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ENGINEERING OPERATIONS REPORT

DIGITAL COMPUTER PROGRAMS FOR STEADY-STATE OR TRANSIENT TEMPERATURE ANALYSIS OF PLANE AND AXISYMMETRIC BODIES BY THE FINITE ELEMENT METHOD

PROGRAMS E12202

E12205

E12206

E12207

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DISCLAIMER

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I. INTRODUCTION

The problem is to determine the temperature distribution of a complex two-dimensional body with various boundary conditions including radiation effects. The body can consist of several different materials; the material property parameters and boundary conditions can be both temperature and time dependent. The purpose of this report is to describe the numerical procedures and the input instructions for the computer programs which provide the solutions.

The basic numerical procedure which is presented here is the finite element method--FEM. Many published papers have demonstrated the validity of the finite element idealization via variational techniques. However, a formal mathematical approach will not be utilized in this report, rather, a completely physical interpretation of the heat transfer equations for a finite element system will be given.

The advantages of the FEM as compared to other numerical approaches are numerous. The method is completely general with respect to geometry and material properties; complex bodies composed of many different materials

are easily represented. Inherent in most numerical procedures is the solution of a set of linear equations for unknown mesh point temperatures. In the FEM the linear equations produce a symmetric positive-definite matrix in band form which is readily solved with a minimum of computer storage and time. In addition, the computer input can be made compatible with existing stress analysis programs; therefore, the computer input and the over-all time necessary for the complete thermal stress analysis is reduced.

II. METHOD OF ANALYSIS*

A. ASSUMPTIONS

The basic element (sub-division) used in the idealization of a two-dimensional body is a triangle of arbitrary shape (Figure 1). Since the thickness of the triangle may be different for each element, axisymmetric bodies are a special case of this formulation. The first step in the

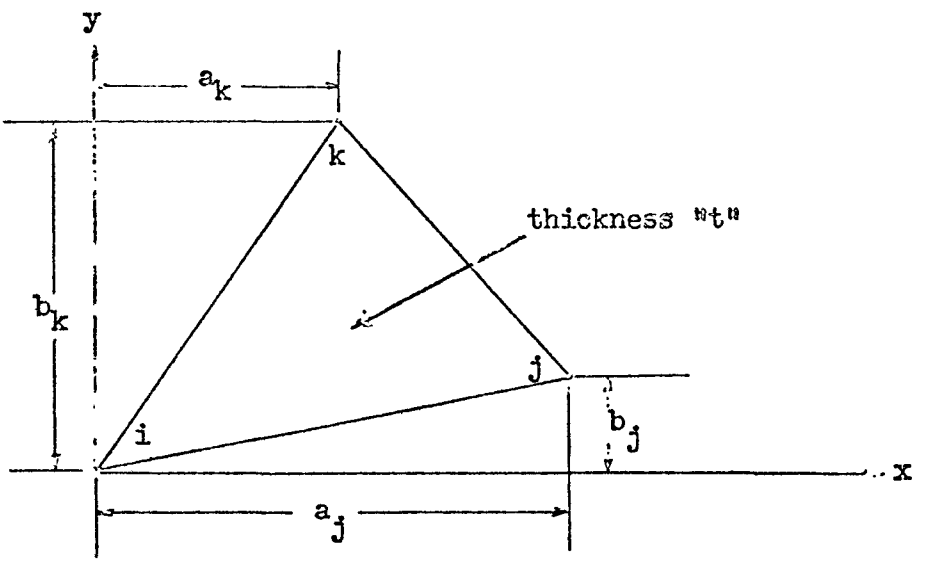


FIGURE 1 - TYPICAL TRIANGULAR ELEMENT

*Most of this section was taken from Aerojet Report No. TD-44, March 1965 by E. L. Wilson.

development of the heat transfer equations is to assume the following temperature distribution within each element:

$$T(x,y) = \beta_1 + \beta_2 x + \beta_3 y \tag{1}$$

If Equation (1) is evaluated at the three vertices and the resulting set of equations is solved, the following relationship for the constants β_1, β_2 and β_3 is obtained:

$$\begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} = \frac{1}{\lambda} \begin{bmatrix} \lambda & 0 & 0 \\ b_j - b_k & b_k & -b_j \\ a_k - a_j & -a_k & a_j \end{bmatrix} \begin{bmatrix} T_i \\ T_j \\ T_k \end{bmatrix} \tag{2a}$$

where $\lambda = a_j b_k - a_k b_j$

or, symbolically

$$[\beta]_v = [D][T]_v \tag{2b}$$

B. TEMPERATURE GRADIENTS

The temperature gradients normal to the boundaries of the element are by definition

$$S_N = \frac{\partial T}{\partial N} \tag{3}$$

If Equation (3) evaluated at the three boundaries of the element, the following normal gradients are found:

NOTE: Subscript stands for vector.

$$\begin{bmatrix} S_i \\ S_j \\ S_k \end{bmatrix} = \begin{bmatrix} 0 & -\sin\theta_{jk} & \cos\theta_{jk} \\ 0 & -\sin\theta_{ki} & \cos\theta_{ki} \\ 0 & -\sin\theta_{ij} & \cos\theta_{ij} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} \tag{4}$$

The angles θ_{mn} are defined in Figure 2. Equation (4) may be written in symbolic form as

$$[S]_V = [g][\beta]_V \tag{5}$$

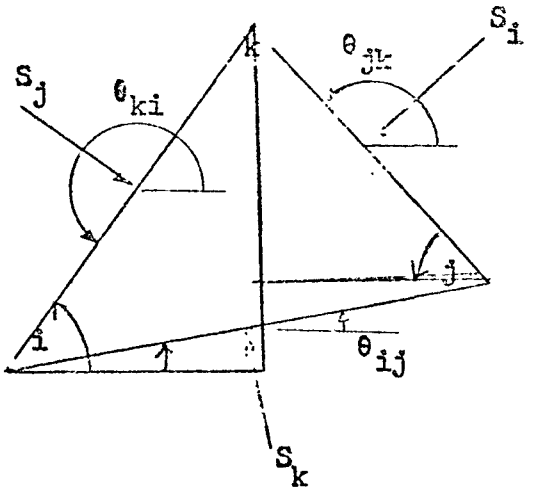


FIGURE 2 - NORMAL GRADIENTS AND REFERENCE ANGLES

C. HEAT FLOW

The rate of heat flow through a boundary is given by

$$q_N = k A S_N$$

where k is the conductivity of the material and A is the surface area of the boundary. Consequently, the heat flow, as shown in Figure 3, through the three interior boundaries, which are one half the length of the sides, is

$$\begin{bmatrix} q_i \\ q_j \\ q_k \end{bmatrix} = \frac{k\,t}{2} \begin{bmatrix} \ell_{jk} & 0 & 0 \\ 0 & \ell_{ki} & 0 \\ 0 & 0 & \ell_{ij} \end{bmatrix} \begin{bmatrix} S_i \\ S_j \\ S_k \end{bmatrix} \qquad (6)$$

where t is the thickness of the element and ℓ_{mn} is the length of side mn Equation (6) written symbolically is

$$[q]_v = [f][S]_v \qquad (7)$$

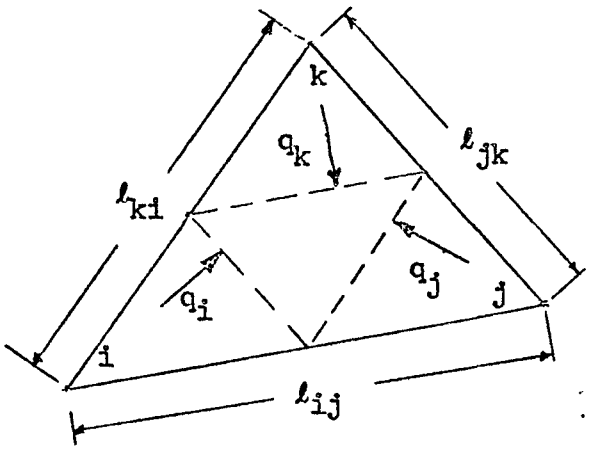


FIGURE 3 - HEAT FLOW VECTORS

D. ELEMENT CONDUCTIVITY MATRIX AND ENERGY EQUATION

Heat flow for a typical element m is expressed in terms of corner temperatures by combining Equations (2), (5) and (7),

$$\left[q^m\right]_v = \left[C^m\right]\left[T^m\right]_v \tag{8}$$

where $\left[C^m\right]$ is defined as the "element conductivity matrix" and is given by

$$\left[C^m\right] = \left[f\right]\left[g\right]\left[D\right] \tag{9}$$

In terms of basic element dimensions and properties, Equation (8) becomes

$$\begin{bmatrix} q_i \\ q_j \\ q_k \end{bmatrix} = \frac{k\,h}{2\lambda} \begin{bmatrix} e^2 + d^2 & b_k e - a_k d & -b_j e + a_j d \\ b_k e - a_k d & b_k^2 + a_k^2 & -b_j b_k - a_j a_k \\ -b_j e + a_j d & -b_j a_k - a_j a_k & b_j^2 + a_j^2 \end{bmatrix} \begin{bmatrix} T_i \\ T_j \\ T_k \end{bmatrix} \tag{10}$$

where $d = a_k - a_j$

$e = b_j - b_k$

E. ELEMENT CONDUCTIVITY MATRIX AND ENERGY EQUATION FOR THE COMPLETE SYSTEM

For a non-steady temperature condition, the heat flow out minus the heat flow into the region can be represented by the expression

$$\left(\rho C_p \frac{\partial T}{\partial t}\right)_n \quad , \; n = 1, 2, \ldots, N$$

where ρ = average material density

C_p = average material specific heat

T = temperature

t = time

and subscript n represents the nodal point. Elements attached to typical nodal point n, as shown in Figure 4, form the basic region where a heat balance requires that

$$\left(\rho C_p \frac{\partial T}{\partial t}\right)_n = Q_n - \sum_{m=1}^{M} q_n^m \, , \; n = 1, 2, \ldots, N \qquad (11)$$

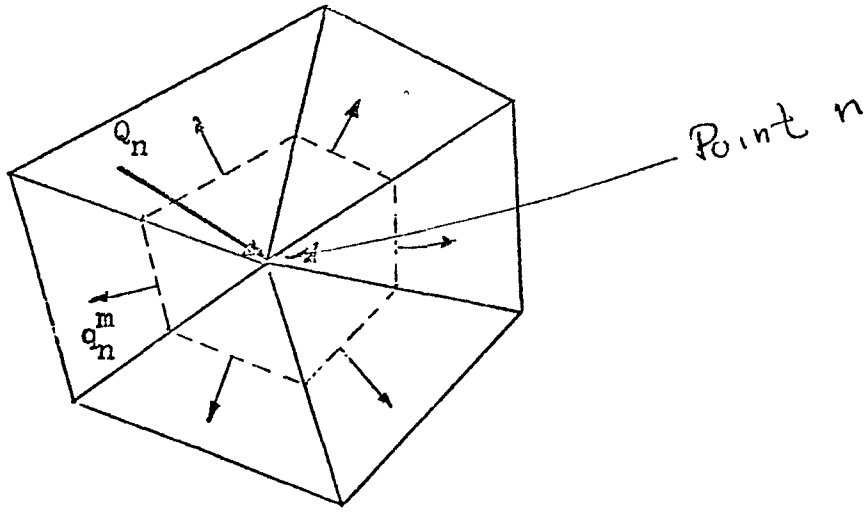


FIGURE 4 - TYPICAL REGION FOR HEAT EQUILIBRIUM

In the latter expression, M is the total number of elements and N is the total number of nodal points in the systems. The set of N Equations (11) may be written in matrix form as

$$\left[\left(\rho C_p \frac{\partial T}{\partial t}\right)_n\right]_v = \left[Q_n\right]_v - \left[\sum_{m=1}^{M} q_n^m\right]_v . \tag{12}$$

In a similar manner, Equation (8) may be expanded in terms of all possible nodal points and be expressed as

$$\left[q_n^m\right]_v = \left[C_n^m\right]\left[T_n\right]_v \tag{13}$$

where zero valued elements have been inserted in order to expand the 3 x 3 C^m matrix to the N x N $\left[C_n^m\right]$ matrix.

The substitution of matrix equation (13) into matrix Equation (12) results in an expression in terms of nodal point temperatures and its partial derivatives,

$$\left[\left(\rho C_p \frac{\partial T}{\partial t}\right)_n\right]_v + \left[C_n\right]\left[T_n\right]_v = \left[Q_n\right]_v \tag{14}$$

where C_n is the N x N "conductivity matrix" (for the complete body) which is given by

$$\left[C_n\right] = \left[\sum_{m=1}^{M} C_n^m\right] \tag{15}$$

The summation of element conductivities to form the complete conductivity matrix is similar to the combination of element stiffnesses in the

"direct stiffness" approach to stress analysis.

Let $\left[D_n \right]$ be a diagonal matrix with $(\rho C_p)_n$ on the diagonal, then one can write

$$\left[D_n \right]\left[\frac{\partial T_n}{\partial t} \right]_{v,t} + \left[C_n \right]\left[T_n \right]_{v,t} = \left[Q_n \right]_{v,t} \qquad (14a)$$

where the new subscript t refers to "at time t".

Now expand $\left[T_n \right]_{v,t}$ in a Taylor's series and truncate after the 2nd order term to get

$$\left[T_n \right]_{v,t} = \left[T \right]_{v,t-\Delta t} + \Delta t \left[\frac{\partial T_n}{\partial t} \right]_{v,t-\Delta t} +$$

$$\frac{(\Delta t)^2}{2} \left[\frac{\partial^2 T_n}{\partial t^2} \right]_{v,t-\Delta t}$$

Then approximate the 2nd partial derivative by

$$\left[\frac{\partial^2 T_n}{\partial t^2} \right]_{v,t-\Delta t} = \frac{1}{\Delta t}\left\{ \left[\frac{\partial T_n}{\partial t} \right]_{v,t} - \left[\frac{\partial T_n}{\partial t} \right]_{v,t-\Delta t} \right\}$$

and one gets for $\left[T_n \right]_{v,t,}$ the following expression:

$$\left[T_n \right]_{v,t} = \left[T_n \right]_{v,t-\Delta t} + \frac{\Delta t}{2} \left[\frac{\partial T_n}{\partial t} \right]_{v,t-\Delta t} + \frac{\Delta t}{2} \left[\frac{\partial T_n}{\partial t} \right]_{v,t}$$

Substitute the latter expression into Eq. (14a) to get

$$\left[D_n\right]\left[\frac{\partial T_n}{\partial t}\right]_{v,t} + \left[C_n\right]\left[T_n\right]_{v,t-\Delta t} + \frac{\Delta t}{2}\left[C_n\right]\left[\frac{\partial T_n}{\partial t}\right]_{v,t-\Delta t}$$

$$+ \frac{\Delta t}{2}\left[C_n\right]\left[\frac{\partial T_n}{\partial t}\right]_{v,t} = \left[Q_n\right]_t$$

Now use the following approximations

$$\left[\frac{\partial T_n}{\partial t}\right]_{v,t-\Delta t} = \frac{1}{\Delta t}\left\{\left[T_n\right]_{v,t} - \left[T_n\right]_{v,t-\Delta t}\right\} \qquad \text{Forward differences}$$

$$\left[\frac{\partial T_n}{\partial t}\right]_{v,t} = \frac{1}{\Delta t}\left\{\left[T_n\right]_{v,t} - \left[T_n\right]_{v,t-\Delta t}\right\} \qquad \text{Backward differences}$$

in the latter expression with re-arrangement to get

$$\frac{1}{\Delta t}\left[D_n\right] + \left[C_n\right]\left[T_n\right]_{v,t} = \left[Q_n\right]_{v,t}$$

$$+ \frac{1}{\Delta t}\left[D_n\right] + \left[C_n\right]\left[T_n\right]_{v,t-\Delta t} \qquad (14b)$$

Matrix Equation (14b) represents the energy equation for a time-dependent system. It may be solved for $\left[T_n\right]_{v,t}$ in terms of $\left[T_n\right]_{v,t-\Delta t}$, the previous time temperatures, and $\left[Q_n\right]_{v,t}$ which comes from the boundary conditions and internal heat generation.

Note that $\frac{1}{\Delta t}\left[D_n\right] + \left[C_n\right]$ is symmetric and positive definite from the original assumptions; and in most cases, it can be placed in band form. By taking advantage of these convenient characteristics, an efficient algorithm (Gaussian elimination with diagonal terms as pivots) was developed to handle the solution of (14b) efficiently.

For steady-state problems, the matrix energy equation is

$$\left[C_n\right]\left[T_n\right]_v = \left[Q_n\right]_v \tag{14c}$$

This comes from matrix Equation (14a) by setting $\left[\frac{\partial T_n}{\partial t}\right]_v = 0$. The solution may require an iterative process (successive substitutions) if the material properties and boundary conditions are temperature dependent or if there are radiation effects.

F. BOUNDARY CONDITIONS

Programs E12202 and E12207 can handle several types of boundary conditions:

1. Convection
2. Sink to wall radiation
3. Surface to surface radiation
4. Specified temperatures

1. Convection

For convection, the programs assume the following heat transfer apply

$$q_i = h(T_e - T_i) \tag{16a}$$

$$q_j = h(T_e - T_j) \tag{16b}$$

for two adjacent boundary nodes. The q_i and q_j are substituted into the right-hand side of Equations (14b) and (14c).

2. Sink to Wall Radiation

For those cases in which there is radiative heat transfer between surface elements and a constant source or sink temperature, the equation used for radiative flux is

$$q_i = F\varepsilon\sigma(T_s^4 - T_i^4) \tag{17}$$

where F is the surface shape factor, ε is the surface emittance constant, σ is the Stefan-Boltzman constant ($.33 \times 10^{-14}$ Btu/in^2-sec-°R^4), T_s is the source or sink temperature and T_i is the node temperature of an element.

3. Surface to Surface Radiation

For the general case of an enclosure consisting of N surfaces, the heat transfer expression is

$$q_i = \frac{\varepsilon_i}{(1-\varepsilon_i)} (B_i - \sigma T_i^4) \tag{18}$$

where ε_i is the surface emittance, σ is the Stefan-Boltzman constant, T_i is the nodal temperature and B_i is the radiosity of the surface. B_i's are obtained by solving a set of linear simultaneous equations. For details, see Bergquam's analysis in the Appendix.

4. Specified Temperatures

This is not really a boundary condition, but there are cases where the temperatures are specified at certain points in the system. The way the program handles this case is by re-arranging the specified temperatures to the righthand side of (14b) and (14c) and solves for the unknown temperatures. For example, rewrite (14c) in the following form:

$$\left[\begin{array}{c|c} C_{aa} & C_{ab} \\ \hline C_{ba} & C_{bb} \end{array}\right]\left[\begin{array}{c} T_a \\ \hline T_b \end{array}\right]_v = \left[\begin{array}{c} Q_a \\ \hline Q_b \end{array}\right]_v \qquad \begin{matrix} (19a) \\ (19b) \end{matrix}$$

where Q_a and T_b are specified and Q_b and T_a are the unknowns in the system. Equation (19a) may be rewritten as

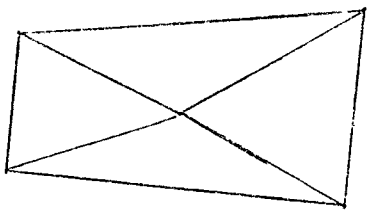
$$\left[C_{aa}\right]\left[T_a\right]_v = \left[Q_a\right]_v - \left[C_{ab}\right]\left[T_b\right]_v \qquad (20)$$

G. SEQUENCE OF OPERATIONS FOR E12202 AND E12207

The following tabulation is a list of the important subprograms in E12202 and E12207 with a brief description of their main functions.

Subprogram Name	Principle Functions
1. CONMAT	Forms the conductivity matrix. For each element the following steps are performed:

(1) Each quadrilateral element is divided into four triangular elements as shown below.



(2) The conductivity matrix for each triangle (Eq. 10) is formed and then combined to form a 5 x 5 conductivity matrix with respect to the five points.

(3) This 5 x 5 matrix is then reduced to the 4 x 4 quadrilateral conductivity matrix by the elementary matrix operations, i.e., elementary column and row operations.

(4) The quadrilateral conductivity matrix is then added to the conductivity matrix for the complete body.

The internal heat generation is also handled by CONMAT.

2. CONVBC — This subprogram handles all of the boundary conditions as described in Section E of Part II.

3. FRAME — This subprogram occurs only in E12202. It is used to draw the graph coordinates for the geometry plot.

4. MAIN — This is the main portion of the program in that it controls the sequences of operations.

5.	RTAB	Reads and initialize the input tables.
6.	SIMEQ	Used to solve a set of linear simultaneous equations. This subroutine is necessary for surface to surface radiation effects.
7.	SUBRO	Reads the header and control cards; sets the flags for proper sequencing. Reads and generates nodal point information. Calls RTAB for tables input.
8.	SUBR1	Main function is to read and generate the elements with their properties. Calls CONMAT.
9.	SUBR2	Reads in the necessary boundary condition cards, sets the necessary boundary flags. Calls CONVBC.
10.	SUBR3	Handles the transient cases with constant material properties and constant boundary conditions. Prints solution.
11.	SUBR4	Handles the transient cases with constant material properties but with time and temperature dependent boundary conditions. Calls SUBR7. Prints solution.
12.	SUBR5	Handles the transient cases with time and temperature dependent material properties and time and temperature dependent boundary conditions. Calls SUBR6, SUBR7. Prints solution.
13.	SUBR6	Keeps track of the element information and calls CONMAT to generate the conductivity matrix.

14.	SUBR7	Keeps track of the boundary conditions information and calls CONVBC.
15.	SUBR8	Handles the steady-state cases and prints solution. Calls SUBR6 and SUBR7.
16.	SYMSØ	Use to solve a set of linear simultaneous equations which is summetric, positive definite and is in band form.

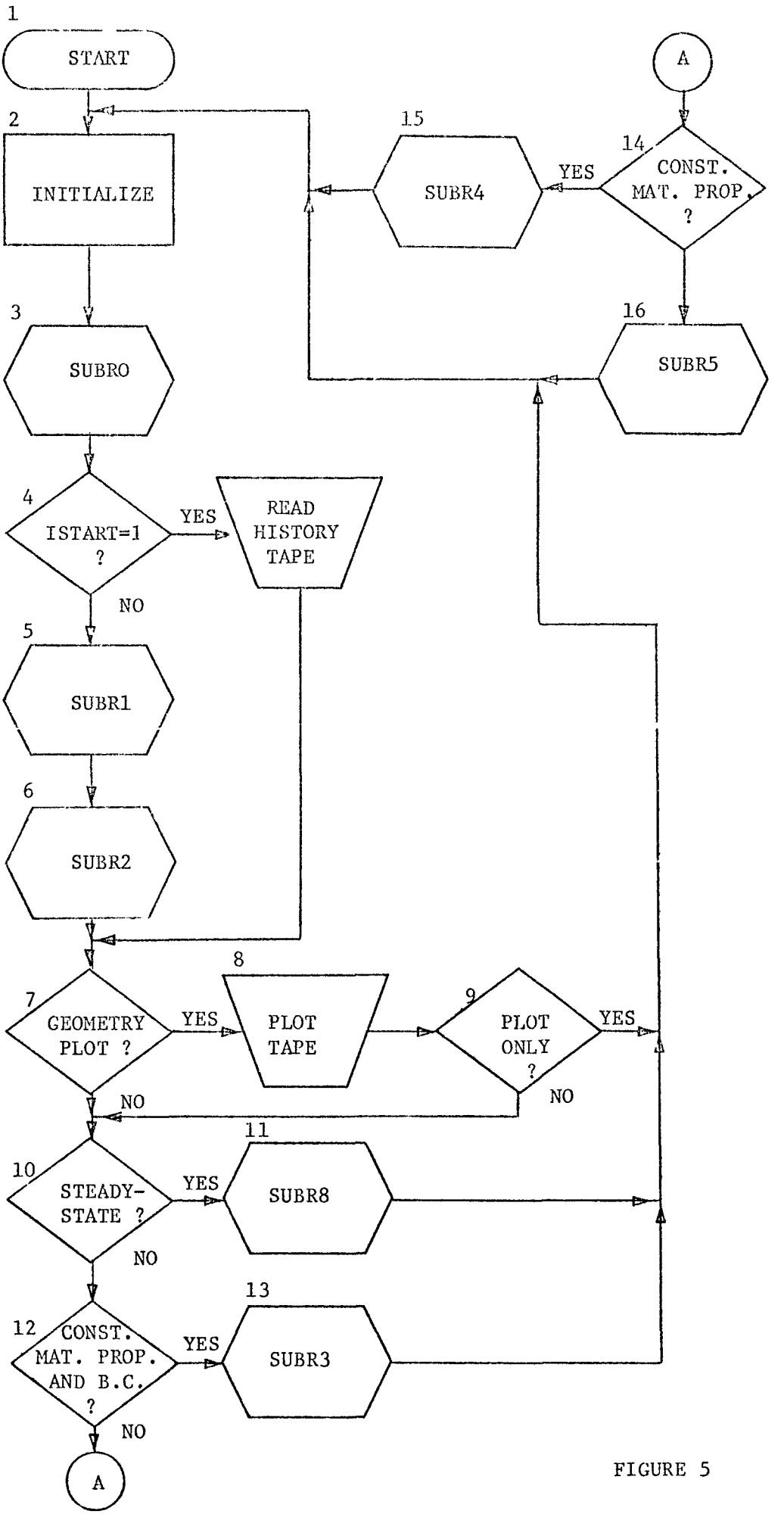

1
START
2
INITIALIZE
3
SUBRO
4
ISTART=1 ?
YES
READ HISTORY TAPE
NO
5
SUBR1
6
SUBR2
7
GEOMETRY PLOT ?
YES
8
PLOT TAPE
9
PLOT ONLY ?
YES
NO
NO
10
STEADY-STATE ?
YES
11
SUBR8
NO
12
CONST. MAT. PROP. AND B.C. ?
YES
13
SUBR3
NO
A
A
14
CONST. MAT. PROP. ?
YES
15
SUBR4
16
SUBR5

FIGURE 5

Explanation of flow chart (Figure 5):

1. Start of program.

2. Initialization. Clearing storages.

3. Call subprogram SUBR0.

4. ISTART is a restart flag. If ISTART = 1, all the rest of the input data will be (or have been obtained) from the history tape. If ISTART = 0, continue to read input cards.

5. Call subprogram SUBR1.

6. Call subprogram SUBR2.

7. Test for geometry plot. This option is not in E12207 because of computer core limitation.

8. Generate geometry plot tape. This process occurs only in E12202.

9. Test for geometry plot only option.

10. Test for steady-state case.

11. Call subprogram SUBR8 for steady-state case.

12. Test for constant properties case.

13. Call subprogram SUBR3 for constant properties transient case.

14. Test for time and temperature dependent boundary conditions.

15. Call subprogram SUBR4 to handle transient cases with time and temperature dependent boundary conditions.

16. Call subprogram SUBR5 which handles transient cases with time and temperature dependent material properties and boundary conditions.

III. INPUT INSTRUCTIONS

The following input instructions are for four computer programs.

Program Code	Function
E12202	Computes the temperature distribution of a two-dimensional body using the method as outlined in Section II for up to 500 nodes.
E12207	Performs the same calculations as E12202, except that E12207 can handle up to 900 nodes but with a smaller band width.
E12205	Generates an isotherm tape from the output created by E12202 or E12207. This isotherm tape is used to generate isotherms via a Calcomp plotting device.
E12206	Generates the time-temperature tape from the output tape created by E12202 and E12207. This tape is used to plot time-temperature graphs via the Calcomp plotting device.

NOTE: The units one should use are any system of units that are consistent.

A. INPUT FOR PROGRAMS E12202 AND E12207

There are nine types or sets of input cards.

1. Identification input card.
2. Control input card.
3. Damping and closure tolerance input card.
4. Material property input cards.
5. Input tables.
6. Nodal point input cards.
7. Element input cards.
8. Boundary conditions input cards.
9. Shape factors input for surface to surface radiation.

NOTE: These cards must be ordered as listed above.

1. Identification Input Card. FORMAT (12A6,6X,2I1)

Col(s). 1-72 Alphanumeric characters to identify the case.

79 Punch a '1' to restart the case from a history tape. Otherwise, leave it blank.

80 Punch a '1' to generate a history tape for isotherm plots, time-temperature plots or restart capability.

2. Control Input Card. FORMAT(6I5,3(E10.4,I5), 4L1,I1)

Col(s).	
1-5	Number of nodal points. (500 maximum for E12202; 900 maximum for E12207)
6-10	Number of elements (2000 maximum).
11-15	Number of boundary condition input cards. This number can exceed the actual number of boundary cards but then the last card must be a "-1" card.
20	= 0 or blank for plane solids. = 1 for axisymmetric solids.
25	= 0 or blank for no plot output. = 1 for plot output. (Option works only for E12202)
26-30	Number of property tables to be input.
31-40	Initial time.
41-45	Table number of the Δt table, if any. This table provides a variable Δt.
46-55	Δt, constant integrating step. If zero, program will seek a steady state solution.

56-60 Print integer; for example, print every fifth integrating step, use a '5'. For steady-state case, this becomes the maximum number of iterations, default value is 20.

61-70 Cut-off time or maximum time.

71-75 Use any positive non-zero integer for punch output.

76 To damp conduction nodes during steady-state iterations, punch a 'T', otherwise, leave it blank.

77 To damp convection nodes during steady-state iterations, punch a 'T'.

78 To damp radiation nodes during steady-state iterations, punch a 'T'.

79 To change the iteration closure tolerance, punch a 'T'. Default value is 0.00005.

80 Punch a '1' to dump intermediate calculations. Use with extreme caution.

3. Damping and Tolerance Input Card. FORMAT(8F10.4)

This input card is required if there is one or more T's punched in the control input card.

Col(s). 1-10 Damping factor for conduction nodes. Default value is 0.5.

11-20 Maximum temperature change for conduction nodes. Default value is 10.

21-30 Damping factor for convection nodes. Default value is 0.5.

31-40 Maximum temperature change for convection nodes. Default value is 10.

41-50 Damping factor for radiation nodes. Default value is 0.5.

51-60 Maximum temperature change for radiation nodes is 10.

61-70 Tolerance for iteration closure. Default value is 0.00005.

The damping and maximum change option applies only if there is a corresponding 'T' punch on the control input card.

4. Material Property Input Cards (20 Maximum)

Col(s). 1-5 Material number for identification. Any integers from '1' to '20'.

6-10 Table number of conductivity vs. temperature. Blank if there is none.

11-20 Conductivity. If there is no table, program will assume a constant conductivity for this material.

21-25 Table number of $\rho \cdot C_p$ vs. temperature. Blank if there is none.

26-35 $\rho \cdot C_p$. If there is no table, program will assume a constant $\rho \cdot C_p$ for this material.

36-40 Table number of Q (heat) generated internally as a function of x (or r) and y (or z).

41-50 Q generated internally per unit volume. If there is no table, program will assume a constant Q for this material.

The property cards must be ended by a '-1' card; i.e., a '-1' punch in columns 1-5.

5. Input Tables (32 Maximum)

This set of cards is optional. The option is triggered by a positive non-zero integer in columns 26-30 of the control card (2). The first card of the table is the identification card.

Col(s).	1-5	Table number identification. Use any integers from 1 to 32.
	6-10	Code for type of table.
	16-72	Any alphanumeric characters for header purposes.

CODES FOR TYPES OF TABLES

Code	
0	Δt vs time.
1	h (convection coefficient) vs. temperature.
2	Temperature (external) vs. time.
3	T_s (Sink temperature) vs. time.
5	k (conductivity) vs. temperature.
6	$\rho \cdot C_p$ (density·specific heat) vs. temperature.
7	Q(x). Internal heat generation as a function of x.
8	Q(y). Internal heat generation as a function of y.
9	Heat flux (into node) vs. time.
10	Temperature of a node vs. time.

-n Time factor table for table number n.

Example: assume that Table 12 has code '-9'. This means that a time factor from Table 12 is used to multiply the value obtained from Table 9. Time factor is 1.0 when there is no time factor table.

The input points of the table follow the below given format:

Col(s). 1-10 Blank.

11-20 Independent variable.

21-30 Dependent variable.

Maximum number of points per table is 30. A '-1' card ('-1' in columns 1-5) ends the table. If there are no table input, indicate this on the control card. Another '-1' card following the last table ends this type of input.

Note on the Δt vs. time table. Assume the latter table has the following values, t_1, Δt_1, t_2, Δt_2, ..., t_n, Δt_n and $t_1 < t_2 < \ldots < t_n$. The computer program will start with Δt_1 as the integrating step (if the initial time is greater or equal to t_1) and use it until the time $t \geq t_2$; then the program will use Δt_2 until $t \geq t_3$, etc. Remember that a Δt must appear on the control card to signal a transient case.

6. Nodal Point Input Cards. FORMAT (215,4E10.4,I5)

One card for each nodal point with the following information.

Col(s).		
	1-5	Nodal point number.
	10	= 0 or blank if external heat into node is specified.
		= 1 if temperature is specified.
	11-20	x (or r) coordinate.
	21-30	y (or z) coordinate.
	31-40	External heat flow or nodal temperature.
	41-50	Initial nodal temperature.
	51-55	Table number corresponding to column 10.

In cases of axisymmetric bodies, the total heat flow for a one radian segment must be supplied in columns 31-40 or by a table. For insulated nodal points, this external heat flow is zero.

Nodal point cards must be in numerical sequence. If nodal points are omitted, the omitted nodal points are generated at equal intervals along a straight line between the last two specified nodal points. For the generated points, the information's equivalent to column 10, columns 31-40, and columns 51-55, are set equal to zero; column 41-50 (initial temperatures) will be repeated.

7. Element Input Card. FORMAT (6I5)

One input card for each element with following information.

Col(s).		
	1-5	Element number.
	6-10	Nodal point I.
	11-15	Nodal point J.
	16-20	Nodal point K.
	21-25	Nodal point L.
	26-30	Material identification.

Nodal points numbers (I, J, K and L) must be input counter-clockwise order around each element. Maximum difference between nodal points (bandwidth) is 41 for program E12202 and 30 for program E12207. See Figure 6. The figure must be in the first quadrant for asymmetric cases.

