT1 2420
```

```
   40 CALL CCOL(K,INXAN,CNDAV,TRNSCO,CFTTRN)
C
C***** FORM COEFFICIENTS IN HEAT BALANCE EQUATION  ************
C
      IF(INXAN.EQ.2)GO TO 45
      TWAD=TWADA(K)
      GO TO 50
   45 TWAD=TWADB(K)
   50 D1=B
      D2=A
      D3=CFT+CAN
      D4=B*TCAS**4+A*TFT(K)**2.5+CFT*TFT(K)+CAN*TAN
      GO TO (110,60,80,90),NHT1
   60 IF(NCOOL.EQ.2)GO TO 70
      D4=D4+CFT*(TWAD-TFT(K))
      GO TO 110
   70 D3=D3+CFTTRN+TRNSCO-CFT
      D4=D4+(CFTTRN-CFT)*TFT(K)+TRNSCO*TAN
      GO TO 110
   80 D1=D1+AA
      D2=0.
      D4=D4+AA*TSTAR1 -A*TFT(K)**2.5
      GO TO 110
   90 IF(NCOOL.EQ.2)GO TO 100
      D1=D1+AA
      D2= 0.
      D4=D4+AA*TSTAR1+CFT*(TWAD-TFT(K))   -A*TFT(K)**2.5
      GO TO 110
  100 D1=D1+AA
      D2=0.
      D3=D3+CFTTRN+TRNSCO-CFT
      D4=D4+(CFTTRN-CFT)*TFT(K)+TRNSCO*TAN+AA*TSTAR1 -A*TFT(K)**2.5
  110 IF(IPRINT.EQ.1)WRITE(6,2)NCOOL,K,NHT1,INXAN
      IF(D4.LE.0.)GOTO290
      CALL TWSOLN(K,D1,D2,D3,D4,DTW1)
      IF(INXAN.EQ.2)GO TO 200
C
C     STORE REQUIRED VARIABLES
C
      TWA(K)=DTW1
      C2A(K)=CAN*(TWA(K)-TAN)
      IF(KANHET.EQ.1.AND.LANHET.EQ.1)GO TO 190
      GO TO (120,120,130,130),NHT1
  120 R1A(K)=A*(TFT(K)**2.5-TWA(K)**2.5)
      GO TO 140
  130 R1A(K)=AA*(TSTAR1-TWA(K)**4)
  140 GO TO (170,150,170,150),NHT1
  150 IF(NCOOL.EQ.2)GO TO 160
      C1A(K)=CFT*(TWADA(K)-TWA(K))
      GO TO 180
  160 C1A(K)=CFTTRN*(TFT(K)-TWA(K))
      OTRA(K)=TRNSCO*(TWA(K)-TAN)
      GO TO 180
  170 C1A(K)=CFT*(TFT(K)-TWA(K))
  180 REAAN(K)=REAN
      PRAAN(K)=PRAN
      TNUAAN(K)=TNUAN
      R2A(K)=B*(TWA(K)**4-TCAS**4)
      TANANA(K)=TAN
      D1A(K)=D1
      D2A(K)=D2
```

```
      D3A(K)=D3                                                         HT1 3040
      D4A(K)=D4                                                         HT1 3050
C                                                                       HT1 3060
C     SET CALCULATION TO OUTER ANNULUS                                  HT1 3070
C                                                                       HT1 3080
  190 INXAN=2                                                           HT1 3090
      AAN =AANB(K)                                                      HT1 3100
      AFAN=AFANB(K)                                                     HT1 3110
      DAN=DANB(K)                                                       HT1 3120
      TAN=TANANB(K)                                                     HT1 3130
      TCAS=TCASB(K)                                                     HT1 3140
      GO TO 10                                                          HT1 3150
C                                                                       HT1 3160
C     STORE REQUIRED VARIABLES                                          HT1 3170
C                                                                       HT1 3180
  200 TWB(K)=DTW1                                                       HT1 3190
      C2B(K)=CAN*(TWB(K)-TAN)                                           HT1 3200
      IF(KANHET.EQ.1.AND.LANHET.EQ.1)GO TO 280                          HT1 3210
      GO TO(210,210,220,220),NHT1                                       HT1 3220
  210 R1B(K)=A*(TFT(K)**2.5-TWB(K)**2.5)                                HT1 3230
      GO TO 230                                                         HT1 3240
  220 R1B(K)=AA*(TSTAR1-TWB(K)**4)                                      HT1 3250
  230 GO TO(260,240,260,240),NHT1                                       HT1 3260
  240 IF(NCOOL.EQ.2)GO TO 250                                           HT1 3270
      C1B(K)=CFT*(TWADB(K)-TWB(K))                                      HT1 3280
      GO TO 270                                                         HT1 3290
  250 C1B(K)=CFTTRN*(TFT(K)-       TWB(K))                              HT1 3300
      QTRB(K)=TRNSCO*(TWB(K)-TAN)                                       HT1 3310
      GO TO 270                                                         HT1 3320
  260 C1B(K)=CFT*(TFT(K)-TWB(K))                                        HT1 3330
  270 REBAN(K)=REAN                                                     HT1 3340
      PRBAN(K)=PRAN                                                     HT1 3350
      TNUBAN(K)=TNUAN                                                   HT1 3360
      R2B(K)=B*(TWB(K)**4-TCAS**4)                                      HT1 3370
      TANANB(K)=TAN                                                     HT1 3380
      D1B(K)=D1                                                         HT1 3390
      D2B(K)=D2                                                         HT1 3400
      D3B(K)=D3                                                         HT1 3410
      D4B(K)=D4                                                         HT1 3420
      FMOCO2(K)=FMCO2                                                   HT1 3430
      FMOH2O(K)=FMH2O                                                   HT1 3440
  280 IF(K.EQ.NLAST)GO TO 290                                           HT1 3450
      K=K+1                                                             HT1 3460
      GO TO 5                                                           HT1 3470
  290 RETURN                                                            HT1 3480
      END                                                               HT1 3490
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$IBFTC HT2     LIST
                                                                        HT2 0010
      SUBROUTINE HEAT2                                                  HT2 0020
C                                                                       HT2 0030
C                    S U B R O U T I N E   H E A T 2                    HT2 0040
C                                                                       HT2 0050
C        THIS SUBROUTINE CARRIES OUT AN ITERATIVE HEAT-TRANSFER CALC.   HT2 0060
C                                                                       HT2 0070
C        THIS SUBROUTINE CALLS FOR ONE SUBROUTINE                       HT2 0080
C              1. TWSOLN                                                HT2 0090
C                                                                       HT2 0100
C        THIS SUBROUTINE IS USED BY THE MAIN PROGRAM CLARE              HT2 0110
C                                                                       HT2 0120
C     THE ROUTE THROUGH THIS PART OF THE PROGRAM IS CONTROLLED BY       HT2 0130
C     THE INDEX NHT2                                                    HT2 0140
C                                                                       HT2 0150
C                    NHT2 = 2 FOR LONGITUDINAL WALL CONDUCTION          HT2 0160
C                    NHT2 = 3 FOR RADIATION INTERCHANGE BETWEEN WALLS   HT2 0170
C                    NHT2 = 4 FOR LONGITUDINAL CONDUCTION AND RADIATION HT2 0180
C                        INTERCHANGE                                    HT2 0190
C                    NHT2 = 1 IF NONE OF THESE OPTIONS ARE REQUIRED     HT2 0200
C                                                                       HT2 0210
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 8   HT2 0220
C     VIZ- B8, B18, B68, B168, B178, B678, B1678, B12678                HT2 0230
C                                                                       HT2 0240
      COMMON/BZERO/TWAX(45),TWBX(45),REST(510)                          HT2 0250
      COMMON/B8/D1A(45),D2A(45),D3A(45),D4A(45),D1B(45),D2B(45),D3B(45) HT2 0260
     1,D4B(45),FMOCO2(45).FMOH2O(45),C1A(45),C1B(45),R1A(45),R1B(45),R2 HT2 0270
     2A(45),R2B(45),R3A(45),R3B(45),TNUAAN(45),TNUBAN(45),TNUFT(45),    HT2 0280
     3TWADA(45),TWADB(45),                                              HT2 0290
     4EMFT(45),FILMFA(45),FILMFB(45),PRAAN(45),PRBAN(45),PRFT(45),REFT(4HT2 0300
     55),FINT(45),TCFA(45),TCFB(45),UFTA(45),UFTB(45),UJ1A(45),UJ1B(45),HT2 0310
     6AFJA(45),AFJB(45),YCFA(45),YCFB(45)                               HT2 0320
      COMMON/B18/ABSW,EMW,EMC,NLUM,                          NHT1,NHT2  HT2 0330
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLTHT2 0340
     2W2,XFILMZ,        TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORMHT2 0350
     3,NCOOL,      NUMAX1,NUMAX2                                        HT2 0360
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)     HT2 0370
     1          ,          AFSYP,FARFT(45),DENANA(45),DENANB(45)        HT2 0380
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)      HT2 0390
     4,TWA(45),TWB(45)                                                  HT2 0400
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST          HT2 0410
     1,KANHET,LANHET,PERCO,THIKFT                                       HT2 0420
     2,DANA(45),DANB(45)                                                HT2 0430
      COMMON/B178/DFT(45)                                               HT2 0440
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TANHT2 0450
     1ANB(45),AFJ1(50),UFT(45)                                          HT2 0460
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI                             HT2 0470
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)  HT2 0480
     2,NCODEB(45),TZ                                                    HT2 0490
      COMMON/B12678/JTAPE ,IPRINT                                       HT2 0500
C                                                                       HT2 0510
      DIMENSION NAME(2)                                                 HT2 0520
C                                                                       HT2 0530
      DATA(NAME(I),I=1,2)/12H INNER OUTER/                              HT2 0540
C                                                                       HT2 0550
    1 FORMAT(6H AFTERI4,30H TRIALS, ERROR IS GREATER THAN,F9.2,6H DEG R)HT2 0560
    2 FORMAT(2I5,5X,4E12.4)                                             HT2 0570
   39 FORMAT(/////51HODIMENSIONLESS GROUPS ASSOCIATED WITH HEAT TRANSFERHT2 0580
     1/1X50(1H-)/6HOAXIAL16X15HREYNOLDS NUMBER15X14HPRANDTL NUMBER12X14HHT2 0590
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     2NUSSELT NUMBER/9H POSITION/5H FROM16X6HANNULI11X5HFLAME1X2(9X16HAN
     3NULI      FLAME)/11H COMPRESSOR27X4HTUBE2X 2(20X5HTUBE    )/10H DISC
     4HARGE6X5HINNER 6X5HOUTER16X2(14H  INNER  OUTER11X)/7H INCHES//(1X
     5F8.3,3X3E11.3,3X3F7.3,4X3F7.2))
    4 FORMAT(/////20H0HEAT TRANSFER RATES/1X19(1H-)/6H0AXIAL12X2(20H  HE
     1AT TRANSFER RATE12X),9HRADIATION6X16HHEAT TRANSFERRED/9H POSITION1
     21X18HFROM FLAME TO WALL14X19HFROM WALL TO ANNULI10X11HINTERCHANGE5
     3X16HTO TRANSPIRATION/5H FROM11X2(21H    BTU PER SQ FT SEC11X),13HF
     4ROM OPPOSITE4X15HAIR IN THE WALL/11H COMPRESSOR69X12HWALL BTU PER5
     5X15HBTU PER SEC PER/10H DISCHARGE2(7X23HRADIATION    CONVECTION2X)
     6,8X9HSQ FT SEC5X18HSQ FT WALL SURFACE/7H INCHES/14XA6,1XA6,2XA6,1X
     7A6,4XA6,1XA6,2XA6,1XA6,5XA6,1XA6,6XA6,1XA6//(1XF8.3,1X2(F10.3,F7.3
     8,F8.3,F7.3),2(F11.3,F7.3)))
   41 FORMAT(/////25H0HEAT TRANSFER PARAMETERS/1X24(1H-)/6H0AXIAL8X18HEM
     1ISSIVITY   FLAME12X12HFILM-COOLING17X17HWALL TEMPERATURES/36H POSI
     2TION     OF FLAME      INTENSITY8X13HEFFECTIVENESS22X5HDEG F/5H FRO
     3M22X7HBTU PER/11H COMPRESSOR16X9HSQ FT SEC33X9HADIABATIC9X6HACTUAL
     4/10H DISCHARGE/7H INCHES32X24HINNER WALL  OUTER WALL  2(17H    INN
     5ER   OUTER)//(1XF8.3,F12.3,F13.3,2F12.3,5X2(F9.1,F8.1)))
C
      NUM=1
   20 K=1
C
C     SET LARGEST ERROR SO FAR TO ZERO
C
      BIGDIF=0.
C
C     SET CALCULATION TO INNER ANNULUS
C
   30 INXAN=1
   40 IF(K.EQ.1)GO TO 300
C
C******CALCULATE LONGITUDINAL CONDUCTION EFFECT
C
      IF(K.EQ.NLAST)GO TO 400
      GO TO (450,50,90,50),NHT2
   50 IF(INXAN.EQ.2)GO TO 70
      DELTW1=TWA(K-1)-TWA(K)
      DELTW2=TWA(K)-TWA(K+1)
      GO TO 80
   70 DELTW1=TWB(K-1)-TWB(K)
      DELTW2=TWB(K)-TWB(K+1)
   80 DELX1=XCP(K)-XCP(K-1)
      DELX2=XCP(K+1)-XCP(K)
      DELK=2.*CONDFT*THIKFT*(DELTW1/DELX1/(DELX1+DELX2)-DELTW2/DELX2/
     1(DELX1+DELX2))    /3600.
      IF(NHT2.EQ.2)GO TO 130
C
C******CALCULATE TOTAL RADIATION INTERCHANGE EFFECT
C
   90 S1=0
      S2=0
      NN=NLAST-1
      DO 120 KK=2,NN
      X1=(XCP(KK+1)-XCP(KK-1))/2.
      IF(INXAN.EQ.2)GO TO 100
      DUMR4=(CCA(KK)/PI+DANA(KK)+DFT(KK))/2.
      DUMR5=(CCA(K)/PI+DANA(K))/2.
      X3=TWB(KK)**4
      GO TO 110
  100 DUMR4=(CCA(KK)/PI+DANA(KK))/2.
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```
      DUMR5=(CCA(K)/PI+DANA(K)+DFT(K))/2.
      X3=TWA(KK)**4
  110 DUMR6=DUMR4-DUMR5
      X4=(DUMR6**2+(XCP(K)-XCP(KK))**2)**1.5
      X2=14.82/(14.82+(FMOCO2(K)+FMOH2O(K))*SQRT(DUMR6**2+(XCP(K)-XCP
     1(KK))**2)*PREFT(K))
      S1=S1+X1*X2*X3*DUMR4/X4/DUMR5
      S2=S2+X1*X2*DUMR4/X4/DUMR5
  120 CONTINUE
C
C     FORM CORRECTED OPPOSITE WALL TEMPERATURE
C
      TSTAR2=S1/S2
C
C******CALCULATE TOTAL RADIATION COEFFICIENT FROM OPPOSITE WALL,AAA
C
      AAA=2.4E-13*EMW**2*DFT(K)**2*S2
      IF(INXAN.EQ.2)GO TO 125
      DELR=AAA*(TSTAR2-TWA(K)**4)
      GO TO 130
  125 DELR=AAA*(TSTAR2-TWB(K)**4)
  130 IF(NHT2.EQ.1)GO TO 450
C
C     MODIFY COEFFICIENTS IN HEAT BALANCE EQUATION
C
      IF(INXAN.EQ.2)GO TO 170
      D1=D1A(K)
      D2=D2A(K)
      D3=D3A(K)
      GO TO(450,140,150,160),NHT2
  140 IF(ABS(DELK).GT.(0.05*D4A(K)))GO TO 145
      D4=D4A(K)+DELK
      GO TO 200
  145 D4=D4A(K)+DELK*0.05*D4A(K)/ABS(DELK)
      GO TO 200
  150 IF(ABS(DELR).GT.(0.05*D4A(K)))GO TO 155
      D4=D4A(K)+DELR
      GO TO 200
  155 D4=D4A(K)+DELR*0.05*D4A(K)/ABS(DELR)
      GO TO 200
  160 IF(ABS(DELK+DELR).GT.(0.05*D4A(K)))GO TO 165
      D4=D4A(K)+DELK+DELR
      GO TO 200
  165 D4=D4A(K)+(DELR+DELK)*0.05*D4A(K)/ABS(DELR+DELK)
      GO TO 200
  170 D1=D1B(K)
      D2=D2B(K)
      D3=D3B(K)
      GO TO(450,171,180,190),NHT2
  171 IF(ABS(DELK).GT.(0.05*D4B(K)))GO TO 175
      D4=D4B(K)+DELK
      GO TO 200
  175 D4=D4B(K)+DELK*0.05*D4B(K)/ABS(DELK)
      GO TO 200
  180 IF(ABS(DELR).GT.(0.05*D4B(K)))GO TO 185
      D4=D4B(K)+DELR
      GO TO 200
  185 D4=D4B(K)+DELR*0.05*D4B(K)/ABS(DELR)
      GO TO 200
  190 IF(ABS(DELK+DELR).GT.(0.05*D4B(K)))GO TO 195
      D4=D4B(K)+DELK+DELR
```

