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ATOMICS INTERNATIONAL A Division of North American Aviation, Inc.		NAA-SR- TDR NO. 11822	APPROVALS
TECHNICAL DATA RECORD		PAGE 1 OF 47	
AUTHOR P. M. Magee <i>P.M. Magee</i> DEPT. & GROUP NO. 731-14 R. W. Winson <i>R.W. Winson</i> 731-14		DATE 2/10/66	
		GO NO. 7569	
TITLE Three-Dimensional Transient Thermal Model of a SNAP Reactor		S/A NO. 2215	TWR
		SECURITY CLASSIFICATION	
		(CHECK ONE BOX ONLY)	(CHECK ONE BOX ONLY)
PROGRAM General Support- ing Technology		AEC ☒ DOD ☒ UNCL. ☒ CONF. ☐ SECRET ☐	RESTRICTED DATA ☐ DEFENSE INFO. ☐
SUBACCOUNT TITLE Reactor Control and Stability Analysis		AUTHORIZED CLASSIFIER SIGNATURE <i>R.F. Audette</i> DATE 2/15/66	
DISTRIBUTION E. B. Ash CA2 R. F. Audette CA5 D. J. Cockeram 2 R. Detterman CA5 E. Donovan CA5 S. R. Fields CA5 R. Gimera CA5 F. J. Halfen CA2 R. I. Jetter CA5 D. J. Mason CA5 L. Maki CA5 J. Marvosh CA2 ✓ L. S. Mims CA5 ✓ L. Moss CA5 H. F. Newman CA5 W. Roberts CA5 H. Rood CA5 W. W. Scott CA4 E. E. Stoner CA2 J. Susnir CA5 C. A. Willis CA5		STATEMENT OF PROBLEM Develop the analytical technique to determine the detailed transient and steady state temperature distributions within SNAP reactors.	
		ABSTRACT: A set of transfer functions and differential and algebraic equations representing the heat transfer in a single reactor fuel rod and a single coolant channel were developed. It was assumed that the fuel rod was cooled by six adjacent coolant channels and that the coolant channel was heated by three adjacent fuel rods. The effect of eccentrically locating the fuel within the cladding was included as was the temperature dependence of hydrogen conductivity and fuel specific heat. Two digital subroutines were written, one simulating the fuel rod and the other the coolant channel. These subroutines were linked by a third subroutine which provides the proper geometric coupling. The technique described herein is applicable to any hexagonal array core; however, the specific reactor described is the S8ER. In order to simulate another core, it would be necessary to modify the coupling subroutine.	
		The subroutines are fully compatible with the digital program Upstart. However, due to the extreme complexity and detail of the thermal model, it is not recommended that the system be operated closed loop. Rather, the core model should be used to obtain transient and steady state thermal response to programmed reactor power, coolant flow and coolant inlet temperature as functions of time.	

I. FUEL ELEMENT DEVELOPMENT

The fuel elements of a SNAP reactor consist of a circular uranium-zirconium hydride fuel rod encased in a thin-walled cladding cylinder. A ceramic barrier material is applied to the inside of the cladding to reduce the hydrogen leak rate from the element. A radial gap of approximately 3 mils is left between the fuel and the barrier; this gap is filled with evolved hydrogen gas in equilibrium with the hydrogen within the fuel and any other gases which are present at the time of final element closure. The gap is probably not uniform, as there is nothing to prevent fuel eccentricity.

The radial heat transfer between the fuel and an adjacent coolant channel is determined by the sum of the thermal resistances of (1) fuel, (2) gas gap, (3) barrier, (4) cladding, and (5) convective film. In terms of the average fuel temperature, this can be expressed as follows:

$$R_T(\bar{T}_f - \bar{T}_{NaK}) = R_f + R_g + R_b + R_c + R_{cf} \quad (\text{sec } ^\circ\text{F/Btu})$$

$$= \frac{3}{\pi L} \left[\frac{1}{4k_f} + \frac{r_g - r_f}{k_g \frac{(r_g + r_f)}{2}} + \frac{r_b - r_g}{k_b \frac{(r_g + r_b)}{2}} + \frac{r_c - r_b}{k_c \frac{(r_c + r_b)}{2}} + \frac{1}{hr_c} \right] \quad (1)$$

As each fuel element is surrounded by six coolant channels, the above equation is written for a surface area of $\frac{\pi r_c L}{3}$, one-sixth the total surface area.

A complete formulation of the general transient problem would include, in addition to fuel nodes, nodes representing the cladding and barrier. This would increase the running time of the digital code by approximately six, and as the cladding does not appreciably lag the adjacent coolant, cladding and barrier nodes were not included in the thermal model. (For an explanation of how the cladding heat capacity is lumped with the coolant capacity, see the section on coolant channel.)

In the digital program, the thermal resistance between the fuel and the coolant is broken into two parts to allow a calculation of the barrier temperature. The first resistance includes the fuel and the gas gap:

$$R_1 (\bar{T}_f - T_b) = \frac{6}{\pi L} \left(\frac{1}{8k_f} + \frac{r_g - r_f}{k_g(r_g + r_f)} \right) \quad (2)$$

The corresponding conductance is H_1 (or TEMP):

$$H_1 = \frac{\pi L}{6 \left[\frac{1}{8k_f} + \frac{r_g - r_f}{k_g(r_g + r_f)} \right]} \quad (3)$$

This expression is used for each fuel element in the reactor core. All quantities are assumed to be invariant throughout the core except the gas gap width $(r_g - r_f)$ which can be expressed as the core average gap width times a local multiplier:

$$r_g - r_f = (r_g - r_f)_{\text{core avg.}} \quad *RATIO(I, J, K) \quad (4)$$

The multiplier $RATIO$ is specified for each fuel-channel pair at each axial plane.

The second resistance term includes the convective film, the clad and the barrier:

$$R_2 (T_b - T_{NaK}) = \frac{6}{\pi L} \left[\frac{1}{2hr_c} + \frac{r_c - r_b}{k_c(r_c + r_b)} + \frac{r_b - r_g}{k_b(r_b - r_g)} \right] \quad (5)$$

and the corresponding conductance H_2 (or HCN) is:

$$H_2 = \frac{\pi L}{6 \left[\frac{1}{2hr_c} + \frac{r_c - r_b}{k_c(r_c + r_b)} + \frac{r_b - r_g}{k_b(r_b - r_g)} \right]} \quad (6)$$

This quantity is assumed constant throughout the core and is input data to the code.

The temperature at the inner surface of the barrier is calculated only at print-out times in order to shorten the running time of the program. It is assumed that the barrier surface temperature has the same relationship to the average fuel and coolant temperatures during a transient as it has in steady

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state. That is, the barrier temperature is specified by the thermal conductances that tie it to the fuel and coolant temperatures.

At steady state,

$$q = \left(\frac{H_1 H_2}{H_1 + H_2} \right) (\bar{T}_f - T_{NaK}) = H_1 (\bar{T}_f - T_b) = H_2 (T_b - T_{NaK})$$

or

$$T_b = T_{NaK} + \frac{H_1}{H_1 + H_2} (\bar{T}_f - T_{NaK}) \quad (7)$$

The rates-of-change of barrier and cladding temperatures are not calculated. Rather, they are assumed to be the same as that of the adjacent coolant node. This is a reasonable assumption as the cladding and the barrier are closely coupled to the coolant.

Assuming that all heat transfer from a fuel node is radial (no axial conduction in the fuel), the governing differential equation for a single fuel node connected to six surrounding coolant channels is:

$$WC_p \dot{T}_F(t) = Q(t) - \sum_{i=1}^6 UA_i \left[T_F(t) - T_{NaKi}(t) \right] \quad (8)$$

where

WC_p = total heat capacity associated with fuel node.

$Q(t)$ = Power generated within fuel node

UA_i = thermal conductance $\left(\frac{H_1 H_2}{H_1 + H_2} \right)$ to adjacent coolant channel.

The specific heat of the fuel is expressed as a linear function of the core average fuel temperature in the program. All fuel element heat transfer calculations are performed in the subroutine ROD, to be discussed later.

II. COOLANT CHANNEL DEVELOPMENT

The basic transfer functions representing the heat transfer within a coolant channel are developed in Reference 1. These functions are:

$$T_o = \frac{\bar{T}_m}{1 + \tau_2 S} - \frac{\bar{T}_m (t - \tau_1) e^{-k}}{1 + \tau_2 S} + T_{in} (t - \tau_1) e^{-k} \quad (9)$$

$$\bar{T} = \frac{1}{1 + \tau_2 S} \left[\bar{T}_m + \frac{1}{K} (T_{in} - T_o) \right] \quad (10)$$

where

$$\tau_1 = \frac{\rho_{AL} C_p}{W C_p}$$

$$\tau_2 = \frac{\rho_{AL} C_p}{UA}$$

$$K = \frac{UA}{W C_p} = \frac{\tau_1}{\tau_2}$$

T_o = Nodal coolant outlet temperature

$\bar{T}$ = Mean nodal coolant temperature

$\bar{T}_m$ = Mean nodal fuel temperature adjacent to coolant node.