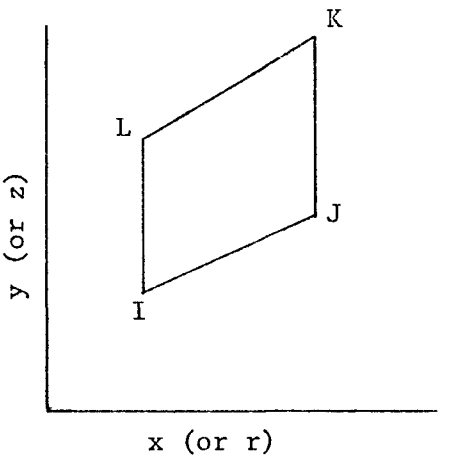


Figure 6

Element cards must be in numerical sequence. If element cards are missing, the program automatically generates the omitted information by incrementing the preceding I, J, K and L. The information in columns 26-30 is set equal to the value on the preceding card. The last element card must always be input.

Triangular elements are possible and are identified by repeating the last nodal points (i.e., I, J, K, K).

*NOTE: For axisymmetric problems the axis of rotation is the Y axis.

8. Boundary Condition Input Cards, FORMAT (2I5,2F10.0,2I5, 2E10.4,2I4,I2,F10.0)

One of the following input cards must be supplied for each boundary element in which the following heat transfer equation applies

$$q = h(T_e - T_w) + F\epsilon\sigma(T_s^4 - T_r^4)$$

where

q is the heat transferred to the element per unit of surface area.

h is an empirical constant, usually called the convection coefficient.

T_e is the external environment temperature.

T_w is the nodal temperature at the wall at node i or j.

F is the shape factor of the surface.

ε is the surface emittance.

σ Stefan-Boltzman constant ($.33 \times 10^{-14}$ Btu/in^{2}sec°R^4)

T_s is the sink or source temperature.

$T_r^4 = (T_i^4 + T_i^3 T_j^1 + T_i^2 T_j^2 + T_i T_j^3 + T_i^4)/5.0$,

i.e., the average wall temperature to the fourth power.

Each card may contain the following information:

Col(s).		
	1-5) 6-10)	Boundary nodal points. If one point is missing the program will use the preceding opposite nodal point. Example: if I is missing, program will set I equal to preceding J.
	11-20	Constant h. Convection coefficient.
	21-30	Temperature of external environment.
	31-35	Table number of h vs surface temperature. If this number is negative, the program will assume the table is an h vs. time.
	36-40	Table number of external temperature vs time.
	41-50	Surface emittance, ε.
	51-60	Surface shape factor, F.

61-64 The number of active surfaces involved in surface to surface radiation. This number must appear on all participating surfaces. For those surfaces not involved, this number is zero. Maximum number is 20 for E12202 and 40 for E12207.

65-68 Table number of sink or source time temperature vs. time.

69-70 Flag. When flag = 0, sink or source temperature equal external temperature. If flag = '1', sink or source temperature comes from columns 71-80.

71-80 Sink or source temperature.

A '-1' card must be used to end the boundary cards if the number in Cols. 11-15 of the control card is greater than the number of boundary cards.

9. Shape Factors Input for Surface to Surface Radiation

FORMAT (I5,5X,7E10.4/(8E10.4))

1st Card.

Col(s). 1-5 Surface number on boundary conditions input cards.

11-20	First seven shape factors.
21-30	
31-40	
41-50	
51-60	
61-70	
71-80	

2nd, 3rd card.

Col(s).	
1-10	Additional shape factors.
11-20	
21-30	
31-40	
41-50	
51-60	
61-70	
71-80	

B. INPUT FOR PROGRAM E12205

There are two types of input required for Program E12205.

1. History Tape

The history tape is created by Programs E12202 or E12207. This tape contains all the original data used by E12202 or E12207 and the transient temperatures for the transient case or the steady-state temperatures for the steady-state case.

2. Input Control Cards. (Two to three cards/case).

1st Card. FORMAT (6F10.2,5I4)

Col(s).	
1-10	Time or iteration number of 1st set of isotherms.
11-20	Time or iteration number of the last set of isotherms.
21-30	X-origin. The X-origin of the plot will start with this input value.
31-40	The incremental value for labeling the X-axis.
41-50	Y-origin. The Y-origin of the plot will start with this input value.
51-60	The incremental value for labeling the Y-axis.
61-64	The incremental labeling of the X-axis will be spaced by this value. The scale is 100 = 1 inch; 50 = 1/2 inch. Default value equals 150 (= 1-1/2 inches).
65-68	The incremental labeling of the Y-axis will be spaced by this value. The scale is 100 = 1 inch; 50 = 1/2 inch. Default value equals 150 (= 1-1/2 inches).

69-72 = 0, gives normal Y-Y plot.

= 1, interchange X and Y.

73-76 = 0, 12 inch plot.

= 1, 30 inch plot.

77-80 Maximum length of the graph in inches.

Default value is 30 inches.

2nd Card. FORMAT (I2,10F7.2)

Col(s). 1-2 Number of isotherms. Maximum number is 20.

3-9
11-16
17-23
24-30
31-37
38-45
46-52
53-59
60-66
67-73

} Isotherms.

3rd Card. FORMAT (10F7.2)

Col(s). 1-7 Isotherms.

8-14 "

15-21	Isotherms.
22-28	
29-35	
36-42	
43-49	
50-56	
57-63	
64-70	

C. INPUT FOR PROGRAM E12206

There are two types of input required for Program E12206:

1. History tape.

The history tape is created by programs E12202 or E12207. This tape contains all the original data used by E12202 or E12207 and the transient temperatures.

2. Input Cards. (Two cards).

1st Card. FORMAT (2F10.2)

Col(s). 1-10 Start time.

11-20 Stop time or maximum time.

2nd Card. FORMAT (4F10.4, 10I3)

Col(s).	
1-10	Labeling of the X-axis (time) origin. Default value is 0.
11-20	Incremental value for labeling X-axis. Default value is 10.
21-30	Labeling of the Y-axis (temperature) origin.
31-40	Incremental value for labeling Y-axis. Default value is 500.
41-43	The node numbers of the nodes to be plotted. The maximum number of nodes that can be plotted is 10. The 1st blank input will end the number of nodes to be plotted.
44-46	
47-49	
50-52	
53-55	
56-58	
59-61	
62-64	
65-67	
68-80	

IV. OUTPUT

A. E12202. Output consists of:

1. Printed hardcopy which lists all input data and nodal temperatures.

2. History tape to be used to restart the problem or isotherm plotting or time-temperature plots. This output is optional.

3. Geometry plot tape to check the geometrical configuration which was input. This output is optional.

4. Punched card output; node number, coordinates, and temperatures. This output was designed as input to stress programs, and is optional.

B. E12207. Program E12207 produces the same output as E12202 except for the geometry plot. This option could be implemented on a computer with a larger core than the UNIVAC 1108.

C. E12205. Output consists of:

1. Printed hardcopy.

2. Plot tape to be used by a plotting device to produce pictures of isotherms.

D. E12206. Output consists of:

1. Printed hardcopy.

2. Plot tape to be used by a plotting device to produce time-temperatures curves.

V. REMARKS AND SUGGESTIONS

REMARKS

The FEM has been applied to temperature analysis of complex plane or axisymmetric bodies by ANSC since 1965. The original FEM was limited to constant material properties and steady-state cases. The modification of the steady-state program to handle temperature dependent properties and boundary conditions proved so successful that the next natural extension was the treatment of transient cases. Extension to the transient was partially successful in that small time steps were required to maintain stability. The stability problem was solved by using the backward difference approximation for the partial derivatives in the energy equation. The last significant addition was the treatment of radiation effects which could be handled properly by damping the oscillations during the iterations.

Those engineers who have used the FEM program successfully are convinced that it is a neat and efficient way to handle two dimensional temperature analysis. Then there are those who have misused it; their comments would not be appropriate here. Since experience is of great help, some minor remarks are given as a guide.

1. The ease in preparation of the data naturally leads people to be careless. Don't be careless! The computer law "garbage in, garbage out" has not been repealed. As a check on the geometrical data, run a plot only option. This option is not available in E12207, but it can be easily implemented.

2. The ratio of the largest length of the quadrilateral to the shortest length, for optimum performance, should be less than 6 in most cases.

3. Remember, all element input nodes should be input in a counter-clockwise fashion.

4. For the transient cases where there are time dependent factors, the time steps should be chosen so that linearity holds. The programs, E12202 and E12207, use linear interpolation exclusively.

5. Remember the basic assumptions (METHOD OF ANALYSIS) and the method of approximations. FEM gives approximate solutions which vary with element size and time steps. For simple cases, the answers are as good as those given by other methods.

6. Since the FEM program uses a backward differencing technique for the transient solutions, the solutions will (theoretically) always be stable regardless of the time step used. However, the solution will not necessarily be correct. Therefore, a smaller time step should be chosen if large temperature variations with time are expected. The variable time step option may be used to provide satisfactory results with minimal computing time.

7. The first and last nodal points should be boundary points; i.e., they should not be interior points.

8. It is true that subprograms SUBR3 and SUBR4 are just special cases of SUBR5. But SUBR3 and SUBR4 do not take up much core space (no extra core

space, if there is overlay capability) and the computer time saved may well justify this approach.

SUGGESTIONS for improving the FEM programs.

1. For transient cases, the predicted new temperatures can be used to iterate a correction. This can be put in as an option.

2. The preliminary computations for the "geometry plot only option" can be eliminated.

3. The subprogram SUBR6's functions can be absorbed by subprogram CONMAT, thus eliminating one extra call.

4. An option to modify to the original data in a restart case.

5. An option to have the geometry coordinates move with respect to time may be useful in ablation problems.

VI. REFERENCES

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3. Brocci, R. A., Analysis of Axisymmetric Linear Heat Conduction Problems by Finite Element Method, ASME Paper 69-WA/HT-37

4. Emery, A. F. and W. W. Carson, An Evaluation of the Use of the Finite-Element Method in the Computation of Temperature, Trans. ASME, May 1971

5. Herrman, L. R., A General Torsion Analysis, Aerojet Technical Memo No. 15, SRO, Feb. 1965

6. Lemmon, E. C. and H. S. Heaton, Accuracy, Stability, and Oscillation Characteristics of Finite Element Method for Solving Heat Conduction Equation, ASME Paper 69-WA/HT-35

7. Richardson, P. D. and Y. M. Shum, Use of Finite Element Methods in Solution of Transient Heat Conduction Problems, ASME Paper 69-WA/HT-36

8. Rybicki, E. F. and A. Hopper, Higher Order Finite Element Method for Transient Temperature Analysis of Inhomogeneous Materials, ASME Paper 69-WA/HT-33

9. Wilson, E. L., Structural Analysis of Axisymmetric Solids, Aerojet Report No. TP-5, SRO, Nov. 1964

10. Wilson, E. L. and R. E. Nickell, Application of the Finite Element Method to Heat Conduction Analysis, Nuclear Engineering and Design 4 (1966) 276-286, North-Holland Publishing Comp., Amsterdam

11. Zienkiewicz, O. C., The Finite Element Method in Structural and Continuum Mechanics, 2nd Ed., McGraw-Hill Publishing Co. Limited

APPENDIX A

EXAMPLES

EXAMPLE PROBLEM NO. 1

SIMPLE STEADY-STATE AXISYMMETRIC CASE

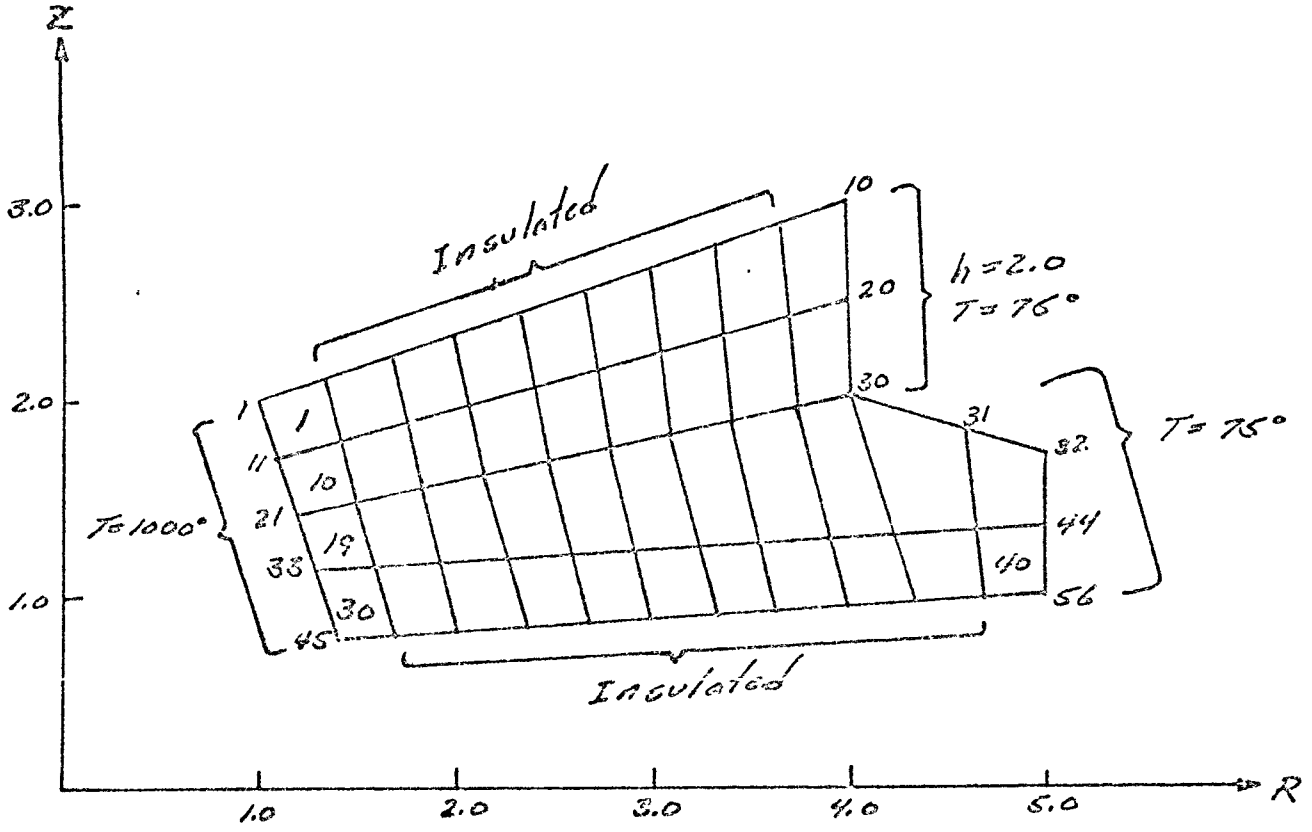

FIGURE A-1 - EXAMPLE PROBLEM NO. 1

Simple steady state axisymmetric case.

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FORTRAN Coding Form

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PROGRAM: E12202 OR E12207 | PUNCHING INSTRUCTIONS: GRAPHIC | PAGE 1 OF 1

PROGRAMMER: ANSC | DATE | PUNCH | CARD ELECTRO NUMBER* 1

STATEMENT NUMBER	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
	EXAMPLE PROBLEM NO. 1, STEADY-STATE CASE.	
56	40 2 1 3	
1	1.0	
- 1		
1	1 1.0 2.0 1000.	
10	4.0 3.0	
11	1 1.1 1.7 1000.	
20	4.0 2.5	
21	1 1.2 1.4 1000.	
30	4.0 2.0	
31	1 4.6 1.8 75.	
32	1 5.0 1.7 75.	
33	1 1.3 1.1 1000.	
44	1 5.0 1.2 75.	
45	1 1.4 0.8 1000.	
56	1 5.0 1.0 75.	
1	11 12 2 1 1	
10	21 22 12 11 1	
19	33 34 22 21 1	
30	45 46 34 33 1	
40	55 56 44 43 1	
10	20 2.0 75.	
20	30 2.0 75.	

*A standard card punch, IBM electric typewriter, or similar machine for punching statements from this form.

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SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

AXISYMMETRIC SOLID BODY

***** STEADY-STATE CASE FOLLOWS *****

EXAMPLE PROBLEM NO. 1, STEADY-STATE CASE.

NUMBER OF NODAL POINTS-- 56
NUMBER OF ELEMENTS------ 40
NUMBER OF CONVECTION BC- 2
NUMBER OF MATERIALS----- 1
OUTPUT INTERVAL--------- 3
TIME INTERVAL------ .000
INITIAL TIME------- .000
MAXIMUM TIME------- .000

M	TABLE-K	K	TABLE-R	RHO-CP	TABLE-Q	Q
1	0	.100000+01	0	.000000	0	.000000

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***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

N.P. NO.	CODE	X	Y	T	TO	CODE TABLE
1	1	1.0000	2.0000	1000.0000	.0000	0
2	0	1.3333	2.1111	.0000	.0000	0
3	0	1.6667	2.2222	.0000	.0000	0
4	0	2.0000	2.3333	.0000	.0000	0
5	0	2.3333	2.4444	.0000	.0000	0
6	0	2.6667	2.5556	.0000	.0000	0
7	0	3.0000	2.6667	.0000	.0000	0
8	0	3.3333	2.7778	.0000	.0000	0
9	0	3.6667	2.8889	.0000	.0000	0
10	0	4.0000	3.0000	.0000	.0000	0
11	1	1.1000	1.7000	1000.0000	.0000	0
12	0	1.4222	1.7889	.0000	.0000	0
13	0	1.7444	1.8778	.0000	.0000	0
14	0	2.0667	1.9667	.0000	.0000	0
15	0	2.3889	2.0556	.0000	.0000	0
16	0	2.7111	2.1444	.0000	.0000	0
17	0	3.0333	2.2333	.0000	.0000	0
18	0	3.3556	2.3222	.0000	.0000	0
19	0	3.6778	2.4111	.0000	.0000	0
20	0	4.0000	2.5000	.0000	.0000	0
21	1	1.2000	1.4000	1000.0000	.0000	0
22	0	1.5111	1.4667	.0000	.0000	0
23	0	1.8222	1.5333	.0000	.0000	0
24	0	2.1333	1.6000	.0000	.0000	0
25	0	2.4444	1.6667	.0000	.0000	0
26	0	2.7556	1.7333	.0000	.0000	0
27	0	3.0667	1.8000	.0000	.0000	0
28	0	3.3778	1.8667	.0000	.0000	0
29	0	3.6889	1.9333	.0000	.0000	0
30	0	4.0000	2.0000	.0000	.0000	0
31	1	4.6000	1.8000	75.0000	.0000	0
32	1	5.0000	1.7000	75.0000	.0000	0
33	1	1.3000	1.1000	1000.0000	.0000	0
34	0	1.6364	1.1091	.0000	.0000	0
35	0	1.9727	1.1182	.0000	.0000	0
36	0	2.3091	1.1273	.0000	.0000	0
37	0	2.6455	1.1364	.0000	.0000	0
38	0	2.9818	1.1455	.0000	.0000	0
39	0	3.3182	1.1545	.0000	.0000	0
40	0	3.6545	1.1636	.0000	.0000	0
41	0	3.9909	1.1727	.0000	.0000	0
42	0	4.3273	1.1818	.0000	.0000	0
43	0	4.6636	1.1909	.0000	.0000	0
44	1	5.0000	1.2000	75.0000	.0000	0
45	1	1.4000	.8000	1000.0000	.0000	0
46	0	1.7273	.8182	.0000	.0000	0
47	0	2.0545	.8364	.0000	.0000	0
48	0	2.3818	.8545	.0000	.0000	0
49	0	2.7091	.8727	.0000	.0000	0
50	0	3.0364	.8909	.0000	.0000	0
51	0	3.3636	.9091	.0000	.0000	0
52	0	3.6909	.9273	.0000	.0000	0
53	0	4.0182	.9455	.0000	.0000	0
54	0	4.3455	.9636	.0000	.0000	0

55	0	4.6727	.9818	.0000	.0000	0
56	1	5.0000	1.0000	75.0000	.0000	0

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N	I	J	K	L	MATERIAL
1	11	12	2	1	1
2	12	13	3	2	1
3	13	14	4	3	1
4	14	15	5	4	1
5	15	16	6	5	1
6	16	17	7	6	1
7	17	18	8	7	1
8	18	19	9	8	1
9	19	20	10	9	1
10	21	22	12	11	1
11	22	23	13	12	1
12	23	24	14	13	1
13	24	25	15	14	1
14	25	26	16	15	1
15	26	27	17	16	1
16	27	28	18	17	1
17	28	29	19	18	1
18	29	30	20	19	1
19	33	34	22	21	1
20	34	35	23	22	1
21	35	36	24	23	1
22	36	37	25	24	1
23	37	38	26	25	1
24	38	39	27	26	1
25	39	40	28	27	1
26	40	41	29	28	1
27	41	42	30	29	1
28	42	43	31	30	1
29	43	44	32	31	1
30	45	46	34	33	1
31	46	47	35	34	1
32	47	48	36	35	1
33	48	49	37	36	1
34	49	50	38	37	1
35	50	51	39	38	1
36	51	52	40	39	1
37	52	53	41	40	1
38	53	54	42	41	1
39	54	55	43	42	1
40	55	56	44	43	1

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I	J	H	TEMPERATURE	H-TAB	T-TAB	RADIATION	EPSILON	F-FACTOR	F-TABLE NO.	
10	20	.200000+01	.750000+02	0	0	.000000	.000000	0	0	.750000+02
20	30	.200000+01	.750000+02	0	0	.000000	.000000	0	0	.750000+02

NUMBER OF CONVECTION BOUNDARY CARDS - - - 2

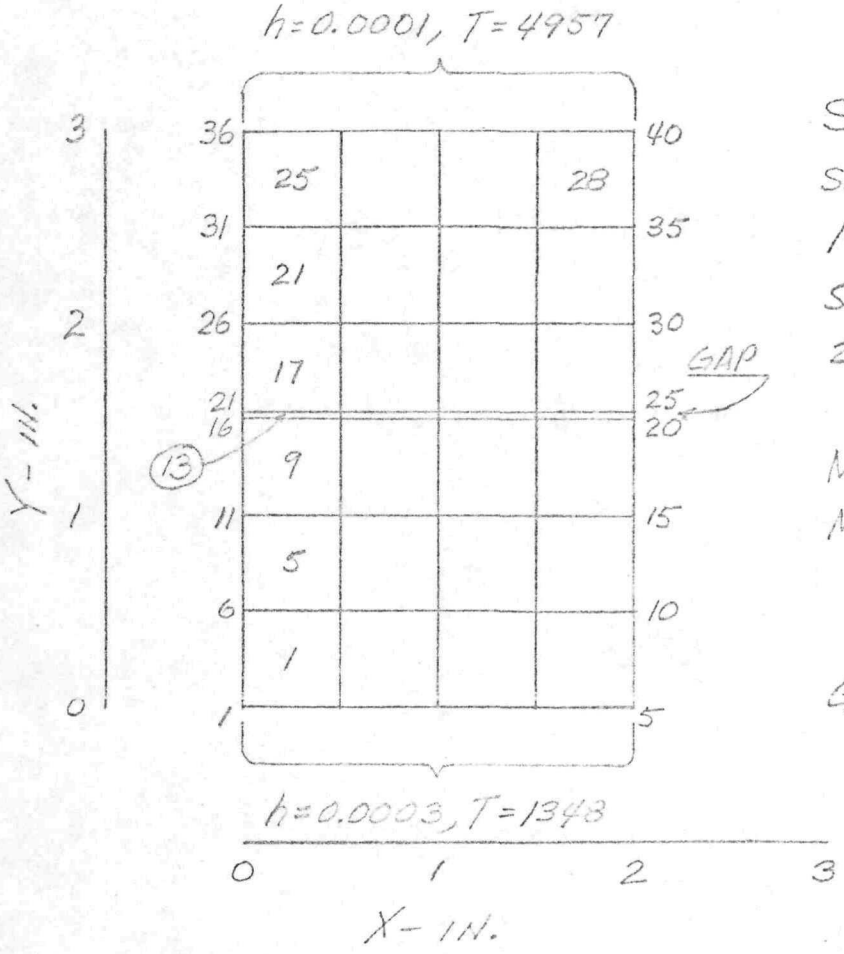
ITERATION NO. 1

1	1000.0000	2	804.7049	3	653.6923	4	532.6948	5	433.7294	6	351.3963
7	281.8225	8	222.2024	9	170.7901	10	128.8492	11	1000.0000	12	812.8808
13	665.7941	14	547.1684	15	449.7447	16	368.4095	17	299.4603	18	240.1645
19	188.2755	20	140.7284	21	1000.0000	22	818.3965	23	673.4250	24	556.4565
25	460.7022	26	380.7993	27	313.0067	28	254.7101	29	204.1052	30	160.3217
31	75.0000	32	75.0000	33	1000.0000	34	802.0491	35	646.6189	36	526.7003
37	430.4523	38	351.0067	39	284.0841	40	226.8365	41	177.2505	42	133.2917
43	102.6116	44	75.0000	45	1000.0000	46	773.8345	47	625.4255	48	511.5615
49	419.7967	50	343.6725	51	279.2493	52	223.9039	53	175.7407	54	134.7405
55	103.0647	56	75.0000								

END OF PROBLEM-- EXAMPLE PROBLEM NO. 1, STEADY-STATE CASE.

EXAMPLE PROBLEM NO. 2

STEADY-STATE CASE WITH RADIATION AND CONDUCTION ACROSS A GAP



Surface emittance for surfaces 16-17, 17-18, 18-19, 19-20 is 0.5; for surfaces 21-22, 22-23, 23-24, 24-25 is 0.8.

Material Properties:
Material No 1.
$K = 0.01$
$\rho \cdot C_p = 0.001$
Gap Material
$K = 0.000001$
$\rho \cdot C_p = 0.000004$

FIGURE A2- EXAMPLE PROBLEM NO. 2

Steady-state case with radiation and conduction across a gap. Note the use of the damping option in this case.

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PROGRAM: E12202 OR E12207 | PUNCHING INSTRUCTIONS | GRAPHIC | PUNCH | PAGE 1 OF 3

PROGRAMMER: ANSC | DATE | CARD ELECTRO NUMBER: 2

C	STATEMENT NUMBER	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
		EXAMPLE PROBLEM NO. 2, STEADY STATE, RADIATION & CONDUCTION ACROSS A GAP	
	40	28 16 1	TTTT
	1.0	200. 1.0 200. .3 200.	
	1	1.01 .001	
	2	.000001 .000004	
-	1		
	1	5 CONDUCTIVITY	
		0. .01	
		900000. .01	
-	1		
	2	1 H VS. TEMP.	
		0. .0003	
		900000. .0003	
-	1		
-	1		
	1	0. 0.	
	5	2. 0.	
	6	0. .5	
	10	2. .5	
	11	0. 1.0	
	15	2. 1.0	
	16	0. 1.5	
	20	2. 1.5	
	21	0. 1.51	

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PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC									PAGE 2 OF 3
PROGRAMMER	DATE		PUNCH									CARD ELECTRO NUMBER* 2

C	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
	25		2. 1.51	
	26		0. 2.01	
	30		2. 2.01	
	31		0. 2.51	
	35		2. 2.51	
	36		0. 3.01	
	40		2. 3.01	
	1		1 2 7 6 1	
	5		6 7 12 11 1	
	9		11 12 17 16 1	
	13		16 17 22 21 2	
	17		21 22 27 26 1	
	21		26 27 32 31 1	
	25		31 32 37 36 1	
	28		34 35 40 39 1	
	1		2 1348. 2	
			3 1348. 2	
			4 1348. 2	
			5 1348. 2	
	36		37 .0001 4957.	
			38 .0001 4957.	
			39 .0001 4957.	
			40 .0001 4957.	
	16		17 .5 8 1	

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FORTRAN Coding Form

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PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 3 OF 3

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER* 2

STATEMENT NUMBER	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
17	18 .5 8 2	
18	19 .5 8 3	
19	20 .5 8 4	
21	22 .8 8 5	
22	23 .8 8 6	
23	24 .8 8 7	
24	25 .8 8 8	
1	0. 0. 0. 0. 1. 0. 0.	
2	0. 0. 0. 0. 0. 1. 0.	
3	0. 0. 0. 0. 0. 0. 1.	
4	0. 0. 0. 0. 0. 0. 0.	
5	1. 0. 0. 0. 0. 0. 0.	
6	0. 1. 0. 0. 0. 0. 0.	
7	0. 0. 1. 0. 0. 0. 0.	
8	0. 0. 0. 1.0 0. 0. 0.	

*A standard card form, IBM e-xerox 885439, is available for punching statements from this form.

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

TWO DIMENSIONAL PLANE BODY

***** STEADY-STATE CASE FOLLOWS *****

EXAMPLE PROBLEM NO. 2, STEADY STATE, RADIATION & CONDUCTION ACROSS A GAP

NUMBER OF NODAL POINTS-- 40
NUMBER OF ELEMENTS------ 28
NUMBER OF CONVECTION BC- 16
NUMBER OF MATERIALS----- 2
OUTPUT INTERVAL--------- 0
TIME INTERVAL------ .000
INITIAL TIME------- .000
MAXIMUM TIME------- .000

DMP1 = .100000+01 DMAX1 = .200000+03
DMP2 = .100000+01 DMAX2 = .200000+03
DMP3 = .300000+00 DMAX3 = .200000+03
TOLN = .500000-04

M	TABLE-K	K	TABLE-R	RHO-CP	TABLE-Q	Q
1	1	.100000-01	0	.100000-02	0	.000000
2	0	.100000-05	0	.400000-05	0	.000000

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

INPUT TABLES

TABLE NO. 1 TYPE 5 CONDUCTIVITY

X	F(X)
.000000	.100000-01
.900000+06	.100000-01

TABLE NO. 2 TYPE 1 H VS. TEMP.