```
      GO TO 200
  195 D4=D4B(K)+(DELR+DELK)*0.05*D4B(K)/ABS(DELR+DELK)
  200 IF(D4.LE.0.)GOTO490
      CALL TWSOLN(K,D1,D2,D3,D4,DTW1)
      IF(INXAN.EQ.2)GO TO 230
      TWAX(K)=(TWA(K)+DTW1)/2.
      R3A(K)=AAA*(TSTAR2-TWAX(K)**4)
      INXAN=2
      GO TO 40
  230 TWBX(K)=(TWB(K)+DTW1)/2.
      R3B(K)=AAA*(TSTAR2-TWBX(K)**4)
  300 K=K+1
      GO TO 30
C
C     CALAULATE FIRST AND LAST CALCULATION POINT TEMPERATURES BY LINEAR
C     EXTRAPOLATION
C
  400 TWAX(1)=(TWAX(2)-TWAX(3))*(XCP(2)-XCP(1))/(XCP(3)-XCP(2))+TWAX(2)
      TWBX(1)=(TWBX(2)-TWBX(3))*(XCP(2)-XCP(1))/(XCP(3)-XCP(2))+TWBX(2)
      TWAX(NLAST)=(TWAX(NLAST-1)-TWAX(NLAST-2))*(XCP(NLAST)-XCP(NLAST-1)
     1)/(XCP(NLAST-1)-XCP(NLAST-2))+TWAX(NLAST-1)
      TWBX(NLAST)=(TWBX(NLAST-1)-TWBX(NLAST-2))*(XCP(NLAST)-XCP(NLAST-1)
     1)/(XCP(NLAST-1)-XCP(NLAST-2))+TWBX(NLAST-1)
      DO 430 NN=1,NLAST
C
C     COMPARE EACH ERROR WITH THE LARGEST ERROR AND STORE THE LARGEST
C
      DIFF=ABS(TWA(NN)-TWAX(NN))
      IF(DIFF.LE.BIGDIF)GO TO 410
      BIGDIF=DIFF
  410 DIFF=ABS(TWB(NN)-TWBX(NN))
      IF(DIFF.LE.BIGDIF)GO TO 420
      BIGDIF=DIFF
C
C     SUBSTITUTE PREVIOUS TEMPERATURE DISTRIBUTION BY CURRENT TEMPERATUR
C     DISTRIBUTION
C
  420 TWA(NN)=TWAX(NN)
      TWB(NN)=TWBX(NN)
  430 CONTINUE
C
C     COMPARE LARGEST ERROR WITH TOLERANCE
C
      IF(BIGDIF.LE.TOLTW2)GO TO 450
C
C     CHECK THAT LOOP COUNTER HAS NOT BEEN EXCEEDED
C
      IF(NUM.LT.NUMAX2)GO TO 440
      WRITE(6,1)NUMAX2,TOLTW2
      GO TO 450
  440 NUM=NUM+1
      GO TO 20
  450 DO 460 KK=1,NLAST
      XCP(KK)=XCP(KK)*12.
      IF(TWADA(KK).NE.0.)TWADA(KK)=TWADA(KK)-TZ
      IF(TWADB(KK).NE.0.)TWADB(KK)=TWADB(KK)-TZ
      TWA(KK)=TWA(KK)-TZ
  460 TWB(KK)=TWB(KK)-TZ
C
C     WRITE OUT ALL REQUIRED OUTPUT
C
```

```
      WRITE(JTAPE,39)(XCP(K),REAAN(K),REBAN(K),REFT(K),PRAAN(K),PRBAN(K)HT2 2430
     1,PRFT(K),TNUAAN(K),TNUBAN(K),TNUFT(K),K=1,NLAST)                  HT2 2440
      WRITE(JTAPE,4)((NAME(I),I=1,2),J=1,6),(XCP(K),R1A(K),R1B(K),C1A(K HT2 2450
     1),C1B(K),R2A(K),R2B(K),C2A(K),C2B(K),R3A(K),R3B(K),QTRA(K),QTRB(K)HT2 2460
     2,K=1,NLAST)                                                       HT2 2470
      WRITE(JTAPE,41)(XCP(K),EMFT(K),FINT(K),FILMFA(K),FILMFB(K),TWADA(KHT2 2480
     1),TWADB(K),TWA(K),TWB(K),K=1,NLAST)                               HT2 2490
      DO 480 KK=1,NLAST                                                 HT2 2500
      XCP(KK)=XCP(KK)/12.                                               HT2 2510
      TWA(KK)=TWA(KK)+TZ                                                HT2 2520
  480 TWB(KK)=TWB(KK)+TZ                                                HT2 2530
  490 RETURN                                                            HT2 2540
      END                                                               HT2 2550
```

```
$IBFTC TWAL
      SUBROUTINE TWSOLN(K,D1,D2,D3,D4,DTW1)
C
C                   S U B R O U T I N E   T W S O L N
C
    THIS SUBROUTINE USES NEWTONS METHOD TO SOLVE THE HEAT BALANCE EQUATI
         D1 * TW**4   +   D2 * TW**2.5   +   D3 * TW   =   D4

         THIS SUBROUTINE IS CALLED FOR BY TWO SUBROUTINES
              1. HEAT1
              2. HEAT2

    IS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 8
      VIZ- B8, B18, B68, B168, B178, B678, B1678, B12678

      COMMON/B8/D1A(45),D2A(45),D3A(45),D4A(45),D1B(45),D2B(45),D3B(45)
     1,D4B(45),FMOCO2(45),FMOH2O(45),C1A(45),C1B(45),R1A(45),R1B(45),R2
     2A(45),R2B(45),R3A(45),R3B(45),TNUAAN(45),TNUBAN(45),TNUFT(45),
     3TWADA(45),TWADB(45),
     4EMFT(45),FILMFA(45),FILMFB(45),PRAAN(45),PRBAN(45),PRFT(45),REFT(4
     55),FINT(45),TCFA(45),TCFB(45),UFTA(45),UFTB(45),UJ1A(45),UJ1B(45),
     6AFJA(45),AFJB(45),YCFA(45),YCFB(45)
      COMMON/B18/ABSW,EMW,EMC,NLUM,                           NHT1,NHT2
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,        TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,       NUMAX1,NUMAX2
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     1          ,          AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B178/DFT(45)
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT

    1 FORMAT(6H AFTERI4,30H TRIALS, ERROR IS GREATER THAN,F9.2,6H DEG R)
    2 FORMAT(38H CHECK INPUT DATA TO SUBROUTINE TWSOLN)

    *** CONVERT THE COEFFICIENTS TO A MORE MANAGABLE SIZE **************

      DEE1=D1*10.**12
      DEE2=D2*3.11*10.**7
      DEE3=D3*10.**3

    *** MAKE FIRST GUESSES AT THE SOLUTION AND CHOOSE THE ONE WHICH
        GIVES THE SMALLEST POSITIVE ERROR *******************************

      DTW1=(D4/DEE1)**0.25
      DUMER1=DEE1*DTW1**4+DEE2*DTW1**2.5+DEE3*DTW1-D4
      DTW2=(D4/DEE2)**0.4
      DUMER2=DEE1*DTW2**4+DEE2*DTW2**2.5+DEE3*DTW2-D4
      DTW3=D4/DEE3
      DUMER3=DEE1*DTW3**4+DEE2*DTW3**2.5+DEE3*DTW3-D4
```

```
      DTW4=TFT(K)/1000.                                                 TWAL0060
      DUMER4=DEE1*DTW4**4+DEE2*DTW4**2.5+DEE3*DTW4-D4                   TWAL0061
      IF(DTW1.LE.DTW2.AND.DUMER1.GE.0.)GO TO 10                         TWAL0062
      DTW1=DTW2                                                         TWAL0063
   10 IF(DTW1.LE.DTW3.AND.DUMER2.GE.0.)GO TO 20                         TWAL0064
      DTW1=DTW3                                                         TWAL0065
   20 IF(DTW1.LE.DTW4.AND.DUMER3.GE.0.)GO TO 30                         TWAL0066
      DTW1=DTW4                                                         TWAL0067
      IF(DUMER4.GE.0.)GO TO 30                                          TWAL0068
      WRITE(6,2)                                                        TWAL0069
   30 NUM=1                                                             TWAL0070
                                                                        TWAL0071
C****** CALCULATE A NEW VALUE USING NEWTONS METHOD                      TWAL0072
                                                                        TWAL0073
   40 DTW1=DTW1-(DEE1*DTW1**4+DEE2*DTW1**2.5+DEE3*DTW1-D4)/(4.*DEE1*DTW1TWAL0074
     1**3+2.5*DEE2*DTW1**1.5+DEE3)                                      TWAL0075
      DUMER1=DEE1*DTW1**4+DEE2*DTW1**2.5+DEE3*DTW1-D4                   TWAL0076
      IF(D4*DEE2.LT.0.)DTW2=0.                                          TWAL0077
      IF(D4*DEE2.GT.0.)DTW2=(D4/DEE2)**.4                               TWAL0078
      IF(DEE2*(DTW1-TOLTW1/1000.).GE.0.)                                TWAL0079
     1DUMER2=DEE1*(DTW1-TOLTW1/1000.)**4+DEE2*(DTW1-TOLTW1/1000.)**2.5+ TWAL0080
     1DEE3*(DTW1-TOLTW1/1000.)-D4                                       TWAL0081
      DUMER3=DEE1*(DTW1+TOLTW1/1000.)**4+DEE2*(DTW1+TOLTW1/1000.)**2.5+ TWAL0082
     1DEE3*(DTW1+TOLTW1/1000.)-D4                                       TWAL0083
      IF((DUMER1.GE.0..AND.DUMER2.LE.0.).OR.(DUMER1.LE.0..AND.DUMER3.GE.TWAL0084
     10.))GO TO 50                                                      TWAL0085
      NUM=NUM+1                                                         TWAL0086
      IF(NUM.LE.NUMAX1)GO TO 40                                         TWAL0087
      WRITE(JTAPE,1)NUMAX1,TOLTW1                                       TWAL0088
   50 DTW1=DTW1*1000.                                                   TWAL0089
      RETURN                                                            TWAL0090
      END                                                               TWAL0091
```

```
$IBFTC EEF     LIST
      SUBROUTINE EEFT(K)
C
C                 S U B R O U T I N E   E E F T
C
C         THIS SUBROUTINE EVALUATES THE FLAME EMMISIVITY FROM ANY ONE
C         OF FIVE CORRELATIONS, OR FROM TABULATED DATA.
C
C         SUBROUTINE EEFT IS CALLED FOR BY ONE SUBROUTINE
C               1. HEAT1
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 8
C      VIZ- B8, B18, B68, B168, B178, B678, B1678, B12678

      COMMON/B8/D1A(45),D2A(45),D3A(45),D4A(45),D1B(45),D2B(45),D3B(45)
     1,D4B(45),FMOCO2(45),FMOH2O(45),C1A(45),C1B(45),R1A(45),R1B(45),R2
     2A(45),R2B(45),R3A(45),R3B(45),TNUAAN(45),TNUBAN(45),TNUFT(45),
     3TWADA(45),TWADB(45),
     4EMFT(45),FILMFA(45),FILMFB(45),PRAAN(45),PRBAN(45),PRFT(45),REFT(4
     55),FINT(45),TCFA(45),TCFB(45),UFTA(45),UFTB(45),UJ1A(45),UJ1B(45),
     6AFJA(45),AFJB(45),YCFA(45),YCFB(45)
      COMMON/B18/ABSW,EMW,EMC,NLUM,                           NHT1,NHT2
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,        TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,       NUMAX1,NUMAX2
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     1          ,           AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B178/DFT(45)
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT

    2 FORMAT(5H EEFT,10X,5(E12.5,2X),I5)
      IF(IPRINT.EQ.1)
     1WRITE(6    ,2) TFT(K),FARFT(K),PREFT(K),FHCR,DFT(K),NLUM
      IF(FARFT(K).LE.0.)FARFT(K)=1.E-4
      IF(NLUM.EQ.6)GO TO 70
      DUMCOR=-(10.**4*( .9*DFT(K)*FARFT(K))**0.5*TFT(K)**(-1.5))
      GO TO(10,20,30,50,60,70),NLUM

C        NLUM=1    NON-LUMINOUS CORRELATION FOR DISTILLATE FUELS

   10 EMFT(K)=1.-EXP(0.00184*PREFT(K)*DUMCOR)
      RETURN

C        NLUM=2    NON-LUMINOUS CORRELATION FOR RESIDUAL FUELS

   20 EMFT(K)=1.-EXP( 0.01530 *PREFT(K)**0.75*DUMCOR)
      RETURN

C        NLUM=3    LEFEBVRE CORRELATION FOR LUMINOUS FLAMES
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```
30 DUMLUM=7.53*(1./FHCR-5.5)**0.85                                     EEFT0600
40 EMFT(K)=1.-EXP(0.00184*DUMLUM*PREFT(K)*DUMCOR)                       EEFT0610
   RETURN                                                               EEFT0620
                                                                        EEFT0630
     NLUM=4    NREC 1964 CORRELATION FOR LUMINOUS FLAMES                EEFT0640
                                                                        EEFT0650
50 DUMLUM=EXP((1.-4.4*FHCR)/(2.3*FHCR))                                 EEFT0660
   GO TO 40                                                             EEFT0670
                                                                        EEFT0680
     NLUM=5    NREC 1966 CORRELATION FOR LUMINOUS FLAMES                EEFT0690
                                                                        EEFT0700
60 DUMLUM=((1.-FHCR*5.)/(FHCR*0.16))**0.74                              EEFT0710
   EMFT(K)=1.-EXP(0.0000474*PREFT(K)**1.3*DUMCOR*DUMLUM)                EEFT0720
   RETURN                                                               EEFT0730
                                                                        EEFT0740
    NLUM=6    VALUE INTERPOLATED FROM DATA                              EEFT0750
                                                                        EEFT0760
70 DUMT=TFT(K)                                                          EEFT0770
   DUMMYP=PREFT(K)                                                      EEFT0780
   CALLINTPL8(DUMT,DUMMYP,TABTFT,TABEFT,TABPFT,NFORM,NEFT,NPFT,         EEFT0790
  1DUMEFT      )                                                        EEFT0800
   EMFT(K)=DUMEFT                                                       EEFT0810
80 RETURN                                                               EEFT0820
   END                                                                  EEFT0830
```

