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**SUPERENERGY-2:
A Multiassembly, Steady-State
Computer Code for LMFBR
Core Thermal-Hydraulic
Analysis**

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N. E. Todreas

MASTER

August 1980

Prepared for the U.S. Department of Energy
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NOMENCLATURE

- A_{C1} = Cross sectional area of a side node in the inner duct wall of a double-ducted assembly $m^2(ft^2)$
- A_{C2} = Cross sectional area of a corner node in the inner duct wall of a double-ducted assembly $m^2(ft^2)$
- A_{C3} = Axial flow area of a bypass gap side channel in a double-ducted assembly $m^2(ft^2)$
- A_{C4} = Axial flow area of a bypass gap corner channel in a double-ducted assembly $m^2(ft^2)$
- A_{r1} = Projected area of wire in interior subchannel $m^2(ft^2)$
- A_{r2} = Projected area of wire in side subchannel $m^2(ft^2)$
- A_{s1} = Interior subchannel area excluding wire $m^2(ft^2)$
- A_{s2} = Side subchannel area excluding wire $m^2(ft^2)$
- A_T = Total bundle axial flow area $m^2(ft^2)$
- A_{TC} = Total axial flow area in bypass gap for double-ducted assembly $m^2(ft^2)$
- A_1 = Interior subchannel axial flow area $m^2(ft^2)$
- A_2 = Side subchannel axial flow area $m^2(ft^2)$
- A_3 = Corner subchannel axial flow area $m^2(ft^2)$
- A_4 = Cross sectional area of assembly duct wall side node $m^2(ft^2)$
- A_5 = Cross sectional area of assembly duct wall corner node $m^2(ft^2)$
- A_6 = Interassembly gap side subchannel axial flow area $m^2(ft^2)$
- A_7 = Interassembly gap corner subchannel axial flow area $m^2(ft^2)$
- C = Ratio of the superficial swirl velocity to the bundle-averaged superficial axial velocity (Table 4.2)
- C_L = Ratio of the superficial swirl velocity to the periphery superficial axial velocity (Table 4.2)

C_p = Coolant specific heat j/kg-K (Btu/lbm-°F)
 C_1 = Ratio of the swirl velocity to the bundle-averaged axial velocity (Table 4.2)
 C_{1L} = Ratio of the swirl velocity to the periphery axial velocity (Table 4.2)
 D = Fuel pin diameter m(ft)
 D_e = Equivalent hydraulic diameter m(ft)
 De_{C1} = Equivalent diameter of a bypass gap side subchannel m(ft)
 De_{C2} = Equivalent hydraulic diameter of a bypass gap corner subchannel m(ft)
 De_1 = Equivalent hydraulic diameter of an interior subchannel m(ft)
 De_2 = Equivalent hydraulic diameter of a side subchannel m(ft)
 De_3 = Equivalent hydraulic diameter of a corner subchannel m(ft)
 De_4 = Equivalent hydraulic diameter of an interassembly gap side subchannel m(ft)
 De_5 = Equivalent hydraulic diameter of an interassembly gap corner subchannel m(ft)
 D_F = Pin bundle duct inside flat-to-flat distance m(ft)
 D_S = Shaved wire wrap diameter m(ft)
 D_w = Wire wrap diameter m(ft)
 f = Smooth tube friction factor
 f_I = Interior channel rod fraction
 f_E = Edge channel rod fraction
 g = Distance between the inside duct wall and the outer ring of fuel pins m(ft)
 g_C = Bypass gap width for double-ducted assembly m(ft)
 g_I = Interassembly gap width m(ft)

g_0 = Acceleration due to gravity
 Gr = Grashoff number
 H = Wire wrap lead length m(ft)
 k = sodium conductivity W/m-C (Btu/hr-ft-°F)
 L = Bundle axial length m(ft)
 L_{C1} = Pin bundle duct wall outside length along perimeter of bypass gap corner channel in double-ducted assembly m(ft)
 L_{C2} = Assembly duct wall inside length along perimeter of bypass gap corner channel in double-ducted assembly m(ft)
 L_1 = Pin bundle duct wall inside length along perimeter of corner channel m(ft)
 L_2 = Assembly duct wall inside length along perimeter of interassembly gap corner channel m(ft)
 M_1 = Interior channel flow rate kg/sec (lbm/hr)
 M_2 = Side channel flow rate kg/sec (lbm/hr)
 M_3 = Corner channel flow rate kg/sec (lbm/hr)
 M_4 = Bypass gap side channel flow rate kg/sec (lbm/hr)
 M_5 = Bypass gap corner channel flow rate kg/sec (lbm/hr)
 M_6 = Interassembly gap side channel flow rate kg/sec (lbm/hr)
 M_7 = Interassembly gap corner channel flow rate kg/sec (lbm/hr)
 N_{RING} = User input number of channel rings in lumped bundle (see Input 2.3 in Appendix A)
 N_{ROD} = Number of fuel rods in bundle
 N_{ROW} = Number of subchannel rings in unlumped bundle
 N_1 = Number of interior subchannels
 N_2 = Number of side subchannels
 N_3 = Number of corner subchannels

P = Fuel pin pitch m(ft)
 P_{C3} = Bypass gap side channel wetted perimeter m(ft)
 P_{C4} = Bypass gap side channel wetted perimeter m(ft)
 P_I = Lumped channel pitch m(ft)
 P_{NII} = Side channel perimeter normal channel flow to interior-side m(ft)
 P_{SII} = Side channel perimeter normal to swirl flow m(ft)
 P_{W1} = Interior subchannel wetted perimeter m(ft)
 P_{W2} = Side subchannel wetted perimeter m(ft)
 P_{W3} = Corner subchannel wetted perimeter m(ft)
 q_{BC}'' = Heat flux applied by facial boundary conditions w/m^2 (Btu/hr-ft²)
 q_o' = Subchannel linear heat generation rate w/m (Btu/hr-ft²)
 q_Y''' = Duct wall gamma heating volumetric source w/m^3 (Btu/hr-ft²)
 Q_p = Peak-to-average bundle radial power skew
 R_A = Inverse equivalent heat transfer coefficient as defined in text
 $m-C/2$ (hr-ft²-°F/Btu)
 R_B = Inverse equivalent heat transfer coefficient as defined in text
 $m-C/w$ (hr-ft²-°F/Btu)
 Re = Reynolds number based on interior subchannel hydraulic diameter
 R_{1c} = IEHTC* between the pin bundle duct wall center and the bypass gap side channel
 R_{2c} = IEHTC* between the assembly duct wall center and the bypass gap side channel
 R_{3c} = IEHTC* between the pin bundle duct wall center and the bypass gap corner channel
 R_{4c} = IEHTC* between the assembly duct wall center and the bypass gap corner channel

* Inverse Equivalent Heat Transfer Coefficient in $m-C/W$ (hr-ft²-°F/Btu)

R_5 = IEHTC* between the side channel and the duct wall center
 R_6 = IEHTC* between the corner channel and the duct wall center
 R_7 = IEHTC* between the interassembly gap side channel and the assembly duct wall center
 R_8 = IEHTC* between the interassembly gap corner channel and the assembly duct wall center
 R_9 = IEHTC* between the interassembly gap side channel and the neighboring assembly duct wall center
 R_{10} = IEHTC* between the interassembly gap corner channel and the neighboring assembly duct wall
 ΔT_A = Temperature difference as defined in text C (°F)
 ΔT_B = Temperature difference as defined in text C (°F)
 ΔT_C = Temperature difference as defined in text C (°F)
 ΔT_{BC} = Boundary condition temperature difference as defined in text C (°F)
 T_{BC} = Temperature of a specified boundary condition C (°F)
 t_C = Thickness of the pin bundle duct wall (inner duct) in a double-ducted assembly m(ft)
 t_D = Thickness of the assembly duct wall m(ft)
 t_I = Neighboring assembly temperature used for interassembly heat transfer (°F)
 T_{IN} = Coolant inlet temperature C (°F)
 T_M = Coolant mean outlet temperature C (°F)
 T_O = Coolant temperature in the node of interest C (°F)
 T_1, T_2, T_3, T_4 = Coolant or duct temperatures in neighboring nodes as defined by figures C (°F)
 U_A = Superficial axial velocity m/sec (ft/hr)
 U_{SII} = Superficial swirl flow velocity m/sec (ft/hr)

s_{X_1} = Interior subchannel velocity flowsplit

s_{X_I} = Interior region velocity flowsplit $s_{X_I} = s_{X_1}$

s_{X_2} = Side subchannel velocity flowsplit $s_{X_2} = s_{X_{II}}$

s_{X_3} = Corner subchannel velocity flowsplit

$s_{X_{II}}$ = Peripheral region (side and corner) velocity flowsplit

ΔZ = Axial node length m(ft)

ΔZ_1 = Maximum allowable axial node length governed by Equation 5-4
m(ft)

ΔZ_2 = Maximum allowable axial node length governed by Equation 5-6
m(ft)

ΔZ_3 = Maximum allowable axial node length governed by Equation 5-8
m(ft)

ΔZ_4 = Maximum allowable axial node length governed by Equation 5-10
m(ft)

ΔZ_5 = Maximum allowable axial node length governed by Equation 5-12
m(ft)

ΔZ_6 = Maximum allowable axial node length governed by Equation 5-14
m(ft)

ΔZ_7 = Maximum allowable axial node length governed by Equation 5-16
m(ft)

GREEK SYMBOLS

- β = Volumetric expansion coefficient
- $\epsilon_H = \epsilon_{H_{NI}}$ = Enhanced eddy diffusivity of heat (assumed isotropic)
 $m^2/sec \text{ (ft}^2/hr)$
- ϵ^* = Superficial dimensionless enhanced eddy diffusivity of heat
(Table 4.2)
- ϵ_1^* = Dimensionless enhanced eddy diffusivity of heat (Table 4.2)
- ϵ_L^* = Superficial dimensionless enhanced eddy diffusivity of heat
(Table 4.2)
- ϵ_{1L}^* = Dimensionless enhanced eddy diffusivity of heat (Table 4.2)
- η_1 = Interior-to-interior channel centroidal distance m(ft)
- η_2 = Interior-to-side channel centroidal distance m(ft)
- η_3 = Side-to-side channel centroidal distance m(ft)
- η_4 = Side-to-corner channel centroidal distance m(ft)
- η_5 = Interassembly gap side-to-side channel centroidal distance m(ft)
- η_6 = Interassembly gap side-to-corner channel centroidal distance m(ft)
- η_C = Bypass gap side-to-corner channel centroidal distance m(ft)
- $p^K = p_{NI}^K$ = Porous body conduction shape factor (assumed isotropic)
- s^K = Subchannel conduction shape factor
- λ_A = Average axial bundle porosity
- λ_{AI} = Average axial bundle porosity in the interior region
- λ_{AII} = Average axial bundle porosity in the peripheral region
- λ_{LI} = Average lateral bundle porosity in the interior region
- λ_{LII} = Average lateral bundle porosity in the peripheral region
- ν = Kinematic viscosity at mean bundle temperature $m^2/sec \text{ (ft}^2/hr)$
- ρ = Coolant density $kg/m^3 \text{ (lbm/ft}^3)$

1.0 SUMMARY

Core thermal-hydraulic design and performance analyses for Liquid Metal Fast Breeder Reactors (LMFBRs) require repeated detailed multiassembly calculations to determine radial temperature profiles and subchannel outlet temperatures for various core configurations and subassembly structural analyses. At steady-state, detailed core-wide temperature profiles are required for core restraint calculations and subassembly structural analysis. In addition, sodium outlet temperatures are routinely needed for each reactor operating cycle.

The SUPERENERGY-2 thermal-hydraulic code was designed specifically to meet these designer needs. It is applicable only to steady-state, forced-convection flow in LMFBR core geometries. The simplified energy equation mixing model used by SUPERENERGY is well established and extremely economical in both computer storage and run time. Most importantly, the code contains many user-convenience features which make it easy to understand and use. The SUPERENERGY-2 code has proven to be a practical, inexpensive thermal hydraulic modeling tool for the designer, capable of making coupled calculations for a large sector of a reactor core with a single computer run.

2.0 INTRODUCTION

The SUPERENERGY series of multiassembly steady-state LMFBR computer codes (Chen and Todreas 1976; Basehore and Todreas 1976, 1977a) are based on the principles of the ENERGY model (Khan et al. 1975, 1979) first used in ENERGY I (Khan et al. 1976). This model describes the intra-assembly thermal hydraulic behavior in a wire-wrapped LMFBR assembly in terms of two correlated parameters. The first of these is ϵ_{1L}^* , a dimensionless enhanced eddy diffusivity of heat, which models the thermal mixing between subchannels induced by wire wrap sweeping. ϵ_{1L}^* provides the dominant means of radial heat transfer in the bundle interior region. The second correlated parameter, C_{1L} , is a ratio of the transverse swirl velocity in the bundle periphery to the average axial velocity in that region. This swirl flow is caused by the unidirectional sweeping of the wire wraps along the duct wall. It is the major source of mixing in the outside edges of the bundle. These parameters when coupled with a numerical form of the energy equation and a suitable subchannel flow-split model, provide a complete representation of the temperature field for the forced convection flow regime. The momentum and continuity equations are not necessary.

The ENERGY I code was the first code released using the ENERGY model. It could compute the temperature field for single assemblies operating in the forced-convection flow regime using radial noding of any size. The extensive user input required for the flexible noding and the inability to handle multiple bundle problems made the code somewhat difficult to use. ENERGY II and III (Khan et al. 1976) were developed along similar lines except that in addition they contain simplified momentum equations to account for buoyancy effects and are therefore applicable at lower flows.

The original version of SUPERENERGY (Chen and Todreas 1976) provided the first multiassembly calculational capability using the ENERGY model. In addition by fixing the radial mesh to a standard subchannel noding, the code input was greatly simplified. The assembly geometry and noding were calculated internally based on a few critical bundle dimensions. Only two different

bundle types per problem were allowed and these had to contain side subchannels that were integer multiples of each other for correct interassembly coupling to occur. No double-ducted assemblies were allowed. Because of its spatially explicit finite differencing scheme and the method used for interassembly coupling, the code had severe stability limitations at low interassembly gap flows. This problem was examined and fixed (Basehore and Todreas 1976) using a resistance coupling between assemblies. The code was also hardwired to couple with Clinch River type secondary control assemblies (Basehore and Todreas 1977a).

SUPERENERGY-2 extends the desirable features of ENERGY I and SUPERENERGY. It contains internally generated variable radial mesh, for many assembly types, including double-ducted assemblies. Interassembly coupling can be achieved between different bundle types using either a flowing interassembly gap or the more stable resistance coupling. To extend the code capability, other features that simplify the input and provide internal error checks have been added. These are described in the sections to follow.

3.0 CONCLUSIONS

SUPERENERGY-2 combines all the desirable features of the previous ENERGY and SUPERENERGY versions. The result is an easily redimensionable, multiassembly code with many user convenience features that help minimize the effort and time associated with setting up large problems. The code automatically generates the geometry and noding for any number of single- or double-ducted assembly types based on a few critical dimensions. Radial noding options are either a standard fine-meshed subchannel layout based on the number of fuel pins or a lumped representation of one to eight rings formed at the user's request. Assemblies may be coupled for interassembly heat transfer effects, using either a conduction or flow solution in the interassembly gap. Generalized boundary conditions can be applied to the noncoupled bundle faces. In addition, a duct wall gamma heating option is available.

SUPERENERGY-2 contains internal checks and correlations to minimize input errors and assure the validity of the code output. The code contains default sodium and stainless steel property correlations, mixing parameter correlations, flowsplit correlations and heat transfer correlations. These can all be overridden by input. A card image listing of the input data cards before code processing begins provides a means of verifying input. A critical modified Grashof number check before the temperature calculation begins determines whether the problem is outside of the forced-convection flow regime, invalidating the SUPERENERGY results. Optional stability controlled axial noding assures a stable solution at minimum cost. The resultant code-calculated bundle temperature profiles are printed out in map form for easy reading at user-specified printout locations. Each printout is concluded by a detailed problem energy balance. These features are discussed in greater detail in Section 4.

The SUPERENERGY-2 code is applicable to steady-state forced-convection problems consisting of bundles with standard LMFBR pin geometries. It is not a benchmark code and should not be treated as such. Off-normal geometry calculations will provide questionable results since the accuracy of the output

depends strongly on the experimentally determined mixing parameters, ϵ_{1L}^* and C_{1L} . If, however, the desired calculation falls within the geometric range of these parameters, SUPERENERGY-2 will provide results comparable in accuracy to any benchmark code at a small fraction of the cost. It can compute problems ranging from a single bundle operating condition parametric study to a large core sector problem which might be used to study the effect of inter-assembly heat transfer on the duct temperature profile for core restraint analysis. SUPERENERGY-2 was written specifically for these design type of calculations.

4.0 CODE FEATURES

The SUPERENERGY-2 code contains many features which are outgrowths of the original SUPERENERGY features. These fall into the general categories of geometry and noding generation, interassembly heat transfer and facial boundary condition models, user convenience features, and input/output capabilities. These categories are discussed in detail in the next four subsections.

4.1 GEOMETRY AND NODING GENERATION

The SUPERENERGY-2 code has the capability to compute temperature distributions in assemblies of two major geometry types. These are the normal single-ducted wire-wrapped fuel pin assembly and the double-ducted bypass assembly. The bypass assembly consists of a central wire-wrapped fuel pin bundle surrounded by two hexagonal cans with a flow bypass region sandwiched between them. The code input for a specific problem can contain any number of variations of these two major types, the quantity limited only by the code dimensions. The variations may include different bundle dimensions, noding or pin numbers. The code generates the noding, connection logic and geometry for the different assembly types based on a few critical input parameters. These are the rod pitch, rod diameter, wire-wrap lead length, wire wrap diameter, duct flat-to-flat distance, duct wall thickness, number of fuel pins and the radial mesh sizing desired. If the assembly is a bypass assembly, the bypass gap thickness and interior duct thickness are also necessary.

The noding configuration is generated in much the same manner as in the original SUPERENERGY, by subroutine NUMB. For a given bundle type, NUMB calculates and stores the identification numbers of the rods and channels for use in the temperature field equations. The interior subchannels are numbered sequentially in a counter-clockwise outward spiral starting with the two o'clock node neighboring the center pin. Next, the side and then the corner subchannels are numbered in the same manner. The pattern is continued for the duct and interassembly gap nodes. An example of a subchannel noding scheme

for a 61-pin assembly is shown in Figure 4.1a. If the bundle is a double-ducted bypass bundle, the noding is extended to include two more rings as shown in Figure 4.1b.

The noding configuration is determined by the parameter NRING, which defines the number of rings of interior nodes. When standard subchannel noding is specified, the code sets NRING to the correct value based on the number of fuel pins. If lumping is desired, this value of NRING can be overridden by input. This allows the user the option of forming large mesh radial nodes in bundles where fine detail is not necessary, saving both computation time and core storage. One consequence of selecting larger than standard subchannel node sizes is, however, that the user must input nodal average linear heat generation rates, rather than the pin heat fluxes necessary for subchannel input. The geometric parameters, such as flow areas, wetted perimeters, and centroidal lengths are modified based on NRING to compensate for the non-standard radial mesh. In order to do this, an assumption must be made that the thickness of the edge and corner nodes, and thus the peripheral swirl flow region, remains the same as the standard mesh thickness. An example of a 61-pin bundle (NRING = 4 standard bundle) lumped into an NRING = 2 bundle is shown in Figure 4.2. Though the code model is valid for any lumping strategy based on the input NRING, it is suggested that channels should be lumped along standard subchannel boundaries to give some physical significance to the node dimensions. That is, the actual NRING based on the standard subchannel mesh should be an integer multiple of the input NRING whenever possible.

4.2 INTERASSEMBLY HEAT TRANSFER AND FACIAL BOUNDARY CONDITION MODELS

One very important feature of the original SUPERENERGY code was its ability to couple assemblies and allow interassembly heat transfer with only minimal user input. This feature has been retained and generalized in SUPERENERGY-2. Model improvements include the availability of two separate interassembly heat transfer models, generalized boundary conditions on the noncoupled faces, a method of coupling neighboring bundles with uneven multiples of facial nodes, and a less restrictive interassembly gap noding scheme.

a) 61-Pin Assembly

b) 37-Pin Double-Ducted Assembly

FIGURE 4.1. Standard Subchannel Noding for 61-Pin and 37-Pin Assemblies

FIGURE 4.2. 61-Pin Bundle Lumped into 2 Rings

A key consideration in the design of the code interassembly heat transfer options was that experience with the original SUPERENERGY showed (Basehore and Todreas 1976) the interassembly gap nodes to be the most limiting nodes for the stability of the explicit temperature expressions in multibundle problems (see Section 5 for a discussion on stability). This is due to the narrow gap width and the extremely low gap flow rates of most real problems. SUPERENERGY-2 suppresses this limitation in two ways. First, the subchannel arrangement in the interassembly gap has been altered so that the two neighboring assemblies contain one common interassembly gap node centered at the middle of the gap between the adjacent duct walls. This is an improvement over the old code, which split the gap into two nodes with boundaries at the gap centerline. These nodes communicated with each other through a resistance that usually proved to be stability limiting. With this stability limitation removed, the SUPERENERGY-2 code shows at least a factor of two improvement in stability limited axial step size for a given flow rate when the interassembly gap flow model is used.

The second method of relaxing the interassembly gap stability constraint for low interassembly gap flow is to allow the gap to be treated as a stagnant wall of sodium. The interassembly heat transfer, then, occurs by one-dimensional conduction using resistances between the coupled assemblies. This imposes no stability constraint in the interassembly gap and duct wall regions since the temperatures are calculated after the adjacent side channel temperatures are known. The equations are presented in Section 5.

When the interassembly gap flow rate is so low that it accounts for an insignificant fraction of the energy convection out of the bundles, which is the case in most problems, use of the conduction model rather than the flowing gap model is suggested. It is less expensive to run. However, if the interassembly gap flow rate is high or if large radial temperature gradients exist in the interassembly gap such that two-dimensional coupling of the interassembly gap nodes is desirable, the flowing gap model is a better choice. For uncoupled bundle faces at the edge of a problem, the conduction model places an adiabatic condition at the duct wall, while the flowing gap model places one at the far edge of the interassembly gap. This should be factored into the model choice since one method may be more correct than the other depending on the intended application.

SUPERENERGY-2 allows neighboring assemblies with different channel mesh sizes to be coupled with no constraints as to how the adjacent channels must line up. The original code allowed coupling only between assemblies with adjacent nodes that were in integer multiples. When two assemblies have different channel pitches or nonmatching adjacent side channel nodes, the new code performs an interpolative averaging technique to obtain the proper interassembly temperature couplings. The duct and interassembly gap side temperatures for both assemblies are calculated at the same time requiring the averaging to be done once per facial coupling per axial level. Any energy error resulting from this interpolation procedure shows up in the energy balance summary that accompanies the temperature map output at each printout location. Usually the error introduced is extremely small because of the relatively flat facial temperature profiles in most problems.

An option to apply a spatially varying volumetric heat generation rate to the duct wall nodes is available when the flowing gap model is used. The heat deposited in the wall is specified by face using radial and axial volumetric heat generation rate multipliers. This can be important in low-power assemblies when the percentage of the total bundle energy resulting from gamma heating effects is high. Gamma energy deposition in the coolant can be simulated by increasing the radial power factor to include the desired effects.

For the noncoupled bundle faces, axially and radially varying heat flux or temperature boundary conditions may be applied. The boundary condition type, heat flux or temperature, is specified by assembly and the axial and radial forcing function profiles are specified by face. These are applied at the duct wall when the conduction model has been specified or at the opposite face of the interassembly gap in the case of the flowing gap model. A summary of the available boundary conditions (B.C.) is shown in Table 4.1. Using the temperature boundary condition with the interassembly gap flowing model can produce an expensive stability constraint as mentioned in Section 5.6. The gap conduction model is recommended for use with temperature boundary conditions whenever possible.

TABLE 4.1. Boundary Conditions

<u>Model Type</u>	<u>Duct Wall B.C.</u>			<u>Interassembly Gap B.C.</u>		<u>Interassembly Heat Transfer</u>
	<u>T</u>	<u>q"</u>	<u>q'''</u>	<u>T</u>	<u>q"</u>	
Interassembly Gap Flowing			X	X	X	X
Interassembly Gap Stagnant	X	X				X

4.3 USER CONVENIENCE FEATURES

SUPERENERGY-2 contains a series of user convenience features which reduce the amount of input necessary, minimize input errors by providing internal checks, and assure the validity of the output. The major features are described in the following subsections.

4.3.1 Critical Modified Grashof Criteria

The solution method in SUPERENERGY-2 is applicable only to the forced-convection flow regime. For most cases, the transition to mixed convection occurs at flow rates below the range of interest for a steady-state code. If, however, the bundle has a severe power skew, it is possible that buoyancy effects may become important. To predict when this will occur, Khan et al. (1975, 1976) have developed a criteria for the ENERGY codes based on a modified Grashof number. Omitting the derivation, which can be found in Khan's (1975) discussion, this criteria is as follows:

$$Gr^* = \frac{G_r}{f Re^2} \chi \quad (4-1)$$

where

$$\chi = \frac{1}{M} \frac{\hat{Q}_p - 1}{\sqrt{2}} \frac{1}{\Gamma L}$$

$$Gr = \frac{g_0 \beta (T_M - T_{IN}) D_e^3}{\sqrt{2}}$$

$$\Gamma = \frac{(P/D - 1)}{\pi} \frac{16}{D_F} \left[s_{X1} \epsilon_{1L}^* + s_{KNI} \alpha_{1L}^* \right]$$

$(T_M - T_{IN})$ = average axial temperature rise across the bundle of height L

Re = Reynolds number based on d_e and the interior subchannel axial velocity, evaluated at the bundle mean temperature

D_F = duct flat-to-flat distance

D_e = hydraulic diameter of an interior subchannel

$f = \frac{\Delta P}{\frac{L}{D_e} \frac{\rho v^2}{2}}$, smooth tube friction factor based on Re above

g_0 = acceleration due to gravity

L = bundle length

P/D = pitch/diameter for interior subchannel

M = Novendstern's multiplication factor for wire-wrapped bundles

$$\left\{ \frac{1.034}{(P/D)^{0.124}} + \frac{29.7(P/D)^{6.94} Re^{0.086}}{(H/D)^{2.239}} \right\}^{0.885}$$

U = bundle superficial average velocity

v = interior subchannel axial velocity

H/D = wire wrap lead/pin diameter

β = volumetric expansion coefficient at bundle mean temperature

α_{1L}^* = $1/Re Pr$ at bundle mean temperature

ν = kinematic viscosity at bundle mean temperature

sX_1 = interior subchannel to bundle average velocity ratio.

ϵ_{1L}^* = dimensionless enhanced eddy diffusivity of heat

sK_{NI} = conduction shape factor

Buoyancy effects begin to become important when

$$Gr^* \geq Gr_c^* = 0.02$$

The above criterion is included in subroutine GRASH, which checks the input of each bundle before the actual temperature calculations begin to determine the validity of the solution. If the criterion is violated, the simulation is stopped and an error message is printed.

4.3.2 Mixing Parameters

SUPERENERGY uses two mixing parameters, ϵ_{HNI} and U_{SII} , to describe the intra-assembly thermal mixing in a wire wrap bundle. The first is the enhanced eddy diffusion of heat which models the wire wrap sweeping effects. The second is the superficial peripheral swirl flow velocity. Assuming this swirl flow to be independent of the wire wrap position has been shown to induce little error (Basehore and Todreas 1976). The mixing parameters were first correlated as a function of geometry by Khan et al. (1975) using the bundle average velocity as a nondimensionalizing parameter (ϵ^* and C in Table 4.2). These correlations provided the basis for the original SUPERENERGY and ENERGY model input. Recently, the mixing parameters were recorrelated by Chiu, Rohsenow and Todreas (1978a) using the local subchannel velocity as a nondimensionalizing parameter, which made the resulting correlation independent of bundle size (ϵ_{1L}^* and C_{1L} in Table 4.2). Also, by taking advantage of a larger data base, the range of the correlations was extended into the blanket bundle region. The two correlations are as follows:

$$\epsilon_{1L}^* = 0.128 \left(\frac{P}{P-D} \right)^{0.5} \left(\frac{A_{r1}}{A_{s1}} \right)^{0.5} \frac{(D + Dw)P^2}{\sqrt{\pi^2 (D + Dw)^2 + H^2}} \left(\frac{1}{A_{s1}} \right) \quad (4-2)$$

where

$$A_{s1} = \frac{\sqrt{3}}{4} P^2 - \frac{\pi}{8} D^2$$

$$A_{r1} = \frac{\pi}{6} \left(P - \frac{D}{2} \right)^2 - \frac{\pi}{24} D^2$$

and

$$C_{1L} = 10.5 \left(\frac{P-D}{P} \right)^{0.35} \left(\frac{A_{r2}}{A_{s2}} \right)^{0.5} \frac{D + Dw}{\sqrt{\pi^2 (D + Dw)^2 + H^2}} \quad (4-3)$$

where

$$A_{s2} = P \left(\frac{D}{2} + Dw \right) - \frac{\pi}{8} D^2$$

$$A_{r2} = \frac{\pi}{4} \left(\frac{D}{2} + Dw \right)^2 - \frac{\pi}{16} D^2$$

Equations 4-2 and 4-3 are part of the default constitutive package inside the SUPERENERGY-2 code. They may be overridden by user tabular input for ϵ_{1L}^* and C_{1L} versus Reynolds number. These are converted to dimensional form by the code for use with the temperature expressions derived in Section 5.

TABLE 4.2. Parameters for Turbulent Bundle Analysis

	Porous Body	Subchannel
Bundle Size Dependent Parameters	$\epsilon^* = \frac{\epsilon_{HNI}}{U_A D e_1}$	$\epsilon_1^* = \frac{\lambda_A}{\lambda_{LI}} \epsilon^*$
	$C = \frac{U_{SII}}{U_A}$	$C_1 = \frac{\lambda_A}{\lambda_{LII}} C$
	ENERGY I, II and III Input	original SUPERENERGY input
Bundle Size Independent Parameters	$\epsilon_L^* = \frac{1}{sX_1} \frac{\lambda_A}{\lambda_{AI}}$	$\epsilon_{1L}^* = \frac{1}{sX_1} \epsilon_1^*$
	$C_L = \frac{1}{sX_{II}} \frac{\lambda_A}{\lambda_{AII}} C$	$C_{1L} = \frac{1}{sX_{II}} C$
		SUPERENERGY-2 input

4.3.3 Flowsplit Models

The ENERGY model assumes incompressible, steady-state, one-dimensional flow in parallel channels. Thus, when a bundle flow rate, a temperature at which to evaluate the constant fluid properties, and appropriate channel flowsplits are specified, the fluid conservation equations do not need to be solved. Of these three, the channel flowsplit is the most difficult to determine. In SUPERENERGY-2 the user can specify either the Novendstern (1972) flowsplit model or the MIT flowsplit correlation (Chiu, Rohsenow and Todreas 1978b). Both are built into the code. The option also exists to supply flow-split versus Reynolds number tables by input.

The Novendstern model assumes that an equal pressure drop boundary condition applies to all the subchannel types, and that this pressure drop is caused primarily by skin frictional losses. The resulting expressions give an inlet flow velocity split as a function of the subchannel equivalent diameter:

interior subchannel

$$s^{X_1} = \frac{A_1 N_1 + A_2 N_2 + A_3 N_3}{N_1 A_1 + N_2 A_2 \left(\frac{De_2}{De_1} \right)^{0.714} + N_3 A_3 \left(\frac{De_3}{De_1} \right)^{0.714}} \quad (4-4)$$

side subchannel

$$s^{X_2} = \frac{A_1 N_1 + A_2 N_2 + A_3 N_3}{N_1 A_1 \left(\frac{De_1}{De_2} \right)^{0.714} + N_2 A_2 + N_3 A_3 \left(\frac{De_3}{De_2} \right)^{0.714}} \quad (4-5)$$

corner subchannel

$$s^{X_3} = \frac{A_1 N_1 + A_2 N_2 + A_3 N_3}{N_1 A_1 \left(\frac{De_1}{De_3} \right)^{0.714} + N_2 A_2 \left(\frac{De_2}{De_3} \right) + N_3 A_3} \quad (4-6)$$

The MIT turbulent flowsplit model also assumes that an equal pressure drop boundary condition applies to all the subchannel types. This pressure drop is made of wire form losses and skin friction induced by the resultant velocity of the axial and sweeping flows. The numerical coefficients in the final expressions have been fit using available flowsplit data:

interior region

$$s^{X_I} = \frac{A_1 N_1 + A_2 N_2 + A_3 N_3}{A_1 N_1 + (A_2 N_2 + A_3 N_3) \left(\frac{De_2}{De_1} \right)^{0.714} (\alpha)^{0.571}} \quad (4-7)$$

Since very little data exists for corner subchannels, the corner and side subchannels have been assumed equal and lumped together to form a peripheral region flowsplit, $s^{X_{II}}$. SUPERENERGY-2 makes the assumption $s^X_2 = s^X_3 = s^{X_{II}}$ as suggested by Chiu (1978b).

peripheral region

$$s^{X_{II}} = \frac{A_1 N_1 + A_2 N_2 + A_3 N_3}{A_1 N_1 \left(\frac{De_1}{De_2} \right)^{0.714} \left(\frac{1}{\alpha} \right)^{0.571} + A_2 N_2 + A_3 N_3} \quad (4-8)$$

where

$$\alpha = \frac{2200 \left(\frac{De_1}{H} \right) \left(\frac{Ar_1}{As_1} \right) \left(\frac{P}{\sqrt{\pi^2 P^2 + H^2}} \right)^2 + 1}{1.2 \left[1 + (1.9 n C_{1L})^2 \right]^{1.375}} \quad (4-9)$$

$$n = \frac{(P-D) \frac{P}{2}}{\left(P - \frac{D}{2} \right) \frac{P}{2} - \frac{\pi D^2}{16}}$$

and C_{1L} , Ar_1 , and As_1 are defined in Equations 4-2 and 4-3.

The resulting uncertainty in sX_I and sX_{II} is $\pm 1\%$ if the bundle has at least 37 pins and the pin pitch to diameter ratio is less than 1.4. (Khan et al. 1979). This correlation is recommended for use with the MIT mixing correlations discussed in Section 4.3.2.

4.3.4 Variable Dimensioning

An auxiliary program, CONVERT, has been written to redimension the SUPERENERGY-2 common and dimension statements. It allows the user to allocate the necessary computer memory effectively to critical variables, and minimize the core requirements for a given problem. Input to CONVERT defines the maximum problem size which is used in determining the size of SUPERENERGY's arrays. CONVERT generates card images of SUPERENERGY's common blocks and dimension statements. The program is described in Appendix D.

4.3.5 Stability Limited Axial Noding

The computational time required for a given SUPERENERGY problem is directly proportional to the number of axial nodes in that problem. However, a problem-dependent, maximum axial node size is necessary to assure a stable solution of the spatially explicit temperature field equations. To eliminate expensive overcompensation by the user, SUPERENERGY-2 contains a subroutine which calculates the minimum number of axial nodes necessary for a stable problem solution. This calculation is done before the temperature solution is initiated using the stability relationships developed in Section 5. The code compares the calculated node size with the input node size. If the input size violates stability, the code either replaces it or terminates execution at the user's option.

4.4 INPUT/OUTPUT FEATURES

The SUPERENERGY-2 code input is arranged into four functional groups. The first of these selects the basic model options, and the printout options and defines the interassembly gap geometry. Group 2 defines the different bundle geometry types, requiring the input of critical dimensions and desired channel noding logic. Group 3 contains the various axial and radial forcing functions and mixing parameter profiles. The final group selects parameters

from the sets created by the first three groups and couples these with operating conditions to form specific assemblies. A description of the input is provided in Appendix A. This input procedure eliminates repetitive data input, reduces storage requirements, and decreases problem setup time. Once the Group 1, 2 and 3 basic data has been set up, bundle and core parametric studies can be made quite easily with small changes in Group 4.

As the input data is being read, SUPERENERGY automatically provides a card image listing to aid the user in finding errors. After processing, all data is printed out with descriptions. While the SUPERENERGY-2 code works exclusively in units of the System and Internationale (SI), input and output may be in either SI or English engineering units at the user's option.

The calculated temperature field is printed out at specified locations in map form by bundle. The variable formatted output routine can print out maps for single-ducted assemblies with $\text{NRING} \leq 8$ and double-ducted assemblies with $\text{NRING} \leq 6$. The maps are easily separated into subchannels with the addition of a few lines as can be seen in Appendix F. A detailed energy balance summary is supplied along with each axial printout. It compares the bundle energy gain through temperature rise against the heat added through rod power, gamma heating, facial boundary conditions and interassembly heat transfer. An optional, facially averaged duct temperature printout summary is also available at user-specified axial locations.

5.0 NUMERICAL FORMULATION

The SUPERENERGY temperature expressions are formulated by using a control volume energy balance rather than the alternative technique of reducing the differential form of the energy equation to finite difference form by using numerical methods. Choice of the control volume approach is advantageous for noncartesian geometries, such as LMFBR subchannels, because it assures an energy balance while being simple and straightforward. Khan et al. 1979 provides a detailed, rigorous development of the ENERGY model temperature expressions using this method. For completeness, an abbreviated formulation will also be provided here.

The nodal energy balance equations are explicitly coupled to each other radially. Temperatures at a given plane are then dependent only on known quantities of the preceding plane, eliminating the need for simultaneous solution. As a result, a substantial reduction in computational storage and running time is possible when compared to implicit formulations. The disadvantage of this method is that the axial node length size is stability limited. Fortunately, due to the simplicity of the ENERGY model, this stability limiting node size can be predicted before the calculation begins and is usually not overly constraining. This is because the limiting node size is proportional to the inlet flow rate which must be in the forced-convection regime for SUPERENERGY results to be valid.

The ENERGY model divides an LMFBR subassembly into two regions: Region I, the bundle interior, where the internodal heat transfer is modeled by an enhanced eddy diffusivity, ϵ_{1L}^* ; and Region II, the bundle periphery, where swirl effects caused by the wire wrap are most important. In this version of SUPERENERGY, these regions may be broken up into subchannels as shown in Figure 5.1 or lumped into larger porous body nodes at the user's option. No fuel rod energy equation is included in SUPERENERGY. The heat is added directly to the coolant as a volumetric heat source. In the subsequent sections the energy balance is developed for each coolant node type using the porous body formulation. The nomenclature developed in Khan et al. 1979 is used here for consistency. The energy balance for the coolant takes the form:

FIGURE 5.1. 37-Pin Bundle Showing Standard Subchannels and ENERGY Model Regions I and II

$$\left[\begin{array}{c} \text{Change in} \\ \text{node} \\ \text{energy} \end{array} \right] = \left[\begin{array}{c} \text{Input} \\ \text{from heat} \\ \text{source} \end{array} \right] + \left[\begin{array}{c} \text{Effective conduction} \\ \text{from} \\ \text{surrounding nodes} \end{array} \right]$$

5.1 INTERIOR CHANNELS

For the interior type of nodes shown in Figure 5.2 the energy balance at axial level J becomes:

$$M_1 C_p (T_o^J - T_o^{J-1}) = q_o' \Delta Z +$$

$$P_I \Delta Z \left(p_{NI}^k + \rho C_p \epsilon_{H_{NI}} \right) \left(\frac{T_1^{J-1} + T_2^{J-1} - 2T_o^{J-1}}{\eta_1} + \frac{T_3^{J-1} - T_o^{J-1}}{\eta_x} \right) \quad (5-1)$$

FIGURE 5.2. Interior Channel Noding

where the subscript

$x = 1$ if node 3 is an interior channel node

$x = 2$ if node 3 is an edge channel node

The other variables are individually defined in the nomenclature section. Rearranging Equation 5-1 yields the final porous body expression for temperature in an interior type node

$$T_o^J = T_o^{J-1} + \frac{q_o' \Delta Z}{M_1 c_p} + \frac{P_I \Delta Z}{M_1 c_p} \left(p_{\kappa\kappa} + \rho c_p \epsilon_H \right) \left(\frac{T_1^{J-1} + T_2^{J-1} - 2T_o^{J-1}}{\eta_1} + \frac{T_3^{J-1} - T_o^{J-1}}{\eta_x} \right) \quad (5-2)$$

Thus, the temperature at axial level J is dependent on the $J-1$ temperature, the axially varying heat source (q_o'), and the mixing between neighboring channels.

The right-hand subscripts on the conduction shape factor, $p_{\kappa\kappa}$, and the eddy diffusivity of heat, ϵ_H , have been omitted because the SUPERENERGY-2 code assumes they are isotropic. The subchannel analog of Equation 5-2 differs only in the definition of effective conduction term variables, and can be found in Khan et al. 1979.

The maximum axial node size allowable for a stable interior channel temperature solution can be prepredicted. The right-hand side of Equation 5-2 must remain positive in the most limiting case. This occurs when the heat generation term is zero and when T_1^{J-1} , T_2^{J-1} , and T_3^{J-1} are small compared to T_0^{J-1} :

$$0 \leq 1 - \frac{P_I \Delta Z}{M_1 C_p} (p^{kk} - \rho C_p \epsilon_H) \left[\frac{2}{\eta_1} + \frac{1}{\eta_x} \right] \quad (5-3)$$

By rearranging 5-3

$$\frac{1}{\Delta Z_1} \geq \frac{P_I}{M_1 C_p} (p^{kk} + \rho C_p \epsilon_H) \left[\frac{2}{\eta_1} + \frac{1}{\eta_x} \right] \quad (5-4)$$

The global maximum axial node size for a given problem can be found by comparing Equation 5-4 with similar equations to be derived for the other channel types.

5.2 SIDE CHANNELS

From a similar energy balance using the noding shown in Figure 5.3, the porous body expression for temperature in a side node is:

$$\begin{aligned} T_0^J = T_0^{J-1} &+ \frac{q_o' \Delta Z}{M_2 C_p} + \frac{P_{NII} \Delta Z}{M_2 C_p} (p^{kk} + \rho C_p \epsilon_H) \left(\frac{T_1^{J-1} - T_0^{J-1}}{\eta_1} \right) \\ &+ \frac{P_{SII} \Delta Z}{M_2 C_p} (p^{kk} + \rho C_p \epsilon_H) \left(\frac{T_2^{J-1} - T_0^{J-1}}{\eta_x} + \frac{T_3^{J-1} - T_0^{J-1}}{\eta_y} \right) \end{aligned}$$

FIGURE 5.3. Side Channel Noding

$$\begin{aligned}
 & + \frac{\rho U_{SII} P_{SII} \Delta Z}{M_2} (T_2^{J-1} - T_0^{J-1}) \\
 & + \frac{P_{NII} \Delta Z}{M_2 c_p} \left[\frac{T_4^{J-1} - T_0^{J-1}}{R_5} \right] + q_{BC}''
 \end{aligned} \tag{5-5}$$

where the subscript

- $x = 3$ if node 2 is a side channel node
- $x = 4$ if node 2 is a corner channel node
- $y = 3$ if node 3 is a side channel node
- $y = 4$ if node 3 is a corner channel node.

Again, isotropy is assumed, eliminating the need for right-hand subscripts on p^k and ϵ_H .

Equation 5-5 contains heat source and mixing terms similar to Equation 5-2 and two extra terms which account for the additional heat transfer into the node from the imposed Region II swirl flow and wall conduction, respectively. The superficial swirl velocity, U_{SII} , is supplied via correlation (Chiu et al. 1978a). The heat source, q_{BC}'' in the wall conduction term is nonzero only when a conduction model heat flux boundary condition is specified and the assembly is not a bypass assembly.

The governing maximum stable axial node size for Equation 5-5 can be predicted in the same manner as for the interior channels. The most limiting case occurs when T_1^{J-1} , T_2^{J-1} , T_3^{J-1} and T_4^{J-1} are negligible compared to T_0^{J-1} and when q'_0 and q''_{BC} are zero. By requiring that the resulting expression be greater than zero, the following inequality results:

$$\begin{aligned} \frac{1}{\Delta Z_2} \geq & \left(\frac{p^{kk} + \rho C_p \epsilon_H}{M_2 C_p} \right) \left(\frac{P_{NII}}{\eta_1} + \frac{P_{SII}}{\eta_x} + \frac{P_{SII}}{\eta_y} \right) \\ & + \frac{\rho U_{SII} P_{SII}}{M_2} + \frac{P_{NII}}{M_2 C_p R_5} \end{aligned} \quad (5-6)$$

The case where subscripts x and y both equal 3 need not be examined since $\eta_3 > \eta_4$.

5.3 CORNER CHANNELS

Performing an energy balance on the noding arrangement shown in Figure 5.4, yields the porous body expression for temperature in a corner node. Since the corner node is bounded by two duct wall faces, it therefore has potentially two different facial boundary conditions or neighboring assemblies. With the additional complication of two interassembly gap model choices (see Section 4), the resulting corner node temperature Equation 5-7 becomes confusing and need some clarification.

$$\begin{aligned} T_0^J = T_0^{J-1} & + \frac{q'_0 \Delta Z}{M_3 C_p} + \frac{\rho U_{SII} P_{SII} \Delta Z}{M_3} (T_1^{J-1} - T_0^{J-1}) \\ & + \frac{P_{SII} \Delta Z}{M_3 C_p} (p^{kk} + \rho C_p \epsilon_H) \left[\frac{T_1^{J-1} + T_2^{J-1} - T_0^{J-1}}{\eta_4} \right] \end{aligned}$$

FIGURE 5.4. Corner Channel Noding

$$\begin{aligned}
 & + \frac{(L_1 + L_2 \Delta Z)}{2M_3 C_p} \left[\frac{\Delta T_A^{J-1}}{2 R_A} + \frac{\Delta T_B^{J-1}}{2 R_B} + \frac{\Delta T_C^{J-1}}{R_6} \right] \\
 & + \frac{L_2 \Delta Z}{2M_3 C_p} \left[q_{BCA}'' + q_{BCB}'' \right] \quad (5-7)
 \end{aligned}$$

where

$$\begin{aligned}
 \Delta T_A^{J-1} &= 0, \text{ if flow exists outside the duct wall; i.e., either the assembly is a double-ducted bypass assembly or the interassembly gap flow model has been specified (MODEL = 2)} \\
 &= (T_{BC}^{J-1} - T_0^{J-1}), \text{ if a temperature boundary condition is defined on face A and the gap conduction model has been specified (MODEL = 1)} \\
 &= (T_I^{J-1} - T_0^{J-1}), \text{ if a neighboring assembly exists on face A and the gap conduction model has been specified (MODEL = 1).}
 \end{aligned}$$

ΔT_B^{J-1} is defined similarly to ΔT_A for face B.

$$\begin{aligned}
 \Delta T_C^{J-1} &= (T_3^{J-1} - T_0^{J-1}), \text{ if flow exists outside the duct wall, i.e., either the assembly is a double-ducted bypass assembly or the interassembly gap flow model has been specified (MODEL = 2)}
 \end{aligned}$$

q''_{BC_A} is nonzero only if a conduction model heat flux boundary condition has been specified on face A and the assembly is not a bypass assembly.

q''_{BC_B} is similar to q''_{BC_A} for face B.

R_A is the equivalent inverse heat transfer coefficient between the corner node and either the face A neighboring assembly corner node or the duct wall temperature boundary condition depending on the definition of ΔT_A .

R_B is similar to R_A for face B.

The last two terms in Equation 5-7 represent the conduction heat transfer through the duct wall resulting from temperature differences and heat flux boundary conditions, respectively. From reading the above definitions it is apparent that the temperature difference between the corner node and the duct wall, ΔT_C , can be nonzero only when the boundary condition temperature differences, ΔT_A and ΔT_B are zero. The reverse is also true. Only the boundary conditions in the second row of Table 4.1 as described in Section 4 have a direct effect on the corner node and appear in the last two terms of Equation 5-7 as q''_{BC_A} , q''_{BC_B} , ΔT_A , and ΔT_B .

The governing maximum stable axial node size for Equation 5-7 is formed in the same manner as Equations 5-4 and 5-6. The limiting case occurs when T_1^{J-1} , T_2^{J-1} and T_3^{J-1} are small compared to T_0^{J-1} and when q'_0 and q''_{BC} are zero.

$$\frac{1}{\Delta Z_3} \geq \frac{\rho U_{SII} P_{SII}}{M_3} + \frac{2P_{SII}}{M_3 C_p \eta_4} (p^{kk} + \rho C_p \epsilon_H) + \frac{(L_1 + L_2)}{2M_3 C_p} \left(\frac{\delta_A}{2R_A} + \frac{\delta_B}{2R_B} + \frac{\delta_C}{R_6} \right) \quad (5-8)$$

The quantities δ_A , δ_B and δ_C are individually set to one if their counterparts ΔT_A , ΔT_B and ΔT_C in Equation 5-7 are nonzero.

5.4 BYPASS GAP SIDE CHANNELS

If the assembly of interest is a double-ducted bypass assembly, then the temperature expression for the bypass gap side channels can be found by performing an energy balance on the noding arrangement shown in Figure 5.5. This results in an expression similar to the side channel Equation 5-5 developed in Section 5.2 with the exception that the bypass region is assumed to have no circumferential swirl flow. In addition, internodal mixing within the bypass gap is assumed to occur by conduction only.

FIGURE 5.5. Bypass Gap Side Channel Noding

$$T_0^J = T_0^{J-1} + \frac{q_o' \Delta Z}{M_4 C_p} + \frac{g_c \Delta Z k}{M_4 C_p} \left(\frac{T_2^{J-1} - T_0^{J-1}}{\eta_x} + \frac{T_3^{J-1} - T_0^{J-1}}{\eta_y} \right) + \frac{P_{NII} \Delta Z}{M_4 C_p} \left(\frac{T_1^{J-1} - T_0^{J-1}}{R_{1c}} + \frac{T_4^{J-1} - T_0^{J-1}}{R_{2c}} + q_{BC}'' \right) \quad (5-9)$$

where the subscript

- x = 3 if node 2 is a bypass side channel node
- x = C if node 2 is a bypass corner channel node
- y = 3 if node 3 is a bypass side channel node
- y = C if node 3 is a bypass corner channel node.

The last term on the right-hand side of Equation 5-9 accounts for the additional heat transfer to the node through the two adjacent duct walls. This includes the influence of the pin bundle through the wall node 1 and the

interassembly gap through the wall node 4. The wall heat flux, q''_{BC} , is nonzero only when a conduction model heat flux boundary condition is specified. A nodal heat source term, q'_0 , has been included throughout the bypass gap to allow the user additional modeling flexibility.

From Equation 5-9, the governing nodal size stability relationship can be developed. As in the previous sections, this occurs when q'_0 and q''_{BC} are zero and when T_1^{J-1} , T_2^{J-1} , T_3^{J-1} and T_4^{J-1} are negligible compared with T_0^{J-1} .

$$\frac{1}{\Delta Z_4} \geq \frac{g_c k}{M_4 C_p} \left(\frac{1}{\eta_x} + \frac{1}{\eta_y} \right) + \frac{P_{NII}}{M_4 C_p} \left(\frac{1}{R_{1c}} + \frac{1}{R_{2c}} \right) \quad (5-10)$$

Where the subscripts x and y are defined in Equation 5-9 above.

5.5 BYPASS GAP CORNER CHANNELS

If the assembly of interest is a double-ducted bypass assembly, then the temperature expression for the bypass gap corner channels can be found by performing an energy balance on the noding arrangement shown in Figure 5.6. With the exception of the extra wall heat transfer and the lack of circumferential swirl flow, the resulting temperature relationship is similar to that obtained for the corner channel in Section 5.3. As with the bypass gap side channel expression, internodal mixing within the gap is assumed to occur by conduction only.

$$T_0^J = T_0^{J-1} + \frac{q'_0 \Delta Z}{M_5 C_p} + \frac{L_{C1} \Delta Z}{M_5 C_p} \left(\frac{T_1^{J-1} - T_0^{J-1}}{R_{3c}} \right) + g_c \frac{k \Delta Z}{M_5 C_p} \left(\frac{T_2^{J-1} + T_3^{J-1} - 2T_0^{J-1}}{\eta_c} \right)$$

FIGURE 5.6. Bypass Gap Corner Channel Noding

$$\begin{aligned}
 & + \frac{L_{C2} + L_2}{2M_5 C_p} \left(\frac{\Delta T_A^{J-1}}{2R_A} + \frac{\Delta T_B^{J-1}}{2R_B} + \frac{\Delta T_C^{J-1}}{R_{4c}} \right) \\
 & + \frac{L_2 \Delta Z}{2M_5 C_p} \left(q_{BCA}'' + q_{BCB}'' \right)
 \end{aligned} \tag{5-11}$$

where

$$\begin{aligned}
 \Delta T_A^{J-1} &= 0, \text{ if the interassembly gap flow model has been specified (MODEL = 2)} \\
 &= (T_{BC}^{J-1} - T_0^{J-1}), \text{ if a temperature boundary is defined on face A and the gap conduction model has been specified (MODEL = 1)} \\
 &= (T_I^{J-1} - T_0^{J-1}), \text{ if a neighboring assembly exists on face A and the gap conduction model has been specified (MODEL = 1).}
 \end{aligned}$$

ΔT_B^{J-1} is defined similarly to ΔT_A for face B.

$\Delta T_C^{J-1} = (T_4^{J-1} - T_0^{J-1})$, if the interassembly gap flow model has been specified (MODEL = 2).

q_{BCA}'' is nonzero only if a conduction model heat flux boundary condition has been specified on face A.

q_{BC_B}'' is similar to q_{BC_A}'' for face B.

R_A is the equivalent inverse heat transfer coefficient between the corner node and either the face A neighboring assembly corner node or the duct wall temperature boundary condition, depending on the definition of T_A .

R_B is similar to R_A for face B.

The last two terms in Equation 5-11 represent the conduction heat transfer through the duct wall resulting from temperature differences and heat flux boundary conditions, respectively. They are used in place of the analogous terms in Equation 5-7, when the assembly is a double-ducted bypass assembly. Their function is described in the definitions above and in Section 5.3

The stability relationship is derived from Equation 5-11 by making the same zero heat source and negligible adjacent nodal temperature assumptions as in the last four sections.

$$\begin{aligned} \frac{1}{\Delta Z_5} \geq & \frac{L_{C1}}{M_{5C} R_{3c}} + \frac{2 g_c k}{M_{5C} \eta_c} \\ & + \frac{L_{C2} + L_2}{2M_{5C} p} \left(\frac{\delta_A}{2R_A} + \frac{\delta_B}{2R_B} + \frac{\delta_C}{R_{4c}} \right) \end{aligned} \quad (5-12)$$

The quantities δ_A , δ_B and δ_C are individually set to one if their counterparts ΔT_A , ΔT_B and ΔT_C in Equation 5-11 are nonzero.

5.6 FLOWING INTERASSEMBLY GAP SIDE CHANNELS

The governing interassembly gap side channel temperature expression for the flowing interassembly gap option (MODEL = 2) is obtained by performing an energy balance on the element shown in Figure 5.7. In SUPERENERGY-2, adjacent assemblies share the same interassembly gap noding and temperature relationships. If the assemblies are of different radial mesh sizes, the interassembly gap mesh overlays. This is illustrated in Figure 5-8. The gap side channel

FIGURE 5.7. Interassembly Gap Side Channel Noding

FIGURE 5.8 Interassembly Gap Radial Mesh

couples with the neighboring assemblies through the adjacent duct walls. Mixing between the interassembly gap nodes is assumed to occur by conduction only. The result is an equation very similar to the bypass gap side channel Equation 5-9 given in Section 5.4.

$$\begin{aligned}
 T_0^J = T_0^{J-1} + g_I \frac{\Delta Z k}{M_6 C_p} & \left(\frac{T_2^{J-1} - T_0^{J-1}}{\eta_x} + \frac{T_3^{J-1} - T_0^{J-1}}{\eta_y} \right) \\
 + \frac{P_{NII} \Delta Z}{M_6 C_p} & \left(\frac{T_1^{J-1} - T_0^{J-1}}{R_7} + \frac{\Delta T_A^{J-1}}{R_7} + \frac{\Delta T_{BC}^{J-1}}{R_9} + q_{BC}'' \right)
 \end{aligned} \quad (5-13)$$

where

$x = 5$ if node 2 is a gap side channel node

$x = 6$ if node 2 is a gap side channel node

$y = 5$ if node 3 is a gap side channel node

$y = 6$ if node 3 is a gap side channel node

and

$T_A^{J-1} = T_4^{J-1} - T_O^{J-1}$, if an adjacent assembly exists. T_4^{J-1} is an average temperature interpolated between duct wall mesh points if the adjacent assembly mesh is of a different size.