It should be noted that $(t - \tau_1)$ and $\frac{1}{1 + \tau_2 S}$ are operator notations denoting a true time delay and a first order lag respectively.

Due to the complexity of the core thermal model, it is desirable to make as many simplifying assumptions as possible without adversely affecting the transient response of the model. The basic objective of the core thermal model is to determine the transient response of the core to non-nuclear accidents. Non-nuclear accidents, such as loss of coolant flow or perturbations in coolant temperature, as well as normal positive power excursions and either normal or abnormal negative power excursions have a relatively low frequency content so far as the coolant and cladding nodes are concerned. Therefore, the model can be greatly simplified by combining the fuel cladding with the coolant channel

thus eliminating the requirement of a separate set of differential equations representing the cladding segment adjacent to the coolant node.

The product $\rho AL C_p$ represents the total heat capacity of the coolant node while $\dot{W} C_p$ represents the heat of transport. The total heat capacity of the coolant node can be modified to include the heat capacity of the cladding without affecting the heat of transport.

Defining the heat capacity of the cladding by:

$$W C_{p_c} = \rho_c V_c C_{p_c}$$

we can define an effective heat capacity of the coolant node by:

$$W C_{p_e} = W C_{p_c} + \rho AL C_p$$

we now re-define:

$$\tau_1 = \frac{W C_{p_e}}{\dot{W} C_{p_e}} \quad (11)$$

and

$$\tau_2 = \frac{W C_{p_e}}{UA} \quad (12)$$

It should be noted that:

$$K = \frac{UA}{\dot{W} C_p} = \frac{\tau_1}{\tau_2} = \frac{\frac{W C_{p_e}}{\dot{W} C_{p_e}}}{\frac{W C_{p_e}}{UA}} \quad (13)$$

It can be seen that the absolute value of K is unchanged and the substitution of the effective nodal heat capacity can be made without effecting a change in the steady state solution. It should be further noted that, due to the tight coupling between the coolant and cladding nodes, the low frequency response of the model is unaffected and that only the high frequency second order coupling has been eliminated.

FIGURE 1A

Equations 9 and 10 are not directly applicable to the system depicted in Figure 1A, as the equations are based on the average fuel temperature in a single node while the system under investigation has three fuel nodes. The equations can be simply modified utilizing an effective average fuel temperature $\bar{T}_e$.

Equation 10 can be rewritten in its differential equation form as:

$$\rho A L C_p \frac{dT}{dx} = UA (\bar{T}_m - \bar{T}) + \dot{W} C_p (T_{in} - T_o) \quad (14)$$

This equation holds for heat being transferred from a single fuel node to a single coolant channel node. For the general case, where there are more than one fuel node, the equation may be written as:

$$\rho A L C_p \frac{dT}{dx} = \dot{W} C_p (T_{in} - T_o) + \sum_{i=1}^n UA_i (\bar{T}_{mi} - \bar{T}) \quad (15)$$

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where

UA_i is the heat transfer coefficient between the coolant channel and the i -th fuel node whose average temperature is $\bar{T}_{mi}$.

Defining

$$UA_T = \sum_{i=1}^n UA_i$$

equation 15 may be written as:

$$\rho AL C_p \dot{T} = \dot{W} C_p (T_{in} - T_o) - \bar{T} UA_T + \sum_{i=1}^n \bar{T}_{mi} UA_i \quad (16)$$

Defining

$$\Gamma_2 = \frac{\rho AL C_p}{UA_T}$$

we may rewrite equation 16 as:

$$\bar{T} = \left[\dot{W} C_p (T_{in} - T_o) + \sum_{i=1}^n UA_i \bar{T}_{mi} \right] \frac{1}{(1 + \Gamma_2 S) UA_T} \quad (17)$$

The effective mean fuel temperature may now be defined as:

$$\bar{T}_e = \frac{\sum_{i=1}^n UA_i \bar{T}_{mi}}{UA_T} \quad (18)$$

and K may be defined as:

$$K = \frac{UA_T}{\dot{W} C_p} \quad (19)$$

Equations 9 and 10 may now be rewritten as:

$$T_o = \frac{\bar{T}_e}{1 + \Gamma_2 S} - \frac{\bar{T}_e (t - \Gamma_1) e^{-K}}{1 + \Gamma_2 S} + T_{in} (t - \Gamma_1) e^{-K} \quad (20)$$

$$\bar{T} = \frac{1}{1 + \Gamma_2 S} \left[\bar{T}_e + \frac{1}{K} (T_{in} - T_o) \right] \quad (21)$$

Equations 18, 19, 20 and 21 now represent the heat transfer within a single coolant node bounded by n fuel nodes each at some mean temperature $\bar{T}_{mi}$.

It should be noted that the transport time τ_1 is not effected by this manipulation unless the cladding specific heat is lumped with the coolant node. In this event, the effective heat capacity used in calculating the values of τ_1 and τ_2 is the summation of all the cladding node heat capacities with the coolant node heat capacity as shown by:

$$W C_{pe} = \rho A L C_p + \sum_{i=1}^n W_i C_{p_i} \quad (22)$$

where W_i = cladding node weight and C_{p_i} = cladding specific heat.

It should be further noted that if $n = 1$, the equations reduce to the single node formulation.

III. DIGITAL SIMULATION OF THE THERMAL MODEL

In order to make the digital program as general as possible in its application to SNAP reactor simulation, comensurate with ease of programming and the maintenance of computational speed and accuracy, the digital program was broken into three distinct subroutines. These subroutines, ROD, CHANL, and GEOM are listed in the appendix of this report.

Subroutine CHANL in essence, contain the time-dependent solution of the heat transfer (described by equations 18, 19, 20, and 21) within each of the coolant channels. Due to the existence of the information contained in a transfer vector used in computations within the subroutine, the instantaneous values of the fuel cladding segment temperatures are also calculated.

The heat transfer process associated with a fuel rod are performed in the subroutine ROD. All heat transfer is assumed to be radial, axial conduction within the fuel being neglected. The fuel is represented as a single node of capacity connected by thermal conductances to the six surrounding coolant channels, each represented by a node.

FIGURE 1B

An energy balance on the fuel yields the governing differential equation:

$$W C_p \dot{T}_F(t) = Q(t) - \sum_{i=1}^6 U A_i (T_F(t) - T_{C_i}(t)) \quad (23)$$

where

$W C_p$ = total heat capacity associated with fuel node.

$Q(t)$ = power generated within fuel node.

$U A_i$ = thermal conductance to coolant channel i
(includes resistances of fuel, gas gap, barrier, clad and convective film).

By defining the time constant $\tau = \frac{W C_p}{\sum U A_i}$ this equation can be rewritten

as:

$$\tau \dot{T}_F = \frac{Q}{\sum U A_i} - T - \frac{\sum U A_i T_{C_i}}{\sum U A_i}$$

or

$$T(1 + \tau S) = \frac{Q}{\sum U A_i} + \frac{\sum U A_i T_{C_i}}{\sum U A_i} \quad (24)$$

where $\frac{1}{1 + \tau S}$ denotes a first order lag. The final form of the differential equation is compatible with the LAGGER integration scheme (Reference 2)

and can be solved numerically by this technique.

It should be noted that the thermal conductance to each adjacent coolant channel is represented by a separate term and, thus, can be varied independently. This is accomplished in the subroutine GEOM by varying the gas gap width and, consequently, the gap conductance. The other heat transfer terms that make up the conductance from the fuel to the coolant are assumed uniform throughout the core.

Subroutine GEOM is the heart of the program, in that it supplies the geometry information which couples the individual fuel rods to the appropriate coolant channels. It further calculates the power distribution within each fuel rod, accounts for fuel eccentricity, both axially and radially within each fuel rod, provides data for coolant cross flow, calculates the proper thermal conductances between nodes as a function of temperature and space, and provides all input and output data for the program. The basic subroutine is quite general; in order to change the simulation from the SNAP 8 Core to another hexagonal-array reactor, only the geometric pattern has to be changed.

FIGURE 2

Figures 2 and 3 illustrate the geometry assignment within the core. Figure 2 shows the cladding segment notation for each fuel rod. Segment 1 is located at the 12-o'clock position which is in the direction of the outside of the core. The segments are numbered counter clockwise. Figure 3 illustrates the rod and channel identification within the minimum symmetrical pie-section

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FIG. 3

$L = 30^\circ$
COOLANT CHANNELS 39

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in the reactor array. Each of the fuel rods and channels may be divided in up to 10 axial nodes. The fuel rod temperatures are represented by a two-dimensional array which identify the physical location in the core. A typical temperature would be given for a fuel rod as TU (N, J) where N corresponds to axial position and J rod number. The cladding temperatures are defined by a three-dimensional array which include the axial position, the fuel rod identification number, and the segment number. A typical cladding node is thus defined by TB (N, J, K) where N and J have the previously defined values and K represents the cladding segment number.