```
$IBFTC PROP    LIST

      SUBROUTINE PROP(K,CNDAV,FMCO2,FMH2O)
C
C                   S U B R O U T I N E   P R O P
C
C         THIS SUBROUTINE EVALUATES THE THERMAL CONDUCTIVITY, DYNAMIC
C         VISCOSITY, SPECIFIC HEAT, REYNOLDS NUMBER, PRANDTL NUMBER,
C         AND NUSSELT NUMBER FOR THE GAS MIXTURE IN THE FLAME TUBE.
C
C         THIS SUBROUTINE CALLS FOR ONE SUBROUTINE
C              1. INTPL8
C
C         SUBROUTINE PROP IS CALLED FOR BY ONE SUBROUTINE
C              1. HEAT1

C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 8
C     VIZ- B8, B18, B68, B168, B178, B678, B1678, B12678

      COMMON/B8/D1A(45),D2A(45),D3A(45),D4A(45),D1B(45),D2B(45),D3B(45)
     1,D4B(45),FMOCO2(45),FMOH2O(45),C1A(45),C1B(45),R1A(45),R1B(45),R2
     2A(45),R2B(45),R3A(45),R3B(45),TNUAAN(45),TNUBAN(45),TNUFT(45),
     3TWADA(45),TWADB(45),
     4EMFT(45),FILMFA(45),FILMFB(45),PRAAN(45),PRBAN(45),PRFT(45),REFT(4
     55),FINT(45),TCFA(45),TCFB(45),UFTA(45),UFTB(45),UJ1A(45),UJ1B(45),
     6AFJA(45),AFJB(45),YCFA(45),YCFB(45)
      COMMON/B18/ABSW,EMW,EMC,NLUM,                          NHT1,NHT2
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,       TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,      NUMAX1,NUMAX2
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     1        ,             AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B178/DFT(45)
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT

C***********************************************************************
C******COMPARE THE CURRENT FUEL-AIR RATIO TO THE STOICHIOMETRIC FUEL-AIR
C******RATIO AND CALCULATE THE MOLE FRACTIONS OF CO2,H2O,N2, AND O2

      FARSTO=0.0862*(1.+FHCR)/(1.+3.*FHCR)
      IF(FARFT(K).GT.FARSTO)GOTO 10
      DUMOLE=25.*FHCR+3.45*(1.+FHCR)/FARFT(K)
      FMO2=(0.72*(1.+FHCR)/FARFT(K)-8.33-25.*FHCR)/DUMOLE
      FMN2=2.75*(1.+FHCR)/FARFT(K)/DUMOLE
      FMCO2=8.33/DUMOLE
      FMH2O=50.*FHCR/DUMOLE
      GOTO 20
   10 FMO2=0.021
      FMN2=0.748
      FMCO2=0.1
```

```
      FMH2O=0.131
   20 T1=TFT(K)*1.E-3
      T2=TFT(K)**2*1.E-6

C****** EVALUATE THE THERMAL CONDUCTIVITY OF THE MIXTURE ***************

      CNDO2 = .0155 + .0157*T1
      CNDN2 = .01352+ .01401*T1
      CNDCO2= .0111 + .0156*T1
      CNDH2O=-.0145 + .0456*T1
      CNDAV=(CNDO2*FMO2*3.18+CNDN2*FMN2*3.04+CNDCO2*FMCO2*3.53+CNDH2O*
     1FMH2O*2.62)/(FMO2*3.18+FMN2*3.04+FMCO2*3.53+FMH2O*2.62)

C****** EVALUATE THE DYNAMIC VISCOSITY OF THE MIXTURE ***************

      VISO2 = .0553 + .0345*T1
      VISN2=.0479+.0277*T1
      VISCO2=.0423+.0296*T1
      VISH2O=.0174+.039*T1
      VISAV=(VISO2*FMO2*5.65+VISN2*FMN2*5.29+VISCO2*FMCO2*6.62+VISH2O*
     1FMH2O*4.24)/(FMO2*5.65+FMN2*5.29+FMCO2*6.62+FMH2O*4.24)

C****** EVALUATE THE SPECIFIC HEAT OF THE MIXTURE ******************

      CPO2=.242+.01057*T1
      CPN2=.232+.0313*T1-.00293*T2
      CPCO2=.228+.0454*T1-.00489*T2
      CPH2O=.334+.141*T1-.0124*T2
      CPAV=(CPO2*FMO2*32.+CPN2*FMN2*28.+CPCO2*FMCO2*44.+CPH2O*FMH2O*18.0
     1)/(FMO2*32.+FMN2*28.+FMCO2*44.+FMH2O*18.)

C******IF CALCULATION POINT IS IN THE PRIMARY ZONE ALLOW FOR
C******RECIRCULATION WHEN CALCULATING REYNOLDS NUMBER IN THE FLAME TUBE

      IF(K.GT.NSHCP) GOTO 30
      REFT(K)=7200.*DFT(K)*(AFPRZ+AFSYP)/(VISAV*AFT(K))
      GOTO 40
   30 REFT(K)=DFT(K)*3600.*AFFT(K)/VISAV/AFT(K)

C******CALCULATE PRANDTL NUMBER IN THE FLAME-TUBE

   40 PRFT(K)=CPAV*VISAV/CNDAV
      IF(REFT(K).LT.1.)REFT(K)=1.
      IF(PRFT(K).LT..01)PRFT(K)=.01

C******CALCULATE NUSSELT NUMBER IN THE FLAME-TUBE

      TNUFT(K)=0.023*REFT(K)**0.8*PRFT(K)**0.4
      RETURN
      END
```

```
$IBFTC COO     LIST
      SUBROUTINE COOL(K,INXAN,CNDAV,TRNSCO,CFTTRN)
C
C                 S U B R O U T I N E   C O O L
C
C         THIS SUBROUTINE EVALUATES FILM COOLING OR TRANSPIRATION
C         COOLING PARAMETERS
C
C         SUBROUTINE COOL IS CALLED FOR BY ONE SUBROUTINE
C              1. HEAT1
C THIS SUBROUTINE USES COMMON BLOCKS WHOSE NAMES CONTAIN THE NUMBER 8
C      VIZ- B8, B18, B68, B168, B178, B678, B1678, B12678

      COMMON/B8/D1A(45),D2A(45),D3A(45),D4A(45),D1B(45),D2B(45),D3B(45)
     1,D4B(45),FMOCO2(45),FMOH2O(45),C1A(45),C1B(45),R1A(45),R1B(45),R2
     2A(45),R2B(45),R3A(45),R3B(45),TNUAAN(45),TNUBAN(45),TNUFT(45),
     3TWADA(45),TWADB(45),
     4EMFT(45),FILMFA(45),FILMFB(45),PRAAN(45),PRBAN(45),PRFT(45),REFT(4
     55),FINT(45),TCFA(45),TCFB(45),UFTA(45),UFTB(45),UJ1A(45),UJ1B(45),
     6AFJA(45),AFJB(45),YCFA(45),YCFB(45)
      COMMON/B18/ABSW,EMW,EMC,NLUM,                           NHT1,NHT2
     1,       X1FCA(45),X1FCB(45),CONDFT,TCASA(45),TCASB(45),TOLTW1,TOLT
     2W2,XFILMZ,       TABTFT(10),TABEFT(100),TABPFT(10),NEFT,NPFT,NFORM
     3,NCOOL,      NUMAX1,NUMAX2
      COMMON/B68/AFANA(45),AFANB(45),AFFT(45),AFPRZ,C2A(45),C2B(45)
     1         ,          AFSYP,FARFT(45),DENANA(45),DENANB(45)
     3,SAFTRA(45),SAFTRB(45),QTRA(45),QTRB(45),REAAN(45),REBAN(45)
     4,TWA(45),TWB(45)
      COMMON/B168/AANA(45),AANB(45),CCA(45),CCB(45),FHCR,NLAST
     1,KANHET,LANHET,PERCO,THIKFT
     2,DANA(45),DANB(45)
      COMMON/B178/DFT(45)
      COMMON/B678/PREFT(45),PREANA(45),PREANB(45),TFT(45),TANANA(45),TAN
     1ANB(45),AFJ1(50),UFT(45)
      COMMON/B1678/NSHCP,XCP(45),AFT(45),PI
     1,NHH(50),KJSN(45,6),HAU(50),CFTA(45),CFTB(45),NAB(50),NCODEA(45)
     2,NCODEB(45),TZ
      COMMON/B12678/JTAPE ,IPRINT

   2  FORMAT(5H COOL,I5,7(E12.5,2X))
      IF(NCOOL.EQ.2) GO TO 60
C**************   FILM COOLING CALCULATION    ************************
C****** SET UP DUMMY FILM-COOLING VARIABLES ****************************
      TFTDYN=UFT(K)**2/(2.*32.2*53.35)
      TFT(K)=TFT(K)+TFTDYN
      IF(INXAN.EQ.2) GO TO 10
      IF(YCFA(K).EQ.0.0.OR.UJ1A(K).LT.0.001) GO TO 45
      UFQ =UFTA(K)
      UJ1 =UJ1A(K)
      X1FC=X1FCA(K)
      YCF =YCFA(K)
      AFJ =AFJA(K)
      TCF =TCFA(K)
      PVZ=PREANA(K)
      GO TO 20
   10 IF(YCFB(K).EQ.0.0.OR.UJ1B(K).LT.0.001) GO TO 55
      UFQ =UFTB(K)
      UJ1 =UJ1B(K)
      X1FC=X1FCB(K)
      YCF =YCFB(K)
```