X	F(X)
.000000	.300000-03
.900000+06	.300000-03

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

N.P. NO.	CODE	X	Y	T	TO	CODE TABLE
1	0	.0000	.0000	.0000	.0000	0
2	0	.5000	.0000	.0000	.0000	0
3	0	1.0000	.0000	.0000	.0000	0
4	0	1.5000	.0000	.0000	.0000	0
5	0	2.0000	.0000	.0000	.0000	0
6	0	.0000	.5000	.0000	.0000	0
7	0	.5000	.5000	.0000	.0000	0
8	0	1.0000	.5000	.0000	.0000	0
9	0	1.5000	.5000	.0000	.0000	0
10	0	2.0000	.5000	.0000	.0000	0
11	0	.0000	1.0000	.0000	.0000	0
12	0	.5000	1.0000	.0000	.0000	0
13	0	1.0000	1.0000	.0000	.0000	0
14	0	1.5000	1.0000	.0000	.0000	0
15	0	2.0000	1.0000	.0000	.0000	0
16	0	.0000	1.5000	.0000	.0000	0
17	0	.5000	1.5000	.0000	.0000	0
18	0	1.0000	1.5000	.0000	.0000	0
19	0	1.5000	1.5000	.0000	.0000	0
20	0	2.0000	1.5000	.0000	.0000	0
21	0	.0000	1.5100	.0000	.0000	0
22	0	.5000	1.5100	.0000	.0000	0
23	0	1.0000	1.5100	.0000	.0000	0
24	0	1.5000	1.5100	.0000	.0000	0
25	0	2.0000	1.5100	.0000	.0000	0
26	0	.0000	2.0100	.0000	.0000	0
27	0	.5000	2.0100	.0000	.0000	0
28	0	1.0000	2.0100	.0000	.0000	0
29	0	1.5000	2.0100	.0000	.0000	0
30	0	2.0000	2.0100	.0000	.0000	0
31	0	.0000	2.5100	.0000	.0000	0
32	0	.5000	2.5100	.0000	.0000	0
33	0	1.0000	2.5100	.0000	.0000	0
34	0	1.5000	2.5100	.0000	.0000	0
35	0	2.0000	2.5100	.0000	.0000	0
36	0	.0000	3.0100	.0000	.0000	0
37	0	.5000	3.0100	.0000	.0000	0
38	0	1.0000	3.0100	.0000	.0000	0
39	0	1.5000	3.0100	.0000	.0000	0
40	0	2.0000	3.0100	.0000	.0000	0

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

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

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE	H-TAB	T-TAB	RADIATION	EPSILON	F-FACTOR	F-TABLE NO.		
1	2	.300000-03	.134800+04	2	0		.000000	.000000	0	0	.134800+04
2	3	.300000-03	.134800+04	2	0		.000000	.000000	0	0	.134800+04
3	4	.300000-03	.134800+04	2	0		.000000	.000000	0	0	.134800+04
4	5	.300000-03	.134800+04	2	0		.000000	.000000	0	0	.134800+04
36	37	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
37	38	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
38	39	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
39	40	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
16	17	.000000	.000000	0	0		.500000+00	.000000	8	1	.000000
17	18	.000000	.000000	0	0		.500000+00	.000000	8	20	.000000
18	19	.000000	.000000	0	0		.500000+00	.000000	8	30	.000000
19	20	.000000	.000000	0	0		.500000+00	.000000	8	40	.000000
21	22	.000000	.000000	0	0		.800000+00	.000000	8	50	.000000
22	23	.000000	.000000	0	0		.800000+00	.000000	8	60	.000000
23	24	.000000	.000000	0	0		.800000+00	.000000	8	70	.000000
24	25	.000000	.000000	0	0		.800000+00	.000000	8	80	.000000

NUMBER OF CONVECTION BOUNDARY CARDS - - - 16

1	.000000	.000000	.000000	.000000	.100000+01	.000000	.000000	.000000
2	.000000	.000000	.000000	.000000	.000000	.100000+01	.000000	.000000
3	.000000	.000000	.000000	.000000	.000000	.000000	.100000+01	.000000
4	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.100000+01
5	.100000+01	.000000	.000000	.000000	.000000	.000000	.000000	.000000
6	.000000	.100000+01	.000000	.000000	.000000	.000000	.000000	.000000
7	.000000	.000000	.100000+01	.000000	.000000	.000000	.000000	.000000
8	.000000	.000000	.000000	.100000+01	.000000	.000000	.000000	.000000

ITERATION NO. 1

1	1856.9196	2	1856.9196	3	1856.9196	4	1856.9196	5	1856.9196	6	1864.5535
7	1864.5535	8	1864.5535	9	1864.5535	10	1864.5535	11	1872.1878	12	1872.1878
13	1872.1878	14	1872.1878	15	1872.1878	16	1879.8224	17	1879.8224	18	1879.8224
19	1879.8224	20	1879.8225	21	3406.7781	22	3406.7781	23	3406.7781	24	3406.7782
25	3406.7782	26	3414.4132	27	3414.4132	28	3414.4132	29	3414.4133	30	3414.4133
31	3422.0489	32	3422.0490	33	3422.0490	34	3422.0490	35	3422.0490	36	3429.6853
37	3429.6853	38	3429.6853	39	3429.6854	40	3429.6855				

ITERATION NO. 2

1	2056.9196	2	2056.9196	3	2056.9196	4	2056.9196	5	2056.9196	6	2064.5535
7	2064.5535	8	2064.5535	9	2064.5535	10	2064.5535	11	2072.1877	12	2072.1878
13	2072.1878	14	2072.1878	15	2072.1878	16	1959.0824	17	1959.0825	18	1959.0825
19	1959.0825	20	1959.0826	21	3206.7781	22	3206.7781	23	3206.7781	24	3206.7782
25	3206.7782	26	3214.4132	27	3214.4132	28	3214.4132	29	3214.4133	30	3214.4133
31	3222.0489	32	3222.0490	33	3222.0490	34	3222.0490	35	3222.0490	36	3229.6853
37	3229.6853	38	3229.6853	39	3229.6854	40	3229.6855				

ITERATION NO. 3

1	2045.2071	2	2045.2071	3	2045.2071	4	2045.2071	5	2045.2071	6	2055.6653
7	2055.6653	8	2055.6653	9	2055.6653	10	2055.6653	11	2066.1239	12	2066.1239
13	2066.1239	14	2066.1240	15	2066.1240	16	1994.3326	17	1994.3326	18	1994.3326
19	1994.3327	20	1994.3327	21	3094.7894	22	3094.7894	23	3094.7893	24	3094.7894
25	3094.7894	26	3014.4132	27	3014.4132	28	3014.4132	29	3014.4133	30	3014.4133
31	3022.0489	32	3022.0490	33	3022.0490	34	3022.0490	35	3022.0490	36	3029.6853
37	3029.6853	38	3029.6853	39	3029.6854	40	3029.6855				

ITERATION NO. 4

1	2013.9594	2	2013.9594	3	2013.9594	4	2013.9594	5	2013.9594	6	2023.9489
7	2023.9489	8	2023.9489	9	2023.9489	10	2023.9489	11	2033.9388	12	2033.9388
13	2033.9388	14	2033.9388	15	2033.9388	16	2009.2115	17	2009.2115	18	2009.2116
19	2009.2116	20	2009.2116	21	3044.9401	22	3044.9401	23	3044.9401	24	3044.9402
25	3044.9402	26	2938.6159	27	2938.6159	28	2938.6159	29	2938.6160	30	2938.6160
31	2948.6072	32	2948.6072	33	2948.6072	34	2948.6073	35	2948.6073	36	2958.5989
37	2958.5990	38	2958.5990	39	2958.5991	40	2958.5991				

ITERATION NO. 5

1	2001.0375	2	2001.0375	3	2001.0375	4	2001.0375	5	2001.0375	6	2010.8332
7	2010.8332	8	2010.8332	9	2010.8332	10	2010.8332	11	2020.6293	12	2020.6293
13	2020.6293	14	2020.6293	15	2020.6293	16	2015.5758	17	2015.5758	18	2015.5758
19	2015.5759	20	2015.5759	21	3021.8490	22	3021.8490	23	3021.8489	24	3021.8490
25	3021.8491	26	2977.7664	27	2977.7664	28	2977.7665	29	2977.7666	30	2977.7666
31	2987.5639	32	2987.5640	33	2987.5640	34	2987.5641	35	2987.5641	36	2997.3619
37	2997.3619	38	2997.3620	39	2997.3621	40	2997.3621				

ITERATION NO. 6

1	1995.2751	2	1995.2751	3	1995.2750	4	1995.2750	5	1995.2751	6	2004.9843
7	2004.9843	8	2004.9843	9	2004.9843	10	2004.9843	11	2014.6939	12	2014.6939
13	2014.6939	14	2014.6939	15	2014.6940	16	2018.2242	17	2018.2242	18	2018.2243
19	2018.2243	20	2018.2243	21	3010.9487	22	3010.9487	23	3010.9487	24	3010.9488
25	3010.9488	26	2995.2252	27	2995.2252	28	2995.2252	29	2995.2253	30	2995.2253
31	3004.9362	32	3004.9362	33	3004.9363	34	3004.9363	35	3004.9363	36	3014.6478
37	3014.6478	38	3014.6478	39	3014.6479	40	3014.6480				

ITERATION NO. 7

1	1992.6198	2	1992.6198	3	1992.6198	4	1992.6198	5	1992.6198	6	2002.2892
7	2002.2892	8	2002.2892	9	2002.2892	10	2002.2892	11	2011.9590	12	2011.9590
13	2011.9590	14	2011.9590	15	2011.9591	16	2019.2457	17	2019.2457	18	2019.2457
19	2019.2458	20	2019.2458	21	3005.7440	22	3005.7439	23	3005.7439	24	3005.7440
25	3005.7440	26	3003.2700	27	3003.2700	28	3003.2701	29	3003.2701	30	3003.2701
31	3012.9412	32	3012.9412	33	3012.9413	34	3012.9413	35	3012.9413	36	3022.6129
37	3022.6129	38	3022.6130	39	3022.6131	40	3022.6131				

ITERATION NO. 8

1	1991.3777	2	1991.3777	3	1991.3777	4	1991.3777	5	1991.3777	6	2001.0285
7	2001.0285	8	2001.0285	9	2001.0285	10	2001.0285	11	2010.6797	12	2010.6797
13	2010.6797	14	2010.6797	15	2010.6797	16	2019.5714	17	2019.5714	18	2019.5714
19	2019.5714	20	2019.5715	21	3003.2352	22	3003.2352	23	3003.2352	24	3003.2352
25	3003.2353	26	3007.0333	27	3007.0334	28	3007.0334	29	3007.0334	30	3007.0334
31	3016.6859	32	3016.6860	33	3016.6860	34	3016.6860	35	3016.6861	36	3026.3391
37	3026.3391	38	3026.3391	39	3026.3392	40	3026.3392				

ITERATION NO. 9

1	1990.7926	2	1990.7926	3	1990.7925	4	1990.7925	5	1990.7925	6	2000.4345
7	2000.4346	8	2000.4345	9	2000.4345	10	2000.4345	11	2010.0769	12	2010.0769
13	2010.0769	14	2010.0769	15	2010.0770	16	2019.6158	17	2019.6159	18	2019.6159
19	2019.6159	20	2019.6160	21	3002.0137	22	3002.0137	23	3002.0137	24	3002.0137
25	3002.0138	26	3008.8066	27	3008.8067	28	3008.8067	29	3008.8067	30	3008.8067
31	3018.4504	32	3018.4504	33	3018.4505	34	3018.4505	35	3018.4505	36	3028.0948

37	3028.0948	38	3028.0948	39	3028.0948	40	3028.0949				
ITERATION NO. 10											
1	1990.5158	2	1990.5158	3	1990.5158	4	1990.5158	5	1990.5158	6	2000.1537
7	2000.1537	8	2000.1536	9	2000.1537	10	2000.1537	11	2009.7919	12	2009.7919
13	2009.7919	14	2009.7919	15	2009.7919	16	2019.5603	17	2019.5603	18	2019.5603
19	2019.5603	20	2019.5604	21	3001.4113	22	3001.4113	23	3001.4113	24	3001.4113
25	3001.4113	26	3009.6447	27	3009.6447	28	3009.6447	29	3009.6447	30	3009.6447
31	3019.2843	32	3019.2844	33	3019.2844	34	3019.2844	35	3019.2845	36	3028.9245
37	3028.9245	38	3028.9245	39	3028.9246	40	3028.9247				
ITERATION NO. 11											
1	1990.3849	2	1990.3849	3	1990.3848	4	1990.3848	5	1990.3848	6	2000.0207
7	2000.0208	8	2000.0207	9	2000.0207	10	2000.0207	11	2009.6570	12	2009.6570
13	2009.6570	14	2009.6570	15	2009.6570	16	2019.4803	17	2019.4803	18	2019.4803
19	2019.4804	20	2019.4804	21	3001.1093	22	3001.1093	23	3001.1093	24	3001.1093
25	3001.1094	26	3010.0417	27	3010.0417	28	3010.0417	29	3010.0418	30	3010.0418
31	3019.6794	32	3019.6794	33	3019.6795	34	3019.6795	35	3019.6795	36	3029.3176
37	3029.3176	38	3029.3177	39	3029.3177	40	3029.3178				
ITERATION NO. 12											
1	1990.3228	2	1990.3227	3	1990.3227	4	1990.3227	5	1990.3227	6	1999.9577
7	1999.9577	8	1999.9577	9	1999.9577	10	1999.9577	11	2009.5930	12	2009.5930
13	2009.5930	14	2009.5930	15	2009.5930	16	2019.4048	17	2019.4048	18	2019.4049
19	2019.4049	20	2019.4049	21	3000.9547	22	3000.9547	23	3000.9546	24	3000.9547
25	3000.9547	26	3010.2299	27	3010.2299	28	3010.2299	29	3010.2299	30	3010.2299
31	3019.8666	32	3019.8666	33	3019.8667	34	3019.8667	35	3019.8667	36	3029.5039
37	3029.5039	38	3029.5039	39	3029.5040	40	3029.5041				
ITERATION NO. 13											
1	1990.2933	2	1990.2933	3	1990.2933	4	1990.2933	5	1990.2933	6	1999.9278
7	1999.9278	8	1999.9278	9	1999.9278	10	1999.9278	11	2009.5627	12	2009.5627
13	2009.5627	14	2009.5627	15	2009.5627	16	2019.3428	17	2019.3428	18	2019.3428
19	2019.3429	20	2019.3429	21	3000.8733	22	3000.8733	23	3000.8733	24	3000.8733
25	3000.8734	26	3010.3191	27	3010.3191	28	3010.3191	29	3010.3192	30	3010.3192
31	3019.9554	32	3019.9554	33	3019.9554	34	3019.9555	35	3019.9555	36	3029.5922
37	3029.5923	38	3029.5923	39	3029.5924	40	3029.5924				

END OF PROBLEM-- EXAMPLE PROBLEM NO. 2, STEADY STATE, RADIATION & CONDUCTION ACROSS A GAP

EXAMPLE PROBLEM NO. 3

TRANSIENT CASE WITH CONVECTION,

SURFACE - SINK RADIATION

IBM

FORTRAN Coding Form

GX28-7327-6 U/M050
Printed in U.S.A.

PROGRAM E12202 OR E12207 | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 1 OF 2

PROGRAMMER ANSC | DATE | PUNCH | CARD ELECTRO NUMBER* 3

FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
EXAMPLE PROBLEM NO. 3, TRANSIENT CASE WITH CONVECTION, SURFACE-SINK RAD.	
40 28 8 1 .5 2 20.	
1 1.01 0.01	
2 .000001 .00004	
-1	
1 5 CONDUCTIVITY	
.1 .01	
9000000. .01	
-1	
-1	
1 0. 0. 2000.	
5 2. 0. 2000.	
6 0. 0.5 2000.	
10 2. 0.5 2000.	
11 0. 1.0 2000.	
15 2. 1.0 2000.	
16 0. 1.5 2000.	
20 2. 1.5 2000.	
21 0. 1.51 3000.	
25 2. 1.51 3000.	
26 0. 2.01 3000.	
30 2. 2.01 3000.	
31 0. 2.51 5000.	
35 2. 2.51 3000.	

*A printed copy of IBM electro sensitive is available for punching statements from this form.

IBM

FORTRAN Coding Form

GX28-7327-6 U/M050
Printed in U.S.A.

PROGRAM E12202 OR E12207

PROGRAMMER DATE

PUNCHING INSTRUCTIONS GRAPHIC PUNCH

CARD ELECTRO NUMBER* 3

STATEMENT NUMBER (1–5)	7–10	11–15	16–20	21–25	26–30	41–45	46–50	56–60
36				3.01		3000.		
40		2.		3.01		3000.		
1	1	2	7	6	1			
5	6	7	12	11	1			
9	11	12	17	16	1			
13	16	17	22	21	2			
17	21	22	27	26	1			
21	26	27	32	31	1			
25	31	32	37	36	1			
28	34	35	40	39	1			
1	2						.5	.7
	3						.5	.7
	4						.5	.7
	5						.5	.7
36	37	.0001		4957.				
	38	.0001		4957.				
	39	.0001		4957.				
	40	.0001		4957.				

*A standard card form, IBM electro 888157, is available for punching statements from this form

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

TWO DIMENSIONAL PLANE BODY

EXAMPLE PROBLEM NO. 3, TRANSIENT CASE WITH CONVECTION, SURFACE-SINK RAD.

NUMBER OF NODAL POINTS-- 40
NUMBER OF ELEMENTS------ 28
NUMBER OF CONVECTION BC- 8
NUMBER OF MATERIALS----- 2
OUTPUT INTERVAL-------- 2
TIME INTERVAL------ .500
INITIAL TIME------- .000
MAXIMUM TIME------- 20.000

M	TABLE-K	K	TABLE-R	RHO-CP	TABLE-Q	Q
1	1	.100000-01	0	.100000-01	0	.000000
2	0	.100000-05	0	.400000-05	0	.000000

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

INPUT TABLES

TABLE NO. 1 TYPE 5 CONDUCTIVITY

X	F(X)
.100000+00	.100000-01
.900000+07	.100000-01

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

N.P. NO.	CODE	X	Y	T	TO	CODE TABLE
1	0	.0000	.0000	.0000	2000.0000	0
2	0	.5000	.0000	.0000	2000.0000	0
3	0	1.0000	.0000	.0000	2000.0000	0
4	0	1.5000	.0000	.0000	2000.0000	0
5	0	2.0000	.0000	.0000	2000.0000	0
6	0	.0000	.5000	.0000	2000.0000	0
7	0	.5000	.5000	.0000	2000.0000	0
8	0	1.0000	.5000	.0000	2000.0000	0
9	0	1.5000	.5000	.0000	2000.0000	0
10	0	2.0000	.5000	.0000	2000.0000	0
11	0	.0000	1.0000	.0000	2000.0000	0
12	0	.5000	1.0000	.0000	2000.0000	0
13	0	1.0000	1.0000	.0000	2000.0000	0
14	0	1.5000	1.0000	.0000	2000.0000	0
15	0	2.0000	1.0000	.0000	2000.0000	0
16	0	.0000	1.5000	.0000	2000.0000	0
17	0	.5000	1.5000	.0000	2000.0000	0
18	0	1.0000	1.5000	.0000	2000.0000	0
19	0	1.5000	1.5000	.0000	2000.0000	0
20	0	2.0000	1.5000	.0000	2000.0000	0
21	0	.0000	1.5100	.0000	3000.0000	0
22	0	.5000	1.5100	.0000	3000.0000	0
23	0	1.0000	1.5100	.0000	3000.0000	0
24	0	1.5000	1.5100	.0000	3000.0000	0
25	0	2.0000	1.5100	.0000	3000.0000	0
26	0	.0000	2.0100	.0000	3000.0000	0
27	0	.5000	2.0100	.0000	3000.0000	0
28	0	1.0000	2.0100	.0000	3000.0000	0
29	0	1.5000	2.0100	.0000	3000.0000	0
30	0	2.0000	2.0100	.0000	3000.0000	0
31	0	.0000	2.5100	.0000	3000.0000	0
32	0	.5000	2.5100	.0000	3000.0000	0
33	0	1.0000	2.5100	.0000	3000.0000	0
34	0	1.5000	2.5100	.0000	3000.0000	0
35	0	2.0000	2.5100	.0000	3000.0000	0
36	0	.0000	3.0100	.0000	3000.0000	0
37	0	.5000	3.0100	.0000	3000.0000	0
38	0	1.0000	3.0100	.0000	3000.0000	0
39	0	1.5000	3.0100	.0000	3000.0000	0
40	0	2.0000	3.0100	.0000	3000.0000	0

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

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

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE	H-TAB	T-TAB	RADIATION	EPSILON	F-FACTOR	F-TABLE NO.		
1	2	.000000	.000000	0	0		.500000+00	.700000+00	0	0	.000000
2	3	.000000	.000000	0	0		.500000+00	.700000+00	0	0	.000000
3	4	.000000	.000000	0	0		.500000+00	.700000+00	0	0	.000000
4	5	.000000	.000000	0	0		.500000+00	.700000+00	0	0	.000000
36	37	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
37	38	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
38	39	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04
39	40	.100000-03	.495700+04	0	0		.000000	.000000	0	0	.495700+04

NUMBER OF CONVECTION BOUNDARY CARDS - - - 8

TIME= .00000

1	2000.0000	2	2000.0000	3	2000.0000	4	2000.0000	5	2000.0000	6	2000.0000
7	2000.0000	8	2000.0000	9	2000.0000	10	2000.0000	11	2000.0000	12	2000.0000
13	2000.0000	14	2000.0000	15	2000.0000	16	2000.0000	17	2000.0000	18	2000.0000
19	2000.0000	20	2000.0000	21	3000.0000	22	3000.0000	23	3000.0000	24	3000.0000
25	3000.0000	26	3000.0000	27	3000.0000	28	3000.0000	29	3000.0000	30	3000.0000
31	3000.0000	32	3000.0000	33	3000.0000	34	3000.0000	35	3000.0000	36	3000.0000
37	3000.0000	38	3000.0000	39	3000.0000	40	3000.0000				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 1.00000

1	2002.2725	2	2002.2725	3	2002.2725	4	2002.2725	5	2002.2725	6	2003.6644
7	2003.6644	8	2003.6645	9	2003.6645	10	2003.6645	11	2006.1746	12	2006.1746
13	2006.1746	14	2006.1747	15	2006.1747	16	2010.1879	17	2010.1879	18	2010.1878
19	2010.1879	20	2010.1879	21	2997.5091	22	2997.5091	23	2997.5092	24	2997.5093
25	2997.5095	26	3002.7027	27	3002.7027	28	3002.7028	29	3002.7029	30	3002.7030
31	3008.9717	32	3008.9717	33	3008.9718	34	3008.9719	35	3008.9719	36	3017.2765
37	3017.2766	38	3017.2765	39	3017.2766	40	3017.2766				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 2.00000

1	2007.2310	2	2007.2310	3	2007.2310	4	2007.2310	5	2007.2310	6	2008.8060
7	2008.8060	8	2008.8060	9	2008.8060	10	2008.8061	11	2011.6906	12	2011.6906
13	2011.6907	14	2011.6907	15	2011.6907	16	2015.9332	17	2015.9332	18	2015.9332
19	2015.9332	20	2015.9333	21	3002.8851	22	3002.8852	23	3002.8853	24	3002.8854
25	3002.8856	26	3008.5502	27	3008.5502	28	3008.5504	29	3008.5505	30	3008.5505
31	3015.7341	32	3015.7341	33	3015.7342	34	3015.7343	35	3015.7344	36	3024.5515
37	3024.5515	38	3024.5516	39	3024.5517	40	3024.5517				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 3.00000

1	2012.5063	2	2012.5062	3	2012.5063	4	2012.5063	5	2012.5063	6	2014.1105
7	2014.1105	8	2014.1105	9	2014.1106	10	2014.1106	11	2017.0435	12	2017.0435
13	2017.0436	14	2017.0437	15	2017.0437	16	2021.3125	17	2021.3125	18	2021.3125
19	2021.3126	20	2021.3126	21	3009.0568	22	3009.0569	23	3009.0569	24	3009.0572
25	3009.0573	26	3014.7725	27	3014.7724	28	3014.7726	29	3014.7727	30	3014.7728
31	3022.0481	32	3022.0481	33	3022.0482	34	3022.0483	35	3022.0483	36	3030.8937
37	3030.8937	38	3030.8937	39	3030.8938	40	3030.8938				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 4.00000

1	2017.8105	2	2017.8105	3	2017.8105	4	2017.8105	5	2017.8106	6	2019.4260
7	2019.4261	8	2019.4261	9	2019.4261	10	2019.4262	11	2022.3709	12	2022.3709
13	2022.3709	14	2022.3710	15	2022.3710	16	2026.6474	17	2026.6474	18	2026.6474
19	2026.6475	20	2026.6475	21	3015.2743	22	3015.2743	23	3015.2744	24	3015.2746
25	3015.2747	26	3020.9942	27	3020.9942	28	3020.9944	29	3020.9945	30	3020.9946
31	3028.2682	32	3028.2682	33	3028.2683	34	3028.2685	35	3028.2685	36	3037.0945
37	3037.0946	38	3037.0946	39	3037.0947	40	3037.0947				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 5.00000

1	2023.1111	2	2023.1111	3	2023.1111	4	2023.1112	5	2023.1112	6	2024.7360
7	2024.7361	8	2024.7360	9	2024.7361	10	2024.7361	11	2027.6886	12	2027.6886
13	2027.6886	14	2027.6886	15	2027.6887	16	2031.9706	17	2031.9706	18	2031.9706
19	2031.9707	20	2031.9707	21	3021.4553	22	3021.4553	23	3021.4554	24	3021.4556
25	3021.4557	26	3027.1743	27	3027.1743	28	3027.1745	29	3027.1746	30	3027.1747
31	3034.4364	32	3034.4364	33	3034.4364	34	3034.4366	35	3034.4366	36	3043.2383
37	3043.2384	38	3043.2385	39	3043.2386	40	3043.2386				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 6.00000

1	2028.4043	2	2028.4043	3	2028.4043	4	2028.4043	5	2028.4044	6	2030.0383
7	2030.0384	8	2030.0384	9	2030.0384	10	2030.0384	11	2032.9981	12	2032.9981
13	2032.9981	14	2032.9981	15	2032.9982	16	2037.2853	17	2037.2853	18	2037.2853
19	2037.2853	20	2037.2854	21	3027.5912	22	3027.5912	23	3027.5913	24	3027.5915
25	3027.5916	26	3033.3087	27	3033.3087	28	3033.3088	29	3033.3090	30	3033.3090
31	3040.5577	32	3040.5577	33	3040.5577	34	3040.5578	35	3040.5579	36	3049.3350
37	3049.3351	38	3049.3351	39	3049.3352	40	3049.3352				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 7.00000

1	2033.6893	2	2033.6892	3	2033.6892	4	2033.6893	5	2033.6893	6	2035.3324
7	2035.3325	8	2035.3325	9	2035.3325	10	2035.3326	11	2038.2993	12	2038.2993
13	2038.2993	14	2038.2993	15	2038.2994	16	2042.5915	17	2042.5915	18	2042.5915
19	2042.5915	20	2042.5915	21	3033.6816	22	3033.6816	23	3033.6817	24	3033.6819
25	3033.6821	26	3039.3973	27	3039.3973	28	3039.3975	29	3039.3976	30	3039.3977
31	3046.6332	32	3046.6332	33	3046.6332	34	3046.6334	35	3046.6334	36	3055.3859
37	3055.3860	38	3055.3860	39	3055.3861	40	3055.3861				

<***Δ****1****Δ****2****Δ****3****Δ****4****Δ****5****Δ****6****Δ****7****Δ****8****Δ****9****Δ****0****Δ****1****Δ****2****Δ****3*
**********ISD-27.16:INFORMATION-SYSTEMS-DESIGN:15-APR-1972**********
Δ1***Δ***2***Δ***3***Δ***4***Δ***5***Δ***6***Δ***7***Δ***0***Δ***1***Δ***2***Δ***3***Δ***4***Δ***5***Δ***6***Δ***7***Δ***0***Δ

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 8.00000

1	2038.9656	2	2038.9656	3	2038.9656	4	2038.9656	5	2038.9657	6	2040.6180
7	2040.6180	8	2040.6180	9	2040.6181	10	2040.6181	11	2043.5918	12	2043.5918
13	2043.5918	14	2043.5919	15	2043.5919	16	2047.8888	17	2047.8889	18	2047.8888
19	2047.8889	20	2047.8889	21	3039.7269	22	3039.7269	23	3039.7271	24	3039.7272
25	3039.7274	26	3045.4407	27	3045.4407	28	3045.4409	29	3045.4410	30	3045.4411
31	3052.6634	32	3052.6634	33	3052.6635	34	3052.6636	35	3052.6637	36	3061.3917
37	3061.3918	38	3061.3918	39	3061.3920	40	3061.3920				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 9.00000

1	2044.2331	2	2044.2330	3	2044.2330	4	2044.2331	5	2044.2331	6	2045.8946
7	2045.8946	8	2045.8946	9	2045.8947	10	2045.8947	11	2048.8754	12	2048.8754
13	2048.8754	14	2048.8755	15	2048.8755	16	2053.1771	17	2053.1772	18	2053.1772
19	2053.1772	20	2053.1772	21	3045.7277	22	3045.7277	23	3045.7278	24	3045.7280
25	3045.7281	26	3051.4395	27	3051.4395	28	3051.4397	29	3051.4398	30	3051.4398
31	3058.6490	32	3058.6490	33	3058.6491	34	3058.6492	35	3058.6493	36	3067.3531
37	3067.3532	38	3067.3532	39	3067.3533	40	3067.3533				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 10.00000

1	2049.4912	2	2049.4912	3	2049.4912	4	2049.4912	5	2049.4913	6	2051.1620
7	2051.1620	8	2051.1620	9	2051.1621	10	2051.1622	11	2054.1497	12	2054.1497
13	2054.1497	14	2054.1498	15	2054.1498	16	2058.4560	17	2058.4560	18	2058.4561
19	2058.4561	20	2058.4561	21	3051.6843	22	3051.6843	23	3051.6844	24	3051.6846
25	3051.6848	26	3057.3940	27	3057.3940	28	3057.3942	29	3057.3943	30	3057.3944
31	3064.5905	32	3064.5905	33	3064.5905	34	3064.5907	35	3064.5907	36	3073.2704
37	3073.2705	38	3073.2705	39	3073.2706	40	3073.2707				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 11.00000

1	2054.7398	2	2054.7398	3	2054.7398	4	2054.7399	5	2054.7399	6	2056.4198
7	2056.4199	8	2056.4199	9	2056.4200	10	2056.4200	11	2059.4144	12	2059.4144
13	2059.4145	14	2059.4145	15	2059.4146	16	2063.7252	17	2063.7252	18	2063.7252
19	2063.7253	20	2063.7253	21	3057.5975	22	3057.5975	23	3057.5976	24	3057.5978
25	3057.5979	26	3063.3050	27	3063.3050	28	3063.3051	29	3063.3052	30	3063.3053
31	3070.4884	32	3070.4884	33	3070.4884	34	3070.4885	35	3070.4886	36	3079.1443
37	3079.1444	38	3079.1444	39	3079.1445	40	3079.1445				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 12.00000

1	2059.9786	2	2059.9786	3	2059.9786	4	2059.9787	5	2059.9787	6	2061.6679
7	2061.6679	8	2061.6680	9	2061.6680	10	2061.6681	11	2064.6693	12	2064.6693
13	2064.6693	14	2064.6693	15	2064.6694	16	2068.9843	17	2068.9843	18	2068.9843
19	2068.9844	20	2068.9844	21	3063.4675	22	3063.4676	23	3063.4677	24	3063.4679
25	3063.4680	26	3069.1727	27	3069.1728	28	3069.1729	29	3069.1731	30	3069.1731
31	3076.3431	32	3076.3431	33	3076.3431	34	3076.3432	35	3076.3433	36	3084.9753
37	3084.9753	38	3084.9753	39	3084.9755	40	3084.9755				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 13.00000

1	2065.2072	2	2065.2072	3	2065.2073	4	2065.2073	5	2065.2074	6	2066.9059
7	2066.9059	8	2066.9059	9	2066.9060	10	2066.9060	11	2069.9139	12	2069.9139
13	2069.9140	14	2069.9141	15	2069.9141	16	2074.2332	17	2074.2332	18	2074.2332
19	2074.2333	20	2074.2334	21	3069.2951	22	3069.2952	23	3069.2953	24	3069.2954
25	3069.2956	26	3074.9980	27	3074.9980	28	3074.9981	29	3074.9982	30	3074.9983
31	3082.1552	32	3082.1552	33	3082.1552	34	3082.1554	35	3082.1555	36	3090.7638
37	3090.7639	38	3090.7639	39	3090.7640	40	3090.7640				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 14.00000

1	2070.4255	2	2070.4255	3	2070.4255	4	2070.4255	5	2070.4256	6	2072.1334
7	2072.1335	8	2072.1335	9	2072.1335	10	2072.1336	11	2075.1482	12	2075.1482
13	2075.1483	14	2075.1483	15	2075.1483	16	2079.4715	17	2079.4716	18	2079.4716
19	2079.4716	20	2079.4716	21	3075.0806	22	3075.0807	23	3075.0808	24	3075.0810
25	3075.0811	26	3080.7809	27	3080.7809	28	3080.7811	29	3080.7812	30	3080.7813
31	3087.9252	32	3087.9252	33	3087.9253	34	3087.9254	35	3087.9254	36	3096.5103
37	3096.5104	38	3096.5104	39	3096.5105	40	3096.5105				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 15.00000

1	2075.6330	2	2075.6330	3	2075.6330	4	2075.6330	5	2075.6331	6	2077.3503
7	2077.3503	8	2077.3503	9	2077.3503	10	2077.3504	11	2080.3717	12	2080.3717
13	2080.3717	14	2080.3717	15	2080.3718	16	2084.6989	17	2084.6989	18	2084.6989
19	2084.6990	20	2084.6990	21	3080.8246	22	3080.8246	23	3080.8247	24	3080.8250
25	3080.8251	26	3086.5223	27	3086.5223	28	3086.5225	29	3086.5226	30	3086.5227
31	3093.6536	32	3093.6536	33	3093.6537	34	3093.6538	35	3093.6539	36	3102.2153
37	3102.2154	38	3102.2154	39	3102.2155	40	3102.2155				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 16.00000

1	2080.8295	2	2080.8295	3	2080.8295	4	2080.8296	5	2080.8296	6	2082.5561
7	2082.5562	8	2082.5562	9	2082.5562	10	2082.5563	11	2085.5842	12	2085.5842
13	2085.5842	14	2085.5842	15	2085.5843	16	2089.9153	17	2089.9153	18	2089.9153
19	2089.9153	20	2089.9154	21	3086.5275	22	3086.5275	23	3086.5276	24	3086.5278
25	3086.5280	26	3092.2225	27	3092.2225	28	3092.2226	29	3092.2228	30	3092.2229
31	3099.3408	32	3099.3409	33	3099.3409	34	3099.3410	35	3099.3411	36	3107.8793
37	3107.8794	38	3107.8794	39	3107.8795	40	3107.8795				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 17.00000

1	2086.0147	2	2086.0147	3	2086.0147	4	2086.0148	5	2086.0148	6	2087.7507
7	2087.7507	8	2087.7508	9	2087.7509	10	2087.7509	11	2090.7853	12	2090.7853
13	2090.7854	14	2090.7854	15	2090.7855	16	2095.1201	17	2095.1202	18	2095.1201
19	2095.1202	20	2095.1202	21	3092.1897	22	3092.1898	23	3092.1899	24	3092.1901
25	3092.1902	26	3097.8820	27	3097.8820	28	3097.8821	29	3097.8823	30	3097.8824
31	3104.9874	32	3104.9874	33	3104.9875	34	3104.9876	35	3104.9876	36	3113.5028
37	3113.5029	38	3113.5029	39	3113.5030	40	3113.5030				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 18.00000

1	2091.1884	2	2091.1884	3	2091.1884	4	2091.1884	5	2091.1885	6	2092.9338
7	2092.9338	8	2092.9338	9	2092.9339	10	2092.9340	11	2095.9749	12	2095.9749
13	2095.9750	14	2095.9750	15	2095.9751	16	2100.3134	17	2100.3134	18	2100.3134
19	2100.3134	20	2100.3135	21	3097.8118	22	3097.8118	23	3097.8119	24	3097.8121
25	3097.8123	26	3103.5012	27	3103.5012	28	3103.5013	29	3103.5014	30	3103.5016
31	3110.5937	32	3110.5937	33	3110.5937	34	3110.5939	35	3110.5939	36	3119.0862
37	3119.0863	38	3119.0863	39	3119.0864	40	3119.0864				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 19.00000

1	2096.3503	2	2096.3503	3	2096.3503	4	2096.3503	5	2096.3503	6	2098.1051
7	2098.1051	8	2098.1052	9	2098.1052	10	2098.1053	11	2101.1527	12	2101.1527
13	2101.1528	14	2101.1528	15	2101.1529	16	2105.4946	17	2105.4947	18	2105.4947
19	2105.4947	20	2105.4948	21	3103.3942	22	3103.3942	23	3103.3943	24	3103.3945
25	3103.3946	26	3109.0806	27	3109.0806	28	3109.0807	29	3109.0809	30	3109.0810
31	3116.1603	32	3116.1603	33	3116.1603	34	3116.1605	35	3116.1605	36	3124.6300
37	3124.6301	38	3124.6300	39	3124.6302	40	3124.6302				

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE
1	2	.000000	.000000
2	3	.000000	.000000
3	4	.000000	.000000
4	5	.000000	.000000
36	37	.100000-03	.495700+04
37	38	.100000-03	.495700+04
38	39	.100000-03	.495700+04
39	40	.100000-03	.495700+04

TIME= 20.00000

1	2101.5001	2	2101.5001	3	2101.5001	4	2101.5002	5	2101.5002	6	2103.2644
7	2103.2644	8	2103.2645	9	2103.2646	10	2103.2646	11	2106.3184	12	2106.3184
13	2106.3185	14	2106.3185	15	2106.3186	16	2110.6637	17	2110.6637	18	2110.6638
19	2110.6638	20	2110.6638	21	3108.9373	22	3108.9373	23	3108.9374	24	3108.9376
25	3108.9377	26	3114.6207	27	3114.6207	28	3114.6208	29	3114.6210	30	3114.6210
31	3121.6875	32	3121.6875	33	3121.6875	34	3121.6877	35	3121.6877	36	3130.1346
37	3130.1347	38	3130.1347	39	3130.1348	40	3130.1348				

END OF PROBLEM-- EXAMPLE PROBLEM NO. 3, TRANSIENT CASE WITH CONVECTION, SURFACE-SINK RAD.

EXAMPLE PROBLEM NO. 4

STEADY-STATE WITH CONVECTION DAMPING

IBM

FORTRAN Coding Form

GX28-7327-6 U/M050
Printed in U.S.A.

PROGRAM: E12207 OR E12207 | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 1 OF 3
PROGRAMMER: ANSC | DATE | PUNCH | CARD ELECTRO NUMBER* 4

C	STATEMENT NUMBER	CONTINUATION	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
			EXAMPLE NO. 4, STEADY STATE WITH CONVECTION DAMPING-	
	54	40 8	1 50	T T
			.10 0.1 0.005	
	1	.4991-3	.07608	
-	1			
	1	1	NATURAL CONVECTION & SUBCOOLED BOILING IN 140F H2O AT 1.5 ATM	
			0. 9.-5	
			140. 9.-5	
			150. 9.292-6	
			180. 1.475-5	
			210. 1.778-5	
			232. 1.947-5	
			236. 3.416-5	
			240. 7.137-5	
			242. 1.097-4	
			244. 1.336-4	
			246. 1.820-4	
			248. 2.581-4	
			250. 2.981-4	
			254. 5.246-4	
			258. 8.500-4	
			262. 1.581-3	
			266. 2.679-3	
			270. 4.748-3	

* A standard card form, IBM electro #83153, is available for punching statements from this form.