In the computation process, GEOM computes a transfer vector which tells each fuel rod and coolant channel which nodes are adjacent, so that appropriate thermal calculations may be made. For example, in calculating the temperature of fuel rod 5, the ROD subroutine transfer vector (KPOS) is set to 5 identifying the rod number. The vector IC identifying the adjacent coolant channels is set to:

IC (1) = 11

IC (2) = 18

IC (3) = 17

IC (4) = 10

IC (5) = 3

IC (6) = 4

Examination of Figure 3 will show that this vector identifies the correct coolant channels. A similar vector is used for identifying the coolant channel boundaries.

A dummy fuel rod and a dummy coolant channel are provided to simulate the boundaries at the edge of the core. It should be noted that, in the SNAP-8 configuration simulated, the heat transfer out of the core vessel was assumed negligible.

The basic call program is similar to all of the UPSTART call programs in that it establishes the computational limits, provides time varying input data, computes the magnitude of the variable time increments, and establishes the time points at which output data will be printed.

IV. DISCUSSION

The program simulates the repeating 1/12-section of the SNAP-8 reactor core. At present, the code is being used to estimate steady-state and transient thermal stresses encountered by the S8ER core. The great utility of the program lies in the various options provided:

1. Any flow profile can be simulated. The flow in each coolant channel can be represented independently as a function of axial position and time.
2. Radial and axial power profiles can be simulated.
3. The code can be started from a uniform temperature, a steady-state distribution (at a given power and flow), or initial temperatures can be read in as input data.
4. The radial gas gap of each element can be varied at each axial position. Initially, each gas gap position (between a fuel and a coolant node) is set equal to the core average gas gap. Then, any gap position can be changed by specifying its location in the core and inputting the ratio of the desired gap width to the core average gap width.

The latter option provides the capability to simulate (1) fuel swelling as a function of core position, (2) fuel eccentricity, and (3) fuel bowing. In particular, worst cases are easily investigated. As an example, three adjacent fuel rods which surrounded a particular coolant channel can all be assumed eccentric towards the channel.

It should be noted that each cladding (or, more correctly, barrier) temperature calculated is an average temperature over the region which faces a coolant channel (i. e., 1/6 of the total surface area). No attempt is made to calculate maximum barrier or clad temperatures which occur at the tricusps separating one coolant channel from the next.

V. INPUT DATA TO THE PROGRAM

1. TMAX - maximum allowable transient time.
2. PRINT - time iterations to printed output ratio.
3. CDELT - maximum fractional change in any variable per time iteration.
Recommended value 0.003.
4. TIN - initial coolant inlet temperature in °R.
5. FLOW - initial total core coolant flow rate in lbs/sec.
6. READ - + 1.0 (not pertinent).
7. PWR - initial reactor power in Btu/sec.
8. H PERT - + 1.0 (not pertinent).
9. TIMTST - This input can be used to compute the steady-state temperature distribution commensurate with the initial power, flow and inlet temperatures. At the end of TIMTST seconds the code will stop, print out the steady-state temperature distribution, recycle and start the transient from the steady-state conditions. It should be noted that TIMTST must be large enough for the system to reach equilibrium (200 sec for the SNAP 8 model) and that TMAX must be extended by this amount. Further, the time-variable power, flow and inlet temperatures must be held constant for TIMTST seconds. If this feature is not desired, TIMTST must be set to 0.
10. DELTMAX - + 1.0 (not pertinent).
11. ANO - number of point pairs to be loaded representing PWR vs time variation.
12. TITLE - PWR vs TIME (or name).
13. TITLE - TIME PWR (center over 1P2E20.7 format).
14. LIST - PWR vs TIME input list containing ANO pairs of data. Data is read sequentially TIME, PWR, TIME, PWR, (etc.)

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15. ANØ - Same as 11 except FLOW vs TIME variation.
16. TITLE - FLOW vs TIME (or NAME).
17. TITLE - TIME FLOW (center as in 13)
18. LIST - Same as 14 except FLOW vs TIME LIST.
19. ANØ - Same as 11 except coolant Inlet temp. vs TIME.
20. TITLE - Inlet Temp. vs TIME (or NAME)
21. TITLE - Inlet Temp. TIME (center as in 13)
22. LIST - Same as 14 except Inlet temp vs TIME.
23. BNØDES - Number of axial nodes (up to 10).
24. BLENTH - Fuel rod length in inches.
25. RADU - Raduis of fuel rod in inches.
26. RADG - Outside radius of gas gap in inches.
27. THICK - Clad thickness in inches.
28. DENU - Fuel density in lbs/in^3 .
29. DENC - Cladding density in lbs/in^3 .
30. WTNAK - Total weight of NaK in core in lbs.
31. CONDU - Fuel conductivity in $\text{Btu}/(\text{sec-in-}^\circ\text{R})$
32. CPUC - C_p fuel constant, $\text{Btu/lb} - ^\circ\text{R}$
33. CPUV - Temperature dependent C_p , $\text{Btu/lb} - ^\circ\text{R}^2$
 $(C_p \text{ fuel} = \text{CPUC} + \text{CPUV} * \bar{T}_f)$
34. CPC - C_p clad, $\text{Btu/lb} - ^\circ\text{R}$
35. HCN - Conductance, film + clad + barrier for total core in $\text{Btu/sec} - ^\circ\text{R}$
36. TBEGIN - Test for temperature input
 - 1 Read in all fuel, clad, and NaK temps.
 - 0 Use values at end of previous case.
 - +1 Set core isothermal at coolant inlet temp.
37. TESTPD - Test, power distributions
 - 1, 0: Use values of previous case.
 - +1: Read new DISR, DISA.

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- 38. TSTFD - Test, flow distribution
 - +1 Read in all coolant node flow ratios.
 - 0 Use previous run values.
 - 1 Uniform flow distribution
- 39. TSTHD - Test, gas gap ratio's
 - +1 Read in all segment gas gap ratio's
 - 0 Use previous run values
 - 1 Partial read or uniform gap ratio's (see*)
- 40. CPNAK - NaK specific heat, Btu/lb°R
- 41. RODNO - Total number of effective fuel rods in core.
- 42. CUANO - Total number of effective coolant channels in core.
- 43. RODSEC - Number of fuel rods in pie-section.
- 44. LIST - If TBEGIN is -1 the initial temperature distribution must be provided. See listing for input order.
- 45. LIST - If TSTPD is +1 the power distribution must be provided. The radial power is read first, followed by the axial power distribution.
- 46. LIST - If TSTFD is +1 the flow distribution list must be provided.
- 47. *LIST - If TSTHD is -1 the ratio's will be automatically set to 1. (Used only when TSTHD = +1)
- 48. *IRODRD - Number of rods to be changed.
(48 and 49 to be read only if 39 is -1.0)
- 49. *LIST - A partial list of gap ratio's must be provided for N rods where
n = IRODRD. See listing for input order.
- 50. ANO - Number of point pairs to be loaded representing H₂ thermal conductivity vs temp.
- 51. TITLE - H₂ conductivity vs temp.
- 52. TEMP CONDUCTIVITY (center over 1PZE20.7 Format)
- 53. LIST - Cond. vs temp. table with ANO pairs of data

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2. R. W. Winson, "A Technique for Solving Dynamics Problems by Digital Computation," NAA-SR-10692.

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C      UPSTART III - SNAP FULL CORE HEAT TRANSFER SIMULATION      00000010
      DIMENSION TITLE(9),AB(10)      00000020
      COMMON READ,TIME,DELT,FLOW      00000030
100    READ INPUT TAPE 5,5,TITLE      00000040
      READ INPUT TAPE 5,4,ANG      00000050
      IF (ANG) 120, 2 ,110      00000060
110    READ INPUT TAPE 5,4,AB      00000070
      GO TO 2      00000080
120    NG=0.01-ANG      00000090
      READ INPUT TAPE 5,1,((IR,(AB(I),I=IR,IR)),K=1,NG)      00000100
      1 FORMAT (I12,E12.8,I12,E12.8,I12,E12.8)      00000110
      2 WRITE OUTPUT TAPE 5,3,TITLE      00000120
      3 FORMAT (1H1/20X,9A6)      00000130
      4 FORMAT (6E12.8)      00000140
      5 FORMAT (9A6)      00000150
      WRITE OUTPUT TAPE 6,6,AB      00000160
      6 FORMAT (1H1//30X,12HINPUT DATA /(1P5E20.7))      00000170
      TMAX=AB(1)      00000180
      PRINT=AB(2)      00000190
      CDELT=AB(3)      00000200
      TIN=AB(4)      00000210
      FLOW=AB(5)      00000220
      READ=AB(6)      00000230
      AB(6)=-1.0      00000240
      PWR=AB(7)      00000250
      HPERT=AB(8)      00000260
      IF (AB(9)) 7,7,8      00000261
      7 AB(9)=AB(1)      00000262
      8 T(MTST=AB(9)+0.01      00000270
      DELTMX=AB(10)      00000272
      TIME=0.0      00000280
      CTIME=TMAX/110.0      00000290
      DELT=0.1      00000350
      SUMT=0.0      00000360
      PLGT=0.0      00000370
      WRITE=1.0      00000380
      COUNT=0.0      00000390
      SC0=0.0      00000400
      CALL FGEN(JA,TIME,PWR,1.0)      00000410