```
      AFJ =AFJB(K)
      TCF =TCFB(K)
      PVZ=PREANB(K)
C****** FORM EXPRESSION FOR FILM-COOLING CORRELATION *****************
   20 AVZ=      PVZ*YCF*3600./TCF/53.3
      XFILM=0.91*(UFQ/UJ1*X1FC/YCF)**0.8*(UJ1*AVZ/(3.057E-3+8.607E-5*TCF
     1-2.279E-8*TCF**2+2.908E-12*TCF**3))**(-0.2)+1.41*(X1FC/YCF*ABS(1.-
     2UFQ/UJ1))**0.5
      IF(IPRINT.EQ.1)
     4WRITE(6    ,2) K,XFILM,UFQ,UJ1,X1FC,YCF,AFJ,TCF
      IF(XFILM.GE.XFILMZ*1.43)GO TO 30
      IF(XFILM.LT.(XFILMZ/3.5))GOTO25
      FILMEF=(XFILMZ/3.5/XFILM)**0.22
      GO TO 40
   25 FILMEF=1.0
      GO TO 40
   30 FILMEF=XFILMZ/XFILM
   40 TWAD=TFT(K)-FILMEF   *(TFT(K)-TCF)
      IF(INXAN.EQ.2)GO TO 50
      FILMFA(K)=FILMEF
      TWADA(K)=TWAD
      GO TO 120
   45 FILMFA(K)=0.
      TWADA(K)=TFT(K)
      GO TO 120
   50 FILMFB(K)=FILMEF
      TWADB(K)=TWAD
      GO TO 120
   55 FILMFB(K)=0.
      TWADB(K)=TFT(K)
      GO TO 120
C**************   TRANSPIRATION COOLING   ********************
   60 IF(INXAN.EQ.2)GO TO 80
      IF(K.EQ.1.AND.KANHET.EQ.1)GO TO 70
      IF(KANHET.EQ.1)GO TO 75
      TWALL=TWA(K)
      GO TO 100
   70 TWALL=(TFT(K)+TANANA(K))/2.
      GO TO 100
   75 TWALL=TWA(K-1)
      GO TO 100
   80 IF(K.EQ.1.AND.KANHET.EQ.1)GO TO 90
      IF(KANHET.EQ.1)GO TO 95
      TWALL=TWB(K)
      GO TO 110
   90 TWALL=(TFT(K)+TANANB(K))/2.
      GO TO 110
   95 TWALL=TWB(K-1)
      GO TO 110
  100 TRNSCO=SAFTRA(K)*(0.2419-0.8181E-5*TWALL+1.791E-8*TWALL**2-0.2743E
     1-11*TWALL**3   )
      CFTTRN=CNDAV *0.002*REFT(K)/DFT(K) /3600.
      GO TO 120
  110 TRNSCO=SAFTRB(K)*(0.2419-0.8181E-5*TWALL+1.791E-8*TWALL**2-0.2743E
     1-11*TWALL**3   )
      CFTTRN=CNDAV *0.002*REFT(K)/DFT(K) /3600.
      TFT(K)=TFT(K)-TFTDYN
  120 RETURN
      END
```

APPENDIX V

PROGRAM MESSAGES

Many of the subroutines contain format statements which are written out in the printout whenever the program wants to convey a particular message, generally as a result of an error which has arisen. A list of these statements is presented below; each statement is accompanied by an interpretation of the message and, where appropriate, an indication of what course of action should be taken. The statements are arranged with the first letters of the messages in alphabetic order to provide easy reference.

1. AFTER (NUMAX2) TRIALS, ERROR IS GREATER THAN (TOLTW2) DEG R (Subroutine HEAT2, Heat-Transfer Subprogram). The iterative solution of the heat-balance equation has not converged to within the tolerance, TOLTW2, on the wall temperature after NUMAX2 attempts. If a solution is obtainable for the case where longitudinal conduction and radiation interchange are ignored, then check the input data relating to these two effects; if the input is correct, increase the values in Subroutine BLOCKDATA of either NUMAX2 or TOLTW2 or both.
2. AFTER (NUMAX1) TRIALS, ERROR IS GREATER THAN (TOLTW1) DEG R. CHECK INPUT DATA TO SUBROUTINE TWSOLN (Subroutine TWSOLN, Heat-Transfer Subprogram). The solution of the heat-balance equation, using Newton's method, has not converged to within the tolerance, TOLTW2, on the wall temperature after NUMAX1 attempts. If the input appears to be correct, increase the values in Subroutine BLOCKDATA of either NUMAX1 or TOLTW1 or both.

3. DIFFUSER DATA INCORRECTLY WRITTEN ON DATA TAPE (Subroutine TAPE). The diffuser-effectiveness data supplied as input through the library tape have been incorrectly specified. Check with the library-data input description.
4. EMPIRICAL FLAME-EMISSIVITY DATA INCORRECTLY WRITTEN ON DATA TAPE (Subroutine TAPE). See Message Number 3.
5. HOLE DISCHARGE COEFFICIENT DATA INCORRECTLY WRITTEN ON DATA TAPE (Subroutine TAPE). See Message Number 3.
6. IF THERE IS NO SNOUT, NXDIF MUST BE SPECIFIED (Subroutine INPUT1). NXDIF is a program input quantity.
7. INCREASE ITERATION CYCLE LIMIT * LCANIL * OR TOLERANCE * FID * (Subroutine AIRFLO, Air-Flow Subprogram). This message is always preceded by Message Number 8. LCANIL is specified in the program input and FID is set in Subroutine BLOCKDATA.
8. IN SUBROUTINE AIRFLO THE MAXIMUM NUMBER OF ITERATIONS ON THE AIR FLOW SPLIT WAS EXCEEDED (Subroutine AIRFLO, Air-Flow Subprogram). This message is followed by either Message Number 7 or Message Number 31. The average of the fractions of the total air mass flow left at the end of the two annuli is not within the tolerance FID after the specified number of iterations, LCANIL.
9. ITERATION ON ALPHA AT STATION NO.(I), CYCLE NO.(LN) HAS NOT CONVERGED. THE LATEST VALUES OF ALPHA ARE (ALPHA(J),J=1,NTUBE) (Subroutine TUBANL, Diffuser Subprogram). The iteration to determine the streamtube slope at the axial Station I has failed to converge after LN cycles. The cycle number refers to the number

of streamtube-boundary-layer iterations which have been made. The solution is continued using the empirical-data method if the portion of the diffuser upstream of the snout is being treated; otherwise the solution is terminated. This difficulty is not expected to occur in reasonably shaped diffusers.

10. ITERATION LIMIT ON TOTAL PRESSURE LOSS DUE TO HEAT RELEASE EXCEEDED (Subroutine PRTEMP, Air-Flow Subprogram). In the iterative calculation of the total pressure at the end of the primary zone, the change in pressure between the last iteration (number NTOTP) and the preceding one was greater than the limit, PLIMIT. The two quantities NTOTP and PLIMIT are set in a data statement in Subroutine PRTEMP.
11. ITERATION ON AREA AT STATION NO.(I), CYCLE NO.(LN) HAS NOT CONVERGED. THE LATEST VALUES OF GUESSED AREA AND FLOW AREA ARE (SUMA, SUMB). (Subroutine TUBAML, Diffuser Subprogram). The iteration in the streamtube method to determine the static pressure at the axial Station I, has failed to converge after LN cycles. The cycle number refers to the number of streamtube-boundary-layer iterations which have been made. The solution is continued using the empirical-data method if the portion of the diffuser upstream of the snout is being treated; otherwise the solution is terminated. This difficulty is not expected to occur in reasonably shaped diffusers.
12. IX HAS EXCEEDED ITS LIMIT IN HOLE ROW NO.(J) (Subroutine GEOM). In the Jth hole row position, more than 6 hole rows have been specified at the same axial location; this is not permitted.

This is a program input error.

13. K HAS EXCEEDED ITS LIMIT IN HOLE ROW NO.(J) (Subroutine GEOM). In the Jth hole row position, the number of calculation points, K has exceeded the maximum permissible number, KMAX. The value of KMAX is set in a data statement in Subroutine GEOM.

14. MACH NUMBER GREATER THAN ONE. SOLUTION CONTINUED (Subroutine GASTBL, Diffuser Subprogram). The Mach number determined by a low value of static-to-total pressure ratio exceeds unity. The solution proceeds in this case, but the results are invalid if the final iteration on mass-flow split retains this difficulty. This is indicative of an error in the diffuser geometry specified as input, or an excessively large mass-flow rate specified as input.

15. MISMATCH AT THE SNOUT IS CHARACTERIZED BY THE RATIO (TOTAL STREAMTUBE AREA JUST BEFORE THE SNOUT)/(FLOW AREA JUST INSIDE THE SNOUT). THIS RATIO IS (AR). AS THIS RATIO IS (IN/OUT)SIDE THE RANGE 0.85-1.15 THE FLOW SPLIT ON THE SNOUT (IS/IS NOT) WELL MATCHED (Subroutine DOUTPT, Diffuser Subprogram). This message is self-explanatory.

16. NABX(1)=4 NOT ALLOWED (Subroutine GEOM). The first hole row specified in the program input must not be a dummy hole, that is, NHTU must not be zero.

17. NEGATIVE QUANTITY IN EXPRESSION FOR JET PENETRATION (Subroutine JETMIX, Air-Flow Subprogram). Following this message, the variables forming the expression for jet penetration are printed out; these are:

DENSJ (density of air in jet)

DENFT(K) (density of flame-tube gases at Calculation Station K)

UJ (initial jet velocity)

UFT(K) (velocity of flame-tube gases at calculation Station K)

X (axial distance downstream from jet origin)

DJA (longitudinal length of hole).

One of these quantities will be found to be negative, indicating the direction in which to search for the source of the error. After encountering this error, the program moves to the next hole row and proceeds with the solution. The above message is not printed out if the air-flow-split iteration is in its first cycle or if a condensed printout has been requested (IPRINT=0).

18. NEGATIVE VALUE CALCULATED FOR MACH NUMBER. SOLUTION TERMINATED (Subroutine GASTBL, Diffuser Subprogram). An attempt has been made to calculate the Mach number from the usual compressible-flow relations with any of the following:

    a. A negative static-to-total pressure ratio
    b. A static-to-total pressure ratio in excess of unity
    c. A flow area smaller than the critical area

The third case is of most frequent occurrance, and is indicative of an error in the diffuser geometry supplied as input (resulting in a too small passage area), a specification of an excessively large mass-flow rate, or an intermediate value of the mass-flow split which is extreme.

19. NU, NH, NWH, AND NSH MUST ALL BE SPECIFIED (Subroutine INPUT1). All of the above quantities are to be supplied in the program input. The appearance of this error message means that one or more of the quantities were omitted.

20. PROGRAM STOPPED IN SUBROUTINE AIRFLO. LOOP COUNTER * LCANL * EXCEEDED. MAX CALL FOR * EQUAN * EXCEEDED (Subroutine AIRFLO, Air-Flow Subprogram). The number of times Subroutine AIRFLO calls Subroutine EQUAN is counted. If this number exceeds the limit, LCANL, which is set in Subroutine BLOCKDATA, the program is returned to the Main Subprogram CLARE.

21. PROGRAM STOPPED IN SUBROUTINE AIRFLO. LOOP COUNTER * LCFTL * EXCEEDED. MAX CALL FOR * EQUFT * EXCEEDED (Subroutine AIRFLO, Air-Flow Subprogram). The number of times Subroutine AIRFLO calls Subroutine EQUFT is counted. If this number exceeds the limit, LCFTL, which is set in Subroutine BLOCKDATA, the program is returned to the Main Subroutine CLARE.

22. PROGRAM STOPPED IN SUBROUTINE PRTEMP. ITERATION LIMIT * LCPTAL * EXCEEDED (Subroutine PRTEMP, Air-Flow Subprogram). The number of iterations to determine the secondary-hole mass-flow split in Subroutine PRTEMP is counted. If this number exceeds the limit, LCPTAL, which is set in Subroutine BLOCKDATA, the iterations are stopped and the solution proceeds with the last calculated value of the secondary-hole flow split.

23. PROGRAM STOPPED IN SUBROUTINE PRTEMP. ITERATION LIMIT * LCPRTL * EXCEEDED (Subroutine PRTEMP, Air-Flow Subprogram). The number of iterations to determine the primary-zone temperature in Subroutine PRTEMP is counted. If this number exceeds the limit, LCPRTL, which

is set in Subroutine BLOCKDATA, the iterations are stopped and the solution proceeds with the last calculated value of primary-zone temperature.

24. SOLUTION FAILED TO CALCULATE STATIC PRESSURE AT COMPRESSOR EXIT (Subroutines EMPCTS and TUBEIN, Diffuser Subprogram). The iteration to determine the static pressure at the compressor exit from a specified mass-average total pressure and velocity profile failed to converge after 40 cycles. If the streamtube method is being used, it is replaced by the empirical-data method. The only time this is expected to occur is if the required solution is highly supersonic; hence this message indicates a mass-flow rate which is too large for the specified areas.

25. SOLUTION FAILED TO CALCULATE THEORETICAL FLOW AREAS FOR A GIVEN FLOW SPLIT. SOLUTION TERMINATED (Subroutine TUBFWI, Diffuser Subprogram). This only occurs if the mass flow to either of the two annuli, obtained from the air-flow subprogram, exceeds the total mass flow. This should never occur if the program input has been prepared properly.

26. SOLUTION FAILED TO CONVERGE AFTER 40 CYCLES. SOLUTION CONTINUED USING EMPIRICAL DATA. THE LAST CALCULATED BOUNDARY LAYER PARAMETERS ARE . . . . (Subroutine TUBCTS, Diffuser Subprogram). In using the streamtube method between the compressor exit and the snout, the iteration on the boundary-layer displacement thickness failed to converge. In general, this will only occur in a badly separated diffuser. The solution continues by employing the empirical-data

method in this portion of the diffuser; if the streamtube method is specified to be used in the subsequent portions of the diffuser, the empirical-data method is also used there.

27. SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBANL. SOLUTION CONTINUED USING EMPIRICAL DATA (Subroutine TUBCTS, Diffuser Subprogram). This message is always preceded by either Message Number 9 or 11. It is an indication that the streamtube method has failed to converge on either streamtube area or slope and that the empirical-data method is used in its place.

28. SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBANL. SOLUTION TERMINATED (Subroutine TUBSA1, Diffuser Subprogram). This message is always preceded by either Message Number 9 or 11. It is an indication that the streamtube method has failed to converge on either streamtube area or slope and that the solution is terminated.

29. SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBEIN. SOLUTION CONTINUED USING EMPIRICAL DATA (Subroutine TUBCTS, Diffuser Subprogram). This message is always preceded by either Message Number 24 or 31. It is indicative of a failure in the calculation in the streamtube method to determine the streamtube properties at the inlet to the first part of the diffuser. The solution is continued using the empirical-data method.

30. SOLUTION FAILED TO CONVERGE IN SUBROUTINE TUBEIN. SOLUTION TERMINATED (Subroutine TUBSA1, Diffuser Subprogram). This message is always preceded by either Message Number 24 or 31. It is indicative of a failure in the calculation in the streamtube method to determine the streamtube properties at the inlet to

the second half of the diffuser (after the snout). The solution is terminated.

31. SOLUTION FAILED TO FIND A CONVERGED VALUE OF U. PROBLEM TERMINATED. THE LAST TWO VALUES OF U WERE . . . (Subroutine TUBEIN, Diffuser Subprogram). The iteration in the streamtube method to determine the appropriate value of the normalization velocity U at the inlet to a diffusing passage has failed to converge after 40 cycles. The solution is continued with the empirical-data method if the first portion of the diffuser is being treated, while the solution is terminated if the portions of the diffuser downstream of the snout are being treated. The latter is the more likely occurrence, and is indicative of a mass-flow rate which is too high for the area of the passage.

32. **TEMPERATURE IN * EQUFT * LESS THAN ZERO (Subroutine EQUFT, Air-**Flow Subprogram). In the iterative solution for the flame-tube temperature, TFT2, in Subroutine EQUFT, a negative value has been calculated for TFT2. This will normally only appear in the first cycle of the air-flow-split iteration when the flow through the snout is close to zero. It is due to neglecting the enthalpy of the fuel in the flame-tube energy equation. When the program encounters this situation, TFT2 is given a value of 100 and the solution leaves the temperature iteration cycle; this value of TFT2 will, however, be reset in subsequent cycles in the air-flow-split iteration.

33. THE COMBUSTER IS BADLY DESIGNED--NEGATIVE PRESSURE DROP IS OCCURRING ACROSS THE HOLES. TO REMEDY:

    1. IF ANNULUS VELOCITIES GREATER THAN 300 FPS, OPEN UP THE ANNULUS
    2. INCREASE SIZE OF WALL HOLES
    3. REDUCE DOME HOLE AREA
    4. USE MORE SCOOPS OVER WALL HOLES

    (Subroutine AIRFLO, Air-Flow Subprogram). This message is always preceded by Message Number 8.. It indicates that the flow resistances through the annuli are too large compared with the flow resistance through the snout and flame tube such that an air-mass flow split cannot be found to satisfy the two conditions:

    a. Zero flow at the downstream end of the annuli
    b. Positive flow from the annuli into the flame tube at all hole rows.

    The message itself indicates various methods for overcoming this problem.

34. THE STREAMTUBE ANALYSIS IN THE DIFFUSING PASSAGES BETWEEN SNOUT AND OUTER CASING HAS FAILED TO CONVERGE. SOLUTION TERMINATED. THE LAST CALCULATED BOUNDARY LAYER PARAMETERS ARE . . . (Subroutine TUBSA1, Diffuser Subprogram). This indicates that the iteration on boundary-layer displacement thickness has failed to converge after 40 cycles. It is expected to occur only in diffusers which are badly separated.

35. THE DIFFUSER TREATMENT USED IN THIS PROGRAM BECOMES INCREASINGLY INACCURATE AT INLET MACH NUMBERS GREATER THAN 0.7 (Subroutines TUBCTS and EMPCTS, Diffuser Subprogram). This is merely an

indication that the Mach number of the flow at the compressor exit is in excess of 0.7.

36. THE JET FROM HOLE ROW NO.(J) IS SPREADING TOO FAR. INCREASE EFC (Subroutine JETMIX, Air-Flow Subprogram). At each calculation station, the program compares the area of each jet with the cross-sectional area of the flame tube. If the total area of all jets from a particular hole row (J) occupies more than one quarter of the flame-tube area, the above message is printed out and the solution continues. It is suggested that the jet entrainment constant, EFC, be increased in such cases.

37. THE TWO-DIMENSIONAL-RADIATION OPTION CANNOT BE USED IN A COMBUSTOR OF RECTANGULAR CROSS SECTION. THE FLAME RADIATION WILL BE CALCULATED ONE-DIMENSIONALLY (Subroutine INPUT2). The program input has been incorrectly specified; the solution proceeds using the one-dimensional-radiation option.

38. THE TWO-DIMENSIONAL-RADIATION OPTION CANNOT BE USED WITH TABULATED EMISSIVITY DATA. NLUM HAS BEEN SET EQUAL TO 4 (Subroutine INPUT2). The program input has been incorrectly specified, the solution proceeds using the NREC 1964 correlation for flame emissivity.

39. THERE ARE NO JET-ANGLE DATA FOR HOLE TYPE NO.(NHTU) THE INITIAL JET-ANGLE ESTIMATE USED IN THE PROGRAM IS NOT AT ALL ACCURATE FOR SCOOPS (Subroutine GEOM). This is an informative message printed out when noncontinuous scoops have been specified for which there are no jet-angle data.