IBM

FORTRAN Coding Form

GX28-7327-6 U/M050
Printed in U.S.A.

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE 2 OF 3

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER 4

STATEMENT NUMBER	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
	275. 9. 289-3	
	900000000. 9. 289-3	
- 1		
- 1		
1	0.5 0. 250.	
9	2.5 0. 250.	
10	0.5 0.1 250.	
18	2.5 0.1 250.	
19	0.5 0.2 250.	
27	2.5 0.2 250.	
28	0.5 0.3 250.	
36	2.5 0.3 250.	
37	0.5 0.4 250.	
45	2.5 0.4 250.	
46	0.5 0.5 250.	
54	2.5 0.5 250.	
1	1 2 11 10 1	
9	10 11 20 19 1	
17	19 20 29 28 1	
25	28 29 38 37 1	
33	37 38 47 46 1	
40	44 45 54 53 1	
46	47 140. 1	
	48 140. 1	

*A standard card form, IBM electro 608157, is available for punching statements from this form.

IBM

FORTRAN Coding Form

GX28-7327-6 U/M050
Printed in U.S.A.

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC									PAGE 3 OF 3
PROGRAMMER	DATE		PUNCH									CARD ELECTRO NUMBER* 4

C S	STATEMENT NUMBER	C O N T	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
1 2 3 4		5	6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72	73 74 75 76 77 78 79 80
			49 140. 1	
			50 140. 1	
			51 140. 1	
			52 140. 1	
			53 140. 1	
			54 140. 1	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

* A standard card form, IBM electro 883137, is available for punching statements from this form.

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

TWO DIMENSIONAL PLANE BODY

***** STEADY-STATE CASE FOLLOWS *****

EXAMPLE NO. 4, STEADY STATE WITH CONVECTION DAMPING

NUMBER OF NODAL POINTS-- 54
NUMBER OF ELEMENTS------ 40
NUMBER OF CONVECTION BC- 8
NUMBER OF MATERIALS----- 1
OUTPUT INTERVAL-------- 0
TIME INTERVAL------ .000
INITIAL TIME------- .000
MAXIMUM TIME------- 500.000

DMP1 = .500000+00 DMAX1 = .100000+02
DMP2 = .100000+00 DMAX2 = .100000+00
DMP3 = .500000+00 DMAX3 = .200000+03
TOLN = .500000-02

M	TABLE-K	K	TABLE-R	RHO-CP	TABLE-Q	Q
1	0	.499100-03	0	.000000	0	.760800-01

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

INPUT TABLES

TABLE NO. 1 TYPE 1 NATURAL CONVECTION & SUBCOOLED BOILING IN 140F H20 AT 1.5 AT

X	F(X)
.000000	.900000-04
.140000+03	.900000-04
.150000+03	.929200-05
.180000+03	.147500-04
.210000+03	.177800-04
.232000+03	.194700-04
.236000+03	.341600-04
.240000+03	.713700-04
.242000+03	.109700-03
.244000+03	.133600-03
.246000+03	.182000-03
.248000+03	.258100-03
.250000+03	.298100-03
.254000+03	.524600-03
.256000+03	.850000-03
.262000+03	.158100-02
.266000+03	.267900-02
.270000+03	.474800-02
.275000+03	.928900-02
.900000+09	.928900-02

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

N.P. NO.	CODE	X	Y	T	TO	CODE TABLE
1	0	.5000	.0000	.0000	250.0000	0
2	0	.7500	.0000	.0000	250.0000	0
3	0	1.0000	.0000	.0000	250.0000	0

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

INPUT TABLES

TABLE NO. 1 TYPE 1 NATURAL CONVECTION & SUBCOOLED BOILING IN 140F H20 AT 1.5 AT

X	F(X)
.000000	.900000-04
.140000+03	.900000-04
.150000+03	.929200-05
.180000+03	.147500-04
.210000+03	.177800-04
.232000+03	.194700-04
.236000+03	.341600-04
.240000+03	.713700-04
.242000+03	.109700-03
.244000+03	.133600-03
.246000+03	.182000-03
.248000+03	.258100-03
.250000+03	.298100-03
.254000+03	.524600-03
.258000+03	.850000-03
.262000+03	.158100-02
.266000+03	.267900-02
.270000+03	.474800-02
.275000+03	.928900-02
.900000+09	.928900-02

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

N.P. NO.	CODE	X	Y	T	TO	CODE TABLE
1	0	.5000	.0000	.0000	250.0000	0
2	0	.7500	.0000	.0000	250.0000	0
3	0	1.0000	.0000	.0000	250.0000	0
4	0	1.2500	.0000	.0000	250.0000	0
5	0	1.5000	.0000	.0000	250.0000	0
6	0	1.7500	.0000	.0000	250.0000	0
7	0	2.0000	.0000	.0000	250.0000	0
8	0	2.2500	.0000	.0000	250.0000	0
9	0	2.5000	.0000	.0000	250.0000	0
10	0	.5000	.1000	.0000	250.0000	0
11	0	.7500	.1000	.0000	250.0000	0
12	0	1.0000	.1000	.0000	250.0000	0
13	0	1.2500	.1000	.0000	250.0000	0
14	0	1.5000	.1000	.0000	250.0000	0
15	0	1.7500	.1000	.0000	250.0000	0
16	0	2.0000	.1000	.0000	250.0000	0
17	0	2.2500	.1000	.0000	250.0000	0
18	0	2.5000	.1000	.0000	250.0000	0
19	0	.5000	.2000	.0000	250.0000	0
20	0	.7500	.2000	.0000	250.0000	0
21	0	1.0000	.2000	.0000	250.0000	0
22	0	1.2500	.2000	.0000	250.0000	0
23	0	1.5000	.2000	.0000	250.0000	0
24	0	1.7500	.2000	.0000	250.0000	0
25	0	2.0000	.2000	.0000	250.0000	0
26	0	2.2500	.2000	.0000	250.0000	0
27	0	2.5000	.2000	.0000	250.0000	0
28	0	.5000	.3000	.0000	250.0000	0
29	0	.7500	.3000	.0000	250.0000	0
30	0	1.0000	.3000	.0000	250.0000	0
31	0	1.2500	.3000	.0000	250.0000	0
32	0	1.5000	.3000	.0000	250.0000	0
33	0	1.7500	.3000	.0000	250.0000	0
34	0	2.0000	.3000	.0000	250.0000	0
35	0	2.2500	.3000	.0000	250.0000	0
36	0	2.5000	.3000	.0000	250.0000	0
37	0	.5000	.4000	.0000	250.0000	0
38	0	.7500	.4000	.0000	250.0000	0
39	0	1.0000	.4000	.0000	250.0000	0
40	0	1.2500	.4000	.0000	250.0000	0
41	0	1.5000	.4000	.0000	250.0000	0
42	0	1.7500	.4000	.0000	250.0000	0
43	0	2.0000	.4000	.0000	250.0000	0
44	0	2.2500	.4000	.0000	250.0000	0
45	0	2.5000	.4000	.0000	250.0000	0
46	0	.5000	.5000	.0000	250.0000	0
47	0	.7500	.5000	.0000	250.0000	0
48	0	1.0000	.5000	.0000	250.0000	0
49	0	1.2500	.5000	.0000	250.0000	0
50	0	1.5000	.5000	.0000	250.0000	0
51	0	1.7500	.5000	.0000	250.0000	0
52	0	2.0000	.5000	.0000	250.0000	0
53	0	2.2500	.5000	.0000	250.0000	0
54	0	2.5000	.5000	.0000	250.0000	0

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

N	I	J	K	L	MATERIAL
1	1	2	11	10	1
2	2	3	12	11	1
3	3	4	13	12	1
4	4	5	14	13	1
5	5	6	15	14	1
6	6	7	16	15	1
7	7	8	17	16	1
8	8	9	18	17	1
9	10	11	20	19	1
10	11	12	21	20	1
11	12	13	22	21	1
12	13	14	23	22	1
13	14	15	24	23	1
14	15	16	25	24	1
15	16	17	26	25	1
16	17	18	27	26	1
17	19	20	29	28	1
18	20	21	30	29	1
19	21	22	31	30	1
20	22	23	32	31	1
21	23	24	33	32	1
22	24	25	34	33	1
23	25	26	35	34	1
24	26	27	36	35	1
25	28	29	38	37	1
26	29	30	39	38	1
27	30	31	40	39	1
28	31	32	41	40	1
29	32	33	42	41	1
30	33	34	43	42	1
31	34	35	44	43	1
32	35	36	45	44	1
33	37	38	47	46	1
34	38	39	48	47	1
35	39	40	49	48	1
36	40	41	50	49	1
37	41	42	51	50	1
38	42	43	52	51	1
39	43	44	53	52	1
40	44	45	54	53	1

25	28	29	38	37	1
26	29	30	39	38	1
27	30	31	40	39	1
28	31	32	41	40	1
29	32	33	42	41	1
30	33	34	43	42	1
31	34	35	44	43	1
32	35	36	45	44	1
33	37	38	47	46	1
34	38	39	48	47	1
35	39	40	49	48	1
36	40	41	50	49	1
37	41	42	51	50	1
38	42	43	52	51	1
39	43	44	53	52	1
40	44	45	54	53	1

AEROJET-GENERAL CORPORATION
SACRAMENTO, CALIFORNIA

***** PROGRAM E12202 ***** FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM

I	J	H	TEMPERATURE	H-TAB	T-TAB	RADIATION	EPSILON	F-FACTOR	F-TABLE NO.		
46	47	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
47	48	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
48	49	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
49	50	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
50	51	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
51	52	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
52	53	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03
53	54	.298100-03	.140000+03	1	0		.000000	.000000	0	0	.140000+03

NUMBER OF CONVECTION BOUNDARY CARDS - - - 8

ITERATION NO. 1

1	286.6593	2	286.6593	3	286.6593	4	286.6592	5	286.6592	6	286.6593
7	286.6593	8	286.6593	9	286.6593	10	285.8971	11	285.8971	12	285.8971
13	285.8971	14	285.8971	15	285.8971	16	285.8971	17	285.8971	18	285.8971
19	283.6106	20	283.6106	21	283.6106	22	283.6106	23	283.6106	24	283.6106
25	283.6106	26	283.6106	27	283.6106	28	279.7999	29	279.7999	30	279.7998
31	279.7998	32	279.7998	33	279.7999	34	279.7999	35	279.7999	36	279.7999
37	274.4648	38	274.4648	39	274.4648	40	274.4648	41	274.4648	42	274.4648
43	274.4648	44	274.4648	45	274.4648	46	250.1000	47	250.1000	48	250.1000
49	250.1000	50	250.1000	51	250.1000	52	250.1000	53	250.1000	54	250.1000

ITERATION NO. 2

1	284.2806	2	284.2806	3	284.2806	4	284.2805	5	284.2806	6	284.2806
7	284.2806	8	284.2806	9	284.2806	10	283.5184	11	283.5184	12	283.5184
13	283.5184	14	283.5184	15	283.5184	16	283.5184	17	283.5184	18	283.5184
19	281.2320	20	281.2319	21	281.2319	22	281.2319	23	281.2319	24	281.2319
25	281.2319	26	281.2319	27	281.2320	28	277.4212	29	277.4212	30	277.4212
31	277.4211	32	277.4212	33	277.4212	34	277.4212	35	277.4212	36	277.4212
37	272.0861	38	272.0861	39	272.0861	40	272.0861	41	272.0861	42	272.0861
43	272.0861	44	272.0861	45	272.0861	46	250.2000	47	250.2000	48	250.2000
49	250.2000	50	250.2000	51	250.2000	52	250.2000	53	250.2000	54	250.2000

ITERATION NO. 3

1	281.9890	2	281.9890	3	281.9890	4	281.9889	5	281.9889	6	281.9890
7	281.9890	8	281.9890	9	281.9890	10	281.2268	11	281.2268	12	281.2268
13	281.2268	14	281.2268	15	281.2268	16	281.2268	17	281.2268	18	281.2268
19	278.9404	20	278.9403	21	278.9403	22	278.9403	23	278.9403	24	278.9403
25	278.9403	26	278.9403	27	278.9403	28	275.1296	29	275.1296	30	275.1295
31	275.1295	32	275.1295	33	275.1295	34	275.1296	35	275.1296	36	275.1296
37	269.7945	38	269.7945	39	269.7945	40	269.7945	41	269.7945	42	269.7945
43	269.7945	44	269.7945	45	269.7945	46	250.3000	47	250.3000	48	250.3000
49	250.3000	50	250.3000	51	250.3000	52	250.3000	53	250.3000	54	250.3000

ITERATION NO. 4

1	279.7798	2	279.7798	3	279.7798	4	279.7798	5	279.7798	6	279.7798
7	279.7798	8	279.7798	9	279.7798	10	279.0177	11	279.0176	12	279.0176
13	279.0176	14	279.0176	15	279.0176	16	279.0176	17	279.0176	18	279.0177
19	276.7312	20	276.7312	21	276.7311	22	276.7311	23	276.7311	24	276.7311
25	276.7312	26	276.7312	27	276.7312	28	272.9204	29	272.9204	30	272.9204
31	272.9204	32	272.9204	33	272.9204	34	272.9204	35	272.9204	36	272.9204
37	267.5853	38	267.5853	39	267.5853	40	267.5853	41	267.5853	42	267.5853
43	267.5853	44	267.5853	45	267.5853	46	250.4000	47	250.4000	48	250.4000
49	250.4000	50	250.4000	51	250.4000	52	250.4000	53	250.4000	54	250.4000

ITERATION NO. 5

1	277.6486	2	277.6485	3	277.6485	4	277.6485	5	277.6485	6	277.6485
7	277.6485	8	277.6485	9	277.6485	10	276.8864	11	276.8864	12	276.8864
13	276.8863	14	276.8863	15	276.8864	16	276.8864	17	276.8864	18	276.8864
19	274.5999	20	274.5999	21	274.5999	22	274.5999	23	274.5999	24	274.5999
25	274.5999	26	274.5999	27	274.5999	28	270.7891	29	270.7891	30	270.7891
31	270.7891	32	270.7891	33	270.7891	34	270.7891	35	270.7891	36	270.7891
37	265.4541	38	265.4540	39	265.4540	40	265.4540	41	265.4540	42	265.4540
43	265.4540	44	265.4540	45	265.4540	46	250.5000	47	250.5000	48	250.5000
49	250.5000	50	250.5000	51	250.5000	52	250.5000	53	250.5000	54	250.5000

ITERATION NO. 6

1	275.5912	2	275.5912	3	275.5912	4	275.5912	5	275.5912	6	275.5912
7	275.5912	8	275.5912	9	275.5912	10	274.8291	11	274.8291	12	274.8291
13	274.8290	14	274.8290	15	274.8290	16	274.8291	17	274.8291	18	274.8291
19	272.5426	20	272.5426	21	272.5426	22	272.5426	23	272.5426	24	272.5426
25	272.5426	26	272.5426	27	272.5426	28	268.7318	29	268.7318	30	268.7318
31	268.7318	32	268.7318	33	268.7318	34	268.7318	35	268.7318	36	268.7318
37	263.3968	38	263.3967	39	263.3967	40	263.3967	41	263.3967	42	263.3967
43	263.3967	44	263.3967	45	263.3967	46	250.6000	47	250.6000	48	250.6000
49	250.6000	50	250.6000	51	250.6000	52	250.6000	53	250.6000	54	250.6000

ITERATION NO. 7

1	273.6041	2	273.6041	3	273.6041	4	273.6040	5	273.6040	6	273.6041
7	273.6041	8	273.6041	9	273.6041	10	272.8419	11	272.8419	12	272.8419
13	272.8419	14	272.8419	15	272.8419	16	272.8419	17	272.8419	18	272.8419
19	270.5555	20	270.5554	21	270.5554	22	270.5554	23	270.5554	24	270.5554
25	270.5554	26	270.5554	27	270.5554	28	266.7447	29	266.7447	30	266.7446
31	266.7446	32	266.7446	33	266.7446	34	266.7447	35	266.7447	36	266.7447
37	261.4096	38	261.4096	39	261.4096	40	261.4096	41	261.4096	42	261.4096
43	261.4096	44	261.4096	45	261.4096	46	250.7000	47	250.7000	48	250.7000
49	250.7000	50	250.7000	51	250.7000	52	250.7000	53	250.7000	54	250.7000

ITERATION NO. 8

1	271.6837	2	271.6836	3	271.6836	4	271.6836	5	271.6836	6	271.6836
7	271.6836	8	271.6836	9	271.6836	10	270.9215	11	270.9215	12	270.9215
13	270.9214	14	270.9214	15	270.9215	16	270.9215	17	270.9215	18	270.9215
19	268.6350	20	268.6350	21	268.6350	22	268.6350	23	268.6350	24	268.6350
25	268.6350	26	268.6350	27	268.6350	28	264.8242	29	264.8242	30	264.8242
31	264.8242	32	264.8242	33	264.8242	34	264.8242	35	264.8242	36	264.8242
37	259.4892	38	259.4891	39	259.4891	40	259.4891	41	259.4891	42	259.4891
43	259.4891	44	259.4891	45	259.4891	46	250.8000	47	250.8000	48	250.8000
49	250.8000	50	250.8000	51	250.8000	52	250.8000	53	250.8000	54	250.8000

ITERATION NO. 9

1	269.8265	2	269.8265	3	269.8265	4	269.8264	5	269.8264	6	269.8264
7	269.8264	8	269.8265	9	269.8265	10	269.0643	11	269.0643	12	269.0643
13	269.0643	14	269.0643	15	269.0643	16	269.0643	17	269.0643	18	269.0643
19	266.7778	20	266.7778	21	266.7778	22	266.7778	23	266.7778	24	266.7778
25	266.7778	26	266.7778	27	266.7778	28	262.9671	29	262.9670	30	262.9670
31	262.9670	32	262.9670	33	262.9670	34	262.9670	35	262.9670	36	262.9670
37	257.6320	38	257.6320	39	257.6319	40	257.6319	41	257.6320	42	257.6320
43	257.6320	44	257.6320	45	257.6320	46	250.7972	47	250.7972	48	250.7972
49	250.7972	50	250.7972	51	250.7972	52	250.7972	53	250.7972	54	250.7972

ITERATION NO. 10

1	269.8766	2	269.8766	3	269.8766	4	269.8765	5	269.8765	6	269.8765
7	269.8766	8	269.8766	9	269.8766	10	269.1144	11	269.1144	12	269.1144
13	269.1144	14	269.1144	15	269.1144	16	269.1144	17	269.1144	18	269.1144

19	266.8279	20	266.8279	21	266.8279	22	266.8279	23	266.8279	24	266.8279
25	266.8279	26	266.8279	27	266.8279	28	263.0172	29	263.0171	30	263.0171
31	263.0171	32	263.0171	33	263.0171	34	263.0171	35	263.0171	36	263.0172
37	257.6821	38	257.6821	39	257.6820	40	257.6820	41	257.6821	42	257.6821
43	257.6821	44	257.6821	45	257.6821	46	250.7998	47	250.7998	48	250.7998
49	250.7998	50	250.7998	51	250.7998	52	250.7998	53	250.7998	54	250.7998

END OF PROBLEM-- EXAMPLE NO. 4, STEADY STATE WITH CONVECTION DAMPING

```
<***Δ****1****Δ****2****Δ****3****Δ****4****Δ****5****Δ****6****Δ****7****Δ****8****Δ****9****Δ****0****Δ****1****Δ****2****Δ****3*
****************************************ISD-27.16:INFORMATION-SYSTEMS-DESIGN:15-APR-1972****************************************
***Δ***1***Δ***2***Δ***3***Δ***4***Δ***5***Δ***6***Δ***7***Δ***0***Δ***1***Δ***2***Δ***3***Δ***4***Δ***5***Δ***6***Δ***7***Δ***0***Δ
[]#Δ ABCDEFGHIJKLMNOPQRSTUVWXYZ)-+<=>&$*(%:?!,\0123456789';/.\ @[]#Δ ABCDEFGHIJKLMNOPQRSTUVWXYZ)-+<=>&$*(%:?!,\0123456789';/.\ @[]#Δ

25 APR 72 P 12:56:00    IDENT=FYEE     ACCOUNT=428235  CARDS IN=  200, OUT=     0

  PAGES=   52, LINES=  1277. TIME=00:00:28 (HMS)
```


* *

*** USER NOTICES - APRIL 20, 1972 ***

(1) ISD 1108 TERMINAL SERVICE IS SCHEDULED AS FOLLOWS

```
MON :          07:00 - 24:00
TUE - FRI :    00:00 - 04:00 ;  07:00 - 24:00
SAT :          00:00 - 22:00
SUN :          04:00 - 22:00
```

(2) LARGE-CORE (LCR) PRODUCTION JOBS ARE NOW BEING RUN ON AN OVERNIGHT BASIS STARTING AT 04:00 EACH DAY.

(3) ISD NOW HAS AVAILABLE REMOTE-BATCH JOB ENTRY VIA LOW-SPEED TELETYPE COMPATIBLE TERMINALS USING DIAL-UP COMMUNICATION LINES. THIS SERVICE HAS BEEN IN USE FOR OVER TWO MONTHS AND IS CALLED RON/I.
THE DIAL-UP TELEPHONE NUMBERS AND TRANSMISSION RATES ARE LISTED BELOW.

```
10 CHAR/SEC    415-562-4035, 415-562-4036, 415-562-5186
30 CHAR/SEC    415-562-4716  **  EFFECTIVE 4/24/72 THIS NUMBER WILL BE CHANGED TO 415-562-4294  **
```

(4) ISD'S SECOND PUBLIC TERMINAL IN SAN FRANCISCO IS LOCATED AT # 1 CALIFORNIA ST., ROOM 2555.

(5) BEGINNING 4/24/72 AND AFFECTIVE MONDAY - FRIDAY TURNAROUND TIME SHOULD BE REDUCED BETWEEN THE HOURS OF 10:30 - 11:30 AND 14:00 - 16:00 FOR USERS SUBMITTING NON-TAPE JOBS WITH RUN TIMES ESTIMATED AT LESS THAN 6 MINUTES.

ADDITIONAL INFORMATION ON (2) & (3) IS NOW AVAILABLE TO ALL INTERESTED USERS BY CONTACTING YOUR SALESMAN AT 415-562-4204.