$T_{BC}^{J-1} = T_{BC}^{J-1} - T_O^{J-1}$, if a temperature boundary condition is specified on the gap outside face.

q_{BC}'' is nonzero if a heat flux boundary condition is specified on the gap outside face.

When a neighboring assembly of a different mesh size is present, SUPER-ENERGY uses the finer mesh noding in the interassembly gap. Adjacent assembly temperatures, T_4 , are found by interpolating between the larger nodes. After the gap temperature profile for the finer mesh bundle is calculated, the larger mesh gap temperatures are back calculated by using interpolation also. These temperatures are used as boundary conditions in obtaining new duct wall temperatures. The necessary interpolation of the duct wall and gap temperature produces a small energy balance error which shows up in the energy balance summary printout. This error is usually very small because of the small azimuthal temperature gradients that exist in most practical problems.

The axial stability relationship of Equation 5-13 is formed in the usual manner.

$$\frac{1}{\Delta Z_6} \frac{g_I k}{M_6 C_p} \left[\frac{1}{\eta_x} + \frac{1}{\eta_y} \right] + \frac{P_{NII}}{M_6 C_p} \left(\frac{1}{R_7} + \frac{\delta_A}{R_7} + \frac{\delta_{BC}}{R_9} \right) \quad (5-14)$$

The quantities δ_A and δ_{BC} are individually set to one if their counterparts ΔT_A and ΔT_{BC} in Equation 5-13 are nonzero. Care should be taken in the

use of the temperature boundary condition, ΔT_{BC} , since it may place an expensive constraint on stability due to the very small R_q . For typical LMFBF problems, axial noding may have to be increased by a factor of ten. The temperature boundary condition associated with gap conductance model in Section 5.8 is recommended for use whenever possible. A discussion of the interassembly conduction versus the flowing gap model is given in Section 4.2.

5.7 FLOWING INTERASSEMBLY GAP CORNER CHANNELS

The interassembly gap corner channel temperature expression for the flowing interassembly gap option (MODEL = 2) is determined by performing an energy balance on the element shown in Figure 5.9. In this case the channel may have up to three adjacent assemblies coupled to it. As in the gap side channel case, radial mixing between neighboring channels occurs by conduction only.

FIGURE 5.9. Interassembly Gap Corner Channel Noding

$$\begin{aligned}
T_o^J = T_o^{J-1} &+ \frac{g_1 \Delta Z k}{M_7 C_p} \left(\frac{T_2^{J-1} + T_3^{J-1} - 2T_o^{J-1}}{\eta_6} + \frac{\Delta T_C^{J-1}}{\eta_6} \right) \\
&+ \frac{L_2 \Delta Z}{M_7 C_p} \left(\frac{T_1^{J-1} - T_o^{J-1}}{R_8} + \frac{T_A^{J-1}}{R_A} + \frac{T_B^{J-1}}{R_B} \right) \\
&+ \frac{L_2 \Delta Z}{2M_7 C_p} \left(\frac{\Delta T_{BCA}^{J-1}}{R_{10}} + \frac{\Delta T_{BCB}^{J-1}}{R_{10}} + q_{BCA}'' + q_{BCB}'' \right)
\end{aligned} \tag{5-15}$$

where

$\Delta T_A^{J-1} = (T_I^{J-1} - T_o^{J-1})$, for the face A neighboring assembly if interassembly heat transfer exists
 $= 0$, if the fact has a specified boundary condition or is adiabatic.

ΔT_B^{J-1} is defined similarly to ΔT_A^{J-1} for face B neighboring assembly.

$\Delta T_C^{J-1} = (T_4^{J-1} - T_o^{J-1})$, if a neighboring assembly is present on either face A or face B.

ΔT_{BCA}^{J-1} is $(T_{BC}^{J-1} - T_o^{J-1})$ if a temperature boundary condition is specified on face A.
 $= 0$, otherwise.

ΔT_{BCB}^{J-1} is defined similarly to ΔT_{BCA}^{J-1} for face B.

q_{BCA}'' is nonzero only if a heat flux boundary condition is specified on face A.

q_{BCB}'' is defined similarly to q_{BCA}'' for face B.

R_A is the total equivalent inverse heat transfer coefficient between the gap corner node and the neighboring assembly corner node for face A.

R_B is the same as R_A for face B.

Some explanation of the terms in Equation 5-15 might be helpful. The second term on the right-hand side represents the radial conduction heat transfer between the interassembly gap corner channel and the two or three neighboring interassembly side-channels. The third term on the right-hand side accounts for the heat conduction through the duct wall into the interassembly corner channel. The last term on the right-hand side contains all the specified facial boundary conditions. On a given face either interassembly heat transfer or a specified boundary condition are allowed; simultaneous use of both is not.

The axial stability criteria for Equation 5-15 is formed in the usual manner:

$$\begin{aligned} \frac{1}{\Delta Z_7} \geq & \frac{g_I \Delta Z k}{M_7 C_P} \left(\frac{2}{\eta_6} + \frac{\delta_C}{\eta_6} \right) + \frac{L_2 \Delta Z}{M_7 C_P} \left(\frac{1}{R_8} + \frac{\delta_A}{R_A} + \frac{\delta_B}{R_B} \right) \\ & + \frac{L_2 \Delta Z}{M_7 C_P} \frac{\delta_{BC_A}}{R_{10}} + \frac{\delta_{BC_B}}{R_{10}} \end{aligned} \quad (5-16)$$

The quantities δ_A , δ_B , δ_C , δ_{BC_A} , and δ_{BC_B} are individually set to one if their counterparts ΔT_A , ΔT_B , ΔT_C , ΔT_{BC_A} , and ΔT_{BC_B} in Equation 5-15 are nonzero. As described in Section 5.6, use of the temperature boundary condition with the flowing gap option may place an expensive constraint on stability because of the very small R_{10} . Use of the gap conductance model (Section 5.9) is recommended with temperature boundary conditions.

5.8 WALL CONDUCTION

SUPERENERGY-2 uses a one-dimensional resistance model to couple flow channels on either side of a duct wall. Azimuthal conduction inside the wall is ignored because the steady-state temperature gradients are generally small because of the high conductivity of the surrounding sodium. By performing an energy balance on the wall section shown in Figure 5.10, the temperature of the duct wall can be found:

FIGURE 5.10. Wall Conduction Model

$$q_{\gamma}''' P_I \Delta Z t_D + \Delta Z P_I \left[\frac{T_1^J - T_0^J}{R_A} + \frac{T_2^J - T_0^J}{R_B} \right] = 0 \quad (5-17)$$

Rearranging gives

$$T_0^J = C_A T_1^J + (1-C_A) T_2^J + q_{\gamma}''' t_D C_A R_B \quad (5-18)$$

where

$$C_A = \frac{R_A}{R_A + R_B}$$

When Equation 5-18 is used for the inner duct wall on a double ducted bypass assembly:

$q_{\gamma}''' = 0$, the gamma heating option is not available

$R_A = R_5$ for a wall side node

$= R_6$ for a wall corner node

$R_B = R_{1c}$ for a wall side node

$= R_{3c}$ for a wall corner node.

If the flowing interassembly gap model is used, Equation 5-18 uses the following variables:

$$\begin{aligned}
 q_Y''' & \text{ is nonzero if a volumetric heat source is applied to the duct wall.} \\
 R_A & = R_5 \text{ for a wall side node in a single-ducted assembly} \\
 & = R_6 \text{ for a wall corner node in a single-ducted assembly} \\
 & = R_{2c} \text{ for a wall side node in a double-ducted assembly} \\
 & = R_{4c} \text{ for a wall corner node in a double-ducted assembly} \\
 R_B & = R_7 \text{ for a wall side node} \\
 & = R_8 \text{ for a wall corner node.}
 \end{aligned}$$

The interassembly gap conduction model assumes that the coolant in the interassembly gap is a stagnant pool. The contact resistance between the bulk liquid and the duct wall is calculated using a heat transfer coefficient based on the actual velocity of the interassembly gap flow. A composite equivalent resistance between the two bundles is formed using this contact conductance and the duct wall resistances. The temperatures of the walls and interassembly gap are determined using the lever rule and the assembly fluid temperatures neighboring the duct wall. Thus the duct side wall temperatures for single-ducted assembly coupled to double-ducted assembly B would be:

$$T_O^J = C T_B^J + (1-C) T_A^J \quad (5-19)$$

where

$$C = \frac{R_5}{R_5 + R_7 + R_7 + R_{2c}}$$

The same method is used for faces that have temperature boundary conditions applied at the outside surface of the duct wall. For heat flux or adiabatic boundary conditions, the duct temperature is set to the adjacent fluid temperature. No volumetric heat source is permitted with the conduction model.

Use of the gap conduction model offers a major advantage over the flowing interassembly gap model described in Sections 5.6 and 5.7. It is not stability limited since the temperatures of the interassembly gap are calculated after the adjacent side channel temperatures are known. This usually allows the code to compute using larger axial nodes. The conduction model does introduce a small error in that energy is not convected out of the bundle by the interassembly gap flow. In most cases this error is insignificant.

5.9 SOLUTION PROCEDURE

SUPERENERGY-2 begins a calculation by processing the input, calculating the connector logic and bundle geometries, determining the properties, flow-split and mixing parameters, and performing some error checking. The maximum stable axial node size is determined using Equations 5-4, 5-6, 5-8, 5-10, 5-12, 5-14, and 5-16 for each bundle. This node size is used to limit or replace the input node size depending on the option selected. A flow chart and subroutine description is given in Appendix B.

The coolant temperature calculation begins with the temperature array of $J = 1$ being initialized to the inlet condition. Equations 5-2, 5-5, 5-6, 5-9, 5-11, 5-13, and 5-15 are used to calculate the coolant temperatures at axial level $J = 2$. The duct wall temperatures at level $J=2$ are determined using Equation 5-18 or 5-19. This procedure is repeated for each axial level, printing out the solution in temperature maps at desired axial locations while marching through the bundle.

6.0 APPLICATIONS

The previous sections have discussed the modeling improvements made in the SUPERENERGY-2 and have shown a brief derivation of the governing temperature expressions. The purpose of this section is to reiterate some of the important information and to provide some hints on how to best use SUPERENERGY for design applications. The first major point to recognize about SUPERENERGY is that it is not a benchmark code. Its range of application should be restricted to steady-state forced-convection flow in bundles with standard LMFBR geometries. The code contains an internal check on flow regime (see Section 4.3.1) and will stop if the calculation enters the mixed convection regime. The code results are strongly dependent on the mixing parameter and flowsplit correlations given in Section 4.3. If the calculation falls within the geometric range of these correlations, SUPERENERGY-2 will provide results comparable to any benchmark code. Otherwise the results will be questionable and the use of a more general LMFBR code such as COBRA-WC (George et al. 1980) is recommended.

When setting up input for a SUPERENERGY calculation, the following procedure is recommended.

1. Draw a map showing the problem orientation, numbering the assemblies in some logical order. An example of this is shown with the Appendix F sample problem. The model should couple the assemblies of interest to other bundles on all sides, whenever possible, so that proper facial boundary conditions are calculated.
2. Determine the degree of radial node lumping desired. Is a standard subchannel mesh in the bundles at the edge of the problem necessary? Storage and running time can be reduced by lumping the nodes. For input simplicity (particularly the radial power factors), however, it may be easier to calculate using a standard subchannel mesh since most computers can easily handle the storage required for large problems (50 bundles), and SUPERENERGY fast running time (see Appendix F) poses no financial constraint.

3. Determine the number of different bundle geometry types, the total number of bypass bundles, total number of axial profiles, etc. as given on the list of critical dimension parameters in Appendix D. Make sure the code is dimensioned large enough for the problem. If not, redimension using auxiliary program CONVERT. Most errors are the result of improper dimensioning.
4. Set up the input using the input description given in Appendix A. The input has been arranged in groups. Group 1 is the general input data including calculation options, property tables and printout information. Group 2 is the bundle type data requiring a geometric input for each bundle type in the problem. Group 3 contains the forcing function and profile data. It contains tabular input for axial and radial forcing functions and flowsplit and mixing parameter profiles. Group 4 is the bundle specific input. Each assembly in the problem is formed using Group 2 and Group 3 information along with specific operating conditions. Extra Group 3 and Group 4 bundle types and profiles may be included even though they are not used by Group 4. This makes it easy to make multiple runs using the same deck by simply changing a few cards in Group 4.

The SUPERENERGY-2 code is written in a modular form making it easy to change when necessary. A code subroutine description and flowchart are given in Appendix C. The bundle geometric parameters, calculated in subroutine GEOM, are listed in Appendix E. SUPERENERGY-2 is written in SI units. The input and output are converted from British engineering units to SI units if the option IFORM=1 is specified.

At various places throughout this document, the interassembly gap conduction model has been recommended instead of the flowing gap model for use with interassembly heat transfer calculations. This recommendation is made because the equations associated with the conduction model impose less of a stability constraint on the axial node size, providing a faster problem solution. A small error is induced, however, because no energy is convected out of the

bundle by interassembly gap flow. For most problems this error is only a small fraction of one percent of the bundle energy. More information about the SUPERENERGY conduction model is available in Basehore and Todreas (1976).

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APPENDIX A
SUPERENERGY-2 INPUT

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SUPERENERGY-2 INPUT

<u>GROUP 1</u>	<u>GENERAL INPUT DATA</u>	
<u>INPUT 1.1</u>	<u>IFORM, TEXT</u>	(FORMAT I5,17A4)
IFORM	= 0	input and output units in international engineering (SI) units
	= 1	input and output units in British engineering units. The code automatically converts to and works in SI units
TEXT	=	an alphanumeric text identifier up to 68 characters long describing the problem to be run
<u>INPUT 1.2</u>	<u>NOASSM, NTYPE, MODEL, NCOENT, NDENT</u>	(FORMAT 5I5)
NOASSM	=	total number of assemblies in this simulation NOASSM ≤ NA
NTYPE	=	total number of different assembly types in this simulation NTYPE ≤ NL
MODEL	=	interassembly gap model
	= 1	no interassembly gap flow, conduction model. For interassembly heat transfer the gap temperatures are found by resistance averaging. All boundary conditions (if any) are applied at the hex can wall exterior faces. This model is recommended for use whenever possible.
	= 2	interassembly gap flow. Intragap heat transfer allowed. All boundary conditions (if any) are applied outside the flowing interassembly gap.

NCOENT	= 0	code correlations for coolant properties are used
	≠ 0	a table of NCOENT values for coolant properties is input in INPUT 1.3 NCOENT ≤ N1
NDENT	= 0	code correlations for duct properties are used
	≠ 0	a table of NDENT values for duct properties is input in INPUT 1.4 NDENT ≤ N1

INPUT 1.3 TEMPC (I), RHOC (I), CPC (I), CONDC (I), VISC (I),
I = 1, NCOENT (FORMAT 5F10.0)

****Optional Input NCOENT > 0**

TEMPC	=	coolant property table temperature (°C or °F)
RHOC	=	coolant density corresponding to TEMPC (kg/m ³ or lbm/ft ³)
CPC	=	coolant specific heat corresponding to TEMPC (J/kg-°K or Btu/lbm-°F)
CONDC	=	coolant thermal conductivity corresponding to TEMPC (W/m-°K or Btu/hr-ft-°F)
VISC	=	coolant dynamic viscosity corresponding to TEMPC (Pa-s or lbm/ft-hr)

INPUT 1.4 TEMPD(I), RHOD(I), CPD(I), CONDD(I), I=1, NDENT
****Optional input NDENT > 0 (FORMAT 4F10.0)**

TEMPD	=	duct property table temperature (°C or °F)
RHOD	=	duct density corresponding to TEMPD (kg/m ³ or lbm/ft ³)

CPD = duct specific heat corresponding to TEMPD
(J/kg-⁰K or Btu/lbm-⁰F)

CONDD = duct thermal conductivity corresponding to
TEMPD (W/m-⁰K or Btu/hr-ft-⁰F)

INPUT 1.5 NOINCR, NAPRNT, ICHK, NDPRNT, NORMAP (FORMAT 5I5)

NOINCR = number of axial nodes for this problem. If
ICHK = 1 or 2, NOINCR can be set to zero and
will be adjusted by the code.

NAPRNT = number of axial locations for temperature map
printout to be specified in INPUT 1.6.
 $1 \leq \text{NAPRNT} \leq \text{NO}$

ICHK = axial stability check indicator
= 0 Check axial stability and stop if NOINCR is
too small for stability.
= 1 Check axial stability and set NOINCR to a
minimum for stability.
= 2 Check axial stability and change NOINCR only
if stability is violated.
= 3 Do not check stability.

NDPRNT = number of axial locations for average duct
wall temperature printout to be specified in
INPUT 1.7. Optional. $\text{NDPRNT} > \text{NO}$

NORMAP = axial power profile normalization option flag
= 1 Axial power profile will be normalized so
that integral is equal to AXBAR (INPUT
3.2). This is to compensate for the fact
that the axial mesh size not known a priori
when the axial stability option is used.

INPUT 1.6

APRNT (I), I = 1, NAPRNT (FORMAT 8F10.0)

APRNT = axial positions of the temperature map
printouts in increasing order (cm or in.).
An energy balance is also printed.

INPUT 1.7

DPRNT (I), I=1, NDPRNT (FORMAT 8F10.0)

****Optional NDPRNT > 0**

DPRNT = axial positions for average duct temperature
printout in increasing order (cm or in.)

INPUT 1.8

LENGTH, FLOWG, GAPTH (FORMAT 8F10.0)

LENGTH = axial height of the simulation (cm or in.)

FLOWG = interassembly gap mass flux ($\text{kg/m}^2\text{-s}$
or $\text{lbm/ft}^2\text{-hr}$). FLOWG must be nonzero if
MODEL = 2. Also due to stability constraints
a small FLOWG may be expensive to run. In
this case MODEL = 1 is suggested. If
MODEL = 1, FLOWG is used to determine the gap
heat transfer coefficient for resistance
averaging.

GAPTH = interassembly gap thickness (cm or in.)

INPUT 1.9

HT1, HT2, HT3, HT4 (FORMAT 4F10.0)

HT1, HT2 = coefficients for the duct wall-to-coolant
HT3, HT4 heat transfer correlation of the form:
$$\text{Nu} = \text{HT1} (\text{Re}^{\text{HT2}} \text{Pr}^{\text{HT3}}) + \text{HT4}.$$

When HT1 and HT2 are zero, default is the
Lyon-Martinelli correlation HT1 = 0.025,
HT2 = HT3 = 0.8 and HT4 = 7.0

GROUP 2BUNDLE TYPE DATA

Repeat Group 2 data for NTYPE assembly types.

INPUT 2.1ID, NROD (ID), ILUMP (ID) (FORMAT 3I5)

ID	=	assembly type identification number. If $ID > NL$, the assembly is a bypass assembly. $1 \leq ID \leq NK$
NROD	=	number of fuel pins in assembly type
ILUMP	=	lumping option
	= 0	nonlumped assembly; assembly nodding by subchannels based on NROD. Radial power are factors input by rod number. See Figure A.1 for standard subchannel nodding scheme.
	= 1	lumped assembly; assembly nodding based on NRING (INPUT 2.3) regardless of NROD. Radial power factors are input by channel number. In a bypass assembly this allows optional heat generation in the bypass coolant channels.

INPUT 2.2P(ID), LEAD(ID), FLAT(ID), DUCTTH(ID), CLADOD(ID)
WIREOD(ID), SHWIRE(ID), SF(ID) (FORMAT 8F10.0)

P	=	fuel pin pitch (cm or in.). P governs where the bundle tolerance (if any) is applied. The gap between the duct and the outermost ring of rods for bundle type ID is calculated as $g = 1/2 (FLAT - \sqrt{3} NRING * P - CLADOD)$ where NRING is set to the number of fuel rod rings or is defined by INPUT 2.3.
LEAD	=	wire wrap lead length (cm or in.)

FIGURE A.1. Standard Subchannel Noding for 61-Pin Assembly

FLAT	=	duct inside flat-to-flat distance for pin bundle. For a bypass assembly this is for the innermost duct. (cm or in.)
DUCTTH	=	duct wall thickness. For a bypass assembly, this is the outer duct thickness (cm or in.)
CLADOD	=	fuel pin diameter (cm or in.)
WIREOD	=	wire wrap diameter (cm or in.)
SHWIRE	=	wire wrap diameter in the side and corner subchannels. Defaults to WIREOD (cm or in.)

SF = conductivity shape factor; multiplier on the conduction term for the pin bundle. This factor is not applied in bypass or inter-assembly gap flow subchannels. A value of 1.0 - 1.3 is recommended, although 0.0 may be used if the user wishes to eliminate the conduction contribution to the radial energy mixing.

INPUT 2.3

NRING (ID) (FORMAT I5)

**Optional ILUMP(ID) = 1

NRING = subchannel nodding index. For a nonlumped bundle, NRING is set automatically by the code to the number of rings of fuel pins surrounding the center rod. Thus, as examples, for a 7-pin bundle, NRING = 1; for a 19-pin bundle, NRING = 2; and for a 217 pin bundle, NRING = 8. When ILUMP = 1, the user specifies the nodding. Thus, for example, if NRING = 4 is set, the bundle is automatically noded like a 61-pin nonlumped bundle, calculating the appropriate lumped flow areas based on the actual geometry specified in INPUT 2.2. The side and corner subchannel thickness remains the same regardless of lumping. See Figure A.2 as compared to Figure A.1.

INPUT 2.4

CWALLT (JX), CGAPTH (JX) (FORMAT 2F10.0)

**Optional ID > NL bypass bundle JX = ID-NL

CWALLT = thickness of the interior duct (cm or in.)

CGAPTH = thickness of the bypass gap (cm or in.)

Example of SUPERENERGY lumping. Here a 61-pin bundle ($\text{NRING} = 4$) is lumped into an $\text{NRING} = 2$ bundle, looking very much like a 19-pin bundle in noding. Notice the thickness of the side and corner subchannels stays the same. Only the side subchannel width varies. This constraint is necessary to simplify the automatic geometry generation.

FIGURE A.2. Automatic Lumping

INPUT 2.5

NPARAM

NPARAM(ID), NFSPLT(ID) (FORMAT 2I5)

- = ϵ_{1L}^* and C_{1L} index;
 ϵ_{1L}^* is the dimensionless enhanced eddy diffusivity of heat applied inside the pin bundle.
 C_{1L} is the ratio of the circumferential swirl velocity to the side subchannel axial velocity (V_s/V_2).
- = 0 Use MIT correlations incorporated in the code.
- > 0 Use profile number NPARAM to be read in INPUT 3.7.

NFSPLT	=	flowsplit index
	= -1	Use MIT correlation incorporated in the code as bulk bundle velocity multipliers. Suggested for use with NPARAM = 0
	= 0	Use NOVENDSTERN correlation incorporated in the code as bulk bundle velocity multipliers.
	> 0	Use profile number NFSPLIT to be read in INPUT 3.6 as bulk bundle velocity multipliers.

GROUP 3

FORCING FUNCTIONS AND PROFILES

INPUT 3.1

NOAXPP, NORPPP, NBCAX, NBCSKW, NFSP, NEPCP, NORHTM
(FORMAT 7I5)

NOAXPP	=	number of axial power profiles to be read in INPUT 3.2 $NOAXPP \leq NH$
NORPPP	=	number of radial pin power profiles to be read in INPUT 3.3. For use with nonlumped assemblies. $NORPPP \leq ND$
NBCAX	=	number of axial boundary condition and gamma heating profiles to be read in INPUT 3.4 $NBCAX \leq NQ$
NBCSKW	=	number of facial skew boundary condition and gamma heating profiles to be read in INPUT 3.5 $NBCSKW \leq NF$
NFSP	=	number of flowsplit versus Reynolds number profiles to be read in INPUT 3.6 $NFSP \leq NN$
NEPCP	=	number of ϵ^*_{IL} and C_{1L} vs Reynolds number profiles to be read in INPUT 3.7 $NEPCP \leq NM$

NORHTM = number of nodal heat generation profiles to be read in INPUT 3.8. For use with lumped assemblies. $NORHTM \leq NE$

INPUT 3.2 NAXPEN(ID), AXBAR(ID) (FORMAT I5, F10.0)
 AXHTPP(I,ID), APP(I,ID), I=1, NAXPEN(ID) (FORMAT 8F10.0)
 Repeat - NOAXPP times ID=1, NOAXPP

NAXPEN = number of tabular entries in axial power profile ID

AXBAR = desired integral of the axial multiplier curve to be used only when NORMAP = 1 (INPUT 4.5); defaults to 1.0 if blank.

AXHTPP = normalized axial height at which APP is applied. Entries for 0.0 and 1.0 required.

APP = axial power multiplier at normalized height AXHTPP. Linear interpolation of axial data is made for each axial node center and held constant throughout the node.

INPUT 3.3 NPINP(ID), ICOBRA, ITAPE (FORMAT 3I5)
 RPPP(I) I = ISTART, ISTOP (FORMAT 8F10.0)
 Repeat - NORPPP times ID = 1, NORPPP

NPINP = number of radial pin powers to be input, equal to the number of rods in the bundle to which they are applied

ICOBRA = option for COBRA code rod sequencing for input
 = 0 SUPERENERGY rod sequencing (Figure A.3a)
 = 1 COBRA code rod sequencing (see Figure A.3b)

with immediate conversion to SUPERENERGY
sequence after input

ITAPE = option for binary read of pin powers
 = 0 read from cards (device ICR) in FORMAT 8F10.0
 > 0 binary read from device ITAPE

SUPERENERGY Rod Numbering

COBRA Rod Numbering(8)

FIGURE A.3. Rod Numbering Schemes (Larger bundles continue in the same manner)

RPPP = radial pin power multipliers. These are compacted into a one-dimensional array with NPLOC(ID) as the pointer for the first pin location of profile ID.

INPUT 3.4 NBCAEN(ID) (FORMAT I5)
BCAXHT(I,ID), BCAXP(I,ID), I=1, NBCAEN(ID) (FORMAT 8F10.0)
**Optional NBCSKW > 0

Repeat - NBCAX times ID=1, NBCAX

NBCAEN = number of tabular entries in axial boundary condition or gamma heating, profile ID

BCAXHT = normalized axial height at which BCAXP is applied. Entries for 0.0 and 1.0 required.

BCAXP = axial multiplier for boundary condition or gamma heating applied at BCAXHT

INPUT 3.5 NBCSEN(ID), NBTYPB(ID) (FORMAT 2I5)
BCSKWT(I,ID), BCSKEW(I,ID), I=1, NBCSEN(ID) (FORMAT 8F10.0)
**Optional NBCSKW > 0

Repeat - NBCSKW times ID=1, NBCSKW

NBCAEN = number of tabular entries in facial skew profile ID

NBTYPB = bundle type number to which this profile is to be applied

BCSKWT = normalized facial position at which BCSKEW is applied. Outside bundle left-hand corner is designated 0.0. Outside bundle right-hand corner is 1.0.

BCSKEW = facial multiplier for boundary condition or gamma heating applied at BCSKWT

INPUT 3.6

NFSENT(ID) (FORMAT I5)

REF(I,ID), X1(I,ID), X2(I,ID), X3(I,ID), I=1, NFSENT(ID)
(FORMAT 4F10.0) **Optional NFSP > 0

Repeat - NFSP times ID = 1, NFSP

NFSENT = number of tabular entries in the flowsplit vs Reynolds number profile ID

REF = Reynolds number based on interior channel equivalent diameter at which the flowsplits are applied

X_1 = interior subchannel bulk bundle velocity multiplier (V_1/V) at Reynolds number REF

X_2 = side subchannel bulk bundle velocity multiplier (V_2/V) at Reynolds number REF

X_3 = corner subchannel bulk bundle velocity multiplier (V_3/V) at Reynolds number REF

INPUT 3.7

NEPENT (ID) (FORMAT I5)

REP(I,ID), ESTAR(I,ID), C(I,ID), I=1, NEPENT(ID)
(FORMAT 6F10.0) **Optional NEPCP > 0

Repeat - NEPCP times ID = 1, NEPCP

NEPENT = number of tabular entries in the ϵ^*_{1L} and C_{1L} vs Reynolds number profile ID

REP = Reynolds number based on the interior channel equivalent diameter at which ϵ^*_{1L} and C_{1L} are applied

ESTAR = dimensionless enhanced eddy diffusivity of heat, ϵ_{1L}^* , applied at REP

C = ratio of the circumferential swirl velocity to the side subchannel axial velocity, C_{1L} , applied at REP

INPUT 3.8

NHTP(ID) (FORMAT I5)

RHTPP(I), I=ISTART, ISTOP (FORMAT 8F10.0)

**Optional NORHTM > 0

Repeat - NORHTM times ID = 1, NORHTM

NHTP = number of nodal heat generation multipliers to be read in, equal to the number of coolant nodes in the lumped bundle it is applied to. If the bundle has a noding index of NRING (see INPUT 2.3) then NHTP = $6 * (NRING^{**}2 + NRING + 1)$. For bypass bundles, heat generation may be applied in the bypass gap by optionally adding an extra $6 * NRING + 6$ nodal heat generation multipliers. See Figure A.4 for the SUPERENERGY heat generation node numbering convention.

RHTPP = nodal heat generation multipliers. These are compacted into a one-dimensional array with NHLOC(ID) as the pointer for the first node location of profile ID.

GROUP 4

BUNDLE SPECIFIC DATA

Repeat - group for NOASSM assemblies

SUPERENERGY subchannel noding scheme for nodal heat generation multiplier input. Here a 19-pin bypass bundle is shown. The heat generation nodes in a non-bypass bundle would stop at the interior duct. Larger bundles are numbered in the same pattern. Interior subchannels first, then side, then corner, followed by bypass side and bypass corner if bypass heat generation is desired in a double-ducted bypass bundle.

FIGURE A.4. Heat Generation Multiplier Noding Scheme

INPUT 4.1	ID,(BUNID(I,ID), I=1, 17)	(FORMAT I5, 17A4)
ID	=	assembly number, assemblies must be input in ascending order
BUNID	=	assembly text identifier up to 68 characters long

INPUT 4.2

ITYPE(ID), IBCTYP(ID), (PROFIL(ID,I), I=1,2), ISOLAT
(FORMAT 5I5)

ITYPE	=	assembly type number, referring to one of the types input in GROUP 2.
IBCTYP	=	facial boundary condition type. With MODEL = 1 (INPUT 1.2), the boundary conditions (if any) are applied at the hex can wall exterior face. If MODEL = 2, the boundary conditions are applied outside the flowing interassembly gap. IBCTYP must be specified, whether or not boundary conditions are used as determined by INPUT 4.6. Defaults to 1.
	= 1	heat flux boundary condition
	= 2	temperature boundary condition
PROFIL(ID,1)	=	axial power profile number (INPUT 3.2) to be used with this bundle
PROFILE (ID,2)	=	radial pin power profile number (INPUT 3.3) to be used with this bundle. If the bundle is lumped (that is, ILUMP = 1 on INPUT 2.1 for bundle type ITYPE), then PROFIL(ID,2) refers to the nodal heat generation profile number (INPUT 3.8) to be used with this bundle.
ISOLAT	=	assembly isolation condition
	= 1	No interassembly heat transfer will be allowed with this bundle. The code automatically zeros all coupling between this and neighboring bundles. Useful for modeling debug, after NEIGHB (INPUT 4.5) has already been set up on all the bundles.

INPUT 4.3

POWER(ID), FLOW(ID), TINLET(ID), TAVEC(ID), TAVEW(ID)
(FORMAT 5F10.0)

POWER = nominal linear pin power for bundle ID
(W/m or Btu/hr-ft). If the bundle is
lumped, ILUMP = 1, POWER is the nominal
coolant channel linear power.

FLOW = bundle nominal flow rate (kg/s or lbm/hr)

TINLET = bundle coolant inlet temperature
(⁰C or ⁰F)

TAVEC = average temperature for coolant property
evaluation (⁰C or ⁰F)

TAVEW = average temperature for duct property
evaluation (⁰C or ⁰F)

INPUT 4.4

FLOWBP(IBP) (FORMAT F10.0)

**Optional input ITYPE(ID) > NL (bypass assembly)

FLOWBP = bypass region flow rate (kg/s or lbm/hr).
Since the bundle is a bypass bundle another
index, IBP, has been assigned to it for
identification of bypass bundle specific
quantities.

INPUT 4.5

NEIGHB(ID,K), K = 1,6 (FORMAT 6I5)

NEIGHB = neighboring bundle numbers for the six
bundle faces if interassembly heat transfer
is desired. See Figure A.3 for face number-
ing convention.

= 0 no neighbor

INPUT 4.6

```
IPROFD(ID,K,1)
```

INPUT 4.7

BC(ID,K)

INPUT 4.8

```
IPROFD(ID,K,3)
```

INPUT 4.9

GHDNOM(ID,K)

APPENDIX B
CODE STRUCTURE AND FLOW CHART

APPENDIX B

CODE STRUCTURE AND FLOWCHART

MAIN PROGRAM SCALL

SCALL calls the subroutines in the order illustrated by Figure B.1.

SUPERENERGY Revision 2 is structured in a modular fashion with each subroutine having a specific purpose. Included below is a short summary of the subroutine functions. The flowchart on Figure B.1 shows the interrelation between the subroutines. A code listing is given in Appendix C.

SUBROUTINE AXSTAB (I,IBP)

Called by SCALL. AXSTAB determines the maximum axial node length possible for bundle number I or bypass bundle number IBP based on the stability relations derived in Section 4 of the main text. The minimum constraining value of ΔZ for all assemblies is found. At the users option (variable ICHK), this value is either used, compared against the input value or discarded. See INPUT 1.5 in Appendix A for options.

SUBROUTINE CALC

Called by SCALL. CALC performs the initialization of temperature power factor and energy balance arrays. It then marches through the problem, calculating temperatures plane by plane and calling subroutine INHEAT for interassembly heat transfer coupling. Subroutines ENERGY, OUTPUT and DTEMP are called whenever a printout is specified. A detailed flowchart and explanation of subroutine CALC is provided in Figure B.2.

SUBROUTINE CHANGE (NTYPE)

Called by SCALL. Converts all metric unit or British engineering unit code unit input from subroutine INPUT to SI units for calculational purposes. Conversion factors used depend on IFORM (INPUT 1.1 in Appendix A). NTYPE is the number of bundle geometry types in this problem.

FIGURE B.1. SUPERENERGY 2 - Flowchart

FIGURE B.2. Subroutine CALC Flowchart

GAP FLOW MODEL, GAMMA HEATING
ALLOWED IN DUCT WALL

IF INTERASSEMBLY HEAT TRANSFER EXISTS ON
FACE J OF ASSEMBLY I, CALCULATE DUCT
WALL AND GAP SIDE CHANNEL TEMPERATURES
WITH SUBROUTINE INHEAT. APPLY GAMMA
HEATING IF SPECIFIED

CALCULATE GAP AND DUCT SIDE CHANNEL
TEMPERATURES APPLYING BOUNDARY
CONDITIONS IF SPECIFIED. FACE J OF
ASSEMBLY I

CALCULATE GAP CORNER TEMPERATURES
APPLYING BOUNDARY CONDITIONS IF
SPECIFIED

CALCULATE DUCT CORNER CHANNELS USING
RESISTANCE AVERAGING

FIGURE B.2. contd

SUBROUTINE CURV (FX, X, F, Y, N, K, B)

Interpolation subroutine called by most other subroutines. CURV determines dependent variable, FX, corresponding to independent variable, X, using the input ordinate array, F, and input abscissa array, Y. N is the number of variables in F and Y. B is the resultant fractional multiplier. K is the interpolation index.

SUBROUTINE DTEMP

Called by CALC if the average duct wall temperature printout option is specified (INPUT 1.5, 1.7 in Appendix A). DTEMP averages the duct wall temperatures by face for all the assemblies at a specified axial height and prints them. Each duct is averaged separately for a double-ducted bypass assembly.

SUBROUTINE ECHO (ICR,7)

Called by INPUT. ECHO prints out a data card image listing of the SUPERENERGY input for debug purposes. In the process, the data input is copied from logical unit ICR to logical unit 7 where it can be read by subroutine INPUT.

SUBROUTINE ENERGY (ZOUT)

Called by CALC when a temperature map printout is specified at axial level ZOUT. ENERGY computes the global energy balance for the problem by assembly and accounts for heat gain or loss by heat generation, facial boundary conditions, gamma heating, and interassembly heat transfer. A summary energy balance is printed.

SUBROUTINE FINDR (I,L)

Called by SCALL. FINDR precalculates all the temperature equation coefficients for Assembly I or bypass Assembly L. Geometric parameters calculated in GEOM, properties from PROP, velocities from FSPLIT and mixing

parameters from FPARAM in temporary storage locations are combined and saved in these coefficients allowing the same variables to be reused from assembly to assembly (see Figure B.1).

SUBROUTINE FPARAM(I)

Called by SCALL. FPARAM calculates the subchannel mixing parameter $\epsilon_H/(\lambda_{LI})$ (Khan et al. 1979) and the swirl velocity V_s for Assembly I. Either the MIT correlations or user-supplied tables are used based on NPARAM(K) (INPUT 2.5 in Appendix A).

SUBROUTINE FSPLIT (I,IBP)

Called by SCALL. FSPLIT calculates the flow velocities of all subchannel types for assembly I or bypass assembly IBP. The interior, side, and corner channel flowsplits can be determined from the MIT correlation, Novendstern's method or a specified input at the user's option based on NFSPLIT(K) (INPUT 2.5 in Appendix A)

SUBROUTINE GEOM(K)

Called by SCALL. GEOM calculates the geometric parameters associated with bundle type K. This includes the flow areas, node centroidal distances, equivalent diameters, nodal widths and flow region porosities.

SUBROUTINE GRASH (I)

Called by SCALL. GRASH calculates the modified Grashof number, GR^* , (see Section 4 of the main text for definition) for bundle I. If this number exceeds the critical Grashof criteria, GR_C^* , bundle I is outside of the flow regime where the SUPERENERGY equations are valid, and the calculation terminates with an error message before any temperatures are computed.

SUBROUTINE INHEAT (I,ID,J,JP,K,IT,IND)

Called by CALC for multibundle problems. INHEAT calculates the duct and interassembly gap side channel temperatures for face J of bundle I which is of

bundle type K when that face is coupled to another assembly. The duct and interassembly gap side temperatures for face JP of neighboring assembly ID of Type IT are calculated at the same time, requiring that INHEAT be called only once per facial coupling per axial node. INHEAT solves different equations for the flowing gap and conduction models which are indicated by IND. When Type IT and Type K have different channel pitches, INHEAT automatically performs an interpolative averaging technique to obtain the proper interassembly temperature couplings. The resultant energy balance error introduced appears in the subroutine ENERGY printout and is usually extremely small.

SUBROUTINE INPUT (NTYPE)

Called by SCALL. INPUT reads in, verifies and prints out the SUPERENERGY input. A list of instructions for INPUT are given in Appendix A.

SUBROUTINE NUMB (K,NL)

Called by SCALL. NUMB automatically numbers the subchannels, rods and connector arrays for bundle Type K. The only input required is NROD(K) or NRING(K) (INPUT 2.1,2.3 in Appendix A) and an indicator to determine if bundle Type K is a bypass bundle (K>NL).

SUBROUTINE PROP (I)

Called by SCALL. Calculates the duct and coolant average properties for bundle I from code correlations or user-supplied tables (INPUT 1.2) based on user-supplied average temperatures (INPUT 4.3).

SUBROUTINE OUTPUT (K,LL,NL)

Called by CALC when a temperature map printout is specified at axial level ZOUT. OUTPUT first converts the spirally numbered coolant temperature array of Bundle LL into integer arrays suitably numbered for printout, and then prints the temperatures in map form. Variable formats are used to enable

printout of 7- to 217-pin bundles. When the bundle is a bypass bundle ($K > NL$), the formats are adjusted to print out the additional bypass duct and bypass gap temperatures.

APPENDIX C
SUPERENERGY 2 - CODE LISTING

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN SCALI

```
*DECK SCALI
  PROGRAM SCALI (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7,TAPE8,T
  TAPE9)
*CALL BLK10
*CALL BLK0
C
C   EXECUTIVE PROGRAM
C   INPUT DATA AND CONVERT UNITS TO SI
C
C   CALL INPUT (NTYPE)
C   CALL CHANGE (NTYPE)
C
C   SETUP GEOMETRY AND COORDINATES FOR EACH BUNDLE TYPE
C
      DO 100 ID=1,NTYPE
        K = ITY(ID)
        CALL NUMR (K)
        CALL GEOM (K)
100    CONTINUE
      ISP = 0
C
C   FIND PROPERTIES, FLOW SPLIT, MIXING PARAMETERS, GRAV, TEMPERATURE
C   COEFFICIENTS AND LIMITING NODE SIZE FOR EACH BUNDLE
C
      DO 110 I=1,NBASSH
        K = ITYPE(I)
        IF (K.GT.NL) ISP = ISP+1
        CALL PROP (I)
        CALL FSPLIT (I,ISP)
        CALL FPARAM (I)
        CALL GRASH (I)
        CALL FINDR (I,ISP)
        CALL AXSTAR (I,IRP)
110    CONTINUE
C
C   COMPUTE TEMPERATURES
C
C   CALL CALC
C   STOP
C   END
```

```
SCALI 1
SCALI 2
SCALI 3
SCALI 4
SCALI 5
SCALI 6
SCALI 7
SCALI 8
SCALI 9
SCALI 10
SCALI 11
SCALI 12
SCALI 13
SCALI 14
SCALI 15
SCALI 16
SCALI 17
SCALI 18
SCALI 19
SCALI 20
SCALI 21
SCALI 22
SCALI 23
SCALI 24
SCALI 25
SCALI 26
SCALI 27
SCALI 28
SCALI 29
SCALI 30
SCALI 31
SCALI 32
SCALI 33
SCALI 34
SCALI 35
SCALI 36
SCALI 37
SCALI 38
SCALI 39
SCALI 40
```

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN AXSTAR

```
*DECK AXSTAR
  SUBROUTINE AXSTAR (I,IRP)
*CALL BLK1
*CALL BLK2
*CALL BLK10
*CALL BLK5
  DATA OYSTAR/0.0/
C
C   FIND LIMITING AXIAL STEP SIZE FOR EACH BUNDLE I AND THEN ENTIRE
```

```
AXSTAR 1
AXSTAR 2
AXSTAR 3
AXSTAR 4
AXSTAR 5
AXSTAR 6
AXSTAR 7
AXSTAR 8
AXSTAR 9
```

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN AXSTAR

```

C      PROBLEM. CHANGE INPUT STEP SIZE BASED ON ICHK.
C
      IF (ICLK, EQ, 3) GO TO 260
      K = JTYPE(I)
      NRNG = NRNG(K)
      KASE = MDEL+IRCTYP(I)
      IF (MDEL, EQ, 1) KASE = KASE+1
      NBC = 0
      NIHT = 0
      DO 100 J=1,6
        I = NEIGH(I,J)
        IF (L, GE, 1) NIHT = NIHT+1
        I = IPRNF(I,J,1)
        IF (L, RE, 1) NBC = 1
      CONTINUE
100
C
C      INTERIOR - INTERIOR CONNECTION
C
      DZ11 = 3.0+C2(I)/ETA(K,1)
C
C      INTERIOR - SIDE CONNECTION
C
      DZ12 = C2(I)*(2.0/ETA(K,1)+1.0/ETA(K,2))
C
C      SIDE - SIDE CONNECTION
C
      EA = ETA(K,3)
      IF (NRNG, EQ, 1) EA = ETA(K,4)
      DZ13 = C4(I)+C6(I)+C7(I)+C5(I)*(1.0/ETA(K,4)+1.0/EA)
C
C      CORNER CONNECTION
C
      XT1 = C12(I)
      IF (KASE, GT, 2, NR, K, GT, NL) GO TO 110
      XT1 = 0.0
      IF (KASE, EQ, 2, AND, NBC, EQ, 1) XT1 = C12(I)
      IF (NIHT, LT, 1) GO TO 110
      MULT = 0.5
      IF (NIHT, GT, 1) MULT = 1.0
      XT1 = XT1+MULT+C13(I)/C33(I)
110
      DZ14 = 2.0+C10(I)+C11(I)+XT1
      IF (K, LE, NL) GO TO 140
C
C      BYPASS ASSEMBLY CONNECTIONS
C
      EA = ETA(K,3)
      EB = AMINI(ETAC(K=NL), ETA(K,3))
      IF (NRNG, GT, 1) GO TO 120
      EA = ETAC(K=NL)
      EB = ETAC(K=NL)
120
      DZB1 = C14(IRP)+C15(IRP)+C16(IRP)*(1.0/EA+1.0/EB)
      XT1 = C19(IRP)

```

AXSTAR	10
AXSTAR	11
AXSTAR	12
AXSTAR	13
AXSTAR	14
AXSTAR	15
AXSTAR	16
AXSTAR	17
AXSTAR	18
AXSTAR	19
AXSTAR	20
AXSTAR	21
AXSTAR	22
AXSTAR	23
AXSTAR	24
AXSTAR	25
AXSTAR	26
AXSTAR	27
AXSTAR	28
AXSTAR	29
AXSTAR	30
AXSTAR	31
AXSTAR	32
AXSTAR	33
AXSTAR	34
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AXSTAR	46
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AXSTAR	48
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AXSTAR	50
AXSTAR	51
AXSTAR	52
AXSTAR	53
AXSTAR	54
AXSTAR	55
AXSTAR	56
AXSTAR	57
AXSTAR	58
AXSTAR	59
AXSTAR	60
AXSTAR	61

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN AXSTAR

	IF (KASE,GT.2) GO TO 130	AXSTAR	62
	XT1 = 0.0	AXSTAR	63
	IF (KASE,EQ.2,AND,NBC,EQ.1) XT1 = C19(IRP)	AXSTAR	64
	IF (NIHT,LT.1) GO TO 130	AXSTAR	65
	MULT = 0.5	AXSTAR	66
	IF (NIHT,GT.1) MULT = 1	AXSTAR	67
	XT1 = XT1+MULT*C21(IRP)/C33(I)	AXSTAR	68
130	DZB2 = C18(IRP)+2.0*C20(IRP)+XT1	AXSTAR	69
140	CONTINUE	AXSTAR	70
	IF (MODEL,EQ.1) GO TO 170	AXSTAR	71
C		AXSTAR	72
C	GAP RINE SURCHANNELS	AXSTAR	73
C		AXSTAR	74
	XA = 0.0	AXSTAR	75
	XB = 0.0	AXSTAR	76
	IF (NIHT,GE.1) XA = C24(I)	AXSTAR	77
	IF (NBC,EQ.1,AND,KASE,EQ.4) XB = C26(I)	AXSTAR	78
	XT1 = AMAX1(XA,XB)	AXSTAR	79
	EA = ETA(K,5)	AXSTAR	80
	EB = AMIN1(ETA(K,5),ETA(K,6))	AXSTAR	81
	IF (NRNG,GT.1) GO TO 150	AXSTAR	82
	EA = ETA(K,6)	AXSTAR	83
	EB = ETA(K,6)	AXSTAR	84
150	DZ15 = C24(I)+C25(I)*(1.0/EA+1.0/EB)+XT1	AXSTAR	85
C		AXSTAR	86
C	GAP CORNER SURCHANNELS	AXSTAR	87
C		AXSTAR	88
	XA = 0.0	AXSTAR	89
	XB = 0.0	AXSTAR	90
	IF (NIHT,LT.1) GO TO 160	AXSTAR	91
	YA = C28(I)	AXSTAR	92
	IF (NIHT,GF.2) XA = XA+C28(I)+C29(I)/ETA(K,6)	AXSTAR	93
160	IF (NBC,GE.1,AND,KASE,EQ.4) XB = 2.0*C30(I)	AXSTAR	94
	XT1 = AMAX1(XA,XB)	AXSTAR	95
	DZ16 = C28(I)+2.0*C29(I)/ETA(K,6)+XT1	AXSTAR	96
	DZIMAX = AMAX1(DZ11,DZ12,DZ13,DZ14,DZ15,DZ16)	AXSTAR	97
	GO TO 180	AXSTAR	98
C		AXSTAR	99
C	NO INTERASSEMBLY GAP	AXSTAR	100
C		AXSTAR	101
170	DZIMAX = AMAX1(DZ11,DZ12,DZ13,DZ14)	AXSTAR	102
180	IF (K,LE,NL) GO TO 190	AXSTAR	103
C		AXSTAR	104
C	BYPASS ASSEMBLY	AXSTAR	105
C		AXSTAR	106
	DZIMAX = AMAX1(DZIMAX,DZB1,DZB2)	AXSTAR	107
190	IF (DZIMAX,LE,DZSTAB) GO TO 200	AXSTAR	108
	DZSTAB = DZIMAX	AXSTAR	109
	ISTAR = 1	AXSTAR	110
200	IF (Y,LT,NDARSH) GO TO 270	AXSTAR	111
	NSTAR = LENGTH+DZSTAB+	AXSTAR	112
	DZB = 1.0/DZSTAB	AXSTAR	113

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN AXSTAB

210	IF (JCHK-1) 210,230,240	AXSTAR	114
	IF (NSTAR.LE.NOINCR) GO TO 220	AXSTAR	115
	WRITE (IPR,240) JSTAB,NSTAR,DZ	AXSTAR	116
	WRITE (IPR,240)	AXSTAR	117
	STOP	AXSTAR	118
220	WRITE (IPR,300) NSTAR	AXSTAR	119
	DZ = LENGTH/NOINCR	AXSTAR	120
	GO TO 270	AXSTAR	121
230	DZ = LENGTH/NSTAR	AXSTAR	122
	NOINCR = NSTAR	AXSTAR	123
	WRITE (IPR,310) JSTAB,NSTAR,DZ	AXSTAR	124
	GO TO 270	AXSTAR	125
240	IF (NSTAR.LE.NOINCR) GO TO 250	AXSTAR	126
	DZ = LENGTH/NSTAR	AXSTAR	127
	WRITE (IPR,240) JSTAB,NSTAR,DZ	AXSTAR	128
	NOINCR = NSTAR	AXSTAR	129
	GO TO 270	AXSTAR	130
250	WRITE (IPR,300) NSTAR	AXSTAR	131
260	DZ = LENGTH/NOINCR	AXSTAR	132
270	CONTINUE	AXSTAR	133
280	FORMAT (/5X,'STABILITY CRITERIA VIOLATED BY ASSEMBLY NUMBER',I5,/ *10X,'MAXIMUM NUMBER OF AXIAL INCREMENTS REQUIRED',I7/10X,'NEW AXIAL *L STEP SIZE',F10.6,' M'//)	AXSTAR	134
290	FORMAT (5X,'PROGRAM TERMINATED AS REQUIRED BY INPUT')	AXSTAR	135
300	FORMAT (/5X,'STABILITY CONDITIONS MET...NUMBER OF AXIAL INCREMEN *TS COULD HAVE BEEN LOWERED TO',I7//)	AXSTAR	136
310	FORMAT (5X,'STABILITY IS GOVERNED BY ASSEMBLY',I5/5X,'NUMBER OF AX *IAL INCREMENTS CHANGED TO',I7/5X,'AXIAL STEP SIZE',F10.6,' M'//)	AXSTAR	137
	RETURN	AXSTAR	138
	END	AXSTAR	139
		AXSTAR	140
		AXSTAR	141
		AXSTAR	142
		AXSTAR	143

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

*DECK	CALC	CALC	1
	SUBROUTINE CALC	CALC	2
*CALL	BLK1	CALC	3
*CALL	BLK2	CALC	4
*CALL	BLK7	CALC	5
*CALL	BLK8	CALC	6
*CALL	BLK9	CALC	7
*CALL	BLK10	CALC	8
*CALL	BLK11	CALC	9
	COMMON/INHT/ LHM,NHM,NINCR,NRNG,IPDS,ZOL	CALC	10
	DIMENSION FXGH(4),FXRC(6),IGAM(6),IRC(6)	CALC	11
*CALL	BLK5	CALC	12
	IF (NORPPP.LE.0) GO TO 180	CALC	13
	NCOUNT = 0	CALC	14
	JX = 0	CALC	15
C		CALC	16
C		CALC	17
C	TRANSFORM RADIAL PIN POWER FACTORS INTO SUBCHANNEL AVERAGE POWER	CALC	18
C	FACTOR = TC(I) ARRAY AND NTLOC(I) ARRAY USED AS TEMPORARY STORAGE	CALC	19

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

```

C      FINAL RESULT IS PUT BACK INTO RPPP(I) = LOCATER ARRAYS NPLOC(I)
C      PROFIL(I,5) ARE CORRECTED
C
      DO 150 I=1,NDASSH
        K = ITYPE(I)
        IF (ILUMP(K),EQ,1) GO TO 150
        M2 = NSC(K,2)
        M3 = NSC(K,3)
        M4 = NSC(K,4)
        MK2 = M2+1
        MK3 = M3+1
        JPIN = PROFIL(I,2)
        JX = JX+1
        MIH1 = MINO(K)-1
        NPM1 = NPLOC(JPIN)-1
        NTLOC(JX) = NCOUNT+1
C
C      INTERIOR SUBCHANNELS
C
      DO 110 L=1,M2
        PRND = 0.0
        LX = MIH1+L
        NX = NCOUNT+L
        DO 100 J=1,3
          MX = MCON(LX,J)+NPLOC(JPIN)-1
          PRND = PRND+RPPP(MX)
100      TC1(MX) = PRND/6.0
110
C
C      SIDE SUBCHANNELS
C
      DO 130 L=MK2,M3
        PRND = 0.0
        LX = MIH1+L
        NX = NCOUNT+L
        DO 120 J=1,2
          MX = MCON(LX,J)+NPM1
          PRND = PRND+RPPP(MX)
120      TC1(MX) = 0.25*PRND
130
C
C      CORNER SUBCHANNELS
C
      DO 140 L=MK3,M4
        LX = MIH1+L
        NX = NCOUNT+L
        MX = MCON(LX,1)+NPM1
140      TC1(NX) = RPPP(MX)/6.0
        NCOUNT = NCOUNT+M4
        PROFIL(I,2) = JX
150      CONTINUE
      DO 160 J=1,NCOUNT
160      RPPP(J) = TC1(J)
      DO 170 J=1,JX

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CALC 20
CALC 21
CALC 22
CALC 23
CALC 24
CALC 25
CALC 26
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CALC 66
CALC 67
CALC 68
CALC 69
CALC 70
CALC 71

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

```

170      NPLDC(J) = NTLOC(J)
180      CONTINUE
C
C
C      ZERO ENERGY BALANCE INDICATORS AND INITIALIZE TEMPERATURE ARRAY
C
      DUMER=100.
      IF (YFORM,FG,1) DUMER = 39.37
      QSGP = 0.0
      DO 190 I=1,NR
190      QSR(I) = 0.0
      NCOUNT = 0
      DO 250 I=1,NPASSM
      DRA(I) = 0.0
      QSD(I) = 0.0
      QSG(I) = 0.0
      QSI(I) = 0.0
      K = ITYPE(I)
      M9 = NAC(K,9)
      NRNG = NRNG(K)
      MX = M9-6*(NRNG+1)
      NTLOC(I) = NCOUNT+1
C
C      INTERIOR OF BUNDLE
C
      MSTART = NCOUNT+1
      MSTOP = NCOUNT+MX
      TDUM = TINLET(I)
      DO 200 NX=MSTART,MSTOP
200      TC1(NX) = TDUM
C
C      INTERASSEMBLY GAP EDGE SUBCHANNELS
C
      MSTART = MSTART+MX
      MSTOP = M9+NCOUNT-6
      DO 220 NX=MSTART,MSTOP
      ID = (NX-MSTART)/NRNG+1
      ID = NFIGHR(I,ID)
      IF (ID,LT,1) GO TO 210
      TC1(NX) = (TDUM+TINLET(ID))*0.5
      GO TO 220
210      TC1(NX) = TDUM
220      CONTINUE
C
C      INTERASSEMBLY GAP CORNER SUBCHANNELS
C
      DO 240 L=1,6
      TSUM = TDUM
      DIV = 1.0
      ID = NEIGHR(I,L)
      IF (ID,LT,1) GO TO 230
      TSUM = TSUM+TINLET(ID)

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CALC      72
CALC      73
CALC      74
CALC      75
CALC      76
CALC      77
FIX01     78
CALC      79
CALC      80
CALC      81
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CALC      83
CALC      84
CALC      85
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CALC     106
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CALC     108
CALC     109
CALC     110
CALC     111
CALC     112
CALC     113
CALC     114
CALC     115
CALC     116
CALC     117
CALC     118
CALC     119
CALC     120
CALC     121
CALC     122
CALC     123