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CALL FGEN(JB,TIME,FLOW,1.0)	00000420
CALL FGEN(JC,TIME,TIN,1.0)	00000430
CALL GEOM(PWR,TIN,WRITE,DMAX)	00000440
TMAXC=TMAX	00000500
READ=0.0	00000510
JTRAN=-1	00000520
KPRINT=PRINT+0.1	00000530
LPRINT=KPRINT	00000540
10 CONTINUE	00000550
TIME=TIME+DELT	00000560
CALL FGEN(JA,TIME,PWR,0.0)	00000570
CALL FGEN(JB,TIME,FLOW,0.0)	00000580
CALL FGEN(JC,TIME,TIN,0.0)	00000590
CALL GEOM(PWR,TIN,WRITE,DMAX)	00000600
IF (JTRAN) 11,11,12	00000620
11 JTRAN=1	00000630
CTIME=(TMAX-TIME)/110.0	00000640
12 SUMT=SUMT+DELT	00000680
IF (PLOT) 15,15,100	00000690
15 WRITE=0.0	00000700
CCOUNT=CCOUNT+1.0	00000710
PLOT=0.0	00000720
IF (CTIME-SUMT) 20,20,35	00000730
20 SUMT=0.0	00000740
PLOT=-1.0	00000750
LPRINT=LPRINT+1	00000760
IF (KPRINT-LPRINT) 25,25,35	00000770
25 LPRINT=0	00000780
DCOUNT=CCOUNT-SC0	00000790
SC0=CCOUNT	00000800
WRITE=1.0	00000810
WRITE OUTPUT TAPE 6,26,DELT,DELTU	00000820
1,DMAXR,DMAX1,DMAX2,DMAX3,DMAX4,CCOUNT,DCOUNT	00000830
26 FORMAT (1H1//((1P5E20.7))	00000840
35 CONTINUE	00000880
IF (DMAX) 45,45,46	00000900
45 DELT=1.0	00000910
GO TO 47	00000920
46 DELT=CDELT/DMAX	00000930

```
DELTU=DELT                                00000940
47 TMAX=TMAXC-DELT                        00000950
   IF (TIME+DELT-TIMTST) 49,49,48         00000952
48 DELT=0.01                              00000953
   CTIME=(TMAX-TIMTST)/110.0              00000954
   TIME=TIMTST                            00000955
   WRITE=1.0                             00000956
   SUMT=0.0                              00000957
   PLOT=-1.0                             00000958
   CDELT=CDELT/2.0                       00000959
   TIMTST=TMAXC+TIMTST                   00000960
   GO TO 10                              00000961
49 IF (TMAX-TIME) 50,50,10                00000965
50 PLOT=1.0                              00000970
   WRITE=1.0                             00000980
   WRITE OUTPUT TAPE 6,25,COUNT          00000990
   GO TO 10                              00001000
END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
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STORAGE NOT USED BY PROGRAM

DEC OCT
412 00634

DEC OCT
32557 77455

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC OCT
DELT 32559 77457

DEC OCT
FLOW 32558 77456

DEC OCT
READ 32561 77461

DEC OCT
TIME 32560 77460

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC OCT
AB 402 00622

DEC OCT
TITLE 411 00633

DEC OCT

DEC OCT

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

AND	DEC OCT	392 00610	CDELT	DEC OCT	391 00607	COUNT	DEC OCT	390 00606	CTIME	DEC OCT	389 00605
DCOUNT	388 00604	DELTMX	387 00603	DELTU	386 00602	DMAX1	385 00601				
DMAX2	384 00600	DMAX3	383 00577	DMAX4	382 00576	DMAXR	381 00575				
DMAX	380 00574	HPERT	379 00573	IR	378 00572	JA	377 00571				
JB	376 00570	JC	375 00567	JTRAN	374 00566	KPRINT	373 00565				
LPRINT	372 00564	NO	371 00563	PL0T	370 00562	PRINT	369 00561				
PWR	368 00560	SC0	367 00557	SUMT	366 00556	TIMTST	365 00555				
TIN	364 00554	TMAXC	363 00553	TMAX	362 00552	WRITE	361 00551				

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	L0C	811	1 00530	EFN	L0C	813	3 00542	EFN	L0C	814	4 00537	EFN	L0C	815	5 00535
		816	6 00534			81Q	26 00525								

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC OCT	21	323 00503	DEC OCT	31	327 00507	DEC OCT	41	32767 77777	DEC OCT	61	333 00515
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2704) UPSTART III - SNAP FULL CORE HEAT TRANSFER SIMULATION

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LOCATIONS OF NAMES IN TRANSFER VECTOR

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
FGEN	7	00007	GEOM	8	00010	(FIL)	6	00006	(FPT)	9	00000
(RTN)	3	00003	(SLI)	2	00002	(SL0)	5	00005	(STH)	4	00004
(TSH)	1	00001									

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

FGEN (TSH)	GEOM	(FIL)	(FPT)	(RTN)	(SLI)	(SL0)	(STH)
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100	10	00016	110	15	00037	120	18	00047	2	30	00101
7	44	00144	8	45	00146	10	64	00250	11	71	00312
12	73	00320	15	75	00326	20	79	00341	25	83	00354
35	89	00413	45	91	00416	46	93	00421	47	95	00426
48	97	00437	49	106	00464	50	107	00470			

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SUBROUTINE R00(NN)                                00010010
DIMENSION TU(10,25),TUG(10,25),DTU(10,25),TC(10,25,6),DTC(10,25, 00010020
16),TNAK(10,40),DTNAK(10,40),HFC(10,25,6),QM(10,24),IC(6) 00010030
COMMON READ,TIME,DELT,FLOW,NODEA,                00010040
1TU,DTU,TC,TUG,DTC,TNAK,DTNAK,HFC,QM,QG,WCPU,WCPC,HCN,DQG,IC 00010050
N=NN                                                00010055
D0 20 IA=1,NODEA                                  00010056
SUMKT=0.0                                           00010060
SUMK=0.0                                             00010070
SUMDKT=0.0                                          00010080
D0 10 I=1,6                                         00010090
J=IC(I)                                             00010095
DTC(IA,N,I)=DTNAK(IA,J)                           00010096
SUMK=SUMK+HFC(IA,N,I)                             00010100
SUMKT=SUMKT+HFC(IA,N,I)*TNAK(IA,J)                00010110
10 SUMDKT=SUMDKT+HFC(IA,N,I)*DTNAK(IA,J)          00010120
TAU=WCPU/SUMK                                       00010130
A=(QG*QM(IA,N)+SUMKT)/SUMK                         00010140
DA=(DQG*QM(IA,N)+SUMDKT)/SUMK                     00010150
TF0=TU(IA,N)                                       00010160
CALL LAGGER(DELT,TAU,TU(IA,N),A,DA)                00010170
DTU(IA,N)=(TU(IA,N)-TF0)/DELT                     00010180
TUG(IA,N)=TF0                                       00010190
20 CONTINUE                                         00010200
RETURN                                              00010280
END(1,C,0,0,0,0,1,0,0,1,0,0,0,0,0,0)

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STORAGE NOT USED BY PROGRAM

DEC OCT
170 00252

DEC OCT
26255 63217

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC OCT
DELT 32559 77457
DTU 32306 77062
IC 26261 63225
READ 32561 77461
TUO 30556 73534

DEC OCT
DQG 26262 63226
FLOW 32558 77456
NODEA 32557 77455
TC 32056 76470
TU 32556 77454

DEC OCT
DTC 30306 73142
HCN 26263 63227
CG 26266 63232
TIME 32560 77460
WCPC 26264 63230

DEC OCT
DTNAK 28406 67366
HFC 28006 66546
QM 26506 63612
TNAK 28806 70206
WCPU 26265 63231

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

DEC OCT
A 169 00251
N 165 00245
TAU 161 00241

DEC OCT
DA 168 00250
SUMDKT 164 00244
TF0 160 00240

DEC OCT