40. THIS SECTION HAS AN AREA RATIO LESS THAN ONE AND ACTS AS A NOZZLE AND NOT AS A DIFFUSER. THE VALUE PRINTED OUT AS THE DIFFUSER EFFECTIVENESS IS NOT AN INDICATION OF HOW WELL THE SECTION PERFORMS (Subroutine DOUPT, Diffuser Subprogram). This indicates that the area at diffuser Station 2 occupied by the flow passing through either annulus is greater than the exit area of the respective diffuser passage. In this case, the empirical-data and streamtube-analysis methods yield essentially no losses due to diffusion, and the values of effectiveness obtained are generally not meaningful since the ideal pressure-recovery coefficients are negative.

41. WHEN SUBROUTINE JETMIX WAS CALLED, K WAS (K), LESS THAN NSHCP+1 (Subroutine JETMIX, Air-Flow Subprogram). JETMIX should not be called for calculation stations in the primary zone. This indicates an error in subroutine EQUFT, from which JETMIX is called.

42. X(I) WAS FOUND TO BE LESS THAN X(I-1) (X(I)) INCHES ALONG THE COMBUSTOR. THIS IS NOT ALLOWED (Subroutine INPUT1). The program input quantity XINCH must increase monotonically with no two values equal.

APPENDIX VI

FORTRAN NOMENCLATURE

This appendix gives the Fortran nomenclature for program CLARE and its subroutines. Only the variables contained in COMMON blocks are included; the others are mainly dummy variables which appear exclusively in a particular subroutine. (The COMMON block BZERO also contains only dummy variables which are not listed here).

In many parts of the program, different quantities apply to the inner (closest to shaft) and outer walls of the combustor; these have generally been given names which are identical except that A is used for the inner wall, B for the outer wall. To avoid extensive duplication of these names, the following shorthand notation has been adopted. When A in a name is underlined, there exists a corresponding quantity with A replaced by B and with "inner" in the definition replaced by "outer". For example,

CA Diameter of inner wall

indicates that there is, in addition to CA, a quantity:

CB Diameter of outer wall.

Variables having names beginning with the letters I,J,K,L,M, and N are integers. All other variables are real.

Units

In some cases, the units used in the program differ from those used for input and output. For example, lengths and diameters are given in inches on input and output, whereas feet units are consistently used in the program. In such cases, the units given in this list are those used in the program.

Subscripts

In this list, the subscripts I, J, and K are used with variables that are defined at each geometric input point, each hole row, and each calculation point respectively. I runs from 1 to NG, J from 1 to NH, and K from 1 to NLAST. The subscripts L and N are used with other variables, as defined below.

Fortran Name	Symbol	Description	Units
A		Enthalpy flow rate with jet from secondary holes on inner wall	lbm ft^2 per sec^3
AAN1	$A_{an,1}$	Cross-sectional area of annulus at previous calculation point	sq ft
AAN2	$A_{an,2}$	Cross-sectional area of annulus at current calculation point	sq ft
AANA(K)	A_{an}	Cross-sectional area of inner annulus	sq ft
ABLOCK		Fraction of boundary-layer blockage at inlet that is on the inner wall	-
ABSW	α_w	Absorptivity of flame-tube wall	-
AF(L)		Air mass flow rate in diffuser annulus. L=1 for inner, 2 for outer	lbm per sec
AF2	$\dot{m}$	Air mass flow rate at combustor inlet	lbm per sec
AF23A(L)		Fraction of inlet air that is bled from the annulus for turbine cooling or other auxiliary purposes	-
AFA	$\dot{m}_{an}$	Air mass flow rate in inner annulus used in the diffuser calculation	lbm per sec
AFAN1	$\dot{m}_{an,1}$	Air mass flow rate in annulus at previous calculation point	lbm per sec

Fortran Name	Symbol	Description	Units
AFAN2	$\dot{m}_{an,2}$	Air mass flow rate in annulus at current calculation point	lbm per sec
AFANA(K)	$\dot{m}_{an}$	Air mass flow rate in inner annulus	lbm per sec
AFCL		Lower bound on ratio of flow through inner annulus to flow through both annuli	-
AFCU		Upper bound on ratio of flow through inner annulus to flow through both annuli	-
AFFT(K)	$\dot{m}_{ft}$	Gas mass flow rate inside flame tube	lbm per sec
AFFT1	$\dot{m}_{ft,1}$	Gas mass flow rate in flame tube at previous calculation point	lbm per sec
AFFTT1		Gas mass flow rate in flame tube at next calculation point	lbm per sec
AFFT2	$\dot{m}_{ft,2}$	Gas mass flow rate in flame tube at current calculation point	lbm per sec
AFJ(J), AFJ1(J)	$\dot{m}_h$	Initial mass flow in jets in Jth hole row	lbm per sec
AFJA(K)		Mass flow through previous cooling slot in inner wall	lbm per sec
AFJZ(J)		Fraction of annulus air flowing through Jth hole row	-
AFPRZ	$\dot{m}_p$	Total mass flow in primary zone	lbm per sec
AFSL		Lower bound on flow through snout	lbm per sec
AFSU		Upper bound on flow through snout	lbm per sec
AFSYIA		Air mass flow rate into intermediate zone, from secondary holes in inner annulus	lbm per sec
AFSYP	$\dot{m}_{sy,p}$	Mass flow rate through secondary holes into primary zone	lbm per sec
AFSYPA		Air mass flow rate into primary zone, from secondary holes in inner annulus	lbm per sec

Fortran Name	Symbol	Description	Units
AFT(K)	A_{ft}	Cross-section area of flame tube	sq ft
AFT1	$A_{ft,1}$	Cross-section area of flame tube at previous calculation point	sq ft
AFT2	$A_{ft,2}$	Cross-section area of flame tube at current calculation point	sq ft
AHDOME	$A_{hT,dome}$	Total hole area in the dome	sq ft
AL(L,N,I)		Difference in angle between mean angle of diffusing passage and angle of passage wall. L=1 for inner passage, 2 for outer; N=1 for inner wall, 2 for outer	radians
ALFA(L,I)		Mean angle of diffuser annulus between stations 2' and 4. L=1 for inner, 2 for outer	radians
ALFC(I), ALFD(I)		Angle of inner, outer casing at the diffuser snout	radians
ALPHA1, ALPA		Angle of inner casing	radians
ALPHA2, ALPB		Angle of inner wall of snout	radians
ALPHA3, ALPC		Angle of outer wall of snout	radians
ALPHA4, ALPD		Angle of outer casing	radians
AR(I,N)		Flow area at diffuser station I for annulus N	sq ft
ARF(L,I)		Area of diffusing passage normal to flow direction, allowing for boundary-layer displacement thickness. L=1 for inner passage, 2 for outer	sq ft
ARDTA(L)	AR	Area ratio for point L in table of empirical diffuser data	-
ARR(L,I)		Area of diffusing passage normal to flow direction. L=1 for inner passage, 2 for outer	sq ft

Fortran Name	Symbol	Description	Units
ARTAB(L)	AR	Area ratio for point L in table of empirical diffuser data for an alternative set of data	-
AREA(I)		Diffuser cross-section area	sq ft
AREA1		Diffuser cross-section area at entry	sq ft
AREF	A_{ref}	Combustor reference cross-section area	sq ft
ASTAR (N)		Critical flow area for stream-tube N	sq ft
ASW	A_{sw}	Swirler area (ignoring blockage due to blades)	sq ft
B		Axial momentum of jet from secondary hole on inner wall	ft lbm per sec^2
BETA	β	Swirler blade stagger angle	radians
BETA1	β	Profile parameter at inlet to inner annulus	-
BETA2	β	Profile parameter at inlet to outer annulus	-
BLOCK(I)		Boundary-layer blockage in the diffuser	-
C(J)	C_d	Discharge coefficient in Jth hole row	-
C1A(K)	C_1	Rate of heat transfer by convection from flame (or cooling film) to inner wall	Btu per sq ft sec
C2A(K)	C_2	Heat transfer rate from wall to air in inner annulus by convection	Btu per sq ft sec
CA(I)		Inner casing diameter	ft

Fortran Name	Symbol	Description	Unit
CAL(I)		Effective radius of inner diffuser wall between stations 1 and 2, accounting for boundary-layer displacement thickness	ft
CCA(K)		Inner casing circumference	ft
CD	C_d	Discharge coefficient uncorrected for velocity	-
CDC(L,N)	C_d^1	Discharge coefficient corrected for velocity	-
CDS(L,N), DUMCD(N)		Discharge coefficient, library value	-
CFTA(K)		Circumference of flame-tube inner wall	ft
CONDFT	K_w	Thermal conductivity of flame-tube wall material	Btu per ft hr deg F
D		Mass flow in jets from secondary hole on inner wall	lbm per sec
D1A(K)		Coefficient of T_w^4 in heat-balance equation on inner wall	deg R^{-4}
D2A(K)		Coefficient of $T_w^{2.5}$ in heat-balance equation on inner wall	deg $R^{-2.5}$
D3A(K)		Coefficient of T_w in heat-balance equation on inner wall	deg R^{-1}
D4A(K)		Constant in heat-balance equation on inner wall	
DANA(K)	D_{an}^1	Hydraulic diameter of inner annulus	ft
DELT(L,I)		Boundary-layer displacement thickness at the diffuser wall. L=1 for inner passage, 2 for outer; I= 1 for inner wall, 2 for outer	ft
DELTA(L,I)	δ	Displacement thickness at point I. L=1 for inner wall, 2 for outer wall	ft
DENAN1	$\rho_{an,1}$	Air density in annulus at previous calculation point	lbm per ft^3

Fortran Name	Symbol	Description	Units
DENAN2	$\rho_{an,2}$	Air density in annulus at current calculation point	lbm per ft^3
DENANA(K)	ρ_{an}	Air density in inner annulus	lbm per ft^3
DENFT(K)	ρ_{ft}	Gas density in flame tube	lbm per ft^3
DENFT1	$\rho_{ft,1}$	Gas density in flame tube at previous calculation point	lbm per ft^3
DENFT2	$\rho_{ft,2}$	Gas density in flame tube at current calculation point	lbm per ft^3
DFFT(J)		Accumulated fraction of inlet air in flame tube after J^{th} hole row	-
DFT(K)	D^{1}_{ft}	Hydraulic diameter of flame tube	ft
DOMLOS		Number of velocity heads (based on velocity at snout entrance) lost between snout entry and dome if the diffuser has a snout. If the diffuser has no snout DOMLOS = no. of velocity heads lost at calculation point NXDIF due to mixing on the dome	-
DPH(J)	$1 + \frac{\Delta p_h}{q_{an}}$	Pressure-loss factor for Jth hole row	-
DPH1	$1 + \frac{\Delta p_h}{q_{an}}$	Current value of pressure-loss value	-
DPHS(L,N), DUMPH(N)	$1 + \frac{\Delta p_h}{q_{an}}$	Library value of pressure-loss value	-
DPHSNT		Dynamic pressure at snout inlet	lbf per sq ft
DPREF	q_{ref}	Reference dynamic pressure	lbf per sq ft
DSWLIN		Inside diameter of swirler	in
DSWLOU		Outside diameter of swirler	in
DUMAE(K)		Accumulated pressure loss in inner annulus due to expansion	lbf per sq ft

Fortran Name	Symbol	Description	Units
DXHU(J)		Hole radius (for noncircular holes, half the axial length)	ft
DYD		Square of mean velocity into inner annulus from first part of diffuser (Station 2)	ft^2 per sec^2
D9(N)		Fractional distance across velocity profile at diffuser Station 2, allowing for blockage	-
E		Momentum of jets from secondary holes on inner wall	ft lbm per sec^2
E1DTA	E_1	(1 - boundary-layer blockage) at inlet for table of empirical diffuser data	-
E1DTAB	E_1	(1 - boundary-layer blockage) at inlet for an alternative table of empirical diffuser data	-
EE1(L)		Parameter used in calculating boundary-layer blockage at entrance to second stage of diffusion (Station 2)	-
EFC(1)		Constant used to denote rate of mixing of penetration jets	-
EFC(2)		Constant used to denote rate of mixing of wall jets	-
EFCL(N)	$\frac{u_{j} - u_{ft}}{u_{j,o} - u_{ft}}$	Local velocity ratio in residual-jet velocity profile	-
EFDT(L)	ξ	Diffuser effectiveness. L = 1 for diffuser inlet to station NXDIF L = 2,3 for two annular passages	-
EFDTA(L)	ξ	Effectiveness for point L in table of empirical diffuser data	-
EFDTAB(L)	ξ	Effectiveness for point L in an alternative table of empirical diffuser data	-

ortran Name	Symbol	Description	Units
EK16	M_{jo}	Total axial jet momentum flow rate of entering jets.	ft lbm per sec^2
EK17	A_{jo}	Total cross-sectional area of entering jets	sq ft
EK19	$\dot{m}_{jo}$	Total air mass-flow rate of entering jets	lbm per sec
EK20		Total jet enthalpy flow rate of entering jets.	lbm ft^2 per sec^3
EMC	ε_c	Emissivity of casing	-
EMFT(K)	ε_{ft}	Flame emissivity	-
EMW	ε_w	Emissivity of flame tube wall	-
ENTHAL		Ratio of mean specific heat at TFT2 to that at TFT1	-
F(I)		Ratio of inner or outer annulus area to total combustor area at diffuser Station 2'	-
FAR		Fuel-air ratio	-
FARFT(K)		Fuel-air ratio in flame tube	-
FARFT1		Fuel-air ratio in flame tube at previous calculation point	-
FARFT2		Fuel-air ratio in flame tube at current calculation point	-
FARL		Fuel air ratio left at the current calculation point	-
FFB(J)		Cumulative fraction of fuel burned up to Jth hole row	-
FFIZ(K)		Mass of fuel available for burning in flame tube between previous calculation point and current one	lbm
FHCR		Fuel hydrogen-carbon ratio	-
FIA		Constant used in deriving new mass flow split	-

Fortran Name	Symbol	Description	Units
FID		Maximum value of $\dot{m}_A^*$ in air mass flow iteration cycle	lbm per sec
FIENTH		Maximum allowable change in temperature in solution of flame-tube equations	deg F
FIFTPR		Maximum allowable error in enthalpy equation to determine primary zone temperature	-
FILMFA(K)	τ	Film-cooling effectiveness	-
FINT(K)		Flame intensity at calculation point K	Btu per sq ft sec
FIPHI		Tolerence on velocity in solving flame-tube equations, expressed as a fraction	-
FIT		Velocity percentage accuracy required in solution of annulus equations	-
FITAU		Constant used in deriving new mass-flow split	-
FLAREA(I)		Flow area in diffuser	sq ft
FLCV		Fuel lower calorific value	Btu per lbm
FMOCO2(K)		Mole fraction of carbon dioxide in burning gas	-
FMOH2O(K)		Mole fraction of water vapor in burning gas	-
FRICFA(K)	f	Friction factor (Fanning) in annulus	-
FTA(I)		Diameter of inner flame-tube wall	ft
GASC	R	Gas constant for air	ft lbf per lbm deg R
GJOULE	J	Mechanical equivalent of heat	ft lbf per Btu
GRAVC	g_o	Gravitational constant	ft lbm per lbf sec^2
GXIA	ξ	Jet angle for secondary-hole jets on inner annulus	radians

Fortran Name	Symbol	Description	Units
GXI	ξ	Initial jet angle	radians
GXIA(J)	ξ	Jet angle in Jth hole row	radians
GXIS(L,N)	ξ	Initial jet angle, library value	radians
HAB(J)		Input value of hole area	sq ft
HAU(J)	A_h	Cross sectional area of each hole in Jth row	sq ft
HAW(J)		Effective total area of Jth hole row	
HRRATE		Effective lower calorific value of fuel times the fuel air ratio	Btu per lbm
IBL		Index. 1 When diffuser calculation has converged 0 Otherwise	-
IDIF		Index. 0 For empirical data from generalized tabulation 1 For empirical data from table for particular geometry	-
IH		Number of hole type on short list	-
IHJ(J)		Hole type number on short list for the Jth hole row	-
INPUT		Index. 0 If input flow conditions varied between cases 1 If program routing varied between cases	-
IPRINT		Index. 1 If intermediate results are to be printed 0 Otherwise	-
ITAPE		Number of computer input device	-
JKSN(J)		Number of calculation point corresponding to Jth hole row	-

Fortran Name	Symbol	Description	Units
JTAPE		Number of computer output device	-
K		Index denoting calculation point	-
K1		Index. 0 For inner annulus 1 For outer annulus	-
K4		Index. 0 For secondary-hole flow split not specified 1 For secondary-hole flow split specified	-
K6		Index. 0 For no swirler 1 For swirler specified 2 For swirler unspecified	-
K30,K40, K50,K60		Integers used in subroutine DISJET to fix pressure reversal or negative air mass flow in the annuli for the whole combustor	-
KANHET		Number of times the heat transfer subprogram has been entered	-
KJSN(K,L)		Hole row number of Lth hole row at calculation point no.K	-
KTAPE		Number of computer input device used for library data	-
LANHET		Index. 0 If heat transfer to annulus air is neglected 1 If heat transfer to annulus air is to be considered 2 If no heat transfer calculation is to be done	-
LCAN		Loop counter in AIRFLO; check on number of times EQUAN is called	-
LCANL		Loop counter limit in AIRFLO; check on number of times EQUAN is called	-

Fortran Name	Symbol	Description	Units
LCANI		Loop counter in AIRFLO; iteration on mass-flow split	-
LCANIL		Loop counter limit in AIRFLO; iteration on mass-flow split	-
LCFT		Loop counter in AIRFLO; check on number of times EQUFT is called	-
LCFTE		Loop counter in EQUFT; iteration on flame-tube temperature	-
LCFTEL		Loop counter limit in EQUFT; iteration on flame-tube temperature	-
LCFTL		Loop counter limit in AIRFLO; check on number of times EQUFT is called	-
LCMF		Loop counter in EQUAN; iteration on annulus velocity	-
LCMFL		Loop counter limit in EQUAN, iteration on annulus velocity	-
LCPRT		Loop counter in PRTEMP; iteration on primary-zone temperature	-
LCPRTL		Loop counter limit in PRTEMP, iteration on primary-zone temperature	-
LCPTA		Loop counter in PRTEMP; iteration on secondary-hole-mass-flow split	-
LCPTAL		Loop counter limit in PRTEMP; iteration on secondary-hole-mass flow-split	-
M		Number of current case	-
NAB(J)		Index indicating hole position; 1. For inner wall 2. For outer wall	-

Fortran Name	Symbol	Description	Units
NABX(K)		Index. 1 For hole on inner wall 2 For hole on outer wall 3 For holes on both walls 4 For no holes on either wall	-
NBLADE		Number of swirler blades	-
NCASE		Number of cases to be considered NCASE = 0 if only a check on the input data is required, and none of the major subroutines are to be entered	-
NCDF		Index indicating form of empirical diffuser data and degree of interpolation used. See page 30 for details (NCDF = NCDIFA)	-
NCDIFB		Index indicating form of empirical diffuser data and degree of interpolation used for an alternative set of data	-
NCODEA(K)		Index. 1 If there is a cooling slot on inner wall at this calculating point 0 Otherwise	-
NCOOL		Index. 1 For film cooling 2 For transpiration cooling	-
NDIFF		Index indicating route through diffuser subprogram. Tens position indicates calculation method in first part of diffuser (Stations 1-2), units position indicates method for second part (Stations 2-4). Can take values 11, 12, 13, 22, 23. See page 40 for details	-
NEF		Index indicating entrainment correlation to be used. 1 For mass-loss method 2 For equivalent-entrainment method 3 For profile-substitution method 4 For instantaneous mixing	-

Fortran Name	Symbol	Description	Units
NDIS(J)		Index indicating state of residual jets from Jth hole row. 0 If jets have not disappeared 1 If jets have disappeared	
NEFT		Number of emissivity values in table of empirical flame-emissivity data	-
NG		Number of geometric input points	-
NGO		Index. 1 For streamtube method 2 For empirical-data method	-
NH		Number of hole rows	-
NHH(J)		Number of holes in hole row J	-
NHT1		Index indicating route through basic heat-transfer calculation. 1 For uncooled wall, 1-dimensional radiation 2 For cooled wall, 1-dimensional radiation 3 For uncooled wall, 2-dimensional radiation 4 For cooled wall, 2-dimensional radiation	-
NHT2		Index indicating the corrections applied to the basic heat-transfer calculation 2 For longitudinal conduction 3 For radiation interchange between walls 4 For longitudinal conduction and radiation interchange 1 No corrections used	-
NHTU		Hole type used in Jth hole row	-
NLAST		Number of calculation points	-