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

230	DIV = DIV+1.0 LX = MOD(L+4,6)+1 ID = NEIGHR(I,LX) IF (ID.LT.1) GO TO 240 TSUM = TSUM+TINLET(ID) DIV = DIV+1.0 TC1(L+MSTOP) = TSUM/DIV	CALC	124
240	NCOUNT = NCOUNT+M9	CALC	125
250		CALC	126
C		CALC	127
C		CALC	128
C	AXIAL PROFILE NORMALIZATION OPTION	CALC	129
C		CALC	130
	IF (NORMAP.NE.1) GO TO 310	CALC	131
	DUMZ = D7/LENGTH	CALC	132
	DO 270 N=1,NOINCR	CALC	133
	Z = N*DZ	CALC	134
	ZOL = (Z-0.5*DZ)/LENGTH	CALC	135
	DO 260 ID=1,NOAXPP	CALC	136
	IF (N.EQ.1) TC2(ID) = 0.0	CALC	137
	JX = MAXPEN(ID)	CALC	138
	CALL CURV (FAX,ZOL,APP(1,ID),AXHTPP(1,ID),JX,IC,B)	CALC	139
260	TC2(ID) = FAX*DUMZ+TC2(ID)	CALC	140
270	CONTINUE	CALC	141
	WRITE (IPR,280) NOINCR	CALC	142
	WRITE (IPR,290) (ID,AXBAR(ID),TC2(ID),ID=1,NOAXPP)	CALC	143
280	FORMAT (////20X,'AXIAL POWER PROFILE NORMALIZATION OPTION'//5X,'F	CALC	144
	*OR THE NUMBER OF AXIAL STEPS =',I5,'. THE INTEGRALS OF THE INPUT P	CALC	145
	*ROFILES ARE '//10X,'PROFILE',6X,'DESIRED',4X,'CALCULATED'//11X,'NUM	CALC	146
	*RER',5X,'INTEGRAL',5X,'INTEGRAL'//)	CALC	147
290	FORMAT (10X,I5,7X,F8.3,5X,F8.3)	CALC	148
	DO 300 ID=1,NOAXPP	CALC	149
300	AXBAR(ID) = AXBAR(ID)/TC2(ID)	CALC	150
310	CONTINUE	CALC	151
C		CALC	152
C		CALC	153
C	DETERMINE BUNDLE TYPE DEPENDENT FACIAL BOUNDARY CONDITION MULTIPLI-	CALC	154
C	ERS IN ADVANCE AND REPLACE IN ORIGINAL ARRAY, AGAIN TC1(I) IS	CALC	155
C	USED ONLY FOR WORKING SPACE	CALC	156
C		CALC	157
	IF (NBCSKW.EQ.0) GO TO 350	CALC	158
	DO 340 J=1,NBC9KW	CALC	159
	K = NRTPR(J)	CALC	160
	NUM = NRING(K)	CALC	161
	FACET = 1.0/(YLEN(K,2)+NUM*PLEN(K))	CALC	162
	R = 0.25*YLEN(K,2)*FACET	CALC	163
	NX = NRCSN(J)	CALC	164
	CALL CURV (RX,R,NBC9KW(1,J),BCSKWT(1,J),NX,IC,B)	CALC	165
	TC2(1) = RX	CALC	166
	R = 1.0-R	CALC	167
	CALL CURV (RX,R,NBC9KW(1,J),BCSKWT(1,J),NX,IC,B)	CALC	168
	TC2(NUM+2) = RX	CALC	169
	DO 320 I=1,NUM	CALC	170
		CALC	171
		CALC	172
		CALC	173
		CALC	174
		CALC	175

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

	R = 0.5*FACEI*(XLEN(K,2)+PLEN(K))+FACEI*(I-1)*PLEN(K)	CALC	176
	CALL CURV (RX,R,BCSKEW(I,J),BCSKWT(I,J),NX,IC,R)	CALC	177
320	TC2(I+1) = RX	CALC	178
	NUM = NUM+2	CALC	179
	DO 330 I=1,NUM	CALC	180
330	BCSKEW(I,J) = TC2(I)	CALC	181
340	CONTINUE	CALC	182
350	CONTINUE	CALC	183
C		CALC	184
C		CALC	185
C	INITIALIZE AND PREPARE FOR MAIN CALCULATIONAL LOOP	CALC	186
C		CALC	187
	IPRNT = 1	CALC	188
	IDPNT = 1	CALC	189
	Z = 0Z	CALC	190
360	CONTINUE	CALC	191
	ISP = 1	CALC	192
	ZDL = (Z+0.5+0Z)/LENGTH	CALC	193
	DO 370 I=1,NUMASH	CALC	194
C		CALC	195
C	FIND AXIAL POWER MULTIPLIER FACTOR	CALC	196
C		CALC	197
	ID = PROFIL(I,1)	CALC	198
	JX = MAXPEN(ID)	CALC	199
	CALL CURV (FAX,ZDL,APP(I,ID),AXHTPP(I,ID),JX,IC,R)	CALC	200
	FAX = FAX+POWER(I)*AXBAR(ID)	CALC	201
	K = ITYPE(I)	CALC	202
	JX = PROFIL(I,2)	CALC	203
	NRNG = NRING(K)	CALC	204
	KARE = IRCTYP(I)+MODEL	CALC	205
	IF (MODEL.EQ.1) KARE = KARE+1	CALC	206
	(IM1 = LIND(K)-1	CALC	207
	NTM1 = NTLOC(I)-1	CALC	208
	IF (ILUMP(K).EQ.1) GO TO 370	CALC	209
	NPM1 = NPLNC(JX)-1	CALC	210
	GO TO 380	CALC	211
370	NPM1 = NPLNC(JX)-1	CALC	212
C		CALC	213
C	DETERMINE AXIAL POWER MULTIPLIERS FOR BC, 6 FACES	CALC	214
C		CALC	215
380	DO 400 J=1,6	CALC	216
	ID = IPRDF(I,J,1)	CALC	217
	IF (ID.GT.0.AND.NEIGHB(I,J).LT.1) GO TO 390	CALC	218
	IBC(J) = 0	CALC	219
	GO TO 400	CALC	220
390	IBC(J) = IPRDF(I,J,2)	CALC	221
	N = NBCAFN(ID)	CALC	222
	CALL CURV (FDUM,ZDL,BCAXP(I,ID),BCAXHT(I,ID),N,IC,R)	CALC	223
	FBC(J) = FDUM+BC(I,J)	CALC	224
400	CONTINUE	CALC	225
	M1 = NSC(K,1)	CALC	226
	M2 = NSC(K,2)	CALC	227

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

M3 = NSC(K,3)
M4 = NSC(K,4)
M5 = NSC(K,5)
M6 = NSC(K,6)
M7 = NSC(K,7)
M8 = NSC(K,8)
MK2 = M2+1
MK3 = M3+1
MK4 = M4+1
MK5 = M5+1
MK6 = M6+1
MK7 = M7+1

C
C
C

CALCULATE NEW INTERIOR SUBCHANNEL TEMPERATURES

DO 440 L=1,M2
LX = NTH1+L
KX = LTH1+L
NX = NPM1+L
MM1 = LCON(KX,1)+NTH1
MM2 = LCON(KX,2)+NTH1
MM3 = LCON(KX,3)+NTH1
EA = ETAK(K,1)
IF (ILIMP(K),EQ,1) GO TO 410
FRAD = RPPP(NX)
GO TO 420
FRAD = RHPPP(NX)
410 IF (L,RT,M1) GO TO 440
420 ES = ETAK(K,1)
430 GO TO 450
440 TQ = (L-M1-1)/(2*VRNG-1)
IR = L-M1-TQ*(2*NRNG-1)
ITEST = IR/2
IF (IR,EQ,2*ITEST) GO TO 430
EB = ETAK(K,2)
450 DTNZ = C1(I)*FRAD*FAX+C2(I)*((TC1(MM1)+T1(MM2)-2.0*TC1(LX))/
EA+(TC1(MM3)-TC1(LX))/EB)
QSA(I) = QSA(I)+FAX*FRAD*DNZ
460 TCP(LX) = TC1(LX)+DTNZ*DNZ

C
C
C

CALCULATE NEW SIDE SUBCHANNEL TEMPERATURES

ITEST = 0
DO 540 L=MK2,M7
LX = NTH1+L
KX = LTH1+L
NX = NPM1+L
MM1 = LCON(KX,1)+NTH1
MM2 = LCON(KX,2)+NTH1
MM3 = LCON(KX,3)+NTH1
MM4 = LCON(KX,4)+NTH1
TQ = (L-M2-1)/NRNG+1

CALC 228
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CALC 279

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

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      IR = L-MP-(IQ-1)*NRNG
      IF (ILHMP(K),EQ.1) GO TO 470
      FRAD = RPPP(NX)
      GO TO 480
470    FRAD = RHPPP(NX)
480    IF (HM2,GT,M3) GO TO 490
      EA = ETA(K,3)
      GO TO 500
490    EA = ETA(K,4)
500    IF (HM3,GT,M3) GO TO 510
      EB = ETA(K,3)
      GO TO 520
510    EB = ETA(K,4)
520    QBC = 0.0
      IF (K,LE,NL) GO TO 530
      IF (KASE,NE.1) GO TO 530
      IC = IRC(IQ)
      IF (IC,LT,1) GO TO 530

C      HEAT FLUX APPLIED TO WALL OF NORMAL ASSEMBLY
C
      QBC = C8(I)*RCRKEW(IR+1,IC)*FXRC(IQ)
530    DTOZ = C3(I)*FAX*FRAD+C4(I)*(TC1(MH1)-TC1(LX))+(C5(I)/EA+C
      +      A(I))*(TC1(MH2)-TC1(LX))+C5(I)*(TC1(MH3)-TC1(LX))/EB+C7(I)
      +      *(TC1(MH4)-TC1(LX))+QBC
      QSA(I) = QSA(I)+FRAD*FAX*DZ
      QSD(I) = QSD(I)+QBC*DZ/C3(I)
540    TC2(LX) = TC1(LX)+DTOZ*DZ

C      CALCULATE NEW CORNER SUBCHANNEL TEMPERATURES
C
      DO 6 TO L=MK3,M4
      LX = NTH1+L
      KX = LTH1+L
      NX = NPH1+L
      MH1 = LCON(KX,1)+NTH1
      MH2 = LCON(KX,2)+NTH1
      MH3 = LCON(KX,3)+NTH1
      JD = L-M3
      IF (ILHMP(K),EQ.1) GO TO 550
      FRAD = RPPP(NX)
      GO TO 560
550    FRAD = RHPPP(NX)
560    QBC = 0.0
      QIHT = 0.0
      CC = C12(I)
      IF (K,GT,NL) GO TO 620
      IF (KASE,GT,2) GO TO 620

C      NORMAL ASSEMBLY WITH NO INTERASSEMBLY GAP FLOW
C
      CC = 0.0

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CALC 240
CALC 241
CALC 242
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CALC 331

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

	IC = IRC(IQ)	CALC	332
	IF (IC,LT,1) GO TO 580	CALC	333
	IF (KASE,EO,2) GO TO 570	CALC	334
C		CALC	335
C	HEAT FLUX BC ON FACE IQ	CALC	336
C		CALC	337
	QBC = FXBC(IQ)+C13(I)*BCSKEW(I,IC)	CALC	338
	GO TO 590	CALC	339
C		CALC	340
C	TEMPERATURE BC ON FACE IQ	CALC	341
C		CALC	342
570	TA = FXBC(IQ)+PC8(GW(I,IC)	CALC	343
	QBC = C12(I)*(TA-TC1(LX))	CALC	344
	GO TO 590	CALC	345
580	ID = NEIGHR(I,JQ)	CALC	346
	IF (ID,LT,1) GO TO 590	CALC	347
C		CALC	348
C	INTERASSEMBLY HEAT TRANSFER ON FACE IQ	CALC	349
C		CALC	350
	NUM = MOD(3+IQ,6)+1	CALC	351
	CA = C13(I)/(C33(I)+C33(ID))	CALC	352
	IT = ITYPE(ID)	CALC	353
	KX = NTLOC(ID)+NSC(IT,9)-12*(NRING(IT)+1)+NUM-7	CALC	354
	QIMT = CA*(TC1(KX)-TC1(LX))	CALC	355
590	IDM1 = MOD(IQ+4,6)+1	CALC	356
	IC = IRC(IQM1)	CALC	357
	IF (IC,LT,1) GO TO 610	CALC	358
	IF (KASE,EO,2) GO TO 600	CALC	359
C		CALC	360
C	HEAT FLUX BC ON FACE IQM1	CALC	361
C		CALC	362
	QBC = QBC+FXBC(IQM1)+C13(I)*BCSKEW(NRING+5,IC)	CALC	363
	GO TO 620	CALC	364
C		CALC	365
C	TEMPERATURE BC ON FACE IQM1	CALC	366
C		CALC	367
600	TS = FXBC(IQM1)+BCSKEW(NRING+2,IC)	CALC	368
	QBC = QBC+C12(I)*(TS-TC1(LX))	CALC	369
	GO TO 620	CALC	370
610	ID = NEIGHR(I,IQM1)	CALC	371
	IF (ID,LT,1) GO TO 620	CALC	372
C		CALC	373
C	INTERASSEMBLY HEAT TRANSFER ON FACE IQM1	CALC	374
C		CALC	375
	NUM = MOD(1+IQ,6)+1	CALC	376
	CR = C13(I)/(C33(I)+C33(ID))	CALC	377
	IT = ITYPE(ID)	CALC	378
	KX = NTLOC(ID)+NSC(IT,9)-12*(NRING(IT)+1)+NUM-7	CALC	379
	QIMT = QIMT+CR*(TC1(KX)-TC1(LX))	CALC	380
620	QTOZ = C9(I)*FAX*FRAD+C10(I)*(TC1(MM1)+TC1(MM2)-2.0*TC1(LX	CALC	381
+	)+C11(I)*(TC1(MM1)-TC1(LX))+C2*(TC1(MM3)-TC1(LX))+QBC+QIM	CALC	382
+	T	CALC	383

C.12

CALC	384
CALC	385
CALC	386
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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

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C      DO 790 L=MK7,MA
      LX = NTH1+L
      KX = LTH1+L
      MM1 = LCON(KX,1)+NTH1
      MM2 = LCON(KX,2)+NTH1
      MM3 = LCON(KX,3)+NTH1
      MM4 = LCON(KX,4)+NTH1
      IQ = L-M7
      FRAD = 0.0
      IF (INDEX,EQ.1) GO TO 720
      NX = NPM1+L
      FRAD = RHTPP(NX)
720    QBC = 0.0
      CC = C19(IRP)
      IF (KASE,GT.2) GO TO 790

C      EXAMINE BC AND INT. ASRM. HEAT TRANSFER IF CONDUCTION MODEL OPTION
C
      CC = 0.0
      IC = IRC(IQ)
      IF (IC,LT.1) GO TO 740

C      BOUNDARY CONDITION APPLIED TO FACE IQM1
C
      IF (KASE,EQ.2) GO TO 730
      QBC = FXRC(IQ)*C21(IRP)*BCSKEW(1,IC)
      GO TO 750
730    TA = FXBC(IQ)*BCSKEW(1,IC)
      QBC = C19(I)*(TA-TC1(LX))
      GO TO 750
740    ID = NEIGHR(I,IQ)
      IF (ID,LT.1) GO TO 750

C      NEIGHBORING ASSEMBLY ON FACE IQ
C
      NUM = MOD(3+IQ,6)+1
      CA = C21(IRP)/(C33(1)+C33(ID))
      IT = ITYPE(ID)
      KX = NTLOC(ID)+NSC(IT,9)-12*(NRING(IT)+1)+NUM-7
      QIHT = CA*(TC1(KX)-TC1(LX))
750    IQM1 = MOD(ID+6,6)+1
      IC = IRC(IQM1)
      IF (IC,LT.1) GO TO 770

C      BOUNDARY CONDITION APPLIED TO FACE IQ
C
      IF (KASE,EQ.2) GO TO 760
      QBC = QBC+FXRC(IQM1)*C21(IRP)*BCSKEW(NRNG+2,IC)
      GO TO 780
760    TB = FXRC(IQM1)*BCSKEW(NRNG+2,IC)
      QBC = QBC+C19(I)*(TB-TC1(LX))

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

	GO TO 780	CALC	488
770	JD = NEIGHB(I, IOM1)	CALC	489
	IF (ID, LY, 1) GO TO 780	CALC	490
C		CALC	491
C	NEIGHBORING ASSEMBLY ON FACE IOM1	CALC	492
C		CALC	493
	NUM = MOD(1+IR, 6)+1	CALC	494
	CB = C21(IRP)/(C33(I)+C33(ID))	CALC	495
	IT = ITYPE(ID)	CALC	496
	KX = NTLOC(ID)+NSC(IT, 9)-12*(NRING(IT)+1)+NUM-7	CALC	497
	QIHT = QIHT+CB*(TC1(KX)-TC1(LX))	CALC	498
780	QTOZ = C41(IRP)*FAX*FRAD+C18(IRP)*(TC1(MM1)-TC1(LX))+C20(I	CALC	499
+	BP)*(TC1(MM2)+TC1(MM3)-2.0*TC1(LX))+CB*(TC1(MM4)-TC1(LX))+	CALC	500
+	QSC+QIHT	CALC	501
	QSR(IRP) = QSR(IRP)+FAX*FRAD+QZ	CALC	502
	QSD(I) = QSD(I)+QSC+QZ/C41(IRP)	CALC	503
	QSI(I) = QSI(I)+QIHT+QZ/C41(IRP)	CALC	504
790	TC2(LX) = TC1(LX)+QTOZ+QZ	CALC	505
C		CALC	506
C	FIND BYPASS INSIDE DUCT TEMPERATURE BY AVERAGING	CALC	507
C	DUCT SIDE SURCHANNELS	CALC	508
C		CALC	509
	DO 800 L=MM4, MM5	CALC	510
	LX = NTM1+L	CALC	511
	KX = LTM1+L	CALC	512
	MM1 = LCON(KX, 1)+NTM1	CALC	513
	MM4 = LCON(KX, 4)+NTM1	CALC	514
800	TC2(LX) = C22(IRP)*TC2(MM4)+(1.0-C22(IRP))*TC2(MM1)	CALC	515
C		CALC	516
C	DUCT CORNER SURCHANNELS	CALC	517
C		CALC	518
	DO 810 L=MM3, MM6	CALC	519
	LX = NTM1+L	CALC	520
	KX = LTM1+L	CALC	521
	MM1 = LCON(KX, 1)+NTM1	CALC	522
	MM4 = LCON(KX, 4)+NTM1	CALC	523
810	TC2(LX) = C23(IRP)*TC2(MM4)+(1.0-C23(IRP))*TC2(MM1)	CALC	524
	IRP = IRP+1	CALC	525
820	CONTINUE	CALC	526
C		CALC	527
	IF (MODEL.EQ, 2) GO TO 930	CALC	528
C		CALC	529
C	NO GAP FLOW, NO GAMMA HEATING	CALC	530
C		CALC	531
	DO 920 I=1, NPA33M	CALC	532
	K = ITYPE(I)	CALC	533
	NRNG = NRING(K)	CALC	534
	KASE = MODEL+IRCTYP(I)-1	CALC	535
	NINCR = 6*(NRNG+1)	CALC	536
	MSTART = NSC(K, 9)-2*NINCR	CALC	537
	NTM1 = NTLOC(I)-1	CALC	538
	LTM1 = LIND(K)-1	CALC	539

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

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C
C   FIND TEMPERATURE FOR EACH SIDE OF HEX
C
      DO 880 J=1,6
      IPNS = (J-1)*NPNNG+MSTART
      ID = IPRNFD(I,J,1)
      IA = NEIGHR(I,J)
      IF (IA,GF,1) GO TO 870
      IF (ID,LT,1) GO TO 830
      IC = IPRNFD(I,J,2)
      N = NSCAEN(ID)
      CALL CURV (FDUM,ZOL,BCAXP(1,ID),BCAXHT(1,ID),N,IX,8)
      FXRC(J) = FDIHM*BC(I,J)
C
C   INTERASSEMBLY GAP SIDE AND DUCT SIDE CHANNEL LOOP
C
830      DO 860 L=1,NRNG
      LX = NTH1+IPDS+L
      KX = LM1+IPDS+L
      MM1 = LCON(KX,1)+NTH1
      MM4 = LCON(KX,4)+NTH1
      IF (JD,LT,1) GO TO 840
      IF (KASE,EO,2) GO TO 850
C
C   HEAT FLUX BOUNDARY CONDITION
C
840      TC2(LX) = TC2(MM1)
      TC2(MM4) = TC2(MM1)
      GO TO 860
C
C   TEMPERATURE BOUNDARY CONDITION
C
850      TA = FXRC(J)*BCAXEN(L+1,IC)
      TC2(MM4) = TA
      TC2(LX) = C32(1)*TC2(MM1)+(1.0-C32(1))*TA
      QSD(I) = QSD(I)+(TA-TC2(MM1))*DZ*C42(I)
      CONTINUE
860      GO TO 880
C
C   INTERASSEMBLY HEAT TRANSFER WITH NEIGHBORING ASSEMBLY IA ON FACE J
C
870      IT = ITYPE(IA)
      JP = MOD(2+J,6)+1
      IF (NEIGHR(IA,JP).NE.I) WRITE (IPR,1240) J,I,JP,IA
      IF (IA,LT,1) GO TO 880
      CALL INHFAT (I,IA,J,JP,K,IT,1)
      CONTINUE
880      YPOS = NSC(K,9)-NINCR-6
      DO 910 J=1,6
C
C   CALCULATE INTERASSEMBLY GAP CORNER AND DUCT CORNER TEMPERATURES
C

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

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      JP = MOD(J+4,6)+1
      ID = NEIGHB(I,J)
      IP = NEIGHB(I,JP)
      LX = NTH1+IPDS+J
      KX = LIM1+IPDS+J
      MH1 = LCON(KX,1)+NTH1
      MH2 = LCON(KX,2)+NTH1
      MH3 = LCON(KX,3)+NTH1
      IF (ID+IP.GE.1) GO TO 900
      IF (ID.GE.1.OR.IP.GE.1) GO TO 890
      TC2(LX) = TC2(LX+NINCR)
      TC2(LX+NINCR) = TC2(LX)
      GO TO 910
890   TC2(LX) = 0.5*(TC2(MH2)+TC2(MH3))
      TCP(LX+NINCR) = 0.5*(TC2(MH2+NINCR)+TC2(MH3+NINCR))
      GO TO 910
C
C   NEIGHBORS ON BOTH FACES
C
900   NUM = MOD(3+J,6)+1
      IT = ITYPE(ID)
      NX = NTLOC(ID)-7+NSC(IT,9)-12*(NRING(IT)+1)+NUM
      TT1 = TC2(NX)
      NUM = MOD(1+J,6)+1
      IT = ITYPE(IP)
      NX = NTLOC(IP)-7+NSC(IT,9)-12*(NRING(IT)+1)+NUM
      TC2(LX+NINCR) = (TC2(MH1)+TT1+TC2(NX))/3
      TC2(LX) = C24(I)*TC2(LX+NINCR)+(1.00-C24(I))*TC2(MH1)
910   CONTINUE
920   CONTINUE
      GO TO 1150
C
C   INTERASSEMBLY GAP FLOW AND GAMMA HEATING ALLOWED
C
930   DO 1140 I=1,NOASSH
      K = ITYPE(I)
      NRNG = NRING(K)
      KASE = MODEL+IRCTYP(I)
      NINCR = 6*(NRNG+1)
      NTH1 = NTLOC(I)-1
      LIM1 = LIND(K)-1
      NCORN = NTH1+NSC(K,9)-6
C
C   FIND TEMPERATURE FOR EACH SIDE OF HEX
C
      DO 1050 J=1,6
      IPDS = (J-1)*NRNG+NSC(K,9)-NINCR
      FXRC(J) = 0.0
      ID = IPRNFD(I,J,1)
      IA = NEIGHB(I,J)
      IF (IA.GE.1) GO TO 1040
      IF (ID.LT.1) GO TO 940

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

	TC = IPRNFD(I,J,2)	CALC	644
	N = NBCEAN(ID)	CALC	645
	CALL CURV (F0UM,ZOL,BCAXP(1,IO),BCAXHT(1,IO),N,IX,8)	CALC	646
	FXBC(J) = F0UM*BC(I,J)	CALC	647
940	IG = IPRNFD(I,J,3)	CALC	648
	IF (IG.GT.0.AND.GHONOM(I,J).GT.0.0) GO TO 950	CALC	649
	IH = 0	CALC	650
	GO TO 960	CALC	651
950	IH = IPRNFD(I,J,4)	CALC	652
	N = NBCEAN(IG)	CALC	653
	CALL CURV (F0UM,ZOL,BCAXP(1,IG),BCAXHT(1,IG),N,IX,8)	CALC	654
	FXGH(J) = F0UM*GHONOM(I,J)	CALC	655
C		CALC	656
C	INTERASSEMBLY GAP SIDE AND DUCT SIDE CHANNEL LOOP	CALC	657
C		CALC	658
960	DO 1030 L=1,NRNG	CALC	659
	LX = NTH1+L+IPDS	CALC	660
	KX = LTH1+L+IPDS	CALC	661
	MM1 = LCON(KX,1)+NTH1	CALC	662
	MM2 = LCON(KX,2)+NTH1	CALC	663
	MM3 = LCON(KX,3)+NTH1	CALC	664
	IF (MM2.GT.NCORN) GO TO 970	CALC	665
	EA = ETA(K,5)	CALC	666
	GO TO 990	CALC	667
970	EA = ETA(K,6)	CALC	668
980	IF (MM3.GT.NCORN) GO TO 990	CALC	669
	EB = ETA(K,5)	CALC	670
	GO TO 1000	CALC	671
990	EB = ETA(K,6)	CALC	672
1000	QBC = 0.0	CALC	673
	QGAM = 0.0	CALC	674
	IF (JD.LT.1) GO TO 1020	CALC	675
	IF (KASE.EQ.4) GO TO 1010	CALC	676
	QBC = C26(I)*QCSKEW(L+1,IC)*FXBC(J)	CALC	677
	GO TO 1020	CALC	678
1010	TA = FXBC(J)*QCSKEW(L+1,IC)	CALC	679
	QBC = C26(I)*(TA-TC1(LX))	CALC	680
1020	NTNZ = C24(I)*(TC1(MM1)-TC1(LX))+C25(I)*((TC1(MM2)-TC1(LX))/EA+(TC1(MM3)-TC1(LX))/EB)+QBC	CALC	681
	QSD(I) = QBD(I)+QBC+DZ+A(K,6)/C27(I)	CALC	682
	QDUM = C24(I)*(TC1(MM1)-TC1(LX))+NZ+A(K,6)/C27(I)	CALC	683
	QSGP = QSGP+QDUM	CALC	684
	QSI(J) = QSI(I)+QDUM	CALC	685
	TC2(LX) = TC1(LX)+DZ+DZ	CALC	686
C		CALC	687
C	FIND DUCT SIDE TEMPERATURES, CHECKING FOR GAMMA HEATING	CALC	688
C		CALC	689
	IF (IH.LT.1) GO TO 1030	CALC	690
	QGAM = C36(I)*QCSKEW(L+1,IH)*FXGH(J)+DUCTTH(K)	CALC	691
	QBG(I) = QBG(I)+PLEN(K)*DZ+QGAM/C36(I)	CALC	692
1030	TC2(MM1) = C31(I)+TC2(LX)+(1.0-C31(I))*TC2(MM1-NINCR)+	CALC	693
	QGAM	CALC	694
		CALC	695

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

	GO TO 1050	CALC	696
C		CALC	697
C	INTERASSEMBLY HEAT TRANSFER WITH NEIGHBORING ASSEMBLY IA ON FACE J	CALC	698
C		CALC	699
1040	IT = ITYPE(IA)	CALC	700
	JP = MOD(2+J,6)+1	CALC	701
	IF (NEIGH8(IA,JP).NE.I) WRITE (IPR,1240) J,I,JP,IA	CALC	702
	IF (IA.LY.I) GO TO 1050	CALC	703
	CALL INHEAT (I,IA,J,JP,K,IT,2)	CALC	704
1050	CONTINUE	CALC	705
	IPDS = NSC(K,9)-6	CALC	706
C		CALC	707
C	CALCULATE INTERASSEMBLY GAP CORNER AND DUCT CORNER TEMPERATURES	CALC	708
C		CALC	709
	DO 1130 J=1,6	CALC	710
	LX = NTM1+IPDS+J	CALC	711
	KX = LYM+IPDS+J	CALC	712
	MM1 = LCON(KX,1)+NTM1	CALC	713
	MM2 = LCON(KX,2)+NTM1	CALC	714
	MM3 = LCON(KX,3)+NTM1	CALC	715
	QBC = 0.0	CALC	716
	QGAM = 0.0	CALC	717
	QIHT = 0.0	CALC	718
	QGP = 0.0	CALC	719
	QSIUM = CP7(I)	CALC	720
	SUM = 1.0	CALC	721
	A7 = 2.0*A(4,7)	CALC	722
	IA = NEIGH8(I,J)	CALC	723
	IF (IA.GE.1) GO TO 1070	CALC	724
	IF (FXBC(J).EQ.0.0) GO TO 1080	CALC	725
	IC = IPRDFD(I,J,2)	CALC	726
	IF (KAGE,EQ.4) GO TO 1060	CALC	727
C		CALC	728
C	BC APPLIED TO FACE J	CALC	729
C		CALC	730
	QBC = C30(I)+FXBC(J)*BCSKEW(1,IC)	CALC	731
	GO TO 1080	CALC	732
1060	TA = FXBC(J)*BCSKEW(1,IC)	CALC	733
	QBC = C30(I)+(TA-TC1(LX))	CALC	734
	GO TO 1080	CALC	735
C		CALC	736
C	NEIGHBORING ASSEMBLY ON FACE J	CALC	737
C		CALC	738
1070	IT = ITYPE(IA)	CALC	739
	JP = MOD(J+2,6)+1	CALC	740
	NUM = MOD(3+J,6)+1	CALC	741
	MMA = NTLOC(IA)+NSC(IT,9)-6*(NRING(IT)+1)-7+NUM	CALC	742
	QIHT = CP8(IA)*(TC1(MMA)-TC1(LX))*C27(I)/C27(IA)	CALC	743
	QSIUM = CP7(IA)+QSIUM	CALC	744
	SUM = SUM+1.0	CALC	745
	A7 = 1.5*(A(K,7)+A(IT,7))	CALC	746
	MMA = MMA+NUM+JP*NRING(IT)+7	CALC	747

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

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      OGP = C29(IA)*(TC1(MMC)-TC1(LX))*C27(I)/(C27(IA)*ETA(IT,6)
+
1080  JP = MOD(J+4,6)+1
      IA = NEIGHR(I,JP)
      IF (IA,GE,1) GO TO 1100
      IF (FXRC(JP),EQ,0.0) GO TO 1110
      IC = IPRNFD(I,JP,2)
      IF (KAGE,EQ,4) GO TO 1090

C
C   RC APPLIED TO FACE JP
C
      OBC = OBC+C30(I)*FXRC(JP)*BCSKEM(NRING(K)+2,IC)
      GO TO 1110
1090  TA = FXRC(JP)*PCSKEM(NRING(K)+2,IC)
      OBC = OBC+C30(I)*(TA-TC1(LX))
      GO TO 1110

C
C   NEIGHBORING ASSEMBLY ON FACE JP
C
1100  IT = ITYPE(IA)
      NUM = MOD(J+1,6)+1
      MMA = NTLOC(IA)+NSC(IT,9)-6*(NRING(IT)+1)-7+NUM
      ODUM = C28(IA)*(TC1(MMA)-TC1(LX))*C27(I)/C27(IA)
      QINT = QINT+ODUM
      OSUM = OSUM+C27(IA)
      SUM = SUM+1.0
      A7 = A7/.5+A(IT,7)
      IF (SUM,EQ,3.0) GO TO 1110
      A7 = 1.5*(A(K,7)+A(IT,7))
      MMA = NUM+(NUM-1)*NRING(IT)+6
      OGP = C29(IA)*(TC1(MMC)-TC1(LX))*C27(I)/(C27(IA)*ETA(IT,6)
+
1110  )
      OTDZ = C28(I)*(TC1(MM1)-TC1(LX))+C29(I)*(TC1(MM2)+TC1(MM3)
+
      -2.0*TC1(LX))/ETA(K,6)+OBC+QINT+OGP
      OSD(I) = OSD(I)+OGP+OZ/C27(I)
      ODUM = C28(I)*(TC1(MM1)-TC1(LX))
      OSI(I) = OSI(I)+ODUM+OZ/C27(I)
      OSGP = ODUM+OZ/C27(I)+OSGP
      TC2(LX) = TC1(LX)+OTDZ+OZ+OSUM/(SUM*C27(I)+A7)

C
C   FIND DUCT CORNER TEMPERATURES, CHECKING FOR GAMMA HEATING
C
      IG = IPRNFD(I,J,3)
      IF (IG,LT,1) GO TO 1120
      IH = IPRNFD(I,J,4)
      N = NBCEAN(IG)
      CALL CHRV (FNUM,ZOL,BCAXP(1,IG),BCAXHT(1,IG),N,IX,8)
      OGAM = C35(I)*BCSKEM(1,IH)*FNUM*GHONDM(I,J)*DUCTTH(K)
      OSG(I) = OSD(I)+0.5*A(K,5)+OZ*OGAM/(C35(I)*DUCTTH(K))
1120  JP = MOD(J+4,6)+1
      IG = IPRNFD(I,JP,3)
      IF (IG,LT,1) GO TO 1130

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CALC	799

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

	TH = IPRNFD(I,JP,4)	CALC	800
	N = NBCAEN(IG)	CALC	801
	CALL CURV (FDUM,ZOL,BCAXP(1,IG),BCAXHT(1,IG),N,IX,8)	CALC	802
	ODUM = C35(I)*RCSE4(NRING(K)+2,1H)*FDUM*GHONDM(I,JP)*DUCT	CALC	803
	TH(K)	CALC	804
	QSG(I) = QSG(I)+0.5*A(K,5)*DZ*ODUM/(C35(I)*DUCTTH(K))	CALC	805
	QGAM = QGAM+ODUM	CALC	806
1130	TC2(MH1) = C32(I)*TC2(LX)+(1.00-C32(I))*TC2(MH1-NINCR)+QRA	CALC	807
		CALC	808
1140	CONTINUE	CALC	809
1150	CONTINUE	CALC	810
	DO 1160 J=1,NC	CALC	811
1160	TC1(J) = TC2(J)	CALC	812
	ZOUT = Z+DUMFR	CALC	813
	Z = Z+DZ	CALC	814
C		CALC	815
C	DETERMINE IF TEMPERATURE MAP PRINTOUT OR DUCT AVERAGE PRINTOUT	CALC	816
C	IS REQUIRED	CALC	817
C	IF Z IS LESS THAN LENGTH CALCULATE THE NEXT AXIAL LEVEL	CALC	818
C		CALC	819
	IF (7.GT.LENGTH+DZ) GO TO 1230	CALC	820
	IF (IPRNT.GT.NAPRNT) GO TO 1220	CALC	821
	IF (7.LT.APRNT(IPRNT)+0.5*DZ) GO TO 1190	CALC	822
	DO 1180 LL=1,NBASSH	CALC	823
	WRITE (IPR,1170) LL,(9UNIO(I,LL),I=1,17),ZOUT,DIM(IFORM+1)	CALC	824
	K = ITYPE(LL)	CALC	825
	CALL OUTPUT (K,LL)	CALC	826
1170	FORMAT (1H,2X,'TEMPERATURE MAP FOR BUNDLE',I4,17A4/3X,'AXIAL HEIG	CALC	827
	+HT',F10.3,A4//)	CALC	828
1180	CONTINUE	CALC	829
	CALL ENERGY (ZOUT)	CALC	830
	IPRNT = IPRNT+1	CALC	831
	IF (IPRNT.GT.NAPRNT) GO TO 1220	CALC	832
1190	IF (NDPRNT-IDPNT,LT.0) GO TO 360	CALC	833
1200	IF (7.LT.OPRNT(IDPNT)+0.5*DZ) GO TO 360	CALC	834
	WRITE (IPR,1210) ZOUT,DIM(IFORM+1)	CALC	835
1210	FORMAT (1H,2X,'AVERAGE DUCT WALL TEMPERATURE SUMMARY FOR AXIAL HE	CALC	836
	+IGHT',F10.3,A4//)	CALC	837
	CALL DTEMP	CALC	838
	IDPNT = IDPNT+1	CALC	839
	IF (NDPRNT.GE.IDPNT) GO TO 360	CALC	840
	IF (IPRNT.GT.NAPRNT) GO TO 1230	CALC	841
	GO TO 360	CALC	842
1220	IF (NDPRNT-IDPNT,GE.0) GO TO 1200	CALC	843
1230	CONTINUE	CALC	844
C		CALC	845
C	ERRDP MESSAGES	CALC	846
C		CALC	847
1240	FORMAT (1X,'***** ERROR - CHECK INTERASSEMBLY HEAT TRANSFER CONNFC	CALC	848
	+TIONS FOR FACE',J3,' OF ASSEMBLY',I3/20X,'AND FACE',I3,' OF ASSEMB	CALC	849
	+LY',J3//)	CALC	850
	RETURN	CALC	851

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CALC

END

CALC

852

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CHANGE

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*DECK CHANGE
  SUBROUTINE CHANGE (NTYPE)
*CALL BLK2
*CALL BLK3
*CALL BLK4
*CALL BLK5
*CALL BLK6
*CALL BLK7
*CALL BLK8
*CALL BLK9
*CALL BLK10
*CALL BLK11
  IF (IFORM.EQ.1) GO TO 120
C
C  CONVERT SI CENTIMETER INPUT TO METERS
C
  LENGTH = 0.01*LENGTH
  GAPTH = 0.01*GAPTH
  DO 100 I=1,NAPRNT
    APRNT(I) = 0.01*APRNT(I)
  100 IF(NOPRNT.LT.1) GO TO 80
    DO 75 I=1,NOPRNT
      OPRNT(I)=0.01*OPRNT(I)
  75 CONTINUE
  80 DO 110 ID=1,NTYPE
    P(ID) = .01*P(ID)
    LEAD(ID) = .01*LEAD(ID)
    FLAT(ID) = .01*FLAT(ID)
    DUCTTH(ID) = .01*DUCTTH(ID)
    CLADOD(ID) = .01*CLADOD(ID)
    WIREOD(ID) = .01*WIREOD(ID)
    SHWIRE(ID) = .01*SHWIRE(ID)
    IF (ID,LE,NL) GO TO 110
    JX = ID-NL
    CWALLT(JX) = CWALLT(JX)*.01
    CGAPTH(JX) = CGAPTH(JX)*.01
  110 CONTINUE
  RETURN
C
C  CONVERT FROM ENGLISH UNITS TO METRIC UNITS
C
  120 IF (NCOENT.LT.1) GO TO 140
    DO 130 I=1,NCOENT
      TEMPC(I) = (TEMPC(I)-32.0)/1.8
      RHOC(I) = 16.02*RHOC(I)
      CPC(I) = 4184.*CPC(I)
      CONDC(I) = 1.729*CONDC(I)
      VISC(I) = 2420.*VISC(I)
  130
  140 IF (NOENT.LT.1) GO TO 160
    DO 150 I=1,NOENT

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```

CHANGE 1
CHANGE 2
CHANGE 3
CHANGE 4
CHANGE 5
CHANGE 6
CHANGE 7
CHANGE 8
CHANGE 9
CHANGE 10
CHANGE 11
CHANGE 12
CHANGE 13
CHANGE 14
CHANGE 15
CHANGE 16
CHANGE 17
CHANGE 18
FIX001 2
FIX001 3
FIX001 4
FIX001 5
CHANGE 19
CHANGE 20
CHANGE 21
CHANGE 22
CHANGE 23
CHANGE 24
CHANGE 25
CHANGE 26
CHANGE 27
CHANGE 28
CHANGE 29
CHANGE 30
CHANGE 31
CHANGE 32
CHANGE 33
CHANGE 34
CHANGE 35
CHANGE 36
CHANGE 37
CHANGE 38
CHANGE 39
CHANGE 40
CHANGE 41
CHANGE 42
CHANGE 43
CHANGE 44

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CHANGE

	TEMPN(I) = (TEMP(I)-32.0)/1.8	CHANGE	45
	RHOD(I) = 16.02*RHO(I)	CHANGE	46
	CPD(I) = 4184.*CPD(I)	CHANGE	47
150	CNDND(I) = 1.729*CNDND(I)	CHANGE	48
160	LENGTH = 0.0254*LENGTH	CHANGE	49
	GAPTH = 0.0254*GAPTH	CHANGE	50
	FLOWG = 1.356E-3*FLOWG	CHANGE	51
	DO 170 I=1,NAPRNT	CHANGE	52
170	APRNT(I) = APRNT(I)*0.0254	CHANGE	53
	IF (NDPRNT.LY.1) GO TO 190	CHANGE	54
	DO 180 I=1,NDPRNT	CHANGE	55
180	DPRNT(I) = DPRNT(I)*0.0254	CHANGE	56
190	DO 200 I=1,NTYPE	CHANGE	57
	JO = ITY(I)	CHANGE	58
	P(ID) = 0.0254*P(ID)	CHANGE	59
	LEAD(ID) = 0.0254*LEAD(ID)	CHANGE	60
	FLAT(ID) = 0.0254*FLAT(ID)	CHANGE	61
	DUCTTH(ID) = 0.0254*DUCTTH(ID)	CHANGE	62
	CLADND(ID) = 0.0254*CLADND(ID)	CHANGE	63
	WIREND(ID) = 0.0254*WIREND(ID)	CHANGE	64
	SHWIRE(ID) = 0.0254*SHWIRE(ID)	CHANGE	65
	IF (ID.LE.NL) GO TO 200	CHANGE	66
	JX = ID-NL	CHANGE	67
	CHALLT(JX) = 0.0254*CHALLT(JX)	CHANGE	68
	CGAPTH(JX) = 0.0254*CGAPTH(JX)	CHANGE	69
200	CONTINUE	CHANGE	70
	IRP = 0	CHANGE	71
	DO 240 ID=1,NOASSH	CHANGE	72
	POWER(ID) = 0.9616*POWER(ID)	CHANGE	73
	FLOW(ID) = 1.26E-04*FLOW(ID)	CHANGE	74
	TINLET(ID) = (TINLET(ID)-32.0)/1.8	CHANGE	75
	TAVEC(ID) = (TAVEC(ID)-32.0)/1.8	CHANGE	76
	TAVEW(ID) = (TAVEW(ID)-32.0)/1.8	CHANGE	77
	IF (ITYPE(ID).LE.NL) GO TO 210	CHANGE	78
	IRP = IRP+1	CHANGE	79
	FLOWAP(IRP) = 1.26E-04*FLOWAP(IRP)	CHANGE	80
210	DO 230 K=1,6	CHANGE	81
	GHDNDM(ID,K) = 10.351*GHDNDM(ID,K)	CHANGE	82
	IF (IRCTYP(ID).EQ.2) GO TO 220	CHANGE	83
	RC(ID,K) = 3.155*RC(ID,K)	CHANGE	84
	GO TO 230	CHANGE	85
220	RC(ID,K) = (RC(ID,K)-32.0)/1.8	CHANGE	86
230	CONTINUE	CHANGE	87
240	CONTINUE	CHANGE	88
	RETURN	CHANGE	89
	END	CHANGE	90

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CURV

*DECK CURV	CURV	1
SUBROUTINE CURV (FX,X,F,Y,N,K,9)	CURV	2
DIMENSION F(1),Y(1)	CURV	3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CURV

	IPR = 6	CURV	4
C		CURV	5
C	FX = QUANTITY TO BE FOUND	CURV	6
C	X = INDEPENDENT VARIABLE	CURV	7
C	F = INPUT ORDINATE ARRAY (MONOTONIC WITH Y)	CURV	8
C	Y = INPUT ARCISSE ARRAY (MONOTONIC INCREASE)	CURV	9
C	N = NUMBER OF F(I) OR Y(I) VALUES	CURV	10
C	R = FRACTIONAL MULTIPLIER	CURV	11
C	K = INTERPOLATION INDEX	CURV	12
C		CURV	13
	IF (X.LT.Y(1)) GO TO 120	CURV	14
	IF (X.GT.Y(N)) GO TO 130	CURV	15
	DO 100 I=1,N	CURV	16
	IF (X.LT.Y(I)) GO TO 110	CURV	17
	K = I	CURV	18
100	CONTINUE	CURV	19
110	R = (X-Y(K))/(Y(K+1)-Y(K))	CURV	20
	FX = F(K)+R*(F(K+1)-F(K))	CURV	21
	RETURN	CURV	22
120	IF (X.LT.0.995*Y(1)) GO TO 150	CURV	23
	K = 1	CURV	24
	GO TO 140	CURV	25
130	IF (X.GT.1.005*Y(N)) GO TO 150	CURV	26
	K = N	CURV	27
140	R = 0.0	CURV	28
	FX = F(K)	CURV	29
	RETURN	CURV	30
150	WRITE (IPR,160) X,Y(1),Y(N),F	CURV	31
	STOP	CURV	32
160	FORMAT (1X,'***X IS OUT OF RANGE OF FX***'/5X,'X=',E12.4,' Y(1)=',E12.4,' Y(N)=',E12.4/10X,'F=''/10E12.4)	CURV	33
	END	CURV	34
		CURV	35

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN DTEMP

*DECK DTEMP	DTEMP	1	
SUBROUTINE DTEMP	DTEMP	2	
*CALL BLK7	DTEMP	3	
*CALL BLK8	DTEMP	4	
*CALL BLK10	DTEMP	5	
*CALL BLK5	DTEMP	6	
C	DTEMP	7	
C	FIND AVERAGE DIRECT TEMPERATURES BY FACE AND PRINTOUT	DTEMP	8
C		DTEMP	9
	DIMENSION DTRAR(4),BTRAR(6)	DTEMP	10
	WRITE (IPR,160) (J,J=1,6)	DTEMP	11
	DO 150 I=1,NPARSH	DTEMP	12
	K = ITYPE(I)	DTEMP	13
	NRNG = NRING(K)	DTEMP	14
	NINCR = 6*(NRNG+1)	DTEMP	15
	NED = NSC(K,0)-2*NINCR+NTLOC(I)-1	DTEMP	16
	NCDR = NED+6*NRNG	DTEMP	17

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN DTMP

	DO 110 J=1,6	DTMP	18
	JP1 = MOD(J,6)+1	DTMP	19
	DTBAR(J) = 0.5*A(K,5)*(TC1(NCOR+J)+TC1(NFOR+JP1))	DTMP	20
	NEDG = NED+(J-1)*NRNG	DTMP	21
	DO 100 N=1,NRNG	DTMP	22
100	DTBAR(J) = DTBAR(J)+A(K,4)*TC1(NEDG+N)	DTMP	23
	DTBAR(J) = DTBAR(J)/(A(K,5)+NRNG*A(K,4))	DTMP	24
	IF (IFORM.EQ.1) DTBAR(J) = DTBAR(J)*1.8+72.0	DTMP	25
110	CONTINUE	DTMP	26
	IF (K.GT.NL) GO TO 120	DTMP	27
	WRITE (IPR,170) I,DTBAR(J),DIM(IFORM+3),J=1,6	DTMP	28
	GO TO 130	DTMP	29
C		DTMP	30
C	DOUBLE DUCTED BYPASS - FIND INNER DUCT TEMPERATURE	DTMP	31
C		DTMP	32
120	NBPE = NBC(K,4)+NTLOC(1)-1	DTMP	33
	NBPC = NBPE+6*NRNG	DTMP	34
	JX = K-NL	DTMP	35
	DO 140 J=1,6	DTMP	36
	JP1 = MOD(J,6)+1	DTMP	37
	BTBAR(J) = 0.5*AC(JX,2)*(TC1(NBPC+J)+TC1(NBPE+JP1))	DTMP	38
	NBPE = NBPE+(J-1)*NRNG	DTMP	39
	DO 130 N=1,NRNG	DTMP	40
130	BTBAR(J) = BTBAR(J)+AC(JX,1)*TC1(NBPE+N)	DTMP	41
	BTBAR(J) = BTBAR(J)/(AC(JX,2)+NRNG*AC(JX,1))	DTMP	42
	IF (IFORM.EQ.1) BTBAR(J) = BTBAR(J)*1.8+72.0	DTMP	43
140	CONTINUE	DTMP	44
	WRITE (IPR,180) I,(BTBAR(J),DIM(IFORM+3),J=1,6),I,(DTBAR(J),N	DTMP	45
	+ M(IFORM+3),J=1,6)	DTMP	46
150	CONTINUE	DTMP	47
160	FORMAT (5X,'ASSEMBLY',10X,6('FACE NO.',I2,5X)/)	DTMP	48
170	FORMAT (5X,I5,4X,6(F11.2,A4))	DTMP	49
180	FORMAT (5X,I5,4X,'INSIDE',F10.2,A4,5(F11.2,A4)/5X,I5,2X,'OUTSIDE',	DTMP	50
	+F10.2,A4,5(F11.2,A4))	DTMP	51
	RETURN	DTMP	52
	END	DTMP	53

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN ECHO

*DECK	ECHO	ECHO	1
	SUBROUTINE ECHO (IPR,ICR,IPL)	ECHO	2
	DIMENSION DATA(20)	ECHO	3
C		ECHO	4
C	READ DATA FROM ICR, PRINT CARD IMAGE TO IPR AND FILE IPL	ECHO	5
C		ECHO	6
	LINE = 0	ECHO	7
	IPAG = 51	ECHO	8
	ICARD = 0	ECHO	9
	WRITE (IPR,170)	ECHO	10
	WRITE (IPR,180)	ECHO	11
100	READ (ICR,150) DATA	ECHO	12
	IF (FOF(ICR).NE.0.0) GO TO 120	ECHO	13

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FCHO

	ICARD = ICARD+1	ECHO	14
	WRITE (IPR,160) ICARD,DATA	ECHO	15
	WRITE (IFL,150) DATA	ECHO	16
	LINE = LINE+1	ECHO	17
	IF (LINE.EQ.IPA0) GO TO 110	ECHO	18
	GO TO 100	ECHO	19
110	WRITE (IPR,140)	ECHO	20
	WRITE (IPR,170)	ECHO	21
	WRITE (IPR,140)	ECHO	22
	LINE = 0	ECHO	23
	GO TO 100	ECHO	24
120	WRITE (IPR,140)	ECHO	25
	REWIND IFL	ECHO	26
	ICR = IFL	ECHO	27
C		ECHO	28
C	FORMAT STATEMENTS	ECHO	29
C		ECHO	30
130	FORMAT (1H1,'***** THE FOLLOWING IS AN IMAGE LISTING OF THE SUPE	ECHO	31
	+RGV INPUT CARDS *****'///)	ECHO	32
140	FORMAT (1H0,9X,'0 1 2 3 4 5	ECHO	33
	+ 6 7 8 '/10X,'1234567890123456789012345678	ECHO	34
	+90123456789012345678901234567890123456789012345678901/)	ECHO	35
150	FORMAT (20A4)	ECHO	36
160	FORMAT (1X,14,5X,20A4)	ECHO	37
170	FORMAT (1H1)	ECHO	38
	RETURN	ECHO	39
	END	ECHO	40

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN ENERGY

*DECK	ENERGY	ENERGY	1
	SUBROUTINE ENERGY (ZOUT)	ENERGY	2
*CALL	BLK1	ENERGY	3
*CALL	BLK2	ENERGY	4
*CALL	BLK3	ENERGY	5
*CALL	BLK10	ENERGY	6
*CALL	BLK5	ENERGY	7
C		ENERGY	8
C	FIND BUNDLE ENERGY BALANCE	ENERGY	9
C		ENERGY	10
	IF (MODEL.EQ.2) GO TO 100	ENERGY	11
	WRITE (IPR,280) TEXT,ZOUT,DIM(IFORM+1),DIM(IFORM+3)	ENERGY	12
	GO TO 110	ENERGY	13
100	WRITE (IPR,290) TEXT,ZOUT,DIM(IFORM+1),DIM(IFORM+3)	ENERGY	14
110	SUMA = 0.0	ENERGY	15
	SUMB = 0.0	ENERGY	16
	SUMD = 0.0	ENERGY	17
	SUMG = 0.0	ENERGY	18
	SUMI = 0.0	ENERGY	19
	ISP = 0	ENERGY	20
	QSSUM = 0.0	ENERGY	21
	QSUMT = 0.0	ENERGY	22

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN ENERGY

	DO 260 I=1,NNASSH	ENERGY	23
	SUMA = SUMA+QSA(I)	ENERGY	24
	SUMD = SUMD+QSD(I)	ENERGY	25
	SUMG = SUMG+QSG(I)	ENERGY	26
	SUMI = SUMI+QSI(I)	ENERGY	27
	QSUM = 0.0	ENERGY	28
	K = ITYPE(I)	ENERGY	29
	NSTART = NTLOC(I)	ENERGY	30
	NSTOP = NTLOC(I)+NSC(K,2)-1	ENERGY	31
	DO 120 J=NSTART,NSTOP	ENERGY	32
120	QSUM = QSUM+(TC1(J)-TINLET(I))/C1(I)	ENERGY	33
	NSTART = NSTOP+1	ENERGY	34
	NSTOP = NTLOC(I)+NSC(K,3)-1	ENERGY	35
	DO 130 J=NSTART,NSTOP	ENERGY	36
130	QSUM = QSUM+(TC1(J)-TINLET(I))/C3(I)	ENERGY	37
	NSTART = NSTOP+1	ENERGY	38
	NSTOP = NSTOP+6	ENERGY	39
	DO 140 J=NSTART,NSTOP	ENERGY	40
140	QSUM = QSUM+(TC1(J)-TINLET(I))/C9(I)	ENERGY	41
	CSUM = 6./C9(I)+NSC(K,2)/C1(I)+(NSC(K,3)-NSC(K,2))/C3(I)	ENERGY	42
	IF (K.LE.NL) GO TO 170	ENERGY	43
C		ENERGY	44
C	DOUBLE DUCTED BYPASS BUNDLE	ENERGY	45
C		ENERGY	46
	IRP = IRP+1	ENERGY	47
	SUMB = SUMB+QSB(IRP)	ENERGY	48
	NSTART = NTLOC(I)+NSC(K,6)	ENERGY	49
	NSTOP = NTLOC(I)+NSC(K,7)-1	ENERGY	50
	DO 150 J=NSTART,NSTOP	ENERGY	51
150	QSUM = QSUM+(TC1(J)-TINLET(I))/C39(IRP)	ENERGY	52
	NSTART = NSTOP+1	ENERGY	53
	NSTOP = NSTOP+6	ENERGY	54
	DO 160 J=NSTART,NSTOP	ENERGY	55
160	QSUM = QSUM+(TC1(J)-TINLET(I))/C41(IRP)	ENERGY	56
	CSUM = CSUM+6./C41(IRP)+(NSC(K,7)-NSC(K,6))/C39(IRP)	ENERGY	57
170	QSUMT = QSUMT+QSUM	ENERGY	58
	TBAR = QSUM/CSUM+TINLET(I)	ENERGY	59
	IF (IFORM.FO.1) TBAR = 1.8*TBAR+32.0	ENERGY	60
	IF (MODEL.NE.2) GO TO 240	ENERGY	61
C		ENERGY	62
C	INTERASSEMBLY GAP FLOW MODEL	ENERGY	63
C		ENERGY	64
	JPOS = NTLOC(I)+NSC(K,9)-6+(NRING(K)+1)	ENERGY	65
	DO 220 J=1,6	ENERGY	66
	DIV = 0.0	ENERGY	67
	TIN = 0.0	ENERGY	68
	DUMY = 0.0	ENERGY	69
	A7 = A(K,7)	ENERGY	70
	ID = NEIGHB(I,J)	ENERGY	71
	IF (ID.LT.1) GO TO 180	ENERGY	72
	IF (ID.LT.1) GO TO 220	ENERGY	73
	DIV = 1.0	ENERGY	74