IA 167 00247
SUMK 163 00243

DEC OCT
J 166 00246
SUMKT 162 00242

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC OCT
1) 152 00230
A1100 130 00202
C1200 159 00237

DEC OCT
2) 143 00217
C160 156 00234
D1402 57 00071

DEC OCT
3) 145 00221
C1100 157 00235

DEC OCT
6) 146 00222
C1101 158 00236

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC OCT
LAGGER 0 00000

DEC OCT

DEC OCT

DEC OCT

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

LAGGER

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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	L0C	EFN	IFN	L0C	EFN	IFN	L0C	EFN	IFN	L0C
10	15	00111	20	24	00164						

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	SUBROUTINE CHANL(NN,WRITE)	00020010
	DIMENSION TU(10,25),TU0(10,25),DTU(10,25),TC(10,25,6),DTC(10,25,	00020020
	16),TNAK(10,40),DTNAK(10,40),HFC(10,25,6),QM(10,24),IC(6),IR(6),FL000020030	
	2WM(10,39),TIN(11,39),DTIN(11,39),TCBL(10,39),TIN0(10,39)	00020040
	3,TNSUM(10,39)	00020045
	COMMON READ,TIME,DELT,AFLOW,N0DEA,	00020050
	1TU,DTU,TC,TU0,DTC,TNAK,DTNAK,HFC,QM,QG,WCPU,WCPC,HCN,DGG,IC,IR,WCN00020060	
	2NL,WS,FL0WM,TIN,DTIN,TCBL,TIN0	00020070
	NC=NN	00020075
	D0 50 IA=1,N0DEA	00020076
	TBAR=0.0	00020080
	USUM=0.0	00020085
	DTB=0.0	00020090
	D0 10 I=1,3	00020100
	K=2*I	00020110
	J=K-1	00020120
C	THE DATA IN IR DEFINES SEQUENTIALY ROD N0,SEG. N0,ROD N0,ETC.	00020125
	J1=IR(J)	00020130
	K1=IR(K)	00020140
	USUM=USUM+HFC(IA,J1,K1)	00020145
	TBAR=TBAR+TU0(IA,J1)*HFC(IA,J1,K1)	00020150
10	DTB=DTB+DTU(IA,J1)*HFC(IA,J1,K1)	00020160
	TBAR=TBAR/USUM	00020170
	IF (READ) 20,40,20	00020172
20	TCBL(IA,NC)=TBAR	00020174
	TNSUM(IA,NC)=TIN(IA,NC)-TCBL(IA,NC)	00020176
	G0 TO 50	00020178
40	DTB=DTB/USUM	00020180
	FLOW=AFLOW*FL0WM(IA,NC)	00020190
	TAUT=WS/FLOW	00020200
	TAUNL=KCNL/USUM	00020205
	AK=TAUT/TAUNL	00020210
	EX=EXP(-AK)	00020220
	TCBL0=TCBL(IA,NC)	00020230
	CALL LAGGER(DELT,TAUNL,TCBL(IA,NC),TBAR,DTB)	00020240
	DTBL=(TCBL(IA,NC)-TCBL0)/DELT	00020250
	A= -TCBL0+TIN0(IA,NC)	00020260
	DA=-DTBL+DTIN(IA,NC)	00020270
	CALL LAGGER (DELT,TAUT,TNSUM(IA,NC),A,DA)	00020280

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TC=TCBL(IA,NC)+EX*TN SUM(IA,NC)	00020290
IP=IA+1	00020300
DTIN(IP,NC)=(TC-TIN(IP,NC))/DELT	00020310
TNAK0=TNAK(IA,NC)	00020320
A=TBAR+(TING(IA,NC)-TIN(IP,NC))/AK	00020330
DA=DTB+(DTIN(IA,NC)-DTIN(IP,NC))/AK	00020340
CALL LAGGER(DELT,TAUNL,TNAK(IA,NC),A,DA)	00020350
DTNAK(IA,NC)=(TNAK(IA,NC)-TNAK0)/DELT	00020360
TING(IA,NC)=TIN(IA,NC)	00020370
TIN(IP,NC)=TC	00020380
IF (WRITE) 50,50,41	00020390
41 DO 42 I=1,3	00020400
K=2*I	00020410
J=K-1	00020420
J1=IR(J)	00020430
K1=IR(K)	00020440
42 TC(IA,J1,K1)=TNAK(IA,NC)+ (TU(IA,J1)-TNAK(IA,NC))*HFC(IA,J1,K1)/HC	00020450
1N	00020460
50 CONTINUE	00020465
RETURN	00020470
END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)	

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STORAGE NOT USED BY PROGRAM

DEC OCT
796 01434

DEC OCT
24219 57233

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
AFLW	32558 77456	DELT	32559 77457	DQG	26262 63226	DTC	30306 73142
DTIN	25428 61524	DTNAK	28406 67366	DTU	32306 77062	FLOWM	26247 63207
HCN	26263 63227	HFC	28006 66546	IC	26261 63225	IR	26255 63217
NODEA	32557 77455	QG	26266 63232	QM	26506 63612	READ	32561 77461
TCBL	24999 60647	TC	32056 76470	TIME	32560 77460	TINO	24609 60041
TIN	25857 62401	TNAK	28806 70206	TUO	30556 73534	TU	32556 77454
WCNNL	26249 63211	WCPC	26264 63230	WCPU	26265 63231	WS	26248 63210

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
INSUM	795 01433						

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

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
AK	405 00625	A	404 00624	DA	403 00623	DTBL	402 00622
DTB	401 00621	EX	400 00620	FLOW	399 00617	IA	398 00616
IP	397 00615	I	396 00614	J1	395 00613	J	394 00612
K1	393 00611	K	392 00610	NC	391 00607	TAUNL	390 00606
TAUT	389 00605	TBAR	388 00604	TCBL0	387 00603	TNAK0	386 00602
TO	385 00601	USUM	384 00600				

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
11	370 00562	21	358 00546	31	363 00553	61	364 00554
A1100	313 00471	A1103	326 00506	A1160	339 00523	C1100	374 00566
C1101	375 00567	C1100	376 00570	C1101	377 00571	C1102	378 00572
C1103	379 00573	C1160	380 00574	C1200	381 00575	C1201	382 00576
C1202	383 00577	D1109	294 00446	D1409	292 00444		

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LOCATIONS OF NAMES IN TRANSFER VECTOR

 DEC OCT
 EXP 0 00000

 DEC OCT
 LAGGER 1 00001

DEC OCT

DEC OCT

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP LAGGER

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

 EFN IFN LOC
 10 17 00162
 42 54 00430

 EFN IFN LOC
 20 20 00200
 50 55 00447

 EFN IFN LOC
 40 23 00210

 EFN IFN LOC
 41 49 00372

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SNAP 8 CORE GEOMETRY

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C   SNAP 8 CORE GEOMETRY                                00030005
    SUBROUTINE GEOM(PWR,TCORIN,WRITE,DMAX)                00030010
    DIMENSION TU(10,25),TU0(10,25),DTU(10,25),TC(10,25,6),DTC(10,25, 00030020
    16),TNAK(10,40),DTNAK(10,40),HFC(10,25,6),QM(10,24),IC(6),IR(6),FL000030030
    2WM(10,39),TIN(11,39),DTIN(11,39),TCBL(10,39),TINO(10,39),DISA(10),00030040
    3DISR(24),RATIO(10,24,6)                                00030050
    4,IRNO(25)                                              00030055
    COMMON READ,TIME,DELT,AFLOW,NODEA,                    00030060
    1TU,DTU,TC,TU0,DTC,TNAK,DTNAK,HFC,QM,QG,WCPU,WPCP,HCN,DQG,IC,IR,WCN00030070
    2NL,WS,FLOWM,TIN,DTIN,TCBL,TINO,TNSUM                  00030080
    IF (READ) 1,100,1                                       00030090
    1 READ INPUT TAPE 5,10,BNODES,BLENT,RADU,RADG,THICK,DENU,DENC,WTNAK00030100
    1,CONDU,CPUC,CPUV,CPC,HCN,TBEGIN,TSTPD,TSTFD,TSTHD,CPNAK 00030110
    2,R0DNO,CHANO,R0DSEC                                     00030111
    10 FORMAT (6E12.8)                                       00030120
    NODEA=BNODES+0.01                                       00030130
    NP1=NODEA+1                                              00030135
    IF (TBEGIN) 15,30,20                                     00030140
    15 READ INPUT TAPE 5,10, ((TU(I,J),I=1,NODEA),J=1,24),(((TC(I,J,K),K=00030150
    11,6),I=1,NODEA),J=1,24),((TNAK(I,J),I=1,NODEA),J=1,39) 00030160
    DO 16 I=1,39                                             00030170
    TIN (1,I)=TCORIN                                         00030180
    DO 16 J=2,NP1                                             00030190