NLUM		Index indicating correlation to be used for flame emissivity. 1 For Reeves correlation for distillate fuels 2 For Reeves correlation for residual fuels 3 For Lefebvre correlation	-

Fortran Name	Symbol	Description	Units
		4 For NREC 1964 correlation 5 For NREC 1966 correlation 6 For emissivity from table of experimental data	
NPFT		Number of values of pressure in table of empirical flame-emissivity data	-
NRECT		Index. 1 For annular combustor 2 For rectangular combustor	-
NSCOOP(L)		Index. 1 In units position for non-continuous scoop 2 In units position for continuous film-cooling slot 0 in units position otherwise 1 in tens position if jet-angle data not available	-
NSH		Hole-row number corresponding to secondary holes	-
NSHCP		Number of calculation point corresponding to secondary holes	-
NSNOUT		Index. 1 If there is a snout 0 Otherwise	-
NSP(L)		Number of points at which discharge-coefficient data given for Lth hole type on short list	
NTUBE		Number of streamtubes in diffuser theoretical calculation	-
NUMAX1		Permissible number of iterations in solving heat-balance equation for noniterative heat-transfer calculation	
NUMAX2		Permissible number of iterations in solving heat balance equation for iterative heat transfer	
NUMSW		Number of swirlers	
NUPR		Number of points across velocity profile in diffuser inlet plane	-

Fortran Name	Symbol	Description	Units
NWALL1		Index indicating set of empirical data to be used in first part of diffuser (Stations 1-2)	-
NWALL2		Index indicating set of empirical data to be used in second part of diffuser (Stations 2-4)	-
NWAY		Index. 1 For streamtube method 2 For empirical-data method 3 For mixing-equation method	-
NWH		Number of first hole row on flame-tube wall, as distinct from dome	-
NXDIF		Number of geometric-input point corresponding to diffuser Station 2 (just before snout)	-
NXDIF1		Number of geometric-input point corresponding to diffuser Station 3 in inner annulus	-
NXDIF2		Number of geometric-input point corresponding to diffuser Station 3 in outer annulus	-
NXDIFA,NXD(1)		Number of geometric-input point corresponding to diffuser Station 4 in inner annulus	-
NXDIFC		Number of area-ratio points in table of empirical diffuser data for an alternative set of data	-
NYDF		Number of effectiveness points in table of empirical diffuser data	-
NYDIFB		Number of effectiveness points in table of empirical diffuser data for an alternative set of data	-
NZDF		Number of nondimensional-length points in table of empirical diffuser data	-

Fortran Name	Symbol	Description	Units
NZDIFB		Number of nondimensional-length points in table of empirical diffuser data for an alternative set of data	-
PAN1A		Static pressure in inner annulus at diffuser exit (Station 4)	lbf per sq ft
PERCO	$1/\alpha$	Permeability coefficient of porous wall	sq ft
PI	π	3.14159	-
PI4	$\pi/4$	3.14159/4	-
PLOSS(I)		Total-pressure loss in the diffuser due to expansion or contraction at the snout	lbf per sq ft
PRAAN(K)	Pr	Prandtl number in inner annulus	-
PREAN1	$p_{an,1}$	Static pressure at previous calculation point in annulus	lbf per sq ft
PREAN2	$p_{an,2}$	Static pressure at current calculation point in annulus	lbf per sq ft
PREANA(K)	p_{an}	Static pressure in inner annulus	lbf per sq ft
PREDM	p_{dome}	Static pressure on dome	lbf per sq ft
PREFT(K)	p_{ft}	Static pressure in flame tube	lbf per sq ft
PREFT1	$p_{ft,1}$	Static pressure at previous calculation point in the flame tube	lbf per sq ft
PREFT2	$p_{ft,2}$	Static pressure at current calculation point in the flame tube	lbf per sq ft
PRES(I)		Diffuser static pressure at point I	lbf per sq ft
PRESIN	p_2	Static pressure at inlet	lbf per sq ft
PRFT(K)	Pr	Prandtl number in flame tube	-
QTRA(K)		Rate of enthalpy added to flame-tube gas due to transpiration cooling through inner annulus wall	Btu per ft^2 sec

Fortran Name	Symbol	Description	Units
R		Distance across annulus, normal to mean flow direction, at diffuser Station 2'	Btu per sq ft sec
R1A(K)	R_1	Rate of heat transfer by radiation from flame to inner wall	Btu per sq ft sec
R2A(K)	R_2	Rate of heat transfer by radiation from flame tube wall to inner casing	Btu per sq ft sec
R3A(K)	R_3	Net rate of heat received by inner wall due to radiation interchange with opposite wall	Btu per sq ft sec
RAD(L)		Mid-point coordinate of streamtube	-
RC(J)		Ratio of corrected to actual discharge coefficient in Jth hole row	-
RDATA(L)		Nondimensional distance across diffuser inlet plane at point L	-
REAAN(K)	Re	Reynolds number in the inner annulus	-
REFT(K)	Re	Reynolds number in the flame [illegible]	-
RHOREF	ρ_2	De[illegible]t diffuser inlet	lbm per ft^3
RO(L,N)		[illegible] in streamtube adjacent to [illegible] station N in diffuser. L= [illegible] or inner wall, 2 for outer	lbm per ft^3
SA(I)		Inner snout diameter	ft
SAFTRA(K)		Air mass flow rate transpiring through the inner annulus walls between current calculation point and the previous one	lbm per sq ft sec
SHAFST		Fraction of air flowing through secondary holes that recirculates upstream	-
SHAPEH(L,I)	H	Shape factor on wall. L=1 for inner wall, 2 for outer wall	-
SHP(L)		Shape factor of boundary layer on wall at diffuser inlet. L=1 for inner wall, 2 for outer	-

Fortran Name	Symbol	Description	Units
STAGP(N)		Stagnation pressure of Nth streamtube in diffuser	lbf per ft^2
STAGT	T_2	Total temperature of air at compressor outlet	deg R
STEP		Step size used in jet mixing calculations	ft
STPREF	P_2	Mass-averaged total pressure at compressor outlet	lbf per sq ft
TABEFT(L)	ε_{ft}	[illegible] of experimental flame emissivities	-
TABPFT(L)	p_{ft}	Gas pressure in table of experimental flame emissivities	lbf per sq ft
TABTFT(L)	T_{ft}	Gas temperature in table of experimental flame emissivities	deg R
TAN1	$T_{an,1}$	Static temperature of annulus air at previous calculation point	deg R
TAN1A		Static temperature in inner annulus at diffuser exit (Station 4)	deg R
TAN2	$T_{an,2}$	Static temperature of annulus air at current calculation point	deg R
TANANA(K)	T_{an}	Static temperature of air in inner annulus	deg R
TCASA(K)	T_c	Temperature of inner casing	deg R
TCATA(K)	T_c	Temperature of inner casing	deg F
TCFA(K)		Temperature of air entering previous cooling slot on inner wall	deg R
TFT(K)	T_{ft}	Total temperature of gas in flame tube	deg R
TFT1	$T_{ft,1}$	Total temperature of gas in flame tube at previous calculation point	deg R
TFT2	$T_{ft,2}$	Total temperature of gas in flame tube at current calculation point	deg R

Fortran Name	Symbol	Description	Units
THA		Theoretical inlet area for inner annulus	sq ft
THET(L)		Momentum thickness on diffuser wall L=1 for inner wall, 2 for outer	ft
THETT(L,I)		Momentum thickness of the boundary layer in the plane of the snout. L=1 for inner passage, 2 for outer; I=1 for inner wall, 2 for outer.	ft
THIKFT	t_w	Flame-tube wall thickness	ft
THS		Theoretical inlet area for snout	sq ft
TNUAAN(K)	Nu	Nusselt number in inner annulus	-
TNUFT(K)	Nu	Nusselt number in flame tube	-
TOLTW1		Accuracy to which solution of noniterative heat balance required	deg F
TOLTW2		Accuracy to which solution of iterative heat balance required	deg F
TWA(K)	T_w	Flame-tube wall temperature	deg R
TWADA(K)	T_{ad}	Adiabatic-wall temperature on inner wall	deg R
TZ		Zero Fahrenheit expressed in deg R	deg R
UAN1	$U_{an,1}$	Velocity of air in annulus at previous calculation point	ft per sec
UAN2	$U_{an,2}$	Velocity of air in annulus at current calculation point	ft per sec
UANA(K)	U_{an}	Velocity of air in inner annulus	ft per sec
UFT(K)	U_{ft}	Velocity of gas in the flame tube	ft per sec
UFT1	$U_{ft,1}$	Velocity of gas at previous calculation point	ft per sec

Fortran Name	Symbol	Description	Units
UFT2	$U_{ft,2}$	Velocity of gas at current calculation point	ft per sec
UFTA(K)		Velocity of gas in flame tube at previous cooling slot on inner wall	ft per sec
UH	u_j	Initial jet velocity	ft per sec
UJ(L)		Velocity of Lth streamtube	ft per sec
UJCL(J)	$u_{j,}$	Centerline velocity of residual jet from Jth hole row	ft per sec
UJETA(N)	$u_{j,}$	Local velocity at station N in residual-jet transverse velocity profile	ft per sec
UJY(N)		Local velocity at station 2 of diffuser	ft per sec
UJ1A(K)		Velocity of air entering previous cooling slot on inner wall	ft per sec
VEL(L,N)		Velocity in streamtube adjacent to diffuser wall at station N. L=1 for inner wall, 2 for outer	ft per sec
VELJ(L)		Velocity in streamtube adjacent to diffuser wall at inlet. L=1 for inner wall, 2 for outer	ft per sec
VPDATA(L)		Nondimensional velocity at point L across diffuser inlet profile	-
WCD(J)	C_d	Discharge coefficients of holes in Jth row	-
WFFIZ(K)		Rate of fuel burning as a function of axial length	lbm per sec per ft
WI(1,1), WI(2,1)		Diameter of inner casing, outer snout	ft
WIDTHI		Width of rectangular combustor	ft
WIL(1,1), WIL(2,1)		Diameter of inner casing, outer snout, allowing for boundary-layer displacement thickness	ft

Fortran Name	Symbol	Description	Units
WO(1,I), WO(2,I)		Diameter of inner snout, outer casing	ft
WOL(1,I), WOL(2,I)		Diameter of inner snout, outer casing allowing for boundary-layer displacement thickness	ft
WUJ(J)	u_j	Initial jet velocity for Jth hole row	ft per sec
X(I)		Axial location of geometric input point	ft
XIFCA(K)		Axial distance from previous cooling slot on inner wall	ft
XAF23A(L)		Axial location at which cooling is bled from annulus	ft
XCP(K)		Axial location of Kth calculation point	ft
XFILMZ	X_o	Constant in film-cooling correlation	-
XFSA		Fraction of secondary air flowing downstream from secondary holes in the inner annulus	-
XH(J)		Axial location of centerline of Jth hole row	ft
XHU(J)		Axial location of upstream edge of Jth hole row	ft
XINT		Interval downstream of cooling slots at which calculation points required	ft
XLNDTA(L)		Nondimensional length for point L in table of empirical diffuser data	-
XLNDTB(L)		Nondimensional length of point L in table of empirical diffuser data for an alternate set of data	-
XMACH	M_2	Mach number at diffuser inlet	-
XMTB(J)		Mass flow in streamtube J	lbm per sec

Fortran Name	Symbol	Description	Units
XMVA		Mean velocity into inner annulus from first part of diffuser (Station 2)	ft per sec
XMVS		Mean velocity into snout from first part of diffuser (Station 2)	ft per sec
YCFA(K)	Y_{cf}	Height of previous cooling slot on inner wall	ft
Y(N)		Fractional distance across velocity profile at diffuser station 2, allowing for blockage	-
YY		Fractional distance across annulus at diffuser station 2	-
ZAJM(K)		Summation of axial jet momentum for hole rows at current calculation point	lbm ft per sec^2
ZMH(K)	$\Sigma \dot{m}_j$	Summation of jet air mass flow for hole rows at current calculation point	lbm per sec
ZMHA(L)	$\dot{m}_{sy}$	Mass flow through secondary holes. L=1 for inner annulus, 2 for outer annulus	lbm per sec
ZMJUJ(K)		Summation of jet momentum for hole rows at current calculation point	lbm ft per sec
ZMJET(K)		Summation of flow rates of enthalpy with jets for hole rows at current calculation point	ft^2 lbm per sec^3
ZSTOC		Stoichiometric fuel air ratio	-
ZZCP	C_p	Specific heat	Btu per lbm deg F
ZZGAMA	γ	Ratio of specific heat	-
ZZR	R	Gas constant	ft lbf per lbm deg R

APPENDIX VII

LISTING OF LIBRARY DATA

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........*.........*.........*.........*.........*.........*.........*.........*
      100                                                               DATA0001
        10.0625    0.01227      10    91.        0.         0.        DADATA0002
           2.         .33                  4.        .477                 DATA0003
           8.         .555                 16.       .597                 DATA0004
           32.        .623                 64.       .642                 DATA0005
           128.       .65                  256.      .656                 DATA0006
        20.125     0.04909      10    91.        0.         0.        DADATA0007
           2.         .347                 4.        .49                  DATA0008
           8.         .556                 16.       .587                 DATA0009
           32.        .597                 64.       .6                   DATA0010
           128.       .6                   256.      .6                   DATA0011
        30.164     0.0845        0    71.        0.         0.        DADATA0012
           2.         .475      62.        4.        .525       66.       DATA0013
           8.         .565      69.        16.       .602       72.       DATA0014
           32.        .635      75.        64.       .655       77.       DATA0015
        40.236     0.175         0    71.        0.         0.        DADATA0016
           2.         .45       52.        4.        .55        63.       DATA0017
           8.         .61       69.        16.       .645       73.       DATA0018
           32.        .66       77.        64.       .67        80.       DATA0019
        5.375      .4418         0    51.        0.         0.        DADATA0020
           2.         .36       50.        4.        .48        62.       DATA0021
           8.         .545      67.        16.       .6         70.       DATA0022
        60.375     0.4418       10    91.        0.         0.        DADATA0023
           2.         .343                 4.        .485                 DATA0024
           8.         .542                 16.       .564                 DATA0025
           32.        .573                 64.       .58                  DATA0026
           128.       .583                 256.      .588                 DATA0027
        70.375     0.4418       10    71.        0.                   DADATA0028
           2.         .365                 4.        .495                 DATA0029
           8.         .55                  16.       .571                 DATA0030
           32.        .584                 64.       .589                 DATA0031
        8.375      .4418        10    61.        0.                   DADATA0032
           2.         .38                  4.        .505                 DATA0033
           8.         .552                 16.       .575                 DATA0034
           32.        .59                                               DATA0035
        9.3795     .4525         0    51.        0.         0.          DATA0036
           2.         .36       55.        4.        .5         56.       DATA0037
           8.         .555      67.        16.       .56        70.       DATA0038
       10.4035     .5115         0    71.        0.         0.        DADATA0039
           2.         .4        57.        4.        .54        67.       DATA0040
           8.         .6        73.        16.       .625       77.       DATA0041
           32.        .64       80.        64.       .64        81.       DATA0042
       11.4925     .762          0    51.        0.         0.        DADATA0043
           2.         .36       58.        4.        .505       67.       DATA0044
           8.         .575      74.        16.       .61        79.       DATA0045
       120.75      1.767        10    71.        0.                   DADATA0046
           2.         .381                 4.        .498                 DATA0047
           8.         .55                  16.       .57                  DATA0048
           32.        .578                 64.       .582                 DATA0049
       130.795     1.986         0    41.        0.         0.        DADATA0050
           2.         .395      63.        4.        .51        70.       DATA0051
           8.         .575      76.                                       DATA0052
       14.9045     2.57          0    51.        0.         0.        DADATA0053
           2.         .38       59.        4.        .52        60.       DATA0054
           8.         .58       70.        16.       .58        80.       DATA0055
       15.25       .25          10    71.        0.                   DADATA0056
           2.         .358                 4.        .495                 DATA0057
           8.         .553                 16.       .578                 DATA0058
           32.        .588                 64.       .585                 DATA0059
       16.354      .5013         0    61.        0.         0.          DATA0060
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*........*.........*.........*.........*.........*.........*.........*.........*
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        8.        .588      72.       16.       .617      78.          DATA0062
       32.        .625.     80.                                        DATA0063
     17.206     .0849        0    71.        0.        0.              DATA0064
        2.        .48       53.        4.       .535      63.          DATA0065
        8.        .585      69.       16.       .62       74.          DATA0066
       32.        .645      76.       64.       .655      78.          DATA0067
     18.218     .0848        0    71.        0.        0.              DATA0068
        2.        .4        52.        4.       .51       61.          DATA0069
        8.        .585      68.       16.       .625      72.          DATA0070
       32.        .645      75.       64.       .65       77.          DATA0071
     19.2955    .1743        0    71.        0.        0.              DATA0072
        2.        .316      48.        4.       .48       58.          DATA0073
        8.        .565      66.       16.       .61       71.          DATA0074
       32.        .62       75.       64.       .627      78.          DATA0075
     20.312     .1738        0    71.        0.        0.              DATA0076
        2.        .325      51.        4.       .51       60.          DATA0077
        8.        .585      66.       16.       .615      71.          DATA0078
       32.        .63       75.       64.       .64       78.          DATA0079
     21.5       .5743        0    71.        0.        0.              DATA0080
        2.        .377      48.        4.       .52       62.          DATA0081
        8.        .587      71.       16.       617.      77.          DATA0082
       32.        .626      81.       64.       .63       84.          DATA0083
     22.5       .5          10    71.        0.                      DADATA0084
        2.        .38                  4.       .508                   DATA0085
        8.        .561                16.       .584                   DATA0086