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN ENERGY

	TIN = TINLET(I0)	ENERGY	75
	DUMY = C27(I0)	ENERGY	76
	IT = ITYPE(I0)	ENERGY	77
	A7 = A(IT,7)	ENERGY	78
180	DIV = DIV+1.0	ENERGY	79
	TIN = (TINLET(I)+TIN)/DIV	ENERGY	80
	DUMY = (DUMY+C27(I))/DIV	ENERGY	81
	A7 = A7+A(K,7)	ENERGY	82
	NSTART = IP08+(J-1)*NRING(K)	ENERGY	83
	NSTOP = NSTART+NRING(K)-1	ENERGY	84
	DO 190 L=NSTART,NSTOP	ENERGY	85
190	QGSUM = QGSUM+A(K,6)*(TC1(L)-TIN)/DUMY	ENERGY	86
	JP = MOD(J+4,6)+1	ENERGY	87
	IP = NEIGHB(I,JP)	ENERGY	88
	IF (IP,LT,1) GO TO 200	ENERGY	89
	IF (IP,LT,1) GO TO 220	ENERGY	90
	IA = ITYPE(IP)	ENERGY	91
	A7 = A7+A(IA,7)	ENERGY	92
	IF (DIV.EQ,1.0) A7 = 0.75*(A7+A(IA,7))	ENERGY	93
	TIN = (DIV*TIN+TINLET(IP))/(DIV+1.0)	ENERGY	94
	DUMY = (DUMY+DIV+C27(IP))/(DIV+1.0)	ENERGY	95
	GO TO 210	ENERGY	96
200	IF (DIV.EQ,2.0) A7 = 1.5*A7	ENERGY	97
210	L = IP08+6*NRING(K)+J-1	ENERGY	98
	QGSUM = QGSUM+A7*(TC1(L)-TIN)/((DIV+1.0)*DUMY)	ENERGY	99
220	CONTINUE	ENERGY	100
C		ENERGY	101
C	PRINTOUT FOR INTERASSEMBLY GAP FLOW MODEL	ENERGY	102
C		ENERGY	103
	IF (K.LE,NL) GO TO 230	ENERGY	104
	WRITE (IPR,300) I,QSA(I),QSB(IP),QSD(I),QSG(I),QSI(I),QSUM,TB	ENERGY	105
+	AR	ENERGY	106
	GO TO 260	ENERGY	107
230	WRITE (IPR,310) I,QSA(I),QSD(I),QSG(I),QSI(I),QSUM,TBAR	ENERGY	108
	GO TO 260	ENERGY	109
C		ENERGY	110
C	PRINTOUT FOR INTERASSEMBLY GAP CONDUCTION MODEL	ENERGY	111
C		ENERGY	112
240	DUMY = QSA(I)+QSD(I)+QSI(I)-QSUM	ENERGY	113
	IF (K.LE,NL) GO TO 250	ENERGY	114
	DUMY = DUMY+QSB(IP)	ENERGY	115
	ERROR = 100.*DUMY/(DUMY+QSUM)	ENERGY	116
	WRITE (IPR,320) I,QSA(I),QSB(IP),QSD(I),QSI(I),QSUM,DUMY,ERR	ENERGY	117
+	R,TBAR	ENERGY	118
	GO TO 260	ENERGY	119
250	ERROR = 100.*DUMY/(DUMY+QSUM)	ENERGY	120
	WRITE (IPR,330) I,QSA(I),QSD(I),QSI(I),QSUM,DUMY,ERROR,TBAR	ENERGY	121
260	CONTINUE	ENERGY	122
	IF (MODEL.EQ,2) GO TO 270	ENERGY	123
	SUMT = SUMA+SUMB+SUMD+SUMI-QSUMT	ENERGY	124
	ERROR = 100.*SUMT/(SUMT+QSUMT)	ENERGY	125
	WRITE (IPR,340) SUMA,SUMB,SUMD,SUMI,QSUMT,SUMT	ENERGY	126

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN ENERGY

	GO TO 370	ENERGY	127
270	SUMT = SUMA+SUMB+SUMD+SUMI+SUMG-QSUMT	ENERGY	128
	WRITE (IPR,350) SUMA,SUMB,SUMD,SUMG,SUMI,QSUMT	ENERGY	129
	SUMIT = SUMT+QSGP-QQSUM	ENERGY	130
	ERROR = 100.*SUMIT/(SUMIT+QQSUM+QSUMT)	ENERGY	131
	WRITE (IPR,360) QSGP,QQSUM,SUMIT,ERROR	ENERGY	132
	GO TO 370	ENERGY	133
C		ENERGY	134
C	FORMAT STATEMENTS	ENERGY	135
C		ENERGY	136
280	FORMAT (1H,5X,17A4/10X,'ENERGY BALANCE THROUGH',F10.3,A4//5X,'COL	ENERGY	137
	+HMM HEADING DEFINITIONS . . .'/10X,'A = HEAT ADDED THROUGH LINEAR	ENERGY	138
	+ROD POWER OR NODAL HEAT GENERATION,IF LUMPED (WATTS)'/10X,'B = HEA	ENERGY	139
	+T ADDED TO BYPASS GAP THROUGH NODAL HEAT GENERATION, IF BYPASS AAS	ENERGY	140
	+EMBLV (WATTS)'/10X,'C = HEAT LOSS OR GAIN THROUGH FACIAL BOUNDARY	ENERGY	141
	+CONDITIONS (WATTS)'/10X,'D = HEAT LOSS OR GAIN THROUGH INTERASSEMB	ENERGY	142
	+LY HEAT TRANSFER (WATTS)'/10X,'E = TOTAL BUNDLE HEAT GAIN THROUGH	ENERGY	143
	+TEMPERATURE RISE (WATTS)'/10X,'SUM = BUNDLE ENERGY BALANCE, A+B+C+	ENERGY	144
	+D+E, (WATTS)'/10X,'ERROR = PERCENTAGE ERROR FOR THIS BUNDLE'/10X,'	ENERGY	145
	+TBAR = BUNDLE BULK TEMPERATURE',A4//2X,'ASSM',7X,'A',14X,'B',14X,	ENERGY	146
	+C',14X,'D',14X,'E',13X,'SUM',8X,'ERROR',5X,'TBAR')/	ENERGY	147
290	FORMAT (1H,5X,17A4/10X,'ENERGY BALANCE THROUGH',F10.3,A4//5X,'COL	ENERGY	148
	+HMM HEADING DEFINITIONS . . .'/10X,'A = HEAT ADDED THROUGH LINEAR	ENERGY	149
	+ROD POWER OR NODAL HEAT GENERATION,IF LUMPED (WATTS)'/10X,'B = HEA	ENERGY	150
	+T ADDED TO BYPASS GAP THROUGH NODAL HEAT GENERATION, IF BYPASS AAS	ENERGY	151
	+EMBLV (WATTS)'/10X,'C = HEAT LOSS OR GAIN THROUGH FACIAL BOUNDARY	ENERGY	152
	+CONDITIONS (WATTS)'/10X,'D = HEAT GAIN THROUGH DICT WALL GAMMA HEA	ENERGY	153
	+TING (WATTS)'/10X,'E = HEAT LOSS OR GAIN THROUGH INTERASSEMBLY HEA	ENERGY	154
	+T TRANSFER (WATTS)'/10X,'F = TOTAL BUNDLE HEAT GAIN THROUGH TEMPER	ENERGY	155
	+ATURE RISE (WATTS)'/10X,'TBAR = BUNDLE BULK TEMPERATURE (EXCLUDING	ENERGY	156
	+ GAP)',A4//2X,'ASSM',7X,'A',14X,'B',14X,'C',14X,'D',14X,'E',14X,'	ENERGY	157
	+F',10X,'TBAR')/	ENERGY	158
300	FORMAT (15,6E15.4,F10.1)	ENERGY	159
310	FORMAT (15,E15.4,7X,'-',7X,4E15.4,F10.1)	ENERGY	160
320	FORMAT (15,6E15.4,F10.2,F10.1)	ENERGY	161
330	FORMAT (15,E15.4,7X,'-',7X,4E15.4,F10.2,F10.1)	ENERGY	162
340	FORMAT (/1X,'TOTAL',E14.4,5E15.4,F10.2)	ENERGY	163
350	FORMAT (/1X,'TOTAL',E14.4,5E15.4)	ENERGY	164
360	FORMAT (/5X,'GAP FLOW MODEL, THE HEAT TRANSFER IN AND OUT OF THE	ENERGY	165
	+GAP IS TREATED INDEPENDENTLY REQUIRING A GLOBAL ENERGY BALANCE'/10	ENERGY	166
	+X,'GAP INTERASSEMBLY HEAT TRANSFER, QGAP=',E14.4,' WATTS'/10X,'GAP	ENERGY	167
	+ ENERGY INCREASE, QGSUM=',E14.4,' WATTS'//10X,'ERROR=A+B+C+D+E+QGA	ENERGY	168
	+P=F-QGSUM=',F14.4,' WATTS'/10X,'PERCENT ERROR =',F10.2)	ENERGY	169
370	RETURN	ENERGY	170
	END	ENERGY	171

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FINDR

*DECK FINDR	FINDR	1
SUBROUTINE FINDR (I,L)	FINDR	2
*CALL BLK1	FINDR	3
*CALL BLK7	FINDR	4

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FINDP

```

*CALL RLK10
*CALL RLK5
C
C      FIND HEAT TRANSFER COEFFICIENTS, RESISTANCES AND TEMPERATURE
C      COEFFICIENTS FOR BUNDLE I
C      GENERAL COEFFICIENTS
C
      K = JTYPE(I)
      KASE = MNOEL+IACTYP(I)
      IF (MNOEL.EQ.1) KASE = KASE+1
      DIFF = SF(K)*CK+CRHO*CCP*EPS
      PR = (CVISC+CCP/CK)**HT3
      DUM1 = CCP*CRHO/CVISC
      HTC2 = CK*(HT4+HT1*PR*(DE(K,2)*DUM1+V2)**HT2)/DE(K,2)
      HTC3 = CK*(HT4+HT1*PR*(DE(K,3)*DUM1+V3)**HT2)/DE(K,3)
      HTC6 = CK*(HT4+HT1*PR*(DE(K,4)*DUM1+V6P)**HT2)/DE(K,4)
      HTC7 = CK*(HT4+HT1*PR*(DE(K,5)*DUM1+V6P)**HT2)/DE(K,5)
      R5 = 1./HTC2+DUCTTH(K)/(2.0*WK)
      R6 = 1./HTC3+DUCTTH(K)/(2.0*WK)
      R7 = 1./HTC6+DUCTTH(K)/(2.0*WK)
      R8 = 1./HTC7+DUCTTH(K)/(2.0*WK)
      C1(I) = 1./(CRHO*V1*CCP*A(K,1))
      C2(I) = PORL1(K)*PLEN(K)*DIFF*C1(I)
      C3(I) = 1./(CRHO*V3*CCP*A(K,2))
      C4(I) = C2(I)*V1*A(K,1)/(V2*A(K,2)*ETA(K,2))
      C5(I) = GAP(K)*DIFF*C3(I)
      C6(I) = VTHETA+GAP(K)/(A(K,2)*V2)
      C8(I) = PLEN(K)*C3(I)
      C9(I) = 1./(CRHO*V3*CCP*A(K,3))
      C10(I) = GAP(K)*DIFF*C9(I)/ETA(K,4)
      C11(I) = VTHETA+GAP(K)/(V3*A(K,3))
      C13(I) = 0.5*XLEN(K,2)*C9(I)
      C27(I) = 1./(CRHO*CCP*V6P)
      C28(I) = XLEN(K,2)*C27(I)/R8
      C29(I) = GAPTH+CK*C27(I)
C
C      GENERAL COEFFICIENTS FOR EACH MODEL OPTION
C      KASE=1 CONDUCTION MODEL WITH HEAT FLUX BC
C      KASE=2 CONDUCTION MODEL WITH TEMPERATURE BC
C      KASE=3 GAP FLOW MODEL WITH HEAT FLUX BC
C      KASE=4 GAP FLOW MODEL WITH TEMPERATURE BC
C
      GO TO (100,110,120,130), KASE
100 CONTINUE
      C25(I) = 0.0
      C30(I) = 0.0
      GO TO 140
110 CONTINUE
      C25(I) = 0.0
      C30(I) = 0.0
      GO TO 140
120 CONTINUE

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FINDP      5
FINDP      6
FINDP      7
FINDP      8
FINDP      9
FINDP     10
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FINDP     52
FINDP     53
FINDP     54
FINDP     55
FINDP     56

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FINDER

	C24(I) = PLEN(K)*C27(I)/(A(K,6)*R7)	FINDER	57
	C25(I) = GAPTH*CK*C27(I)/A(K,6)	FINDER	58
	C26(I) = C24(I)*R7	FINDER	59
	C30(I) = 0.5*XLEN(K,2)*C27(I)	FINDER	60
	GO TO 140	FINDER	61
130	CONTINUE	FINDER	62
	C24(I) = PLEN(K)*C27(I)/(A(K,6)*R7)	FINDER	63
	C25(I) = GAPTH*CK*C27(I)/A(K,6)	FINDER	64
	C26(I) = PLEN(K)*HTC6*C27(I)/A(K,6)	FINDER	65
	C30(I) = 0.5*XLEN(K,2)*HTC7*C27(I)	FINDER	66
140	IF (K.GT.NL) GO TO 170	FINDER	67
C		FINDER	68
C	SINGLE DUCTED NORMAL ASSEMBLY - GENERAL COEFFICIENTS	FINDER	69
C		FINDER	70
	C7(I) = PLEN(K)*C3(I)/R5	FINDER	71
	C12(I) = 0.5*(XLEN(K,1)*XLEN(K,2))*C9(I)/R6	FINDER	72
	C31(I) = R5/(R5+R7)	FINDER	73
	C32(I) = R6/(R4+R6)	FINDER	74
	C33(I) = R6+R8	FINDER	75
	C35(I) = C31(I)*R7	FINDER	76
	C36(I) = C32(I)*R8	FINDER	77
	C42(I) = PLEN(K)/(R5+0.5*DUCTTH(K)/WK)	FINDER	78
C		FINDER	79
C	KASE DEPENDENT COEFFICIENTS	FINDER	80
C		FINDER	81
	GO TO (150,160,220,220), KASE	FINDER	82
150	CONTINUE	FINDER	83
	C12(I) = 0.0	FINDER	84
	C24(I) = R6/(R4+R6)	FINDER	85
	C26(I) = R5+R7	FINDER	86
	C32(I) = 0.0	FINDER	87
	GO TO 220	FINDER	88
160	CONTINUE	FINDER	89
	C12(I) = 0.25*C9(I)*(XLEN(K,2)+XLEN(K,1))/(R6+0.5*DUCTTH(K)/WK)	FINDER	90
	C24(I) = R6/(R4+R6)	FINDER	91
	C26(I) = R5+R7	FINDER	92
	C32(I) = (DUCTTH(K)/(2.0*WK))/(R5+DUCTTH(K)/(2.0*WK))	FINDER	93
	GO TO 220	FINDER	94
C		FINDER	95
C	DOUBLE DUCTED BYPASS ASSEMBLY - GENERAL COEFFICIENTS	FINDER	96
C		FINDER	97
170	J = K-NL	FINDER	98
	HTB4 = CK*(HT4+HT1*PR+(DEC(J,1)*DUH1+VBP)**HT2)/DEC(J,1)	FINDER	99
	HTB5 = CK*(HT4+HT1*PR+(DEC(J,2)*DUH1+VBP)**HT2)/DEC(J,2)	FINDER	100
	R1C = 1./HTB4+CWALLT(J)/(2.0*WK)	FINDER	101
	R2C = 1./HTB4+DUCTTH(K)/(2.0*WK)	FINDER	102
	R3C = 1./HTB5+CWALLT(J)/(2.0*WK)	FINDER	103
	R4C = 1./HTB5+DUCTTH(K)/(2.0*WK)	FINDER	104
	R5C = 1./HTC2+CWALLT(J)/(2.0*WK)	FINDER	105
	R6C = 1./HTC3+CWALLT(J)/(2.0*WK)	FINDER	106
	C7(I) = PLEN(K)*C3(I)/R5C	FINDER	107
	C12(I) = 0.5*(XLEN(K,1)+XLENC(J,1))*C9(I)/R6C	FINDER	108

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FINDR

	C39(I) = 1./ (CRHD*CCP*AC(J,3)*VBP)	FINDR	109
	C14(I) = PLEN(K)+C39(I)/RIC	FINDR	110
	C15(I) = C14(I)*RIC/R2C	FINDR	111
	C16(I) = CGAPTH(J)*CK+C39(I)	FINDR	112
	C17(I) = C14(I)*RIC	FINDR	113
	C41(I) = 1.0/(CRHD*CCP*AC(J,4)*VBP)	FINDR	114
	C18(I) = 0.5*(XLEN(K,1)+XLENC(J,1))*C41(I)/R3C	FINDR	115
	C20(I) = CGAPTH(J)*CK+C41(I)/ETAC(J)	FINDR	116
	C21(I) = 0.5*XLEN(K,2)*C41(I)	FINDR	117
	C22(I) = R5C/(R5C+R1C)	FINDR	118
	C23(I) = R6C/(R6C+R3C)	FINDR	119
	C31(J) = R2C/(R2C+R7)	FINDR	120
	C32(J) = R4C/(R4C+R8)	FINDR	121
	C33(J) = R4C+R4	FINDR	122
	C35(J) = C31(I)*R7	FINDR	123
	C36(J) = C32(I)*R4	FINDR	124
	C42(J) = PLEN(K)/(R2C+0.5*DUCTTH(K)/WK)	FINDR	125
	GO TO (180,190,200,210), CASE	FINDR	126
C		FINDR	127
C	CASE DEPENDENT COEFFICIENTS	FINDR	128
C		FINDR	129
180	CONTINUE	FINDR	130
	C19(I) = 0.0	FINDR	131
	C24(J) = R4C/(R8+R4C)	FINDR	132
	C26(J) = R7+R2C	FINDR	133
	C32(J) = 0.0	FINDR	134
	GO TO 220	FINDR	135
190	CONTINUE	FINDR	136
	C19(I) = 0.25*C41(I)*(XLENC(J,2)+XLEN(K,2))/(R4C+0.5*DUCTTH(K)/WK)	FINDR	137
	C24(J) = R4C/(R8+R4C)	FINDR	138
	C26(J) = R7+R2C	FINDR	139
	C32(J) = (DUCTTH(K)/(2.0*WK))/(R2C+DUCTTH(K)/(2.0*WK))	FINDR	140
	GO TO 220	FINDR	141
200	CONTINUE	FINDR	142
	C19(I) = XLEN(K,2)*C41(I)/R4C	FINDR	143
	GO TO 220	FINDR	144
210	CONTINUE	FINDR	145
	C19(I) = XLEN(K,2)*C41(I)/R4C	FINDR	146
220	RETURN	FINDR	147
	END	FINDR	148

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FPARAM

*DECK	FPARAM	FPARAM	1
	SUBROUTINE FPARAM (I)	FPARAM	2
*CALL	BLK8	FPARAM	3
*CALL	BLK3	FPARAM	4
*CALL	BLK4	FPARAM	5
*CALL	BLK7	FPARAM	6
*CALL	BLK10	FPARAM	7
*CALL	BLK5	FPARAM	8
C		FPARAM	9

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FPARAM

C	FIND MIXING PARAMETERS FOR BUNDLE I	FPARAM	10
C		FPARAM	11
	K = JTYPE(I)	FPARAM	12
	REY = V*DEIN(K)*CRWD/CVISC	FPARAM	13
	IF (NPARAM(K).GT.0) GO TO 110	FPARAM	14
C		FPARAM	15
C	MIT CORRELATED PARAMETERS	FPARAM	16
C		FPARAM	17
	PI = 3.14159	FPARAM	18
	STH = 1.73205	FPARAM	19
	IF (NFSPLIT(K).LT.0) GO TO 100	FPARAM	20
	ARE = 0.25*PI*(WIRED(K)**2+CLADD(K)*WIRED(K))	FPARAM	21
	ASE = P(K)*(WIRED(K)+0.5*CLADD(K))*0.125*PI*CLADD(K)**2	FPARAM	22
	FAC = SQRT(ARE/(ASE*(PI*PI*(CLADD(K)+WIRED(K))**2+LEAD(K)**2)))	FPARAM	23
	CEE = 10.5*(WIRED(K)+CLADD(K))*FAC*((P(K)-CLADD(K))/P(K))**0.75	FPARAM	24
	VTHETA = CEE*V2	FPARAM	25
100	ABI = 0.25*STH*P(K)**2-0.125*PI*CLADD(K)**2	FPARAM	26
	ARI = PI*P(K)*(P(K)-CLADD(K))/6.0	FPARAM	27
	BA = (CLADD(K)+WIRED(K))/(SQRT(PI*PI*(CLADD(K)+WIRED(K))**2+LEAD(K)**2))	FPARAM	28
	AB = SQRT(P(K)*ARI/((P(K)-CLADD(K))*ASI))	FPARAM	29
	EPS = 0.12*BA*AB*P(K)**2/ABI	FPARAM	30
	EPS = EPS*V1*DEIN(K)	FPARAM	31
	RETURN	FPARAM	32
C		FPARAM	33
C	USER INPUT TABLE OF PARAMETERS VERSUS RE	FPARAM	34
C		FPARAM	35
110	M = NEPENT(NPARAM(K))	FPARAM	36
	L = NPARAM(K)	FPARAM	37
	CALL CURV (EPS,REY,ESTAR(1,L),REP(1,L),M,IC,B)	FPARAM	38
	CEE = C(TC,L)*R*(C(IC+J,L)-C(IC,L))	FPARAM	39
	VTHETA = CEE*V2	FPARAM	40
	EPS = EPS*V1*DEIN(K)	FPARAM	41
	RETURN	FPARAM	42
	END	FPARAM	43
		FPARAM	44

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN FSPLIT

*DECK	FSPLIT	FSPLIT	1
	SUBROUTINE FSPLIT (I,IRP)	FSPLIT	2
*CALL	BLK6	FSPLIT	3
*CALL	BLK4	FSPLIT	4
*CALL	BLK7	FSPLIT	5
*CALL	BLK10	FSPLIT	6
*CALL	BLK5	FSPLIT	7
	DATA C1/2200./,C2/1.9/,C3/1.2/	FSPLIT	8
C		FSPLIT	9
C	FIND SUBCHANNEL FLOWSPLIT FOR BUNDLE I	FSPLIT	10
C		FSPLIT	11
	K = JTYPE(J)	FSPLIT	12
	N11 = NSC(K,2)	FSPLIT	13
	N22 = NSC(K,3)-NSC(K,2)	FSPLIT	14

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN F8PL1T

```

V = FLOW(I)/(ATOT(K)*CRHO)
REY = V*DEIN(K)*CRHO/CVISC
VBP = FLOWG/CRHO
IF (K.LE.NL) GO TO 100
J = K-NL
VBP = FLOWBP(I*P)/(CRHO*ATOTC(J))
IF (NFSPLT(K)) 110,120,130
100 C
C HIT CORRELATION FOR FLOWSP1T
C
110 PI = 3.14159
STH = 1.73205
ARE = 0.25*PI*(WIREOD(K)**2+CLADOD(K)*WIREOD(K))
ASE = P(K)*(WIREOD(K)+0.5*CLADOD(K))-0.125*PI*CLADOD(K)**2
ARI = PI*P(K)*(P(K)-CLADOD(K))/6.0
ASI = 0.25*STH*P(K)**2-0.125*PI*CLADOD(K)**2
FAC = SQRT(ARE/(ASE*(PI*PI*(CLADOD(K)+WIREOD(K))**2+LEAD(K)**2)))
VTVA = 10.5*(WIREOD(K)+CLADOD(K))*FAC*((P(K)-CLADOD(K))/P(K))**0.3
+5
FAC = (P(K)-CLADOD(K))/(P(K)-0.5*CLADOD(K))-0.125*PI*CLADOD(K)**2
+7/P(K))
ANUM = C*(1.0+(C2+FAC+VTVA)**2)**1.375
DENOM = C*(DEIN(K)*ARI*P(K)**2/(ASI*LEAD(K))*((PI*P(K))**2+LEAD(K)**
+2))+1
RATIO = ((ANUM/DENOM)**0.571)*(DEIN(K)/DEOD(K))**0.714
V1 = V*ATOT(K)/(A(K,1)*N11+(A(K,2)*N22+6*A(K,3))/RATIO)
V2 = V*ATOT(K)/(A(K,1)*N11+RATIO+A(K,2)*N22+A(K,3)*6)
V3 = V2
VTHETA = VTV**V2
RETURN
C
C NOVENDSTERN CORRELATION
C
120 V1 = V*(ATOT(K)/(N11+A(K,1)+N22*A(K,2))*((DE(K,2)/DE(K,1))**0.714)+
+6.0*A(K,3)*((DE(K,3)/DE(K,1))**0.714))
V2 = V*(ATOT(K)/(N11+A(K,1))*((DE(K,1)/DE(K,2))**0.714)+N22*A(K,2)+
+6.0*A(K,3)*((DE(K,1)/DE(K,2))**0.714))
V3 = V*(ATOT(K)/(N11+A(K,1))*((DE(K,1)/DE(K,3))**0.714)+N22*A(K,2)+
+((DE(K,2)/DE(K,3))**0.714)+6.0*A(K,3))
RETURN
C
C USER INPUT TABLES OF FLOWSP1TS VERSUS REYNOLDS NUMBER
C
130 N = NPSNT(NFSPLT(K))
L = NFSPLT(K)
CALL CURV (VAL,REY,X1(1,L),REF(1,L),N,IC,B)
V1 = V*VAL
V2 = V*(X2(IC,L)+5*(X2(IC+1,L)-X2(IC,L)))
V3 = V*(X3(IC,L)+8*(X3(IC+1,L)-X3(IC,L)))
RETURN
END

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F8PL1T 15
F8PL1T 16
F8PL1T 17
F8PL1T 18
F8PL1T 19
F8PL1T 20
F8PL1T 21
F8PL1T 22
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F8PL1T 59
F8PL1T 60
F8PL1T 61
F8PL1T 62
F8PL1T 63
F8PL1T 64
F8PL1T 65