    K=J-1                                                     00030200
    16 TIN (J,I)= 2.0*TNAK(K,I)-TIN(K,I)                     00030210
    GO TO 30                                                  00030220
    20 DO 25 I=1,NODEA                                       00030230
    DO 23 J=1,24                                              00030240
    DO 22 K=1,6                                               00030250
    22 TC(I,J,K)=TCORIN                                       00030260
    23 TU(I,J)=TCORIN                                         00030270
    DO 25 J=1,39                                              00030280
    TIN(I,J)=TCORIN                                           00030290
    25 TNAK(I,J)=TCORIN                                       00030300
    DO 26 J=1,39                                              00030310
    26 TIN(NP1,J)=TCORIN                                       00030320
    30 IF (TSTPD) 40,40,31                                    00030325
    31 READ INPUT TAPE 5,10,DISR,(DISA(I),I=1,NODEA)         00030330
    XA=R0DNO*BNODES                                          00030335

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	D0 32 I=1,N0DEA	00030340
	D0 32 J=1,24	00030350
32	QM(I,J)=(DISA(I)*DISR(J))/XA	00030370
	XA=R0DSEC*BN0DES	00030375
40	IF (TSTFD) 41,50,44	00030380
41	D0 42 I=1,N0DEA	00030390
	D0 42 J=1,39	00030400
42	FLOWM(I,J)=1.0	00030410
	GO TO 46	00030420
44	READ INPUT TAPE 5,10,((FLOWM(I,J),I=1,N0DEA),J=1,39)	00030430
46	D0 48 I=1,N0DEA	00030450
	D0 48 J=1,39	00030460
48	FLOWM(I,J)=FLOWM(I,J)/CHANG	00030470
C	RATIO = TRUE GAP WIDTH/CORE AVG. GAP WIDTH	00030480
50	IF (TSTHD) 51,60,54	00030490
51	D0 52 I=1,N0DEA	00030500
	D0 52 J=1,24	00030510
	D0 52 K=1,6	00030520
52	RATIO(I,J,K)=1.0	00030530
	READ INPUT TAPE 5,56,IR0DRD	00030531
56	FORMAT (6I12)	00030532
	IF(IR0DRD) 60,60,55	00030533
55	READ INPUT TAPE 5,56,((IRN0(I),I=1,IR0DRD)	00030534
	D0 57 L=1,IR0DRD	00030535
	J=IRN0(L)	00030536
57	READ INPUT TAPE 5,10, ((RATIO(I,J,K),K=1,6),I=1,N0DEA)	00030537
	GO TO 60	00030540
54	READ INPUT TAPE 5,10,(((RATIO(I,J,K),K=1,6),I=1,N0DEA),J=1,24)	00030550
60	CALL FGEN(IX,TFAVG,GC0ND,READ)	00030560
	PI=3.141593	00030570
	HCN=HCN/(R0DNG*6.0*BN0DES)	00030575
	RC1=(PI*BLENTH)/(6.0*BN0DES)	00030580
	RC2=(RADG-RADU)/(RADG+RADU)	00030590
	RC3=0.25/C0NDU	00030600
	WTCLAD=DENC*PI*RADG*BLENTH*THICK/BN0DES	00030610
	WCPC=CPC*WTCLAD	00030620
	WTFUEL=DENU*PI*RADU*RADU*BLENTH/BN0DES	00030630
	WS=WTNAK/(BN0DES*CHANG)	00030640
	WCNNL=WS*CPNAK + WCPC	00030650

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WS=	WCNNL/CPNAK	00030655
WRITE OUTPUT TAPE 6,62,BNODES,BLENTN,RADU,RADG,THICK,DENU,DENC,		00030660
1WTNAK,CNDU,CPUC,CPUV,CPC,HCN,TBEGIN,TSTPD,TSTFD,TSTHD,CPNAK,WCPC,		00030670
2WTFUEL,WS,WCNNL		00030680
3,R0DNO,CHANO,R0DSEC		00030685
62 FORMAT (1H1,35X,11H GEOM INPUT//((1P6E15.6))		00030700
WRITE OUTPUT TAPE 6,63,DISR,(DISA(I),I=1,N0DEA)		00030720
63 FORMAT (1H0,15X,17H GEOM. POWER DIST//((1P6E15.6))		00030730
WRITE OUTPUT TAPE 6,64,((FLOWM(I,J),I=1,N0DEA),J=1,39)		00030740
64 FORMAT (1H0,15X,15H GEOM FLOW DIST//((1P6E15.6))		00030750
WRITE OUTPUT TAPE 6,65,(((RATIO(I,J,K),K=1,6),I=1,N0DEA),J=1,24)		00030760
65 FORMAT (1H0,15X,16H GEOM GAP RATIOS//((1P6E15.6))		00030770
DQG=0.0		00030775
D0 73 I=1,N0DEA		00030780
D0 70 J=1,24		00031000
DTU(I,J)=0.0		00031010
TU0(I,J)=TU(I,J)		00031020
D0 70 K=1,6		00031030
70 DTC(I,J,K)=0.0		00031050
D0 72 J=1,39		00031060
DTNAK(I,J)=0.0		00031070
DTIN(I,J)=0.0		00031080
72 TIN0(I,J)=TIN(I,J)		00031090
DTNAK(I,40)=0.0		00031092
D0 73 K=1,6		00031094
73 DTC(I,25,K)=0.0		00031096
D0 74 J=1,39		00031100
74 TIN0(NP1,J)=TIN(NP1,J)		00031110
C		00031117
C BEGIN LOOP CALCULATIONS		00031118
C		00031119
100 SUMFU=C.0		00031120
DQG=(PWR-CG)/DELT		00031125
D0 101 I=1,N0DEA		00031130
D0 101 J=1,24		00031140
101 SUMFU=SUMFU+TU(I,J)		00031150
TFAVG=SUMFU/XA		00031160
CALL FGEN(IX,TFAVG,GCOND,0.0)		00031170
WCPU=WTFUEL*(CPUC+CPUV*TFAVG)		00031180

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	RC4=RC2/GCOND	00031190
	D0 103 I=1,NODEA	00031200
	D0 103 J=1,24	00031202
	D0 103 K=1,6	00031204
	TEMP=RC1/(RC3+RC4*RATIO(I,J,K))	00031205
103	HFC(I,J,K)=HCN*TEMP/(HCN+TEMP)	00031206
C		00031207
C	GEOMETRY -- FUEL ELEMENT PATTERN	00031208
C		00031209
	D0 190 I=1,6	00031210
190	IC(I)=1	00031211
	KPOS=0	00031212
195	KPOS=KPOS+1	00031214
200	CALL RCD(KPOS)	00031218
	G0 T0 (201,202,203,204,205,206,207,208,209,210,211,212,213,214,215	00031220
	1,216,217,218,219,220,221,222,223,224),KPOS	00031222
201	IC(1)=9	00031223
	IC(2)=9	00031224
	IC(3)=2	00031225
	IC(6)=2	00031226
	G0 T0 195	00031227
202	IC(1)=3	00031228
	IC(2)=10	00031229
	IC(3)=9	00031230
	IC(4)=2	00031231
	IC(5)=9	00031232
	IC(6)=10	00031233
	G0 T0 195	00031234
203	IC(1)=17	00031235
	IC(2)=17	00031236
	IC(3)=10	00031237
	IC(4)=9	00031238
	G0 T0 195	00031239
204	IC(1)=11	00031240
	IC(2)=18	00031241
	IC(3)=17	00031242
	IC(4)=10	00031243
	IC(5)=3	00031244
	IC(6)=4	00031245

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	GO TO 195	00031246
205	IC(1)=23	00031247
	IC(2)=23	00031248
	IC(3)=18	00031249
	IC(4)=17	00031250
	IC(5)=17	00031251
	IC(6)=18	00031252
	GO TO 195	00031253
206	IC(1)=5	00031254
	IC(2)=12	00031255
	IC(3)=11	00031256
	IC(4)=4	00031257
	IC(5)=11	00031258
	IC(6)=12	00031259
	GO TO 195	00031260
207	IC(1)=19	00031261
	IC(2)=24	00031262
	IC(3)=23	00031263
	IC(4)=18	00031264
	GO TO 195	00031265
208	IC(1)=29	00031266
	IC(2)=29	00031267
	IC(3)=24	00031268
	IC(4)=23	00031269
	IC(5)=23	00031270
	IC(6)=24	00031271
	GO TO 195	00031272
209	IC(1)=13	00031273
	IC(2)=20	00031274
	IC(3)=19	00031275
	IC(4)=12	00031276
	IC(5)=5	00031277
	IC(6)=6	00031278
	GO TO 195	00031279
210	IC(1)=25	00031280
	IC(2)=30	00031281
	IC(3)=29	00031282
	IC(4)=24	00031283
	IC(5)=19	00031284

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	IC(6)=20	00031285
	GO TO 195	00031286
211	IC(1)=33	00031287
	IC(2)=33	00031288
	IC(3)=30	00031289
	IC(4)=29	00031290
	IC(5)=29	00031291
	IC(6)=30	00031292
	GO TO 195	00031293
212	IC(1)=7	00031294
	IC(2)=14	00031295
	IC(3)=13	00031296
	IC(4)=6	00031297
	IC(5)=13	00031298
	IC(6)=14	00031299
	GO TO 195	00031300
213	IC(1)=21	00031301
	IC(2)=26	00031302
	IC(3)=25	00031303
	IC(4)=20	00031304
	GO TO 195	00031305
214	IC(1)=31	00031306
	IC(2)=34	00031307
	IC(3)=33	00031308
	IC(4)=30	00031309
	IC(5)=25	00031310
	IC(6)=26	00031311
	GO TO 195	00031312
215	IC(1)=37	00031313
	IC(2)=37	00031314
	IC(3)=34	00031315
	IC(4)=33	00031316
	IC(5)=33	00031317