* *

APPENDIX B

LISTING

PROGRAM E12202

```
@ ELT CONMAT,1,720405, 56711

000001                SUBROUTINE CONMAT
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000017              C                (TEM(4),XTEM4)
000018                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000019              C                (ITEM(4),MTYPE)
000020                EQUIVALENCE (TI(1),TC(1))
000021              C-------------------------------------------------------------------
000022                DO 120 I=1,5
000023                DD(I)=0.0
000024                P(I)=0.0
000025                DO 120  J=1,5
000026               120  S(I,J)=0.0
000027                I=LM(1)
000028                J=LM(2)
000029                K=LM(3)
000030                L=LM(4)
000031                LM(5)=I
000032                   TEMPX = (TC(I)+TC(J)+TC(K)+TC(L) )/4.0
000033                   FAC = 1.0
000034              C-------------------------------------------------------------------
000035              C     ITABQ .LT. 0     Q VS. TIME TABLE.
000036              C     ITABQ .EQ. 0     NO TABLE.
000037              C     ITABQ .GT. 0     Q VS X OR Y TABLE.
000038              C-------------------------------------------------------------------
000039                IF(ITABQ)    128,130,129
000040               128  ITABQ  = -ITABQ
000041                CALL LINT (TIME,TAB(1,ITABQ),QZZ,DX)
000042                GO TO 130
000043               129  CONTINUE
000044                LOC  = ITFAC(ITABQ)
000045                     IF(LOC .GT. 0) CALL LINT(TIME,TAB(1,LOC),FAC,DX)
000046               130  QXX  = QZZ*FAC
000047                XX = (X(I)+X(J)+X(K)+X(L))/4.0
000048                YY = (Y(I)+Y(J)+Y(K)+Y(L))/4.0
000049              C-------------------------------------------------------------------
000050              C     COMPUTE GEOMETRICAL CHARACTERISTIC
000051              C-------------------------------------------------------------------
000052                DO 152 K=1,4
000053              C
000054                I = LM(K)
000055                J = LM(K+1)
000056                IF(I .EQ. J)       GO TO 152
```

```
000057          135 AJ=X(J)-X(I)
000058              AK=XX-X(I)
000059              BJ=Y(J)-Y(I)
000060              BK=YY-Y(I)
000061              C=BJ-BK
000062              DX=AK-AJ
000063              XMUL=1.0
000064              IF (KAT) 136,137,136
000065          136 XMUL=XMUL*(X(I)+X(J)+XX)/3.0
000066            C
000067          137 XLAM=AJ*BK-AK*BJ
000068              XTEM1 = .5*XMUL/XLAM
000069              XTEM2 = XLAM*XMUL/4.0
000070              Z1        =(C*C+DX*DX) * XTEM1
000071              Z2        =(BK*C-AK*DX) * XTEM1
000072              Z3        =(-BJ*C+AJ*DX) * XTEM1
000073              Z4        =(BK*BK+AK*AK) * XTEM1
000074              Z5        =(-BJ*BK-AJ*AK) * XTEM1
000075              Z6        =(BJ*BJ+AJ*AJ) * XTEM1
000076              Z7        = XTEM2
000077              XTEM3 = (TC(I)+TC(J)+TEMPX)/3.
000078              IF(ITABK .GT. 0)        CALL LINT (XTEM3,TAB(1,ITABK),COND,DX)
000079              FAC  = 1.0                                                          *NEW
000080              LOC = ITFAC(ITABK)                                                  *NEW
000081              IF(LOC .GT. 0)          CALL LINT (TIME,TAB(1,LOC),FAC,DX)          *NEW
000082              COND = COND*FAC                                                     *NEW
000083              IF(ITABR .GT. 0)        CALL LINT (XTEM3,TAB(1,ITABR),RHO,DX)
000084              FAC  = 1.0                                                          *NEW
000085              LOC = ITFAC(ITABR)                                                  *NEW
000086              IF(LOC .GT. 0)          CALL LINT (TIME,TAB(1,LOC),FAC,DX)          *NEW
000087              RHO  = RHO*FAC                                                      *NEW
000088              QQ   =  Z7*QXX
000089              QSTORE = Z7*RHO
000090              E(1,1)  = Z1
000091              E(1,2)  = Z2
000092              E(1,3)  = Z3
000093              E(2,1)  = E(1,2)
000094              E(2,2)  = Z4
000095              E(2,3)  = Z5
000096              E(3,1)  = E(1,3)
000097              E(3,2)  = E(2,3)
000098              E(3,3)  = Z6
000099              IX(1)=K
000100              IX(2)=K+1
000101              IF (K-4) 145,140,145
000102          140 IX(2)=1
000103          145 IX(3)=5
000104            C
000105              DO 151 I=1,3
000106              II=IX(I)
000107              P(II)=P(II)+QQ
000108              DD(II)=DD(II)+QSTORE
000109              DO 151 J=1,3
000110              JJ=IX(J)
000111          151 S(II,JJ)  = S(II,JJ) + E(I,J)*COND
000112            C
000113          152 CONTINUE
000114            C
000115              DO 155 I=1,4
000116              DO 155 J=1,4
```

```
000117          155 S(I,J)=S(I,J)-S(I,5)*S(J,5)/S(5,5)
000118            C
000119            C       3. ADD ELEMENT CONDUCTIVITY TO COMPLETE CONDUCTIVITY MATRIX
000120                    DO 175 L=1,4
000121                    I=LM(L)
000122                    D(I)=D(I)+DD(L)
000123                    B(I)=B(I)+P(L)
000124                    DO 175 M=1,4
000125                    J=LM(M)-I+1
000126                    IF(NDIM-J)   185,158,158
000127          158 IF(MBAND-J) 160,165,165
000128          160 MBAND=J
000129          165 IF(J) 175,175,170
000130          170 A(I,J)=A(I,J)+S(L,M)
000131          175 CONTINUE
000132            C
000133           180  CONTINUE
000134                RETURN
000135           185  WRITE (6,2021) NUM
000136                GO TO 180
000137          2021 FORMAT ('0BAD CARD NO.' I4 )
000138                END
```

```
000001                SUBROUTINE CONVBC (III, JJJ, NNN)
000002                DIMENSION IEPS(200)
000003                DIMENSION TC(500)
000004                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000005                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000006                COMMON QZZS(500), TAB(60,32)
000007                COMMON XCOND(20), DENS(20), QX(20)
000008                COMMON TEM(10)
000009                COMMON COND,RHO,QXX,QZZ
000010                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000011                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000012                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000013                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000014                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000015                COMMON IKODE(500)
000016                COMMON INTAB(20,3)
000017                COMMON /BC/ IBC(200), JBC(200), IHBC(200), ITBC(200), HBBC(200),
000018               1 TEMEBC(200), XLBC(200), IIBC(200), JJBC(200)
000019                COMMON /RADCON/EPS(200), F(20,20),  SIGMA, NRF(200), IFLAGR
000020               1 , FN(200), BQ(20), KTEM(20), TS(200)
000021                DIMENSION FM(20,20)
000022                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000023               C                (TEM(4),XTEM4)
000024                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000025               C                (ITEM(4),MTYPE)
000026                EQUIVALENCE (TI(1),TC(1))
000027                EQUIVALENCE (H,IHH), (EPS(1),IEPS(1))
000028          C      I = II
000029          C      J = JJ
000030          C     TEMP   = H*XL*TEMP/2.0
000031          C     B(I)=B(I)+TEMP
000032          C     B(J)=B(J)+TEMP
000033                I  = III
000034                J  = JJJ
000035                N  = NNN
000036                IF(IHH .EQ. 0)          GO TO 215
000037                TEMPI  = TEMEBC(N)
000038                TEMPJ  = TEMPI
000039                II = IIBC(N)
000040                JJ = JJBC(N)
000041                IF(II .GT. 0)           TEMPI = (TEMPI+TEMEBC(II))/2.0
000042                IF(JJ .GT. 0)           TEMPJ = (TEMPJ+TEMEBC(JJ))/2.0
000043                TEMPI  = H*XL*TEMPI/2.0
000044                TEMPJ  = H*XL*TEMPJ/2.0
000045                B(I) = B(I)+TEMPI
000046                B(J) = B(J)+TEMPJ
000047          C     H=H*XL/4.
000048                H=H*XL/2.
000049                A(I,1)=A(I,1)+H
000050                A(J,1)=A(J,1)+H
000051          C     K=J-I+1
000052          C     IF (K) 212,212,210
000053          C 210 A(I,K)=A(I,K)+H
000054          C     GO TO 215
000055          C 212 K=I-J+1
000056          C     A(J,K)=A(J,K)+H
```

```
000057          215 CONTINUE
000058              IF(IEPS(N) .EQ. 0)      GO TO 220
000059              T1 = TC(I)*TC(I)
000060              T2 = TC(J)*TC(J)
000061              T3 = TC(I)*TC(J)
000062              TR = (T1*T1+T1*T3+T1*T2+T2*T3+T2*T2)/5.0
000063              TEMP = TS(N)
000064              TEMX = XL*FN(N)*EPS(N)*SIGMA*(TEMP**4-TR)/2.0
000065              B(I) = TEMX+B(I)
000066              B(J) = TEMX+B(J)
000067          220 CONTINUE
000068              RETURN
000069      C-------------------------------------------------------------------
000070      C     BERQUAM'S RADIATION CALCULATION FOR SURFACE TO SURFACE.
000071      C-------------------------------------------------------------------
000072              ENTRY RAD
000073              M  = 0
000074              DO 2200  I=1,20
000075              DO 2200  J=1,20
000076          2200 FM(I,J)  = F(I,J)
000077              DO 221   N=1,NUMBC
000078              NRFI = NRF(N)
000079              IF(NRFI .EQ. 0)         GO TO 221
000080              I  = IBC(N)
000081              M  = M+1
000082              J  = JBC(N)
000083              TK = TC(I)
000084              TL = TC(J)
000085              T2 = TL*TL
000086              T4 = T2*T2
000087              TR = TK*(TK*(TK*(TK+TL)+T2)+T2*TL) + T4
000088              BQ(M)    = EPS(N)*SIGMA*TR/5.0
000089          221 CONTINUE
000090              CALL SIMEQ (FM,BQ, NRFI, 1, 20, KTEM, DET, ND, KERR)
000091              M  = 0
000092              DO 222  N=1,NUMBC
000093              IF(NRF(N) .EQ. 0)       GO TO 222
000094              M  = M+1
000095              I  = IBC(N)
000096              J  = JBC(N)
000097              XL = XLBC(N)
000098              TEMP = EPS(N)/(1.-EPS(N))*XL/2.0
000099              T1 = TC(I)*TC(I)
000100              T2 = TC(J)*TC(J)
000101              T3 = TC(I)*TC(J)
000102              TR = (T1*T1+T1*T3+T1*T2+T2*T3+T2*T2)/5.0
000103              TEMP = TEMP* (BQ(M)-SIGMA*TR)
000104              B(I) = TEMP + B(I)
000105              B(J) = TEMP + B(J)
000106          222 CONTINUE
000107              RETURN
000108      C-------------------------------------------------------------------
000109              ENTRY TEMPBC
000110      C
000111      C     2.  TEMPERATURE BOUNDARY CONDITIONS
000112      C
000113              DO 300 N=1,NUMNP
000114              LOC = IKODE(N)
000115              IF(LOC .GT. 0)   CALL LINT (TIME,TAB(1,LOC),T(N),DX )
000116              B(N)=B(N)+T(N)
```

```
000117              IF(KODE(N)) 225,300,225
000118          225 DO 250 M=2,MBAND
000119              K=N-M+1
000120              IF(K) 235,235,230
000121          230 B(K)=B(K)-A(K,M)*T(N)
000122              A(K,M)=0.0
000123          235 L=N+M-1
000124              IF(NUMNP-L) 245,240,240
000125          240 B(L)=B(L)-A(N,M)*T(N)
000126          245 A(N,M)   = 0.0
000127          250 CONTINUE
000128              A(N,1)=1.0
000129              B(N)=T(N)
000130          300 CONTINUE
000131              RETURN
000132            C-------------------------------------------------------------
000133              ENTRY CONVBI
000134              DO 405  II=1,NUMBC
000135              IIBC(II) = 0
000136          405 JJBC(II) = 0
000137              DO 415  II=1,NUMBC
000138              I  = IBC(II)
000139              J  = JBC(II)
000140              DO 410  JJ=1,NUMBC
000141              IF(I .EQ. JBC(JJ))      IIBC(II)  = JJ
000142              IF(J .EQ. IBC(JJ))      JJBC(II)  = JJ
000143          410 CONTINUE
000144          415 CONTINUE
000145              RETURN
000146              END
```

```
@ ELT DATA,1,720212, 62590

000001          JACK,S MODEL CONVECTION BOUNDARY ,CONDUCTION,AND SURF-SINK RADIATION
000002           40   24   16                                        1.      5    200.
000003            1     .01                    .001
000004           -1
000005            1
000006            5     2.
000007            6                 .5
000008           10     2.         .5
000009           11                1.0
000010           15     2.         1.
000011           16                1.5
000012           20     2.         1.5
000013           21                1.51                  3000.
000014           25     2.         1.51                  3000.
000015           26                2.01                  3000.
000016           30     2.         2.01                  3000.
000017           31                2.51                  3000.
000018           35     2.         2.51                  3000.
000019           36                3.01                  3000.
000020           40     2.         3.01                  3000.
000021            1    1    2    7    6    1
000022            5    6    7   12   11    1
000023            9   11   12   17   16    1
000024           13   21   22   27   26    1
000025           17   26   27   32   31    1
000026           21   31   32   37   36    1
000027           24   34   35   40   39    1
000028           36   37      .0001  3224.555
000029                38      .0001  3224.555
000030                39      .0001  3224.555
000031                40      .0001  3224.555
000032            1    2                                  1.      1.
000033                 3                                  1.      1.
000034                 4                                  1.      1.
000035                 5                                  1.      1.
000036           16   17                          .5                  8   1
000037           17   18                          .5                  8   2
000038           18   19                          .5                  8   3
000039           19   20                          .5                  8   4
000040           21   22                          .8                  8   5
000041           22   23                          .8                  8   6
000042           23   24                          .8                  8   7
000043           24   25                          .8                  8   8
000044            1                                    1.
000045      0.
000046            2                                            1.
000047      0.
000048            3                                                    1.
000049      0.
000050            4
000051      1.
000052            5     1.
000053      0.
000054            6                 1.
000055      0.
000056            7                           1.
```

```
000057          0.
000058             8                                    1.0
000059          0.
000060           JACK,S MODEL CONVECTION BOUNDARY ,CONDUCTION,AND SURF-SINK RADIATION
000061             40   28   08                 1                          .5      2      20.
000062              1    1.01                          0.01
000063              2     .000001                .000004
000064             -1
000065              1    5              CONDUCTIVITY
000066                    0.             .01
000067                    9000000.       .01
000068          -1
000069          -1
000070              1                                                2000.
000071              5     2.                                         2000.
000072              6                    .5                         2000.
000073             10     2.             .5                         2000.
000074             11                    1.0                        2000.
000075             15     2.             1.                         2000.
000076             16                    1.5                        2000.
000077             20     2.             1.5                        2000.
000078             21                    1.51                       3000.
000079             25     2.             1.51                       3000.
000080             26                    2.01                       3000.
000081             30     2.             2.01                       3000.
000082             31                    2.51                       3000.
000083             35     2.             2.51                       3000.
000084             36                    3.01                       3000.
000085             40     2.             3.01                       3000.
000086              1    1     2     7     6     1
000087              5    6     7    12    11     1
000088              9   11    12    17    16     1
000089             13   16    17    22    21     2
000090             17   21    22    27    26     1
000091             21   26    27    32    31     1
000092             25   31    32    37    36     1
000093             28   34    35    40    39     1
000094              1    2                                                    .5      .7
000095                   3                                                    .5      .7
000096                   4                                                    .5      .7
000097                   5                                                    .5      .7
000098             36   37 .0001     4957.
000099                  38 .0001     4957.
000100                  39 .0001     4957.
000101                  40 .0001     4957.
000102          D12207 RADIANT INTERCHANGE 4 SURFACES
000103             12    4    4
000104              1                .01
000105              2               .001
000106             -1
000107              1    1           0.          4.       3000.
000108              2                0.          3.
000109              3                0.          1.
000110              4    1           0.          0.       2000.
000111              5    1           2.          4.       3000.
000112              6                2.          3.
000113              7                2.          1.
000114              8    1           2.          0.       2000.
000115              9    1           4.          4.       3000.
000116             10                4.          3.
```

```
000117      11                4.          1.
000118      12    1           4.          0.      2000.
000119       1    1    2      6     5     1
000120       2    3    4      8     7     2
000121       3    5    6     10     9     1
000122       4    7    8     12    11     2
000123       2    6                                        .9          4   1
000124            10                                       .9          4   2
000125       3    7                                        .5          4   3
000126            11                                       .5          4   4
000127       1                                        .7      .3
000128       2                                        .3      .7
000129       3               .7          .3
000130       4               .3          .7
000131  SAMPLE PROBLEMS,  CASE 1', K1=.01,  STEADY STATE, RAD.+ COND. ACROSS GAP
000132      40   28   16                  1                                                TTTT
000133      1.        200.          1.          200.      .3        200.
000134       1      1.01                      .001
000135       2       .000001              .000004
000136      -1
000137       1      5                CONDUCTIVITY
000138              0.               .01
000139              9000000.         .01
000140      -1
000141       2      1          H VS. TEMP.
000142                           .0003
000143              9000000.     .0003
000144      -1
000145      -1
000146       1
000147       5      2.
000148       6                    .5
000149      10      2.           .5
000150      11                   1.0
000151      15      2.           1.
000152      16                   1.5
000153      20      2.           1.5
000154      21                   1.51
000155      25      2.           1.51
000156      26                   2.01
000157      30      2.           2.01
000158      31                   2.51
000159      35      2.           2.51
000160      36                   3.01
000161      40      2.           3.01
000162       1    1    2     7     6     1
000163       5    6    7    12    11     1
000164       9   11   12    17    16     1
000165      13   16   17    22    21     2
000166      17   21   22    27    26     1
000167      21   26   27    32    31     1
000168      25   31   32    37    36     1
000169      28   34   35    40    39     1
000170       1    2              1348.          2
000171            3              1348.          2
000172            4              1348.          2
000173            5              1348.          2
000174      36   37 .0001        4957.
000175           38 .0001         4957.
000176           39 .0001         4957.
```

```
                   40 .0001    4957.
        16    17                               .5                          8    1
        17    18                               .5                          8    2
        18    19                               .5                          8    3
        19    20                               .5                          8    4
        21    22                               .8                          8    5
        22    23                               .8                          8    6
        23    24                               .8                          8    7
        24    25                               .8                          8    8
         1                                                 1.
0.
         2                                                           1.
0.
         3                                                                     1.
0.
         4
1.
         5      1.
0.
         6                1.
0.
         7                          1.
0.
         8                                     1.0
0.
1ST EXAMPLE PROBLEM FOR STEADY STATE CASE. PROGRAM D12202. SEPT 10,1971
        56    40     2     1                                          3
         1     1.0
-        1
         1     1        1.0        2.0       1000.                                      12401499
        10              4.0        3.0                                                  12401500
        11     1        1.1        1.7       1000.                                      12401501
        20              4.0        2.5                                                  12401502
        21     1        1.2        1.4       1000.                                      12401503
        30              4.0        2.0                                                  12401504
        31     1        4.6        1.8         75.                                      12401505
        32     1        5.0        1.7         75.                                      12401506
        33     1        1.3        1.1       1000.                                      12401507
        44     1        5.0        1.2         75.                                      12401508
        45     1        1.4        0.8       1000.                                      12401509
        56     1        5.0        1.0         75.                                      12401510
         1    11    12     2     1     1                                                12401511
        10    21    22    12    11     1                                                12401512
        19    33    34    22    21     1                                                12401513
        30    45    46    34    33     1                                                12401514
        40    55    56    44    43     1                                                12401515
        10    20        2.0        75.
        20    30        2.0        75.
  TEST CASE 2.  CONVECTION DANPING OF E12207.
        54    40     8                 1                                 50                 T T
                                     .10   0.1                              0.005
         1          .4991-3                                  .07608
        -1
         1     1        NATURAL CONVECTION & SUBCOOLED BOILING IN 140F H2O A1.5 ATM
                          0.         9.-5
                        140.         9.-5
                        150.     9.292-6
                        180.     1.475-5
                        210.     1.778-5
                        232.     1.947-5
```

```
000237                          236.    3.416-5
000238                          240.    7.137-5
000239                          242.    1.097-4
000240                          244.    1.336-4
000241                          246.     1.82-4
000242                          248.    2.581-4
000243                          250.    2.981-4
000244                          254.    5.246-4
000245                          258.    8.500-4
000246                          262.    1.581-3
000247                          266.    2.679-3
000248                          270.    4.748-3
000249                          275.    9.289-3
000250                  900000000.      9.289-3
000251  -1
000252  -1
000253   1                      0.5       0.0                   250.
000254   9                      2.5       0.0                   250.
000255  10                      0.5       0.1                   250.
000256  18                      2.5       0.1                   250.
000257  19                      0.5       0.2                   250.
000258  27                      2.5       0.2                   250.
000259  28                      0.5       0.3                   250.
000260  36                      2.5       0.3                   250.
000261  37                      0.5       0.4                   250.
000262  45                      2.5       0.4                   250.
000263  46                      0.5       0.5                   250.
000264  54                      2.5       0.5                   250.
000265   1   1   2   11   10    1
000266   9  10  11   20   19    1
000267  17  19  20   29   28    1
000268  25  28  29   38   37    1
000269  33  37  38   47   46    1
000270  40  44  45   54   53    1
000271  46  47                      140.    1
000272      48                      140.    1
000273      49                      140.    1
000274      50                      140.    1
000275      51                      140.    1
000276      52                      140.    1
000277      53                      140.    1
000278      54                      140.    1
000279          TEST CASE 3   H = 0.000050      E = 0.0
000280  10   4   1
000281   1       0.00020
000282  -1
000283   1   1 0.          0.          3000.
000284   2       1.          0.
000285   5       4.          0.
000286   6   1 0.          1.          3000.
000287   7       1.          1.
000288  10       4.          1.
000289   1   1   2   7   6   1
000290   4   4   5  10   9   1
000291   5  10 0.000050  0.
000292          TEST CASE 4   H = 0.0           E = 1.0
000293  10   4   1                                                TT
000294                                          0.5       200.      0.0005
000295   1       0.00020
000296  -1
```

```
000297        1    1 0.          0.          3000.
000298        2      1.          0.
000299        5      4.          0.
000300        6    1 0.          1.          3000.
000301        7      1.          1.
000302       10      4.          1.
000303        1    1    2    7    6    1
000304        4    4    5   10    9    1
000305        5   10              0.                    1.          1.
000306            TEST CASE 5   H = 0.00005      E = 1.0
000307       10    4    2                                                  TT
000308                                                 0.5         200.        0.0005
000309        1       0.00020
000310       -1
000311        1    1 0.          0.          3000.
000312        2      1.          0.
000313        5      4.          0.
000314        6    1 0.          1.          3000.
000315        7      1.          1.
000316       10      4.          1.
000317        1    1    2    7    6    1
000318        4    4    5   10    9    1
000319        5   10 0.000050    0.
000320        5   10              0.                    1.          1.
```

```
@ ELT FRAME,1,720212, 62556

000001              SUBROUTINE FRAME (XMIN,XMAX,YMIN,YMAX,XL,YL,TITLE,K,J,LENGTH,     12401823
000002             1ISCALE)                                                           12401824
000003              DIMENSION CONST(10),XI(5),YI(5),XL(3),YL(3),TITLE(12)
000004              DATA CONST/1.,1.25,1.5,2.0,2.5,4.0,5.0,6.0,8.0,10.0/               12401826
000005            C-------------------------------------------------------------------
000006              MOVEON   = 0                                                       12401827
000007              IF(K.EQ.0 )    K = 1                                               12401828
000008              XORI     = XMIN                                                    12401829
000009              YORI     = YMIN                                                    12401830
000010              NXPLOT   = 200                                                     12401831
000011              NYPLOT   = 100                                                     12401832
000012              NXLABL   = 150                                                     12401834
000013              NYLABL   = 150                                                     12401835
000014              NXFRAC   = 3                                                       12401836
000015              NYFRAC   = 3                                                       12401837
000016              NXLINE   = 175                                                     12401838
000017              NYLINE   = 75                                                      12401839
000018              NXSCAL = 0                                                         12401857
000019              NYSCAL = 0                                                         12401855
000020              XLABLD = XMAX
000021              YLABLD = YMAX
000022              IF(J .LT. -1)          GO TO 50
000023              YLABLD   = (YMAX-YMIN)*.18
000024              TEST     = YLABLD                                                  12401840
000025              FACT = 1.0                                                         12401841
000026        10    IF(TEST.LT.10.0)       GO TO 12                                   12401842
000027              TEST = TEST/10.                                                    12401843
000028              FACT = FACT*10.                                                    12401844
000029              GO TO 10                                                           12401845
000030        12    IF(TEST.GE.1.0)        GO TO 14                                   12401846
000031              TEST = TEST*10.                                                    12401847
000032              FACT = FACT/10.                                                    12401848
000033              GO TO 12                                                           12401849
000034        14    DO 16   I=1,10                                                     12401850
000035              DELT = CONST(I)                                                    12401851
000036              IF(TEST.LE.DELT )      GO TO 25                                   12401852
000037        16    CONTINUE                                                         12401853
000038        25    YLABLD= DELT*FACT                                                12401854
000039              XLABLD = YLABLD                                                    12401856
000040              TEST   = XORI/XLABLD
000041        30    TEST     = AINT(TEST)                                            12401859
000042              XORI   = XLABLD*TEST                                               12401860
000043              IF(XORI .GT. XMIN)     XORI = XORI-XLABLD
000044        32    TEST     = YORI/YLABLD
000045        34    TEST     = AINT(TEST)                                            12401862
000046              YORI   = YLABLD*TEST                                               12401863
000047              IF(YORI .GT. YMIN)     YORI = YORI-YLABLD
000048        36    CONTINUE                                                         12401864
000049              FACT = (XMAX-XORI)/XLABLD*150.                                     12401865
000050              LENGTH = FACT                                                      12401866
000051              IF(LENGTH-4000)        50,50,40                                   12401867
000052        40    TEST =   LENGTH                                                  12401868
000053              LENGTH = 4000                                                      12401869
000054              XLABLD   = XLABLD*TEST/4000.                                       12401870
000055        50    CONTINUE                                                         12401871
000056              MAXX = LENGTH+300                                                12401872
```

```
000057          C-------------------------------------------------------------------
000058          C     XORI,YORI                 PLOT ORIGIN.
000059          C     NXPLOT,NYPLOT             LOCATION (RASTERS) OF VERTICAL AND HRIZONTAL
000060          C                               LINES,RESPECTIVELY.
000061          C     XLABLD,YLABLD             DELTA-X AND DELTA-Y,RESPECTIVELY.
000062          C     NXLABL,NYLABL             NUMBER OF RASTERS PER DELTA-X AND
000063          C                               DELTA-Y,RESPECTIVELY.
000064          C     NXFRAC,NYFRAC             NO./DECIMAL PLACES FOR X AND Y LABELS.
000065          C     NXLINE,NYLINE             RASTER LINE TO PRINT THE X AND Y LABELS.
000066          C     MAXX                      MAXIMUM LENGTH.
000067          C     NXSCAL,NYSCAL             SCALE FACTORS FOR X AND Y.
000068          C-------------------------------------------------------------------
000069                CALL PLTSU (MOVEON,XORI,YORI,NXPLOT,NYPLOT,XLABLD,YLABLD,NXLABL,  12401873
000070               1NYLABL,NXFRAC,NYFRAC,NXLINE,NYLINE,MAXX,NXSCAL,NYSCAL )           12401874
000071                NUMBCI    = 72
000072                NXBEGN    = 210                                                  12401876
000073                NYBEGN    = 1050                                                 12401877
000074                ISIZE     = 2                                                    12401878
000075                IVERT     = 0                                                    12401879
000076                CALL PLTBC (TITLE,NUMBCI,NXBEGN,NYBEGN,ISIZE,IVERT )             12401880
000077                NUMBCI    = 6
000078                NXBEGN    = LENGTH/2  + 200                                      12401882
000079                NYBEGN    = 20                                                   12401883
000080                ISIZE     = 2                                                    12401884
000081                IVERT     = 0                                                    12401885
000082                CALL PLTBC (XL,   NUMBCI,NXBEGN,NYBEGN,ISIZE,IVERT )             12401886
000083                NUMBCI    = 6
000084                NXBEGN    = 100                                                  12401888
000085                NYBEGN    = 400                                                  12401889
000086                ISIZE     = 2                                                    12401890
000087                IVERT     = 1
000088                CALL PLTBC (YL,   NUMBCI,NXBEGN,NYBEGN,ISIZE,IVERT )             12401892
000089                GO TO 100                                                        12401893
000090                ENTRY CURVE (XI,YI,NPTI,L )                                      12401894
000091                IPLOT     = 0                                                    12401895
000092                NUMPT     = NPTI                                                 12401896
000093                INCX      = 4
000094                INCY      = 4
000095          C     ICODE     = 64
000096                ICODE     = 0
000097                INCSYM    = 5                                                    12401900
000098                CALL PLTPT (IPLOT,NUMPT,INCX,INCY,ICODE,INCSYM,XI,YI)            12401901
000099                GO TO 100                                                        12401902
000100                ENTRY ENDPLT                                                     12401903
000101                CALL PLTFIN                                                      12401904
000102           100  RETURN                                                         12401905
000103                END                                                            12401906
```

```
@ EL? LINT,1,720212, 62558

000001                SUBROUTINE LINT (X,TABLE,Y,DY)
000002          C-----------------------------------------------------------------
000003          C     LINEAR INTERPOLATION WITH INDEPENDENT VARIABLE IN ASCENDING ORDER.
000004          C     THIS SUBROUTINE IS NOT THE ORGINAL LINT/LINTS.
000005          C     THIS IS A SPECIAL SUBROUTINE FOR E12202 AND E12401.
000006          C     THE SUBROUTINE WILL STOP THE PROGRAM IF THE INPUT-X
000007          C     IS NOT WITHIN THE TABLE RANGE.
000008          C-----------------------------------------------------------------
000009                DIMENSION TABLE(2)
000010          C-----------------------------------------------------------------
000011                IF(X .LT. TABLE(1)-.05)          GO TO 15
000012                DO 10   I=3,60,2
000013                IF (X .LE. TABLE(I))   GO TO 20
000014           10   CONTINUE
000015           15   WRITE (6,6000) X
000016           6000 FORMAT ('0X = ', E14.6, ' IS BEYOND THE TABLE RANGE OF THE FOLLOWI
000017               1NG TABLE.' // )
000018                WRITE (6,6005)  (TABLE(I), I=1,60)
000019           6005 FORMAT (1X, 2E14.6)
000020                STOP
000021           20   X1 = TABLE(I-2)
000022                X2 = TABLE(I)
000023                Y1 = TABLE(I-1)
000024                Y2 = TABLE(I+1)
000025                DY = (Y2-Y1)/(X2-X1)
000026                Y  = Y1+DY*(X-X1)
000027           30   RETURN
000028                ENTRY LINTS (TABLE,N)
000029                NN = N+N+1
000030                IF(NN .GT. 58 )          NN = 59
000031                DO 70   I=NN,60
000032           70   TABLE(I) = 0.
000033                GO TO 30
000034          C-----------------------------------------------------------------
000035                END
```

```
@ ELT MAIN,1,720212, 62549

000001          C-------------------------------------------------------------
000002          C     A(500,30)     CONDUCTIVITY MATRIX
000003          C     B(500)        Q-HEAT (FROM NODE I) VECTOR
000004          C     D(500)        HEAT CAPACITANCE (FOR NODE I) VECTOR
000005          C     DD(5)         TEMPORARY STORAGES FOR Q-HEAT FOR 5 NODES
000006          C     E(3,3)        GEOMETRICAL PARAMETERS OF ELEMENT
000007          C     HED(18)       TITLE STORAGE
000008          C     P(5)          TEMPORARY STORAGES FOR HEAT CAPACITANCE FOR 5 NODES.
000009          C     Q(500)        INTERMEDIATE STORAGE OF TEMPERATURE DISTRIBUTION
000010          C     S(5,5)        ITERMEDIATE STORAGE FOR CONDUCTIVITY ELEMENT
000011          C     T(500)        TEMPERATURE DISTRIBUTION VECTOR
000012          C     X(500)        X OR R-ORDINATE
000013          C     Y(500)        Y OR Z-ORDINATE
000014          C     HBC(200)
000015          C     TBC(200)
000016          C     TAB(60,32)    PARAMETER TABLES STORAGES
000017          C     TI(500)       INITIAL TEMPERATURES
000018          C     COND          CONDUCTIVITY
000019          C     RHO           RHO-CP
000020          C     QXX           RATE OF HEAT GENERATED/UNIT VOLUME OF ELEMENT
000021          C     QZZ           = FAC*QXX WHERE FAC = TIME FACTOR
000022          C     TIME          TIME OF TEMPERATURE PROFILE
000023          C     DT            DELTA TIME FOR INTEGRATING TIME
000024          C     DT2           1./DT
000025          C     H             FILM COEFFICIENT
000026          C     TEMP          EXTERNAL TEMPERATURE
000027          C     XL
000028          C     XX
000029          C     YY
000030          C     TMAX          MAXIMUM TIME OR CUT-OFF TIME
000031          C     TINIT         INITIAL TIME
000032          C     NUMBC         NO./COUNDARY CONDITION CARDS
000033          C     NUMMT         NO./DIFFERENT MATERIALS
000034          C     NDT
000035          C     INTER         PRINT INTERVAL
000036          C     MBAND         BAND WIDTH
000037          C     NUM           ELEMENT NUMBER
000038          C     NTAB          NO./INPUT TABLES
000039          C     NDIM          MAXIMUM BAND WIDTH
000040          C     IVARH         FLAG FOR VARIABLE ELEMENT PROPERTIES
000041          C     IVARC         FLAG FOR VARIABLE BOUNDARY CONDITIONS
000042          C     IPT           PLOT FLAG
000043          C     IDT           DELTA TIME TABLE NO.
000044          C     KODE(500,     FLAG FOR NODE POINT
000045          C     IX(3)         ITERMEDIATE STORAGE
000046          C     KX(4)         INPUT NODE NUMBERS OF ELEMENT
000047          C     LM(5)         WORKING STORAGE OF NODAL NOS. OF ELEMENT
000048          C     KAT           = 0,FOR PLANE SOLID
000049          C                   =1 ,FOR AXISYMMETRIC SOLID
000050          C     NUMNP         NO. OF NODAL POINT
000051          C     NUMEL         NO. OF ELEMENTS
000052          C     TEM(10)       TEMPORARY WORKING STORAGES FOR REAL NUMBERS
000053          C     ITEM(10)      TEMPORARY WORKING STORAGES FOR INTEGERS
000054          C     IDTAB(32)     STORAGE FOR STORING TABLE CODES
000055          C     ITFAC(32)     STORAGE FOR STORING TIME FACTOR TABLE
000056          C-------------------------------------------------------------
```

```
000057          C     SUBROUTINE SUBRO
000058          C               READS AND PRINTS CONTROL INFORMATION.
000059          C               READS OR GENERATE NODAL POINT INFORMATION.
000060          C     SUBROUTINE SUBR1
000061          C               FORMS CONDUCTIVITY MATRIX FOR WHOLE BODY.
000062          C     SUBROUTINE SUBR2
000063          C               HANDLES THE BOUNDARY CONDITION INPUT.
000064          C     SUBROUTINE SUBR3
000065          C               SOLVES FOR THE TEMPERATURE DISTRIBUTION FOR A 2-DIMENSION
000066          C               BODY WITH CONSTANT PROPERTIES.
000067          C     SUBROUTINE SUBR4
000068          C               BODY WITH VARIABLE BOUNDARY CONDITIONS.
000069          C     SUBROUTINE SUBR5
000070          C               BODY WITH VARIABLE ELEMENT PROPERTIES - THIS INCLUDES
000071          C               THE BOUNDARY CONDITIONS.
000072          C     SUBROUTINE SUBR6
000073          C               HANDLES THE VARIABLE ELEMENT PROPERTIES AND BOUNDARY
000074          C               CONDITIONS FOR SUBROUTINE SUBR5.
000075          C     SUBROUTINE SUBR7
000076          C               HANDLES VARIATIONS IN BOUNDARY CONDITIONS.
000077          C     SUBROUTINE SUBR8
000078          C               HANDLES STEADY-STATE CASE.
000079          C     SUBROUTINE RETAB
000080          C               READS AND INITIALIZES THE INPUT TABLES.
000081          C     SUBROUTINE CONMAT
000082          C               HANDLES THE ACTUAL CONSTRUCTION OF ELEMENT CONDUCTIVITY
000083          C               MATRIX AND ADDS IT TO THE COMPLETE CONDUCTIVITY MATRIX.
000084          C     SUBROUTINE CONVBC
000085          C               HANDLES THE BOUNDARY CONDITION COMPUTATIONS.
000086          C     SUBROUTINE SYMSO
000087          C               SOLVES THE BAND MATRIX EQUATION -  A*B = Q
000088          C-----------------------------------------------------------------------
000089                DIMENSION TC(500)
000090                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000091                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000092                COMMON QZZS(500), TAB(60,32)
000093                COMMON XCOND(20), DENS(20), QX(20)
000094                COMMON TEM(10)
000095                COMMON COND,RHO,QXX,QZZ
000096                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000097                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000098                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000099                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000100                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000101                COMMON IKODE(500)
000102                COMMON INTAB(20,3)
000103                COMMON /IJK/ IPTC
000104                COMMON /BC/ IBC(200), JBC(200), IHBC(200), ITBC(200), HBBC(200),
000105               1 TEMEBC(200), XLBC(200), IIBC(200), JJBC(200)
000106                COMMON /RADCON/EPS(200), F(20,20),  SIGMA, NRF(200), IFLAGR
000107               1 , FN(200), BQ(20), KTEM(20), TS(200)
000108                COMMON /SAVE1/ ISAVE(500,5)
000109                COMMON /TAPE/  ITAPE, ISTART, ISS
000110                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000111               C               (TEM(4),XTEM4)
000112                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000113               C               (ITEM(4),MTYPE)
000114                EQUIVALENCE (TI(1),TC(1))
000115          C-----------------------------------------------------------------------
000116                IPTC = 0
```

```
000117            NDIM = 41
000118            SIGMA  = .33E-14
000119       50   CONTINUE
000120             IVARH = 0
000121             IVARC = 0
000122            REWIND 1
000123            DO 52  I=1,32
000124            ITFAC(I) = 0
000125       52   IDTAB(I) = 0
000126            DO 60   I=1,10
000127            DO 60   J=1,3
000128       60   INTAB(I,J)   = 0
000129            ISS  = 0
000130            CALL SUBR0
000131            IF(ISTART .EQ. 1)      GO TO 180
000132       100  CALL SUBR1
000133           C-------------------------------------------------------------------
000134           C     IF IVARC IS NON-ZERO, CONDUCTIVITY IS VARIABLE WITH TEMPERATURE.
000135           C     OTHERWISE, ONLY THE H ON THE BOUNDARY ARE VARIABLE WITH TEMPERATURE
000136           C-------------------------------------------------------------------
000137            CALL SUBR2
000138       180  CONTINUE
000139           C-------------------------------------------------------------------
000140           C     IPT  = 0,    NO PLOTS.
000141           C     IPT .GT. 0   GEOMETRY PLOTS.
000142           C     IPT .LT. 0   GEOMETRY PLOTS ONLY. PROGRAM WILL CYCLE TO NEXT CASE
000143           C                  IF ANY.
000144           C-------------------------------------------------------------------
000145            IF(IPT .NE. 0)          CALL PDATA
000146            IF(IPT .LT. 0)          GO TO 420
000147           C-------------------------------------------------------------------
000148           C     TEST FOR STEADY-STATE CASE.
000149           C-------------------------------------------------------------------
000150            IF(ISS .EQ. 1)          GO TO 430
000151            IF(NTAB+IFLAGR)         400,200,400
000152       200  CALL SUBR3
000153            GO TO 420
000154       400  CONTINUE
000155            IF(IVARC .NE. 0)        GO TO 410
000156            CALL SUBR4
000157            GO TO 420
000158       410  CONTINUE
000159            CALL SUBR5
000160       420  WRITE (6,6000)  HED
000161            GO TO 50
000162       430  CONTINUE
000163           C-------------------------------------------------------------------
000164           C     STEADY-STATE PROBLEM.
000165           C-------------------------------------------------------------------
000166            CALL SUBR8
000167            GO TO 420
000168           C-------------------------------------------------------------------
000169       6000 FORMAT ('1',14X,'END OF PROBLEM--',12A6 )
000170            END
```

```
@ ELT NTAB$,1,720212, 62592

000001          NTAB$  10
000002          DRUM 1,40000
000003          TAPE 2,'R'      . RECALL TAPE
000004          TAPE 3,'S'      . RESTART TAPE
000005          DRUM 4,20000
000006          READ 5
000007          PRINT 6
000008          PUNCH 7
000009          DRUM 8,20000
000010          TAPE 9,'H'      . ANSC PLOT TAPE
000011          END
```

```
000001                SUBROUTINE PDATA
000002          C-----------------------------------------------------------------------
000003          C     PLOT THE GEOMETRICAL CONFIGURATION.
000004          C-----------------------------------------------------------------------
000005                COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000006               COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000007               COMMON QZZS(500), TAB(60,32)
000008               COMMON XCOND(20), DENS(20), QX(20)
000009               COMMON TEM(10)
000010               COMMON COND,RHO,QXX,QZZ
000011               COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000012               COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000013               COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000014               COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000015               COMMON ITEM(10), IDTAB(32), ITFAC(32)
000016               COMMON IKODE(500)
000017               COMMON INTAB(20,3)
000018               COMMON /SAVE1/ ISAVE(500,5)
000019               DIMENSION AXES(2), RR(5), ZZ(5)
000020               DATA AXES(1)/'X-AXIS'/ AXES(2)/'Y-AXIS'/
000021          C-----------------------------------------------------------------------
000022          C     GET MIN AND MAX OF X AND Y.
000023          C-----------------------------------------------------------------------
000024               I = 1
000025               J = 0
000026               ISCALE = 0
000027               LENGTH = 180
000028               II = IABS(IPT)
000029               IF(II .LT. 10)          GO TO 4
000030               RMIN = TAB(1,II)
000031               ZMIN = TAB(2,II)
000032               RMAX = TAB(3,II)
000033               ZMAX = TAB(4,II)
000034               LENGTH = TAB(5,II)*100 + 300
000035               IF(LENGTH .LT. 1800)   LENGTH = 1800
000036               IF(LENGTH .GT. 4000)   LENGTH = 4000
000037               J = -1
000038               GO TO 12
000039          4    CONTINUE
000040               RMIN = X(1)
000041               RMAX = RMIN
000042               ZMIN = Y(1)
000043               ZMAX = ZMIN
000044               DO 10  I=1,NUMNP
000045               IF(X(I) .LT. RMIN)      RMIN = X(I)
000046               IF(RMAX .LT. X(I))      RMAX = X(I)
000047               IF(Y(I) .LT. ZMIN)      ZMIN = Y(I)
000048               IF(ZMAX .LT. Y(I))      ZMAX = Y(I)
000049           10  CONTINUE
000050          C-----------------------------------------------------------------------
000051          C     X-AXIS,R-AXIS (HORIZONTAL).
000052          C     Y-AXIS,Z-AXIS (VERTICAL)
000053          C-----------------------------------------------------------------------
000054           12  ITRA = 1
000055               IF(ABS(ZMAX-ZMIN) .GT. ABS(RMAX-RMIN))      ITRA = 2
000056               GO TO (13,14), ITRA
```

```
000057          13   CALL FRAME (RMIN,RMAX,ZMIN,ZMAX,AXES(1),AXES(2),HED,I,J,
000058             1 LENGTH,ISCALE)
000059               GO TO 15
000060          14   CALL FRAME (ZMIN,ZMAX,RMIN,RMAX,AXES(2),AXES(1),HED,I,J,
000061             1 LENGTH,ISCALE)
000062          15   CONTINUE
000063               DO 24   N=1,NUMEL
000064         C-------------------------------------------------------------------
000065         C     PLOT LOOP FOR CURVES (ELEMENTS).
000066         C-------------------------------------------------------------------
000067               DO 16  M=1,4
000068          16   LM(M) = ISAVE(N,M)
000069               DO 18   M=1,5
000070               I  = LM(M)
000071               IF(M.EQ. 5)  I=LM(1)
000072               ZZ(M)  = Y(I)
000073               RR(M)  = X(I)
000074          18   CONTINUE
000075               GO TO (21,22), ITRA
000076          21   CALL CURVE (RR,ZZ,5,-1)
000077               GO TO 24
000078          22   CALL CURVE (ZZ,RR,5,-1)
000079          24   CONTINUE
000080               RETURN
000081               END
```

```
D ELT PLTSU,1,720212, 62560

000001                SUBROUTINE PLTSU (MOVEON,XORIG,  YORIG,  NXPLOT,NYPLOT,XLABLD,
000002               1 YLABLD,NXLAB,NYLAB,NXFRAC,NYFRAC,NXLINE,NYLINE,
000003               2 MAXX,NXSCAL,NYSCAL)
000004                DATA IPLOTF, NPLOTS /0,0/
000005                DIMENSION IBUF(1000)
000006              C-------------------------------------------------------------------
000007                IF(IPLOTF .EQ. 1)       GO TO 10
000008                REWIND 9
000009                CALL PLOTS (IBUF,1000,9)
000010              C-------------------------------------------------------------------
000011              C     CONVERT OFF-SET ORIGIN TO INCHES.
000012              C-------------------------------------------------------------------
000013                IPLOTF = 1
000014                NPLOTS = 0
000015                XCONST = 0.
000016                GO TO 15
000017              C10   XLEN = MAXLEN
000018              C     CALL PLOT (XLEN,0.,998)
000019               10   CONTINUE
000020                IF(MOVEON .EQ. 1)       GO TO 15
000021                XCONST = XCONST + FLOAT(MAXLEN)
000022               15   NPLOTS = NPLOTS+1
000023                SCALEX = 1.
000024                SCALEY = 1.
000025                IF(NXSCAL .NE. 0)       SCALEX = 10.**NXSCAL
000026                IF(NYSCAL .NE. 0)       SCALEY = 10.**NYSCAL
000027                XORIGN = XORIG*SCALEX
000028                YORIGN = YORIG*SCALEY
000029                XORI = FLOAT(NXPLOT)/100.
000030                YORI = FLOAT(NYPLOT)/100.
000031                DXL  = FLOAT(NXLAB )/100.
000032                DYL  = FLOAT(NYLAB )/100.
000033                DELTAX = XLABLD/DXL*SCALEX
000034                DELTAY = YLABLD/DYL*SCALEY
000035                MAXLEN = IABS(MAXX)/100 + 2
000036              C-------------------------------------------------------------------
000037              C     SET-UP NEW LOGICAL ORIGIN.
000038              C-------------------------------------------------------------------
000039                XORIG = XORI+XCONST
000040                CALL PLOT (XORIG,YORI,-3)
000041                LEN  = (IABS(MAXX)-NXPLOT+99)
000042              C-------------------------------------------------------------------
000043              C     CONVERT LENGTH OF X-AXIS TO INCHES.
000044              C-------------------------------------------------------------------
000045                ITICK  = LEN/NXLAB + 1
000046                XLEN = FLOAT(ITICK-1)*DXL
000047                XL   = XLEN + DXL
000048                XV = FLOAT(ITICK)  *XLABLD + XORIGN
000049                HEIGHT = 0.0007*FLOAT(NXLAB)
000050              C-------------------------------------------------------------------
000051              C     DRAW X-AXIS
000052              C-------------------------------------------------------------------
000053                CALL PLOT (0.,0.,3)
000054                CALL PLOT (XLEN,0.,2)
000055              C-------------------------------------------------------------------
000056              C     DRAW TICK MARKS AND LABELS.
```

```
000057      C-------------------------------------------------------------------
000058      C-------------------------------------------------------------------
000059            WRITE (6,6000) NPLOTS, XORI, YORI, XLEN, DXL, XORIGN,  YORIGN,
000060           1   ITICK
000061      C-------------------------------------------------------------------
000062            DO 100  I=1,ITICK
000063            XL = XL - DXL
000064            CALL PLOT (XL,0.,3)
000065            CALL PLOT(XL,-0.14,2)
000066            XV = XV-XLABLD
000067            CALL NUMBER (XL,-.25,HEIGHT,XV,0.,NXFRAC)
000068       100  CONTINUE
000069      C-------------------------------------------------------------------
000070      C     DRAW Y-AXIS.
000071      C-------------------------------------------------------------------
000072            YLEN = 1000.
000073            IF(MAXX .LT. 0)         YLEN = 2850.
000074            YLEN = YLEN - YORI
000075            ITICK = IFIX(YLEN)/NYLAB + 1
000076            YLEN = FLOAT(ITICK-1)*DYL
000077            YL = YLEN+DYL
000078            YV = FLOAT(ITICK)  *YLABLD + YORIGN
000079            HEIGHT = 0.0007*FLOAT(NYLAB)
000080            CALL PLOT (0.,0.,3)
000081            CALL PLOT (0.,YLEN,2)
000082            DO 110  I=1,ITICK
000083            YL = YL - DYL
000084            CALL PLOT (0.,YL,3)
000085            CALL PLOT (-.14,YL,2)
000086            YV = YV-YLABLD
000087            CALL NUMBER (-0.25,YL,HEIGHT,YV,90.,NYFRAC)
000088       110  CONTINUE
000089            RETURN
000090      C-------------------------------------------------------------------
000091            ENTRY PLTBC (BCI,NUMBCI,NXBEGN,NYBEGN,ISIZE,IVERT)
000092      C-------------------------------------------------------------------
000093      C     CONVERT TO INCHES.
000094      C-------------------------------------------------------------------
000095            XPAGE  = FLOAT(NXBEGN)/100.-XORI
000096            YPAGE  = FLOAT(NYBEGN)/100.-YORI
000097            NCHAR  = NUMBCI
000098            ANGLE  = 0.
000099            IF(IVERT .EQ. 1)        ANGLE = 90.
000100            HEIGHT = FLOAT(ISIZE)*0.10
000101            CALL SYMBOL (XPAGE,YPAGE,HEIGHT,BCI,ANGLE,NCHAR)
000102            RETURN
000103      C-------------------------------------------------------------------
000104            ENTRY PLTPT (IPLOT,NUMPT,INCX,INCY,ICODE,INCSYM,X,Y)
000105      C-------------------------------------------------------------------
000106            DIMENSION XARRAY(102),YARRAY(102),X(1), Y(1)
000107      C-------------------------------------------------------------------
000108            INTEQ  = ICODE
000109            LINTYP = INCSYM
000110            IF(IPLOT .EQ. 1)        LINTYP = - LINTYP
000111            ICOUNT = NUMPT
000112            IX = INCX/4
000113            IY = INCY/4
000114            II = 1
000115            JJ = 1
000116            XARRAY(1)  = X(1)*SCALEX
```

```
000117            YARRAY(1)  = Y(1)*SCALEY
000118       200  NPTS = 100
000119            IF(ICOUNT .LT.'100)    NPTS = ICOUNT
000120            ICOUNT = ICOUNT-100
000121            DO 210  I=2,NPTS
000122            II = II+IX
000123            JJ = JJ+IY
000124            XARRAY(I)  = X(II)*SCALEX
000125            YARRAY(I)  = Y(II)*SCALEY
000126       210  CONTINUE
000127            XARRAY(NPTS+1) = XORIGN
000128            XARRAY(NPTS+2) = DELTAX
000129            YARRAY(NPTS+1) = YORIGN
000130            YARRAY(NPTS+2) = DELTAY
000131             CALL LINE (XARRAY,YARRAY,NPTS,1,  LINTYP,INTEQ)
000132            XARRAY(1)  = XARRAY(100)
000133            YARRAY(1)  = YARRAY(100)
000134            IF(ICOUNT .GT. 0)      GO TO 200
000135            RETURN
000136       C----------------------------------------------------------------------
000137            ENTRY PLTNU (XLOC,NUMDEC,NXLOC,NYLOC,ISIZE,IVERT)
000138       C----------------------------------------------------------------------
000139            XORR = FLOAT (NXLOC)/100. - XORI
000140            YORR = FLOAT (NYLOC)/100. - YORI
000141            HEIGHT = FLOAT (ISIZE)*.12
000142            ANGLE  = 0.
000143            IF(IVERT .GT. 0)       ANGLE = 90.
000144            CALL NUMBER (XORR,YORR,HEIGHT,XLOC,ANGLE,NUMDEC)
000145            RETURN
000146       C----------------------------------------------------------------------
000147            ENTRY PLTFIN
000148       C----------------------------------------------------------------------
000149            XLEN = MAXLEN
000150            CALL PLOT (XLEN,0.,999)
000151            REWIND 9
000152            WRITE (6,9000)
000153       C    WRITE (10,9000)
000154            RETURN
000155        6000 FORMAT ('1 ENTRY PLTSU, PLOT NO.',I3/ '  X-ORIG DIST = ', F10.6/
000156           1 '  Y-ORIG DIST = ', F10.6 / '  PLOT SIZE = ', F10.4, ' INCHES'/
000157           2 '  TICK MARK INCR. = ', F10.6,' INCHES'/ '  1ST TICK MARK AT : '/
000158           3  '  X = ', F10.6, '   Y = ', F10.6 /
000159           4 '  NO. OF TICK MARKS ON X-AXIS = ', I6 )
000160        9000 FORMAT ('0FILE CLOSED ON TAPE H,DISMOUNT AND SEND TO ANSC,SACRAMEN
000161           1TO. THANK YOU.' )
000162            END
```

```
@ ELT RTAB,1,720212, 62564

000001              SUBROUTINE RTAB
000002              DIMENSION TC(500)
000003               COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004              COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005              COMMON QZZS(500), TAB(60,32)
000006              COMMON XCOND(20), DENS(20), QX(20)
000007              COMMON TEM(10)
000008              COMMON COND,RHO,QXX,QZZ
000009              COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010              COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011              COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012              COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013              COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014              COMMON IKODE(500)
000015              COMMON INTAB(20,3)
000016                 EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000017            C                (TEM(4),XTEM4)
000018                 EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000019            C                (ITEM(4),MTYPE)
000020               EQUIVALENCE (TI(1),TC(1))
000021           C-------------------------------------------------------------------
000022           C     READ AND WRITE INPUT TABLES FOR VARIABLE PROPERTIES,B.C.,AND TIME
000023           C     FUNCTION.
000024           C-------------------------------------------------------------------
000025           C   TABLE CODE NO. CODE
000026           C     1             H (CONVECTION COEFFICIENT)
000027           C     2             TEMP. OF EXTERNAL BOUNDARY.
000028           C     5             K (CONDUCTIVITY)
000029           C     6             RHO-CP
000030           C     7             Q(X)
000031           C     8             Q(Y)
000032           C     9             HEAT FLUX INTO NODE
000033           C    10             TEMPERATURE OF NODE
000034           C     -N            TABLE N HAS A TIME FUNCTION WHOSE LOCATION IS
000035           C                   IN ITFAC(N)
000036           C-------------------------------------------------------------------
000037               IVARH = 1
000038               DO 5 I=1,32
000039            5  ITFAC(I) = 0
000040               LINE   = 60
000041           10  IF(LINE+20.LE.60)      GO TO 20
000042               WRITE (6,9000)
000043               WRITE (6,6000)
000044               LINE = 1
000045           20  READ (5,5000)  ID,IC, TEM
000046               IF(ID .LE. 0)    GO TO 70
000047               IF(ID .GT. 32)     GO TO 90
000048               IF(IC .GT. 4)          IVARC =1
000049               IDTAB(ID)  = IC
000050               WRITE (6,6010) ID,IC,TEM
000051               IF(IC.GE.0)            GO TO 30
000052               IC   = -IC
000053               ITFAC(IC)  = ID
000054           30  N  = 0
000055               K  = 1
000056           40  READ (5,5010) IEND,XTEM,YTEM
```

```
000057            IF(IEND)     60,50,50
000058       50   WRITE (6,6020) XTEM,YTEM
000059            LINE   = LINE+1
000060            N  = N+1
000061            IF(N .GT. 30)  GO TO 80
000062            TAB(K,ID)  = XTEM
000063            TAB(K+1,ID)  = YTEM
000064            K  = K+2
000065            GO TO 40
000066       60   IF(IC .EQ. 0)    GO TO 65
000067       62   CALL LINTS (TAB(1,ID),N )
000068            GO TO 10
000069       65   TAB(K,ID) = TMAX+1.
000070            TAB(K+1,ID)  = TAB(K-1,ID)
000071            N  = N+1
000072            GO TO 62
000073       70   RETURN
000074       80   WRITE (6,6030) ID
000075            GO TO 40
000076       90   WRITE (6,6040) ID
000077       95   READ (5,5010) IEND,XTEM,YTEM
000078            IF(IEND .LT. 0)  GO TO 10
000079            WRITE (6,6020) XTEM,YTEM
000080            GO TO 95
000081          C-------------------------------------------------------------
000082          C     FORMAT STATEMENTS
000083          C-------------------------------------------------------------
000084           5000 FORMAT (2I5,5X,10A6 )
000085           5010 FORMAT (I5,5X,2E10.4)
000086           6000 FORMAT ('0',53X,'INPUT TABLES')
000087           6010 FORMAT ('0TABLE NO.',I5,3X,'TYPE',I5,5X,10A6/8X,'X',14X,'F(X)'/ )
000088           6020 FORMAT (1X,2E16.6)
000089           6030 FORMAT ('/TABLE',I4,' HAS EXCEEDED 30 POINTS OR THERE NO -1 CARD T
000090               CO END THE TABLE'       )
000091           6040 FORMAT ('0TABLE NO.',I5,'EXCEEDS 32. PROGRAM WILL SKIP TABLE.' )
000092           9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000093              1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000094              2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000095            END
```

```
@ ELT SIMEQ,1,720212, 62567

000001            SUBROUTINE SIMEQ(A,B,NN,MM,NA ,ITEM,DD,NND,KERR)                61210002
000002          C-------------------------------------------------------------------
000003          C     SOLVES MATRIX EQUATIONS - AX = B                            61210004
000004          C     GAUSS ELIMINATION WITH COMPLETE PIVOTING ON ABSOLUTE LARGEST 61210005
000005          C     ELEMENT TO FORM TRIANGULAR MATRIX,WITH BACK SUBSTITUTION FOR 61210006
000006          C     SOLUTION VECTORS.                                           61210007
000007          C-------------------------------------------------------------------
000008          C                                                                 61210009
000009          C     CALL SIMEQ (A,B,NN,MM,NA ,ITEM,DD,NND,KERR )                61210010
000010          C     A         =    A(1,1) OF INPUT MATRIX                       61210011
000011          C     B         =    INPUT VECTORS                                61210012
000012          C     NN        = NUMBER OF SIMULTANEOUS EQUATIONS.               61210013
000013          C     MM        = NUMBER OF B-VECTORS.                            61210014
000014          C     NA        = DIMENSION OF MATRIX A,THAT IS, A(NA,--)         61210015
000015          C     ITEM      = TEMPORARY STORAGE (FOR PERMUTATION VECTOR)      61210016
000016          C                 WITH DIMENSION - ITEM(NA)                       61210017
000017          C     DD        = DETERMINANT                                     61210018
000018          C     NND       = POWER OF TEN TO MULTIPLY DETERMINANT            61210019
000019          C     ND        = POWERS OF TENS FACTOR FOR DETERMINANT.          61210025
000020          C     KERR      = ERROR CODE,  =K, SINGULAR RANK , =-1 SOLVED EQUATIONS 61210020
000021          C-------------------------------------------------------------------
000022                DIMENSION        A(NA,NA),B(NA,1 )                          61210021
000023                DIMENSION ITEM(2)                                           61210022
000024                EQUIVALENCE (ID,D)
000025          C-------------------------------------------------------------------
000026                D         = 1.0                                             61210024
000027                ND        = 0                                               61210026
000028                N=NN                                                        61210027
000029                M=MM                                                        61210028
000030          C-------------------------------------------------------------------
000031          C     TEST FOR TRIVIAL CASE N=1.
000032          C-------------------------------------------------------------------
000033                IF(N .EQ. 1)            GO TO 110
000034          C-------------------------------------------------------------------
000035          C     SET-UP THE PERMUTATION VECTOR.                              61210030
000036          C-------------------------------------------------------------------
000037                DO 1      I=1,N                                             61210031
000038           1    ITEM(I)   = I                                               61210032
000039                N1        = N-1                                             61210033
000040                DO 60     K=1,N                                             61210034
000041          C-------------------------------------------------------------------
000042          C     SEARCH AND SET THE ABSOLUTE LARGEST ELEMENT AS THE PIVOT.   61210036
000043          C-------------------------------------------------------------------
000044                PIVOT     = 0.                                              61210038
000045                DO 10     I=K,N                                             61210039
000046                DO 9      J=K,N                                             61210040
000047                XTEM      = A(I,J)                                          61210041
000048                IF( ABS(XTEM) .LE.  ABS(PIVOT))  GO TO 9                    61210042
000049                PIVOT     = XTEM                                            61210043
000050                IS        = I                                               61210044
000051                IT        = J                                               61210045
000052           9    CONTINUE                                                    61210046
000053           10   CONTINUE                                                    61210047
000054          C-------------------------------------------------------------------
000055          C     COMPUTE DETERMINANT AND TEST FOR SINGULAR MATRIX.           61210048
000056          C-------------------------------------------------------------------
```

```
000057              D         = D*PIVOT                                          61210051
000058              IF(ID .NE. 0)            GO TO 11                            61210052
000059            C-------------------------------------------------------------
000060            C     IF MATRIX IS SINGULAR,SET THE RANK OF MATRIX A IN KERR    AND EXIT61210053
000061            C-------------------------------------------------------------
000062              KERR      =    K-1                                           61210054
000063              GO TO 100                                                     61210055
000064         11   XTEM      =     ABS(D)                                      61210056
000065              IF(XTEM.LE.1.0 )         GO TO 13                            61210057
000066              D         = D/10.                                           61210058
000067              ND        = ND+1                                            61210059
000068              GO TO 11                                                    61210060
000069         13   IF(XTEM.GE.0.1)          GO TO 14                           61210061
000070              D         = D*10.0                                          61210062
000071              ND        = ND-1                                            61210063
000072              GO TO 11                                                    61210064
000073         14   CONTINUE                                                    61210065
000074              IF(K.EQ.IS)              GO TO 30                           61210066
000075            C-------------------------------------------------------------
000076            C     IF THE PIVOT IS NOT IN THE RIGHT ROW,INTERCHANGE ROWS.    61210068
000077            C-------------------------------------------------------------
000078              DO 20     J=1,N                                             61210070
000079              XTEM      = A(IS,J)                                         61210071
000080              A(IS,J)   = A(K,J)                                          61210072
000081              A(K ,J)   = XTEM                                            61210073
000082         20   CONTINUE                                                    61210074
000083              DO 21     J=1,M                                             61210075
000084              XTEM      = B(IS,J)                                         61210076
000085              B(IS,J)   = B(K ,J)                                         61210077
000086              B(K ,J)   = XTEM                                            61210078
000087         21   CONTINUE                                                    61210079
000088              D         = -D                                              61210080
000089         30   IF(K.EQ.IT)              GO TO 40                           61210081
000090            C-------------------------------------------------------------
000091            C     IF THE PIVOT IS NOT IN THE RIGHT COL.,EXCHANGE COLS AND RECORD 61210083
000092            C     THIS IN THE PERMUTATION VECTOR.                           61210084
000093            C-------------------------------------------------------------
000094              DO 31     I=1,N                                             61210086
000095              XTEM      = A(I,IT)                                         61210087
000096              A(I,IT)   = A(I,K )                                         61210088
000097              A(I,K )   = XTEM                                            61210089
000098         31   CONTINUE                                                    61210090
000099              D         = -D                                              61210091
000100            C                                                             61210092
000101            C     SET PERMUTATION VECTOR                                  61210093
000102            C                                                             61210094
000103              I         = ITEM(IT)                                        61210095
000104              ITEM(IT)  = ITEM(K )                                        61210096
000105              ITEM(K )  = I                                               61210097
000106            C-------------------------------------------------------------
000107         40   CONTINUE                                                    61210099
000108              K1        = K+1                                             61210100
000109              IF(K1.GT.N)              GO TO 60                           61210101
000110            C-------------------------------------------------------------
000111            C     MULTIPLY THE K-TH ROW BY -A(I,K)/PIVOT AND ADD TO THE I-TH ROW 61210103
000112            C-------------------------------------------------------------
000113              DO 50     I=K1,N                                            61210104
000114              DO 50     J=K1,N                                            61210105
000115              A(I,J)    = A(I,J) - A(K,J)/PIVOT * A(I,K)                  61210106
000116         50   CONTINUE                                                    61210107
```

```
000117            DO 51    I=K1,N                                          61210108
000118            DO 51    J=1,M                                           61210109
000119            B(I,J)   = B(I,J) - A(I,K)/PIVOT*B(K,J)                  61210110
000120       51   CONTINUE                                                 61210111
000121       60   CONTINUE                                                 61210112
000122      C-------------------------------------------------------------
000123      C     BACKSUBSTITUTION FOLLOWS.                                61210114
000124      C-------------------------------------------------------------
000125            DO 70    J=1,M                                           61210116
000126            B(N,J)   = B(N,J)/A(N,N)                                 61210117
000127       70   CONTINUE                                                 61210118
000128            I        = N                                             61210119
000129            DO 73    K=2,N                                           61210120
000130            I1       = I                                             61210121
000131            I        = I-1                                           61210122
000132            PIVOT    = A(I,I)                                        61210123
000133            DO 72    IT=1,M                                          61210124
000134            XTEM     = 0.D0                                          61210125
000135            DO 71    J=I1,N                                          61210126
000136       71   XTEM     = A(I,J)*B(J,IT) + XTEM                         61210127
000137       72   B(I,IT)  = (B(I,IT) - XTEM)/PIVOT                        61210128
000138       73   CONTINUE                                                 61210129
000139      C-------------------------------------------------------------
000140      C     USE PERMUTATION VECTOR TO EXCHANGE ROWS OF B-MATRIX.     61210131
000141      C-------------------------------------------------------------
000142            DO 81    I=1,N                                           61210133
000143       79   IF(ITEM(I).EQ.I)        GO TO 81                        61210134
000144            K        = ITEM(I)                                       61210135
000145            DO 80    J=1,M                                           61210136
000146            XTEM     = B(K,J)                                        61210137
000147            B(K,J)   = B(I,J)                                        61210138
000148            B(I,J)   = XTEM                                          61210139
000149       80   CONTINUE                                                 61210140
000150            ITEM(I)  = ITEM(K)                                       61210141
000151            ITEM(K)  = K                                             61210142
000152            GO TO 79                                                 61210143
000153       81   CONTINUE                                                 61210144
000154       82   KERR=-1                                                  61210145
000155            DD       =    D                                          61210146
000156            NND      =    ND                                         61210147
000157       100  RETURN                                                   61210148
000158       110  DO 115 J=1,M
000159       115  B(1,J) = B(1,J)/A(1,1)
000160            D  = A(1,1)
000161            GO TO 82
000162            END                                                      61210149
```

```
@ EL  SUBR0,1,720405, 56715

000001                SUBROUTINE SUBR0
000002          C
000003                DIMENSION TC(500)
000004                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000005                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000006                COMMON QZZS(500), TAB(60,32)
000007                COMMON XCOND(20), DENS(20), QX(20)
000008                COMMON TEM(10)
000009                COMMON COND,RHO,QXX,QZZ
000010                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000011                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000012                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000013                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000014                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000015                COMMON IKODE(500)
000016                COMMON INTAB(20,3)
000017                COMMON JNODE(500)
000018                COMMON /IJK/ IPTC
000019                COMMON /BC/ IBC(200), JBC(200), IHBC(200), ITBC(200), HBBC(200),
000020               1 TEMEBC(200), XLBC(200), IIBC(200), JJBC(200)
000021                COMMON /RADCON/EPS(200), F(20,20),  SIGMA, NRF(200), IFLAGR
000022               1 , FN(200), BQ(20), KTEM(20), TS(200)
000023                COMMON /SAVE1/ ISAVE(500,5)
000024                COMMON /TAPE/  ITAPE, ISTART, ISS
000025                LOGICAL DAMP, DF1, DF2, DF3, TOL4
000026                COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000027                COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000028                EQUIVALENCE (IDMP1,DMP1), (IDMP2,DMP2), (IDMP3,DMP3),
000029               1   (IMAX1,DMAX1), (IMAX2,DMAX2), (IMAX3,DMAX3), (ITOL,TOLN)
000030                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000031               C                (TEM(4),XTEM4)
000032                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000033               C                (ITEM(4),MTYPE)
000034                EQUIVALENCE (TI(1),TC(1)), (DT,INTDT)
000035          C*****************************************************************
000036          C     READ AND PRINT OF CONTROL INFORMATION
000037          C*****************************************************************
000038                IDMP1 = 0                                                    *NEW
000039                IDMP2 = 0                                                    *NEW
000040                IDMP3 = 0                                                    *NEW
000041                IDMAX1 = 0                                                   *NEW
000042                IDMAX2 = 0                                                   *NEW
000043                IDMAX3 = 0                                                   *NEW
000044                ITOL = 0                                                     *NEW
000045           50   READ (5,1000,ERR=7010,END=7000)
000046               1 HED,ISTART,JTAPE,NUMNP,NUMEL,NUMBC,KAT,IPT,NTAB,TINIT,IDT,DT,
000047               2 INTER, TMAX, IPUNCH, DF1, DF2, DF3, TOL4, IDUM
000048                ITAPE  = JTAPE
000049                IF(INTDT .GT. 0)        DT2 = 1./DT
000050                TIME = TINIT
000051                IF(ISTART .EQ. 1)       GO TO 7050
000052                IF(IPT .NE. 0)          IPTC = 1
000053                WRITE (6,9000)
000054                IF(IDT .EQ. 0  .AND.  INTDT .EQ. 0)         ISS=1
000055                NUMMT  = 0
000056                DAMP = DF1 .OR. DF2 .OR. DF3
```

```
000057          IF(DAMP .OR. TOL4)      READ (5,5010) DMP1, DMAX1, DMP2, DMAX2,
000058         1              DMP3, DMAX3, TOLN
000059        C-------------------------------------------------------------------
000060        C     SET DEFAULT VALUES.
000061        C-------------------------------------------------------------------
000062          IF(IDMP1 .EQ. 0)        DMP1 = 0.5
000063          IF(IDMP2 .EQ. 0)        DMP2 = 0.5
000064          IF(IDMP3 .EQ. 0)        DMP3 = 0.5
000065          IF(IMAX1 .EQ. 0)        DMAX1 = 10.
000066          IF(IMAX2 .EQ. 0)        DMAX2 = 10.
000067          IF(IMAX3 .EQ. 0)        DMAX3 = 200.
000068          IF(ITOL .EQ. 0)         TOLN=0.00005
000069        C-------------------------------------------------------------------
000070           51   READ (5,1003,ERR=7010,END=7000)
000071         1                        M,ITABK,XTEM1,ITABR,XTEM2,ITABQ,XTEM3
000072          IF(M.LE.0)   GO TO 52
000073          IF(M .GT. 20)           WRITE (6,6020)
000074          NUMMT  = NUMMT+1
000075          XCOND(M) = XTEM1
000076          DENS(M)  = XTEM2
000077          QX(M)    = XTEM3
000078          IF(ITABK .GT. 32)       ITABK = 0
000079          IF(ITABR .GT. 32)       ITABR = 0
000080          IF(ITABQ .GT. 32)       ITABQ = 0
000081             INTAB(M,1)  = ITABK
000082             INTAB(M,2)  = ITABR
000083             INTAB(M,3)  = ITABQ
000084            GO TO 51
000085           52   IF(NUMNP) 900,900,53
000086           53   IF(KAT) 54,56,54
000087             54 WRITE (6,2010)
000088             GO TO 58
000089             56 WRITE (6,2011)
000090           58   IF(ISS .EQ. 1)          WRITE (6,6000)
000091          WRITE (6,2000) HED,NUMNP,NUMEL,NUMBC,NUMMT,INTER,DT,TINIT,TMAX
000092          IF(DAMP .OR. TOL4)      WRITE (6,2012) DMP1, DMAX1, DMP2, DMAX2,        *NEW
000093         1                        DMP3, DMAX3, TOLN                               *NEW
000094           WRITE (6,2009) (M,INTAB(M,1),XCOND(M),INTAB(M,2),DENS(M),
000095         C   INTAB(M,3),QX(M),M=1,NUMMT )
000096          IF(NTAB.NE.0)           CALL RTAB
000097          IF(IPT .NE. 0)          WRITE (6,2013)                                  *NEW
000098          IF(JTAPE .EQ. 1)        WRITE (6,2014)                                  *NEW
000099        C
000100        C*****************************************************************
000101        C     READ OR GENERATE NODAL POINT INFORMATION
000102        C*****************************************************************
000103          WRITE (6,9000)
000104          WRITE (6,2001)
000105          L=1
000106        C
000107             60 READ  (5,1001,ERR=7010,END=7000)
000108            1 N, ITEM(1), XTEM1, XTEM2, XTEM3, XTEM4, ITEM(2)
000109          KODE(N)  = ITEM(1)
000110          X(N) = XTEM1
000111          Y(N) = XTEM2
000112          T(N) = XTEM3
000113          TI(N)  = XTEM4
000114          IKODE(N) = ITEM(2)
000115          IF(IKODE(N) .GT. 32)    IKODE(N) = 0
000116          DIFF=N+1-L
```

```
000117            IF (N-L) 65,80,70
000118         65 WRITE (6,2020) N
000119            GO TO 60
000120         70 DX=(X(N)-X(L-1))/DIFF
000121            DY=(Y(N)-Y(L-1))/DIFF
000122         75 KODE(L)=0
000123            IKODE(L) = 0
000124            X(L)=X(L-1)+DX
000125            Y(L)=Y(L-1)+DY
000126            T(L)=0.0
000127            TI(L)  = TI(L-1)
000128         80 WRITE (6,2002) L,KODE(L),X(L),Y(L),T(L),TI(L),IKODE(L)
000129            L  = L+1
000130            IF (N-L) 90,80,75
000131         90 IF (NUMNP+1-L) 100,100,60
000132        100 CONTINUE
000133            DO 110 I=1,NUMNP
000134            D(I)=0.
000135            B(I)=0.
000136            DO 110 J=1,NDIM
000137        110 A(I,J)=0.
000138            MBAND=0
000139            NUM=0
000140            WRITE (6,9000)
000141            WRITE (6,2003)
000142            DO 115 I = 1,4
000143        115 LM(I) = 0
000144        120 CONTINUE
000145            RETURN
000146        900 WRITE (6,3000)
000147            GO TO 120
000148          C-------------------------------------------------------------------
000149          C     END OF FILE RETURN.
000150         7000 IF( IPTC .EQ. 1)        CALL ENDPLT
000151            IF(ITAPE .GT. 0)         END FILE 2
000152            STOP
000153         7010 WRITE (6,3005)
000154            READ (5,3010,END=7000)  (HED(I),I=1,12)
000155            WRITE (6,3010) (HED(I), I=1,12)
000156            GO TO 7000
000157         7050 CONTINUE
000158            REWIND 3
000159            READ  (3) HED, NUMNP, NUMEL, KAT, NUMMT, NTAB, ISS, IVARC
000160           1 , ((INTAB(I,J), J=1,3), XCOND(I), DENS(I), QX(I),  I=1,NUMMT),
000161           2   ((TAB(K,L), K=1,60), IDTAB(L), ITFAC(L), L=1,32),
000162           3 (MM,KODE(M),IKODE(M),X(M),Y(M),T(M),TI(M),QZZS(M), M=1,NUMNP)
000163           4   ,        DAMP, DF1, DF2, DF3, TOL4,  DMP1, DMAX1, DMP2, DMAX2,
000164           5 DMP3, DMAX3, TOLN
000165            DO 7060  N=1,NUMEL
000166            READ  (3) NN, (ISAVE(N,J), J=1,5)
000167         7060 CONTINUE
000168            WRITE (6,2000) HED,NUMNP,NUMEL,NUMBC,NUMMT,INTER,DT,TINIT,TMAX
000169             WRITE (6,2009) (M,INTAB(M,1),XCOND(M),INTAB(M,2),DENS(M),
000170           C   INTAB(M,3),QX(M),M=1,NUMMT )
000171            READ  (3) NUMBC, MBAND, IFLAGR, IDF, SIGMA,
000172           1 (IBC(I), JBC(I), IHBC(I), ITBC(I),  HBBC(I), TEMEBC(I), XLBC(I),
000173           2 IIBC(I), JJBC(I), EPS(I), NRF(I), TS(I), FN(I), I=1,NUMBC),
000174           3 ((F(I,J), J=1,IDF), I=1,IDF), (JNODE(I), I=1,NUMNP)
000175         7065 READ (3) TIME, (TC(N), N=1,NUMNP)
000176            IF(TINIT .GT. TIME)     GO TO 7065
```

```
000177              CALL SUBR6
000178              WRITE (1) ((A(I,J),J=1,MBAND),I=1,NUMNP)
000179              WRITE (1)  (T(I), B(I), D(I), I=1,NUMNP)
000180              REWIND 1
000181              LL = 0
000182              CALL SUBR7 (LL)
000183              GO TO 120
000184            C-----------------------------------------------------------------
000185            C     FORMAT STATEMENTS
000186            C-----------------------------------------------------------------
000187             1000 FORMAT (12A6, 6X, 2I1/ 6I5, E10.4, I5, E10.4,I5,E10.4,I5,4L1,I1)
000188             1001 FORMAT (2I5,4F10.0,I5)
000189             1003 FORMAT (I5,4(I5,E10.4) )
000190             2000 FORMAT (1H0 12A6// 25H0NUMBER OF NODAL POINTS-- I4/
000191                1 25H NUMBER OF ELEMENTS------ I4 / 25H NUMBER OF CONVECTION BC-I4/
000192                2 25H NUMBER OF MATERIALS----- I4 /
000193                3 25H OUTPUT INTERVAL--------- I4 / 20H TIME INTERVAL------ F10.3/
000194                4 20H INITIAL TIME------- F10.3/ 20H MAXIMUM TIME------- F10.3 )
000195             2001 FORMAT (20H0 N.P. NO.      CODE 14X,1HX,14X,1HY,14X,1HT,13X,2HT0,
000196                1   12H  CODE TABLE   )
000197             2002 FORMAT (2I10,4F15.4,I12 )
000198             2003 FORMAT (35H0   N    I    J    K    L  MATERIAL )
000199             2009 FORMAT ('0  M',10X,'TABLE-K',14X,'K',10X,'TABLE-R',9X,'RHO-CP',10X
000200                C   ,   'TABLE-Q',14X,'Q'/ 10(I4,3(10X,I7,E15.6)/) )                12200258
000201             2010 FORMAT (24H0AXISYMMETRIC SOLID BODY )
000202             2011 FORMAT ('0TWO DIMENSIONAL PLANE BODY' )
000203             2012 FORMAT ('0DMP1 = ', E14.6, '  DMAX1 = ', E14.6/ ' DMP2 = ', E14.6,        *NEW
000204                1  '  DMAX2 = ', E14.6/ ' DMP3 = ', E14.6, '  DMAX3 = ', E14.6/             *NEW
000205                2 ' TOLN = ', E14.6 )                                                      *NEW
000206             2013 FORMAT ('0OUTPUT INCLUDES GEOMETRY PLOT')                                *NEW
000207             2014 FORMAT ('0OUTPUT INCLUDES RECALL TAPE' )                                 *NEW
000208             2020 FORMAT (10H0CARD NO. I4, 13H OUT OF ORDER )
000209             3000 FORMAT (16H0ERROR.NUMNP = 0  )
000210             3005 FORMAT ('0INPUT ERROR. NEXT CARD,IF ANY,IS'//)
000211             3010 FORMAT (1X, 12A6 )
000212             5010 FORMAT (8F10.4)
000213             6000 FORMAT ('0***** STEADY-STATE CASE FOLLOWS *****'  )
000214             6020 FORMAT ('0CAUTION. NUMBER OF PROPERTY CARDS EXCEEDS 20.' )
000215             9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000216                1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000217                2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000218              END
```

```
@ ELT SUBR1,1,720214, 34816

000001                SUBROUTINE SUBR1
000002              C*************************************************************************
000003              C     FORM CONDUCTIVITY MATRIX FOR COMPLETE BODY
000004              C*************************************************************************
000005                DIMENSION TC(500)
000006                 COMMON A(500,41), B(500), D(500), DD(5),  E(3,3), HED(12), P(5)
000007                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000008                COMMON QZZS(500), TAB(60,32)
000009                COMMON XCOND(20), DENS(20), QX(20)
000010                COMMON TEM(10)
000011                COMMON COND,RHO,QXX,QZZ
000012                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000013                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000014                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000015                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000016                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000017                COMMON IKODE(500)
000018                COMMON INTAB(20,3)
000019                COMMON /SAVE1/ ISAVE(500,5)
000020                LOGICAL DAMP, DF1, DF2, DF3, TOL4
000021                COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000022                COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000023                EQUIVALENCE (IDMP1,DMP1), (IDMP2,DMP2), (IDMP3,DMP3),
000024               1   (IMAX1,DMAX1), (IMAX2,DMAX2), (IMAX3,DMAX3), (ITOL,TOLN)
000025                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000026               C                (TEM(4),XTEM4)
000027                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000028               C                (ITEM(4),MTYPE)
000029                EQUIVALENCE (I1,ITEM(5)), (I2,ITEM(6)), (I3,ITEM(7)), (I4,ITEM(8))
000030                EQUIVALENCE (TI(1),TC(1))
000031                COMMON /TAPE/ ITAPE, ISTART, ISS
000032              C-------------------------------------------------------------------------
000033              C     GENERATE RECALL TAPE IF ITAPE IS NONZERO.
000034              C-------------------------------------------------------------------------
000035                ITRA = 1
000036                IF (ITAPE.EQ.0)        GO TO 70
000037                WRITE (2) HED, NUMNP, NUMEL, KAT, NUMMT, NTAB, ISS, IVARC
000038               1 , ((INTAB(I,J), J=1,3), XCOND(I), DENS(I), QX(I),  I=1,NUMMT),
000039               2   ((TAB(K,L), K=1,60), IDTAB(L), ITFAC(L), L=1,32),
000040               3 (M, KODE(M),IKODE(M),X(M),Y(M),T(M),TI(M),QZZS(M), M=1,NUMNP)
000041               4   ,       DAMP, DF1, DF2, DF3, TOL4,  DMP1, DMAX1, DMP2, DMAX2,
000042               5 DMP3, DMAX3, TOLN
000043                ITRA = 2
000044               70   CONTINUE
000045              C-------------------------------------------------------------------------
000046                DO 200 N=1,NUMEL
000047              C-------------------------------------------------------------------------
000048              C       1. READ OR GENERATE ELEMENT PROPERTIES
000049              C-------------------------------------------------------------------------
000050                 IF (NUM-N) 120,121,121
000051               120 READ (5,1002) NUM,KX(1),KX(2),KX(3),KX(4),MTYPE
000052                IERR = 0
000053                DO 90   I=1,3
000054                DO 90   J=I,3
000055                IF( IABS(KX(I)-KX(J+1)) .GT. 40) IERR = 1
000056               90   CONTINUE
```

```
000057            IF(IERR .EQ. 1)        WRITE (6,8005)
000058          C-------------------------------------------------------------
000059          C     CHECK INPUT FOR COUNTER-CLOCKWISE DIRECTION.
000060          C-------------------------------------------------------------
000061            AREA = 0.
000062            DO 100  I=1,4
000063            J  = I+1
000064            IF(J .GT. 4)           J = 1
000065            K  = KX(I)
000066            L  = KX(J)
000067            YB = (Y(K)+Y(L))/2.0
000068            DX = X(L) - X(K)
000069        100 AREA = YB*DX+AREA
000070            IF(AREA .GT. 0.)       WRITE (6,8000) NUM
000071        121 DO 122 I=1,4
000072        122 LM(I)=LM(I)+1
000073            IF (NUM-N) 123,124,126
000074        123 WRITE (6,2021) NUM
000075            GO TO 120
000076        124 DO 125 I=1,4
000077        125 LM(I)=KX(I)
000078            ITYPE  = MTYPE
000079            IF(ITYPE .EQ. 0)       ITYPE = 1
000080            COND = XCOND(ITYPE)
000081            RHO  = DENS(ITYPE)
000082            QZZ  = QX(ITYPE)
000083            ITABK  = INTAB(ITYPE,1)
000084            ITABR  = INTAB(ITYPE,2)
000085            ITABQ  = INTAB(ITYPE,3)
000086        126 CONTINUE
000087        127 CONTINUE
000088            WRITE (6,2004) N, (LM(M), M=1,4), ITYPE
000089            GO TO (142,140), ITRA
000090        140 WRITE (2) N, (LM(M), M=1,4), ITYPE
000091        142 CONTINUE
000092          C-------------------------------------------------------------
000093          C       2. FORM ELEMENT CONDUCTIVITY MATRIX
000094          C-------------------------------------------------------------
000095            I=LM(1)
000096            J=LM(2)
000097            K=LM(3)
000098            L=LM(4)
000099            LM(5)=I
000100          C
000101            XX=(X(I)+X(J)+X(K)+X(L))/4.
000102            YY=(Y(I)+Y(J)+Y(K)+Y(L))/4.
000103          C-------------------------------------------------------------
000104          C     ITABQ .LT. 0     Q VS. TIME TABLE.
000105          C     ITABQ .EQ. 0     NO TABLE.
000106          C     ITABQ .GT. 0     Q VS X OR Y TABLE.
000107          C-------------------------------------------------------------
000108            IF(ITABQ)    128,130,129
000109        128 ITABQ  = -ITABQ
000110            CALL LINT (TIME,TAB(1,ITABQ),QZZ,DX)
000111            GO TO 130
000112        129 CONTINUE
000113            ZZ   = XX
000114            IF(IDTAB(ITABQ).EQ.8)  ZZ = YY
000115            CALL LINT (ZZ,TAB(1,ITABQ),QZZ,DX)
000116        130 CONTINUE
```

```
000117                QZZS(N)  = QZZ
000118                ISAVE(N,1) = LM(1)
000119                ISAVE(N,2) = LM(2)
000120                ISAVE(N,3) = LM(3)
000121                ISAVE(N,4) = LM(4)
000122                ISAVE(N,5) = ITYPE
000123          C
000124                CALL CONMAT
000125           200  CONTINUE
000126                WRITE (1) ((A(I,J),J=1,MBAND),I=1,NUMNP)
000127                WRITE (1)  (T(I), B(I), D(I), I=1,NUMNP)
000128                REWIND 1
000129                RETURN
000130          C-------------------------------------------------------------------
000131          C     FORMAT STATEMENTS
000132          C-------------------------------------------------------------------
000133           1002 FORMAT (10I5)
000134           2021 FORMAT (13H0BAD CARD NO. I4)
000135           2004 FORMAT (5I5,I10)
000136           8000 FORMAT ('0POSSIBLE ERROR IN ELEMENT',I4,'.CHECK FOR CLOCKWISE NODA
000137              1L INPUT.' )
000138           8005 FORMAT ('0CHECK NEXT CARD FOR NODAL WIDTH ERROR. ')
000139                END
```