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN GEOM

```

*DECK GEOM
SUBROUTINE GEOM (K)
*CALL BLK7
*CALL BLK10
*CALL BLK5
C      FIND BUNDLE TYPE K GEOMETRY
C
      STH = 1.73205
      STHI = 0.5773503
      PI = 3.14159
      N11 = NSC(K,2)
      N22 = NSC(K,3) - NSC(K,2)
      N33 = NSC(K,4) - NSC(K,3)
C
C      CALCULATE THE NUMBER OF RINGS OF PINS IN THE ASSEMBLY TYPE
C
      XNORIN = (NR0D(K)-1)/3.0
      NORING = SQRT(XNORIN)
C
C      CALCULATE DISTANCE BETWEEN OUTERMOST PIN AND INSIDE DUCT WALL
C
      GAP(K) = 0.5*(FLAT(K)-STH*NORING*P(K)-CLADD(K))
      IF (GAP(K).GE.8HWIRE(K)) GO TO 110
      WRITE (IPR,100) K,GAP(K),8HWIRE(K),P(K),CLADD(K),FLAT(K)
100  FORMAT (//'*** INPUT ERROR = GAP LESS THAN 8HWIRE FOR ASSEMBLY TYP
      *E K=',15/10X,'GAP =',F10.5,5X,'8HWIRE =',F10.5,5X,'P=',F10.5,5X,'C
      *LADD=',F10.5,5X,'FLAT=',F10.5//)
C
C      CALCULATE NODE PITCH BASED ON USER SELECTED NODE NUMBER
C
C      110 PLEN(K) = NORING*P(K)/NRING(K)
C
C      CALCULATE CORNER CHANNEL INSIDE DUCT WALL LENGTH
C
      XLEN(K,1) = (CLADD(K)+2.*GAP(K))/STH
      IF (K.LE.NL) GO TO 120
      J = K-NL
C
C      FOR ASSEMBLY WITH BYPASS FLOW REGION, CALCULATE FOR THE CORNER
C      CHANNEL = 1ST DUCT WALL OUTSIDE LENGTH, 2ND DUCT WALL INSIDE LENGTH
C      2ND DUCT WALL OUTSIDE LENGTH, INTERASSEMBLY GAP LENGTH ALONG CENTE
C
      XLENC(J,1) = XLEN(K,1)+2.0*STHI*CHALLT(J)
      XLENC(J,2) = XLENC(J,1)+2.0*STHI*CGAPTH(J)
      XLEN(K,2) = XLENC(J,2)+2.0*STHI*DUCTTH(K)
      XLEN(K,3) = XLEN(K,2)+RTHI*GAPTH
C
C      NOODAL DISTANCE BETWEEN CORNER AND EDGE NODES IN BYPASS REGION
C
      ETAC(J) = 0.5*PLEN(K)+0.25*(XLENC(J,1)+XLENC(J,2))
      ETAI(K) = 0.5*(PLEN(K)+XLENC(J,2))

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GEOM	103
GEOM	104

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN GEOM

	ATOTC(J) = 6.0*(NRING(K)*AC(J,3)+AC(J,4))	GEOM	105
C		GEOM	106
C	EQUIVALENT DIAMETER OF THE BYPASS GAP EDGE AND CORNER CHANNELS	GEOM	107
C		GEOM	108
	DEC(J,1) = 4.0*AC(J,3)/(2.0*PLEN(K))	GEOM	109
	DEC(J,2) = 4.0*AC(J,4)/(XLENC(J,1)+XLENC(J,2))	GEOM	110
	GO TO 150	GEOM	111
140	A(K,5) = 0.5*(XLEN(K,1)+XLEN(K,2))*DUCTTH(K)	GEOM	112
C		GEOM	113
C	TOTAL FLOW AREAS IN BUNDLE AND GAP	GEOM	114
C		GEOM	115
150	ATOT(K) = N11*A(K,1)+N22*A(K,2)+N33*A(K,3)	GEOM	116
	ATOTGP(K) = 6.0*NRING(K)*A(K,6)+12.0*A(K,7)	GEOM	117
C		GEOM	118
C	EQUIVALENT DIAMETERS IN CHANNELS--INTERIOR, EDGE, CORNER, GAP EDGE,	GEOM	119
C	GAP CORNER RESPECTIVELY	GEOM	120
C		GEOM	121
	DE(K,1) = 4.0*A(K,1)/(RFRAC1*PI*(CLADD(K)+WIRED(K)))	GEOM	122
	DE(K,2) = 4.0*A(K,2)/(PLEN(K)+RFRAC2*PI*(CLADD(K)+SHWIRE(K)))	GEOM	123
	DE(K,3) = 4.0*A(K,3)/(PI*(CLADD(K)+SHWIRE(K))/6.+FLAT(K)/STH*PLEN	GEOM	124
	+A(K,4)*NRING(K))	GEOM	125
	DE(K,4) = 4.0*A(K,6)/(2.0*PLEN(K))	GEOM	126
	DE(K,5) = 8.0*A(K,7)/(2.0*XLEN(K,2))	GEOM	127
C		GEOM	128
C	EQUIVALENT DIAMETER OF AN ACTUAL INTERIOR SURCHANNEL	GEOM	129
C		GEOM	130
	DEIN(K) = (2.0*STH*P(K)**2-PI*(CLADD(K)**2+WIRED(K)**2))/(PI*(CL	GEOM	131
	+ADD(K)+WIRED(K)))	GEOM	132
	DEDS(K) = 4.0*(P(K)*(0.5*CLADD(K)+GAP(K))-0.125*PI*(CLADD(K)**2+	GEOM	133
	+WIRED(K)**2))/(P(K)+0.5*PI*(CLADD(K)+WIRED(K)))	GEOM	134
C		GEOM	135
C	AVERAGE LATERAL AND AXIAL POROSITIES IN THE INTERIOR REGION	GEOM	136
C		GEOM	137
	PORL(K) = (P(K)-CLADD(K))/P(K)	GEOM	138
	PORAY(K) = A(K,1)/(0.25*STH*PLEN(K)**2)	GEOM	139
	END	GEOM	140

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN GRASH

*DECK	GRASH	GRASH	1
	SUBROUTINE GRASH (I)	GRASH	2
*CALL	RLK2	GRASH	3
*CALL	RLK7	GRASH	4
*CALL	RLK9	GRASH	5
*CALL	RLK10	GRASH	6
*CALL	RLK5	GRASH	7
C		GRASH	8
C		GRASH	9
C	THIS SUBROUTINE DETERMINES IF THE FLOW IN A PARTICULAR BUNDLE HAS	GRASH	10
C	EXCEEDED THE GR* CRITERIA AND THEREFORE CANNOT BE REPRESENTED BY	GRASH	11
C	FORCED CONVECTION EQUATIONS.	GRASH	12
C		GRASH	13

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN GRASH

	GRCRJT = 0.02	GRAQH	14
	K = JTYPE(I)	GRAQH	15
	J = PROFIL(I,2)	GRAQH	16
	ID = PROFIL(I,1)	GRAQH	17
C		GRAQH	18
C	CALCULATE EXPECTED TEMPERATURE RISE BASED ON POWER(I)	GRAQH	19
C		GRAQH	20
	NMULT = NR0D(K)	GRAQH	21
	JF (JLUMP(K),EQ,1) NMULT = NSC(K,4)	GRAQH	22
	DELTA = NMULT*POWER(I)*LENGTH*XBAR(ID)/(CCP*CRHO*V*ATOT(K))	GRAQH	23
C		GRAQH	24
C	CALCULATE RE,PR AND GR FOR BUNDLE	GRAQH	25
C		GRAQH	26
	RE = V1*DEIN(K)*CRHO/CVISC	GRAQH	27
	RE = AMAX1(RE,100.)	GRAQH	28
	PR = CCP*CVISC/CK	GRAQH	29
	GR = 9.8067*CBETA*DELTA*DEIN(K)**3/(CVISC/CRHO)**2	GRAQH	30
	H = (1.034/(P(K)/CLADD(K))**0.124+29.7*((P(K)/CLADD(K))**6.94)+(	GRAQH	31
	+RE**0.086)/(LEAD(K)/CLADD(K))**2.239)**0.885	GRAQH	32
	GAMMA = 16.0*(P(K)/CLADD(K)-1.00)*(EP5/(V*DEIN(K))+SF(K)/(RE*PR))	GRAQH	33
	+/((3.14159+FLAT(K))	GRAQH	34
	IF (JLUMP(K),EQ,1) GO TO 110	GRAQH	35
	MX = NPLNC(J)-1	GRAQH	36
	PMIN = RPPP(MX+1)	GRAQH	37
	PMAX = RPPP(MX+1)	GRAQH	38
	NX = NR0D(K)	GRAQH	39
	DO 100 NPP=1,NX	GRAQH	40
	JF (RPPP(MX+NPP),GT,PMAX) PMAX = RPPP(MX+NPP)	GRAQH	41
100	JF (RPPP(MX+NPP),LT,PMIN) PMIN = RPPP(MX+NPP)	GRAQH	42
	GO TO 130	GRAQH	43
110	MX = NPLNC(J)-1	GRAQH	44
	PMIN = RHTPP(MX+1)	GRAQH	45
	PMAX = RHTPP(MX+1)	GRAQH	46
	NX = NSC(K,4)	GRAQH	47
	DO 120 NPP=1,NX	GRAQH	48
	JF (RHTPP(MX+NPP),GT,PMAX) PMAX = RHTPP(MX+NPP)	GRAQH	49
	JF (RHTPP(MX+NPP),LT,PMIN) PMIN = RHTPP(MX+NPP)	GRAQH	50
120	GP = 2.0*PMAX/(PMAX+PMIN)	GRAQH	51
130	CHI = (GP-1.00)/(2.00*M*LENGTH+GAMMA)	GRAQH	52
C		GRAQH	53
C	FRICTION FACTOR CALCULATION	GRAQH	54
C		GRAQH	55
	ARG = 16.76/RE	GRAQH	56
	ARG = -(3.028/RE)*ALOG10(ARG)	GRAQH	57
	F = 1.00/(2.0*ALOG10(ARG))**2	GRAQH	58
	GRSTAR = GR*CHI/(F*RE**2)	GRAQH	59
	IF (GRSTAR,LT,GRCHIT) GO TO 160	GRAQH	60
	WRITE (IPR,140) J	GRAQH	61
	WRITE (IPR,150) RE,PR,GR,GRSTAR	GRAQH	62
140	FORMAT (//5X,'*** CRITICAL GR+ CRITERIA HAS BEEN EXCEEDED FOR BUN	GRAQH	63
	+DLE',13,' -FORCED CONVECTION REPRESENTATION OF THIS FLOW IS IN FOR	GRAQH	64
	+DR')	GRAQH	65

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN GRASH

GRASH	150	FORMAT (/10X,'RE=1,E12.4,5X,'PR=1,E12.4,5X,'GR=1,E12.4,5X,'GR==1,E	GRASH	66
GRASH		+12.4)	GRASH	67
GRASH		STOP	GRASH	68
GRASH	160	CONTINUE	GRASH	69
GRASH		IF (JFORM.FO.1) GO TO 200	GRASH	70
GRASH		IF (K.LE.NL) GO TO 180	GRASH	71
GRASH		WRITE (IPR,170) J,V,V1,V2,V3,VBP,VGP,VTHETA,EPS,GRSTAR,RE	GRASH	72
GRASH	170	FORMAT (4X,14,1X,7F10.3,F10.4,F10.5,F10.0)	GRASH	73
GRASH		RETURN	GRASH	74
GRASH	180	WRITE (IPR,190) J,V,V1,V2,V3,VBP,VTHETA,EPS,GRSTAR,RE	GRASH	75
GRASH	190	FORMAT (4X,14,1X,4F10.3,6X,'-',3X,2F10.3,F10.4,F10.5,F10.0)	GRASH	76
GRASH		RETURN	GRASH	77
GRASH	200	FAC = 3.2808	GRASH	78
GRASH		VEL = V*FAC	GRASH	79
GRASH		VEL1 = V1*FAC	GRASH	80
GRASH		VEL2 = V2*FAC	GRASH	81
GRASH		VEL3 = V3*FAC	GRASH	82
GRASH		VELGP = VGP*FAC	GRASH	83
GRASH		VTH = VTHETA*FAC	GRASH	84
GRASH		EPO = EPS*FAC*FAC	GRASH	85
GRASH		IF (K.LE.NL) GO TO 210	GRASH	86
GRASH		VELBP = VBP*FAC	GRASH	87
GRASH		WRITE (IPR,170) J,VEL,VEL1,VEL2,VEL3,VELBP,VELGP,VTH,EPO,GRSTAR,RE	GRASH	88
GRASH		RETURN	GRASH	89
GRASH	210	WRITE (IPR,190) J,VEL,VEL1,VEL2,VEL3,VELGP,VTH,EPO,GRSTAR,RE	GRASH	90
GRASH		RETURN	GRASH	91
GRASH		END	GRASH	92

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

INHEAT	*DECK	INHEAT	INHEAT	1
INHEAT		SUBROUTINE INHEAT (I,JD,J,JP,K,IT,IND)	INHEAT	2
INHEAT		COMMON/INHT/ LIM,NTM1,NINCR,NRNG,IPOS,ZOL	INHEAT	3
INHEAT		*CALL BLK1	INHEAT	4
INHEAT		*CALL BLK2	INHEAT	5
INHEAT		*CALL BLK7	INHEAT	6
INHEAT		*CALL BLK8	INHEAT	7
INHEAT		*CALL BLK10	INHEAT	8
INHEAT		*CALL BLK11	INHEAT	9
INHEAT		*CALL BLK5	INHEAT	10
INHEAT	C		INHEAT	11
INHEAT	C	DETERMINES INTERASSEMBLY GAP TEMPERATURES FOR ASSEMBLY I,FACE J	INHEAT	12
INHEAT	C	OF TYPE K NEIGHBORING ASSEMBLY ID, FACE JP, OF TYPE IT	INHEAT	13
INHEAT	C	IND=1 CONDUCTION MODEL	INHEAT	14
INHEAT	C	IND=2 GAP FLOW MODEL	INHEAT	15
INHEAT	C		INHEAT	16
INHEAT		IM1 = 0	INHEAT	17
INHEAT		IM2 = 0	INHEAT	18
INHEAT		IG1 = 0	INHEAT	19
INHEAT		IG2 = 0	INHEAT	20
INHEAT		IF (IND.EQ.1) GO TO 110	INHEAT	21
INHEAT	C		INHEAT	22

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

INHEAT	C	CHECK FOR GAMMA HEATING IN DUCT FOR CASE IND=2	INHEAT	23
INHEAT	C		INHEAT	24
INHEAT		IG1 = IPROFD(I,J,3)	INHEAT	25
INHEAT		IF (IG1.LT.1.OR.GHONNM(I,J).EQ.0.0) GO TO 100	INHEAT	26
INHEAT		IM1 = IPROFD(I,J,4)	INHEAT	27
INHEAT		N = N8CAEN(IG1)	INHEAT	28
INHEAT		CALL CURV (FDUM,70L,BCAXP(1,IG1),BCAXHT(1,IG1),N,IX,8)	INHEAT	29
INHEAT		FXGH1 = FDUM*GHONNM(I,J)	INHEAT	30
INHEAT	100	IG2 = IPROFD(ID,JP,3)	INHEAT	31
INHEAT		IF (IG2.LT.1.OR.GHONNM(ID,JP).EQ.0.0) GO TO 110	INHEAT	32
INHEAT		IM2 = IPROFD(ID,JP,4)	INHEAT	33
INHEAT		N = N8CAEN(IG2)	INHEAT	34
INHEAT		CALL CURV (FDUM,70L,BCAXP(1,IG2),BCAXHT(1,IG2),N,IX,8)	INHEAT	35
INHEAT		FXGH2 = FDUM*GHONNM(ID,JP)	INHEAT	36
INHEAT	110	IF (PLEN(IT).NE.PLEN(K)) GO TO 210	INHEAT	37
INHEAT		IF (NSC(IT,9).NE.NSC(K,9)) GO TO 210	INHEAT	38
INHEAT	C		INHEAT	39
INHEAT	C	NEIGHBORING ASSEMBLER OF SIMILAR TYPE - NO INTERPOLATION NECESSARY	INHEAT	40
INHEAT	C		INHEAT	41
INHEAT		IPNA = NTLDC(ID)+JP*NRNG+NSC(IT,9)-3*NINCR	INHEAT	42
INHEAT		IF (JND.EQ.1) GO TO 190	INHEAT	43
INHEAT	C		INHEAT	44
INHEAT	C	INTERASSEMBLY GAP FLOW CASE	INHEAT	45
INHEAT	C		INHEAT	46
INHEAT		NCORN = NTH1+NSC(K,9)-6	INHEAT	47
INHEAT		DO 140 L=1,NRNG	INHEAT	48
INHEAT		IX = NTH1+IPNS+L	INHEAT	49
INHEAT		KX = LTH1+IPNS+L	INHEAT	50
INHEAT		MM1 = LCON(KX,1)+NTH1	INHEAT	51
INHEAT		MM2 = LCON(KX,2)+NTH1	INHEAT	52
INHEAT		MM3 = LCON(KX,3)+NTH1	INHEAT	53
INHEAT		MM4 = IPNA+L+NINCR	INHEAT	54
INHEAT		IF (MM2.GT.NCORN) GO TO 120	INHEAT	55
INHEAT		FA = ETA(K,5)	INHEAT	56
INHEAT		GO TO 130	INHEAT	57
INHEAT	120	FA = ETA(K,6)	INHEAT	58
INHEAT	130	IF (MM3.GT.NCORN) GO TO 140	INHEAT	59
INHEAT		FB = ETA(K,5)	INHEAT	60
INHEAT		GO TO 150	INHEAT	61
INHEAT	140	FB = ETA(K,6)	INHEAT	62
INHEAT	150	OGAM1 = 0.0	INHEAT	63
INHEAT		OGAM2 = 0.0	INHEAT	64
INHEAT		IF (IM1.LT.1) GO TO 160	INHEAT	65
INHEAT		OGAM1 = C36(I)*BCSKEW(L+1,IM1)+FXGH1*OZ	INHEAT	66
INHEAT		OG(I) = OG(I)+OGAM1+A(K,4)/C36(I)	INHEAT	67
INHEAT	160	IF (IM2.LT.1) GO TO 170	INHEAT	68
INHEAT		LO = NRNG-L+2	INHEAT	69
INHEAT		OGAM2 = C36(ID)*BCSKEW(LD,IM2)+FXGH2*OZ	INHEAT	70
INHEAT		OG(ID) = OG(ID)+OGAM2+A(IT,4)/C36(ID)	INHEAT	71
INHEAT	170	OTDZ = C24(I)*(TC1(MM1)-TC1(LX))+C25(I)*((TC1(MM2)-TC1(LX))/EA	INHEAT	72
INHEAT	+	+(TC1(MM3)-TC1(LX))/E3)+C24(ID)*(TC1(MM4)-TC1(LX))+C27(I)/C27(I	INHEAT	73
INHEAT	+	JD)	INHEAT	74

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

	TC2(LX) = TC1(LX)+0.5*DZ*DTDZ*(C27(I)+C27(ID))/C27(I)	INHEAT	75
	DDUM1 = C24(I)*(TC1(LX)-TC1(MM1))*DZ*A(K,6)/C27(I)	INHEAT	76
	Q91(I) = Q91(I)+DDUM1	INHEAT	77
	DDUM2 = C24(ID)*(TC1(LX)-TC1(MM4))*DZ*A(V,6)/C27(ID)	INHEAT	78
	Q91(ID) = Q91(ID)+DDUM2	INHEAT	79
	Q9GP = Q9GP+DDUM1-DDUM2	INHEAT	80
	LYP = MM4+1INCR	INHEAT	81
	TC2(LXP) = TC2(LX)	INHEAT	82
	TC2(MM1) = C31(I)*TC2(LX)+(1.0-C31(I))*TC2(MM1-NINCR)+Q9AM1	INHEAT	83
180	TC2(MM4) = C31(ID)*TC2(LXP)+(1.0-C31(ID))*TC2(MM4-NINCR)+Q9AM2	INHEAT	84
	RETURN	INHEAT	85
C		INHEAT	86
C	CONDUCTION MODEL CASE	INHEAT	87
C		INHEAT	88
190	DO 200 L=1,NRNG	INHEAT	89
	LX = NTH1+IPDS+L+NINCR	INHEAT	90
	KX = LIM1+IPDS+L+NINCR	INHEAT	91
	MM1 = LCON(KX,1)+NTH1-NINCR	INHEAT	92
	MM4 = JPN4-L	INHEAT	93
	TC2(LX) = (C26(I)*TC2(MM4)+C26(ID)*TC2(MM1))/(C26(I)+C26(ID))	INHEAT	94
	LXP = MM4+2*NINCR	INHEAT	95
	TC2(LXP) = TC2(LX)	INHEAT	96
	TC2(MM1+NINCR) = C31(I)*TC2(LX)+(1.0-C31(I))*TC2(MM1)	INHEAT	97
	TC2(MM4+NINCR) = C31(ID)*TC2(LXP)+(1.0-C31(ID))*TC2(MM4)	INHEAT	98
	DDUM = PLEN(K)*DZ*(TC1(MM4)-TC1(MM1))/(C26(I)+C26(ID))	INHEAT	99
	Q91(I) = Q91(I)+DDUM	INHEAT	100
200	Q91(ID) = Q91(ID)+DDUM	INHEAT	101
	RETURN	INHEAT	102
C		INHEAT	103
C	NEIGHBORING ASSEMBLIES OF DIFFERENT TYPES - INTERPOLATION MUST	INHEAT	104
C	BE USED. DETERMINE WHICH ASSEMBLY HAS LARGER NUMBER OF FACIAL	INHEAT	105
C	MESH POINTS AND CALCULATE CRITICAL PARAMETERS	INHEAT	106
C	L = LARGER NUMBER OF MESH POINTS	INHEAT	107
C	S = SMALLER NUMBER OF MESH POINTS	INHEAT	108
C		INHEAT	109
210	IF (NRNG.GF.NPING(IT)) GO TO 220	INHEAT	110
	IL = ID	INHEAT	111
	IS = I	INHEAT	112
	IDL = JP	INHEAT	113
	IDS = J	INHEAT	114
	IMS = 0	INHEAT	115
	IF (JND.EQ.1) GO TO 230	INHEAT	116
	JML = IM2	INHEAT	117
	IMS = IM1	INHEAT	118
	FYGL = FYGH2	INHEAT	119
	FYGS = FYGH1	INHEAT	120
	GO TO 230	INHEAT	121
220	IL = I	INHEAT	122
	IS = ID	INHEAT	123
	IDL = J	INHEAT	124
	IDS = JP	INHEAT	125
	IF (JND.EQ.1) GO TO 230	INHEAT	126

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

	IML = IM1	INHEAT	127
	IMS = IM2	INHEAT	128
	FXGL = FXGH1	INHEAT	129
	FXGS = FXGH2	INHEAT	130
230	KL = IYPE(IL)	INHEAT	131
	KS = IYPE(IS)	INHEAT	132
	ETAL = ETAL(KL)	INHEAT	133
	ETAS = ETAS(KS)	INHEAT	134
	PLL = PLEN(KL)	INHEAT	135
	PLS = PLEN(KS)	INHEAT	136
	NRL = NRJNG(KL)	INHEAT	137
	NRS = NRJNG(KS)	INHEAT	138
	NCRS = 6*(NRS+1)	INHEAT	139
	NCRL = 6*(NRL+1)	INHEAT	140
	CPOS = 0.5*((NRL-1)*PLL-(NRS-1)*PLS+2.0*(ETAL-ETAS))	INHEAT	141
	IX = MOD(IQS,6)+1	INHEAT	142
	MDC1 = NTLOC(IQS)+NSC(KS,9)-2*NCRS-7+IX	INHEAT	143
	MDC2 = MDC1-IX+IQS	INHEAT	144
	IX = MOD(IQL,6)+1	INHEAT	145
	MDC3 = NTLOC(IQL)+NSC(KL,9)-7+IX	INHEAT	146
	MDC4 = MDC3-IX+IQL	INHEAT	147
	IEND1 = (NRL+1)/2	INHEAT	148
	IEND2 = MINO(NRS,(NRS+1)/2+1)	INHEAT	149
	IPL = (IQL-1)*NRL+NSC(KL,9)-NCRL-1	INHEAT	150
	IPS = IQS*NRS+NSC(KS,9)-3*NCRS+NTLOC(IS)	INHEAT	151
C		INHEAT	152
C	INTERPOLATE TO FIND TEMPERATURES CORRESPONDING TO LARGE NUMBER FAC	INHEAT	153
C		INHEAT	154
	DO 340 IRL=1,IEND1	INHEAT	155
	DISL = ETAL+(IRL-1)*PLL	INHEAT	156
	DO 240 IRS=1,IEND2	INHEAT	157
	DISS = ETAS+(IRS-1)*PLS+CPOS	INHEAT	158
	IF (DISS.GE.DISL) GO TO 260	INHEAT	159
240	CONTINUE	INHEAT	160
	TEST = DISS+0.01*PLL	INHEAT	161
	IF (TEST.GE.DISL) GO TO 260	INHEAT	162
	WRITE (6,250) I,J	INHEAT	163
	STOP	INHEAT	164
250	FORMAT (/,' *** - LEMAX GT. LEMIN AT END OF DO LOOP - INCORRECT A	INHEAT	165
	VERAGING OF TEMPERATURES WILL RESULT/5X/ PROGRAM STOPPED AT ASSFM	INHEAT	166
	*RLY NO.,I4, FACE NO.,I4)	INHEAT	167
260	IF (IND.EQ.2) GO TO 310	INHEAT	168
C		INHEAT	169
C	FIND INTERASSEMBLY GAP TEMPERATURES FOR LARGE MESH NUMBER	INHEAT	170
C	FOR JND=1	INHEAT	171
C		INHEAT	172
	MD1 = IPS-IRS	INHEAT	173
	MD2 = MD1-NRS+2*IRS-1	INHEAT	174
	IF (IRS.GT.1) GO TO 270	INHEAT	175
	AMULT = AMINI(1.0,(DISS-DISL)/ETAS)	INHEAT	176
	TT1 = AMULT*TC2(MDC1)+(1.00-AMULT)*TC2(MD1)	INHEAT	177
	TT2 = AMULT*TC2(MDC2)+(1.00-AMULT)*TC2(MD2)	INHEAT	178

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

	TT3 = AMULT*TC1(MD1)+(1.00-AMULT)*TC1(MD1)	INHEAT	179
	TT4 = AMULT*TC1(MD2)+(1.00-AMULT)*TC1(MD2)	INHEAT	180
	GO TO 280	INHEAT	181
270	AMULT = (DIS8-DISL)/PL8	INHEAT	182
	TT1 = AMULT*TC2(MD1+1)+(1.00-AMULT)*TC2(MD1)	INHEAT	183
	TT2 = AMULT*TC2(MD2+1)+(1.00-AMULT)*TC2(MD2)	INHEAT	184
	TT3 = AMULT*TC1(MD1+1)+(1.00-AMULT)*TC1(MD1)	INHEAT	185
	TT4 = AMULT*TC1(MD2+1)+(1.00-AMULT)*TC1(MD2)	INHEAT	186
280	IX = NTLOC(IL)+IPL+IRL	INHEAT	187
	KX = LIND(KL)+IPL+IRL	INHEAT	188
	LDUCT = LCON(KX,1)+NTLOC(IL)-1	INHEAT	189
	MM1 = LDUCT-NCR1	INHEAT	190
	JBAC = 1	INHEAT	191
	GO TO 300	INHEAT	192
290	IF (2*IRL.GT.NRL) GO TO 380	INHEAT	193
	JBAC = 0	INHEAT	194
	IX = LX+NPL-2*IRL+1	INHEAT	195
	MM1 = MM1+NRL-2*IRL+1	INHEAT	196
	LDUCT = LX-NCR1	INHEAT	197
	TT1 = TT2	INHEAT	198
	TT3 = TT4	INHEAT	199
300	TC2(LX) = (C26(IL)*TT1+C26(IS)*TC2(MM1))/(C2A(IL)+C26(IS))	INHEAT	200
	TC2(LDUCT) = C31(IL)*TC2(LX)+(1.0-C31(IL))*TC2(MM1)	INHEAT	201
	DDUM = PLEN(KL)*DZ*(TT3-TC1(MM1))/(C26(IL)+C26(IS))	INHEAT	202
	DS1(IL) = DSJ(TL)+DDUM	INHEAT	203
	IF (JBAC.EQ.1) GO TO 290	INHEAT	204
	GO TO 380	INHEAT	205
C		INHEAT	206
C	FIND INTERASSEMBLY GAP TEMPERATURES FOR LARGE MESH NUMBER	INHEAT	207
C	FOR IND=2	INHEAT	208
C		INHEAT	209
310	OGAM = 0.0	INHEAT	210
	MD1 = JF9-IR9+NCR9	INHEAT	211
	MD2 = MD1-NR9+2*IR9-1	INHEAT	212
	IF (IR9.GT.1) GO TO 320	INHEAT	213
	AMULT = AMIN1(1.0,(DIS9-DISL)/ETA9)	INHEAT	214
	TT1 = AMULT*TC1(MD1+1)+(1.00-AMULT)*TC1(MD1)	INHEAT	215
	TT2 = AMULT*TC1(MD2+1)+(1.00-AMULT)*TC1(MD2)	INHEAT	216
	GO TO 330	INHEAT	217
320	AMULT = (DIS9-DISL)/PL9	INHEAT	218
	TT1 = AMULT*TC1(MD1+1)+(1.00-AMULT)*TC1(MD1)	INHEAT	219
	TT2 = AMULT*TC1(MD2+1)+(1.00-AMULT)*TC1(MD2)	INHEAT	220
330	IX = NTLOC(IL)+IPL+IRL	INHEAT	221
	KX = LIND(KL)+IPL+IRL	INHEAT	222
	IF (IRL.LT.1) GO TO 340	INHEAT	223
	OGAM = C36(IL)*BCSKEW(IRL+1,IRL)+FXGL*DZ	INHEAT	224
	DSG(IL) = DSG(TL)+OGAM*A(KL,4)/C36(IL)	INHEAT	225
340	EA = ETA(KL,5)	INHEAT	226
	FB = ETA(KL,5)	INHEAT	227
	IF (IRL.EQ.1) EA = ETA(KL,6)	INHEAT	228
	JBAC = 1	INHEAT	229
	TA = TT1	INHEAT	230

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

INHEAT		GO TO 370	INHEAT	231
INHEAT	350	JF (2*IRL.GT,NRL) GO TO 380	INHEAT	232
INHEAT		LX = LY+NRL-2*IRL+1	INHEAT	233
INHEAT		KX = KX+NRL-2*IRL+1	INHEAT	234
INHEAT		OGAM = 0.0	INHEAT	235
INHEAT		JF (IHL.LI,1) GO TO 360	INHEAT	236
INHEAT		JC = NRL-IRL+2	INHEAT	237
INHEAT		OGAM = C36(IL)*8C8KEW(IC,IHL)*FXGL*OZ	INHEAT	238
INHEAT		OSG(IL) = OSG(IL)+OGAM*A(KL,4)/C36(IL)	INHEAT	239
INHEAT	360	TSAC = 0	INHEAT	240
INHEAT		TA = IT2	INHEAT	241
INHEAT		FA = ETA(KL,4)	INHEAT	242
INHEAT		FB = ETA(KL,4)	INHEAT	243
INHEAT		JF (IRL.EQ,1) FB = ETA(KL,6)	INHEAT	244
INHEAT	370	MM1 = LCON(KX,1)+NTLOC(IL)-1	INHEAT	245
INHEAT		MM2 = LCON(KX,2)+NTLOC(IL)-1	INHEAT	246
INHEAT		MM3 = LCON(KX,3)+NTLOC(IL)-1	INHEAT	247
INHEAT		OIH1 = C24(IS)*(TA-TC1(LX))*PLEN(KL)*C27(IL)*A(K8,6)/(PLEN(K9)	INHEAT	248
INHEAT	+	+C27(IS)*A(KL,6))	INHEAT	249
INHEAT		OTDZ = C24(IL)*(TC1(MM1)-TC1(LX))+C25(IL)*((TC1(MM2)-TC1(LX))/	INHEAT	250
INHEAT	+	FA+((TC1(MM3)-TC1(LX))/EB)+OIH1	INHEAT	251
INHEAT		TC2(LX) = TC1(LX)+0.5*OZ*OTDZ*(C27(IL)+C27(I9))/C27(IL)	INHEAT	252
INHEAT		DOUM1 = C24(IL)*((TC1(LX)-TC1(MM1))*OZ*A(KL,6)/C27(IL)	INHEAT	253
INHEAT		OS1(IL) = OS1(IL)+DOUM1	INHEAT	254
INHEAT		OSGP = OSGP+DOUM1	INHEAT	255
INHEAT		TC2(MM1) = C31(IL)*TC2(LX)+(1.00-C31(IL))*TC2(MM1-NCRL)+OGAM	INHEAT	256
INHEAT		JF (TSAC.EQ,1) GO TO 350	INHEAT	257
INHEAT	380	CONTINUE	INHEAT	258
INHEAT	C		INHEAT	259
INHEAT	C	RACK OUT INTERASSEMBLY GAP TEMPERATURES FOR CORRESPONDING SMALL	INHEAT	260
INHEAT	C	MESH NUMBER FACE	INHEAT	261
INHEAT	C		INHEAT	262
INHEAT		IEND2 = (NR8+1)/2	INHEAT	263
INHEAT		IEND1 = MINO(NRL,(NRL+1)/2+1)	INHEAT	264
INHEAT	C		INHEAT	265
INHEAT	C	INTERPOLATE	INHEAT	266
INHEAT	C		INHEAT	267
INHEAT		DO 440 IPS=1,IEND2	INHEAT	268
INHEAT		DISS = ETAS+(IPS-1)*PL9+CPDS	INHEAT	269
INHEAT		DO 390 IRL=1,IEND1	INHEAT	270
INHEAT		DISL = ETAL*(IRL-1)*PLL	INHEAT	271
INHEAT		IF (DISL.GT,DISS) GO TO 400	INHEAT	272
INHEAT	390	CONTINUE	INHEAT	273
INHEAT		TEST = DISL+0.01*PL9	INHEAT	274
INHEAT		JF (TEST.GE,DISS) GO TO 400	INHEAT	275
INHEAT		WRITE (6,250) I,J	INHEAT	276
INHEAT		STOP	INHEAT	277
INHEAT	400	MD1 = NTLOC(IL)+IPL+NRL-IRL+1	INHEAT	278
INHEAT		MD2 = NTLOC(IL)+IPL+IRL	INHEAT	279
INHEAT		LY = IPS+2*NCRS-IRS	INHEAT	280
INHEAT		LX = LY-IRS+2*IRS-1	INHEAT	281
INHEAT		JF (IRL.GT,1) GO TO 410	INHEAT	282

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INHEAT

	AMULT = AMIN(1.00, (DISL-DISS)/ETAL)	INHEAT	293
	TC2(LX) = AMULT*(TC1(MDC3)-TC1(MD1))+TC2(MD1)	INHEAT	294
	TC2(LY) = AMULT*(TC1(MDC4)-TC1(MD2))+TC2(MD2)	INHEAT	295
	GO TO 420	INHEAT	296
410	AMULT = (DISL-DISS)/PLL	INHEAT	297
	TC2(LX) = AMULT*TC2(MD1+1)+(1.00-AMULT)*TC2(MD1)	INHEAT	298
	TC2(LY) = AMULT*TC2(MD2+1)+(1.00-AMULT)*TC2(MD2)	INHEAT	299
420	QGAM1 = 0.0	INHEAT	300
	QGAM2 = 0.0	INHEAT	301
	IF (IHS.LT.1) GO TO 430	INHEAT	302
	QGAM1 = C36(I8)*RCSEW(I8+1, IHS)*FXG8+DZ	INHEAT	303
	IF (2*I8.LE.NR8) QGAM2 = C36(I8)*RCSEW(NR8-I8+2, IHS)*FXG9+D	INHEAT	304
	7	INHEAT	305
	QSG(I8) = QSG(I8)+(QGAM1+QGAM2)*A(K8,4)/C36(I8)	INHEAT	306
430	LDUCT = LX-NCR8	INHEAT	307
	MM1 = LX-2*NCR8	INHEAT	308
	TC2(LDUCT) = C31(I8)*TC2(LX)+(1.00-C31(I8))*TC2(MM1)+QGAM1	INHEAT	309
	IF (2*I8.GT.NR8) GO TO 440	INHEAT	310
	LDUCT = LY-NCR8	INHEAT	311
	MM1 = LY-2*NCR8	INHEAT	312
	TC2(LDUCT) = C31(I8)*TC2(LY)+(1.00-C31(I8))*TC2(MM1)+QGAM2	INHEAT	313
440	CONTINUE	INHEAT	314
	LSTART = IPS+2*NCR8-NR8	INHEAT	315
	LSTOP = LSTART+NR8-1	INHEAT	316
	DO 460 LX=LSTART, LSTOP	INHEAT	317
	IF (IND.EQ.2) GO TO 450	INHEAT	318
	MM1 = LX-2*NCR8		
	QSI(I8) = QSI(I8)+PLEN(K8)*DZ*(TC1(LX)-TC1(MM1))/C26(I8)		
	GO TO 460		
450	MM1 = LX-NCR8		
	DDUM = C24(I8)*(TC1(LX)-TC1(MM1))*DZ*A(K8,6)/C27(I8)		
	QSI(I8) = QSI(I8)+DDUM		
	QSGP = QSGP+DDUM		
460	CONTINUE		
	RETURN		
	END		

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

*DECK INPUT	INPUT	1
SUBROUTINE INPUT (NTYPE)	INPUT	2
*CALL BLK2	INPUT	3
*CALL BLK8	INPUT	4
*CALL BLK3	INPUT	5
*CALL BLK4	INPUT	6
*CALL BLK6	INPUT	7
*CALL BLK7	INPUT	8
*CALL BLK9	INPUT	9
*CALL BLK10	INPUT	10
*CALL BLK5	INPUT	11
DATA ICNVR/1,4,3,2,7,6,5,12,11,10,9,8,19,18,17,16,15,14,13,26,25,	INPUT	12
24,23,22,21,20,17,16,35,34,33,32,31,30,29,28,27,46,45,44,43,42.	INPUT	13

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

	+ 41,40,39,38,61,60,59,58,57,56,55,54,53,52,51,40,49,48,47,72,71,	INPUT	14
	+ 70,69,68,67,66,65,64,63,62,91,90,89,88,87,86,85,84,83,82,81,90,	INPUT	15
	+ 79,78,77,76,75,74,73,104,103,102,101,100,99,98,97,96,95,94,93,	INPUT	16
	+ 92,127,126,125,124,123,122,121,120,119,118,117,116,115,114,113,	INPUT	17
	+ 112,111,110,109,108,107,106,105,104,101,100,109,108,107,106,	INPUT	18
	+ 135,134,133,132,131,130,129,128,169,168,167,166,165,164,163,	INPUT	19
	+ 162,161,160,159,158,157,156,155,154,153,152,151,150,149,148,	INPUT	20
	+ 147,146,145,144,143,142,141,140,139,138,137,136,135,134,	INPUT	21
	+ 176,175,174,173,172,171,170,217,216,215,214,213,212,211,210,	INPUT	22
	+ 209,208,207,206,205,204,203,202,201,200,199,198,197,196,195,	INPUT	23
	+ 194,193,192,191,190,189,188,187,	INPUT	24
	DATA DIM/ CM ' ' IN ' ' C ' ' F ' /, IPR/6/ ICR/5/	INPUT	25
C		INPUT	26
C	PRINTOUT SUPREENERGY DIMENSIONING PARAMETERS AND CARD ECHO LISTING	INPUT	27
C		INPUT	28
	WRITE (IPR,1040) NA,NR,NC,ND,NE,NF,NG,NH,NJ,NK,NL,NM,NN,NO,NP,NG,N	INPUT	29
	+W,N1	INPUT	30
	INP = ICP	INPUT	31
	CALL ECHO (IPR,ICR,7)	INPUT	32
C		INPUT	33
C	READ IN CHOICE OF INPUT AND OUTPUT UNITS AND TITLE	INPUT	34
C	IFORM=0 INTERNATIONAL ENGINEERING UNITS	INPUT	35
C	IFORM=1 BRITISH ENGINEERING UNITS	INPUT	36
C		INPUT	37
	READ (ICR,1020) IFORM,TEXT	INPUT	38
C		INPUT	39
C	INPUT GENERAL DATA	INPUT	40
C		INPUT	41
C	INPUT NO. ASSEMBLIES, NO. ASSEMBLY TYPES, AND MODEL TYPE	INPUT	42
C		INPUT	43
C	1=CONDUCTION MODEL, THERMAL RESISTANCE ACROSS GAP, BUT	INPUT	44
C	DUCT IS MODALIZED.	INPUT	45
C	2=BOTH DUCT AND GAP ARE MODALIZED.	INPUT	46
C	INPUT PROPERTY OPTIONS FOR COOLANT, DUCT	INPUT	47
C	(0= CODE DEFAULT)	INPUT	48
C		INPUT	49
	READ (ICR,970) N0ASSH,NTYPE,MODEL,NCOENT,NDENT	INPUT	50
	IF (NCOENT.LT.1) GO TO 100	INPUT	51
C		INPUT	52
C	COOLANT PROPERTY INPUT	INPUT	53
C	TEMPERATURE (C OR F), DENSITY (KG/M**3 OR LBM/FT**3),	INPUT	54
C	SPECIFIC HEAT (J/KG-K OR BTU/LBM-F), THERMAL CONDUCTIVITY	INPUT	55
C	(W/M-K OR BTU/HR-FT-F), DYNAMIC VISCOSITY (PA-S OR LBM/FT-HR)	INPUT	56
C		INPUT	57
	READ (ICR,1000) (TEMPC(I),RHOC(I),CPC(I),CONDC(I),VISC(I),I=1,NCOE	INPUT	58
	+NT)	INPUT	59
100	IF (NDENT.LT.1) GO TO 110	INPUT	60
C		INPUT	61
C	INPUT DUCT WALL PROPERTIES	INPUT	62
C	ONLY THE CONDUCTIVITY IS USED IN STEADY STATE	INPUT	63
C		INPUT	64
	READ (ICR,1010) (TEMPD(I),RHOD(I),CPD(I),CONDD(I),I=1,NDENT)	INPUT	65

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

C		INPUT	66
C	INPUT NO. OF AXIAL INCREMENTS, NO. OF AXIAL LOCATIONS FOR	INPUT	67
C	TEMPERATURE MAP PRINTOUT, AXIAL STABILITY CHECK CONDITION, AND	INPUT	68
C	OPTIONAL NO. OF AXIAL LOCATIONS FOR AVERAGE DUCT WALL TEMPERATURE	INPUT	69
C	PRINTOUT	INPUT	70
C	STABILITY CHECK CONDITION	INPUT	71
C	IF ICHK = 0 - CHECK AXIAL STABILITY AND STOP IF STABILITY VIOLATED	INPUT	72
C	1 - CHECK AXIAL STABILITY, SET DELTAZ TO MAXIMUM	INPUT	73
C	2 - CHECK AXIAL STABILITY, CHANGE DELTAZ ONLY IF STABILITY	INPUT	74
C	CRITERIA VIOLATED	INPUT	75
C	3 - DO NOT CHECK AXIAL STABILITY	INPUT	76
C		INPUT	77
110	READ (ICR,970) NOINCR,NAPRNT,ICLK,NOPRNT,NORMAP	INPUT	78
C		INPUT	79
C	AXIAL POSITIONS OF PRINTOUTS IN INCREASING ORDER (CM OR IN)	INPUT	80
C		INPUT	81
C	READ (ICR,980) (APRNT(I),I=1,NAPRNT)	INPUT	82
C		INPUT	83
C	AXIAL POSITIONS FOR AVERAGE DUCT TEMPERATURE PRINTOUT , OPTIONAL	INPUT	84
C		INPUT	85
C	IF (NOPRNT.GT.0) READ (ICR,980) (OPRNT(I),I=1,NOPRNT)	INPUT	86
C		INPUT	87
C	INPUT BUNDLE LENGTH(CM OR IN),GAP MASSFLUX(KG/M**2-S OR	INPUT	88
C	LRM/FT**2-HR), AND GAP THICKNESS(CM OR IN)	INPUT	89
C		INPUT	90
C	READ (ICR,980) LENGTH,FLOWG,GAPTH	INPUT	91
C		INPUT	92
C	INPUT COEFFICIENTS FOR DUCT WALL TO COOLANT HEAT TRANSFER	INPUT	93
C	CORRELATIONS OF THE FORM ...	INPUT	94
C	NU=HT1*RE**HT2*PR**HT3 + HT4	INPUT	95
C		INPUT	96
C	READ (ICR,980) HT1,HT2,HT3,HT4	INPUT	97
C	IF (HT1*HT4.NE.0.0) GO TO 120	INPUT	98
C	HT1 = 0.025	INPUT	99
C	HT2 = 0.2	INPUT	100
C	HT3 = 0.8	INPUT	101
C	HT4 = 7.0	INPUT	102
C		INPUT	103
C	BUNDLE TYPE DATA	INPUT	104
C		INPUT	105
120	DO 140 K=1,NTYPE	INPUT	106
C		INPUT	107
C	INPUT BUNDLE TYPE IDENTIFICATION NUMBER, # OF RODS, AND BUNDLE	INPUT	108
C	LUMPING INSTRUCTIONS.	INPUT	109
C	IF IL EQUALS 1, USE POROUS MEDIUM TYPE INPUT.	INPUT	110
C	IF IL DOES NOT EQUAL 1, USE REGULAR SUBCHANNEL TYPE INPUT.	INPUT	111
C		INPUT	112
C	READ (ICR,970) ID,NROD(ID),ILUMP(ID)	INPUT	113
C	JTY(K) = ID	INPUT	114
C		INPUT	115
C	INPUT GEOMETRIC DIMENSIONS (ALL IN CM OR IN)	INPUT	116
C	ROD PITCH, WIRE WRAP LEAD, DUCT INSIDE FLAT-TO-FLAT DISTANCE.	INPUT	117

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

C	HEX CAN THICKNESS, ROD DIAMETER, WIRE WRAP DIAMETER, WIRE WRAP	INPUT	118
C	DIAMETER IN THE PERIPHERAL REGION, SHAPE FACTOR ON THE	INPUT	119
C	CONDUCTION TERM (NO UNITS)	INPUT	120
C		INPUT	121
C	READ (ICR,980) P(ID), LEAD(ID), FLAT(ID), DUCTTH(ID), CLADD(ID), W	INPUT	122
	* YREOD(ID), SHWIRE(ID), SF(ID)	INPUT	123
	IF (SHWIRE(ID).EQ.0.0) SHWIRE(ID) = WIREOD(ID)	INPUT	124
	IF (JLUMP(ID).NE.1) GO TO 130	INPUT	125
C		INPUT	126
C	INPUT NUMBER OF RADIAL NODE RINGS FOR POROUS BODY INPUT.	INPUT	127
C		INPUT	128
C	READ (ICR,970) NRING(IN)	INPUT	129
130	IF (ID.LE.NL) GO TO 140	INPUT	130
	JX = ID-NL	INPUT	131
C		INPUT	132
C	IF ASSEMBLY TYPE IS GREATER THAN NL, ASSEMBLY IS CONTROL ASSEMBLY	INPUT	133
C	INPUT INNER DUCT THICKNESS AND BYPASS DUCT THICKNESS	INPUT	134
C	DIMENSIONS IN CM OR IN	INPUT	135
C		INPUT	136
C	READ (ICR,980) CWallT(JX), CGAPTH(JX)	INPUT	137
C		INPUT	138
C	INPUT APPLICABLE PROFILE FOR EPSILON *, AND C1 VS RE	INPUT	139
C	IF NPARAM=0, USE CORRELATIONS IN CODE BY DEFAULT	INPUT	140
C	INPUT APPLICABLE PROFILE FOR FLOWSPLIT VS RE	INPUT	141
C	IF NFSPLT(ID)=1, USE M1T CORRELATION	INPUT	142
C	IF NFSPLT(ID)=0, USE NOVENDSTERN CORRELATION	INPUT	143
C	USE OF CODE FLOWSPLIT CORRELATION IS RECOMMENDED TO GO ALONG	INPUT	144
C	WITH CODE EPSILON, C1 CORRELATIONS.	INPUT	145
C		INPUT	146
C	READ (ICR,970) NPARAM(ID), NFSPLT(ID)	INPUT	147
140	CONTINUE	INPUT	148
150		INPUT	149
C		INPUT	150
C	INPUT PROFILES	INPUT	151
C		INPUT	152
C	INPUT THE NUMBER OF DIFFERENT I	INPUT	153
C	AXIAL ROD POWER PROFILES	INPUT	154
C	RADIAL PIN POWER PROFILES	INPUT	155
C	AXIAL BC AND GAMMA PROFILES	INPUT	156
C	RADIAL BC AND GAMMA PROFILES	INPUT	157
C	FLOWSPLIT VS RE NUMBER PROFILES	INPUT	158
C	EPSILON *, C1 VS RE NUMBER PROFILES	INPUT	159
C	COOLANT NODAL HEAT GENERATION PROFILES (REQUIRED FOR POROUS BODY	INPUT	160
C	INPUT ONLY)	INPUT	161
C		INPUT	162
C	READ (ICR,970) NOAXPP, NORPPP, N8CAX, N8CSKW, NFSP, NFPCP, NORH1H	INPUT	163
C		INPUT	164
C	INPUT AXIAL ROD POWER PROFILES, IF APPLICABLE	INPUT	165
C		INPUT	166
C	IF (NOAXPP.LT.1) STOP	INPUT	167
C		INPUT	168
C	FOR EACH PROFILE, ENTER THE NUMBER OF TABULAR ENTITIES	INPUT	169

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

C	DO 160 ID=1,NMAXPP	INPUT	170
	READ (ICR,1090) MAXTEM,AXBAR(ID)	INPUT	171
	IF (AXBAR(ID).EQ.0.0.OR.NORMAP.NE.1) AXBAR(ID) = 1.0	INPUT	172
	MAXPEN(ID) = MAXTEM	INPUT	173
C	INPUT TABULAR ENTRIES : NORMALIZED HEIGHT,NORMALIZED POWER FACTOR	INPUT	174
C		INPUT	175
C	READ (ICR,980) (AXHTPP(I,ID),APP(I,ID),I=1,NMAXTEM)	INPUT	176
160		INPUT	177
C	INPUT RADIAL PIN POWER PROFILES, IF APPLICABLE	INPUT	178
C		INPUT	179
C	IF (NORPPP.LT.1) GO TO 230	INPUT	180
		INPUT	181
C	NUMBER OF RADIAL PIN PROFILE ENTRIES, ICOBRA=1 OPTION TO READ IN	INPUT	182
C	DATA WITH COBRA TYPE ROD NUMBERING SCHEME AND PERFORM AN	INPUT	183
C	IMMEDIATE CONVERSION TO SUPERENERGY ROD NUMBERING SCHEME,	INPUT	184
C	ALSO OPTION TO PERFORM BINARY READ FROM DEVICE ITAPE(DEVICES 8,9	INPUT	185
C	AVAILABLE)	INPUT	186
C		INPUT	187
C	NSTOP = 0	INPUT	188
	DO 200 ID=1,NORPPP	INPUT	189
	READ (ICR,970) NPDUH,ICOBRA,ITAPE	INPUT	190
	NPINP(ID) = NPDUH	INPUT	191
	NPLDC(ID) = NSTOP+1	INPUT	192
	NSTART = NSTOP	INPUT	193
	NSTOP = NSTART+NPDUH	INPUT	194
C	INPUT NORMALIZED RADIAL PIN PROFILE	INPUT	195
C		INPUT	196
C	IF (ITAPE.GT.0) GO TO 170	INPUT	197
	READ (ICR,980) (PDUM(I),I=1,NPDUM)	INPUT	198
	GO TO 180	INPUT	199
170	READ (ITAPE) (PDUM(I),I=1,NPDUM)	INPUT	200
180	IF (ICOBRA.EQ.1) GO TO 200	INPUT	201
	DO 190 I=1,NPDUM	INPUT	202
190	RPPP(NSTART+I) = PDUM(I)	INPUT	203
	GO TO 220	INPUT	204
200	DO 210 I=1,NPDUM	INPUT	205
	J = ICONVR(I)	INPUT	206
210	RPPP(NSTART+J) = PDUM(I)	INPUT	207
220	CONTINUE	INPUT	208
C	INPUT AXIAL RC AND GAMMA PROFILES, IF APPLICABLE	INPUT	209
C		INPUT	210
C	IF (NBCAX.LT.1) GO TO 250	INPUT	211
230		INPUT	212
C	FOR EACH PROFILE,ENTER THE NUMBER OF TABULAR ENTRIES	INPUT	213
C		INPUT	214
C	DO 240 ID=1,NBCAX	INPUT	215
	READ (ICR,970) NBCTEM	INPUT	216
	NBCAEN(ID) = NBCTEM	INPUT	217
		INPUT	218
		INPUT	219
		INPUT	220
		INPUT	221

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

C		INPUT	222
C	INPUT TABULAR ENTRIES RELATIVE HEIGHT,NORMALIZED MULTIPLIER	INPUT	223
C		INPUT	224
240	READ (ICR,980) (RCAXHT(I,ID),BCAXP(I,ID),I=1,NBCTEM)	INPUT	225
C		INPUT	226
C	INPUT FACIAL RC AND GAMMA PROFILES,IF APPLICABLE	INPUT	227
C		INPUT	228
250	IF (NBCSKW,LT.1) GO TO 270	INPUT	229
C		INPUT	230
C	FOR EACH PROFILE,ENTER # OF TABULAR ENTRIES AND ASSOCIATED BUNDLE	INPUT	231
C	TYPE NUMBER.	INPUT	232
C	CAUTION****THIS MUST BE A BUNDLE TYPE NUMBER IN USE	INPUT	233
C		INPUT	234
	DO 260 ID=1,NBCSKW	INPUT	235
	READ (ICR,970) NBCTEM,NBTYPB(ID)	INPUT	236
	NBCSEN(ID) = NBCTEM	INPUT	237
C		INPUT	238
C	INPUT TABULAR ENTRIES; NORMALIZED POSITION ALONG FACE (STARTING	INPUT	239
C	FROM OUTSIDE BUNDLE LEFT CORNER (POSITION/FACE LENGTH),NORMALIZED	INPUT	240
C	FACTOR	INPUT	241
C		INPUT	242
260	READ (ICR,980) (RCXKWT(I,ID),BCXKEW(I,ID),I=1,NBCTEM)	INPUT	243
C		INPUT	244
C	INPUT CONSTANT NODAL HEAT GENERATION PROFILES, IF APPLICABLE	INPUT	245
C	INPUT FLOW SPLIT VS RE PROFILES,IF APPLICABLE	INPUT	246
C		INPUT	247
270	IF (NFSP,LT.1) GO TO 290	INPUT	248
C		INPUT	249
C	FOR EACH PROFILE INPUT THE NUMBER OF TABULAR ENTRIES	INPUT	250
C		INPUT	251
	DO 280 ID=1,NFSP	INPUT	252
	READ (ICR,970) L	INPUT	253
	NFBENT(ID) = L	INPUT	254
C		INPUT	255
C	INPUT ENTRIES IN FLOW SPLIT TABLE IRE,X1,X2,X3	INPUT	256
C		INPUT	257
280	READ (ICR,1010) (REF(J,ID),X1(J,ID),X2(J,ID),X3(J,ID),J=1,L)	INPUT	258
C		INPUT	259
C	INPUT EPSILON # AND C1 VS RE PROFILES,IF APPLICABLE	INPUT	260
C		INPUT	261
290	IF (NEPCP,LT.1) GO TO 310	INPUT	262
C		INPUT	263
C	FOR EACH PROFILE INPUT THE NUMBER OF TABULAR ENTRIES	INPUT	264
C		INPUT	265
	DO 300 ID=1,NEPCP	INPUT	266
	READ (ICR,970) L	INPUT	267
	NEPENT(ID) = L	INPUT	268
C		INPUT	269
C	INPUT ENTRIES OF: REYNOLDS NUMBER,EPSILON STAR(I), AND C1	INPUT	270
C		INPUT	271
300	READ (ICR,990) (REP(J,ID),ESTAR(J,ID),C(J,ID),J=1,L)	INPUT	272
310	IF (NORMTM,LT.1) GO TO 330	INPUT	273

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

	NSTOP = 0	INPUT	274
	NHLOC(1) = 1	INPUT	275
	DO 320 ID=1,NORPTH	INPUT	276
C		INPUT	277
C	ENTER NUMBER OF SUBCHANNELS IN CURRENT RODS BODY REPRESENTATION	INPUT	278
C	GAMMA HEATING IN THE BYPASS CHANNEL OF A BYPASS ASSEMBLY MAY BE	INPUT	279
C	REPRESENTED BY ADDING AN ADDITIONAL RING OF SUBCHANNEL POWER FACTO	INPUT	280
C		INPUT	281
	READ (ICR,970) NHTP(ID)	INPUT	282
	NSTART = NHLOC(ID)	INPUT	283
	NSTOP = NSTART+NHTP(ID)-1	INPUT	284
	NHLOC(ID+1) = NSTOP+1	INPUT	285
C		INPUT	286
C	INPUT NORMALIZED RADIAL POWER GENERATION RATE (Q _r)	INPUT	287
C		INPUT	288
320	READ (ICR,980) (RHTPP(I),I=NSTART,NSTOP)	INPUT	289
C		INPUT	290
C	INPUT BUNDLE SPECIFIC DATA	INPUT	291
C		INPUT	292
C	INPUT BUNDLE IDENTIFICATION NUMBER AND BUNDLE TYPE NUMBER	INPUT	293
C		INPUT	294
330	I8P = 0	INPUT	295
	DO 370 J=1,NBASSH	INPUT	296
C		INPUT	297
C	READ IN BUNDLE NUMBER AND TEXT IDENTIFIER	INPUT	298
C		INPUT	299
	READ (ICR,1000) ID,(BUNID(I,J),I=1,17)	INPUT	300
C		INPUT	301
C	BUNDLES MUST BE INPUT IN ASCENDING ORDER	INPUT	302
C		INPUT	303
	IF (ID.NE.J) WRITE (IPR,1940) ID	INPUT	304
C		INPUT	305
C	INPUT THE FOLLOWING IDENTIFIERS.....	INPUT	306
C	• BUNDLE TYPE	INPUT	307
C	• BC TYPE 1=HEAT FLUX 2=TEMPERATURE	INPUT	308
C	• AXIAL POWER PROFILE NUMBER	INPUT	309
C	• RADIAL POWER PROFILE NUMBER, OR NODAL POWER PROFILE IF LUMPED	INPUT	310
C	• ISOLATION CONDITION = IF ISOLAT=1 NO INTERASSEMBLY HEAT	INPUT	311
C	TRANSFER WILL BE ALLOWED WITH THIS BUNDLE	INPUT	312
C		INPUT	313
	READ (ICR,970) ITYPE,I8CT,(PROFIL(ID,I),I=1,2),ISOLAT	INPUT	314
	ITYPE(ID) = ITYPEI	INPUT	315
	I8CTP(ID) = MINO(2,MAXO(1,I8CT))	INPUT	316
	NHLOC(J) = ISOLAT	INPUT	317
	IF (ITYPEI.GT.NL) I8P = I8P+1	INPUT	318
C		INPUT	319
C		INPUT	320
C	NUMBER OF ENTRIES IN RADIAL POWER PROFILE MUST EQUAL THE NUMBER	INPUT	321
C	OF RODS IN THE SPECIFIED BUNDLE TYPE	INPUT	322
C		INPUT	323
	IF (ILUMP(ITYPEI).EQ.1) GO TO 340	INPUT	324
	JA = PROFIL(JD,2)	INPUT	325

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

	IF (NR0D(IITYPE),NE,NP1NP(IA)) WRITE (IPR,1900) IA,ID	INPUT	326
C		INPUT	327
C	INPUT NOMINAL LINEAR ROD POWER (W/M OR BTU/HR-FT), NOMINAL FLOW	INPUT	328
C	RATE(KG/S OR LB/H/HR), INLET TEMPERATURE, AVERAGE COOLANT AND	INPUT	329
C	DUCT TEMPERATURES FOR PROPERTY EVALUATION(C OR F)	INPUT	330
C		INPUT	331
340	READ (ICR,980) POWER(ID),FLOW(ID),TINLET(ID),TAVFC(ID),TAVEN(I	INPUT	332
	N)	INPUT	333
C		INPUT	334
C	RYPARS REGION FLOW (KG/S OR LB/H/HR)	INPUT	335
C		INPUT	336
	IF (IITYPE,GT,NL) READ (ICR,980) FLOWBP(1SP)	INPUT	337
C		INPUT	338
C	NEIGHBORING BUNDLE NUMBERS FOR THE 6 FACES (NO NEIGHBOR=0)	INPUT	339
C		INPUT	340
	READ (ICR,970) (NEIGH3(ID,K),K=1,6)	INPUT	341
C		INPUT	342
C	BOUNDARY CONDITION AXIAL PROFILE AND FACIAL SKEW PROFILE NUMBERS	INPUT	343
C	FOR EACH FACE (NO RC = 0)	INPUT	344
C		INPUT	345
	READ (ICR,970) ((IPROFD(ID,K,L),L=1,2),K=1,6)	INPUT	346
C		INPUT	347
C	NOMINAL VALUE OF HEAT FLUX OR TEMPERATURE BC FOR EACH FACE	INPUT	348
C	(UNITS OF (W/M**2 OR BTU/HR-FT**2) OR (C OR F)	INPUT	349
C		INPUT	350
	READ (ICR,980) (RC(ID,K),K=1,6)	INPUT	351
C		INPUT	352
C	GAMMA HEATING AXIAL PROFILE AND FACIAL SKEW PROFILE NUMBERS FOR	INPUT	353
C	EACH FACE (NO GAMMA HEATING = 0)	INPUT	354
C		INPUT	355
	READ (ICR,970) ((IPROFD(ID,K,L),L=3,4),K=1,6)	INPUT	356
C		INPUT	357
C	NOMINAL VALUE OF GAMMA HEATING FOR DUCT WALL FOR EACH FACE	INPUT	358
C	(UNITS OF (W/M**3 OR BTU/HR-FT**3)	INPUT	359
C		INPUT	360
	READ (ICR,980) (GH0NOM(ID,K),K=1,6)	INPUT	361
C		INPUT	362
C	ERROR CHECKS	INPUT	363
C		INPUT	364
	DO 360 K=1,6	INPUT	365
	IF (NEIGH3(ID,K),GT,0) GO TO 350	INPUT	366
	M = IPROFD(J,K,2)	INPUT	367
	IF (M.LT,1) GO TO 350	INPUT	368
C		INPUT	369
C	BOUNDARY CONDITION FACIAL SKEW PROFILE SPECIFIED MUST BE ASSOCIATE	INPUT	370
C	WITH SAME BUNDLE TYPE AS CURRENT ASSEMBLY.	INPUT	371
C		INPUT	372
	IF (NBTYPE(M),NE,IITYPE) WRITE (IPR,2000) J,M	INPUT	373
350	M = IPROFD(J,K,4)	INPUT	374
	IF (M.LT,1) GO TO 360	INPUT	375
C		INPUT	376
C	DUCT GAMMA HEATING FACIAL SKEW PROFILE SPECIFIED MUST BE ASSOCIATE	INPUT	377

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

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INPUT  C
INPUT  IF (NRTYPR(M),NE,IYPTET) WRITE (IPR,2010) J,M
INPUT  360  CONTINUE
INPUT  370  CONTINUE
INPUT  DO 360 J=1,NDASSH
INPUT  ISOLAT = NTLOC(J)
INPUT  IF (ISOLAT,NE,1) GO TO 390
INPUT  DO 360 K=1,6
INPUT  KN = MOD(K+2,6)+1
INPUT  JN = NEIGHR(J,K)
INPUT  NEIGHR(J,K) = 0
INPUT  IF (JN,LT,1) GO TO 390
INPUT  NEIGHR(JN,KN) = 0
INPUT  380  CONTINUE
INPUT  390  CONTINUE
INPUT  C
INPUT  C
INPUT  C      OUTPUT GENERAL DATA
INPUT  C
INPUT  WRITE (IPR,1050) TFX(17)
INPUT  IF (JFORM,EQ,1) GO TO 400
INPUT  WRITE (IPR,1060)
INPUT  GO TO 410
INPUT  400  WRITE (IPR,1070)
INPUT  410  IF (MODEL,EQ,2) GO TO 420
INPUT  WRITE (IPR,1090)
INPUT  GO TO 430
INPUT  420  WRITE (IPR,1100)
INPUT  430  WRITE (IPR,1080) NDASSH,NTYPE
INPUT  IF (NDEENT,GT,0) GO TO 440
INPUT  WRITE (IPR,1150)
INPUT  GO TO 470
INPUT  440  WRITE (IPR,1160)
INPUT  IF (JFORM,EQ,1) GO TO 450
INPUT  WRITE (IPR,1190)
INPUT  GO TO 460
INPUT  450  WRITE (IPR,1200)
INPUT  460  WRITE (IPR,1210) (TEMP(I),RHOC(I),CPC(I),CONOC(I),VISC(I),I=1,NDEENT)
INPUT  IF (NDEENT,GT,0) GO TO 480
INPUT  WRITE (IPR,1240)
INPUT  GO TO 510
INPUT  480  WRITE (IPR,1250)
INPUT  IF (JFORM,EQ,1) GO TO 490
INPUT  WRITE (IPR,1170)
INPUT  GO TO 500
INPUT  490  WRITE (IPR,1180)
INPUT  500  WRITE (IPR,1220) (TEMP(I),RHOC(I),CPC(I),CONOC(I),I=1,NDEENT)
INPUT  510  IF (NORMAP,EQ,1) WRITE (IPR,1280)
INPUT  WRITE (IPR,1290) NMINCR
INPUT  WRITE (IPR,1300)
INPUT  WRITE (IPR,1320) (APRNT(I),DIM(IPRHM+1),I=1,NAPRNT)

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INPUT  378
INPUT  379
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INPUT  429

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

	IF (NOPRNT,LT,1) GO TO 520	INPUT	430
	WRITE (IPR,1310)	INPUT	431
	WRITE (IPR,1320) (NOPRNT(I),DIM(IFORM+1),I=1,NOPRNT)	INPUT	432
520	WRITE (IPR,1270) LENGTH,DIM(IFORM+1)	INPUT	433
	IF (IFORM,EQ,1) GO TO 530	INPUT	434
	WRITE (IPR,1330) FLOWG	INPUT	435
	GO TO 540	INPUT	436
530	WRITE (IPR,1340) FLOWG	INPUT	437
540	WRITE (IPR,1460) GAPTH,DIM(IFORM+1)	INPUT	438
	WRITE (IPR,1230) ICHK	INPUT	439
	WRITE (IPR,550) HT1,HT2,HT3,HT4	INPUT	440
550	FORMAT (1X,'DUCT-TN=COOLANT HEAT TRANSFER COEFFICIENT',10X,'NUM=',F	INPUT	441
	+6.4,'RE=*(1,F5.3,')*PR*(1,F5.3,') + 1,F6.4)	INPUT	442
C		INPUT	443
C		INPUT	444
C	OUTPUT BUNDLE TYPE DATA	INPUT	445
C		INPUT	446
	WRITE (IPR,1350)	INPUT	447
	NO 640 K=1,NTYPE	INPUT	448
	J = JTY(X)	INPUT	449
	WRITE (IPR,1360) J	INPUT	450
	IF (JLUMP(J),LT,1) GO TO 560	INPUT	451
	WRITE (IPR,1380) NPING(J)	INPUT	452
	GO TO 570	INPUT	453
560	WRITE (IPR,1370)	INPUT	454
570	IF (J,LE,NL) GO TO 580	INPUT	455
	JX = J-NL	INPUT	456
	WRITE (IPR,1390) CHALLT(JX),DIM(IFORM+1)	INPUT	457
	WRITE (IPR,1400) CGAPTH(JX),DIM(IFORM+1)	INPUT	458
580	WRITE (IPR,1410) WROD(J)	INPUT	459
	WRITE (IPR,1500) SF(J)	INPUT	460
	WRITE (IPR,1420) P(J),DIM(IFORM+1)	INPUT	461
	WRITE (IPR,1430) LEAD(J),DIM(IFORM+1)	INPUT	462
	WRITE (IPR,1440) FLAT(J),DIM(IFORM+1)	INPUT	463
	WRITE (IPR,1450) DUCTTH(J),DIM(IFORM+1)	INPUT	464
	WRITE (IPR,1470) CLADD(J),DIM(IFORM+1)	INPUT	465
	WRITE (IPR,1480) WJREOD(J),DIM(IFORM+1)	INPUT	466
	WRITE (IPR,1490) SHWIRE(J),DIM(IFORM+1)	INPUT	467
	IF (NPARAM(J),GE,1) GO TO 590	INPUT	468
	WRITE (IPR,1510)	INPUT	469
	GO TO 600	INPUT	470
590	WRITE (IPR,1590) NPARAM(J)	INPUT	471
600	IF (NF8PLT(J)) 610,620,630	INPUT	472
610	WRITE (IPR,1540)	INPUT	473
	GO TO 640	INPUT	474
620	WRITE (IPR,1550)	INPUT	475
	GO TO 640	INPUT	476
630	WRITE (IPR,1600) NF8PLT(J)	INPUT	477
640	CONTINUE	INPUT	478
C		INPUT	479
C		INPUT	480
C	OUTPUT PROFILES	INPUT	481

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

C	WRITE (IPR,1580)	INP:IT	452
	WRITE (IPR,1630) NMAXPP	INP:IT	453
	WRITE (IPR,1650) NORPPP	INP:IT	454
	WRITE (IPR,1700) NBCAX	INP:IT	455
	WRITE (IPR,1730) NRCCKW	INP:IT	456
	WRITE (IPR,1680) NFSP	INP:IT	457
	WRITE (IPR,1690) NEPCP	INP:IT	458
	WRITE (IPR,1940) NORHTM	INP:IT	459
	IF (NMAXPP,LT,1) GO TO 660	INP:IT	460
	DO 650 J=1,NMAXPP	INP:IT	461
	WRITE (IPR,1640) J	INP:IT	462
	I = MAXPPN(J)	INP:IT	463
650	WRITE (IPR,1610) (AXHTPP(I,J),APP(I,J),I=1,L)	INP:IT	464
660	IF (NORPPP,LT,1) GO TO 680	INP:IT	465
	DO 670 J=1,NORPPP	INP:IT	466
	WRITE (IPR,1660) J	INP:IT	467
	I = NPJNP(J)	INP:IT	468
	NSTART = NPLNC(J)-1	INP:IT	469
670	WRITE (IPR,1670) (I,RPPP(NSTART+I),I=1,L)	INP:IT	500
680	IF (NBCAX,LT,1) GO TO 700	INP:IT	501
	DO 690 J=1,NBCAX	INP:IT	502
	WRITE (IPR,1710) J	INP:IT	503
	I = NBCAEN(J)	INP:IT	504
690	WRITE (IPR,1620) (RCAXWT(I,J),RCAXP(I,J),I=1,L)	INP:IT	505
700	IF (NRCCKW,LT,1) GO TO 720	INP:IT	506
	DO 710 J=1,NRCCKW	INP:IT	507
	WRITE (IPR,1740) J	INP:IT	508
	I = NRCSEN(J)	INP:IT	509
	WRITE (IPR,1620) (RCCKWT(I,J),RCCKEW(I,J),I=1,L)	INP:IT	510
710	WRITE (IPR,1950) NRTYPR(J)	INP:IT	511
720	IF (NEPCP,LT,1) GO TO 740	INP:IT	512
	DO 730 J=1,NEPCP	INP:IT	513
	WRITE (IPR,1520) J	INP:IT	514
	I = NEPEPT(J)	INP:IT	515
	WRITE (IPR,1530) (REP(I,J),ESTAR(I,J),C(I,J),I=1,L)	INP:IT	516
730	CONTINUE	INP:IT	517
740	IF (NFSP,LT,1) GO TO 760	INP:IT	518
	DO 750 J=1,NFSP	INP:IT	519
	WRITE (IPR,1560) J	INP:IT	520
	I = NFSENT(J)	INP:IT	521
750	WRITE (IPR,1570) (REP(I,J),X1(I,J),X2(I,J),X3(I,J),I=1,L)	INP:IT	522
760	IF (NORHTM,LT,1) GO TO 780	INP:IT	523
	DO 770 J=1,NORHTM	INP:IT	524
	WRITE (IPR,1720) J	INP:IT	525
	I = NHTP(J)	INP:IT	526
	NSTART = NHLOC(J)-1	INP:IT	527
770	WRITE (IPR,1670) (I,RHTPP(NSTART+I),I=1,L)	INP:IT	528
C		INP:IT	529
C		INP:IT	530
C	OUTPUT BUNDLE SPECIFIC DATA	INP:IT	531
C		INP:IT	532
		INP:IT	533

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

780	WRITE (IPR,1760)	INPUIT	534
	IBP = 0	INPUIT	535
	DO 950 J=1,NDASSH	INPUIT	536
	WRITE (IPR,1750) J,(BUNID(I,J),I=1,17)	INPUIT	537
	WRITE (IPR,1770) ITYPE(J)	INPUIT	538
	KASE = IACTYP(J)+MODEL	INPUIT	539
	IF (MODEL.EQ.1) KASE = KASE-1	INPUIT	540
	GO TO (790,800,810,820), KASE	INPUIT	541
790	WRITE (IPR,1120)	INPUIT	542
	GO TO 830	INPUIT	543
800	WRITE (IPR,1140)	INPUIT	544
	GO TO 830	INPUIT	545
810	WRITE (IPR,1110)	INPUIT	546
	GO TO 830	INPUIT	547
820	WRITE (IPR,1130)	INPUIT	548
830	WRITE (IPR,1780) PROFIL(J,1)	INPUIT	549
	IF (ILUMP(ITYPE(J)).EQ.1) GO TO 840	INPUIT	550
	WRITE (IPR,1800) PROFIL(J,2)	INPUIT	551
	GO TO 850	INPUIT	552
840	WRITE (IPR,1810) PROFIL(J,2)	INPUIT	553
850	WRITE (IPR,1790) TINLET(J),DIM(IFORM+3)	INPUIT	554
	WRITE (IPR,1260) TAVEC(J),DIM(IFORM+3),TAVEN(J),DIM(IFORM+3)	INPUIT	555
	IF (IFORM.EQ.1) GO TO 860	INPUIT	556
	WRITE (IPR,1820) POWER(J)	INPUIT	557
	WRITE (IPR,1840) FLOW(J)	INPUIT	558
	GO TO 870	INPUIT	559
860	WRITE (IPR,1830) POWER(J)	INPUIT	560
	WRITE (IPR,1850) FLOW(J)	INPUIT	561
870	IF (NTLOC(J).EQ.1) WRITE (IPR,1930)	INPUIT	562
	IF (ITYPE(J).LE.NL) GO TO 890	INPUIT	563
	IBP = IBP+1	INPUIT	564
	IF (IFORM.EQ.1) GO TO 880	INPUIT	565
	WRITE (IPR,1960) FLOWBP(IBP)	INPUIT	566
	GO TO 890	INPUIT	567
880	WRITE (IPR,1970) FLOWBP(IBP)	INPUIT	568
890	IF (IACTYP(J).EQ.2) GO TO 910	INPUIT	569
	IF (IFORM.EQ.1) GO TO 900	INPUIT	570
	WRITE (IPR,1860)	INPUIT	571
	GO TO 930	INPUIT	572
900	WRITE (IPR,1870)	INPUIT	573
	GO TO 930	INPUIT	574
910	IF (IFORM.EQ.1) GO TO 920	INPUIT	575
	WRITE (IPR,1880)	INPUIT	576
	GO TO 930	INPUIT	577
920	WRITE (IPR,1890)	INPUIT	578
930	DO 940 K=1,6	INPUIT	579
	M = 16-2*K	INPUIT	580
	IF (K.EQ.1) M = 2	INPUIT	581
940	WRITE (IPR,1900) M,NEISHG(J,K),(IPROFD(J,K,L),L=1,4),SC(J,K),RHDHOM(J,K)	INPUIT	582
950	CONTINUE	INPUIT	583
	IF (IFORM.EQ.1) GO TO 960	INPUIT	584
		INPUIT	585

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

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WRITE (IPR,1910)
GO TO 2020
960 WRITE (IPR,1920)
GO TO 2020

C
C INPUT FORMAT STATEMENTS
C
970 FORMAT (16I5)
980 FORMAT (6F10.5)
990 FORMAT (6F10.5)
1000 FORMAT (6F10.0)
1010 FORMAT (6F10.0)
1020 FORMAT (15,17A4)
1030 FORMAT (15,F10.0)

C
C OUTPUT FORMAT STATEMENTS
C
1040 FORMAT (1H1,T10,110(1H*)//T53,'SUPERENERGY=I1'//T31,'STEADY STATE,
+ MULTIBUNDLE, LMFBR THERMAL-HYDRAULIC ANALYSIS CODE'/T31,'DEVELOPE
+D AT MIT AND BNWL, BASED ON THE SUPERENERGY AND ENERGY MODELS'/T43
+, 'PRINCIPAL AUTHOR = K.L.BASCHORE'/T10,110(1H*)//T10,'NA=',15,2X,
+ 'NB=',15,2X,'NC=',15,2X,'ND=',15,2X,'NE=',15,2X,'NF=',15,2X,'NG=',
+ 'IS,2X,'NH=',15,2X,'NJ=',15,2X,'NK=',15,2X,'NL=',15,2X,'NM=',15,2X
+ 'NN=',15,2X,'NO=',15,2X,'NP=',15,2X,'NQ=',15,2X,'NW=',15,2X,'NI='
+,15)
1050 FORMAT (1H1,10X,17A4//10X,'GENERAL DATA'//)
1060 FORMAT (1X,'INPUT AND OUTPUT IN INTERNATIONAL ENGINEERING UNITS')
1070 FORMAT (1X,'INPUT AND OUTPUT IN ENGLISH ENGINEERING UNITS')
1080 FORMAT (1X,21HNUMBER OF ASSEMBLIES,35X,15,/,1X,25HNUMBER OF ASSEM
+ BLY TYPES,31X,15)
1090 FORMAT (1X,103HASSEMBLY MODEL CHOSEN USES THERMAL RESISTANCE IN PL
+ ACE OF INTERASSEMBLY GAP,BUT DUCT WALL IS NODALIZED )
1100 FORMAT (1X,70HASSEMBLY MODEL CHOSEN HAS BOTH DUCT AND INTERASSEMBL
+ Y GAP SUBCHANNELS.)
1110 FORMAT (1X,72HBOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSID
+ E INTERASSEMBLY GAP.)
1120 FORMAT (1X,64HBOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSID
+ E DUCT WALL.)
1130 FORMAT (1X,73HBOUNDARY CONDITIONS ARE TEMPERATURES SPECIFIED OUTSI
+ DE INTERASSEMBLY GAP.)
1140 FORMAT (1X,65HBOUNDARY CONDITIONS ARE TEMPERATURES SPECIFIED OUTSI
+ DE DUCT WALL.)
1150 FORMAT (1X,42HCODE CORRELATION FOR COOLANT (NA) PROPERTIES USED)
1160 FORMAT (1X,40HUSER INPUT TABLES OF COOLANT PROPERTIES)
1170 FORMAT (1X,19HTEMPERATURE (DEG-C),5X,17HDENSITY (KG/M**3),5X,22HSP
+ ECIFIC HEAT (J/KG-K),5X,29HTHERMAL CONDUCTIVITY (W/M-K))
1180 FORMAT (1X,19HTEMPERATURE (DEG-F),4X,19HDENSITY (LBH/FT**3),3X,25H
+ SPECIFIC HEAT (BTU/LBH-F),4X,24HCONDUCTIVITY (BTU/HR-FT-F))
1190 FORMAT (1X,19HTEMPERATURE (DEG-C),5X,17HDENSITY (KG/M**3),5X,22HSP
+ ECIFIC HEAT (J/KG-K),5X,29HTHERMAL CONDUCTIVITY (W/M-K),18HVISCOSI
+ TY (PA-S) )

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LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

1200	FORMAT (1X,19HTEMPERATURE (DEG-F),4X,19HDENSITY (LBM/FT**3),3X,25H	INPIT	638
	+SPECIFIC HEAT (BTU/LBM-F),4X,26HCONDUCTIVITY (BTU/HR-FT-F),2X,21HV	INPIT	639
	+ISCOSITY (LBM/HR-FT))	INPIT	640
1210	FORMAT (5X,F10.4,12X,F10.4,15X,F10.4,18X,F10.4,9X,F10.4)	INPIT	641
1220	FORMAT (5X,F10.4,12X,F10.4,15X,F10.4,18X,F10.4)	INPIT	642
1230	FORMAT (1X,32HAXIAL STABILITY CHECK INDICATOR ,26X,15)	INPIT	643
1240	FORMAT (1X,30HCODE CORRELATION FOR DUCT (316 SS) PROPERTIES USED)	INPIT	644
1250	FORMAT (1X,37HUSER INPUT TABLES OF DUCT PROPERTIES)	INPIT	645
1260	FORMAT (1X,69HINITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWI	INPIT	646
	+NG TEMPERATURES ,/2X'COOLANT',42X,F10.2,44/1X,'DUCT WALL',42X,F10	INPIT	647
	+2,A4)	INPIT	648
1270	FORMAT (1X,'ASSEMBLY LENGTH',35X,F10.2,A4)	INPIT	649
1280	FORMAT (1X,'AXIAL POWER PROFILE NORMALIZATION OPTION SELECTED')	INPIT	650
1290	FORMAT (1X,32HNUMBER OF AXIAL NODES IN COOLANT,26X,15)	INPIT	651
1300	FORMAT (1X,'AXIAL HEIGHTS FOR TEMPERATURE MAP PRINTOUTS')	INPIT	652
1310	FORMAT (1X,'AXIAL HEIGHTS FOR AVERAGE DUCT WALL TEMPERATURE PRINTO	INPIT	653
	+UTS')	INPIT	654
1320	FORMAT (5X,6(F10.5,A4,3X))	INPIT	655
1330	FORMAT (1X,47HCOOLANT MASS VELOCITY THROUGH INTERASSEMBLY GAP,4X,F	INPIT	656
	+10.5,12H KG/SEC-M**2)	INPIT	657
1340	FORMAT (1X,'COOLANT MASS VELOCITY THROUGH INTERASSEMBLY GAP',4X,F1	INPIT	658
	+0.1,' LBM/FT**2-HR)	INPIT	659
1350	FORMAT (1H,9X,16HBUNDLE TYPE DATA)	INPIT	660
1360	FORMAT (/,1X,18HBUNDLE TYPE NUMBER,40X,14)	INPIT	661
1370	FORMAT (1X,34HCOOLANT NODES ARE STANDARD SUBCHANNELS)	INPIT	662
1380	FORMAT (1X,46HCOOLANT NODES ARE DEFINED BY POROUS BODY INPUT,/,1X,	INPIT	663
	+45HNUMBER OF RINGS IN POROUS BODY REPRESENTATION,12X,15)	INPIT	664
1390	FORMAT (1X,24HBUNDLE IS A BYPASS ASSEMBLY ,/1X,21HSECOND WALL THIC	INPIT	665
	+KNES8,31X,F10.5,A4)	INPIT	666
1400	FORMAT (1X,'BYPASS GAP THICKNESS',32X,F10.4,A4)	INPIT	667
1410	FORMAT (1X,14HNUMBER OF PINS,43X,15)	INPIT	668
1420	FORMAT (1X,'IRON CENTER TO CENTER DISTANCE (PITCH)',15X,F10.4,A4)	INPIT	669
1430	FORMAT (1X,'WIRE WRAP PERIOD (LEAD LENGTH)',22X,F10.4,A4)	INPIT	670
1440	FORMAT (1X,'DUCT INTERIOR FLAT TO FLAT DISTANCE',17X,F10.4,A4)	INPIT	671
1450	FORMAT (1X,'DUCT THICKNESS',38X,F10.4,A4)	INPIT	672
1460	FORMAT (1X,'INTERASSEMBLY GAP THICKNESS',24X,F10.5,A4)	INPIT	673
1470	FORMAT (1X,'CLAD OUTSIDE DIAMETER (RND DIAMETER)',16X,F10.4,A4)	INPIT	674
1480	FORMAT (1X,'SPACER WIRE DIAMETER',32X,F10.4,A4)	INPIT	675
1490	FORMAT (1X,'SPACER WIRE DIAMETER ADJACENT TO DUCT',15X,F10.4,A4)	INPIT	676
1500	FORMAT (1X,12HSHAPE FACTOR,40X,F10.5)	INPIT	677
1510	FORMAT (1X,44HCODE CORRELATIONS FOR EPSILON(1) AND C1 USED)	INPIT	678
1520	FORMAT (/, EPSILON * AND C1 VERSUS REYNOLDS NUMBER PROFILE NUMBER'	INPIT	679
	+ ,14/10X,2HRE,7X,10HEPSILON * ,10X,2HC1)	INPIT	680
1530	FORMAT (5X,F10.3,3X,F10.6,5X,F10.6)	INPIT	681
1540	FORMAT (1X,31HMIT FLOW SPLIT CORRELATION USED)	INPIT	682
1550	FORMAT (1X,39HNOVE'DOSTERN FLOW SPLIT CORRELATION USED)	INPIT	683
1560	FORMAT (/, FLOW SPLIT VERSUS REYNOLDS NUMBER PROFILE NUMBER',9X,15	INPIT	684
	+ /10X,2HRE,10X,2HX1,10X,2HX2,10X,2HX3)	INPIT	685
1570	FORMAT (5X,F10.3,5X,F10.7,5X,F10.7,5X,F10.7)	INPIT	686
1580	FORMAT (1H,9X,8HPROFILES,/))	INPIT	687
1590	FORMAT (1X,'EPSILON * AND C1 VERSUS RE PROFILE NUMBER',17X,15)	INPIT	688
1600	FORMAT (1X,'FLOW SPLIT VERSUS RE PROFILE NUMBER',23X,15)	INPIT	689

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

1610	FORMAT (1X,10(F7,4,3X))	INPUT	690
1620	FORMAT (1X,F9.4,12Y,F10.5)	INPUT	691
1630	FORMAT (32H NUMBER OF AXIAL POWER PROFILES ,26X,15)	INPUT	692
1640	FORMAT (/27H AXIAL POWER PROFILE NUMBER,31X,15/5(' RELATIVE POWE +R',3X)/5(' HEIGHT',4X,'FACTOR',2X))	INPUT	693
1650	FORMAT (37H NUMBER OF RADIAL PIN POWER PROFILES ,21X,15)	INPUT	694
1660	FORMAT (/32H RADIAL PIN POWER PROFILE NUMBER,26Y,15,/, (1X,8(4X,7H +PIN,7X,5HPower)))	INPUT	695
1670	FORMAT (3X,15,1X,FA.5,1X,15,1X,F8.5,1X,15,1X,F8.4,1X,15,1X,FA.5,1X +,15,1X,FA.4,1X,15,1X,F8.5,1X,15,1X,F8.5,1X,15,1X,F8.5)	INPUT	696
1680	FORMAT (1X,42HNUMBER OF FLOWSPIT VS. RE NUMBER PROFILES,15X,15)	INPUT	697
1690	FORMAT (1X,42HNUMBER OF E* AND C1 VS. RE NUMBER PROFILES,15X,15)	INPUT	698
1700	FORMAT (1X,44HNUMBER OF AXIAL BOUNDARY CONDITION PROFILES ,13X,15)	INPUT	699
1710	FORMAT (/1X,40HAXIAL BOUNDARY CONDITION PROFILE NUMBER ,17X,15,/ +1X,17HNORMALIZED HEIGHT,4X,17HNORMALIZED FACTOR)	INPUT	700
1720	FORMAT (/1X,44HPOROUS BODY ENERGY GENERATION PROFILE NUMBER,13X,1 +5,/,1X,8(2X,5HCHAN.,3X,5HPower)))	INPUT	701
1730	FORMAT (1X,50HNUMBER OF BOUNDARY CONDITION FACIAL SKEW PROFILES ,7 +X,15)	INPUT	702
1740	FORMAT (/1X,46HBOUNDARY CONDITION FACIAL SKEW PROFILE NUMBER ,11X +,15,/,20H NORMALIZED DISTANCE,2X,17HNORMALIZED FACTOR,/,1X,11HACRO +SS FACE)	INPUT	703
1750	FORMAT (///1X,'ASSEMBLY NUMBER',15,5X,17A4/)	INPUT	704
1760	FORMAT (1H1,9X,20HBOUNDLE SPECIFIC DATA)	INPUT	705
1770	FORMAT (1X,13HASSEMBLY TYPE,44X,15)	INPUT	706
1780	FORMAT (1X,23HAXIAL PIN POWER PROFILE,34X,15)	INPUT	707
1790	FORMAT (1X,'COOLANT INLET TEMPERATURE',26X,F10.2,'44)	INPUT	708
1800	FORMAT (1X,24HRADIAL PIN POWER PROFILE,33X,15)	INPUT	709
1810	FORMAT (1X,'POROUS BODY ENERGY GENERATION PROFILE',20X,15)	INPUT	710
1820	FORMAT (1X,34HMINIMAL LINEAR ROD POWER IN BUNDLE,18X,F10.1,4H W/H)	INPUT	711
1830	FORMAT (1X,'MINIMAL LINEAR ROD POWER IN BUNDLE',18X,F10.1,' 8TU/HR +FT')	INPUT	712
1840	FORMAT (1X,23HMINIMAL BUNDLE FLOWRATE,29X,F10.5,7H KG/SEC)	INPUT	713
1850	FORMAT (1X,'MINIMAL FLOW RATE',35X,F10.1,' LHM/H2O')	INPUT	714
1860	FORMAT (/9H FACE,4X,11HNEIGHBORING,4(4X,10HAPPLICABLE),2(4X,7 +HMINIMAL),/,14X,4HASSSEMBLY,2X,2(6X,5HAXIAL,7X,11HFACIAL SKEW),4X,6 +HMIN OF,4X,8HMIN FOR/,20X,2(12X,2HBC),8X,2(9HOUT WALL,5X),2X,2HR +C,7X,9HOUT WALL,/,29X,2(7HPROFILE,7X),2(8HGAMMA HT,6X),10X,4HGAMM +A HT/57X,2(7HPROFILE,7X),6HW/4**2,5X,6HW/H**3,/,1X,110(1H-1)	INPUT	715
1870	FORMAT (/9H FACE,4X,11HNEIGHBORING,4(4X,10HAPPLICABLE),2(4X,7 +HMINIMAL),/,14X,4HASSSEMBLY,2X,2(6X,5HAXIAL,7X,11HFACIAL SKEW),4X,6 +HMIN OF,4X,8HMIN FOR/,20X,2(12X,2HBC),8X,2(9HOUT WALL,5X),2X,2HR +C,7X,9HOUT WALL,/,29X,2(7HPROFILE,7X),2(8HGAMMA HT,6X),10X,4HGAMM +A HT/57X,2(7HPROFILE,7X),6HDEG. C,5X,6HW/H**3,/,1X,110(1H-1)	INPUT	716
1880	FORMAT (/9H FACE,4X,11HNEIGHBORING,4(4X,10HAPPLICABLE),2(4X,7 +HMINIMAL),/,14X,4HASSSEMBLY,2X,2(6X,5HAXIAL,7X,11HFACIAL SKEW),4X,6 +HMIN OF,4X,8HMIN FOR/,20X,2(12X,2HBC),8X,2(9HOUT WALL,5X),2X,2HR +C,7X,9HOUT WALL,/,29X,2(7HPROFILE,7X),2(8HGAMMA HT,6X),10X,4HGAMM +A HT/57X,2(7HPROFILE,7X),6HDEG. C,5X,6HW/H**3,/,1X,110(1H-1)	INPUT	717
1890	FORMAT (/9H FACE,4X,11HNEIGHBORING,4(4X,10HAPPLICABLE),2(4X,7 +HMINIMAL),/,14X,4HASSSEMBLY,2X,2(6X,5HAXIAL,7X,11HFACIAL SKEW),4X,6 +HMIN OF,4X,8HMIN FOR/,20X,2(12X,2HBC),8X,2(9HOUT WALL,5X),2X,2HR	INPUT	718

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN INPUT

	+C,7X,9HDUCT WALL,/,29X,2(7HPROFILE,7X),2(8HGAMMA HT,6X),10X,8HGAMM	INPIIT	742
	+A HT/57X,2(7HPROFILE,7X),1DEG-F BTU/HR-FT**3,/,1Y,110(1H-))	INPIIT	743
1900	FORMAT (1X,12,7HNCLOCK,5X,13,4(9X,15),7X,F10,2,5X,F10,2)	INPIIT	744
1910	FORMAT (1H),9X,'CALCULATED DATA'//2X,'ASSEMBLY',58X,'VELOCITIES (M	INPIIT	745
	+/S)',28X,'EDDY DJF.',3X,'GQ+',6X,'CHANNEL'/3X,'NUMBER',3X,'AVERAGE	INPIIT	746
	+1,3X,'INTERIOR',4X,'EDGE',5X,'CORNER',4X,'BYPASS',3X,'INTR.GAP',3X	INPIIT	747
	+',5HTRL',4X,'(M**2/S)',3X,'INDEX',7X,'RE'//)	INPIIT	748
1920	FORMAT (1H),9X,'CALCULATED DATA'//2X,'ASSEMBLY',58X,'VELOCITIES(FT	INPIIT	749
	+/S)',28X,'EDDY DJF.',3X,'GQ+',6X,'CHANNEL'/3X,'NUMBER',3X,'AVERAGE	INPIIT	750
	+1,3X,'INTERIOR',4X,'EDGE',5X,'CORNER',4X,'BYPASS',3X,'INTR.GAP',3X	INPIIT	751
	+',5HTRL',3X,'(FT**2/S)',3X,'INDEX',7X,'RE'//)	INPIIT	752
1930	FORMAT (/,1X,'NO INTERASSEMBLY HEAT TRANSFER IN THIS ASSEMBLY - 140	INPIIT	753
	+LATION CONDITION SPECIFIED BY INPUT')	INPIIT	754
1940	FORMAT (1X,50HNUMBER OF POROUS BODY COOLANT HEAT GENERATION PROFIL	INPIIT	755
	+E9,3Y,15)	INPIIT	756
1950	FORMAT (1X,47HTHIS PROFILE ASSOCIATED WITH BUNDLE TYPE NUMBER,10X,	INPIIT	757
	+15)	INPIIT	758
1960	FORMAT (1X,'BYPASS REGION FLOW RATE',29X,F10,2,' KG/8')	INPIIT	759
1970	FORMAT (1X,'BYPASS REGION FLOW RATE',29X,F10,2,' LBM/HR')	INPIIT	760
C		INPIIT	761
C	ERROR MESSAGE FORMAT STATEMENTS	INPIIT	762
C		INPIIT	763
1980	FORMAT (1X,33HBUNDLE SPECIFIC DATA FOR BUNDLE #,15,23H INPUT OUT O	INPIIT	764
	+F SEQUENCE,)	INPIIT	765
1990	FORMAT (1X,35HNORMALIZED RADIAL PIN POWER PROFILE,15,41H HAS DIFFE	INPIIT	766
	+RENT NUMBER OF PINS THAN BUNDLE,15)	INPIIT	767
2000	FORMAT (1X,13HBUNDLE NUMBER,15,79H IS THE WRONG TYPE TO BE ASSOCIA	INPIIT	768
	+TED WITH BOUNDARY CONDITION FACIAL SKEW PROFILE,15)	INPIIT	769
2010	FORMAT (1X,13HBUNDLE NUMBER,15,79H IS THE WRONG TYPE TO BE ASSOCIA	INPIIT	770
	+TED WITH DUCT GAMMA HEATING FACIAL SKEW PROFILE,15)	INPIIT	771
2020	RETURN	INPIIT	772
	FND	INPIIT	773

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN NUMB

*DECK	NUMB	NUMB	1
	SUBROUTINE NUMB (X)	NUMB	2
*CALL	BLK10	NUMB	3
*CALL	BLK11	NUMB	4
*CALL	RLK5	NUMB	5
	DATA LCOUNT/O/,MCOUNT/O/	NUMB	6
C		NUMB	7
C	NUMBER SUBCHANNELS FOR ASSEMBLY TYPE K	NUMB	8
C	THIS ROUTINE WAS DEVELOPED FOR ORIG. SUPERENERGY BY R. CHEN	NUMB	9
C		NUMB	10
	NWALLS = 2	NUMB	11
	IF (K.GT.NL) NWALLS = 4	NUMB	12
	IF (TLUMP(K).EQ.1) GO TO 100	NUMB	13
C		NUMB	14
C	NON LUMPED ASSEMBLY = FIND NUMBER OF RINGS	NUMB	15
C		NUMB	16
	NRORD = NRORD(K)	NUMB	17

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN NUMB

	YNORIN = (NORIN-1)/3.	NUMB	18
	NORIN(K) = SQRT(YNORIN)	NUMB	19
100	NORING = NRING(K)	NUMB	20
	NOTRG = 6*NORING*NORING	NUMB	21
	NOTRG1 = NOTRG+1	NUMB	22
	NOTG1 = 6*(NORING-1)*(NORING-1)	NUMB	23
	NOG1 = 3*(NORING-1)*NORING	NUMB	24
	NOIN = 6*(NORING+1)	NUMB	25
	LSTCH = NOTRG+NOIN	NUMB	26
	LSTCH1 = LSTCH+1	NUMB	27
	LSTW = LSTCH-6	NUMB	28
	LSTCHG = LSTCH+NOIN	NUMB	29
	LSTW = LSTCHG-6	NUMB	30
	NSC(K,1) = NOTG1	NUMB	31
C		NUMB	32
C	NUMBER INTERIOR SURCHANNELS. FIND NEIGHBORING SURCHANNEL AND RND	NUMB	33
C	NUMBERS	NUMB	34
C		NUMB	35
	NSC(K,2) = NOTRG	NUMB	36
	NSC(K,3) = LSTW	NUMB	37
	NSC(K,4) = LSTCH	NUMB	38
	NSC(K,5) = LSTCH+6*NORING	NUMB	39
	NSC(K,6) = NSC(K,5)+6	NUMB	40
	NSC(K,7) = NSC(K,6)+6*NORING	NUMB	41
	NSC(K,8) = NSC(K,7)+6	NUMB	42
	DO 160 I=1,NOTRG	NUMB	43
	I = I+LCOUNT	NUMB	44
	M = I+MCOUNT	NUMB	45
	Z = (I-1)/6.	NUMB	46
	N = SQRT(Z)+1.0001	NUMB	47
	NOTR0 = 6*N*N	NUMB	48
	NOTR1 = 6*(N-1)*(N-1)	NUMB	49
	NOTR2 = 6*(N-2)*(N-2)	NUMB	50
	NOT01 = 3*N*(N-1)	NUMB	51
	NOT12 = 3*(N-1)*(N-2)	NUMB	52
	J0 = (J-NOTR1-1)/(2*N-1)+0.0001	NUMB	53
	JR = 1-NOTR1-IQ*(2*N-1)+0.0001	NUMB	54
	TY = 1.6-1/N	NUMB	55
	ICON(L,4) = J	NUMB	56
	JF (I-NOTR1,EQ,1) GO TO 150	NUMB	57
	JF (I,EQ,NOTR0) GO TO 140	NUMB	58
	J = JR/2	NUMB	59
	JF (JR-J*2,GE,1) GO TO 110	NUMB	60
	JZ = 1.0001/(NOTR0-I)	NUMB	61
	ICON(L,1) = NOTR2+J0*(2*N-3)+JR-1	NUMB	62
	ICON(L,2) = J-1	NUMB	63
	ICON(L,3) = J+1	NUMB	64
	JF (JLIMP(K),EQ,1) GO TO 160	NUMB	65
	MCON(M,1) = J+NOT12+JZ*(N-1)+JR/2	NUMB	66
	MCON(M,2) = MCON(M,1)+1-6*JZ*(N-1)	NUMB	67
	MCON(M,3) = NOT01+J0*N+JR/2+2	NUMB	68
	GO TO 160	NUMB	69

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN NIMB

110	LCN(L,1) = J-1	NIMB	70
	LCN(L,2) = J+1	NIMB	71
	IF (ILUMP(K),EQ,1) GO TO 120	NIMB	72
	MCON(M,1) = NOT12+JQ*(N-1)+(IR+1)/2+IY	NIMB	73
	MCON(M,2) = 1+NOT01+JQ*N+(IR+1)/2	NIMB	74
	MCON(M,3) = MCON(M,2)+1	NIMB	75
120	IF (N,EO,NORING) GO TO 130	NIMB	76
	LCN(L,3) = NOTR0+JQ*(2*N+1)+IR+1	NIMB	77
	GO TO 160	NIMB	78
130	LCN(L,3) = NOTR0+JQ*N+(IR+1)/2	NIMB	79
	GO TO 160	NIMB	80
140	LCN(L,1) = NOTR1+1	NIMB	81
	LCN(L,2) = NOTR0-1	NIMB	82
	IF (ILUMP(K),EQ,1) GO TO 120	NIMB	83
	MCON(M,1) = J+IY+NOT12	NIMB	84
	MCON(M,2) = 2+NOT01	NIMB	85
	MCON(M,3) = 1+3*N*(N+1)	NIMB	86
	GO TO 120	NIMB	87
150	LCN(L,1) = NOTR1+2	NIMB	88
	LCN(L,2) = NOTR0	NIMB	89
	IF (ILUMP(K),EQ,1) GO TO 120	NIMB	90
	MCON(M,1) = J+IY+NOT12	NIMB	91
	MCON(M,2) = 2+NOT01	NIMB	92
	MCON(M,3) = MCON(M,2)+1	NIMB	93
	GO TO 120	NIMB	94
160	CONTINUE	NIMB	95
C		NIMB	96
C	NUMBER SIDE AND CORNER SUBCHANNELS, FIND NEIGHBORING SUBCHANNEL	NIMB	97
C	AND ROD NUMBERS	NIMB	98
C		NIMB	99
	DO 2=0 J=NOTR01,LSTCH	NIMB	100
	I = I+LCOUNT	NIMB	101
	M = J+MCON	NIMB	102
	IF (ILUMP(K),EQ,1) GO TO 170	NIMB	103
	MCON(M,1) = NOTR0+1	NIMB	104
170	IF (I,LE,LSTW) GO TO 200	NIMB	105
C		NIMB	106
C	CORNER	NIMB	107
C		NIMB	108
	JQ = I-LSTCH+5	NIMB	109
	LCN(L,2) = NOTR0+JQ+VDRING+1	NIMB	110
	LCN(L,3) = LSTCHG-5+I0	NIMB	111
	LCN(L,4) = 1	NIMB	112
	IF (ILUMP(K),EQ,1) GO TO 180	NIMB	113
	MCON(M,1) = 2+NOTR0+JQ+VDRING	NIMB	114
	MCON(M,2) = NOTR0+1	NIMB	115
180	IF (I0,EO,0) GO TO 190	NIMB	116
	LCN(L,1) = NOTR0+JQ+VDRING	NIMB	117
	GO TO 250	NIMB	118
190	LCN(L,1) = J-1	NIMB	119
	GO TO 250	NIMB	120
C		NIMB	121

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN NUMB

C	810E	NUMA	122
C		NUMA	123
200	JZ = 1.0001/(LATCH-5-1)	NUMA	124
	JQ = (I-NOTRG-1)/NORING+0.0001	NUMA	125
	JR = I-NOTRG-ID*NORING+0.0001	NUMA	126
	LCOM(L,1) = NOTG1+JQ*(2*NORING-1)+2*IR-1	NUMA	127
	LCOM(L,4) = LSTCH+IQ*NORING+IR	NUMA	128
	IF (ILUMP(K),EQ,1) GO TO 210	NUMA	129
	MCON(M,1) = I+HUGO1+IQ*NORING+IR	NUMA	130
	MCON(M,2) = MCON(M,1)+1-6*JZ*NORING	NUMA	131
210	IF (JR,EQ,1) GO TO 220	NUMA	132
	LCOM(L,2) = I-1	NUMA	133
	GO TO 230	NUMA	134
220	LCOM(L,2) = LSTW+ID+1	NUMA	135
230	IF (IR,EQ,NORING) GO TO 240	NUMA	136
	LCOM(L,3) = J+1	NUMA	137
	GO TO 250	NUMA	138
240	LCOM(L,3) = (1-IZ)*(LSTW+ID+2)+IZ*(I+1)	NUMA	139
250	CONTINUE	NUMA	140
C		NUMA	141
C	NUMBER DIFFER SUBCHANNEL RINGS, FIND NEIGHBORING SUBCHANNEL	NUMA	142
C	NUMBERS NWALL=2 FOR NORMAL ASSEMBLIES	NUMA	143
C	NWALL=4 FOR BYPASS ASSEMBLIES	NUMA	144
C		NUMA	145
	DO 360 J=1,NWALLS	NUMA	146
	DO 350 I=LSTCH,LSTCHG	NUMA	147
	L = I+LCOUNT	NUMA	148
	M = I+MCOUNT	NUMA	149
	IF (I.LE,LSTWG) GO TO 290	NUMA	150
C		NUMA	151
C	CORNER SUBCHANNELS	NUMA	152
C		NUMA	153
	ID = I-LSTWG-1	NUMA	154
	LCOM(L,1) = LSTW+I+IQ	NUMA	155
	LCOM(L,3) = LSTCH+IU*NORING+1	NUMA	156
	IF (J.FQ,NWALLS) GO TO 260	NUMA	157
	LCOM(L,4) = LSTWG+MUIN+IQ+1	NUMA	158
	GO TO 270	NUMA	159
260	LCOM(L,4) = I	NUMA	160
270	IF (ID,EQ,0) GO TO 280	NUMA	161
	LCOM(L,2) = LSTCH+IQ*NORING	NUMA	162
	GO TO 350	NUMA	163
280	LCOM(L,2) = I-1	NUMA	164
	GO TO 350	NUMA	165
C		NUMA	166
C	SIDE SUBCHANNELS	NUMA	167
C		NUMA	168
290	IX = 1.0001/(LSTWG+1-I)	NUMA	169
	JQ = (I-LSTCH-1)/NORING+0.0001	NUMA	170
	JR = I-LATCH-ID*NORING+0.0001	NUMA	171
	LCOM(L,1) = NOTRG+IQ*NORING+IR	NUMA	172
	IF (J.FQ,NWALLS) GO TO 300	NUMA	173

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN NUMB

	LCNN(L,4) = LSTCHG+IQ*NURING+IR	NUMB	174
	GO TO 310	NUMB	175
300	LCNN(L,4) = I	NUMB	176
310	IF (IR,EO,1) GO TO 320	NUMB	177
	LCNN(L,2) = I-1	NUMB	178
	GO TO 330	NUMB	179
320	LCNN(L,2) = LSTWG+IQ+1	NUMB	180
330	IF (IR,EO,NURING) GO TO 340	NUMB	181
	LCNN(L,3) = I+1	NUMB	182
	GO TO 350	NUMB	183
340	LCNN(L,3) = (1-IX)*(LSTWG+IQ+2)+IX*(I+1)	NUMB	184
350	CONTINUE	NUMB	185
	IF (J,EO,NWALLS) GO TO 360	NUMB	186
	NOTRG = NOTRG+NOIN	NUMB	187
	LSTCH = LSTCH+NOIN	NUMB	188
	LSTCH1 = LSTCH1+NOIN	NUMB	189
	LSTW = LSTW+NOIN	NUMB	190
	LSTWG = LSTWG+NOIN	NUMB	191
	LSTCHG = LSTCHG+NOIN	NUMB	192
360	CONTINUE	NUMB	193
	LIND(K) = LCOUNT+1	NUMB	194
	LCOUNT = LCOUNT+LSTCHG	NUMB	195
	IF (JLUMP(K),EO,1) GO TO 370	NUMB	196
	MIND(K) = MCOUNT+1	NUMB	197
	MCOUNT = MCOUNT+NSC(K,4)	NUMB	198
370	NSC(K,9) = LSTCHG	NUMB	199
	RETURN	NUMB	200
	END	NUMB	201

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PROP

*DECK	PROP	PROP	1
	SUBROUTINE PROP (I)	PROP	2
*CALL	BLK6	PROP	3
*CALL	BLK5	PROP	4
C		PROP	5
C	CODE CORRELATIONS FOR PROPERTIES OF MATERIALS TAKEN FROM FOLLOWING	PROP	6
C	SOURCES:	PROP	7
C		PROP	8
C	MATERIAL	PROPERTY	REFERENCE "
C			
C	COOLANT	DENSITY	1
C	(MODJUH)	SPECIFIC HEAT	1
C		CONDUCTIVITY	1
C		VISCOSITY	2
C			
C	FUEL (UO2)	DENSITY	1
C		SPECIFIC HEAT	1
C		CONDUCTIVITY	1
C			
C	CLAD AND DUCT	DENSITY	1
C	(316 89)	SPECIFIC HEAT	3
C			
		PROP	20
		PROP	21

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PROG

C	CONDUCTIVITY	1	PROP	22
C			PROP	23
C	REFERENCES:		PROP	24
C	1) ANL-CEN-RSD-74-1; SUPPLEMENT 1, LMFBR SAFETY (UC-79P)		PROP	25
C	PROPERTIES FOR LMFBR SAFETY ANALYSES 1, APRIL, 1976		PROP	26
C			PROP	27
C	2) SANDJUH PROPERTIES HANDBOOK - ANL-		PROP	28
C			PROP	29
C	3) NUCLEAR SYSTEMS MATERIALS HANDBOOK, VOL. 1-DESIGN DATA		PROP	30
C	THIS ROUTINE WAS ORIGINALLY SET UP FOR THE TRANSIENT VERSION OF		PROP	31
C	THIS CODE, INCLUDING THE ABOVE PROPERTIES. THIS CURRENT ROUTINE		PROP	32
C	CONTAINS ONLY THE NECESSARY STEADY STATE PROPERTIES.		PROP	33
C			PROP	34
	TAVGC = TAVEC(I)		PROP	35
	TAVGW = TAVEH(I)		PROP	36
	IF (NCOENT,LT.1) GO TO 100		PROP	37
C			PROP	38
C	USER INPUT TABLES OF COOLANT PROPERTIES		PROP	39
C			PROP	40
	CALL CURV (CCP,TAVGC,CPC,TEMPC,NCOENT,IC,B)		PROP	41
	CRHO = RHOC(IC)+R*(RHOC(IC+1)-RHOC(IC))		PROP	42
	CK = CONDC(IC)+R*(CONDC(IC+1)-CONDC(IC))		PROP	43
	CVISC = VISC(IC)+R*(VISC(IC+1)-VISC(IC))		PROP	44
	TOUM = TAVGC-10.		PROP	45
	CALL CURV (RHOUM,TOUM,RHOC,TEMPC,NCOENT,IC,B)		PROP	46
	CBETA = (RHOUM-CRHO)/(10.*CRHO)		PROP	47
	GO TO 110		PROP	48
C			PROP	49
C	CODE CORRELATIONS FOR COOLANT PROPERTIES		PROP	50
C			PROP	51
100	CK = 93.0-.0581*TAVGC+1.173E-5*TAVGC**2		PROP	52
	CRHO = 950.1-.22976*TAVGC-1.460E-5*TAVGC**2+5.634E-9*TAVGC**3		PROP	53
	CCP = 1630.16-0.46269*(1.8*TAVGC+491.67)+1.4276E-04*(1.8*TAVGC+491		PROP	54
	+67)**2		PROP	55
	CVISC = .001*10.**(.518+220.65/(TAVGC+273.15)-.4025*ALOG10(TAVGC+2		PROP	56
	+73.15))		PROP	57
	TLOW = TAVGC-10.		PROP	58
	CRLOW = 950.1-.22976*TLOW-1.460E-5*TLOW**2+5.638E-9*TLOW**3		PROP	59
	CBETA = -.1*(CRHO-CRLOW)/CRHO		PROP	60
110	IF (NCOENT,LT.1) GO TO 120		PROP	61
C			PROP	62
C	USER INPUT TABLES OF DUCT WALL PROPERTIES		PROP	63
C			PROP	64
	CALL CURV (WK,TAVGW,CONOD,TEMPD,NCOENT,IC,B)		PROP	65
	RETURN		PROP	66
C			PROP	67
C	CODE CORRELATIONS FOR DUCT WALL PROPERTIES		PROP	68
C			PROP	69
120	WK = 9.248+.01571*(TAVGW+273.15)		PROP	70
	RETURN		PROP	71
	END		PROP	72

C.65

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C THIS SUBROUTINE CONVERTS A SPIRALLY NUMBERED COOLANT TEMPERATURE
C ARRAY INTO TWO INTEGER ARRAYS (TO(I),TI(I)) THAT ARE IN SUITABLE
C FORM FOR A TEMPERATURE MAP PRINTOUT - IT WILL HANDLE BUNDLES WITH
C 1 THRU 8 RINGS OF PINS