       32.        .594                64.       .6                     DATA0087
     23.531     .5035        0    71.        0.        0.              DATA0088
        2.        .385      49.        4.       .503      62.          DATA0089
        8.        .552      72.       16.       .575      78.          DATA0090
       32.        .58       81.       64.       .585      83.          DATA0091
     24.62      .7688        0    51.        0.        0.              DATA0092
        2.        .39       47.        4.       .504      64.          DATA0093
        8.        .564      73.       16.       .59       79.          DATA0094
     25.656     .7685        0    61.        0.        0.              DATA0095
        2.        .412      51.        4.       .537      66.          DATA0096
        8.        .575      74.       16.       .595      79.          DATA0097
       32.        .595      81.                                        DATA0098
     261.       2.688        0    51.        0.        0.              DATA0099
        2.        .44       56.        4.       .538      70.          DATA0100
        8.        .567      76.       16.       .575      77.          DATA0101
     271.       2.          10    71.        0.                      DADATA0102
        2.        .388                 4.       .511                   DATA0103
        8.        .563                16.       .587                   DATA0104
       32.        .596                64.       .6                     DATA0105
     281.067    2.0138       0    41.        0.        0.              DATA0106
        2.        .44       57.        4.       .55       70.          DATA0107
        8.        .59       76.                                        DATA0108
     29.71      .5041        0    61.        0.        0.              DATA0109
        2.        .413      42.        4.       .525      60.          DATA0110
        8.        .585      71.       16.       .611      78.          DATA0111
       32.        .62       83.                                        DATA0112
     30.7485    .53128       0    61.        0.        0.              DATA0113
        2.        .45       49.        4.       .565      64.          DATA0114
        8.        .62       73.       16.       .645      80.          DATA0115
       32.        .65       84.                                        DATA0116
     312.       2.          10    71.        0.                      DADATA0117
        2.        .425                 4.       .537                   DATA0118
        8.        .576                16.       .592                   DATA0119
       32.        .597                64.       .6                     DATA0120
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    321.        .5041         0  61.        0.         0.              DATA0121
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          8.        .605    74.      16.       .62        79.          DATA0123
         32.         .63    82.                                        DATA0124
    331.05      .9534         0  61.        0.         0.              DATA0125
          2.        .435    55.       4.       .56        63.          DATA0126
          8.        .605    69.      16.       .625       74.          DATA0127
         32.        .635    78.                                        DATA0128
    342.        1.           10  71.        0.                       DADATA0129
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    35.2375     .1772        10  61.        0.                       DADATA0133
          2.         .43              4.       .57                     DATA0134
          8.         .65             16.       .683                    DATA0135
         32.          .7                                               DATA0136
    36.3125     .3068        10  61.        0.                       DADATA0137
          2.         .47              4.       .58                     DATA0138
          8.         .64             16.       .67                     DATA0139
         32.        .705                                               DATA0140
    37.396      .4927        10  61.        0.                       DADATA0141
          2.         .38              4.       .506                    DATA0142
          8.         .58             16.       .633                    DATA0143
         32.         .65                                               DATA0144
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          2.          .4    65.       4.       .585       68.          DATA0146
          8.        .687    75.      16.       .735       75.          DATA0147
    39 .1       2.602         0  51.        0.         86.           DADATA0148
          2.        .425    65.       4.       .59        70.          DATA0149
          8.        .685    77.      16.       .75        84.          DATA0150
    40.914      2.624         0  51.        0.         87.           DADATA0151
          2.         .44    63.       4.       .62        68.          DATA0152
          8.         .73    73.      16.       .8         80.          DATA0153
    41.916      2.636         0  51.        0.         84.           DADATA0154
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          8.        .594    74.      16.       .63        76.          DATA0156
    421.1405    2.57          0  51.        0.         56.           DADATA0157
          2.          .5    54.       4.       .685       62.          DATA0158
          8.         .76    70.      16.       .765       80.          DATA0159
    430.        .095         12  8.519      0.                       DADATA0160
          1.        .855              2.       .85                     DATA0161
          4.        .832              8.       .817                    DATA0162
         16.        .804             32.       .798                    DATA0163
         64.         .79                                               DATA0164
    440.        .095         12  8.519      0.                       DADATA0165
          1.        .832              2.       .836                    DATA0166
          4.        .827              8.       .817                    DATA0167
         16.        .813             32.       .812                    DATA0168
         64.        .812                                               DATA0169
    450.        .104         12  8.531      0.                       DADATA0170
          1.        .924              2.       .895                    DATA0171
          4.        .842              8.       .805                    DATA0172
         16.        .784             32.       .763                    DATA0173
         64.         .75                                               DATA0174
    460.        .168         12  8.531      0.                         DATA0175
          1.        .947              2.       .905                    DATA0176
          4.        .842              8.       .795                    DATA0177
         16.        .768             32.       .747                    DATA0178
         64.        .737                                               DATA0179
    470.        .25          12  9.43       0.                       DADATA0180
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P.B.....*.........*.........*.........*.........*.........*.........*.........*
      .5       .858               1.      .922                 DATA0181
      2.       .89                4.      .856                 DATA0182
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     32.       .8                64.      .79                  DATA0184
  480.        .25        12    9.43     0.                   DADATA0185
      .5       .917               1.      .878                 DATA0186
      2.       .852               4.      .83                  DATA0187
      8.       .813              16.      .8                   DATA0188
     32.       .787              64.      .78                  DATA0189
  490.        .255       12    9.465    0.                   DADATA0190
      .5       .6                 1.      .976                 DATA0191
      2.       .896               4.      .853                 DATA0192
      8.       .781              16.      .751                 DATA0193
     32.       .73               64.      .717                 DATA0194
  500.        .26        12    9.44     0.                   DADATA0195
      .5       .665               1.      .958                 DATA0196
      2.       .905               4.      .816                 DATA0197
      8.       .79               16.      .758                 DATA0198
     32.       .737              64.      .721                 DATA0199
  510.        .38        12    9.4      0.                     DATA0200
      .5       .77                1.      .958                 DATA0201
      2.       .915               4.      .833                 DATA0202
      8.       .768              16.      .735                 DATA0203
     32.       .71               64.      .69                  DATA0204
  520.        .623       12   10.219    0.                   DADATA0205
      .25      .215               .5      .85                  DATA0206
      1.       .974               2.      .926                 DATA0207
      4.       .833               8.      .773                 DATA0208
     16.       .716              32.      .687                 DATA0209
     64.       .666                                            DATA0210
  53.9215     2.668       1    6.66     0.        0.         DADATA0211
      1.       .36      48.       2.      .49      33.         DATA0212
      4.       .51      32.       8.      .495     35.         DATA0213
     16.       .44      38.                                    DATA0214
  541.        1.3097      1    6.82     0.        0.         DADATA0215
      1.       .22      60.       2.      .62      78.         DATA0216
      4.       .62      85.       8.      .62      84.         DATA0217
     16.       .62      84.                                    DATA0218
  551.        2.28        1    6.56     0.        0.         DADATA0219
      1.       .66      48.       2.      .835     48.         DATA0220
      4.       .85      49.       8.      .81      50.         DATA0221
     16.       .7       50.                                    DATA0222
  56.643      .958        1    7.28     0.        85.        DADATA0223
      .5       .32      85.       1.      .67      73.         DATA0224
      2.       .74      70.       4.      .73      68.         DATA0225
      8.       .71      67.      16.      .71      67.         DATA0226
  571.        1.679       1    6.58     0.        58.        DADATA0227
      1.       .52      58.       2.      .63      38.         DATA0228
      4.       .66      35.       8.      .66      35.         DATA0229
     16.       .66      35.                                    DATA0230
  581.15      1.3         1    6.8      0.        50.        DADATA0231
      1.       .64      45.       2.      .86      38.         DATA0232
      4.       .913     38.       8.      .915     38.         DATA0233
     16.       .91      38.                                    DATA0234
  59.525      .99         0    6.96     0.                   DADATA0235
      1.       .12      0.        2.      .66      46.         DATA0236
      4.       .84      56.       8.      .915     65.         DATA0237
     16.       .94      72.                                    DATA0238
  60.525      .99         1    6.92     0.        80.        DADATA0239
      1.       .14      80.       2.      .55      80.         DATA0240
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*.........*.........*.........*.........*.........*.........*.........*.........*
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           16.        .68         78.                                     DATA0242
        61.525      .99             0   6.92       0.        80.        DADATA0243
            1.        .18         80.       2.       .58       80.        DATA0244
            4.        .67         58.       8.       .69       66.        DATA0245
           16.        .7          90.                                     DATA0246
        62.525      .99             0   6.94       0.        80.        DADATA0247
            1.        .12         80.       2.       .55       80.        DATA0248
            4.        .65         63.       8.       .685      68.        DATA0249
           16.        .7          80.                                     DATA0250
        63.395      .4582           0   6.96       0.        0.         DADATA0251
            1.        .2          10.       2.       .75       50.        DATA0252
            4.        .87         62.       8.       .95       70.        DATA0253
           16.        .98         72.                                     DATA0254
        64.395      .4582           0   6.8        0.        82.        DADATA0255
            1.        .24         82.       2.       .72       78.        DATA0256
            4.        .87         74.       8.       .9        74.        DATA0257
           16.        .91         70.                                     DATA0258
        65.395      .4582           1   6.86       0.        90.        DADATA0259
            1.        .18         90.       2.       .68       90.        DATA0260
            4.        .775        75.       8.       .8        75.        DATA0261
           16.        .8          75.                                     DATA0262
        66.395      .4582           1   6.84       0.        90.        DADATA0263
            1.        .32         90.       2.       .73       65.        DATA0264
            4.        .79         65.       8.       .79       65.        DATA0265
           16.        .75         65.                                     DATA0266
        671.15      1.3             1   6.52       0.        90.        DADATA0267
            1.        .64         62.       2.       .765      51.        DATA0268
            4.        .79         51.       8.       .79       52.        DATA0269
           16.        .79         52.                                     DATA0270
        681.15      1.561           1   7.4        0.        55.        DADATA0271
            .5        .14         55.       1.       .56       55.        DATA0272
            2.        .72         55.       4.       .72       55.        DATA0273
            8.        .72         55.      16.       .72       55.        DATA0274
        691.15      1.822           1   7.43       0.        48.        DADATA0275
            .5        .12         48.       1.       .48       48.        DATA0276
            2.        .57         44.       4.       .57       45.        DATA0277
            8.        .56         45.      16.       .54       45.        DATA0278
        701.15      1.3             1   6.54       0.        58.          DATA0279
            1.        .63         58.       2.       .77       60.        DATA0280
            4.        .8          57.       8.       .8        56.        DATA0281
           16.        .8          55.                                     DATA0282
        711.15      2.598           1   7.48       0.        57.        DADATA0283
            .5        .04         57.       1.       .6        57.        DATA0284
            2.        .72         58.       4.       .7        58.        DATA0285
            8.        .69         60.      16.       .69       60.        DATA0286
        720.01      .1367          11   8.521      0.                   DADATA0287
            1.        .885                  2.       .837                 DATA0288
            4.        .8                    8.       .772                 DATA0289
           16.        .757                 32.       .747                 DATA0290
           64.        .741                                                DATA0291
        730.01      .2186          11   9.476      0.                   DADATA0292
            .5        .2                    1.       .877                 DATA0293
            2.        .882                  4.       .853                 DATA0294
            8.        .807                 16.       .772                 DATA0295
           32.        .747                 64.       .73                  DATA0296
        74.375      .4418          11  10.216      0.                   DADATA0297
           .25        .1                    .5       .37                  DATA0298
            1.        .437                  2.       .434                 DATA0299
            4.        .415                  8.       .4                   DATA0300
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*.........*.........*.........*.........*.........*.........*.........*.........*
           16.        .39                 32.       .38                 DATA0301
           64.        .37                                               DATA0302
       75.375       .4418        11   11.088      0.                  DADATA0303
           .125       .38                 .25       .46                 DATA0304
           .5         .515                1.        .534                DATA0305
           2.         .535                4.        .53                 DATA0306
           8.         .524                16.       .517                DATA0307
           32.        .51                 64.       .502                DATA0308
       76.375       .4418        11   13.022      0.                  DADATA0309
           .03125     .17                 .0625     .86                 DATA0310
           .125       .67                 .25       .585                DATA0311
           .5         .6                  1.        .605                DATA0312
           2.         .6                  4.        .597                DATA0313
           8.         .59                 16.       .586                DATA0314
           32.        .585                64.       .583                DATA0315
       77.01        .4418        11   9.286       0.                  DADATA0316
           .5         .46                 1.        .57                 DATA0317
           2.         .576                4.        .566                DATA0318