	IC(6)=34	00031318
	GO TO 195	00031319
216	IC(1)=15	00031320
	IC(2)=22	00031321
	IC(3)=21	00031322
	IC(4)=14	00031323

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	IC(5)= 7	00031324
	IC(6)=8	00031325
	G0 T0 195	00031326
217	IC(1)=27	00031327
	IC(2)=32	00031328
	IC(3)=31	00031329
	IC(4)=26	00031330
	IC(5)=21	00031331
	IC(6)=22	00031332
	G0 T0 195	00031333
218	IC(1)=35	00031334
	IC(2)=38	00031335
	IC(3)=37	00031336
	IC(4)=34	00031337
	IC(5)=31	00031338
	IC(6)=32	00031339
	G0 T0 195	00031340
219	IC(1)=39	00031341
	IC(2)=39	00031342
	IC(3)=38	00031343
	IC(4)=37	00031344
	IC(5)=37	00031345
	IC(6)=38	00031346
	G0 T0 195	00031347
220	IC(1)=40	00031348
	IC (2)=16	00031349
	IC(3)=15	00031350
	IC(4)=8	00031351
	IC(5)=15	00031352
	IC(6)=16	00031353
	NR0=20	00031354
230	NR0=NR0+1	00031355
	D0 231 I=1,N0DEA	00031356
	TNAK(I,40)=TU(I,NR0)	00031357
231	TC(I,NR0,1)=TU(I,NR0)	00031358
	G0 T0 195	00031359
221	IC(2)=28	00031360
	IC(3)=27	00031361
	IC(4)=22	00031362

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	IC(5)=15	00031363
	IC(6)=16	00031364
	GO TO 230	00031365
222	IC(2)=36	00031367
	IC(3)=35	00031368
	IC(4)=32	00031369
	IC(5)=27	00031370
	IC(6)=28	00031371
	GO TO 230	00031372
223	IC(2)=40	00031374
	IC(3)=39	00031375
	IC(4)=38	00031376
	IC(5)=35	00031377
	IC(6)=36	00031378
	DO 225 I=1,NODEA	00031379
225	TC(I,24,2)=TU(I,24)	00031380
	GO TO 230	00031381
C		00031997
C	GEOMETRY -- COOLANT CHANNEL PATTERN	00031998
C		00031999
224	KPOS=0	00032000
	IR(1)=1	00032010
	IR(2)=1	00032020
	IR(3)=2	00032030
	IR(4)=5	00032040
	IR(5)=2	00032050
	IR(6)=5	00032060
240	KPOS=KPOS+1	00032061
250	CALL CHANL(KPOS,WRITE)	00032063
	GO TO (251,252,253,254,255,256,257,258,259,260,261,262,263,264,265)	00032064
	1,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,	00032065
	282,283,284,285,286,287,288,300),KPOS	00032066
251	IR(1)=2	00032067
	IR(2)=6	00032068
	IR(4)=6	00032070
	IR(5)=3	00032071
	IR(6)=4	00032072
	GO TO 240	00032073
252	IR(1)=5	00032074

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	IR(2)=5	00032075
	IR(3)=5	00032076
	IR(4)=5	00032077
	IR(6)=1	00032078
	G0 T0 240	00032079
253	IR(2)=6	00032080
	IR(4)=6	00032081
	IR(5)=7	00032082
	IR(6)=4	00032083
	G0 T0 240	00032084
254	IR(1)=10	00032085
	IR(2)=5	00032086
	IR(3)=10	00032087
	IR(4)=5	00032088
	IR(6)=1	00032089
	G0 T0 240	00032090
255	IR(2)=6	00032091
	IR(4)=6	00032092
	IR(5)=13	00032093
	IR(6)=4	00032094
	G0 T0 240	00032095
256	IR(1)=17	00032096
	IR(2)=5	00032097
	IR(3)=17	00032098
	IR(4)=5	00032099
	IR(6)=1	00032100
	G0 T0 240	00032101
257	IR(2)=6	00032102
	IR(4)=6	00032103
	IR(5)=21	00032104
	IR(6)=4	00032105
	G0 T0 240	00032106
258	IR(1)=3	00032107
	IR(2)=3	00032108
	IR(3)=4	00032109
	IR(4)=5	00032110
	IR(5)=2	00032111
	IR(6)=1	00032112
	G0 T0 240	00032113

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259	IR(5)=5	00032116
	GO TO 293	00032117
260	IR(1)=7	00032119
	IR(3)=8	00032121
	GO TO 294	00032123
261	IR(5)=10	00032127
	GO TO 293	00032128
262	IR(1)=13	00032130
	IR(3)=14	00032132
	GO TO 294	00032134
263	IR(5)=17	00032138
	GO TO 293	00032139
264	IR(1)=21	00032140
	IR(3)=22	00032142
	GO TO 294	00032144
265	IR(2)=2	00032146
	IR(4)=6	00032147
	IR(5)=25	00032148
	IR(6)=1	00032149
	GO TO 290	00032151
266	IR(1)=5	00032152
	IR(3)=6	00032154
	IR(5)=4	00032156
	GO TO 294	00032157
267	IR(5)=8	00032161
	GO TO 293	00032162
268	IR(1)=10	00032164
	IR(3)=11	00032166
	GO TO 294	00032167
269	IR(5)=14	00032172
	GO TO 293	00032173
270	IR(1)=17	00032175
	IR(3)=18	00032177
	GO TO 294	00032178
271	IR(5)=22	00032181
	GO TO 293	00032182
272	IR(1)=8	00032183
	IR(3)=9	00032184
	IR(5)=6	00032185

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	G0 T0 294	00032186
273	IR(5)=11	00032187
	G0 T0 293	00032188
274	IR(1)=14	00032189
	IR(3)=15	00032190
	G0 T0 294	00032191
275	IR(5)=18	00032192
	G0 T0 293	00032193
276	IR(1)=22	00032194
	IR(3)=23	00032195
	G0 T0 294	00032196
277	IR(2)=2	00032197
	IR(4)=6	00032198
	IR(5)=25	00032199
	IR(6)=1	00032200
	G0 T0 290	00032201
278	IR(1)=11	00032202
	IR(3)=12	00032203
	IR(5)=9	00032204
	G0 T0 294	00032205
279	IR(5)=15	00032206
	G0 T0 293	00032207
280	IR(1)=18	00032208
	IR(3)=19	00032209
	G0 T0 294	00032210
281	IR(5)=23	00032211
	G0 T0 293	00032212
282	IR(1)=15	00032213
	IR(3)=16	00032214
	IR(5)=12	00032215
	G0 T0 294	00032216
283	IR(5)=19	00032217
	G0 T0 293	00032218
284	IR(1)=23	00032219
	IR(3)=24	00032220
	G0 T0 294	00032221
285	IR(2)=2	00032222
	IR(4)=6	00032223
	IR(5)=25	00032224

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	IR(6)=1	00032225
	GO TO 290	00032226
286	IR(1)=19	00032227
	IR(3)=20	00032228
	IR(5)=16	00032229
	GO TO 294	00032230
287	IR(5)=24	00032231
	GO TO 293	00032232
288	IR(1)=24	00032233
	IR(2)=3	00032234
	IR(3)=20	00032235
	IR(4)=1	00032236
	IR(5)=25	00032237
	IR(6)=1	00032238
290	DO 292 I=1,NODEA	00032981
292	HFC(I,25,1)=0.0	00032982
	GO TO 240	00032983
293	IR(2)=2	00032984
	IR(4)=6	00032985
	IR(6)=4	00032986
	GO TO 240	00032987
294	IR(2)=3	00032988
	IR(4)=5	00032989
	IR(6)=1	00032990
	GO TO 240	00032991
300	KDO=1	00033000
	DMAX=0.0	00033010
310	GO TO (320,360,370,380),KDO	00033020
320	KDO=2	00033030
	KR=1	00033040
	KCH=1	00033050
325	DO 330 I=1,NODEA	00033060
330	DMAX=MAX1F(DMAX,ABSF(DTU(I,KR)/TU(I,KR)),ABSF(DTNAK(I,KCH)/TNAK(I,	00033090
	1KCH)))	00033100
	GO TO 310	00033110
360	KDO=3	00033120
	KR=9	00033130
	KCH=24	00033140
	GO TO 325	00033150

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370	KDC=4	00033160
	KR=20	00033170
	KCH=38	00033180
	GO TO 325	00033190
C		00033195
C	OUTPUT STATEMENTS	00033196
C		00033197
380	QG=PKR	00033199
	IF (WRITE) 500,500,390	00033200
390	SUM=0.0	00033201
	DO 391 I=1,8	00033202
391	SUM=SUM+TIN(NP1,I)/2.0	00033204
	DO 392 I=9,39	00033206
392	SUM=SUM+TIN(NP1,I)	00033208
	SUM=SUM/35.0	00033210
	WRITE OUTPUT TAPE 6,400,TIME,QG,AFLOW,TCORIN,TF AVG,SUM	00033215
400	FORMAT (1H1/6H TIME=1P1E14.7/4H QG=1P1E14.7/6H FLOW=1P1E14.7/5H T	00033220
	IN=1P1E14.7/7H TFAVG=1P1E14.7/6H TOUT=1P1E14.7)	00033230
	DO 410 ID0=1,24	00033240
	WRITE OUTPUT TAPE 6,415,ID0,(TU(I,ID0),(TC(I,ID0,K),K=1,6),I=1,	00033250
	IN0DEA)	00033260
410	WRITE OUTPUT TAPE 6,416,(DTU(I,ID0),(DTC(I,ID0,K),K=1,6),I=1,	00033270
	IN0DEA)	00033280
415	FORMAT (1H-//32X,10HELEMENT N013,32H FUEL AND CLAD TEMP DISTRIBUTI	00033290
	10N//((1P7E15.5))	00033300
416	FORMAT(1H-//40X,25HFUEL AND CLAD DERIVATIVES//((1P7E15.5))	00033310
	DO 420 ID0=1,39	00033320
420	WRITE OUTPUT TAPE 6,430,ID0,((TIN(J,ID0)),J=2,NP1)	00033330
430	FORMAT (1H-//40X,26HTEMP NAK OUTLET CHANNEL N013/((1P5E20.7))	00033340