```

OUTPUY	1
OUTPUY	2
OUTPUY	3
OUTPUY	4
OUTPUY	5
OUTPUY	6
OUTPUY	7
OUTPUY	8
OUTPUY	9
OUTPUY	10
OUTPUY	11
OUTPUY	12
OUTPUY	13
OUTPUY	14
OUTPUY	15
OUTPUY	16
OUTPUY	17
OUTPUY	18
OUTPUY	19
OUTPUY	20
OUTPUY	21
OUTPUY	22
OUTPUY	23
OUTPUY	24
OUTPUY	25
OUTPUY	26
OUTPUY	27
OUTPUY	28
OUTPUY	29
OUTPUY	30
OUTPUY	31
OUTPUY	32
OUTPUY	33
OUTPUY	34
OUTPUY	35
OUTPUY	36
OUTPUY	37
OUTPUY	38
OUTPUY	39
OUTPUY	40
OUTPUY	41
OUTPUY	42
OUTPUY	43
OUTPUY	44
OUTPUY	45
OUTPUY	46
OUTPUY	47
OUTPUY	48
OUTPUY	49
OUTPUY	50
OUTPUY	51
OUTPUY	52

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN OUTPUT

C		OUTPUT	53
C	CONVERT EDGE,CORNER,DUCT WALL,AND INTERASSEMBLY GAP SUBCHANNELS	OUTPUT	54
C	INTD ARRAY TO(1)	OUTPUT	55
C		OUTPUT	56
110	LOCAT = NTLOC(LL)-1	OUTPUT	57
	NR = NRING(K)	OUTPUT	58
	NINCR = 6*(NR+1)	OUTPUT	59
	NWALLS = 3	OUTPUT	60
	IF (K.GT.NL) NWALLS = 5	OUTPUT	61
	NCOUNT = 0	OUTPUT	62
C		OUTPUT	63
C	CONVERT FACE 2 ROWS	OUTPUT	64
C		OUTPUT	65
	DO 130 J=1,NWALLS	OUTPUT	66
	JX = NSC(K,9)-(J-1)*NINCR-3+LOCAT	OUTPUT	67
	LX = NSC(K,9)-(J-1)*NINCR-4*NR-6+LOCAT	OUTPUT	68
	TO(NCOUNT+1) = TC2(JX)	OUTPUT	69
	TO(NCOUNT+NR+2) = TC2(JX-1)	OUTPUT	70
	DO 120 M=1,NR	OUTPUT	71
120	TO(NCOUNT+M+1) = TC2(LX-M+1)	OUTPUT	72
130	NCOUNT = NCOUNT+NR+2	OUTPUT	73
C		OUTPUT	74
C	CONVERT FACE 3 AND FACE 1 ROWS	OUTPUT	75
C		OUTPUT	76
	LX = NSC(K,9)-4*NR-6+LOCAT	OUTPUT	77
	DO 150 M=1,NR	OUTPUT	78
	DO 140 J=1,NWALLS	OUTPUT	79
	JX = LX+M-(J-1)*NINCR	OUTPUT	80
	TO(NCOUNT+J) = TC2(JX)	OUTPUT	81
	JX = LX+2*NR+(NR-4)-(NWALLS-J)*NINCR+1	OUTPUT	82
140	TO(NCOUNT+J+NWALLS) = TC2(JX)	OUTPUT	83
150	NCOUNT = NCOUNT+2*NWALLS	OUTPUT	84
C		OUTPUT	85
C	CONVERT 9 O'CLOCK AND 3 O'CLOCK CORNER SUBCHANNELS	OUTPUT	86
C		OUTPUT	87
	LX = NSC(K,9)-2+LOCAT	OUTPUT	88
	DO 160 J=1,NWALLS	OUTPUT	89
	JX = LX-(J-1)*NINCR	OUTPUT	90
	TO(NCOUNT+J) = TC2(JX)	OUTPUT	91
	JX = LX+3-(NWALLS-J)*NINCR	OUTPUT	92
160	TO(NCOUNT+J+NWALLS) = TC2(JX)	OUTPUT	93
	NCOUNT = NCOUNT+2*NWALLS	OUTPUT	94
C		OUTPUT	95
C	CONVERT FACE 4 AND FACE 6 ROWS	OUTPUT	96
C		OUTPUT	97
	LX = NSC(K,9)-3*NR-6+LOCAT	OUTPUT	98
	DO 180 M=1,NR	OUTPUT	99
	DO 170 J=1,NWALLS	OUTPUT	100
	JX = LX+M-(J-1)*NINCR	OUTPUT	101
	TO(NCOUNT+J) = TC2(JX)	OUTPUT	102
	JX = LX+2*NR-(NWALLS-J)*NINCR+(NR-M)+1	OUTPUT	103
170	TO(NCOUNT+J+NWALLS) = TC2(JX)	OUTPUT	104

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN OUTPUT

180	NCOUNT = NCOUNT+2*NWALLS	OUTPUT	105
C		OUTPUT	106
C	CONVERT FACE 5 ROWS	OUTPUT	107
C		OUTPUT	108
	DO 200 J=1,NWALLS	OUTPUT	109
	JX = NBC(K,9)-(NWALLS-J)*NINCR-1+LOCAT	OUTPUT	110
	LX = NBC(K,9)-(NWALLS-J)*NINCR-2*NR-6+LOCAT	OUTPUT	111
	TC(NCOUNT+1) = TC2(JX)	OUTPUT	112
	TC(NCOUNT+NR+2) = TC2(JX+1)	OUTPUT	113
	DO 190 M=1,NR	OUTPUT	114
190	TC(NCOUNT+M+1) = TC2(LX+M)	OUTPUT	115
200	NCOUNT = NCOUNT+NR+2	OUTPUT	116
C		OUTPUT	117
C		OUTPUT	118
C	CONVERT INTERIOR SUBCHANNELS INTO ARRAY TI(I)	OUTPUT	119
C		OUTPUT	120
C	CONVERT UPPER HALF OF BUNDLE	OUTPUT	121
C		OUTPUT	122
	NCOUNT = 0	OUTPUT	123
	DO 200 N=1,NR	OUTPUT	124
	L = NR-N+1	OUTPUT	125
	IF (N.EQ.1) GO TO 220	OUTPUT	126
	JX = N-1	OUTPUT	127
	DO 210 J=1,JX	OUTPUT	128
	ID = 6*(NR-J+1)**2+LOCAT-4*(2*(NR-J+1)-1)+2*(N-J)	OUTPUT	129
210	TI(J+NCOUNT) = TC2(ID)	OUTPUT	130
	NCOUNT = NCOUNT+JX	OUTPUT	131
220	LX = 6*L**2+LOCAT-4*(2*L-1)+1	OUTPUT	132
	DO 230 J=1,L	OUTPUT	133
	ID = LX+2*J+1	OUTPUT	134
230	TI(J+NCOUNT) = TC2(ID)	OUTPUT	135
	NCOUNT = NCOUNT+L	OUTPUT	136
	IF (N.EQ.1) GO TO 260	OUTPUT	137
	DO 240 J=1,JX	OUTPUT	138
	ID = 6*(1+J)**2+LOCAT-5*(2*(L+J)-1)+1-2*N	OUTPUT	139
240	TI(J+NCOUNT) = TC2(ID)	OUTPUT	140
	NCOUNT = NCOUNT+JX	OUTPUT	141
	DO 250 J=1,JX	OUTPUT	142
	ID = 6*(NR-J+1)**2+LOCAT-4*(2*(NR-J+1)-1)+2*(N-J)+1	OUTPUT	143
250	TI(J+NCOUNT) = TC2(ID)	OUTPUT	144
	NCOUNT = NCOUNT+JX	OUTPUT	145
260	NX = L+1	OUTPUT	146
	DO 270 J=1,NX	OUTPUT	147
	ID = LX-2*(J-1)	OUTPUT	148
270	TI(J+NCOUNT) = TC2(ID)	OUTPUT	149
	NCOUNT = NCOUNT+NX	OUTPUT	150
	IF (N.EQ.1) GO TO 290	OUTPUT	151
	DO 280 J=1,JX	OUTPUT	152
	ID = 6*(1+J)**2+LOCAT-5*(2*(L+J)-1)-2*N	OUTPUT	153
280	TI(J+NCOUNT) = TC2(ID)	OUTPUT	154
	NCOUNT = NCOUNT+JX	OUTPUT	155
290	CONTINUE	OUTPUT	156

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN OUTPUT

C		OUTPUT	157
C	CONVERT LOWER HALF OF THE BUNDLE	OUTPUT	158
C		OUTPUT	159
	DO 300 L=1,NP	OUTPUT	160
	IF (L.EQ.NP) GO TO 310	OUTPUT	161
	JX = NR-L	OUTPUT	162
	DO 300 J=1,JX	OUTPUT	163
	IO = 6*(NR-J+1)**2+LOCAT-3*(2*(NR-J+1)-1)+2*L-1	OUTPUT	164
300	TI(J+NCOUNT) = TC2(IO)	OUTPUT	165
	NCOUNT = NCOUNT+JX	OUTPUT	166
310	IX = 6*L**2+LOCAT-2*(2*L-1)	OUTPUT	167
	NX = L+1	OUTPUT	168
	DO 320 J=1,NX	OUTPUT	169
	IO = LX+2*(J-1)	OUTPUT	170
320	TI(J+NCOUNT) = TC2(IO)	OUTPUT	171
	NCOUNT = NCOUNT+NX	OUTPUT	172
	IF (L.EQ.NP) GO TO 350	OUTPUT	173
	DO 330 J=1,JX	OUTPUT	174
	IO = 6*(L+J)**2+LOCAT-2*(L-1)	OUTPUT	175
330	TI(J+NCOUNT) = TC2(IO)	OUTPUT	176
	NCOUNT = NCOUNT+JX	OUTPUT	177
	DO 340 J=1,JX	OUTPUT	178
	IO = 6*(NR-J+1)**2+LOCAT-3*(2*(NR-J+1)-1)+2*L	OUTPUT	179
340	TI(J+NCOUNT) = TC2(IO)	OUTPUT	180
	NCOUNT = NCOUNT+JX	OUTPUT	181
350	DO 360 J=1,L	OUTPUT	182
	IO = LX+2*(J-1)	OUTPUT	183
360	TI(J+NCOUNT) = TC2(IO)	OUTPUT	184
	NCOUNT = NCOUNT+L	OUTPUT	185
	IF (L.EQ.NP) GO TO 380	OUTPUT	186
	DO 370 J=1,JX	OUTPUT	187
	IO = 6*(L+J)**2+LOCAT-2*(L-1)-1	OUTPUT	188
370	TI(J+NCOUNT) = TC2(IO)	OUTPUT	189
	NCOUNT = NCOUNT+JX	OUTPUT	190
380	CONTINUE	OUTPUT	191
C		OUTPUT	192
C		OUTPUT	193
C	PRINTOUT PORTION OF THE ROUTINE	OUTPUT	194
C		OUTPUT	195
C	PRINT OUT FACE 2 INTERASSEMBLY GAP AND DUCT WALL ROWS	OUTPUT	196
C		OUTPUT	197
	ISTART = 0	OUTPUT	198
	ISTOP = 0	OUTPUT	199
	IF (NVAL(LB,ED,X) GO TO 390	OUTPUT	200
	FHV(2) = LSKP(NR+3)	OUTPUT	201
	FHV(6) = FINT(NR)	OUTPUT	202
	ISTART = 1	OUTPUT	203
	ISTOP = NR+2	OUTPUT	204
	WRITE (6,FHV) (TO(I),I=ISTART,ISTOP)	OUTPUT	205
	FHV(2) = LSKP(NR+1)	OUTPUT	206
	FHV(6) = FINT(NR)	OUTPUT	207
	ISTART = ISTOP+1	OUTPUT	208

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN OUTPUT

	ISTOP = ISTOP+NR+2	OUTPUT	209
	WRITE (6,FMW) (TO(I),I=ISTART,ISTOP)	OUTPUT	210
390	FMX(2) = LSKP(NR+1)	OUTPUT	211
	FMX(4) = FINT(NR)	OUTPUT	212
	ISTART = ISTOP+1	OUTPUT	213
	ISTOP = ISTOP+NR+2	OUTPUT	214
	WRITE (6,FMX) (TO(I),I=ISTART,ISTOP)	OUTPUT	215
	FMY(2) = LSKP(NR+1)	OUTPUT	216
	FMY(4) = FINT(NR)	OUTPUT	217
	FMY(6) = XTRA(2)	OUTPUT	218
	ISTART = ISTOP+1	OUTPUT	219
	ISTOP = ISTOP+NR+2	OUTPUT	220
	WRITE (6,FMY) (TO(I),I=ISTART,ISTOP)	OUTPUT	221
C		OUTPUT	222
C	PRINT OUT ASTERISKS DESIGNATING THE INSIDE DUCT WALL POSITION	OUTPUT	223
C		OUTPUT	224
	IND = INDEX(NR)	OUTPUT	225
	FMA(2) = SSKP(NR)	OUTPUT	226
	WRITE (6,FMA) (ASTAR(I),I=1,IND)	OUTPUT	227
C		OUTPUT	228
C	PRINT OUT FACE 3 EDGE AND CORNER SUBCHANNELS	OUTPUT	229
C		OUTPUT	230
	FMZ(2) = SSKP(NR)	OUTPUT	231
	FMZ(4) = FINT(NR)	OUTPUT	232
	FMZ(10) = XTRA(1)	OUTPUT	233
	ISTART = ISTOP+1	OUTPUT	234
	ISTOP = ISTOP+NR+2	OUTPUT	235
	WRITE (6,FMZ) (TO(I),I=ISTART,ISTOP)	OUTPUT	236
C		OUTPUT	237
C	PRINTOUT FACE 3 AND FACE 1 ROWS	OUTPUT	238
C		OUTPUT	239
	KE = 0	OUTPUT	240
	FMS(A) = XTRA(2)	OUTPUT	241
	IF (NHALLS,ED,5) GO TO 400	OUTPUT	242
	FML(3) = XTRA(3)	OUTPUT	243
	FML(11) = XTRA(3)	OUTPUT	244
	IE = 3	OUTPUT	245
	IS = 4	OUTPUT	246
	JE = 6	OUTPUT	247
	GO TO 410	OUTPUT	248
400	FML(3) = XTRA(4)	OUTPUT	249
	FML(11) = XTRA(4)	OUTPUT	250
	IE = 5	OUTPUT	251
	IS = 6	OUTPUT	252
	JE = 10	OUTPUT	253
410	JSTOP = 2*NR-1	OUTPUT	254
	DO 400 J=NR,JSTOP	OUTPUT	255
	KS = KF+1	OUTPUT	256
	KE = KF+J	OUTPUT	257
	FMS(2) = SSKP(J)	OUTPUT	258
	FMS(5) = FINT(J)	OUTPUT	259
	WRITE (6,FMS) (TI(KK),KK=K9,KE)	OUTPUT	260

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN OUTPUT

```

      KS = KE+1
      KE = KE+J+1
      IF (NWALLS.EQ.9) GO TO 420
      FML(2) = LSKP(J+1)
      GO TO 430
420   FML(2) = SSKP(J+8)
430   FML(7) = FINT(J+1)
      IF (J.FD.JSTOP) FML(12) = XTRA(2)
      WRITE (6,FML) (TO(I+ISTOP),I=1,IE),(TI(KK),KK=KS,KE),(TO(I+IST
+      OP),I=JS,JF)
      JSTOP = ISTOP+JE
440   CONTINUE
      FMS(8) = XTRA(1)
C
C   PRINT OUT 9 O'CLOCK AND 3 O'CLOCK CORNER SUBCHANNELS
C
      IF (NWALLS.EQ.9) GO TO 450
      FMC(2) = LSKP(JSTOP+1)
      FMC(3) = XTRA(3)
      GO TO 460
450   FMC(2) = SSKP(J+7)
      FMC(3) = XTRA(4)
460   FMC(7) = CSKP(NR)
      FMC(10) = CSKP(NR)
      WRITE (6,FMC) (TO(I+ISTOP),I=1,JE)
      ISTOP = ISTOP+JE
C
C   PRINTOUT FACE 4 AND FACE 6 ROWS
C
      DO 490 I=1,NR
      J = 2*NR-I
      KS = KE+1
      KE = KE+J+1
      IF (NWALLS.EQ.9) GO TO 470
      FML(2) = LSKP(J+1)
      GO TO 480
470   FML(2) = SSKP(J+8)
480   FML(7) = FINT(J+1)
      WRITE (6,FML) (TO(N+ISTOP),N=1,IE),(TI(KK),KK=KS,KE),(TO(N+IST
+      OP),N=JS,JE)
      JSTOP = ISTOP+JE
      KS = KE+1
      KE = KE+J
      FMS(2) = SSKP(J)
      FMS(5) = FINT(J)
      WRITE (6,FMS) (TI(KK),KK=KS,KE)
490   CONTINUE
      FML(12) = XTRA(1)
C
C   PRINT OUT FACE 5 EDGE AND CORNER SUBCHANNELS
C
      FHZ(10) = XTRA(2)

```

OUTPUT	261
OUTPUT	262
OUTPUT	263
OUTPUT	264
OUTPUT	265
OUTPUT	266
OUTPUT	267
OUTPUT	268
OUTPUT	269
OUTPUT	270
OUTPUT	271
OUTPUT	272
OUTPUT	273
OUTPUT	274
OUTPUT	275
OUTPUT	276
OUTPUT	277
OUTPUT	278
OUTPUT	279
OUTPUT	280
OUTPUT	281
OUTPUT	282
OUTPUT	283
OUTPUT	284
OUTPUT	285
OUTPUT	286
OUTPUT	287
OUTPUT	288
OUTPUT	289
OUTPUT	290
OUTPUT	291
OUTPUT	292
OUTPUT	293
OUTPUT	294
OUTPUT	295
OUTPUT	296
OUTPUT	297
OUTPUT	298
OUTPUT	299
OUTPUT	300
OUTPUT	301
OUTPUT	302
OUTPUT	303
OUTPUT	304
OUTPUT	305
OUTPUT	306
OUTPUT	307
OUTPUT	308
OUTPUT	309
OUTPUT	310
OUTPUT	311
OUTPUT	312

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN OUTPUT

	ISTART = ISTOP+1	OUTPUT	313
	ISTOP = ISTOP+NR+2	OUTPUT	314
	WRITE (6,FMZ) (TO(I),I=ISTART,ISTOP)	OUTPUT	315
C		OUTPUT	316
C	PRINT OUT ASTERISKS DESIGNATING THE INSIDE DUCT WALL POSITION	OUTPUT	317
C		OUTPUT	318
	WRITE (6,FMA) (ASTAR(I),I=1,IND)	OUTPUT	319
C		OUTPUT	320
C	PRINT OUT FACE 5 INTERASSEMBLY GAP AND DUCT WALL ROWS	OUTPUT	321
C		OUTPUT	322
	FMY(9) = XTRA(1)	OUTPUT	323
	ISTART = ISTOP+1	OUTPUT	324
	ISTOP = ISTOP+NR+2	OUTPUT	325
	WRITE (6,FMY) (TO(I),I=ISTART,ISTOP)	OUTPUT	326
	ISTART = ISTOP+1	OUTPUT	327
	ISTOP = ISTOP+NR+2	OUTPUT	328
	WRITE (6,FMX) (TO(I),I=ISTART,ISTOP)	OUTPUT	329
	IF (NWALL(8,EO,1) GO TO 500	OUTPUT	330
	ISTART = ISTOP+1	OUTPUT	331
	ISTOP = ISTOP+NR+2	OUTPUT	332
	WRITE (6,FMW) (TO(I),I=ISTART,ISTOP)	OUTPUT	333
	ISTART = ISTOP+1	OUTPUT	334
	ISTOP = ISTOP+NR+2	OUTPUT	335
	WRITE (6,FMV) (TO(I),I=ISTART,ISTOP)	OUTPUT	336
500	CONTINUE	OUTPUT	337
	RETURN	OUTPUT	338
	END	OUTPUT	339

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK0

*COMDECK BLK0

NA#
NB#
NC#
ND#
NE#
NF#
NG#
NH#
NJ#
NK#
NL#
NM#
NN#
NO#
NP#
NQ#
NW#
NI#

BLK0 1
BLK0 2
BLK0 3
BLK0 4
BLK0 5
BLK0 6
BLK0 7
BLK0 8
BLK0 9
BLK0 10
BLK0 11
BLK0 12
BLK0 13
BLK0 14
BLK0 15
BLK0 16
BLK0 17
BLK0 18
BLK0 19

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK1

*COMDECK BLK1

COMMON/COEF/ C1(NA),C2(NA),C3(NA),C4(NA),C5(NA),C6(NA),C7(NA),
1 C8(NA),C9(NA),C10(NA),C11(NA),C12(NA),C13(NA),C14(NB),C15(NB),
2 C16(NB),C17(NB),C18(NB),C19(NB),C20(NB),C21(NB),C23(NB),C24(NA),
3 C25(NA),C26(NA),C27(NA),C28(NA),C29(NA),C30(NA),C31(NA),C32(NA),
4 C33(NA),C35(NA),C36(NA),C39(NB),C41(NB),C42(NA),C22(NB)
COMMON/ENRGY/ QSA(NA),QSB(NA),QSO(NA),QSG(NA),QST(NA),QSGP

BLK1 1
BLK1 2
BLK1 3
BLK1 4
BLK1 5
BLK1 6
BLK1 7

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK2

*COMDECK BLK2

COMMON/INCALC/ TYNLET(NA),NAXPEN(NH),AXHTPP(NO,NH),APP(NO,NH),
1 NBCCEN(NF),RC9KWT(NZ,NF),RC9KEW(NZ,NF),NBTPB(NF),BC(NA,6),
2 NEICHR(NA,6),IPROFO(NA,6.4),GHDNOM(NA,6),N8C9KW,BCAXHT(NJ,NQ),
3 RCAXP(NJ,NQ),NBCEEN(NQ),APRNT(NO),OPRNT(NO),NAPRNT,NOPRNT,
4 NORPPP,NQAXPP,NORHAP,AXBAR(NH)

BLK2 1
BLK2 2
BLK2 3
BLK2 4
BLK2 5
BLK2 6

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK3

*COMDECK BLK3

COMMON/INFP1/ HPARAM(NK),NEPENT(VH),ESTAR(NJ,NH),REP(NJ,NH),
1 C(NJ,NH)

BLK3 1
BLK3 2
BLK3 3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK4

*COMDECK BLK4

COMMON/INF81/ NFRPLT(NK),VFSENT(NN),FLNWG,FLNW(N6),FLOWBP(NB),
1 RFF(NJ,NN),X1(NJ,NN),X2(NJ,NN),X3(NJ,NN)

BLK4 1
BLK4 2
BLK4 3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK5

*COMDECK BLK5
 COMMON/GENRL/ NRND(NK),NRING(NK),NSC(NK,9),ILUMP(NK),MODEL,
 1 PLEN(NK),XLEN(NK,3),CGAPTH(NI),ETA(NK,6),A(NK,7),ETAC(NK),
 2 LENGTH,LEAD(NK),DZ,PROFIL(NA,2),IBCTYP(NA),SF(NK),ETAI(NK),
 3 IFOPM,TEXT(17),RUNDID(17,NA),DIM(4),IPR,ICR
 COMMON/PRO/ V,VGP,V8P,V1,V2,V3,VTHETA,EP5,CK,CRHO,CCP,CBETA,
 1 CVISC,WK,HT1,HT2,HT3,HT4,IREF
 REAL LEAD,LENGTH
 INTEGER PROFIL

BLK5	1
BLK5	2
BLK5	3
BLK5	4
BLK5	5
BLK5	6
BLK5	7
BLK5	8
BLK5	9

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK6

*COMDECK BLK6
 COMMON/INPR/ TEMPC(N1),RHOC(N1),CPC(N1),CONDC(N1),VISC(N1),
 1 TEMPD(N1),CONDD(N1),CPD(N1),RHOD(N1),TAVEC(NA),TAVEW(NA),MCOENT,
 2 NDENT

BLK6	1
BLK6	2
BLK6	3
BLK6	4

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK7

*COMDECK BLK7
 COMMON/GE0/ GAP(NK),P(NK),CLADD(NK),WIRED(NK),YLENC(NI,2),
 1 CWallT(NI),DUCTTH(NK),ATOTGP(NK),DE(NK,5),DEC(NI,2),ATOT(NK),
 2 AC(NI,4),ATOTC(NI),FLAT(NK),PORL1(NK),PORAX1(NK),GAPTH,DEIN(NK),
 3 SHWTRE(NK),DENG(NK)

BLK7	1
BLK7	2
BLK7	3
BLK7	4
BLK7	5

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK8

*COMDECK BLK8
 COMMON/ITT/ TC1(NC),TC2(NC),NTLOC(NA),TO(270),TI(400)
 DIMENSION TCONVR(217),POUM(217)
 EQUIVALENCE (TCONVR(1),TO(1)),(POUM(1),TC1(1))
 INTEGER TO,TI
 LEVEL 2,TC1

BLK8	1
BLK8	2
BLK8	3
BLK8	4
BLK8	5
BLK8	6

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK9

*COMDECK BLK9
 COMMON/GR/ NPLNC(N0),NHLOC(NH),RPPP(N0),RHTPP(NP),NHTP(NE),
 1 POWER(NA),NPIMP(N0)

BLK9	1
BLK9	2
BLK9	3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK10

*COMDECK BLK10
 COMMON/AY/ NOINCR,ICHH,NOASSH,ITYPE(NA),ITY(NK)
 COMMON/OPRAH/NA,HB,NC,ND,NE,NF,NG,NH,NJ,NK,NL,NM,NH,NO,NP,NQ,NW,N1

BLK10	1
BLK10	2
BLK10	3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BLK11

*COMDECK BLK11
 COMMON/IND/ LCON(NH,4),MCON(NH,3),LIND(NK),MIND(NK)
 LEVEL 2,LCON

BLK11	1
BLK11	2
BLK11	3
BLK11	4

LAST

APPENDIX D
PROGRAM CONVERT

APPENDIX D

PROGRAM CONVERT

This short auxiliary program is used to redimension SUPERENERGY Revision 2 in order to minimize computer storage requirements. CONVERT is a simplified version of SPECSET (Wheeler et al. 1976) which provides a similar function for the COBRA-IV (Wheeler et al. 1976; Stewart et al. 1977) code. CONVERT allows SUPERENERGY to be variably dimensionable without suffering from the constraints of other in-code redimensioning schemes, such as the use of machine dependent programming, argument lists, and singly dimensioned variables. With it, SUPERENERGY can be quickly dimensioned to handle any program from single bundle size to large core sectors with only the available core storage as an upper bound on calculational flexibility.

The input to CONVERT is supplied in two separate data groups. The first group consists of card images of the SUPERENERGY common and dimension statements which contain dummy dimension parameters. A listing of this card image deck, called SDECK, is included. It is input to CONVERT via logical Unit 2. SDECK needs to be modified only if the user desires to add new variables or rearrange the storage locations of existing ones (e.g., to move a common block to large core memory in a CDC machine). The second group of input data is a set of 18 critical parameters which define the size of the SUPERENERGY problem to be computed. The form of these critical parameters are discussed in more detail below. This set of parameters is input to CONVERT by logical Unit 5.

The function of CONVERT is to perform a systematic character-by-character search for SDECK dummy dimension parameters. These dummy dimensions are replaced by integers, based on the user input critical parameters, as SDECK is written to an output file, logical Unit 1.

The user critical input parameters take the form:

Columns 1 and 2	3	4-8
"parameter"	=	"value"

where "parameter" is a two-letter code and "value" is its required numerical value, which must be right justified in the field and have a minimum value of 1.

The parameters may be input in any order.

The required parameters are as follows. The default values for each are listed in parentheses.

- NA - maximum number of assemblies, both normal and double ducted (2)
- NB - maximum number of double ducted bypass type assemblies (1)
- NC - maximum number of channels for both lumped and subchannel models.
 $NC \geq NG + NP$ (700). For a single bundle of Type I, the number of channels is $N = 6 * (N_{RING})^2 + 18 * (N_{RING} + 1)$ where N_{RING} is defined in Appendix A INPUT 2.3. If bundle Type I is a double-ducted bundle add $12 * (N_{RING} + 1)$ to N . NC represents the sum of N for all the bundles in the simulation.
- ND - maximum number of radial pin power profiles - subchannel model (2)
- NE - maximum number of radial power profiles - lumped model (1)
- NF - maximum number of boundary condition and gamma heating facial skew profiles (2)
- NG - maximum number of channels (including duct nodes) for subchannel model
 $NG \leq NC - NP$ (600)
- NH - maximum number of axial power profiles (2)
- NJ - maximum number of tabular entries for all tabular input except the axial printout, axial power profile and the property table. (4)
- NK - maximum number of bundle types, both double and single ducted assemblies (3)
- NL - maximum number of single ducted assemblies $NL < NK$ (2)
- NM - maximum number of ϵ_{1L}^* and C_{1L} profiles (1)
- NN - maximum number of flowsplit profiles (1)
- NO - maximum number of entries in the axial power profiles and printout arrays (35)
- NP - maximum number of channels for lumped model $NP \leq NC - NG$ (100)
- NQ - maximum number of boundary condition axial profiles (2)

NW - maximum number of locations for channel connector storage, equal to NK times the average number of channels per bundle type
NW < NC (usually much less) (700)

N1 - maximum number of property table entries (4)

The auxiliary program dimensioning technique was originally developed to use with machines that do not allow dummy dimensioning of common blocks within the main code, such as the CDC 7600. For computers with extended fortran capabilities, like the UNIVAC 1108, the dummy dimensioned SDECK can be placed directly into SUPERENERGY, superceding the need for CONVERT by using the PARAMETER statement.

A list and explanation of the control cards which could be used to change the dimensions in a SUPERENERGY-2 file is included. If the user intends to run a series of problems of similar size, the SUPERENERGY file need only be redimensioned once and permanently cataloged. Any problem with smaller dimensions will run on the file, though it may not be economical to do so depending on the computer charge algorithm. It is assumed in the control statements listed below that the user has cataloged under ID=SUPER permanent files for updatable versions of SUPERENERGY-2, CONVERT and SDECK. The control statements will probably require some modification for each computer installation, but the general sequence described in the comments should be followed.

COMMENTS

ATTACH,NEWS,USDECK,ID=SUPER	Updatable version of SDECK
UPDATE (P=NEWS,S=TAPE2,F,N,L=12347)	Creates the source file on logical unit 2 of the specdecks with variable subscripts
RETURN,NEWS.	
RETURN,NEWPL.	
REWIND(TAPE2)	
COPYSBF(TAPE2,OUTPUT)	List comdecks

REWIND(TAPE2)

ATTACH(SPFIX,UCONVERT,ID=SUPER

UPDATE(P=SPFIX,F,N)

RETURN,NEWPL.

FTN,I,L=0,B=SPEC.

RETURN,COMPILE

SPEC.

REWIND(NEWPU)

COPYSBF(NEWPU,OUTPUT)

REWIND(NEWPU)

ATTACH(DUM1,USUPER2,ID=SUPER)

UPDATE(P=DUM1,N=NUM1,C=0,L=1,F,E)

UPDATE(P=NUM1,N=NUM2,C=0,L=1234,F,E)

RETURN(NUM1,DUM1)

REQUEST(NEWPL,*PF)

UPDATE(P=NUM2,F,E,N,L=1)

CATALOG,NEWPL,FNU,ID=SUPER,RP=999

Updatable version of CONVERT

Creates compilable version of CONVERT. Changes to program CONVERT can be made at this point.