@ ELT SUBR2,1,720212, 62576

```
000001                SUBROUTINE SUBR2
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                COMMON JNODE(500)
000017                COMMON /BC/ IBC(200), JBC(200), IHBC(200), ITBC(200), HBBC(200),
000018               1 TEMEBC(200), XLBC(200), IIBC(200), JJBC(200)
000019                COMMON /RADCON/EPS(200), F(20,20),  SIGMA, NRF(200), IFLAGR
000020               1 , FN(200), B0(20), KTEM(20), TS(200)
000021                COMMON /SAVE1/ ISAVE(500,5)
000022                COMMON /TAPE/  ITAPE, ISTART, ISS
000023                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000024              C                (TEM(4),XTEM4)
000025                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000026              C                (ITEM(4),MTYPE)
000027                EQUIVALENCE (TI(1),TC(1)), (IEPSI,EPSI)
000028                DATA IDF/20/
000029            C*****************************************************************
000030            C     BOUNDARY CONDITIONS
000031            C*****************************************************************
000032            C-----------------------------------------------------------------
000033            C     SIGMA        STEFAN-BOLTZMAN CONSTANT.
000034            C-----------------------------------------------------------------
000035                DO 180  I=1,NUMNP
000036             180  JNODE(I) = 0
000037                IFLAGR = 0
000038                WRITE (6,9000)
000039                IF(IDUM .EQ. 0)    GO TO 602
000040                WRITE (6,6011)
000041                WRITE (6,6000) (D(I),I=1,NUMNP)
000042                WRITE (6,6012)
000043                WRITE (6,6000) (B(I),I=1,NUMNP)
000044                WRITE (6,6050)
000045                DO 600 I=1,NUMNP
000046             600  WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000047             602  CONTINUE
000048            C
000049            C     1. CONVECTION BOUNDARY CONDITIONS
000050            C
000051                INBC = 0
000052                IF(NUMBC .EQ. 0)       GO TO 225
000053             203  WRITE (6,2006)
000054                ISAV  = 0
000055                JSAV  = 0
000056            C-----------------------------------------------------------------
```

```
000057      C     INPUT CONTROL BY EITHER NUMBC = EXACT NUM    OF CONVECTION CARDS
000058      C     OR SET NUMBC = NUMNP AND END CONVECTION BOUNDARY INPUT BY A
000059      C     NEGATIVE INTEGER
000060      C-----------------------------------------------------------------------
000061            DO 215  N=1,NUMBC
000062            READ (5,5001) I,J,H,TEME,IH,ITEMP,EPSI,FI,NRFI,IS,ITS,TEMS
000063      C-----------------------------------------------------------------------
000064      C     SET FLAG FOR RADIATION CALCULATIONS.
000065      C-----------------------------------------------------------------------
000066            IF(I)         217,206,206
000067       206  INBC =INBC+1
000068               TEMP = TEME
000069            IF(I.EQ.0)    I=JSAV
000070            IF(J.EQ.0)    J=ISAV
000071            ISAV    = I
000072            JSAV    = J
000073            XL=SQRT((X(J)-X(I))**2+(Y(J)-Y(I))**2)
000074            IF (KAT)      207,208,207
000075       207  XL=XL*(X(I)+X(J))/2.
000076       208  CONTINUE
000077      C-----------------------------------------------------------------------
000078      C     SET NODE FLAGS.
000079      C     JNODE(I) = 0, CONDUCTION NODE.
000080      C     JNODE(I) = 1, CONVECTION NODE.
000081      C     JNODE(I) = 2, RADIATION NODE.
000082      C-----------------------------------------------------------------------
000083            NI = 0
000084            IF(IEPSI .NE. 0)        NI = 1
000085            JNODE(I) = 1+NI
000086            JNODE(J) = 1+NI
000087            IBC(N) = I
000088            JBC(N) = J
000089            IHBC(N)  = IH
000090            ITBC(N)  = ITEMP
000091            XLBC(N)  = XL
000092            EPS(N) = EPSI
000093            FN(N)  = FI
000094            NRF(N) = NRFI
000095            IF(NRFI .GT. 0.)        IFLAGR  = 1
000096      C-----------------------------------------------------------------------
000097      C     CHECK FOR H AND TEMP TABLES.
000098      C-----------------------------------------------------------------------
000099            IF(NTAB .EQ. 0)  GO TO 210
000100            IF(ITEMP .GT. 32)       ITEMP = 0
000101            IF(IH .GT. 32)          IH = 0
000102      C-----------------------------------------------------------------------
000103      C     IH .LT. 0    H VS. TIME TABLE.
000104      C     IH .EQ. 0    NO H-TABLE.
000105      C     IH .GT. 0    H VS. TEMP. TABLE.
000106      C-----------------------------------------------------------------------
000107            IF(IH)        201,204,202
000108       201  IH = -IH
000109            CALL LINT (TIME,TAB(1,IH),H,DX)
000110            GO TO 204
000111       202  CONTINUE
000112            TEMPX  = (TI(I)+TI(J))/2.0
000113                     CALL LINT (TEMPX,TAB(1,IH),H, DX)
000114                LOC = ITFAC(IH)
000115                FAC = 1.0
000116            IF(LOC .GT. 0) CALL LINT(TIME,TAB(1,LOC),FAC,DX)
```

```
000117            H  = H*FAC
000118       204  CONTINUE
000119            IF(ITEMP .GT. 0)        CALL LINT(TIME,TAB(1,ITEMP),TEMP,DX)
000120       210  CONTINUE
000121           C-------------------------------------------------------------------
000122           C     CHECK VALUE OF EXTERNAL TEMPERATURE.
000123           C-------------------------------------------------------------------
000124            HBBC(N)  = H
000125            TEMEBC(N)= TEMP
000126            TS(N)  = TEMS
000127            IF(ITS .EQ. 0)          TS(N) = TEMP
000128            WRITE (6,6007) I,J,H,TEMP,IH,ITEMP,EPSI,FI,NRFI,IS,TS(N)
000129       215  CONTINUE
000130       217  NUMBC  = INBC
000131            WRITE (6,2010) NUMBC
000132            CALL CONVBI
000133           C-------------------------------------------------------------------
000134           C     CALL CONVBC TO CALCULATE THE CONVECTION EFFECTS.
000135           C-------------------------------------------------------------------
000136            DO 218   N=1,NUMBC
000137            I  = IBC(N)
000138            J  = JBC(N)
000139            H  = HBBC(N)
000140            TEMP = TEMEBC(N)
000141            XL = XLBC(N)
000142       218  CALL CONVBC(I,J,N)
000143           C-------------------------------------------------------------------
000144           C     CHECK FOR SURFACE-TO-SURFACE RADIATION COMPUTATIONS.
000145           C     MORE DATA IS REQUIRED FOR THE LATTER OPTION.
000146           C-------------------------------------------------------------------
000147            IF(IFLAGR .EQ. 0)       GO TO 225
000148            DO 220  N=1,NUMBC
000149            NRFI = NRF(N)
000150            IF(NRFI .EQ. 0)         GO TO 220
000151            READ (5,5005,END=800) IS, (F(IS,I), I=1,NRFI)
000152            WRITE (6,6005) IS, (F(IS,I), I=1,NRFI)
000153            DO 219   I=1,NRFI
000154            F(IS,I)  = (EPS(N)-1.0)*F(IS,I)
000155            IF(IS .EQ. I)           F(IS,I) = F(IS,I)+1.
000156       219  CONTINUE
000157       220  CONTINUE
000158            CALL RAD
000159            IF(IDUM .EQ. 0)    GO TO 612
000160            WRITE (6,6011)
000161            WRITE (6,6000) (D(I),I=1,NUMNP)
000162            WRITE (6,6012)
000163            WRITE (6,6000) (B(I),I=1,NUMNP)
000164            WRITE (6,6050)
000165            DO 610 I=1,NUMNP
000166       610  WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000167       612  CONTINUE
000168       225  CONTINUE
000169           C-------------------------------------------------------------------
000170           C     CALCULATE THE TEMPERATURE BOUNDARY CONDITIONS.
000171           C-------------------------------------------------------------------
000172            CALL TEMPBC
000173            IF(IDUM .EQ. 0)    GO TO 622
000174            WRITE (6,6011)
000175            WRITE (6,6000) (D(I),I=1,NUMNP)
000176            WRITE (6,6012)
```

```
000177            WRITE (6,6000) (B(I),I=1,NUMNP)
000178            WRITE (6,6050)
000179            DO 620 I=1,NUMNP
000180          620 WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000181          622 CONTINUE
000182           C-------------------------------------------------------------------
000183           C     GENERATE RECALL TAPE IF ITAPE IS NONZERO.
000184           C-------------------------------------------------------------------
000185            IF (ITAPE.EQ.0)         GO TO 624
000186            WRITE (2) NUMBC, MBAND, IFLAGR, IDF, SIGMA,
000187           1 (IBC(I), JBC(I), IHBC(I), ITBC(I),  HBBC(I), TEMEBC(I), XLBC(I),
000188           2 IIBC(I), JJBC(I), EPS(I), NRF(I), TS(I), FN(I), I=1,NUMBC),
000189           3 ((F(I,J), J=1,IDF), I=1,IDF), (JNODE(I), I=1,NUMNP)
000190          624 RETURN
000191          800 WRITE (6,8000)
000192            STOP
000193           C-------------------------------------------------------------------
000194           C     FORMAT STATEMENTS
000195           C-------------------------------------------------------------------
000196          1001 FORMAT (2I5,2F10.0,2I5, 2E10.4,I4, I4, 2A6 )
000197          2006 FORMAT ('0    I    J',14X,'H    TEMPERATURE H-TAB T-TAB RADIATION
000198             1EPSILON         F-FACTOR     F-TABLE NO. ' )
000199          2007 FORMAT (1X,2I5,2E15.6,I5,I6, 7X,E15.6,E17.6,I5, 1X, 2A6 )
000200          2010 FORMAT ('0NUMBER OF CONVECTION BOUNDARY CARDS - - -',I5 )
000201          5001 FORMAT (2I5, 2F10.0, 2I5, 2E10.4, 2I4, I2, F10.0 )
000202          5005 FORMAT (I5, 5X, 7E10.4/(8E10.4) )
000203          6000 FORMAT (1X,10E12.4 )
000204          6005 FORMAT (1X, I5, 8E14.6 / (1X,5X, 8E14.6) )
000205          6007 FORMAT (1X, 2I5, 2E15.6, I5, I6, 7X, E15.6, E17.6,2I5, 1X, E14.6)
000206          6011 FORMAT ('0VECTOR D')
000207          6012 FORMAT ('0VECTOR B')
000208          6600 FORMAT ('0ROW',I5/ (1X,10E12.4 / ) )
000209          6050 FORMAT ('0MATRIX A' )
000210          9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000211             1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000212             2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000213          8000 FORMAT ('0 EOF DURING THE READING OF RADIATION CARDS.' )
000214            END
```

```
@ ELT SUBR3,1,720212, 62578

000001                SUBROUTINE SUBR3
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                COMMON /TAPE/  ITAPE
000017                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000018              C                (TEM(4),XTEM4)
000019                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000020              C                (ITEM(4),MTYPE)
000021                EQUIVALENCE (TI(1),TC(1))
000022            C-----------------------------------------------------------------
000023                  NPT  = 0
000024            C      2. SOLVE FOR TEMPERATURES
000025            C*****************************************************************
000026            C     SOLVE FOR NODAL POINT TEMPERATURES
000027            C*****************************************************************
000028            C     FORM EFFECTIVE CONDUCTIVITY MATRIX FOR TIME INCREMENT
000029            C-----------------------------------------------------------------
000030                  DO 320 N=1,NUMNP
000031                  IF (KODE(N)) 320,305,320
000032              305 IF (D(N)) 310,320,310
000033              310 D(N)=DT2*D(N)
000034                  A(N,1)=A(N,1)+D(N)
000035              320 CONTINUE
000036                   WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000037                  CALL SYMSO (1)
000038            C
000039            C     CALCULATE TEMPERATURE AT THE END OF EACH TIME INCREMENT
000040            C
000041                  LL = 1
000042            C
000043              340     CONTINUE
000044            C
000045            C      1. CALCULATE EFFECTIVE LOAD MATRIX
000046            C
000047                  DO 400 I=1,NUMNP
000048                  Q(I)=B(I)
000049                  IF (KODE(I)) 400,395,400
000050              395 Q(I)=B(I)+D(I)*TC(I)
000051              400 CONTINUE
000052            C
000053                  CALL SYMSO (2)
000054            C
000055                  DO 500 I=1,NUMNP
000056              500 TC(I) = Q(I)
```

```
000057          C
000058                TIME =TIME+DT
000059                   IF(TIME .GE. TMAX)  GO TO 550
000060                LL=LL+1
000061                IF(LL-INTER) 600,550,550
000062           550  WRITE (6,2005) TIME,(N,TC(N),N=1,NUMNP )
000063                LL=0
000064          C
000065           600  CONTINUE
000066                IF (ITAPE.GT.0)
000067               *WRITE (2)  TIME,(TC(N),N=1,NUMNP)
000068                IF(TIME .LT. TMAX)      GO TO 340
000069            50  CONTINUE
000070                IF(IPUNCH .EQ. 0)       GO TO 710
000071          C-----------------------------------------------------------------------
000072          C     PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000073          C-----------------------------------------------------------------------
000074                DO 700 N=1,NUMNP
000075           700  WRITE (7,7000) N,KODE(N),X(N),Y(N),T(N),TI(N),IKODE(N)
000076           710  CONTINUE
000077                RETURN
000078          C
000079          C     FORMAT STATEMENTS
000080          C
000081          C
000082           2005 FORMAT (6H0TIME= F12.5/ ( 6(I6,F14.4) )  )
000083           7000 FORMAT (2I5,4F10.2,I5 )
000084          C
000085          C
000086                END
```

```
@ ELT SUBR4,1,720214, 51605

000001                SUBROUTINE SUBR4
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NJM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                COMMON /TAPE/  ITAPE, ISTART
000017                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000018              C                (TEM(4),XTEM4)
000019                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000020              C                (ITEM(4),MTYPE)
000021                EQUIVALENCE (TI(1),TC(1))
000022                LL = 1
000023                NPT  = 0
000024              C     IF(ISTART .EQ. 0)       GO TO 301
000025              C300  READ (3) TIME, (TC(N), N=1,NUMNP)
000026              C     IF(TINIT .GT. TIME)     GO TO 300
000027               301   WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000028                M  = 1
000029                GO TO 304
000030              C
000031              C      2. SOLVE FOR TEMPERATURES
000032              C
000033              C*************************************************************************
000034              C     SOLVE FOR NODAL POINT TEMPERATURES
000035              C*************************************************************************
000036              C     FORM EFFECTIVE CONDUCTIVITY MATRIX FOR TIME INCREMENT
000037              C
000038               302  CONTINUE
000039                    READ (1) ((A(I,J), J=1,MBAND),I=1,NUMNP)
000040                    READ (1) (T(I), B(I), D(I), I=1,NUMNP)
000041                    REWIND 1
000042                    LL=LL+1
000043                    CALL SUBR7(LL)
000044               304  IF(IDT .EQ. 0)   GO TO 305
000045                    IF(TIME .LT. TAB(M,IDT) )   GO TO 305
000046                    DT = TAB(M+1,IDT)
000047                    DT2  = 1./DT
000048                    M  = M+2
000049                    GO TO 304
000050               305  DO 320 N=1,NUMNP
000051                    IF(KODE(N))  320,308,320
000052               308  IF(D(N))     310,320,310
000053                310  D(N)=DT2*D(N)
000054                    A(N,1)=A(N,1)+D(N)
000055                320  CONTINUE
000056                    CALL SYMSO (1)
```

```
000057          C
000058          C     CALCULATE TEMPERATURE AT THE END OF EACH TIME INCREMENT
000059          C
000060          C
000061          C
000062          C      1. CALCULATE EFFECTIVE LOAD MATRIX
000063          C
000064                DO 400 I=1,NUMNP
000065                Q(I)=B(I)
000066                IF (KODE(I)) 400,395,400
000067           395  Q(I)=B(I)+D(I)*TC(I)
000068           400  CONTINUE
000069          C
000070                CALL SYMSO (2)
000071          C
000072                DO 500 I=1,NUMNP
000073           500  TC(I) = Q(I)
000074          C
000075                TIME =TIME+DT
000076                   IF(TIME .GE. TMAX)  GO TO 550
000077          C
000078                IF(LL-INTER) 555,550,550
000079           550   WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000080                LL=0
000081           555  CONTINUE
000082                IF (ITAPE.GT.0)
000083               *WRITE (2)  TIME,(TC(N),N=1,NUMNP)
000084                IF(TIME .LT. TMAX)      GO TO 302
000085           50   CONTINUE
000086                IF(IPUNCH .EQ. 0)       GO TO 710
000087          C-----------------------------------------------------------------
000088          C     PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000089                DO 700 N=1,NUMNP
000090           700  WRITE (7,7000) N,KODE(N),X(N),Y(N),T(N),TI(N),IKODE(N)
000091           710  CONTINUE
000092                RETURN
000093          C
000094          C     FORMAT STATEMENTS
000095          C
000096          C
000097           1007 FORMAT (2I5,2F10.4,2I5 )
000098           2005 FORMAT (6H0TIME= F12.5/ ( 6(I6,F14.4) )  )
000099           2007 FORMAT (2I5,2E15.6,2I5 )
000100           7000 FORMAT (2I5,4F10.2,I5 )
000101          C
000102          C
000103                END
```

```
@ ELT SUBR5,1,720214, 51608

000001                SUBROUTINE SUBR5
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                COMMON /SAVE1/ ISAVE(500,5)
000017                COMMON /TAPE/  ITAPE, ISTART
000018                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000019              C                (TEM(4),XTEM4)
000020                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000021              C                (ITEM(4),MTYPE)
000022                EQUIVALENCE (TI(1),TC(1))
000023                NPT  = 0
000024                M  = 1
000025                LL = 1
000026           C    IF(ISTART .EQ. 0)       GO TO 301
000027           C300 READ (3) TIME, (TC(N), N=1,NUMNP)
000028           C    IF(TINIT .GT. TIME)     GO TO 300
000029            301  WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000030                GO TO 304
000031            303    CONTINUE
000032                CALL SUBR6
000033                LL=LL+1
000034                CALL SUBR7(LL)
000035           C
000036           C     2. SOLVE FOR TEMPERATURES
000037           C
000038           C*************************************************************************
000039           C     SOLVE FOR NODAL POINT TEMPERATURES
000040           C*************************************************************************
000041           C     FORM EFFECTIVE CONDUCTIVITY MATRIX FOR TIME INCREMENT
000042           C
000043            304  IF(IDT .EQ. 0)   GO TO 305
000044                IF(TIME .LT. TAB(M,IDT) )   GO TO 305
000045                DT = TAB(M+1,IDT)
000046                DT2  = 1./DT
000047                M  = M+2
000048                GO TO 304
000049            305  DO 320 N=1,NUMNP
000050                IF(KODE(N))  320,308,320
000051            308  IF(D(N))     310,320,310
000052             310 D(N)=DT2*D(N)
000053                A(N,1)=A(N,1)+D(N)
000054             320 CONTINUE
000055           C-------------------------------------------------------------------------
000056           C     OPTIONAL DUMP OF VECTOR D AND MATRIX A.
```

```
000057      C-----------------------------------------------------------------------
000058            IF(IDUM .EQ. 0)         GO TO 330
000059            WRITE (6,6011)
000060            WRITE (6,6000) (D(I),I=1,NUMNP)
000061            DO 325 I=1,NUMNP
000062       325  WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000063       6000 FORMAT (1X,10E12.4 )
000064       6011 FORMAT ('0VECTOR D' )
000065       6013 FORMAT ('0VECTOR Q' )
000066       6600 FORMAT ('0ROW',I5/ 3(1X,10E12.4/) )
000067      C-----------------------------------------------------------------------
000068       330  CONTINUE
000069            CALL SYMSO (1)
000070      C
000071      C     CALCULATE TEMPERATURE AT THE END OF EACH TIME INCREMENT
000072      C
000073      C
000074      C
000075      C      1. CALCULATE EFFECTIVE LOAD MATRIX
000076      C
000077            DO 400 I=1,NUMNP
000078            Q(I)=B(I)
000079            IF (KODE(I)) 400,395,400
000080       395  Q(I)=B(I)+D(I)*TC(I)
000081       400  CONTINUE
000082      C
000083      C-----------------------------------------------------------------------
000084      C     OPTIONAL DUMP OF VECTOR Q AND MATRIX A.
000085      C-----------------------------------------------------------------------
000086            IF(IDUM .EQ. 0)         GO TO 340
000087            IDUM = 0
000088            WRITE (6,6013)
000089            WRITE (6,6000) (Q(I),I=1,NUMNP)
000090            DO 335 I=1,NUMNP
000091       335  WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000092      C-----------------------------------------------------------------------
000093       340  CONTINUE
000094            CALL SYMSO (2)
000095      C
000096            DO 500 I=1,NUMNP
000097       500  TC(I) = Q(I)
000098      C
000099            TIME =TIME+DT
000100               IF(TIME .GE. TMAX)  GO TO 550
000101      C
000102            IF(LL-INTER) 555,550,550
000103       550   WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000104            LL = 0
000105       555  CONTINUE
000106            IF (ITAPE.GT.0)
000107           *WRITE (2)  TIME,(TC(N),N=1,NUMNP)
000108            IF(TIME .LT. TMAX)      GO TO 303
000109       50   CONTINUE
000110            IF(IPUNCH .EQ. 0)       GO TO 710
000111      C-----------------------------------------------------------------------
000112      C     PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000113      C-----------------------------------------------------------------------
000114            DO 700 N=1,NUMNP
000115       700  WRITE (7,7000) N,KODE(N),X(N),Y(N),T(N),TI(N),IKODE(N)
000116       710  CONTINUE
```

```
000117            RETURN
000118          C
000119          C     FORMAT STATEMENTS
000120          C
000121          C
000122           1007 FORMAT (2I5,2F10.4,2I5 )
000123           2005 FORMAT (6H0TIME= F12.5/ ( 6(I6,F14.4) )  )
000124           2006 FORMAT (40H0    I     J                H     TEMPERATURE )
000125           2007 FORMAT (2I5,2E15.6,2I5 )
000126           7000 FORMAT (2I5,4F10.2,I5 )
000127                END
```

```
@ ELT SUBR6,1,720212, 62583

000001                SUBROUTINE SUBR6
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),  E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                COMMON /SAVE1/ ISAVE(500,5)
000017                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000018              C                (TEM(4),XTEM4)
000019                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000020              C                (ITEM(4),MTYPE)
000021                EQUIVALENCE (TI(1),TC(1))
000022              C-------------------------------------------------------------------
000023                   DO 110 I=1,NUMNP
000024                   D(I)=0.
000025                   B(I)=0.
000026                   DO 110 J=1,NDIM
000027               110 A(I,J)=0.
000028              C*******************************************************************
000029              C-------------------------------------------------------------------
000030              C      FORM CONDUCTIVITY MATRIX FOR COMPLETE BODY
000031              C*******************************************************************
000032                   DO 200 N=1,NUMEL
000033              C       1. READ OR GENERATE ELEMENT PROPERTIES
000034              C-------------------------------------------------------------------
000035                   LM(1) = ISAVE(N,1)
000036                   LM(2) = ISAVE(N,2)
000037                   LM(3) = ISAVE(N,3)
000038                   LM(4) = ISAVE(N,4)
000039                   MTYPE = ISAVE(N,5)
000040                   QZZ    = QZZS(N)
000041                   COND   = XCOND(MTYPE)
000042                   RHO    = DENS(MTYPE)
000043                      ITABK = INTAB(MTYPE,1)
000044                      ITABR = INTAB(MTYPE,2)
000045                      ITABQ = INTAB(MTYPE,3)
000046              C-------------------------------------------------------------------
000047              C       2. FORM ELEMENT CONDUCTIVITY MATRIX
000048              C-------------------------------------------------------------------
000049                   CALL CONMAT
000050               200 CONTINUE
000051                   RETURN
000052                   END
```

```
@ ELT SUBR7,1,720212, 62585

000001                SUBROUTINE SUBR7(LL)
000002                DIMENSION TC(500)
000003                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000004                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000005                COMMON QZZS(500), TAB(60,32)
000006                COMMON XCOND(20), DENS(20), QX(20)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(500)
000015                COMMON INTAB(20,3)
000016                COMMON /BC/ IBC(200), JBC(200), IHBC(200), ITBC(200), HBBC(200),
000017               1 TEMEBC(200), XLBC(200), IIBC(200), JJBC(200)
000018                COMMON /RADCON/EPS(200), F(20,20),  SIGMA, NRF(200), IFLAGR
000019               1 , FN(200), BQ(20), KTEM(20), TS(200)
000020                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000021               C                (TEM(4),XTEM4)
000022                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000023               C                (ITEM(4),MTYPE)
000024                EQUIVALENCE (TI(1),TC(1))
000025              C-------------------------------------------------------------------
000026                IF(NUMBC .LE. 0)       GO TO 220
000027                IF(LL .LT. INTER)      GO TO 200
000028                WRITE (6,9000)
000029                WRITE (6,2006)
000030             200 CONTINUE
000031                DO 210   N=1,NUMBC
000032                IH = IHBC(N)
000033                ITEMP  = ITBC(N)
000034                H  = HBBC(N)
000035                TEMP = TEMEBC(N)
000036                I  = IBC(N)
000037                J  = JBC(N)
000038              C-------------------------------------------------------------------
000039              C     IH .LT. 0    H VS. TIME TABLE.
000040              C     IH .EQ. 0    NO H-TABLE.
000041              C     IH .GT. 0    H VS. TEMP. TABLE.
000042              C-------------------------------------------------------------------
000043                IF(IH)        201,204,202
000044             201 IH = -IH
000045                CALL LINT (TIME,TAB(1,IH),H,DX)
000046                GO TO 204
000047             202 CONTINUE
000048                TEMPX  = (TC(I)+TC(J))/2.0
000049                                CALL LINT (TEMPX,TAB(1,IH),H, DX )
000050                LOC  = ITFAC(IH)
000051                     FAC = 1.0
000052                  IF(LOC .GT. 0) CALL LINT(TIME,TAB(1,LOC),FAC,DX)
000053                H  = H*FAC
000054             204 CONTINUE
000055                IF(ITEMP .LE. 0)       GO TO 205
000056                CALL LINT (TIME,TAB(1,ITEMP),TEMP,DX)
```

```
000057            LOC  = ITFAC(ITEMP)
000058            FAC  = 1.0
000059            IF(LOC .GT. 0)   CALL LINT (TIME,TAB(1,LOC),FAC,DX)
000060            TEMP = FAC*TEMP
000061          205 CONTINUE
000062            HBBC(N)  = H
000063            TEMEBC(N)  = TEMP
000064          C-------------------------------------------------------------------
000065          210 CONTINUE
000066            DO 215   N=1,NUMBC
000067          C     CORRECT FOR NODAL OFF-SET.
000068            I  = IBC(N)
000069            J  = JBC(N)
000070            H  = HBBC(N)
000071            TEMP = TEMEBC(N)
000072            XL = XLBC(N)
000073            IF(LL .GE. INTER)      WRITE (6,2007) I, J, H, TEMP
000074          C-------------------------------------------------------------------
000075          C     CALL CONVBC TO CALCULATE THE CONVECTION EFFECTS.
000076          C-------------------------------------------------------------------
000077            CALL CONVBC (I,J,N)
000078          215 CONTINUE
000079            IF(IFLAGR .EQ. 1)      CALL RAD
000080            REWIND 1
000081          220 CONTINUE
000082          C-------------------------------------------------------------------
000083          C     CALCULATE THE TEMPERATURE BOUNDARY CONDITIONS.
000084          C-------------------------------------------------------------------
000085            CALL TEMPBC
000086            RETURN
000087          2006 FORMAT (40H0   I    J              H    TEMPERATURE )
000088          2007 FORMAT (2I5,2E15.6)
000089          9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000090             1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000091             2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000092            END
```

```
@ ECT SUBR8,1,720212, 62588

000001                SUBROUTINE SUBR8
000002          C-----------------------------------------------------------------
000003          C     STEADY-STATE PROBLEM.
000004          C-----------------------------------------------------------------
000005                DIMENSION TC(500), NTC(500), IEPS(250)
000006                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000007                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000008                COMMON QZZS(500), TAB(60,32)
000009                COMMON XCOND(20), DENS(20), QX(20)
000010                COMMON TEM(10)
000011                COMMON COND,RHO,QXX,QZZ
000012                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000013                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000014                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000015                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000016                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000017                COMMON IKODE(500)
000018                COMMON INTAB(20,3)
000019                COMMON JNODE(500)
000020                COMMON /TAPE/ ITAPE
000021                COMMON /BC/ IBC(200), JBC(200), IHBC(200), ITBC(200), HBBC(200),
000022               1 TEMEBC(200), XLBC(200), IIBC(200), JJBC(200)
000023                LOGICAL DAMP, DF1, DF2, DF3, TOL4
000024                COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000025                COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000026                COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000027               1 , FN(250), BQ(40), KTEM(40)
000028                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000029          C                (TEM(4),XTEM4)
000030                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000031          C                (ITEM(4),MTYPE)
000032                EQUIVALENCE (TI(1),TC(1),NTC(1))
000033                EQUIVALENCE (IEPS(1),EPS(1))
000034          C-----------------------------------------------------------------
000035                IRAD = 0
000036                IRAD1  = 0
000037                DO 290  I=1,NUMBC
000038                IF(IEPS(I) .EQ. 0)      GO TO 290
000039                IRAD = 1
000040                GO TO 292
000041           290  CONTINUE
000042           292  CONTINUE
000043                IF(INTER .LE. 0)        INTER = 20
000044                ICONV  = 0
000045                ITER = IVARC+NTAB+IRAD
000046                NITER  = 1
000047                LL   = 0
000048                GO TO 305
000049           300  CONTINUE
000050          C-----------------------------------------------------------------
000051          C     IF IVARC IS NON-ZERO, CONDUCTIVITY IS VARIABLE WITH TEMPERATURE.
000052          C     OTHERWISE, ONLY THE H ON THE BOUNDARY ARE VARIABLE WITH TEMPERATURE
000053          C-----------------------------------------------------------------
000054                IF(IVARC .GT. 0)        GO TO 302
000055                IF(IRAD .GT. 0)         GO TO 304
000056                IF(NTAB .EQ. 0)         GO TO 303
```

```
000057          304  CONTINUE
000058               READ (1) ((A(I,J), J=1,MBAND), I=1,NUMNP)
000059               READ (1) (T(I), B(I), D(I), I=1,NUMNP)
000060               REWIND 1
000061               GO TO 303
000062          302  CONTINUE
000063               CALL SUBR6
000064          303  CONTINUE
000065               LL = LL+1
000066               CALL SUBR7(LL)
000067          305  CONTINUE
000068               DO 310  I=1,NUMNP
000069          310  Q(I) = B(I)
000070               CALL SYMSO(1)
000071               CALL SYMSO(2)
000072               IF(ITER  .EQ. 0)        GO TO 350
000073               IF(NITER .EQ. 1)        GO TO 460
000074          C----------------------------------------------------------------------
000075          C    CHECK FOR DAMPING.
000076          C----------------------------------------------------------------------
000077               IF(DAMP)     GO TO 400
000078          311  CONTINUE
000079               DO 312   I=1,NUMNP
000080               IF(NTC(I) .EQ. 0)       GO TO 312
000081               TEMP = ABS((TC(I)-Q(I))/TC(I) )
000082               IF(TEMP .GT. TOLN)      GO TO 314
000083          312  CONTINUE
000084               GO TO 350
000085          314  CONTINUE
000086               IF(NITER .GE. INTER)    GO TO 350
000087          C    IF(NITER .GE. INTER-2 )
000088          C   1WRITE (6,2005) NITER, (N,Q(N), N=1,NUMNP)
000089               WRITE (6,2005) NITER, (N, Q(N), N=1,NUMNP)
000090               DO 320  I=1,NUMNP
000091          320  TC(I)  = Q(I)
000092               NITER  = NITER+1
000093               GO TO 300
000094          350  CONTINUE
000095               WRITE (6,2005) NITER, (N,Q(N), N=1,NUMNP)
000096               RITER  = NITER
000097               IF(ITAPE .GT. 0)        WRITE (2) RITER, (Q(N), N=1,NUMNP)
000098               IF(IPUNCH .EQ. 0)       GO TO 710
000099          C----------------------------------------------------------------------
000100          C    PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000101          C----------------------------------------------------------------------
000102               DO 700 N=1,NUMNP
000103           700 WRITE (7,7000) N, X(N), Y(N), Q(N)
000104           710 CONTINUE
000105               RETURN
000106           400 CONTINUE
000107          C----------------------------------------------------------------------
000108          C    DAMP ITERATED VALUES.
000109          C----------------------------------------------------------------------
000110               DO 450  N=1,NUMNP
000111               ITRA = JNODE(N)+1
000112          C----------------------------------------------------------------------
000113          C    IF ITRA EQUAL 1, CONDUCTION NODE.
000114          C    IF ITRA EQUAL 2, CONVECTION NODE.
000115          C    IF ITRA EQUAL 3, RADIATION NODE.
000116          C----------------------------------------------------------------------
```

```
000117            GO TO (410, 415, 420), ITRA
000118       410  IF( .NOT. DF1)          GO TO 450
000119           C-------------------------------------------------------------------
000120           C     DAMP CONDUCTION NODES.
000121           C-------------------------------------------------------------------
000122            DMP  = DMP1
000123            DMAX = DMAX1
000124            GO TO 425
000125       415  IF( .NOT. DF2)          GO TO 450
000126           C-------------------------------------------------------------------
000127           C     DAMP CONVECTION NODES.
000128           C-------------------------------------------------------------------
000129            DMP  = DMP2
000130            DMAX = DMAX2
000131            GO TO 425
000132       420  IF( .NOT. DF3)          GO TO 450
000133           C-------------------------------------------------------------------
000134           C     DAMP RADIATION NODES.
000135           C-------------------------------------------------------------------
000136            DMP  = DMP3
000137            DMAX = DMAX3
000138       425  DIFF = Q(N)-TC(N)
000139            XTEM = DIFF*DMP
000140            Q(N) = TC(N)+XTEM
000141            IF(ABS(XTEM) .GT. DMAX)          Q(N) = TC(N)+SIGN(DMAX,DIFF)
000142       450  CONTINUE
000143            GO TO 311
000144       460  CONTINUE
000145           C-------------------------------------------------------------------
000146           C     CHECK FOR INITIAL GUESSES.
000147           C     INIT = 0,    NO INITIAL GUESSES.
000148           C     INIT = 1,    INITIAL GUESSES ARE GIVEN FOR SOME OR ALL NODES.
000149           C-------------------------------------------------------------------
000150            INIT = 0
000151            DO 465  N=1,NUMNP
000152            IF(NTC(N) .GT. 0)        INIT = 1
000153       465  CONTINUE
000154            DO 470   N=1,NUMBC
000155            IF(NTC(N) .GT. 0)        GO TO 470
000156            TC(N)  = Q(N)
000157       470  CONTINUE
000158            IF(INIT .EQ. 1)          GO TO 400
000159            GO TO 314
000160           C
000161           C     FORMAT STATEMENTS
000162           C
000163           C
000164       2005 FORMAT ('0ITERATION NO.', I4/ ( 6(I6,F14.4) ) )
000165       7000 FORMAT (I5, 5X, 2F10.4, 20X, F10.2 )
000166            END
000167            END
```

```
@ ELT SYMSO,1,720212, 62590

000001                SUBROUTINE SYMSO (KKK)
000002          C
000003                DIMENSION TC(500), IA(500,41)
000004                 COMMON A(500,41), B(500), D(500), DD(5),   E(3,3), HED(12), P(5)
000005                COMMON Q(500), S(5,5), T(500), X(500), Y(500), TI(500)
000006                COMMON QZZS(500), TAB(60,32)
000007                COMMON XCOND(20), DENS(20), QX(20)
000008                COMMON TEM(10)
000009                COMMON COND,RHO,QXX,QZZ
000010                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000011                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000012                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000013                COMMON KODE(500), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000014                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000015                COMMON IKODE(500)
000016                COMMON INTAB(20,3)
000017                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000018          C                    (TEM(4),XTEM4)
000019                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000020          C                    (ITEM(4),MTYPE)
000021                EQUIVALENCE (TI(1),TC(1))
000022                EQUIVALENCE (NN,NUMNP),(MM,MBAND)
000023                EQUIVALENCE (A(1,1),IA(1,1) )
000024                DATA NAZ/0/
000025                GO TO (1000,2000),KKK
000026          C
000027          C     REDUCE MATRIX
000028          C
000029           1000 DO 280 N=1,NN
000030                DO 270 L=2,MM
000031                IF(IA(N,L) .EQ. 0)     GO TO 270
000032                C=A(N,L)/A(N,1)
000033                I = N+L-1
000034                IF(NN-I) 260,240,240
000035            240 J=0
000036                DO 250 K=L,MM
000037                J=J+1
000038            250 A(I,J)=A(I,J)-C*A(N,K)
000039            260 A(N,L)=C
000040            270 CONTINUE
000041            280 CONTINUE
000042                GO TO 500
000043          C
000044          C     REDUCE VECTOR
000045          C
000046           2000 DO 295 N=1,NN
000047                DO 285 L=2,MM
000048                I=N+L-1
000049                IF(NN-I) 290,285,285
000050            285 Q(I)=Q(I)-A(N,L)*Q(N)
000051            290  CONTINUE
000052                IF(IA(N,1) .NE. 0)     GO TO 295
000053          C-------------------------------------------------------------------
000054          C     IF A(N,1) = 0.,PRINT ERROR MESSAGE.
000055          C
000056                NAZ  = NAZ+1
```

```
000057                IF(NAZ .GT. 100)        GO TO 295
000058                A(N,1) = 1.0
000059                WRITE (6,6000) N
000060           6000 FORMAT ('0A(',I3,',1) = 0.' )
000061               C-------------------------------------------------------------------
000062            295 Q(N) = Q(N)/A(N,1)
000063               C
000064               C     BACK SUBSTITUTION
000065               C
000066                N=NN
000067            300 N = N-1
000068                IF(N) 350,500,350
000069            350 DO 400 K=2,MM
000070                L = N+K-1
000071                IF(NN-L) 400,370,370
000072            370 Q(N) = Q(N) - A(N,K) * Q(L)
000073            400 CONTINUE
000074                GO TO 300
000075               C
000076            500 RETURN
000077               C
000078                END

      END CUR
```