500	RETURN	00033355
	END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)	

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STORAGE NCT USED BY PROGRAM

DEC OCT
3581 06775DEC OCT
24218 57232

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

 DEC OCT
 AFLW 32558 77456
 DTIN 25428 61524
 HCN 26263 63227
 NDEA 32557 77455
 TCBL 24999 60647
 TIN 25857 62401
 TU 32556 77454
 WS 26248 63210

 DEC OCT
 DELT 32559 77457
 DTNAK 28406 67366
 HFC 28006 66546
 QG 26266 63232
 TC 32056 76470
 TNAK 28806 70206
 WCNNL 26249 63211

 DEC OCT
 DQG 26262 63226
 DTU 32306 77062
 IC 26261 63225
 QM 26506 63612
 TIME 32560 77460
 TNSUM 24219 57233
 WCPC 26264 63230

 DEC OCT
 CTC 30306 73142
 FLOWM 26247 63207
 IR 26255 63217
 READ 32561 77461
 TIN 24609 60041
 TU 30556 73534
 WCPU 26265 63231

STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC OCT
DISA 3580 06774DEC OCT
DISR 3570 06762DEC OCT
IRNO 3546 06732DEC OCT
RATIO 3521 06701

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

 DEC OCT
 BLENTH 2081 04041
 CPC 2077 04035
 DENC 2073 04031
 IRUORD 2069 04025
 KCH 2065 04021
 K 2061 04015
 RADG 2057 04011
 RC3 2053 04005
 SUMFU 2049 04001
 TFAVG 2045 03775
 TSTPD 2041 03771
 XA 2037 03765

 DEC OCT
 BNODES 2080 04040
 CPNAK 2076 04034
 DENU 2072 04030
 I 2068 04024
 KDO 2064 04020
 NP1 2060 04014
 RADU 2056 04010
 RC4 2052 04004
 SUM 2048 04000
 THICK 2044 03774
 WTCLAD 2040 03770

 DEC OCT
 CHANO 2079 04037
 CPUC 2075 04033
 GCND 2071 04027
 IX 2067 04023
 KPOS 2063 04017
 NR 2059 04013
 RC1 2055 04007
 RDN 2051 04003
 TBEGIN 2047 03777
 TSTFD 2043 03773
 WTFUEL 2039 03767

 DEC OCT
 CONDU 2078 04036
 CPUV 2074 04032
 ID 2070 04026
 J 2066 04022
 KR 2062 04016
 PI 2058 04012
 RC2 2054 04006
 RDNSEC 2050 04002
 TEMP 2046 03776
 TSTHD 2042 03772
 WTNAK 2038 03766

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SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC		EFN	LOC		EFN	LOC		EFN	LOC
81A	10	03723	8110	56	03721	811U	62	03717	811V	63	03710
8120	64	03700	8121	65	03671	81CG	400	03662	81CV	415	03640
81D0	416	03623	81DE	430	03612						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	DEC	OCT		DEC	OCT		DEC	OCT		DEC	OCT
11	2004	03724	21	1866	03512	31	1908	03564	61	1916	03574
A1103	1840	03460	A1104	1853	03475	C1G0	2008	03730	C1G2	2009	03731
C1G3	2010	03732	C1G5	2011	03733	C1100	2012	03734	C1101	2013	03735
C1102	2014	03736	C1103	2015	03737	C1104	2016	03740	C1105	2017	03741
C1106	2018	03742	C1107	2019	03743	C1108	2020	03744	C1109	2021	03745
C110D	2022	03746	C11G0	2023	03747	C11G1	2024	03750	C11G2	2025	03751
C11G3	2026	03752	C11G5	2027	03753	C1200	2028	03754	C1201	2029	03755
C1202	2030	03756	C1205	2031	03757	C1206	2032	03760	C1207	2033	03761
C120B	2034	03762	C120C	2035	03763	C120D	2036	03764	D110H	178	00262
D1134	701	01275	D120R	245	00365	D1261	1578	03052	D126E	1739	03313
D126J	1769	03351	D126S	1835	03453	D1361	1577	03051	D136E	1738	03312
D136J	1768	03350	D136S	1834	03452	D140I	187	00273	D1414	297	00451
D1424	423	00647	D142T	669	01235	D1432	687	01257	D144K	1208	02270
D144L	1261	02355	D1440	1296	02420	D144P	1309	02435	D144S	1342	02476
D145B	1436	02634	D145D	1447	02647	D145H	1476	02704	D145J	1487	02717
D145L	1500	02734	D145N	1511	02747	D145R	1546	03012	D145U	1555	03023
D1514	296	00450	D1524	422	00646	D152T	668	01234	D1632	686	01256
E13N	846	01516	E130	856	01530	E13P	870	01546	E13Q	880	01560
E13R	894	01576	E13S	908	01614	E13T	922	01632	E13U	932	01644
E13V	946	01662	E140	960	01700	E141	974	01716	E142	988	01734
E143	1002	01752	E144	1012	01764	E145	1026	02002	E147	1053	02035
E148	1067	02053	E149	1081	02071	E14A	1095	02107	E14E	1146	02172
E14F	1158	02206	E14G	1170	02222	E14L	1260	02354	E14M	1273	02371
E14N	1285	02405	E140	1295	02417	E14P	1308	02434	E14Q	1319	02447
E14R	1331	02463	E14S	1341	02475	E14T	1356	02514	E14U	1360	02520
E14V	1366	02526	E151	1375	02537	E152	1379	02543	E153	1385	02551
E154	1395	02563	E155	1403	02573	E156	1407	02577	E157	1413	02605
E158	1417	02611	E159	1423	02617	E15A	1427	02623	E15B	1435	02633
E15C	1440	02640	E15D	1446	02646	E15E	1451	02653	E15F	1457	02661
E15G	1467	02673	E15H	1475	02703	E15I	1480	02710	E15J	1486	02716

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E15K	1491	02723	E15L	1499	02733	E15M	1504	02740	E15N	1510	02746
E150	1521	02761	E15P	1529	02771	E15Q	1533	02775	E160	1570	03042
E169	1659	03173									

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
CHANL	8 00010	FGEN	3 00003	R0D	7 00007	(FIL)	5 00005
(RTN)	1 00001	(SLI)	2 00002	(SL0)	6 00006	(STH)	4 00004
(TSH)	0 00000						

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

CHANL	FGEN	R0D	(FIL)	(RTN)	(SLI)	(SL0)	(STH)
(TSH)							

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	L0C	EFN	IFN	L0C	EFN	IFN	L0C	EFN	IFN	L0C
1	16	00046	15	21	00142	16	48	00305	20	50	00340
22	53	00350	23	54	00355	25	57	00370	26	59	00410
30	60	00415	31	61	00421	32	70	00453	40	72	00472
41	73	00475	42	75	00500	44	77	00510	46	85	00537
48	87	00542	50	88	00552	51	89	00555	52	92	00560
55	96	00604	57	103	00625	54	112	00670	60	123	00722
70	168	01242	72	172	01264	73	175	01276	74	177	01330
100	178	01336	101	182	01347	103	191	01416	190	193	01443
195	195	01453	200	196	01457	201	198	01517	202	203	01531
203	210	01547	204	215	01561	205	222	01577	206	229	01615
207	236	01633	208	241	01645	209	248	01663	210	255	01701
211	262	01717	212	269	01735	213	276	01753	214	281	01765
215	288	02003	216	295	02020	217	302	02036	218	309	02054
219	316	02072	220	323	02110	230	330	02126	231	333	02163
221	335	02173	222	341	02207	223	347	02223	225	353	02241
224	355	02247	240	362	02271	250	363	02275	251	365	02356
252	371	02372	253	377	02406	254	382	02421	255	388	02436
256	393	02450	257	399	02464	258	404	02477	259	411	02515
260	413	02521	261	416	02527	262	418	02532	263	421	02540
264	423	02544	265	426	02552	266	431	02564	267	435	02574

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268	437	02600	269	440	02606	270	442	02612	271	445	02620
272	447	02624	273	451	02635	274	453	02641	275	456	02650
276	458	02654	277	461	02662	278	466	02674	279	470	02705
280	472	02711	281	475	02720	282	477	02724	283	481	02735
284	483	02741	285	486	02750	286	491	02762	287	495	02772
288	497	02776	290	503	03013	292	504	03016	293	506	03024
294	510	03033	300	514	03043	310	516	03053	320	517	03057
325	520	03067	330	521	03114	360	523	03143	370	527	03154
380	531	03165	390	533	03174	391	535	03200	392	537	03216
410	551	03343	420	560	03431	500	569	03454			

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