Creates binary version of CONVERT

Runs program CONVERT - requires input from unit 2 and spec parameters as shown below - writes specdecks to file NEWPU

Lists specdecks with constant subscripts

Updatable version of SUPERENERGY-2

First SUPERENERGY update - removes old specdecks from file

Second SUPERENERGY update - removes old specdeck idents from file - changes to SUPER2 can be made at this point

Third SUPERENERGY Update - inserts new specdecks (on file NEWPU) - creates new updatable version of SUPER2

Permanently stores updatable version of SUPERENERGY under file name FNU

RETURN(NUM2,NEWPU,NEWPL)

REQUEST(NEWB,*PF)

RFL(160000)

FTN,I,L=0,PL=99999,B=NEWB.

CATALOG,NEWB,FNB,ID=SUPER,RP=999

Permanently stores binary version
of SUPERENERGY under file name FNB

REDUCE

EOF

*/SDECK UPDATES

Updates to USDECK, if any

EOF

*/CONVERT UPDATES

Updates to UCONVERT, if any

EOF

CONVERT parameter input

NA= 12

NB= 4

NC= 7000

ND= 10

NE= 2

NF= 2

NG= 6500

NH= 5

NJ= 3

NK= 5

NL= 3

NM= 1

NN= 1

NO= 20

NP= 500

NQ= 1

NW= 1800

N1= 3

EOF

*PD BLK0,BLK11

Updates command to remove old
specdecks

EOF

*/SUPERENERGY UPDATES

Updates to USUPER2, if any

EOF

*AF NEWPU,YANK\$\$\$

Updates command to add new
specdecks

EOF

D.7

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C
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DEFAULT DIMENSIONING PARAMETERS

NA	=	2
NR	=	1
NC	=	700
ND	=	2
NE	=	1
NF	=	2
NG	=	600
NH	=	2
NJ	=	4
NK	=	3
NL	=	2
NM	=	1
NN	=	1
NO	=	35
NP	=	100
NQ	=	2
NR	=	700
NI	=	4

CONVERT	1
CONVERT	2
CONVERT	3
CONVERT	4
CONVERT	5
CONVERT	6
CONVERT	7
CONVERT	8
CONVERT	9
CONVERT	10
CONVERT	11
CONVERT	12
CONVERT	13
CONVERT	14
CONVERT	15
CONVERT	16
CONVERT	17
CONVERT	18
CONVERT	19
CONVERT	20
CONVERT	21
CONVERT	22
CONVERT	23
CONVERT	24
CONVERT	25
CONVERT	26
CONVERT	27
CONVERT	28
CONVERT	29
CONVERT	30
CONVERT	31
CONVERT	32
CONVERT	33
CONVERT	34
CONVERT	35
CONVERT	36
CONVERT	37
CONVERT	38
CONVERT	39
CONVERT	40
CONVERT	41
CONVERT	42
CONVERT	43
CONVERT	44
CONVERT	45
CONVERT	46
CONVERT	47
CONVERT	48
CONVERT	49
CONVERT	50
CONVERT	51
CONVERT	52

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CONVERT

C	THEIR MEANINGS -	CONVERT	53
C	NA = MAX. NO. OF ASSEMBLIES, BOTH NORMAL AND BYPASS	CONVERT	54
C	NB = MAX. NO. BYPASS TYPE ASSEMBLIES	CONVERT	55
C	NC = MAX. NO. OF CHANNELS FOR BOTH POROUS AND SUBCHANNEL MODELS	CONVERT	56
C	ND = MAX. NO. RADIAL PIN POWER PROFILES - SUBCHANNEL MODEL	CONVERT	57
C	NE = MAX. NO. RADIAL POWER PROFILES - POROUS MODEL	CONVERT	58
C	NF = MAX. NO. BOUNDARY FACIAL SKEW PROFILES	CONVERT	59
C	NG = MAX. NO. OF CHANNELS FOR SUBCHANNEL MODEL	CONVERT	60
C	NH = MAX. NO. AXIAL POWER PROFILES	CONVERT	61
C	NJ = MAX. NO. TABULAR ENTRIES FOR ALL TABLES EXCEPT AXIAL PRINTOUT	CONVERT	62
C	AXIAL POWER PROFILE AND PROPERTY TABLE	CONVERT	63
C	NK = MAX. NO. BUNDLE TYPES, BOTH BYPASS AND NORMAL	CONVERT	64
C	NL = MAX. NO. OF NORMAL ASSEMBLY TYPES NL.LT.NK	CONVERT	65
C	NM = MAX. NO. OF E* AND C1 PROFILES	CONVERT	66
C	NN = MAX. NO. FLOW SPLIT PROFILES	CONVERT	67
C	NO = MAX. NO. ENTRIES IN AXIAL POWER PROFILE AND PRINTOUT ARRAY	CONVERT	68
C	NP = MAX. NO. OF CHANNELS FOR POROUS MODEL NC.GF.NG+NP	CONVERT	69
C	NQ = MAX. NO. OF BOUNDARY CONDITION AXIAL POWER PROFILES	CONVERT	70
C	NW = MAX. SIZE OF ASSEMBLY TYPE SUBCHANNEL STORAGE FOUND BY	CONVERT	71
C	SUMMING THE NUMBER OF SUBCHANNELS IN THE VARIOUS ASSEMBLY	CONVERT	72
C	TYPES NW.LE.NC	CONVERT	73
C		CONVERT	74
C		CONVERT	75
C	N1 = MAX. NO. PROPERTY TABLE ENTRIES	CONVERT	76
C	READ IN USER SPECIFIED DIMENSION PARAMETERS	CONVERT	77
C		CONVERT	78
110	CONTINUE	CONVERT	79
	READ (5,120) IC1,IC2,IVAL	CONVERT	80
120	FORMAT (2A1,1X,15)	CONVERT	81
	IF (ABS(EOF(5)).NE.0) GO TO 170	CONVERT	82
	IF (IC1.EQ.1CHK1) GO TO 140	CONVERT	83
C		CONVERT	84
C	ERROR == INVALID INPUT SPECIFICATION	CONVERT	85
C		CONVERT	86
	WRITE (6,130) IC1,IC2,IVAL	CONVERT	87
130	FORMAT (1H0,15X,'CONVERT ERROR...INVALID INPUT...','5X,2A1,'1','14,'	CONVERT	88
	+ RUN ABORTED')	CONVERT	89
	STOP	CONVERT	90
140	DO 150 J=1,35	CONVERT	91
	IF (IC2.NE.1CHK(J)) GO TO 150	CONVERT	92
	JNDX = J	CONVERT	93
	GO TO 160	CONVERT	94
150	CONTINUE	CONVERT	95
C		CONVERT	96
C	ERROR == INVALID INPUT SPECIFICATION	CONVERT	97
C		CONVERT	98
	WRITE (6,130) IC1,IC2,IVAL	CONVERT	99
	STOP	CONVERT	100
160	IVALH(JNDX) = IVAL	CONVERT	101
	GO TO 110	CONVERT	102
170	CONTINUE	CONVERT	103
C		CONVERT	104

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CONVERT

C	CALCULATE VALUES FOR DIMENSIONING PARAMETERS NOT BEING READ IN	CONVERT	105
C		CONVERT	106
	NC = MAX0(NC,NG+NP)	CONVERT	107
	NI = MAX0(NK-NL,1)	CONVERT	108
	NU = NE+1	CONVERT	109
	NZ = 10	CONVERT	110
	DO 180 J=1,35	CONVERT	111
	NCH(J) = 0	CONVERT	112
	IF (IVALU(J).LT.1) GO TO 180	CONVERT	113
	NCH(J) = ALOR10(FLOAT(IVALU(J)))+1	CONVERT	114
180	CONTINUE	CONVERT	115
	WRITE (6,190)	CONVERT	116
190	FORMAT (/1X,'SUMMARY OF DIMENSION VARIABLES')	CONVERT	117
	WRITE (6,200) (ICHK1,ICHK(J),IEQUAL,IVALU(J),J=1,35)	CONVERT	118
200	FORMAT (10(2X,1A),15)/)	CONVERT	119
C		CONVERT	120
C	READ IN FIXED COMMON BLOCKS AND DIMENSION STATEMENTS FROM LOGICAL	CONVERT	121
C	UNIT NUMBER 2	CONVERT	122
C		CONVERT	123
	DO 210 I=1,72	CONVERT	124
210	RUFOUT(I) = JBLANK	CONVERT	125
220	READ (2,230) (RUFIN(I),I=1,72)	CONVERT	126
230	FORMAT (72A1)	CONVERT	127
	IF (A98(RUF(2)).NE.0) GO TO 440	CONVERT	128
	IF (RUFIN(I).EQ.ICHK(21)) GO TO 440	CONVERT	129
C		CONVERT	130
C	SCAN INPUT LINE FOR SPECIAL CHARACTERS ',(	CONVERT	131
C		CONVERT	132
	K0 = 1	CONVERT	133
	KI = 1	CONVERT	134
240	CONTINUE	CONVERT	135
	IF (RUFIN(KI).EQ.IEQUAL) GO TO 290	CONVERT	136
	IF (RUFIN(KI).EQ.IPL) GO TO 340	CONVERT	137
	RUFOUT(K0) = BUFJN(KI)	CONVERT	138
	KI = KI+1	CONVERT	139
	K0 = K0+1	CONVERT	140
	IF (KI.LT.73.AND.K0.LT.73) GO TO 240	CONVERT	141
	IF (KI.GT.72) GO TO 260	CONVERT	142
	IF (K0.GT.72.AND.RUFOUT(72).EQ.IBLANK) GO TO 260	CONVERT	143
250	CALL BUFF (RUFOUT)	CONVERT	144
	RUFOUT(6) = ISTAR	CONVERT	145
	K0 = 7	CONVERT	146
	GO TO 240	CONVERT	147
260	DO 270 I=KI,72	CONVERT	148
	IF (RUFIN(I).NE.IBLANK) GO TO 250	CONVERT	149
270	CONTINUE	CONVERT	150
280	CALL BUFF (RUFOUT)	CONVERT	151
	GO TO 220	CONVERT	152
C		CONVERT	153
C	HAVE FOUND EQUALS SIGN	CONVERT	154
C		CONVERT	155
290	RUFOUT(K0) = BUFJN(KI)	CONVERT	156

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CONVERT

	KO = KO+1	CONVERT	157
	KI = KI+1	CONVERT	158
	IF (KO,LT,73) GO TO 300	CONVERT	159
	CALL BUFF (RUFOUT)	CONVERT	160
	RUFOUT(6) = ISTAR	CONVERT	161
	KO = 7	CONVERT	162
C		CONVERT	163
C	SEARCH	CONVERT	164
C		CONVERT	165
300	IF (RUFIN(KI),NE,IRLANK) GO TO 240	CONVERT	166
	IC1 = RUFIN(KI-3)	CONVERT	167
	IC2 = RUFIN(KI-2)	CONVERT	168
	IF (IC1,NE,ICMK1) GO TO 240	CONVERT	169
	DO 310 J=1,34	CONVERT	170
	IF (IC2,NE,ICMK(J)) GO TO 310	CONVERT	171
	JNDX = J	CONVERT	172
	GO TO 320	CONVERT	173
310	CONTINUE	CONVERT	174
	GO TO 240	CONVERT	175
320	NDIG = NCM(JNDX)	CONVERT	176
	IVL = IVALL(JNDX)	CONVERT	177
	DO 330 N=1,NDIG	CONVERT	178
	ICH = IVL/(10**((N-1)*NDIG))	CONVERT	179
	IF (ICH,GT,0) RUFOUT(KO) = ICHK(ICH)	CONVERT	180
	IF (ICH,EQ,0) RUFOUT(KO) = IHO	CONVERT	181
	KO = KO+1	CONVERT	182
330	IVL = IVL-(ICH*(10**((N-1)*NDIG)))	CONVERT	183
	IF (KO,LT,73) GO TO 240	CONVERT	184
	CALL BUFF (RUFOUT)	CONVERT	185
	RUFOUT(6) = ISTAR	CONVERT	186
	KO = 7	CONVERT	187
	GO TO 240	CONVERT	188
C		CONVERT	189
C	HAVE FOUND LEFT PARENTHESIS	CONVERT	190
C		CONVERT	191
340	RUFOUT(KO) = RUFIN(KI)	CONVERT	192
	KO = KO+1	CONVERT	193
	KI = KI+1	CONVERT	194
	IF (KO,LT,73) GO TO 350	CONVERT	195
	CALL BUFF (RUFOUT)	CONVERT	196
	RUFOUT(6) = ISTAR	CONVERT	197
	KO = 7	CONVERT	198
350	IC1 = RUFIN(KI)	CONVERT	199
	IC2 = RUFIN(KI+1)	CONVERT	200
	IF (IC2,NE,ICOMMA) GO TO 360	CONVERT	201
	RUFOUT(KO) = IC1	CONVERT	202
	RUFOUT(KO+1) = IC2	CONVERT	203
	KO = KO+2	CONVERT	204
	KI = KI+2	CONVERT	205
	IC1 = RUFIN(KI)	CONVERT	206
	IC2 = RUFIN(KI+1)	CONVERT	207
360	IF (RUFIN(KI+2),EQ,ICOMMA) GO TO 370	CONVERT	208

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN CONVERT

	IF (RUFIN(KI+2).EQ.IPR) GO TO 370	CONVERT	209
	GO TO 240	CONVERT	210
370	IF (IC1.NE.ICHK1) GO TO 420	CONVERT	211
	DO 380 J=1,35	CONVERT	212
	IF (IC2.NE.ICHK(J)) GO TO 380	CONVERT	213
	JNDX = J	CONVERT	214
	GO TO 400	CONVERT	215
380	CONTINUE	CONVERT	216
	WRITE (6,390) (RUFIN(I),I=1,72)	CONVERT	217
390	FORMAT (1H0,15X,'ERROR...NONIDENTIFIABLE CHARACTER FOUND FOLLOWING	CONVERT	218
	+ AN N WITHIN THE ARRAY INDICIES',/15X,72A1)	CONVERT	219
	STOP	CONVERT	220
400	NDIG = NCH(JNDX)	CONVERT	221
	IVL = IVAL(JNDX)	CONVERT	222
	DO 410 N=1,NDIG	CONVERT	223
	ICH = IVL/(10**(NDIG-N))	CONVERT	224
	IF (ICH.GT.0) RUFOUT(KD) = ICHK(ICH)	CONVERT	225
	IF (ICH.EQ.0) RUFOUT(KD) = 1H0	CONVERT	226
	KD = KD+1	CONVERT	227
410	IVL = IVL-(ICH*(10**(NDIG-N)))	CONVERT	228
	KI = KI+2	CONVERT	229
	IF (KO.LT.73) GO TO 420	CONVERT	230
	CALL BUFF (RUFOUT)	CONVERT	231
	KD = 1	CONVERT	232
420	IF (RUFIN(KI).EQ.IPR) GO TO 240	CONVERT	233
	IF (RUFIN(KI).EQ.ICOMMA) GO TO 340	CONVERT	234
	DO 430 N=1,9	CONVERT	235
	IF (RUFIN(KI).NE.ICHK(N)) GO TO 430	CONVERT	236
	RUFOUT(KD) = RUFIN(KI)	CONVERT	237
	KI = KI+1	CONVERT	238
	KD = KD+1	CONVERT	239
	GO TO 420	CONVERT	240
430	CONTINUE	CONVERT	241
	GO TO 240	CONVERT	242
440	CONTINUE	CONVERT	243
	STOP	CONVERT	244
	END	CONVERT	245

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN BUFF

*DECK	BUFF	BUFF	1
	SUBROUTINE BUFF (RUFOUT)	BUFF	2
	INTEGER RUFOUT(72)	BUFF	3
	DATA IRLANK/1H /	BUFF	4
	WRITE (1,100) (RUFOUT(J),J=1,72)	BUFF	5
100	FORMAT (72A1)	BUFF	6
	WRITE (6,110) (RUFOUT(J),J=1,72)	BUFF	7
110	FORMAT (5X,72A1)	BUFF	8
	DO 120 I=1,72	BUFF	9
120	RUFOUT(I) = IRLANK	BUFF	10
	RETURN	BUFF	11
	END	BUFF	12

D.12

BLK0	1
BLK0	2
BLK0	3
BLK0	4
BLK0	5
BLK0	6
BLK0	7
BLK0	8
BLK0	9
BLK0	10
BLK0	11
BLK0	12
BLK0	13
BLK0	14
BLK0	15
BLK0	16
BLK0	17
BLK0	18
BLK0	19

NA=1P
NB=4
NC=7000
ND=10
NE=2
NF=2
NG=6400
NH=5
NJ=3
NK=3
NL=3
NM=1
NN=1
NO=20
NP=500
NQ=1
NW=1400
NI=3

0	L	K	1	1
9	L	K	1	2
8	L	K	1	3
7	L	K	1	4
6	L	K	1	5
5	L	K	1	6
4	L	K	1	7

0	L	K	1	1
9	L	K	1	2
8	L	K	1	3
7	L	K	1	4
6	L	K	1	5
5	L	K	1	6
4	L	K	1	7

```

COMMON,CNEF/ C1(12),C2(12),C3(12),C4(12),C5(12),C6(12),C7(12),
1 C8(12),C9(12),C10(12),C11(12),C12(12),C13(12),C14(8),C15(8),
2 C16(4),C17(4),C18(4),C19(4),C20(4),C21(4),C23(4),C24(12),
3 C25(12),C26(12),C27(12),C28(12),C29(12),C30(12),C31(12),C32(12),
4 C33(12),C35(12),C36(12),C39(4),C41(4),C42(12),C22(4)
COMMON,ENRG/ QSA(12),QSB(12),QSD(12),QSE(12),QSF(12),QSGP

```

8	X	1
8	X	2
8	X	3
8	X	4
8	X	5
8	X	6

8	X	1
8	X	2
8	X	3
8	X	4
8	X	5
8	X	6

```
COMMON/INCLC/ 1)NLET(12),NXPEN(5),AXHTPP(20,5),APP(20,5),
1 NBCREN(2),BCSKWT(10,2),BCKEW(10,2),NATYPB(2),BC(12,6),
2 NEIGHB(12,6),PRPFD(12,6,4),GHNDNM(12,6),NBCSKW,BCAXHT(3,1),
3 BCAYP(3,1),NBCAFV(1),APRNT(20),DPRNT(20),NAPRNT,NOPRNT,
4 NOPRFP,NOAXPP,NORMAP,AXBAR(5)
```

B L K 3	1
B L K 3	2
B L K 3	3

B L K 3	1
B L K 3	2
B L K 3	3

```
COMMON/INFP1/ NPARAM(5),NEPENT(1),ESTAR(3,1),REP(3,1),
1 C(3,1)
```

BLK 5	1
BLK 4	2
BLK 3	3

BLK 5	1
BLK 4	2
BLK 3	3

```
COMMON/INF81/ NPSPLT(5),NPSENT(1),FLOWG,FLOW(12),FLOWBP(4),
1 REF(3,1),X1(3,1),X2(3,1),X3(3,1)
```

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK5

*COMDECK BLK5
 COMMON/GENRL/ NR00(3),NRING(5),NSC(5,9),ILUMP(5),MODEL,
 1 PLEN(5),XLEN(5,3),CGAPTH(2),ETA(5,6),A(5,7),ETAQ(5),
 2 LENGTH,LEAD(5),DZ,PROFIL(12,2),IRCTYP(12),SF(5),ETAI(5),
 3 IFORM,TEXT(17),RUMID(17,12),DIM(4),IPR,ICR
 COMMON/PRO/ V,VOP,VBP,V1,V2,V3,VTHETA,EPS,CK,CRHn,CCP,CBETA,
 1 CVIRC,WK,HT1,HT2,HT3,HT4,IREF
 REAL LEAD,LENGTH
 INTEGER PROFIL

BLK5 1
 BLK5 2
 BLK5 3
 BLK5 4
 BLK5 5
 BLK5 6
 BLK5 7
 BLK5 8
 BLK5 9

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK6

*COMDECK BLK6
 COMMON/INPR/ TEMPC(3),RHOC(3),CPC(3),CONDC(3),VIAC(3),
 1 TEMPD(3),CONDN(3),CPD(3),RHOD(3),TAVEC(12),TAVEW(12),NCOENT,
 2 NDENT

BLK6 1
 BLK6 2
 BLK6 3
 BLK6 4

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK7

*COMDECK BLK7
 COMMON/GEN/ GAP(5),P(5),CLA000(5),WIREND(5),XLENF(2,2),
 1 CHALIT(2),OUCTTH(4),ATOTGP(5),DE(5,5),DEC(2,2),ATPT(5),
 2 AC(2,4),ATOTC(2),PLAT(5),PORL1(5),PORAX1(5),GAPTH,DEIN(5),
 3 RHWYRE(4),DFNG(4)

BLK7 1
 BLK7 2
 BLK7 3
 BLK7 4
 BLK7 5

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK8

*COMDECK BLK8
 COMMON/ITT/ TC1(7000),TC2(7000),NTLOC(12),TO(270),TI(400)
 DIMENSION ICONVR(217),PDUM(217)
 EQUIVALENCE (ICONVR(1),TO(1)),(PDUM(1),TC1(1))
 INTEGER TO, TI
 LEVEL 2, TC1

BLK8 1
 BLK8 2
 BLK8 3
 BLK8 4
 BLK8 5
 BLK8 6

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK9

*COMDECK BLK9
 COMMON/GR/ NPLQC(10),NHLOC(3),RPPP(6500),RHTPP(500),NHYP(2),
 1 POWER(12),NPJNP(10)

BLK9 1
 BLK9 2
 BLK9 3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK10

*COMDECK BLK10
 COMMON/AY/ NDINCR,ICLK,NDASHM,ITYPE(12),ITY(5)
 COMMON/DPRAM/NA,NB,NC,ND,NE,NF,NG,NH,NJ,NK,NL,NM,NN,NO,NP,ND,NW,N1

BLK10 1
 BLK10 2
 BLK10 3

LIST OF CONTROL, ACTIVE, AND/OR INACTIVE CARDS IN PLK11

*COMDECK BLK11
 COMMON/IND/ LCHNF(1800,8),MCUN(1800,3),LIND(5),MIND(5)
 LEVEL 2,ICON

BLK11 1
 BLK11 2
 BLK11 3

REFERENCES

- Wheeler, C. L., et al. 1976. COBRA-IV-I: An Interim Version of COBRA for Thermal-Hydraulic Analysis of Rod Bundle Nuclear Fuel Elements and Cores. BNWL-1962, Pacific Northwest Laboratory, Richland, WA.
- Stewart, C. W., et al. COBRA-IV: The Model and the Method. BNWL-2214, Pacific Northwest Laboratory, Richland, WA.

APPENDIX E
GEOMETRY AND CONNECTOR INFORMATION

APPENDIX E
GEOMETRY AND CONNECTOR INFORMATION

E.1 General Information

Gap between duct wall and outer row of pins

$$g = \frac{1}{2} (D_F - \sqrt{3} N_{ROW} P - D) \quad (E-1)$$

Lumped node pitch based on N_{RING}

$$P_I = \frac{N_{ROW}}{N_{RING}} P \quad (E-2)$$

Interior region rod fraction

$$f_I = (N_{ROD} - 3 N_{ROW} - 1) \frac{1}{N_1} \quad (E-3)$$

Edge region rod fraction

$$f_E = \frac{3 N_{ROW}}{N_2} \quad (E-4)$$

Total pin bundle flow area

$$A_T = N_1 A_1 + N_2 A_2 + N_3 A_3 \quad (E-5)$$

Total bypass region flow area

$$A_{TC} = 6 (N_{RING} A_{C3} + A_{C4}) \quad (E-6)$$

E.2 Interior Channel Geometry

Channel flow area

$$A_1 = \frac{\sqrt{3}}{4} P_I^2 - \frac{\pi}{4} f_I (D^2 + D_W^2) \quad (E-7)$$

Wetted perimeter

$$P_{W1} = f_I \pi (D + D_W) \quad (E-8)$$

Equivalent diameter

$$De_1 = \frac{4A_1}{P_{W1}} \quad (E-9)$$

Distance between interior channel nodes

$$\eta_1 = \frac{P_I}{\sqrt{3}} \quad (E-10)$$

Distance between interior and side channel nodes

$$\eta_2 = \frac{1}{2} \left(\frac{P_I}{\sqrt{3}} + g + \frac{D}{2} \right) \quad (E-11)$$

E.3 Side Channel Geometry

Channel flow area

$$A_2 = P_I \left(\frac{D}{2} + g \right) - \frac{\pi}{4} f_E (D^2 + D_S^2) \quad (E-12)$$

Wetted perimeter

$$P_{W2} = P_I + f_E \pi (D + D_S) \quad (E-13)$$

Equivalent diameter

$$De_2 = \frac{4A_2}{P_{W2}} \quad (E-14)$$

Distance between side channel nodes

$$\eta_3 = P_I \quad (E-15)$$

Distance between side and corner channel nodes

$$\eta_4 = \frac{1}{2} \left(P_I + \frac{D}{2\sqrt{3}} + \frac{g}{\sqrt{3}} \right) \quad (E-16)$$

E.4 Corner Channel Geometry

Channel flow area

$$A_3 = \frac{1}{2} \left(\frac{D_F}{\sqrt{3}} - N_{RING} P_I \right) \left(g + \frac{D}{2} \right) - \frac{\pi}{24} (D^2 + D_S^2) \quad (E-17)$$

Wetted perimeter

$$P_{W3} = \frac{\pi}{6} (D + D_S) + \frac{D_F}{\sqrt{3}} - N_{RING} P_I \quad (E-18)$$

Equivalent diameter

$$De_3 = \frac{4A_3}{P_{W3}} \quad (E-19)$$

Duct wall inside length

$$L_1 = \frac{1}{\sqrt{3}} (D + 2g) \quad (E-20)$$

E.5 Outer Duct Wall Node Geometry

Side node area

$$A_4 = P_I t_D \quad (E-21)$$

Corner node area (single-ducted assembly)

$$A_5 = \frac{1}{2} (L_1 + L_2) t_D \quad (E-22)$$

Corner node area (double-ducted assembly)

$$A_5 = \frac{1}{2} (L_{C2} + L_2) t_D \quad (E-23)$$

Second duct wall outside length (double-ducted assembly)

$$L_2 = L_{C2} + \frac{2}{\sqrt{3}} t_D \quad (E-25)$$

E.6 Bypass Gap Side Geometry (double-ducted assembly)

Channel flow area

$$A_{C3} = P_I g_c \quad (E-26)$$

Wetted perimeter

$$P_{C3} = 2 P_I \quad (E-27)$$

Equivalent diameter

$$De_{C1} = \frac{4 A_{C3}}{P_{C3}} \quad (E-28)$$

Distance between gap side and corner channel nodes

$$\eta_c = \frac{1}{2} P_I + \frac{1}{4} (L_{C1} + L_{C2}) \quad (E-29)$$

E.7 Bypass Gap Corner Geometry (double-ducted assembly)

Channel flow area

$$A_{C4} = \frac{1}{2} (L_{C1} + L_{C2}) g_c \quad (E-30)$$

Wetted perimeter

$$P_{C4} = L_{C1} + L_{C2} \quad (E-31)$$

Equivalent diameter

$$De_{C2} = \frac{4A_{C4}}{P_{C4}} \quad (E-32)$$

First duct wall outside length

$$L_{C1} = L_1 + \frac{2}{\sqrt{3}} t_c \quad (E-33)$$

Second duct wall outside length

$$L_{C2} = L_{C1} + \frac{2}{\sqrt{3}} g_c \quad (E-34)$$

E.8 First Duct Wall Node Geometry (double-ducted assembly)

Side node area

$$A_{C1} = P_I t_c \quad (E-35)$$

Corner node area

$$A_{C2} = \frac{1}{2} (L_1 + L_{C1}) t_c \quad (E-36)$$

E.9 Interassembly Gap Side Channel Geometry

Channel flow area

$$A_6 = P_I g_I \quad (E-37)$$

Wetter perimeter

$$P_{W6} = 2 P_I \quad (E-38)$$

Equivalent diameter

$$D_{e4} = \frac{4A_6}{P_{W6}} \quad (E-39)$$

Distance between gap side nodes

$$\eta_5 = P_I \quad (E-40)$$

Distance between gap side and gap corner nodes

$$\eta_6 = \frac{1}{2} (P_I + L_3) \quad (E-41)$$

E.10 Interassembly Gap Corner Channel Geometry

Channel flow area

$$A_7 = L_2 g_I + \frac{\sqrt{3}}{6} g_I^2 \quad (\text{E-42})$$

Wetted perimeter

$$P_{W7} = 2L_2 \quad (\text{E-43})$$

Equivalent diameter

$$D_{e5} = \frac{4A_7}{P_{W7}} \quad (\text{E-44})$$

Length along centerline

$$L_3 = L_2 + \frac{g_I}{\sqrt{3}} \quad (\text{E-45})$$

APPENDIX F
SAMPLE PROBLEM

APPENDIX F

SAMPLE PROBLEM

A ten-assembly cluster from rows three, four and five of the Fast Flux Test Facility (FFTF) was chosen for the sample problem to illustrate SUPERENERGY's modeling flexibility. The sample problem layout and operating conditions are illustrated in Figure F.1. FFTF bundles 1502, 1504, and 1302 are low-power double-ducted control and safety assemblies. Large radial temperature gradients occur between these and the neighboring 217-pin driver assemblies causing a significant amount of interassembly heat transfer.

SUPERENERGY models all the assemblies, except assembly #8, with standard subchannels. Assembly #8 is lumped to a four-ring assembly to illustrate the use of that option. The average duct wall temperatures by face are printed out at three axial locations. An energy balance and detailed coolant temperature maps are printed out at the top of the assemblies. The printout for bundle 4 shows how to convert the SUPERENERGY temperature map to a standard subchannel map (as in Figure F.2) with the addition of a few lines. The asterisks in the output maps always indicate the location of the inside surface of the bundle duct wall. Running time for this problem was 5.9 sec on a CDC 7600.

FIGURE F.1. Sample Problem Geometry

FIGURE F.2. Temperature Map for Bundle 4: 61-Pin Control Assembly Number 1504

SUPERENERGY-T1

STEADY STATE, MULTIRING, LMFBR THERMAL-HYDRAULIC ANALYSIS CODE
DEVELOPED AT MIT AND BNWL, BASED ON THE SUPERENERGY AND ENERGY MODELS
PRINCIPAL AUTHOR - K.L. BASFORD

NA#	12	NR#	4	NC#	7000	ND#	10	NE#	2	NF#	2	NG#	6500	NH#	5	NI#	7
NK#	5	NL#	7	NM#	1	NN#	1	NO#	20	NP#	500	NQ#	1	NW#	1400	NI#	7

***** THE FOLLOWING IS AN IMAGE LISTING OF THE SUPERENERGY INPUT CARDS *****

	0	1	2	3	4	5	6	7	8
	12345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901	2345678901
1	10 ASSEMBLY SAMPLE PROBLEM								
2	10	0	1						
3	0	1	1	3					
4	30.0								
5	0.0	36.0	90.0						
6	90.0	550.0	0.175						
7									
8	1	217	0						
9	.288	12.0	4.335	0.120	0.230	0.056	0.056	1.1	
10	0	-1							
11	2	217	0						
12	.288	6.0	4.335	0.120	0.230	0.056	0.056	1.1	
13	0	-1							
14	2	217	1						
15	.288	12.0	4.335	0.120	0.230	0.056	0.056	1.1	
16	0	-1							
17	0	61	0						
18	0.502	20.56	4.015	0.120	0.474	0.024	0.024	1.1	
19	0.044	0.1155							
20	0	-1							
21	0	9	1	1	0	1			
22	16								
23	0.	.8212	.018	.865	.0536	.9540	.0891	1.044	
24	.1251	1.153	.1607	1.213	.1963	1.203	.2323	1.143	
25	.2679	1.104	.3034	.944	.3394	.865	.375	.704	
26	.3333	.654	.4000	.612	.4001	0.	1.	0.	
27	0.0	0.00	0.199	0.00	0.200	2.30	0.400	0.80	
28	0.50	0.380	0.400	0.200	0.501	0.00	1.00	0.00	
29	0								
30	0.00	0.00	0.399	0.00	0.400	0.92	0.500	0.42	
31	0.600	0.22	0.700	0.100	0.800	0.050	0.401	0.00	
32	1.00	0.00							
33	217								
34	1.007	1.022	1.005	.991	.993	1.009	1.024	1.024	
35	1.019	1.001	.988	.975	.977	.979	.994	1.009	
36	1.024	1.040	1.038	1.049	1.032	1.014	.994	.983	
37	.971	.958	.962	.964	.964	.978	.993	1.007	
38	1.020	1.040	1.055	1.054	1.053	1.053	1.045	1.027	
39	1.009	.990	.978	.965	.954	.942	.944	.949	
40	.950	.949	.963	.977	.991	1.005	1.022	1.039	
41	1.055	1.070	1.070	1.060	1.066	1.076	1.059	1.040	
42	1.022	1.003	.983	.971	.959	.948	.937	.926	
43	.931	.924	.936	.936	.935	.948	.960	.974	
44	.987	1.001	1.019	1.037	1.053	1.070	1.085	1.085	
45	1.084	1.082	1.080	1.088	1.071	1.053	1.035	1.016	

[illegible]

0 1 2 3 4 5 6 7 8
123456789012345678901234567890123456789012345678901234567890

	1		2		3		4		5		6		7		8	
	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6
150		.931	.932	.931	.931	.931	.942	.953	.963							
151		.972	.981	.989	.999	1.005	1.015	1.025	1.034							
152		1.050	1.062	1.076	1.080	1.082	1.083	1.082	1.080							
153		1.075	1.076	1.061	1.045	1.030	1.016	1.002	.989							
154		.976	.964	.941	.958	.953	.947	.941	.933							
155		.928	.915	.897	.918	.919	.919	.919	.919							
156		.919	.919	.931	.942	.952	.962	.971	.979							
157		.986	.992	1.002	1.011	1.022	1.033	1.045	1.057							
158		1.071	1.085	1.089	1.093	1.095	1.095	1.093	1.090							
159		1.080														
160	61															
161		.933	.950	.938	.906	.909	.943	.976	1.033							
162		.987	.956	.917	.894	.891	.904	.927	.967							
163		.993	1.037	1.027	1.111	1.055	1.016	.993	.983							
164		.911	.806	.808	.985	.915	.930	.959	1.004							
165		1.023	1.060	1.115	1.099	1.097	1.204	1.140	1.000							
166		1.058	1.039	.983	.942	.918	.912	.899	.900							
167		.916	.945	.950	.969	1.004	1.054	1.084	1.004							
168		1.143	1.204	1.185	1.177	1.184										
169	217															
170		1.000	1.016	1.002	.990	.992	1.005	1.017	1.028							
171		1.010	1.000	.988	.974	.979	.981	.993	1.005							
172		1.017	1.030	1.023	1.041	1.027	1.012	.997	.985							
173		.973	.962	.965	.968	.970	.982	.990	1.000							
174		1.017	1.029	1.042	1.043	1.042	1.054	1.039	1.024							
175		1.009	.993	.981	.969	.958	.947	.951	.953							
176		.957	.959	.970	.981	.992	1.003	1.015	1.028							
177		1.041	1.055	1.055	1.056	1.055	1.047	1.052	1.037							
178		1.022	1.006	.990	.977	.965	.954	.942	.940							
179		.937	.941	.944	.947	.948	.959	.970	.980							
180		.990	1.000	1.013	1.026	1.039	1.053	1.067	1.083							
181		1.069	1.069	1.068	1.080	1.066	1.051	1.035	1.019							
182		1.003	.986	.973	.951	.949	.937	.927	.917							
183		.922	.927	.931	.934	.936	.937	.948	.958							
184		.968	.978	.987	.996	1.003	1.003	1.034	1.050							
185		1.064	1.078	1.080	1.082	1.082	1.082	1.081	1.084							
186		1.079	1.064	1.049	1.033	1.017	1.000	.983	.969							
187		.956	.944	.932	.921	.911	.901	.907	.913							
188		.918	.922	.924	.926	.927	.937	.947	.954							
189		.966	.974	.983	.991	1.005	1.019	1.033	1.047							
190		1.061	1.075	1.090	1.092	1.094	1.095	1.096	1.096							
191		1.095	1.107	1.092	1.077	1.062	1.046	1.030	1.014							
192		.997	.979	.965	.951	.938	.926	.915	.904							
193		.885	.885	.892	.898	.904	.908	.912	.915							
194		.916	.916	.926	.936	.945	.953	.962	.970							
195		.978	.986	1.000	1.014	1.028	1.043	1.057	1.072							
196		1.086	1.101	1.104	1.107	1.108	1.109	1.110	1.109							
197		1.108														
198	217															
199		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
200		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00							
	0	1	2	3	4	5	6	7	8							
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6

[illegible]

INPUT AND OUTPUT IN ENGLISH ENGINEERING UNITS
 ASSEMBLY MODEL CHOSEN USES THERMAL RESISTANCE IN PLACE OF INTERASSEMBLY GAP, BUT DUCT WALL IS NONALIZED
 NUMBER OF ASSEMBLIES 10
 NUMBER OF ASSEMBLY TYPES 4
 CODE CORRELATION FOR COOLANT (NA) PROPERTIES USED
 CODE CORRELATION FOR DUCT (316 SS) PROPERTIES USED
 NUMBER OF AXIAL NODES IN COOLANT 0
 AXIAL HEIGHTS FOR TEMPERATURE MAP PRINTOUTS
 90.00000 IN
 AXIAL HEIGHTS FOR AVERAGE DUCT WALL TEMPERATURE PRINTOUTS
 0.00000 IN 36.00000 IN 90.00000 IN
 ASSEMBLY LENGTH 90.00 IN
 COOLANT MASS VELOCITY THROUGH INTERASSEMBLY GAP 55000.0 LBM/FT**2-HR
 INTERASSEMBLY GAP THICKNESS .17500 IN
 AXIAL STABILITY CHECK INDICATOR 1
 DUCT-TO-COOLANT HEAT TRANSFER COEFFICIENT $NU = .0250 * RE^{.8} * (.800) * PR^{.4} * (.800) + 7.0000$

BUNDLE TYPE DATA

BUNDLE TYPE NUMBER 1
 COOLANT NODES ARE STANDARD SUBCHANNELS
 NUMBER OF PINS 217
 SHAPE FACTOR 1.10000
 ROD CENTER TO CENTER DISTANCE (PITCH) .2490 IN
 WIRE WRAP PERIOD (LEAD LENGTH) 12.0000 IN
 DUCT INTERIOR FLAT TO FLAT DISTANCE 4.3350 IN
 DUCT THICKNESS .1200 IN
 CLAD OUTSIDE DIAMETER (ROD DIAMETER) .2300 IN
 SPACER WIRE DIAMETER .0560 IN
 SPACER WIRE DIAMETER ADJACENT TO DUCT .0560 IN
 CODE CORRELATIONS FOR EPSILON(1) AND C1 USED
 HIT FLOW SPLIT CORRELATION USED

BUNDLE TYPE NUMBER 2
 COOLANT NODES ARE STANDARD SUBCHANNELS
 NUMBER OF PINS 217
 SHAPE FACTOR 1.10000
 ROD CENTER TO CENTER DISTANCE (PITCH) .2490 IN
 WIRE WRAP PERIOD (LEAD LENGTH) 12.0000 IN
 DUCT INTERIOR FLAT TO FLAT DISTANCE 4.3350 IN
 DUCT THICKNESS .1200 IN
 CLAD OUTSIDE DIAMETER (ROD DIAMETER) .2300 IN
 SPACER WIRE DIAMETER .0560 IN
 SPACER WIRE DIAMETER ADJACENT TO DUCT .0560 IN
 CODE CORRELATIONS FOR EPSILON(1) AND C1 USED
 HIT FLOW SPLIT CORRELATION USED

BUNDLE TYPE NUMBER 3
 COOLANT NODES ARE DEFINED BY POROUS BODY INPUT
 NUMBER OF RINGS IN POROUS BODY REPRESENTATION 4
 NUMBER OF PINS 217
 SHAPE FACTOR 1.10000
 ROD CENTER TO CENTER DISTANCE (PITCH) .2490 IN
 WIRE WRAP PERIOD (LEAD LENGTH) 12.0000 IN
 DUCT INTERIOR FLAT TO FLAT DISTANCE 4.3350 IN
 DUCT THICKNESS .1200 IN
 CLAD OUTSIDE DIAMETER (ROD DIAMETER) .2300 IN
 SPACER WIRE DIAMETER .0560 IN
 SPACER WIRE DIAMETER ADJACENT TO DUCT .0560 IN
 CODE CORRELATIONS FOR EPSILON(1) AND C1 USED
 HIT FLOW SPLIT CORRELATION USED

BUNDLE TYPE NUMBER 4
 COOLANT MODES ARE STANDARD SUBCHANNELS
 BUNDLE IS A BYPASS ASSEMBLY
 SECOND WALL THICKNESS .04400 IN
 BYPASS GAP THICKNESS .1153 IN
 NUMBER OF PINS 61
 SHAPE FACTOR 1.10000
 ROD CENTER TO CENTER DISTANCE (PITCH) .5020 IN
 WIRE WRAP PERIOD (LEAD LENGTH) 20.5400 IN
 DUCT INTERIOR FLAT TO FLAT DISTANCE 4.0150 IN
 DUCT THICKNESS .1200 IN
 CLAD OUTSIDE DIAMETER (ROD DIAMETER) .4740 IN
 SPACER WIRE DIAMETER .0240 IN
 SPACER WIRE DIAMETER ADJACENT TO DUCT .0240 IN
 CODE CORRELATIONS FOR EPSILON(1) AND C1 USED
 MIT FLOW SPLIT CORRELATION USED
 PROFILES

NUMBER OF AXIAL POWER PROFILES 3
 NUMBER OF RADIAL PIN POWER PROFILES 7
 NUMBER OF AXIAL BOUNDARY CONDITION PROFILES 1
 NUMBER OF BOUNDARY CONDITION FACIAL SKEW PROFILES 1
 NUMBER OF FLOW SPLIT VS. REF NUMBER PROFILES 0
 NUMBER OF E* AND C1 VS. REF NUMBER PROFILES 0
 NUMBER OF POROUS BODY COOLANT HEAT GENERATION PROFILES 1

AXIAL POWER PROFILE NUMBER 1									
RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER
HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR
0.0000	.0212	.0180	.0650	.0536	.9540	.0891	1.0640	.1251	1.1530
.1607	1.2130	.1063	1.2030	.2123	1.1430	.2679	1.1040	.3038	.9040
.3394	.8650	.3750	.7460	.3933	.6560	.4000	.6120	.4001	0.0000
1.0000	0.0000								

AXIAL POWER PROFILE NUMBER 2									
RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER
HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR
0.0000	0.0000	.1990	0.0000	.2000	2.3000	.0000	.0000	.0000	.3800
.6000	.2000	.6010	0.0000	1.0000	0.0000				

AXIAL POWER PROFILE NUMBER 3									
RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER	RELATIVE	POWER
HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR	HEIGHT	FACTOR
0.0000	0.0000	.7990	0.0000	.4000	.9200	.0000	.4200	.0000	.2200
.7000	.1000	.8000	.0500	.8010	0.0000	1.0000	0.0000		

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
1	1.00300	2	1.00200	3	1.00150	4	.99100	5	.99300	6	1.00000	7	1.02000	8	1.03000
9	1.00100	10	1.00100	11	.99400	12	.97500	13	.97700	14	.97900	15	.99400	16	1.00000
17	1.00400	18	1.00100	19	1.00400	20	1.00900	21	1.00200	22	1.01400	23	.99400	24	.99300
25	.97100	26	.95800	27	.96200	28	.96400	29	.96400	30	.97000	31	.99300	32	1.00500
33	1.00400	34	1.00000	35	1.00500	36	1.00500	37	1.00300	38	1.00300	39	1.00500	40	1.00700
41	1.00300	42	.99000	43	.97400	44	.96500	45	.95000	46	.94200	47	.94000	48	.94000
49	.95000	50	.94000	51	.93000	52	.92700	53	.92100	54	1.00500	55	1.00200	56	1.00300
57	1.00500	58	1.00000	59	1.00100	60	1.00600	61	1.00600	62	1.00600	63	1.00500	64	1.00000
65	1.00200	66	1.00300	67	.99300	68	.97100	69	.95900	70	.94900	71	.93700	72	.92600
73	.93100	74	.92400	75	.91600	76	.90600	77	.89500	78	.88000	79	.86000	80	.84000
81	.82700	82	1.00100	83	1.00100	84	1.003700	85	1.005300	86	1.007000	87	1.008500	88	1.008500
89	1.009400	90	1.008000	91	1.007000	92	1.008000	93	1.007100	94	1.005300	95	1.003500	96	1.001600
97	.99600	98	.97600	99	.95400	100	.93200	101	.94100	102	.93000	103	.92000	104	.91000
105	.91600	106	.90000	107	.88400	108	.86800	109	.85200	110	.83600	111	.82000	112	.80400
113	.78800	114	.77200	115	.75600	116	.74000	117	.72400	118	.70800	119	.69200	120	.67600
121	1.00400	122	1.00900	123	1.00000	124	1.00900	125	1.00800	126	1.00600	127	1.00200	128	1.00100
129	1.00800	130	1.00600	131	1.00400	132	1.00200	133	1.00000	134	.99800	135	.99600	136	.99600
137	.99400	138	.99300	139	.99200	140	.99100	141	.99000	142	.98900	143	.98800	144	.98700
145	.98600	146	.98500	147	.98400	148	.98300	149	.98200	150	.98100	151	.98000	152	.97900
153	.97800	154	.97700	155	.97600	156	.97500	157	1.001000	158	1.002000	159	1.003000	160	1.004000
161	1.005000	162	1.006000	163	1.007000	164	1.008000	165	1.009000	166	1.010000	167	1.011000	168	1.012000
169	1.013000	170	1.014000	171	1.015000	172	1.016000	173	1.017000	174	1.018000	175	1.019000	176	1.020000
177	.99100	178	.98000	179	.96900	180	.95800	181	.94700	182	.93600	183	.92500	184	.91400
185	.90300	186	.89200	187	.88100	188	.87000	189	.85900	190	.84800	191	.83700	192	.82600
193	.81500	194	.80400	195	.79300	196	.78200	197	.77100	198	.76000	199	.74900	200	.73800
201	.72700	202	.71600	203	.70500	204	.69400	205	.68300	206	.67200	207	.66100	208	.65000
209	.63900	210	.62800	211	.61700	212	.60600	213	.59500	214	.58400	215	.57300	216	.56200
217	1.11600														

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
1	1.00300	2	1.00150	3	1.00100	4	.99100	5	.99100	6	1.00300	7	1.01500	8	1.02400
9	1.01500	10	1.00400	11	.99200	12	.97900	13	.97800	14	.97800	15	.99100	16	1.00400
17	1.001500	18	1.00400	19	1.00400	20	1.003600	21	1.00400	22	1.00400	23	1.00400	24	.99300
25	.98000	26	.96500	27	.96500	28	.96400	29	.96500	30	.97900	31	.99300	32	1.00500
33	1.01600	34	1.00600	35	1.003600	36	1.003600	37	1.003600	38	1.00500	39	1.003600	40	1.00700
41	1.001700	42	1.000700	43	.99500	44	.98100	45	.96700	46	.95200	47	.93100	48	.95000
49	.95000	50	.95100	51	.96600	52	.98000	53	.99300	54	1.00600	55	1.01700	56	1.00700
57	1.003700	58	1.004700	59	1.004600	60	1.004500	61	1.004500	62	1.00400	63	1.00400	64	1.003700
65	1.002800	66	1.001900	67	1.000900	68	.99700	69	.98300	70	.96900	71	.95300	72	.93800
73	.93600	74	.92500	75	.91300	76	.90000	77	.88700	78	.87200	79	.85700	80	.84100
81	.82600	82	1.008000	83	1.001900	84	1.002900	85	1.003900	86	1.004900	87	1.005700	88	1.005400
89	1.005500	90	1.005400	91	1.005400	92	1.006200	93	1.005500	94	1.004700	95	1.003000	96	1.001000
97	1.002100	98	1.001100	99	.99900	100	.98500	101	.97100	102	.95500	103	.94000	104	.92300
105	.92100	106	.90000	107	.87900	108	.85800	109	.83700	110	.81600	111	.79500	112	.77400
113	.75300	114	.73200	115	.71100	116	.69000	117	.66900	118	.64800	119	.62700	120	.60600
121	1.005900	122	1.006700	123	1.006500	124	1.006400	125	1.006300	126	1.006200	127	1.006000	128	1.000000
129	1.004300	130	1.005600	131	1.004800	132	1.004000	133	1.003200	134	1.002400	135	1.001600	136	1.001000
137	.99800	138	.97300	139	.94800	140	.92200	141	.89600	142	.87000	143	.84400	144	.81800
145	.79200	146	.76600	147	.74000	148	.71400	149	.68800	150	.66200	151	.63600	152	.61000
153	.58400	154	.55800	155	.53200	156	.50600	157	.48000	158	.45400	159	.42800	160	.40200
161	.37600	162	.35000	163	.32400	164	.29800	165	.27200	166	.24600	167	.22000	168	.19400
169	.16800	170	.14200	171	.11600	172	.09000	173	.06400	174	.03800	175	.01200	176	.00000
177	1.002500	178	1.001400	179	1.000300	180	.999000	181	.997000	182	.995000	183	.993000	184	.991000
185	.989000	186	.987000	187	.985000	188	.983000	189	.981000	190	.979000	191	.977000	192	.975000
193	.973000	194	.971000	195	.969000	196	.967000	197	.965000	198	.963000	199	.961000	200	.959000
201	1.000100	202	1.001500	203	1.002900	204	1.004300	205	1.005700	206	1.007100	207	1.008500	208	1.009900
209	1.011300	210	1.012700	211	1.014100	212	1.015500	213	1.016900	214	1.018300	215	1.019700	216	1.021100
217	1.022500														

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER
1	1.00200	2	1.01300
9	1.01000	10	.99700
17	1.02000	18	1.03000
25	.97000	26	.95700
33	1.02400	34	1.03400
41	1.00600	42	.99300
49	.95200	50	.95600
57	1.04700	58	1.05500
65	1.01700	66	1.00500
73	.92700	74	.91000
81	1.00900	82	1.02400
89	1.05900	90	1.05600
97	1.00500	98	.99300
105	.91000	106	.91300
113	.98200	114	.99800
121	1.07200	122	1.08000
129	1.05700	130	1.04700
137	.96600	138	.95200
145	.83800	146	.90200
153	.94700	154	1.00300
161	1.07700	162	1.08400
169	1.05900	170	1.07400
177	1.00500	178	.99300
185	.88900	186	.87300
193	.83900	194	.90500
201	1.02200	202	1.03600
209	1.03600	210	1.10300
217	1.07600		

3

PIN	POWER	PIN	POWER
3	.99900	4	.98800
11	.98500	12	.97300
19	1.02600	20	1.03200
27	.96000	28	.96400
35	1.04300	36	1.03900
43	.98100	44	.96800
51	.97300	52	.98900
59	1.05100	60	1.04900
67	.99300	68	.98000
75	.93100	76	.93900
83	1.03300	84	1.04200
91	1.05300	92	1.05900
99	.94700	100	.96600
107	.91600	108	.92100
115	1.01300	116	1.02800
123	1.07500	124	1.07100
131	1.03700	132	1.02700
139	.93700	140	.92200
147	.90700	148	.91200
155	1.01900	156	1.03200
163	1.08200	164	1.08700
171	1.04500	172	1.05600
179	.94000	180	.96600
187	.87400	188	.87600
195	.92400	196	.94200
203	1.01900	204	1.05500
211	1.09900	212	1.09400

4

PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
5	.99100	6	1.00600	7	1.01400	8	1.02300	13	.97600	14	.98000
11	.97300	12	1.02000	13	.97600	14	.98000	15	.99500	16	1.01000
19	1.03200	20	1.03200	21	1.02000	22	1.00800	23	.99500	24	.98300
27	.96400	28	.96800	29	.96800	30	.98400	31	1.00000	32	1.01400
35	1.03900	36	1.03500	37	1.03500	38	1.04200	39	1.03000	40	1.01800
43	.96800	44	.95500	45	.95500	46	.96100	47	.94400	48	.94800
51	.97300	52	1.00400	53	1.00400	54	1.01900	55	1.02000	56	1.03800
59	1.04900	60	1.04900	61	1.04400	62	1.05000	63	1.03000	64	1.02800
67	.98000	68	.96700	69	.96700	70	.95300	71	.93700	72	.92500
75	.93900	76	.94400	77	.94400	78	.96100	79	.97800	80	.99300
83	1.04200	84	1.05100	85	1.05100	86	1.06000	87	1.06900	88	1.06400
91	1.05900	92	1.05900	93	1.04800	94	1.03900	95	1.02700	96	1.01600
99	.96600	100	.96600	101	.95200	102	.93900	103	.92300	104	.90700
107	.92100	108	.92100	109	.92600	110	.93100	111	.94700	112	.96600
115	1.02800	116	1.03700	117	1.03700	118	1.04700	119	1.05400	120	1.06400
123	1.07100	124	1.06700	125	1.06700	126	1.06400	127	1.06100	128	1.06700
131	1.02700	132	1.01600	133	1.01600	134	1.00500	135	.99300	136	.98000
139	.92200	140	.90400	141	.90400	142	.89000	143	.89200	144	.89400
147	.91200	148	.91800	149	.91800	150	.93600	151	.95400	152	.97100
155	1.03200	156	1.04200	157	1.04200	158	1.05100	159	1.06000	160	1.06800
163	1.08700	164	1.09300	165	1.09300	166	1.07900	167	1.07500	168	1.07100
171	1.05600	172	1.04700	173	1.04700	174	1.03700	175	1.02700	176	1.01700
179	.96600	180	.95200	181	.95200	182	.93700	183	.92100	184	.90500
187	.87600	188	.87900	189	.87900	190	.88300	191	.88800	192	.89300
195	.94200	196	.95900	197	.95900	198	.97600	199	.99200	200	1.00700
203	1.05500	204	1.06400	205	1.06400	206	1.07200	207	1.08100	208	1.08900
211	1.09400	212	1.09000	213	1.09000	214	1.08600	215	1.08200	216	1.07900

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER
1	.93200	2	.97200
9	.98500	10	.95900
17	.99200	18	1.03900
25	.92000	26	.90800
33	1.02200	34	1.06400
41	1.06100	42	1.05100
49	.90800	50	.92600
57	1.15300	58	1.22000

4

PIN	POWER	PIN	POWER
3	.93700	4	.90600
11	.92000	12	.89700
19	1.02600	20	1.10500
27	.89200	28	.89200
35	1.12100	36	1.10100
43	.92600	44	.96100
51	.93200	52	.95100
59	1.19300	60	1.17800

4

PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
5	.90700	6	.94100	7	.97500	8	1.03000	13	.89100	14	.88900
11	.89700	12	.89700	13	.89100	14	.88900	15	.92300	16	.96300
19	1.10500	20	1.05000	21	1.05000	22	1.01500	23	.99800	24	.95100
27	.89200	28	.90700	29	.90700	30	.92000	31	.95000	32	.99700
35	1.10100	36	1.09500	37	1.09500	38	1.14500	39	1.13200	40	1.08700
43	.96100	44	.93900	45	.93900	46	.93300	47	.91000	48	.90200
51	.93200	52	.98600	53	.98600	54	1.03900	55	1.06200	56	1.10000

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER
1	1.00000	2	1.01800
9	1.01600	10	1.00400
17	1.01800	18	1.02900
25	.98400	26	.97500
33	1.01700	34	1.02800
41	1.00800	42	.99500
49	.96600	50	.96600
57	1.03700	58	1.04800
65	1.01400	66	1.00100
73	.95300	74	.95400
81	.99300	82	1.00100
89	1.06100	90	1.06000
97	.99400	98	.98100
105	.98100	106	.94300
113	.97400	114	.98300
121	1.05400	122	1.06700
129	1.05400	130	1.03900
137	.96500	138	.95900
145	.93100	146	.94200
153	.97200	154	.98100
161	1.05000	162	1.06200
169	1.07500	170	1.07600
177	.97600	178	.96400
185	.92400	186	.91500
193	.91900	194	.91900
201	.98600	202	.99200
209	1.07100	210	1.08500
217	1.08400		