PROGRAM E12205

```
000001          C-----------------------------------------------------------------
000002          C     PROGRAM E12205. PLOTS ISOTHERMS FROM OUTPUT TAPE GENERATED
000003          C     BY PROGRAM E12202.
000004                REAL*4          TARRAY(20), HEDING(12)
000005                DIMENSION IBC(900), HED(12)
000006                COMMON TA(900), TAB(60,32)
000007                COMMON INTAB(10,3), ISAVE(900,5), KODE(900)
000008                REAL*4          TIMEIS(2)/'TIME IS '/, TEMPS(2)/'TEMPS   '/
000009                COMMON /COM/  K, NUMEL, IA(1200), IB(1200), IC(1200), ID(1200),
000010               *              KA(1200), B(1200), C(1200), D(1200)
000011                COMMON /PDATA/XOR, DXL, YOR, DYL, JFLAG, ISIZE, MAXLN, ITRA
000012               1 , NXL, NYL
000013                EQUIVALENCE (KODE(1),IBC(1)),  (KSTOP,TSTOP), (HEDING(1),HED(1))
000014                EQUIVALENCE (TSTOP,ISTOP)
000015          C-----------------------------------------------------------------
000016                ISTOP = 0
000017                REWIND 2
000018          C-----------------------------------------------------------------
000019          C     READ FIRST RECORD.
000020          C-----------------------------------------------------------------
000021                READ  (2) HED, NUMNP, NUMEL, KAT, NUMMT, NTAB, ISS, IVARC
000022               1 , ((INTAB(I,J), J=1,3), TA(I), TA(I), TA(I),        I=1,NUMMT),
000023               2   ((TAB(K,L), K=1,60), KODE(L), KODE(L),   L=1,32),
000024               3  (MM,KODE(M),KODE(M), B(M), C(M),TA(M),TA(M),TA(M), M=1,NUMNP)
000025          C-----------------------------------------------------------------
000026          C     READ THE ELEMENT CARDS.
000027          C-----------------------------------------------------------------
000028                DO 4    I=1,NUMEL
000029                READ (2) N, IA(I), IB(I), IC(I), ID(I), ITYPE
000030           4    CONTINUE
000031          C-----------------------------------------------------------------
000032          C     READ THE B.C. CARDS.
000033          C-----------------------------------------------------------------
000034                READ  (2) NUMBC, IFLAGR, NF, SIGMA, (IBC(I),II,II,II,II,II,II
000035               1 , II, II, II, II, II,   I=1,NUMBC),
000036               2 ((ISAVE(I,J), J=1,NF), I=1,NF), (IBC(I), I=1,NUMNP)
000037            10 READ (5,100, END=99)  TSTART, TSTOP,
000038               1 XOR,  DXL, YOR,  DYL, NXL, NYL, JFLAG, ISIZE, MAXLN,
000039               2 NTEMP, (TARRAY(I), I=1,NTEMP)
000040                IF (ISTOP .EQ. 0)       TSTOP = 1000000.
000041          C-----------------------------------------------------------------
000042          C     MODIFY INPUT DATA FOR POSSIBLE ROUNDOFF.
000043          C-----------------------------------------------------------------
000044                TSTART = TSTART - 1.0E-6
000045                TSTOP = TSTOP   - 1.0E-6
000046          C-----------------------------------------------------------------
000047          C     SETUP THE DX AND DY FOR PLOT.
000048          C-----------------------------------------------------------------
000049                WRITE (6,200) HEDING, TSTART, TSTOP, NTEMP,(TARRAY(I), I=1,NTEMP)
000050                CALL PLSCAL (NUMNP,B,C)
000051            20 READ (2)                TIME, (D(I), I=1,NUMNP)
000052            30 IF (TIME.LT.TSTART)     GO TO 20
000053                IF (TIME.GT.TSTOP)      GO TO 40
000054                ISTOP = 0
000055                WRITE (6,400)  TIME
000056                WRITE (6,500)  (KA(I),B(I),C(I),D(I),I=1,NUMNP)
```

```
000057      C-----------------------------------------------------------------
000058      C     DRAW AXES AND LABELS.
000059      C-----------------------------------------------------------------
000060            CALL NEWFRM (HEDING)
000061      C-----------------------------------------------------------------
000062      C     DRAW GEOMETRY.
000063      C-----------------------------------------------------------------
000064            CALL PLBOUN
000065      C-----------------------------------------------------------------
000066      C     PLOT THE ISOTHERMS.
000067      C-----------------------------------------------------------------
000068            CALL PLTEMP (TARRAY,NTEMP)
000069            CALL PLTBC (TIMEIS,8,400,20,2,0)
000070            CALL PLTNU (TIME,2,600,20,2,0)
000071            CALL PLTBC (TEMPS,8,0,1000,2,0)
000072            LINELE = 1000
000073            DO 35 I=1,NTEMP
000074            LINELE = LINELE - 40
000075            CALL PLTNU (TARRAY(I),1, 0,LINELE,2,0)
000076            CALL PLTBC (I, -1, 175, LINELE, 2, 0)
000077         35 CONTINUE
000078            IF(TIME .LT. TSTOP)    GO TO 20
000079         40 ISTOP = 1
000080            GO TO 10
000081      C 999 WRITE (6,600)  TIME
000082         99 CALL PLTFIN
000083            STOP
000084      C-----------------------------------------------------------------
000085        100  FORMAT (6F10.2, 5I4/ I2,  10F7.2/ 10F7.2 )
000086        200 FORMAT ('1', 24X, 12A6/ '0 START TIME=',
000087           * F10.2,10X,'STOP TIME=',F10.2/'0NUMBER OF TEMPERATURES='I2//
000088           * (1X,10F10.2))
000089        300 FORMAT (10X,5I10)
000090        400 FORMAT (//12X,'TIME=',F10.2/12X,'NODE',13X,'R',19X,'Z',19X,'T'//)
000091        500 FORMAT (10X,I5,3F20.5)
000092        600 FORMAT ('0LAST TIME READ FROM TAPE=',F10.2)
000093            END
```