           8.         .55                 16.       .536                DATA0319
           32.        .525                64.       .516                DATA0320
       781.5775     2.616        10   6.96        0.                  DADATA0321
           1.         .055                2.        .560                DATA0322
           4.         .710                8.        .786                DATA0323
           16.        .78                                               DATA0324
       791.5775     1.876        11   6.63        0.                  DADATA0325
           1.         .35                 2.        .75                 DATA0326
           4.         .805                8.        .81                 DATA0327
           16.        .81                                               DATA0328
       801.5775     1.659        11   6.7         0.                  DADATA0329
           1.         .31                 2.        .89                 DATA0330
           4.         .96                 8.        .965                DATA0331
           16.        .94                                               DATA0332
       81.4075      .2543        11   9.36        0.                  DADATA0333
           .5         .65                 1.        .83                 DATA0334
           2.         .815                4.        .72                 DATA0335
           8.         .656                16.       .612                DATA0336
           32.        .6                  64.       .6                  DATA0337
       82.4075      .2543        11   9.345       0.                  DADATA0338
           .5         .72                 1.        .858                DATA0339
           2.         .85                 4.        .79                 DATA0340
           8.         .736                16.       .687                DATA0341
           32.        .65                 64.       .64                 DATA0342
       83.4         .2543        11   9.36        0.                  DADATA0343
           .5         .6                  1.        .92                 DATA0344
           2.         .915                4.        .843                DATA0345
           8.         .745                16.       .7                  DATA0346
           32.        .675                64.       .665                DATA0347
       84.4075      .2543        11   9.42        0.                  DADATA0348
           .5         .37                 1.        .725                DATA0349
           2.         .74                 4.        .704                DATA0350
           8.         .666                16.       .63                 DATA0351
           32.        .61                 64.       .58                 DATA0352
       85.35        .2125        11   6.4         0.                  DADATA0353
           .5         .68                 1.        .73                 DATA0354
           2.         .7                  4.        .676                DATA0355
           8.         .66                                               DATA0356
       86.35        .425         11   5.5         0.                  DADATA0357
           1.         .28                 2.        .608                DATA0358
           4.         .65                 8.        .632                DATA0359
       87.23        .578         11   13.011      0.                  DADATA0360
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.........*.........*.........*.........*.........*.........*.........*.........*
           .03125    .4                  .0625     .5                  DATA0361
           .125      .6                  .25       .665                DATA0362
           .5        .684                1.        .69                 DATA0363
           2.        .68                 4.        .674                DATA0364
           8.        .67                 16.       .664                DATA0365
           32.       .66                 64.       .66                 DATA0366
       88.075      .3871        11    8.17       0.                  DADATA0367
           .25       .578                .5        .74                 DATA0368
           1.        .79                 2.        .775                DATA0369
           4.        .72                 8.        .67                 DATA0370
           16.       .636                                              DATA0371
       89.24       .3871        11    8.17       0.                  DADATA0372
           .25       .507                .5        .55                 DATA0373
           1.        .52                 2.        .52                 DATA0374
           4.        .508                8.        .51                 DATA0375
           16.       .515                                              DATA0376
       90.12       .3871        11    8.17       0.                  DADATA0377
           .25       .185                .5        .27                 DATA0378
           1.        .29                 2.        .28                 DATA0379
           4.        .29                 8.        .295                DATA0380
           16.       .313                                              DATA0381
       91.285      .2775        11   10.125      .69                 DADATA0382
           .25       .88                 .5        .917                DATA0383
           1.        .9                  2.        .86                 DATA0384
           4.        .8                  8.        .75                 DATA0385
           16.       .725                32.       .715                DATA0386
           64.       .705                                              DATA0387
       92.1625     .2405        11   10.15       0.                  DADATA0388
           .25       .65                 .5        .88                 DATA0389
           1.        .945                2.        .92                 DATA0390
           4.        .88                 8.        .87                 DATA0391
           16.       .835                32.       .82                 DATA0392
           64.       .825                                              DATA0393
       93.1625     .4028        11   10.15       0.                  DADATA0394
           .25       .35                 .5        .52                 DATA0395
           1.        .58                 2.        .54                 DATA0396
           4.        .52                 8.        .505                DATA0397
           16.       .5                  32.       .5                  DATA0398
           64.       .495                                              DATA0399
       94.375      .4169        11   11.12       0.                  DADATA0400
           .125      .045                .25       .772                DATA0401
           .5        .8                  1.        .754                DATA0402
           2.        .684                4.        .61                 DATA0403
           8.        .57                 16.       .558                DATA0404
           32.       .552                64.       .55                 DATA0405
       95.4375     .3853        11    9.33       0.                  DADATA0406
           .5        .55                 1.        .82                 DATA0407
           2.        .83                 4.        .8                  DATA0408
           8.        .75                 16.       .71                 DATA0409
           32.       .67                 .64       .653                DATA0410
       96.1875     .1134        11    8.5        .8                  DADATA0411
           1.        .836                2.        .826                DATA0412
           4.        .79                 8.        .75                 DATA0413
           16.       .72                 32.       .69                 DATA0414
           64.       .68                                               DATA0415
       97.34       .104         11    8.565      0.                  DADATA0416
           1.        .817                2.        .822                DATA0417
           4.        .78                 8.        .742                DATA0418
           16.       .717                32.       .69                 DATA0419
           64.       .66                                               DATA0420
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*.........*.........*.........*.........*.........*.........*.........*.........*
        98.345      .1291        11   8.52       0.                  DADATA0421
            1.        .82                2.         .83                DATA0422
            4.        .82                8.         .773               DATA0423
           16.        .73               32.         .69                DATA0424
           64.        .66                                              DATA0425
        99.345      .1958        11   9.39       0.                  DADATA0426
            .5        .66                1.         .832               DATA0427
            2.        .827               4.         .77                DATA0428
            8.        .71               16.         .66                DATA0429
           32.        .635              64.         .643               DATA0430
       100.46       .4423        11   9.39       0.                  DADATA0431
            .5        .74                1.         .86                DATA0432
            2.        .86                4.         .81                DATA0433
            8.        .74               16.         .67                DATA0434
           32.        .64               64.         .65                DATA0435
                                                                       I
         2                                                              DIFF0001
        50        50                                                    DIFF0002
         1        168       168        12      -133  0.98               DIFF0003
  0.85      0.75      0.3       0.2       0.2       0.2       0.2       DIFF0004
  0.2       0.2       0.2       0.2       0.2       0.2       0.2       DIFF0005
  0.73      0.85      0.85      0.78      0.6       0.4       0.2       DIFF0006
  0.2       0.2       0.2       0.2       0.2       0.2       0.2       DIFF0007
  0.67      0.8       0.85      0.85      0.83      0.8       0.7       DIFF0008
  0.6       0.4       0.2       0.2       0.2       0.2       0.2       DIFF0009
  0.63      0.76      0.81      0.83      0.85      0.83      0.8       DIFF0010
  0.7       0.6       0.4       0.2       0.2       0.2       0.2       DIFF0011
  0.58      0.72      0.78      0.81      0.83      0.83      0.8       DIFF0012
  0.7       0.6       0.4       0.2       0.2       0.2       0.2       DIFF0013
  0.5       0.69      0.76      0.79      0.83      0.83      0.8       DIFF0014
  0.7       0.6       0.4       0.2       0.2       0.2       0.2       DIFF0015
  0.5       0.66      0.74      0.77      0.79      0.80      0.83      DIFF0016
  0.83      0.8       0.7       0.6       0.4       0.2       0.2       DIFF0017
  0.5       0.63      0.72      0.76      0.78      0.8       0.83      DIFF0018
  0.83      0.8       0.7       0.6       0.4       0.2       0.2       DIFF0019
  0.5       0.62      0.71      0.75      0.77      0.80      0.83      DIFF0020
  0.83      0.8       0.7       0.6       0.4       0.2       0.2       DIFF0021
  0.5       0.61      0.69      0.74      0.77      0.8       0.83      DIFF0022
  0.83      0.8       0.7       0.6       0.4       0.2       0.2       DIFF0023
  0.5       0.58      0.62      0.71      0.74      0.75      0.8       DIFF0024
  0.83      0.83      0.8       0.7       0.6       0.4       0.2       DIFF0025
  0.5       0.55      0.58      0.65      0.72      0.75      0.8       DIFF0026
  0.83      0.83      0.8       0.7       0.6       0.4       0.2       DIFF0027
  1.1       1.2       1.3       1.4       1.5       1.6       1.7       DIFF0028
  1.8       1.9       2.0       2.1       2.2       2.3       2.4       DIFF0029
  1.1       1.2       1.3       1.4       1.52      1.62      1.75      DIFF0030
  1.8       1.9       2.0       2.1       2.2       2.3       2.4       DIFF0031
  1.1       1.2       1.3       1.4       1.51      1.6       1.74      DIFF0032
  1.83      2.0       2.27      2.4       2.5       3.0       3.5       DIFF0033
  1.1       1.2       1.3       1.4       1.5       1.69      1.84      DIFF0034
  2.05      2.16      2.45      2.9       3.1       3.3       3.5       DIFF0035
  1.1       1.2       1.3       1.4       1.56      1.78      2.09      DIFF0036
  2.36      2.5       2.95      3.6       3.7       3.8       3.9       DIFF0037
  1.1       1.2       1.3       1.4       1.67      2.08      2.32      DIFF0038
  2.68      2.86      3.5       4.4       4.6       4.8       5.0       DIFF0039
  1.1       1.2       1.3       1.4       1.5       1.54      1.8       DIFF0040
  2.3       2.6       3.0       3.25      4.12      5.5       5.6       DIFF0041
  1.1       1.2       1.3       1.4       1.5       1.6       1.91      DIFF0042
  2.53      2.84      3.36      3.67      4.83      6.5       6.6       DIFF0043
  1.1       1.2       1.3       1.4       1.5       1.69      2.03      DIFF0044
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*........*.........*.........*.........*.........*.........*.........*.........*
  2.77      3.15      3.75      4.15      5.6       7.6       7.8       DIFF0045
  1.1       1.2       1.3       1.4       1.5       1.78      2.14      DIFF0046
  3.05      3.45      4.2       4.65      6.5       8.9       9.0       DIFF0047
  1.1       1.2       1.3       1.4       1.5       1.56      1.96      DIFF0048
  2.36      3.68      4.17      5.17      5.85      8.4       11.0      DIFF0049
  1.1       1.2       1.3       1.4       1.5       1.72      2.21      DIFF0050
  2.68      4.8       5.4       7.0       8.0       10.0      15.0      DIFF0051
  1.0       2.0       3.0       4.0       5.0       6.0       7.0       DIFF0052
  8.0       9.0       10.0      12.0      15.0                          DIFF0053
         2       168       168        12      -133  0.98                DIFF0054
  0.9       0.9       0.88      0.87      0.86      0.8       0.67      DIFF0055
  0.58      0.47      0.4       0.3       0.3       0.3       0.3       DIFF0056
  0.88      0.9       0.9       0.88      0.86      0.85      0.8       DIFF0057
  0.7       0.6       0.4       0.3       0.3       0.3       0.3       DIFF0058
  0.87      0.9       0.9       0.9       0.88      0.875     0.85      DIFF0059
  0.8       0.7       0.6       0.4       0.3       0.3       0.3       DIFF0060
  0.85      0.88      0.9       0.9       0.9       0.9       0.875     DIFF0061
  0.85      0.8       0.7       0.6       0.4       0.3       0.3       DIFF0062
  0.82      0.875     0.9       0.9       0.91      0.9       0.875     DIFF0063
  0.85      0.8       0.7       0.6       0.4       0.3       0.3       DIFF0064
  0.77      0.86      0.875     0.89      0.91      0.91      0.9       DIFF0065
  0.875     0.85      0.8       0.7       0.6       0.4       0.3       DIFF0066
  0.74      0.85      0.87      0.88      0.91      0.91      0.9       DIFF0067
  0.875     0.85      0.8       0.7       0.6       0.4       0.3       DIFF0068
  0.875     0.85      0.8       0.7       0.6       0.4       0.3       DIFF0069
  0.7       0.84      0.86      0.88      0.9       0.91      0.9       DIFF0070
  0.6       0.82      0.85      0.88      0.9       0.9       0.9       DIFF0071
  0.875     0.85      0.8       0.7       0.6       0.4       0.3       DIFF0072
  0.5       0.8       0.85      0.87      0.875     0.9       0.9       DIFF0073
  0.875     0.85      0.8       0.7       0.6       0.4       0.3       DIFF0074
  0.5       0.7       0.8       0.86      0.875     0.89      0.89      DIFF0075
  0.875     0.85      0.8       0.75      0.7       0.6       0.5       DIFF0076
  0.5       0.6       0.7       0.8       0.85      0.875     0.885     DIFF0077
  0.875     0.85      0.8       0.75      0.7       0.6       0.5       DIFF0078
  1.1       1.2       1.3       1.4       1.5       1.6       1.7       DIFF0079
  1.8       1.9       2.0       2.1       2.2       2.3       2.4       DIFF0080
  1.1       1.2       1.3       1.4       1.5       1.62      1.7       DIFF0081
  1.84      2.0       2.3       2.6       2.9       3.0       3.1       DIFF0082
  1.1       1.2       1.3       1.4       1.5       1.55      1.7       DIFF0083
  1.84      2.07      2.26      2.7       3.0       3.3       3.6       DIFF0084
  1.1       1.2       1.3       1.4       1.5       1.55      1.66      DIFF0085
  1.8       2.0       2.31      2.53      3.2       3.5       3.7       DIFF0086
  1.1       1.2       1.3       1.4       1.5       1.67      1.77      DIFF0087
  1.93      2.2       2.57      2.83      3.65      4.0       4.2       DIFF0088
  1.1       1.2       1.3       1.4       1.5       1.65      1.76      DIFF0089
  1.9       2.07      2.4       2.8       3.17      4.1       4.6       DIFF0090
  1.1       1.2       1.3       1.4       1.5       1.7       1.9       DIFF0091
  2.04      2.25      2.6       3.08      3.48      4.7       5.0       DIFF0092
  1.1       1.2       1.3       1.4       1.48      1.7       2.04      DIFF0093
  2.18      2.45      2.8       3.32      3.8       5.2       6.0       DIFF0094
  1.1       1.2       1.3       1.4       1.53      1.7       2.08      DIFF0095
  2.32      2.6       3.0       3.6       4.1       5.8       6.5       DIFF0096
  1.1       1.2       1.3       1.4       1.42      1.6       2.07      DIFF0097
  2.43      2.75      3.2       3.9       4.5       6.3       7.0       DIFF0098
  1.1       1.2       1.3       1.4       1.52      1.7       2.1       DIFF0099
  2.55      3.05      3.55      4.0       4.5       5.2       6.0       DIFF0100
  1.1       1.2       1.3       1.4       1.5       1.74      2.3       DIFF0101
  2.8       3.55      4.0       4.8       5.4       6.5       7.5       DIFF0102
  1.0       2.0       3.0       4.0       5.0       6.0       7.0       DIFF0103
  8.0       9.0       10.0      12.0      15.0                          DIFF0104
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  YOUR CARD TCTAL IS ---              541
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