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PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
3	1.00700	4	.99700	5	.99800	6	1.00900	7	1.01800	8	1.02700	9	.99800	10	1.00400
11	.99600	12	.98600	13	.98700	14	.98800	15	.99800	16	1.00400	17	1.01800	18	1.02900
19	1.02900	20	1.03600	21	1.02400	22	1.01200	23	1.00100	24	.99300	25	.98400	26	.97500
27	.97600	28	.97700	29	.97700	30	.98700	31	.99700	32	1.00600	33	1.01700	34	1.02800
35	1.03900	36	1.03900	37	1.03900	38	1.04500	39	1.03200	40	1.02000	41	1.00800	42	.99500
43	.98900	44	.98100	45	.97200	46	.96300	47	.96500	48	.96600	49	.96600	50	.96600
51	.97600	52	.98600	53	.99500	54	1.00400	55	1.01500	56	1.02600	57	1.03700	58	1.04800
59	1.05000	60	1.05000	61	1.04800	62	1.04500	63	1.04000	64	1.03700	65	1.01400	66	1.00100
67	.94900	68	.98300	69	.97700	70	.96900	71	.96100	72	.95100	73	.95300	74	.95400
75	.93500	76	.95500	77	.95400	78	.96300	79	.97500	80	.98400	81	.99300	82	1.00100
83	1.01200	84	1.02300	85	1.03400	86	1.04600	87	1.05800	88	1.06000	89	1.06100	90	1.06000
91	1.05700	92	1.06100	93	1.04700	94	1.03300	95	1.02000	96	1.00700	97	.99400	98	.98100
99	.97700	100	.97100	101	.96500	102	.95700	103	.94900	104	.93900	105	.93100	106	.92200
107	.91300	108	.90300	109	.89300	110	.88300	111	.87300	112	.86400	113	.85400	114	.84300
115	.83100	116	.81800	117	.80900	118	.79900	119	.78900	120	.77900	121	.76900	122	.75900
123	1.07000	124	1.07100	125	1.07200	126	1.07000	127	1.06800	128	1.06900	129	1.05400	130	1.03900
131	1.02500	132	1.01100	133	.99800	134	.98500	135	.97300	136	.96900	137	.96500	138	.95900
139	.95300	140	.94500	141	.93700	142	.92700	143	.92000	144	.91000	145	.90300	146	.89200
147	.88100	148	.87100	149	.86100	150	.85200	151	.84200	152	.83300	153	.82200	154	.81100
155	.80000	156	.79500	157	1.00500	158	1.01500	159	1.02600	160	1.03800	161	1.05000	162	1.06200
163	1.07400	164	1.08000	165	1.08200	166	1.08300	167	1.08200	168	1.08000	169	1.07500	170	1.07600
171	1.06100	172	1.04500	173	1.03000	174	1.01600	175	1.00200	176	.98900	177	.97600	178	.96400
179	.95100	180	.93800	181	.92500	182	.91700	183	.90400	184	.89300	185	.88100	186	.86900
187	.85700	188	.84800	189	.83900	190	.83000	191	.82000	192	.81000	193	.80100	194	.79200
195	.78300	196	.77400	197	.76500	198	.75600	199	.74700	200	.73800	201	.72900	202	.72000
203	1.00200	204	1.01100	205	1.02200	206	1.03300	207	1.04500	208	1.05700	209	1.07100	210	1.08500
211	1.09900	212	1.09300	213	1.09500	214	1.09300	215	1.09300	216	1.09000				

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER
1	.93300	2	.95000
9	.98700	10	.95600
17	.99300	18	1.03700
25	.91100	26	.90600
33	1.02300	34	1.06000
41	1.05800	42	1.03900
49	.91600	50	.94500
57	1.19300	58	1.20600

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PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
3	.93800	4	.90600	5	.90900	6	.90300	7	.97600	8	1.03300	9	.98700	10	.95600
11	.91700	12	.89400	13	.89100	14	.90000	15	.92700	16	.96700	17	.99300	18	1.03700
19	1.02700	20	1.11100	21	1.05500	22	1.01600	23	.99300	24	.94300	25	.91100	26	.90600
27	.94800	28	.98500	29	.91500	30	.93000	31	.95900	32	1.00400	33	1.02300	34	1.06000
35	1.11500	36	1.09900	37	1.09700	38	1.20400	39	1.14000	40	1.09000	41	1.05800	42	1.03900
43	.94300	44	.94200	45	.91800	46	.91200	47	.89200	48	.90000	49	.91600	50	.94500
51	.95000	52	.96900	53	1.00400	54	1.05400	55	1.08600	56	1.09600	57	1.19300	58	1.20600
59	1.14500	60	1.17700	61	1.19400										

RADIAL		PIN POWER		PROFILE		NUMBER		A		PIN POWER		PIN POWER		PIN POWER	
PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
1	1.000000	2	1.000000	3	1.000000	4	1.000000	5	1.000000	6	1.000000	7	1.000000	8	1.000000
9	1.000000	10	1.000000	11	1.000000	12	1.000000	13	1.000000	14	1.000000	15	1.000000	16	1.000000
17	1.000000	18	1.000000	19	1.000000	20	1.000000	21	1.000000	22	1.000000	23	1.000000	24	1.000000
25	1.000000	26	1.000000	27	1.000000	28	1.000000	29	1.000000	30	1.000000	31	1.000000	32	1.000000
33	1.000000	34	1.000000	35	1.000000	36	1.000000	37	1.000000	38	1.000000	39	1.000000	40	1.000000
41	1.000000	42	1.000000	43	1.000000	44	1.000000	45	1.000000	46	1.000000	47	1.000000	48	1.000000
49	1.000000	50	1.000000	51	1.000000	52	1.000000	53	1.000000	54	1.000000	55	1.000000	56	1.000000
57	1.000000	58	1.000000	59	1.000000	60	1.000000	61	1.000000	62	1.000000	63	1.000000	64	1.000000
65	1.000000	66	1.000000	67	1.000000	68	1.000000	69	1.000000	70	1.000000	71	1.000000	72	1.000000
73	1.000000	74	1.000000	75	1.000000	76	1.000000	77	1.000000	78	1.000000	79	1.000000	80	1.000000
81	1.000000	82	1.000000	83	1.000000	84	1.000000	85	1.000000	86	1.000000	87	1.000000	88	1.000000
89	1.000000	90	1.000000	91	1.000000	92	1.000000	93	1.000000	94	1.000000	95	1.000000	96	1.000000
97	1.000000	98	1.000000	99	1.000000	100	1.000000	101	1.000000	102	1.000000	103	1.000000	104	1.000000
105	1.000000	106	1.000000	107	1.000000	108	1.000000	109	1.000000	110	1.000000	111	1.000000	112	1.000000
113	1.000000	114	1.000000	115	1.000000	116	1.000000	117	1.000000	118	1.000000	119	1.000000	120	1.000000
121	1.000000	122	1.000000	123	1.000000	124	1.000000	125	1.000000	126	1.000000	127	1.000000	128	1.000000
129	1.000000	130	1.000000	131	1.000000	132	1.000000	133	1.000000	134	1.000000	135	1.000000	136	1.000000
137	1.000000	138	1.000000	139	1.000000	140	1.000000	141	1.000000	142	1.000000	143	1.000000	144	1.000000
145	1.000000	146	1.000000	147	1.000000	148	1.000000	149	1.000000	150	1.000000	151	1.000000	152	1.000000
153	1.000000	154	1.000000	155	1.000000	156	1.000000	157	1.000000	158	1.000000	159	1.000000	160	1.000000
161	1.000000	162	1.000000	163	1.000000	164	1.000000	165	1.000000	166	1.000000	167	1.000000	168	1.000000
169	1.000000	170	1.000000	171	1.000000	172	1.000000	173	1.000000	174	1.000000	175	1.000000	176	1.000000
177	1.000000	178	1.000000	179	1.000000	180	1.000000	181	1.000000	182	1.000000	183	1.000000	184	1.000000
185	1.000000	186	1.000000	187	1.000000	188	1.000000	189	1.000000	190	1.000000	191	1.000000	192	1.000000
193	1.000000	194	1.000000	195	1.000000	196	1.000000	197	1.000000	198	1.000000	199	1.000000	200	1.000000
201	1.000000	202	1.000000	203	1.000000	204	1.000000	205	1.000000	206	1.000000	207	1.000000	208	1.000000
209	1.000000	210	1.000000	211	1.000000	212	1.000000	213	1.000000	214	1.000000	215	1.000000	216	1.000000
217	1.000000														

RADIAL PIN POWER PROFILE NUMBER

PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER	PIN	POWER
1	.99800	2	1.00300	3	.99800	4	.99300	5	.99300	6	.99800	7	1.00300	8	1.00900
9	1.00300	10	.99800	11	.99200	12	.98700	13	.98800	14	.98800	15	.99300	16	.99800
17	1.00300	18	1.00800	19	1.00900	20	1.01600	21	1.01000	22	1.00400	23	.99800	24	.99200
25	.98700	26	.98200	27	.98300	28	.98300	29	.98400	30	.98900	31	.99400	32	.99800
33	1.00300	34	1.00800	35	1.01400	36	1.01400	37	1.01500	38	1.02300	39	1.01600	40	1.01000
41	1.00400	42	.99800	43	.99200	44	.98700	45	.98200	46	.97700	47	.97700	48	.97800
49	.97900	50	.98000	51	.98500	52	.99000	53	.99400	54	.99900	55	1.00300	56	1.00700
57	1.01300	58	1.01900	59	1.02000	60	1.02100	61	1.02200	62	1.03000	63	1.02300	64	1.01600
65	1.01000	66	1.00400	67	.99800	68	.99200	69	.98600	70	.98100	71	.97600	72	.97100
73	.97200	74	.97300	75	.97400	76	.97500	77	.97700	78	.98200	79	.98700	80	.99100
81	.99500	82	.99900	83	1.00200	84	1.00700	85	1.01200	86	1.01800	87	1.02400	88	1.02600
89	1.02700	90	1.02800	91	1.02900	92	1.03700	93	1.03000	94	1.02300	95	1.01600	96	1.01000
97	1.00300	98	.99700	99	.99200	100	.98600	101	.98100	102	.97600	103	.97100	104	.96600
105	.96700	106	.96700	107	.96900	108	.97000	109	.97200	110	.97400	111	.97900	112	.98400
113	.98800	114	.99200	115	.99600	116	.99900	117	1.00200	118	1.00600	119	1.01100	120	1.01700
121	1.02300	122	1.03000	123	1.03200	124	1.03300	125	1.03500	126	1.03600	127	1.03700	128	1.04500
129	1.03700	130	1.03000	131	1.02300	132	1.01600	133	1.00900	134	1.00300	135	.99700	136	.99100
137	.98600	138	.98100	139	.97500	140	.97000	141	.96500	142	.96000	143	.95500	144	.95200
145	.95700	146	.96400	147	.96600	148	.96800	149	.97000	150	.97600	151	.98100	152	.98500
153	.99000	154	.99300	155	.99700	156	1.00000	157	1.00200	158	1.00600	159	1.01000	160	1.01500
161	1.02100	162	1.02800	163	1.03500	164	1.03800	165	1.04000	166	1.04100	167	1.04300	168	1.04400
169	1.04400	170	1.04200	171	1.04400	172	1.03700	173	1.03000	174	1.02200	175	1.01600	176	1.00900
177	1.00300	178	.99600	179	.99100	180	.98600	181	.98000	182	.97500	183	.97000	184	.96500
185	.96000	186	.95400	187	.95500	188	.95600	189	.95700	190	.95800	191	.96000	192	.96200
193	.96400	194	.96700	195	.97300	196	.97800	197	.98300	198	.98700	199	.99100	200	.99500
201	.99800	202	1.00000	203	1.00200	204	1.00500	205	1.00900	206	1.01400	207	1.01900	208	1.02500
209	1.03300	210	1.04000	211	1.04300	212	1.04600	213	1.04800	214	1.05000	215	1.05100	216	1.05200
217	1.05200														

AXIAL BOUNDARY CONDITION PROFILE NUMBER

NORMALIZED HEIGHT	NORMALIZED FACTOR
0.0000	1.00000
1.0000	1.00000

BOUNDARY CONDITION FACIAL SKEW PROFILE NUMBER

NORMALIZED DISTANCE	NORMALIZED FACTOR
0.0000	1.00000
1.0000	1.00000

THIS PROFILE ASSOCIATED WITH BUNDLE TYPE NUMBER

POROUS BODY ENERGY GENERATION PROFILE NUMBER

CHAN.	POWER	CHAN.	POWER	CHAN.	POWER	CHAN.	POWER	CHAN.	POWER	CHAN.	POWER	CHAN.	POWER	CHAN.	POWER
1	2.00000	2	2.00000	3	2.00000	4	2.00000	5	2.00000	6	2.00000	7	2.00000	8	2.00000
9	2.00000	10	2.00000	11	2.00000	12	2.00000	13	2.00000	14	2.00000	15	2.00000	16	2.00000
17	2.00000	18	2.00000	19	2.00000	20	2.00000	21	2.00000	22	2.00000	23	2.00000	24	2.00000
25	2.00000	26	2.00000	27	2.00000	28	2.00000	29	2.00000	30	2.00000	31	2.00000	32	2.00000
33	2.00000	34	2.00000	35	2.00000	36	2.00000	37	2.00000	38	2.00000	39	2.00000	40	2.00000
41	2.00000	42	2.00000	43	2.00000	44	2.00000	45	2.00000	46	2.00000	47	2.00000	48	2.00000
49	2.00000	50	2.00000	51	2.00000	52	2.00000	53	2.00000	54	2.00000	55	2.00000	56	2.00000
57	2.00000	58	2.00000	59	2.00000	60	2.00000	61	2.00000	62	2.00000	63	2.00000	64	2.00000
65	2.00000	66	2.00000	67	2.00000	68	2.00000	69	2.00000	70	2.00000	71	2.00000	72	2.00000
73	2.00000	74	2.00000	75	2.00000	76	2.00000	77	2.00000	78	2.00000	79	2.00000	80	2.00000
81	2.00000	82	2.00000	83	2.00000	84	2.00000	85	2.00000	86	2.00000	87	2.00000	88	2.00000
89	2.00000	90	2.00000	91	2.00000	92	2.00000	93	2.00000	94	2.00000	95	2.00000	96	2.00000
97	1.00000	98	1.00000	99	1.00000	100	1.00000	101	1.00000	102	1.00000	103	1.00000	104	1.00000
105	1.00000	106	1.00000	107	1.00000	108	1.00000	109	1.00000	110	1.00000	111	1.00000	112	1.00000
113	1.00000	114	1.00000	115	1.00000	116	1.00000	117	1.00000	118	1.00000	119	1.00000	120	1.00000
121	.16667	122	.16667	123	.16667	124	.16667	125	.16667	126	.16667				

BUNDLE SPECIFIC DATA

ASSEMBLY NUMBER 1 217 PIN ASSEMBLY NO.1402 5.39 MW

ASSEMBLY TYPE 1
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL:
 AXIAL PIN POWER PROFILE 1
 RADIAL PIN POWER PROFILE 1
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 840.00 F
 DUCT WALL 840.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 29300.0 BTU/HR-FT
 NOMINAL FLOW RATE 203600.0 GPM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL Q''' OF RC BTU/HR-FT**2	NOMINAL Q''' FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	3	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	4	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	5	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	6	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	2	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	10	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 2 217 PIN ASSEMBLY NO.1401 6.29 MW

ASSEMBLY TYPE 2
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL:
 AXIAL PIN POWER PROFILE 1
 RADIAL PIN POWER PROFILE 2
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 860.00 F
 DUCT WALL 860.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 32970.0 BTU/HR-FT
 NOMINAL FLOW RATE 195000.0 GPM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL Q''' OF RC BTU/HR-FT**2	NOMINAL Q''' FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	10	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	1	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	6	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	7	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	8	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	9	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 3 217 PIN ASSEMBLY NO.1403 5.55 MW

ASSEMBLY TYPE 1
 BOUNDARY CONDITIONS ARE TEMPERATURES SPECIFIED OUTSIDE DUCT WALL.
 AXIAL PIN POWER PROFILE 1
 RADIAL PIN POWER PROFILE 3
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 830.00 F
 DUCT WALL 830.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 29090.0 BTU/HR-FT
 NOMINAL FLOW RATE 203600.0 LBM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL TMP OF RC DEG-F BTU/HR-FT**3	NOMINAL TMP OF DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	4	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	1	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	10	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 4 61 PIN CONTROL ASSEMBLY NO.1504 0.192 MW

ASSEMBLY TYPE 4
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL.
 AXIAL PIN POWER PROFILE 2
 RADIAL PIN POWER PROFILE 4
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 750.00 F
 DUCT WALL 750.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 3580.0 BTU/HR-FT
 NOMINAL FLOW RATE 21960.0 LBM/HR
 BYPASS REGION FLOW RATE 14040.00 LBM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL TMP OF RC BTU/HR-FT**3	NOMINAL TMP OF DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	5	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	1	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	3	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 4 217 PIN ASSEMBLY NO.1503 4.94 MW

ASSEMBLY TYPE 1
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL:
 AXIAL PIN POWER PROFILE 1
 RADIAL PIN POWER PROFILE 1
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 830.00 F
 DUCT WALL 830.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 25890.0 BTU/HR-FT
 NOMINAL FLOW RATE 193800.0 GPM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL OF OF RC BTU/HR-FT**2	NOMINAL OF OF FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	4	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	6	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	1	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 6 61 PIN CONTROL ASSEMBLY NO.1502 0.192 MW

ASSEMBLY TYPE 4
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL:
 AXIAL PIN POWER PROFILE 2
 RADIAL PIN POWER PROFILE 6
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 750.00 F
 DUCT WALL 750.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 3580.0 BTU/HR-FT
 NOMINAL FLOW RATE 21960.0 GPM/HR
 BYPASS REGION FLOW RATE 14040.00 GPM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL OF OF RC BTU/HR-FT**2	NOMINAL OF OF FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	1	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	5	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	7	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	2	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 7 217 PIN ASSEMBLY NO.1501 6.36 MW

ASSEMBLY TYPE 1
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL.
 AXIAL PIN POWER PROFILE 1
 RADIAL PIN POWER PROFILE 7
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 870.00 F
 DUCT WALL 870.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 33330.0 BTU/HR-FT
 NOMINAL FLOW RATE 193800.0 GPM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW RC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL Q' OF RC BTU/HR-FT**3	NOMINAL Q' FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	2	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	6	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	8	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER A 217 PIN ASSEMBLY NO.3406 6.45 MW

ASSEMBLY TYPE 3
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL.
 AXIAL PIN POWER PROFILE 1
 POROUS BODY ENERGY GENERATION PROFILE 1
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 870.00 F
 DUCT WALL 870.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 34850.0 BTU/HR-FT
 NOMINAL FLOW RATE 203600.0 GPM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW RC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL Q' OF RC BTU/HR-FT**3	NOMINAL Q' FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	9	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	2	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	7	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 9 217 PIN ASSEMBLY NO.1301 6.69 MW

ASSEMBLY TYPE 1
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL 1
 AXIAL PIN POWER PROFILE 1
 RADIAL PIN POWER PROFILE 9
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 870.00 F
 DUCT WALL 870.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 34750.0 RTU/HR-FT
 NOMINAL FLOW RATE 203600.0 LBM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL Q' OF RC BTU/HR-FT**3	NOMINAL Q' FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	10	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	2	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	8	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00

ASSEMBLY NUMBER 10 61 PIN SAFETY ASSEMBLY NO.1302 0.0636 MW

ASSEMBLY TYPE 4
 BOUNDARY CONDITIONS ARE HEAT FLUXES SPECIFIED OUTSIDE DUCT WALL 4
 AXIAL PIN POWER PROFILE 3
 RADIAL PIN POWER PROFILE 6
 COOLANT INLET TEMPERATURE 680.00 F
 INITIAL MATERIAL PROPERTIES EVALUATED AT THE FOLLOWING TEMPERATURES
 COOLANT 750.00 F
 DUCT WALL 750.00 F
 NOMINAL LINEAR ROD POWER IN BUNDLE 1223.0 RTU/HR-FT
 NOMINAL FLOW RATE 21960.0 LBM/HR
 BYPASS REGION FLOW RATE 14040.00 LBM/HR

FACE	NEIGHBORING ASSEMBLY	APPLICABLE AXIAL RC PROFILE	APPLICABLE FACIAL SKEW SC PROFILE	APPLICABLE AXIAL DUCT WALL GAMMA HT PROFILE	APPLICABLE FACIAL SKEW DUCT WALL GAMMA HT PROFILE	NOMINAL Q' OF RC BTU/HR-FT**3	NOMINAL Q' FOR DUCT WALL GAMMA HT BTU/HR-FT**3
20'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00
120'CLOCK	3	-0	-0	-0	-0	-0.00	-0.00
100'CLOCK	1	-0	-0	-0	-0	-0.00	-0.00
80'CLOCK	2	-0	-0	-0	-0	-0.00	-0.00
60'CLOCK	9	-0	-0	-0	-0	-0.00	-0.00
40'CLOCK	0	-0	-0	-0	-0	-0.00	-0.00

CALCULATED DATA

ASSEMBLY NUMBER	AVERAGE	INTERIOR	VELOCITIES (FT/8)		BYPASS	INTR. GAP	SWIRL	EDDY DIF. (FT**2/8)	GR% INDEX	CHANNEL R _P
			EDGE	CORNER						
1	22.972	22.844	23.467	23.467	-	.290	2.221	.0067	.00029	71025
2	22.071	21.928	22.627	22.627	-	.291	4.248	.0127	.00016	69287
3	22.936	22.808	23.430	23.430	-	.289	2.218	.0066	.00078	70370
4	5.184	4.950	5.577	5.577	6.223	.286	.241	.0041	.00161	12187
5	21.832	21.710	22.302	22.302	-	.289	2.111	.0063	.00022	66983
6	5.184	4.950	5.577	5.577	6.223	.286	.241	.0041	.00156	12187
7	21.970	21.848	22.443	22.443	-	.291	2.124	.0064	.00035	69464
8	23.081	22.953	23.578	23.578	-	.291	2.232	.0067	.00140	72977
9	23.081	22.953	23.578	23.578	-	.291	2.232	.0067	.00014	72977
10	5.184	4.950	5.577	5.577	6.223	.286	.241	.0041	.00053	12187

STABILITY IS GOVERNED BY ASSEMBLY 2
 NUMBER OF AXIAL INCREMENTS CHANGED TO 139
 AXIAL STEP SIZE .016446 M

AVERAGE DUCT WALL TEMPERATURE SUMMARY FOR AXIAL HEIGHT .447 IN

ASSEMBLY	FACE NO. 1	FACE NO. 2	FACE NO. 3	FACE NO. 4	FACE NO. 5	FACE NO. 6
1	682.90 F	681.77 F	682.29 F	681.81 F	682.64 F	682.16 F
2	682.47 F	682.75 F	682.02 F	682.88 F	683.08 F	683.09 F
3	682.59 F	682.33 F	681.71 F	682.35 F	682.04 F	682.71 F
4 INSIDE	680.00 F	680.00 F	680.00 F	680.00 F	680.00 F	680.00 F
4 OUTSIDE	680.03 F	680.00 F	680.03 F	680.58 F	680.62 F	680.55 F
5	681.83 F	682.20 F	682.15 F	682.23 F	681.84 F	682.43 F
6 INSIDE	680.00 F	680.00 F	680.00 F	680.00 F	680.00 F	680.00 F
6 OUTSIDE	680.68 F	680.59 F	680.03 F	680.04 F	680.69 F	680.70 F
7	683.05 F	682.14 F	682.72 F	682.87 F	683.15 F	683.26 F
8	683.00 F	683.03 F	683.09 F	683.01 F	683.00 F	683.01 F
9	683.05 F	682.26 F	682.93 F	682.97 F	683.09 F	683.14 F
10 INSIDE	680.00 F	680.00 F	680.00 F	680.00 F	680.00 F	680.00 F
10 OUTSIDE	680.04 F	680.46 F	680.75 F	680.82 F	680.74 F	680.04 F

AVERAGE DUCT WALL TEMPERATURE SUMMARY FOR AXIAL HEIGHT 36.559 IN

ASSEMBLY	FACE NO. 1	FACE NO. 2	FACE NO. 3	FACE NO. 4	FACE NO. 5	FACE NO. 6
1	916.63 F	857.33 F	893.48 F	853.63 F	930.24 F	884.22 F
2	926.55 F	957.68 F	899.78 F	939.04 F	974.62 F	982.42 F
3	926.85 F	906.46 F	847.02 F	899.61 F	848.54 F	929.73 F
4 INSIDE	707.04 F	703.79 F	702.75 F	724.81 F	729.44 F	724.32 F
4 OUTSIDE	703.15 F	699.08 F	700.51 F	767.11 F	774.14 F	750.47 F
5	859.09 F	887.97 F	883.75 F	886.86 F	845.22 F	904.87 F
6 INSIDE	729.88 F	727.48 F	708.68 F	707.41 F	732.74 F	737.30 F
6 OUTSIDE	774.37 F	766.26 F	706.14 F	707.03 F	714.37 F	794.39 F
7	972.36 F	894.11 F	933.10 F	946.39 F	967.22 F	980.02 F
8	953.69 F	962.43 F	964.42 F	955.84 F	955.04 F	955.25 F
9	968.90 F	897.09 F	958.79 F	935.79 F	962.84 F	971.85 F
10 INSIDE	642.02 F	707.60 F	712.14 F	717.94 F	715.44 F	697.37 F
10 OUTSIDE	645.23 F	763.34 F	778.42 F	796.60 F	777.44 F	887.87 F

TEMPERATURE MAP FOR BUNDLE 1 217 PIN ASSEMBLY NO.1402 4.59 MW
AXIAL HEIGHT 90.007 IN

901 878 876 878 879 882 884 887 897 904
917 906 907 910 914 916 919 922 927 934
* 932 934 938 942 944 949 953 956 959 963 *
938 934 * 931 935 943 951 957 961 964 966 967 967 966 * 958 943
938 934 * 930 938 952 964 973 978 982 984 984 989 978 968 * 967 945
937 934 * 931 941 959 975 987 994 998 1001 1002 990 991 978 969 * 958 947
936 934 * 932 943 964 982 995 1004 1006 1013 1016 1014 1010 998 981 969 * 959 948
935 934 * 933 945 966 985 1000 1009 1015 1020 1024 1026 1025 1018 1003 982 967 * 959 950
933 934 * 930 944 966 986 1001 1011 1018 1023 1028 1032 1034 1031 1023 1005 981 965 * 958 950
931 933 * 934 942 963 984 1001 1012 1019 1025 1030 1034 1038 1040 1036 1025 1004 978 963 * 957 941
929 931 * 933 937 955 978 997 1011 1019 1026 1031 1036 1040 1044 1047 1037 1029 1009 983 * 954 950
929 912 * 931 931 942 965 989 1006 1017 1025 1031 1037 1041 1045 1047 1044 1032 1011 984 * 960 * 932 945
873 901 * 928 935 954 978 994 1012 1021 1028 1033 1038 1043 1046 1046 1039 1023 968 972 961 * 924 886
868 898 * 927 938 962 986 1005 1018 1026 1033 1038 1043 1047 1048 1044 1031 1007 979 963 * 924 883
867 897 * 926 940 967 992 1010 1023 1031 1037 1043 1047 1049 1044 1038 1019 982 964 * 923 882
867 897 * 926 942 970 986 1014 1026 1034 1040 1045 1048 1045 1034 1013 984 964 * 923 881
868 897 * 926 943 972 997 1015 1026 1038 1039 1043 1044 1035 1015 988 964 * 923 880
870 899 * 926 944 971 994 1010 1020 1027 1031 1032 1025 1008 983 964 * 923 881
873 900 * 926 942 966 984 996 1004 1010 1013 1014 1000 980 963 * 923 883
880 903 * 925 947 953 964 973 980 985 987 985 974 964 * 928 893
927 950 954 959 964 968 973 974 978 982
929 972 976 979 983 986 980 991 992 980

TEMPERATURE MAP FOR BUNDLF 2 217 PIN ASSEMBLY NO.1401 6.29 MW
 AXIAL HEIGHT 90.000 IN

929 972 976 979 984 986 989 991 992 940
 972 994 997 999 1001 1003 1004 1005 1006 981
 * 1013 1016 1017 1019 1020 1020 1020 1020 1019 1020 *
 * 1015 1019 1022 1025 1026 1026 1025 1024 *
 929 971 * 1011 1013 1018 1023 1027 1029 1030 1030 1028 1025 1021 * 975 928
 * 1014 1021 1028 1033 1037 1039 1038 1035 1030 *
 926 968 * 1009 1012 1019 1027 1034 1040 1042 1043 1041 1034 1029 1023 * 975 925
 * 1014 1023 1033 1042 1044 1051 1052 1049 1044 1035 *
 924 966 * 1007 1011 1020 1031 1041 1049 1054 1056 1055 1041 1043 1043 1025 * 975 925
 * 1013 1025 1037 1048 1056 1062 1065 1064 1049 1050 1039 *
 923 964 * 1005 1009 1021 1034 1046 1056 1061 1068 1069 1064 1059 1044 1035 1026 * 975 924
 * 1012 1025 1039 1052 1062 1070 1074 1076 1073 1064 1055 1041 *
 922 963 * 1003 1008 1020 1034 1049 1060 1069 1075 1078 1078 1073 1064 1041 1036 1024 * 976 924
 * 1009 1023 1039 1054 1065 1074 1080 1084 1084 1079 1070 1057 1042 *
 922 962 * 1001 1005 1017 1033 1049 1062 1072 1080 1085 1086 1084 1074 1067 1052 1037 1027 * 977 925
 * 1006 1020 1037 1053 1066 1076 1080 1088 1090 1089 1083 1072 1057 1041 *
 922 961 * 999 1001 1013 1030 1047 1061 1073 1082 1088 1091 1092 1088 1080 1047 1051 1036 1027 * 978 927
 * 1001 1014 1032 1049 1064 1076 1084 1090 1094 1094 1091 1083 1070 1054 1039 *
 924 962 * 996 997 1007 1023 1041 1058 1071 1081 1089 1093 1095 1094 1088 1074 1043 1027 1034 1028 * 981 924
 962 979 * 995 * 1029 * 992 944
 1013 1004 * 995 997 1007 1024 1042 1059 1073 1083 1090 1095 1097 1095 1089 1079 1064 1048 1035 1030 * 1019 1088
 * 1001 1015 1033 1051 1067 1079 1087 1093 1096 1097 1093 1085 1071 1056 1040 *
 1015 1005 * 995 1000 1014 1032 1051 1067 1079 1088 1094 1097 1097 1093 1084 1070 1054 1038 1030 * 1020 1009
 * 1005 1022 1041 1059 1073 1084 1091 1095 1097 1095 1088 1074 1061 1044 *
 1016 1006 * 996 1003 1019 1039 1057 1072 1082 1090 1094 1095 1092 1085 1074 1054 1040 1029 * 1019 1010
 * 1009 1027 1044 1063 1076 1085 1091 1094 1093 1088 1077 1062 1045 *
 1018 1007 * 998 1006 1023 1042 1060 1073 1082 1088 1090 1089 1083 1072 1057 1049 1027 * 1019 1011
 * 1012 1031 1049 1064 1076 1083 1087 1088 1084 1074 1061 1045 *
 1018 1009 * 999 1008 1025 1043 1058 1070 1077 1081 1081 1077 1064 1050 1037 1025 * 1018 1011
 * 1014 1032 1048 1061 1070 1076 1078 1076 1069 1058 1042 *
 1019 1010 * 1000 1009 1025 1040 1052 1061 1067 1068 1067 1060 1049 1034 1022 * 1016 1011
 * 1014 1029 1042 1052 1059 1063 1063 1050 1051 1034 *
 1019 1010 * 1001 1009 1021 1032 1041 1047 1051 1051 1044 1041 1030 1020 * 1015 1010
 * 1012 1023 1032 1038 1043 1045 1044 1040 1032 *
 1010 1010 * 1002 1007 1014 1021 1024 1030 1032 1032 1030 1025 1014 * 1014 1009
 * 1007 1013 1017 1021 1024 1026 1024 1024 *
 * 1002 1003 1004 1006 1009 1011 1014 1015 1017 1017 *
 * * * * * * * * * *
 1010 1005 1007 1009 1011 1013 1014 1015 1014 1014
 1018 1010 1011 1012 1013 1014 1015 1015 1015 1011

F.29

TEMPERATURE MAP FOR BUNDLE 3 217 PIN ASSEMBLY NO.1403 5.55 MW
AXIAL HEIGHT 90.000 IN

913 954 958 961 964 965 967 969 970 972
932 954 958 961 964 965 967 969 970 972
* 951 954 958 961 964 965 967 969 970 972
950 957 962 964 969 971 972 973 974 975
872 909 * 945 946 954 962 967 971 973 974 975 * 973 973
947 959 969 976 980 983 984 981 977
873 907 * 940 943 956 968 977 984 987 989 988 987 978 975 * 975 975
947 963 977 987 992 997 999 994 995 984
871 904 * 936 942 959 975 987 995 1000 1003 1004 1000 992 981 976 * 976 976
947 966 984 995 1002 1008 1011 1012 1009 1000 987
870 901 * 932 941 960 979 993 1002 1004 1013 1015 1014 1009 997 984 976 * 976 976
946 968 986 999 1008 1013 1018 1021 1021 1014 1005 989
869 899 * 929 939 960 981 996 1006 1013 1018 1021 1023 1022 1014 1001 985 975 * 975 975
944 964 984 1001 1010 1016 1021 1025 1027 1026 1020 1007 990
868 898 * 926 934 960 982 998 1008 1015 1020 1025 1024 1029 1024 1017 1002 984 974 * 974 974
941 966 987 1002 1012 1018 1023 1027 1030 1032 1030 1023 1004 984
864 896 * 923 933 946 980 994 1009 1017 1022 1026 1030 1033 1033 1029 1018 1001 982 973 * 973 973
935 960 984 1002 1012 1019 1024 1028 1032 1035 1036 1032 1022 1005 985
872 896 * 920 926 949 975 995 1009 1017 1023 1027 1031 1035 1037 1036 1029 1015 986 978 971 * 971 971
904 912 * 919
944 931 * 920 927 949 976 997 1011 1020 1025 1029 1033 1036 1038 1037 1031 1016 986 977 970 * 970 970
* 936 963 984 1006 1017 1024 1028 1032 1036 1034 1039 1035 1024 1006 985
945 933 * 922 934 960 986 1006 1018 1025 1030 1034 1038 1040 1040 1035 1023 1003 981 968 * 968 968
* 944 972 996 1013 1023 1029 1034 1037 1039 1040 1034 1029 1011 984
987 936 * 925 940 964 994 1012 1023 1030 1035 1038 1040 1041 1034 1025 1004 985 966 * 966 964
* 951 979 1003 1018 1027 1033 1037 1040 1041 1039 1030 1013 980
948 938 * 928 945 974 999 1016 1027 1033 1037 1040 1040 1036 1025 1006 981 963 * 962 962
* 956 984 1007 1021 1030 1035 1038 1039 1034 1029 1014 984
990 941 * 932 949 978 1002 1017 1027 1035 1035 1036 1034 1024 1004 974 957 * 957 957
* 960 987 1007 1020 1027 1031 1033 1032 1025 1010 986
950 943 * 935 952 979 999 1012 1019 1023 1025 1024 1016 999 974 952 * 952 952
* 961 983 1001 1011 1014 1019 1019 1014 1002 981
991 944 * 934 953 974 984 997 1002 1004 1004 1000 984 967 987 * 987 947
* 958 974 984 991 994 996 994 987 971
950 944 * 934 948 959 966 970 973 975 974 989 957 942 * 942 942
* 944 954 958 961 963 964 964 954
* 934 936 936 937 934 934 941 941 940 939 *
* 904 900 900 901 901 901 900 907
921
905 870 863 862 861 861 860 854 854 897

F.30

TEMPERATURE MAP FOR BUNDLE 4 61 PIN CONTROL ASSEMBLY NO. 1504 0.192 MW
 AXIAL HEIGHT 90.000 IN

TEMPERATURE MAP FOR BUNDLE 5 217 PIN ASSEMBLY NO.1503 4.94 MW
 AXIAL HEIGHT 90.000 IN

929 929 930 930 930 929 928 928 927 891
 929 929 930 930 930 929 928 928 927 910
 * 929 929 930 930 930 929 928 928 927 927 *
 * 931 936 939 940 940 939 938 937 *
 928 928 * 928 931 937 942 945 946 945 944 940 934 929 * 893 855
 * 935 945 952 957 959 959 956 951 942 *
 927 927 * 927 933 944 954 960 964 965 964 960 959 947 933 * 898 863
 * 939 953 964 971 974 977 976 972 967 950 *
 927 927 * 927 935 950 963 973 974 981 982 980 974 962 947 936 * 902 867
 * 941 957 971 980 986 989 990 989 983 972 955 *
 928 928 * 928 936 952 969 980 987 991 993 994 991 987 964 950 938 * 905 870
 * 951 959 974 985 992 994 998 999 997 990 977 954 *
 928 928 * 928 936 953 970 983 991 996 999 1001 1001 998 988 972 953 940 * 907 873
 * 941 959 975 987 994 999 1002 1004 1005 1003 995 980 960 *
 928 928 * 928 935 953 970 984 992 998 1002 1005 1006 1004 1002 992 975 954 941 * 908 874
 * 939 957 975 987 995 1000 1002 1007 1009 1009 1007 994 982 967 *
 927 927 * 927 933 950 969 983 993 999 1003 1006 1009 1011 1010 1005 994 975 954 942 * 910 877
 * 934 952 971 986 995 1000 1004 1008 1011 1013 1013 1009 998 980 959 *
 928 928 * 928 934 953 963 980 991 998 1003 1007 1010 1013 1014 1013 1006 991 971 951 943 * 913 882
 928 928 * 928 934 953 964 981 992 1000 1004 1008 1011 1014 1015 1014 1007 993 972 953 946 * 942 978
 928 928 * 928 934 953 974 988 997 1003 1007 1010 1013 1016 1016 1012 1001 983 941 *
 928 928 * 928 931 951 971 987 997 1003 1008 1011 1014 1016 1014 1012 1000 980 958 946 * 942 978
 * 939 960 979 992 1000 1006 1010 1013 1016 1017 1014 1004 980 964 *
 925 925 * 925 935 956 976 991 1000 1006 1010 1014 1016 1017 1017 1002 987 960 944 * 940 937
 * 942 964 982 995 1003 1008 1012 1015 1016 1015 1007 991 968 *
 926 926 * 926 937 959 978 993 1001 1007 1011 1014 1015 1012 1002 983 959 940 * 938 936
 * 945 966 984 996 1003 1008 1012 1013 1012 1004 990 964 *
 927 927 * 927 939 960 979 992 1000 1004 1008 1010 1007 998 981 956 937 * 936 935
 * 946 967 983 993 1000 1004 1006 1004 1000 986 943 *
 928 928 * 928 940 959 975 985 992 996 998 997 990 975 952 937 * 933 933
 * 945 963 976 984 989 992 992 980 978 958 *
 929 929 * 929 938 952 964 971 974 978 978 975 960 945 928 * 920 931
 * 941 952 961 966 969 970 969 943 949 *
 928 928 * 928 934 940 945 948 951 952 951 947 946 925 * 927 929
 * 932 936 939 941 942 943 941 935 *
 * 924 924 923 923 924 924 924 924 922 *
 * 924 924 923 923 924 924 924 924 922 *
 914 892 895 894 894 894 894 894 897 908
 901 873 865 864 864 864 864 867 871 992

TEMPERATURE MAP FOR BUNDLE 6 61 PIN CONTROL ASSEMBLY No.1302 0.192 MW
 AXIAL HEIGHT 90.000 IN

```

      812                866 862 865 867                892
      796                835 834 834 837                847
      834                805 805 804 808                824
      820                799 797 799 804                816
      * 807 * 794 * 795 * 794 * 799 808 *
      776 781 784 786
758 758 758 762 * 765 766 777 782 784 786 797 * 802 807 838 849
      764 780 786 788 786
734 734 734 738 * 741 754 776 784 790 789 788 787 * 802 804 836 867
      760 781 791 795 794 790
728 728 728 730 * 733 749 775 789 795 797 794 790 * 806 810 839 869
      757 780 792 798 800 798 794
737 737 737 738 * 739 748 771 788 798 800 801 797 799 812 * 815 818 846 874
804 804 804 788 * 772 748 771 788 798 * 802 803 799 804 823 * 840 840 888 929
746 746 746 748 * 750 752 772 790 798 802 803 802 799
      759 782 795 800 803 802 799
731 731 731 734 * 736 752 778 793 801 803 802 804 821 * 820 836 879 923
      761 785 797 802 802 801
727 727 727 729 * 732 752 779 798 800 800 805 823 * 840 837 879 922
      763 786 796 799 801
734 734 734 736 * 738 757 783 793 798 806 828 * 835 841 881 922
      774 791 798 804
      * 767 790 805 814 823 841 *
      * * * * *
      776 800 814 822 831 843
      785 810 824 831 840 864
      795 855 867 876 885 913
      818 902 914 922 931 962
  
```

TEMPERATURE MAP FOR BUNDLE 7 217 PIN ASSEMBLY NO.1501 6.36 MW
AXIAL HEIGHT 90.00 IN

936 893 903 909 914 920 925 930 939 962
959 939 947 953 959 963 968 973 981 995
* 981 984 990 996 1001 1006 1011 1016 1021 1027
979 979 * 979 985 997 1004 1010 1015 1019 1022 1028 1029 1031 * 1022 1013
* 993 1009 1021 1029 1035 1038 1040 1049 1036 *
979 979 * 979 990 1008 1023 1033 1040 1044 1047 1047 1047 103A 1034 * 1025 1015
* 999 1020 1037 1048 1055 1059 1062 1061 1055 1046 *
980 980 * 980 993 1016 1036 1049 1058 1064 1067 1068 1065 1056 1044 1037 * 1027 1016
* 1003 1028 1048 1061 1069 1074 1078 1080 1076 1067 1042 *
981 981 * 981 996 1021 1044 1060 1070 1074 1081 1084 1084 1077 1064 1044 1038 * 1028 1014
* 1004 1032 1053 1065 1077 1083 1088 1091 1092 1087 1074 1054 *
983 983 * 983 998 1024 1044 1065 1076 1083 1088 1093 1095 1094 1085 1070 1050 103A * 1028 1014
* 1007 1033 1056 1071 1081 1087 1093 1097 1100 1100 1093 1078 1057 *
984 984 * 984 998 1025 1049 1067 1079 1086 1092 1097 1101 1103 1101 1091 1073 1054 1037 * 1024 1019
* 1005 1032 1056 1072 1083 1090 1094 1100 1104 1107 1106 1094 1080 1057 *
985 985 * 985 996 1022 1044 1067 1080 1088 1094 1099 1104 1108 1109 1105 1093 1072 1048 1037 * 1028 1019
* 1000 1027 1052 1071 1083 1090 1096 1101 1106 1110 1112 1109 1098 1077 1053 *
986 986 * 986 991 1014 1042 1064 1079 1088 1095 1100 1105 1110 1113 1113 1106 1090 1046 1044 1036 * 1029 1019
986 986 * 986 992 1015 1043 1066 1091 1090 1097 1102 1107 1112 1115 1115 1108 1091 1047 1045 1037 * 1032 1027
986 986 * 986 998 1026 1053 1074 1087 1095 1102 1107 1112 1116 1117 1113 1109 1076 1050 1037 * 1032 1027
* 1009 1034 1063 1081 1092 1099 1104 1110 1115 1117 1116 1104 1086 1060 *
988 988 * 988 1003 1033 1060 1079 1092 1100 1104 1111 1115 1117 1116 1102 1080 1054 1036 * 1032 1027
* 1014 1044 1069 1085 1096 1103 1109 1114 1117 1115 1107 1088 1062 *
990 990 * 990 1007 1037 1064 1082 1094 1102 1108 1113 1115 1112 1101 1080 1052 1034 * 1030 1026
* 1014 1048 1071 1087 1097 1104 1110 1113 1113 1104 1047 1061 *
993 993 * 993 1010 1040 1065 1082 1093 1101 1106 1109 1107 1097 1077 1050 1030 * 1028 1025
* 1021 1049 1070 1085 1094 1100 1105 1105 1099 1083 1048 *
996 996 * 996 1012 1039 1061 1076 1085 1091 1095 1095 1088 1071 1086 1027 * 1025 1024
* 1021 1045 1063 1075 1082 1087 1090 1084 1074 1053 *
997 997 * 997 1011 1032 1049 1060 1067 1072 1074 1071 1080 1040 1024 * 1023 1022
* 1017 1034 1046 1055 1060 1064 1064 1048 1044 *
998 998 * 998 1007 1019 1028 1035 1040 1044 1045 1041 1031 1021 * 1020 1020
* 1007 1016 1022 1027 1032 1035 1035 1030 *
* 998 998 1001 1004 1007 1011 1015 1014 1010 1019 *
* * * * * * * * * *
998 998 998 1001 1004 1007 1011 1015 1014 1010 1020
998 998 1001 1004 1007 1011 1015 1014 1010
998 998 1001 1004 1007 1011 1015 1014 1010 1019

F.34

TEMPERATURE MAP FOR BUNDLE A 217 PIN ASSEMBLY NO.340A 6.65 MW
 AXIAL HEIGHT 90.000 IN

```

1018      1010 1012 1014 1015      1011
      1017      1013 1014 1015 1015      1013
            * * * * *
      * 1016 1017 1018 1016 1014 1015 *
            *
      1027 1022 * 1016 1027 1028 1052 1047 1026 1015 * 1012 1009
            *
      1027 1023 * 1019 1037 1074 1084 1086 1073 1034 1017 * 1014 1011
            *
      1024 1022 * 1020 1038 1079 1096 1098 1096 1079 1035 1016 * 1014 1012
            *
1021 1020 * 1019 1028 1074 1096 1100 1100 1095 1073 1024 1014 * 1013 1015
1019 1019 * 1018      *
1017 1017 * 1017 1027 1073 1096 1100 1100 1095 1073 1024 1016 * 1016 1014
            *
      1047 1086 1098 1100 1098 1084 1047 *
1018 1018 * 1018 1036 1079 1096 1098 1095 1079 1036 1017 * 1017 1017
            *
      1052 1086 1095 1095 1086 1052 *
1019 1019 * 1019 1037 1073 1084 1086 1073 1035 1016 * 1016 1014
            *
      1047 1073 1079 1073 1046 *
1018 1018 * 1018 1027 1047 1052 1047 1024 1015 * 1015 1015
            *
      1026 1035 1036 1026 *
            *
      * 1017 1016 1017 1018 1017 1016 *
            *
      1017      1016 1017 1018 1017      1016
1017      1016 1017 1018 1017      1016

```

TEMPERATURE MAP FOR BUNDLE 9 217 PIN ASSEMBLY NO.1301 6.69 MW
AXIAL HEIGHT 90.000 IN

954 912 906 905 904 907 911 914 931 977
970 950 949 951 953 955 959 964 974 999
* 986 988 991 995 999 1002 1004 1011 1015 1021 *
* 995 1003 1009 1014 1016 1018 1019 1020 *
1004 997 * 987 995 1005 1014 1019 1022 1025 1026 1029 1024 1024 * 1024 1024
* 1005 1020 1030 1036 1040 1041 1041 1047 1031 *
1009 999 * 989 1002 1020 1034 1042 1047 1049 1050 1047 1040 1031 1024 * 1026 1026
* 1012 1033 1049 1057 1062 1064 1064 1061 1052 1039 *
1010 1001 * 991 1007 1030 1044 1060 1066 1070 1071 1069 1043 1051 1046 1027 * 1027 1027
* 1017 1041 1060 1071 1077 1080 1081 1080 1073 1060 1043 *
1011 1002 * 994 1010 1035 1056 1070 1078 1082 1084 1085 1091 1072 1054 1034 1027 * 1027 1027
* 1020 1045 1065 1077 1084 1088 1090 1091 1088 1080 1065 1045 *
1011 1004 * 997 1012 1034 1060 1075 1083 1088 1091 1092 1092 1088 1077 1049 1036 1024 * 1026 1026
* 1021 1044 1067 1080 1087 1091 1094 1095 1094 1063 1084 1047 1045 *
1011 1005 * 999 1013 1038 1061 1075 1085 1090 1094 1096 1097 1094 1091 1074 1059 1037 1026 * 1026 1026
* 1020 1045 1066 1080 1088 1092 1094 1097 1099 1099 1095 1085 1066 1044 *
1010 1005 * 1001 1012 1035 1059 1076 1086 1091 1094 1097 1099 1100 1099 1093 1079 1057 1034 1025 * 1025 1025
* 1015 1039 1063 1079 1088 1092 1095 1098 1100 1101 1101 1095 1042 1061 1048 *
1009 1005 * 1001 1007 1028 1053 1073 1085 1091 1095 1097 1099 1101 1102 1100 1091 1074 1050 1030 1024 * 1024 1024
1011 1006 * 1001 *
1004 1005 * 1002 1008 1028 1053 1073 1085 1092 1095 1098 1100 1102 1103 1100 1092 1074 1050 1030 1025 * 1025 1025
* 1016 1040 1064 1080 1089 1094 1097 1099 1101 1103 1102 1097 1084 1042 1036 *
1009 1006 * 1003 1013 1037 1062 1079 1089 1094 1097 1100 1102 1103 1102 1095 1041 1059 1045 1025 * 1025 1025
* 1022 1088 1070 1084 1092 1096 1099 1101 1103 1104 1099 1094 1064 1046 *
1011 1007 * 1005 1017 1042 1066 1082 1091 1096 1099 1101 1102 1101 1094 1094 1062 1034 1024 * 1024 1024
* 1026 1052 1073 1086 1093 1097 1100 1101 1102 1098 1088 1070 1046 *
1011 1009 * 1006 1020 1045 1067 1083 1091 1095 1098 1100 1099 1095 1082 1042 1037 1024 * 1023 1023
* 1029 1053 1073 1096 1092 1094 1098 1098 1094 1084 1064 1044 *
1012 1010 * 1004 1022 1046 1066 1080 1088 1095 1094 1094 1090 1079 1060 1036 1021 * 1021 1021
* 1029 1052 1070 1081 1087 1090 1091 1089 1081 1065 1043 *
1012 1011 * 1009 1022 1043 1061 1072 1074 1081 1082 1080 1071 1055 1033 1019 * 1019 1019
* 1028 1047 1061 1070 1074 1076 1076 1070 1054 1039 *
1012 1011 * 1010 1020 1035 1048 1056 1060 1062 1061 1057 1045 1029 1017 * 1017 1017
* 1023 1036 1045 1050 1053 1054 1052 1045 1032 *
1012 1011 * 1009 1015 1023 1029 1033 1036 1037 1036 1031 1023 1015 * 1015 1015
* 1014 1020 1024 1027 1029 1029 1027 1024 *
* 1009 1004 1009 1010 1012 1014 1015 1014 1014 1015 *
1009 * 1004 1009 1010 1012 1014 1015 1014 1014 1015
1010 1009 1009 1010 1012 1014 1015 1014 1014 1015

F.36

TEMPERATURE MAP FOR BUNDLE 10 61 PIN SAFETY ASSEMBLY NO. 1302 0.0656 MW
 AXIAL HEIGHT 90.000 IN

```

      905      864 861 860 858      778
      860      825 821 819 815      756
      816      787 781 779 772      752
      805      780 774 769 762      702
      * 793 772 768 760 751 731 *
      * 741 731 727 720 *
  883 841 800 792 * 784 745 722 717 714 703 694 * 698 698 698 698
      * 726 708 703 701 696 *
  881 837 794 786 * 777 737 709 701 699 696 691 687 * 687 687 687 687
      * 722 702 696 695 694 690 *
  881 837 793 785 * 776 737 706 696 694 693 692 688 685 * 685 684 684 684
      * 727 702 695 693 693 692 689 *
  884 842 801 792 * 783 749 711 697 694 693 693 692 688 685 * 684 684 684 684
  940 889 838 824 * 811      886 * 685 682 684 684
  925 874 823 813 * 802 755 712 697 694 693 693 692 689 688 * 687 687 687 687
      * 733 704 695 693 694 693 691 *
  924 870 818 807 * 797 747 709 698 695 695 695 694 696 * 694 693 693 693
      * 729 704 694 697 697 697 *
  925 870 817 806 * 795 747 713 704 703 704 704 705 705 * 702 708 708 708
      * 734 713 708 709 711 *
  924 875 823 812 * 801 757 732 726 727 733 734 * 732 728 728 728
      * 757 744 742 746 *
      * 821 801 786 787 795 822 *
      * 809 794 797 806 804
      848      816 807 807 817      867
      901      861 854 857 867      807
      954      907 904 909 914      833
  
```

AVERAGE DUCT WALL TEMPERATURE SUMMARY FOR AXIAL HEIGHT 90.000 IN

ASSEMBLY	FACE NO. 1	FACE NO. 2	FACE NO. 3	FACE NO. 4	FACE NO. 5	FACE NO. 6
1	955.14 F	916.62 F	931.94 F	901.62 F	943.14 F	924.33 F
2	978.06 F	999.19 F	966.12 F	1006.81 F	1011.93 F	1016.50 F
3	974.23 F	962.80 F	903.89 F	936.98 F	902.89 F	957.12 F
4 INSIDE	742.40 F	731.03 F	730.71 F	793.85 F	809.53 F	808.80 F
4 OUTSIDE	744.14 F	732.97 F	733.96 F	832.33 F	841.24 F	834.63 F
5	906.07 F	928.50 F	927.81 F	926.19 F	897.50 F	934.34 F
6 INSIDE	809.78 F	802.90 F	751.38 F	743.73 F	816.87 F	834.74 F
6 OUTSIDE	807.50 F	833.59 F	753.18 F	749.36 F	847.41 F	855.16 F
7	1025.59 F	962.66 F	981.27 F	991.88 F	1009.56 F	1027.81 F
8	1013.90 F	1015.17 F	1021.80 F	1018.63 F	1017.12 F	1016.57 F
9	1024.57 F	960.31 F	1001.34 F	1009.08 F	1013.01 F	1021.30 F
10 INSIDE	692.51 F	771.69 F	792.81 F	812.94 F	808.12 F	719.43 F
10 OUTSIDE	695.67 F	817.76 F	847.39 F	877.71 F	849.19 F	717.34 F

10 ASSEMBLY SAMPLE PROBLEM
ENERGY BALANCE THROUGH 90,000 IN

COLUMN HEADING DEFINITIONS . . .

A = HEAT ADDED THROUGH LINEAR ROD POWER OR NODAL HEAT GENERATION, IF LUMPED (WATTS)
B = HEAT ADDED TO BYPASS GAP THROUGH NODAL HEAT GENERATION, IF BYPASS ASSEMBLY (WATTS)
C = HEAT LOSS OR GAIN THROUGH FACIAL BOUNDARY CONDITIONS (WATTS)
D = HEAT LOSS OR GAIN THROUGH INTERASSEMBLY HEAT TRANSFER (WATTS)
E = TOTAL BUNDLE HEAT GAIN THROUGH TEMPERATURE RISE (WATTS)
SUM = BUNDLE ENERGY BALANCE, A+B+C+D-E, (WATTS)
ERROR = PERCENTAGE ERROR FOR THIS BUNDLE
TBAR = BUNDLE BULK TEMPERATURE F

ASSEM.	A	B	C	D	E	SUM	ERROR	TBAR
1	.5709E+07	-	0.	-.1001E+04	.5609E+07	-.1A30E-04	-.00	989.9
2	.6424E+07	-	0.	-.1156E+04	.6309E+07	-.2010E-04	-.00	1044.4
3	.5658E+07	-	0.	-.6538E+04	.5592E+07	-.1A29E-03	-.00	989.7
4	.1894E+06	0.	0.	.1122E+04	.3015E+06	-.1A27E-04	-.00	773.5
5	.5005E+07	-	0.	-.7200E+04	.4973E+07	-.1604E-04	-.00	968.4
6	.1897E+06	0.	0.	.1706E+04	.3602E+06	-.2136E-04	-.00	791.7
7	.6404E+07	-	0.	-.5717E+04	.6437E+07	-.2038E-04	-.00	1054.4
8	.6790E+07	-	0.	.6963E+04	.6797E+07	-.5764E-04	-.00	1056.3
9	.6771E+07	-	0.	-.3600E+04	.6735E+07	-.2099E-04	-.00	1052.9
10	.1998E+05	0.	0.	.1949E+04	.2149E+06	-.4A43E-07	-.00	746.6
TOTAL	.4329E+08	0.	0.	.3831E+04	.4333E+08	-.2103E-02		

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