@ ELT NTAB$,1,720113, 47756

```
000001          NTAB$  10
000002          READ 5
000003          PRINT 6
000004          TAPE 2,'R'     . RECALL TAPE FOR ISOTHERMS AND NODAL PLOTS.
000005          TAPE 9,'H'     . ANSC PLOT TAPE
000006          TYPE 10
000007          END
```

```
000001            SUBROUTINE PLBOUN
000002          C-----------------------------------------------------------------
000003          C     LOCATE AND DRAW THE CONFIGURATION.
000004          C-----------------------------------------------------------------
000005          C     GIVEN- N1 AND N2                                        00194000
000006          C            MULTIPLY N2 BY 10**(-3)                          00195000
000007          C            ADD N1 AND N2                                    00196000
000008          C            R=N1+N2= XXX.YYY
000009                INTEGER*4      NS(5)
000010                REAL*4         G(1000), R1(2), Z1(2)
000011                COMMON /COM/   K, NUMEL, IA(1200), IB(1200), IC(1200), ID(1200),
000012               *               KA(1200), B(1200), C(1200), D(1200)
000013                COMMON /PDATA/XOR, DXL, YOR, DYL, JFLAG, ISIZE, MAXLN, ITRA
000014               1 , NXL, NYL
000015          C-----------------------------------------------------------------
000016                K=0                                                     00204000
000017                DO 10 I=1,NUMEL
000018                NS(1)=IA(I)                                             00206000
000019                NS(2)=IB(I)                                             00206100
000020                NS(3)=IC(I)                                             00206200
000021                NS(4)=ID(I)                                             00206300
000022                NS(5)=NS(1)                                             00207000
000023                DO 11 J=1,4                                             00208000
000024                IF (NS(J+1)-NS(J)) 7,11,8
000025           7    R = FLOAT(NS(J+1)) + FLOAT(NS(J))/1000.
000026                GO TO 9                                                 00212000
000027           8    R = FLOAT(NS(J)) + FLOAT(NS(J+1))/1000.
000028             9  IF (K) 16,16,12                                         00215000
000029            12  DO 13 L=1,K                                            00216000
000030                IF ((R+.0001)-G(L)) 13,14,14
000031            14  IF (G(L)-(R-.0001)) 13,15,15                           00218000
000032            15  G(L)=-1.                                               00219000
000033                GO TO 11                                                00220000
000034            13  CONTINUE                                               00221000
000035            16  K=K+1
000036                G(K)=R                                                  00223000
000037            11  CONTINUE                                               00224000
000038                J=0                                                     00225000
000039                DO 17 L=1,K                                             00226000
000040                IF (G(L)) 18,18,19                                      00227000
000041            18  J=J+1
000042                GO TO 17                                                00229000
000043            19  IF (J) 17,17,20                                        00230000
000044            20  LL=L-J                                                 00231000
000045                G(LL)=G(L)                                              00232000
000046            17  CONTINUE                                               00233000
000047                K=K-J                                                   00234000
000048            10  CONTINUE                                               00235000
000049          C-----------------------------------------------------------------
000050                WRITE (6,110) (G(I),I=1,K)
000051           110  FORMAT (//(10F10.3))                                   00239000
000052                DO 30 I=1,K
000053                N1=IFIX(G(I))                                           00254000
000054                R = ( G(I) - FLOAT(N1) + 0.0005 )*1000.
000055                N2=IFIX(R)                                              00256000
000056                R1(1)=B(N1)                                             00256100
```

```
000057              R1(2)=B(N2)                                          00256200
000058              Z1(1)=C(N1)                                          00256300
000059              Z1(2)=C(N2)                                          00256400
000060              GO TO (24,26), ITRA
000061           24 WRITE (6,100) N1, N2, G(I), R1, R1
000062              CALL PLTPT (0,2,4,4, 0,1,R1(1),Z1(1))
000063              GO TO 30
000064           26 WRITE (6,100) N1, N2, G(I), Z1, R1
000065              CALL PLTPT (0,2,4,4, 0,1,Z1(1),R1(1))
000066           30 CONTINUE
000067              RETURN                                               00262000
000068          100 FORMAT (5X,2I5,5F15.5)
000069              END                                                  00263000
```

```
000001            SUBROUTINE PLSCAL (NUMNP,B,C)
000002          C-------------------------------------------------------------------
000003          C     SET-UP THE COORDINATE SYSTEM.
000004          C-------------------------------------------------------------------
000005            DIMENSION        HEDING(12), B(1200), C(1200), CONST(10)
000006            DATA CONST/1.,1.25,1.5,2.0,2.5,4.0,5.0,6.0,8.0,10.0/                12401826
000007            COMMON /PDATA/XOR, DXL, YOR, DYL, JFLAG, ISIZE, MAXLN, ITRA
000008           1 , NXL, NYL
000009            EQUIVALENCE (DXL,IXL), (DYL,IYL), (XORI,RORI), (YORI,ZORI)
000010          C-------------------------------------------------------------------
000011            IFLAG  = 0
000012            XORI = XOR
000013            YORI = YOR
000014            XLAB = DXL
000015            YLAB = DYL
000016            NXLAB  = NXL*100
000017            NYLAB  = NYL*100
000018            IF(NXL .EQ. 0)          NXLAB = 150
000019            IF(NYL .EQ. 0)          NYLAB = 150
000020            IF(MAXLEN .EQ. 0)       MAXLEN = 3300
000021            IF( (IXL .NE. 0) .AND. (IYL .NE. 0))       GO TO 40
000022            RMIN =  1000000.0
000023            RMAX = -1000000.0
000024            ZMIN =  1000000.0
000025            ZMAX = -1000000.0
000026            DO 5    I=1,NUMNP
000027            IF (B(I).GT.RMAX)     RMAX = B(I)
000028            IF (B(I).LT.RMIN)     RMIN = B(I)
000029            IF (C(I).GT.ZMAX)     ZMAX = C(I)
000030            IF (C(I).LT.ZMIN)     ZMIN = C(I)
000031          5 CONTINUE
000032            RRANG=ABS(RMAX-RMIN)
000033            ZRANG  = ABS(ZMAX-ZMIN)
000034            IF(ZRANG .GT. RRANG)    IFLAG = 1
000035          C-------------------------------------------------------------------
000036            XORI = RMIN
000037            YORI = ZMIN
000038            TEST     = (ZMAX-ZMIN)*.18
000039            IF(IFLAG .GT. 0)        TEST = (RMAX-RMIN)*0.18
000040            FACT = 1.0                                                          12401841
000041         10 IF(TEST.LT.10.0)        GO TO 12                                  12401842
000042            TEST = TEST/10.                                                     12401843
000043            FACT = FACT*10.                                                     12401844
000044            GO TO 10                                                          12401845
000045         12 IF(TEST.GE.1.0)         GO TO 14                                  12401846
000046            TEST = TEST*10.                                                     12401847
000047            FACT = FACT/10.                                                     12401848
000048            GO TO 12                                                          12401849
000049         14 DO 16   I=1,10                                                    12401850
000050            DELT = CONST(I)                                                   12401851
000051            IF(TEST.LE.DELT )       GO TO 25                                  12401852
000052         16 CONTINUE                                                          12401853
000053         25 CONTINUE
000054            SIZE = 1.0
000055            IF(ISIZE .GT. 0)        SIZE = 3.0
000056            YLAB = DELT*FACT/SIZE
```

```
000001            SUBROUTINE PLSCAL (NUMNP,B,C)
000002          C-------------------------------------------------------------------
000003          C     SET-UP THE COORDINATE SYSTEM.
000004          C-------------------------------------------------------------------
000005            DIMENSION        HEDING(12), B(1200), C(1200), CONST(10)
000006            DATA CONST/1.,1.25,1.5,2.0,2.5,4.0,5.0,6.0,8.0,10.0/              12401826
000007            COMMON /PDATA/XOR, DXL, YOR, DYL, JFLAG, ISIZE, MAXLN, ITRA
000008           1 , NXL, NYL
000009            EQUIVALENCE (DXL,IXL), (DYL,IYL), (XORI,RORI), (YORI,ZORI)
000010          C-------------------------------------------------------------------
000011            IFLAG  = 0
000012            XORI = XOR
000013            YORI = YOR
000014            XLAB = DXL
000015            YLAB = DYL
000016            NXLAB  = NXL*100
000017            NYLAB  = NYL*100
000018            IF(NXL .EQ. 0)          NXLAB = 150
000019            IF(NYL .EQ. 0)          NYLAB = 150
000020            IF(MAXLEN .EQ. 0)       MAXLEN = 3300
000021            IF( (IXL .NE. 0) .AND. (IYL .NE. 0))       GO TO 40
000022            RMIN =  1000000.0
000023            RMAX = -1000000.0
000024            ZMIN =  1000000.0
000025            ZMAX = -1000000.0
000026            DO 5    I=1,NUMNP
000027            IF (B(I).GT.RMAX)     RMAX = B(I)
000028            IF (B(I).LT.RMIN)     RMIN = B(I)
000029            IF (C(I).GT.ZMAX)     ZMAX = C(I)
000030            IF (C(I).LT.ZMIN)     ZMIN = C(I)
000031          5 CONTINUE
000032            RRANG=ABS(RMAX-RMIN)
000033            ZRANG  = ABS(ZMAX-ZMIN)
000034            IF(ZRANG .GT. RRANG)    IFLAG = 1
000035          C-------------------------------------------------------------------
000036            XORI = RMIN
000037            YORI = ZMIN
000038            TEST     = (ZMAX-ZMIN)*.18
000039            IF(IFLAG .GT. 0)        TEST = (RMAX-RMIN)*0.18
000040            FACT = 1.0                                                        12401841
000041         10 IF(TEST.LT.10.0)        GO TO 12                                  12401842
000042            TEST = TEST/10.                                                   12401843
000043            FACT = FACT*10.                                                   12401844
000044            GO TO 10                                                          12401845
000045         12 IF(TEST.GE.1.0)         GO TO 14                                  12401846
000046            TEST = TEST*10.                                                   12401847
000047            FACT = FACT/10.                                                   12401848
000048            GO TO 12                                                          12401849
000049         14 DO 16   I=1,10                                                    12401850
000050            DELT = CONST(I)                                                   12401851
000051            IF(TEST.LE.DELT )       GO TO 25                                  12401852
000052         16 CONTINUE                                                          12401853
000053         25 CONTINUE
000054            SIZE = 1.0
000055            IF(ISIZE .GT. 0)        SIZE = 3.0
000056            YLAB = DELT*FACT/SIZE
```

```
000057              XLAB = YLAB
000058              TEST = XORI/XLAB
000059           30 TEST   = AINT(TEST)                                    12401859
000060              XORI = XLAB*TEST
000061              IF(XORI .GT. RMIN)      XORI = XORI-XLAB
000062           32 TEST = YORI/YLAB
000063           34 TEST   = AINT(TEST)                                    12401862
000064              YORI = YLAB*TEST
000065              IF(YORI .GT. ZMIN)      YORI = YORI-YLAB
000066              IF(IFLAG .GT. 0)        GO TO 37
000067              FACT = (RMAX-XORI)/XLAB*FLOAT(NXLAB) + 400
000068              GO TO 38
000069           37 FACT = (ZMAX-YORI)/YLAB*FLOAT(NYLAB) + 400
000070           38 MAXLEN = FACT
000071              IF(MAXLEN .LE. 4000)    GO TO 40
000072              IF(IFLAG .GT. 0)        GO TO 39
000073              XLAB = XLAB*FACT/4000.
000074              GO TO 40
000075           39 YLAB = YLAB*FACT/4000.
000076           40 CONTINUE
000077              RETURN
000078            C-------------------------------------------------------------
000079              ENTRY NEWFRM (HEDING)
000080              IF(JFLAG .GT. 0)        IFLAG = JFLAG
000081              ITRA = 1
000082              IF(IFLAG .GT. 0)        ITRA = 2
000083              IF(IXL .EQ. 0)          GO TO 42
000084              XLAB = DXL
000085              RORI = XOR
000086           42 IF(IYL .EQ. 0)          GO TO 44
000087              YLAB = DYL
000088              ZORI = YOR
000089           44 CONTINUE
000090              IF(MAXLN .GT. 0)        MAXLEN = 100*MAXLN
000091              IF(NXL .GT. 0)          NXLAB = NXL
000092              IF(NYL .GT. 0)          NYLAB = NYL
000093              MXRS = MAXLEN
000094              IF(ISIZE .GT. 0)        MXRS  = -MXRS
000095              IF (IFLAG .GT. 0)       GO TO 50
000096              CALL PLTSU (0, RORI, ZORI, 400, 150, XLAB, YLAB, NXLAB, NYLAB,2,2,
000097             1 150, 175, MXRS, 0, 0)
000098              GO TO 60
000099           50 CONTINUE
000100              CALL PLTSU (0, ZORI, RORI, 400, 150, YLAB, XLAB, NYLAB, NXLAB,2,2,
000101             1 150, 175, MXRS, 0, 0)
000102           60 CONTINUE
000103              CALL PLTBC (HEDING, 72, 400,  70, 2, 0)
000104              RETURN
000105          101 FORMAT(2F15.5)                                         00071000
000106              END                                                    00073000
```

```
000001            SUBROUTINE PLTEMP (TARAY,NTEMP)
000002          C-------------------------------------------------------------------
000003          C     PLOT THE ISOTHERMS.
000004          C-------------------------------------------------------------------
000005            DIMENSION NS(5),R(5),Z(5),T(5),TARAY(20),DATA(20,2,2)              00271000
000006            DIMENSION PT(2),PS(2)                                            00271500
000007            COMMON /COM/  K, NUMEL, IA(1200), IB(1200), IC(1200), ID(1200),
000008           *              KA(1200), B(1200), C(1200), D(1200)
000009            COMMON /PDATA/XOR, DXL, YOR, DYL, JFLAG, ISIZE, MAXLN, ITRA
000010           1 , NXL, NYL
000011          C-------------------------------------------------------------------
000012            WRITE (6,100)
000013            DO 40 I=1,NUMEL                                                  00275000
000014            DO 8 J=1,NTEMP                                                   00276000
000015          8 DATA(J,1,1)=-1.                                                  00277000
000016            NS(1)=IA(I)                                                      00278000
000017            NS(2)=IB(I)                                                      00278100
000018            NS(3)=IC(I)                                                      00278200
000019            NS(4)=ID(I)                                                      00278300
000020            DO 10 J=1,4                                                      00279000
000021            K=NS(J)                                                          00280000
000022            N=KA(K)                                                          00281000
000023            R(J)=B(K)                                                        00281100
000024            Z(J)=C(K)                                                        00281200
000025         10 T(J)=D(K)                                                        00281300
000026            R(5)=R(1)                                                        00282000
000027            Z(5)=Z(1)                                                        00283000
000028            T(5)=T(1)                                                        00284000
000029            DO 30 J=1,4                                                      00285000
000030            IF (T(J)-T(J+1)) 11,12,12
000031         11 I1=J                                                             00287000
000032            I2=J+1
000033            GO TO 13                                                         00289000
000034         12 I1=J+1
000035            I2=J                                                             00291000
000036         13 DO 20 K=1,NTEMP                                                  00292000
000037            IF (T(I1)-TARAY(K)) 22,22,20                                     00293000
000038         20 CONTINUE                                                         00294000
000039            GO TO 30                                                         00295000
000040         22 K1=K                                                             00296000
000041            DO 23 K=1,NTEMP                                                  00297000
000042            IF (T(I2)-TARAY(K)) 25,25,23                                     00298000
000043         23 CONTINUE                                                         00299000
000044            K2 = NTEMP
000045            GO TO 26                                                         00301000
000046         25 K2=K-1                                                           00302000
000047         26 IF (K2-K1) 30,27,27                                              00303000
000048         27 TDIST=SQRT((R(I1)-R(I2))**2+(Z(I1)-Z(I2))**2)
000049            DO 38 K=K1,K2
000050            TTEMP=T(I2)-T(I1)                                                00306000
000051            CTEMP=TARAY(K)-T(I1)                                             00307000
000052            PERCT=CTEMP/TTEMP                                                00308000
000053            RDIST=PERCT*ABS(R(I1)-R(I2))                                     00309000
000054            ZDIST=PERCT*ABS(Z(I1)-Z(I2))                                     00310000
000055            IF (DATA(K,1,1)) 35,36,36                                        00311000
000056         35 KK=1                                                             00312000
```

```
000057            GO TO 37                                                00313000
000058         36 KK=2                                                    00314000
000059         37 IF (R(I1)-R(I2)) 29,29,31                               00315000
000060         29 DATA(K,KK,1)=R(I1)+RDIST
000061            GO TO 32                                                00317000
000062         31 DATA(K,KK,1)=R(I1)-RDIST                                00318000
000063         32 IF (Z(I1)-Z(I2)) 33,33,34                               00319000
000064         33 DATA(K,KK,2)=Z(I1)+ZDIST
000065            GO TO 38
000066         34 DATA(K,KK,2)=Z(I1)-ZDIST                                00322000
000067         38 CONTINUE
000068         30 CONTINUE                                                00323000
000069            DO 40 K=1,NTEMP                                         00324000
000070            IF (DATA(K,1,1)) 40,39,39                               00325000
000071         39 PT(1)=DATA(K,2,2)                                       00325500
000072            PT(2)=DATA(K,1,2)                                       00326000
000073            PS(1)=DATA(K,2,1)                                       00326500
000074            PS(2)=DATA(K,1,1)                                       00327000
000075            GO TO (50,52),ITRA
000076         50 CALL PLTPT (0, 2, 4, 4, K, 1, PS(1), PT(1))
000077            GO TO 54
000078         52 CALL PLTPT (0, 2, 4, 4, K, 1, PT(1), PS(1))
000079         54 CONTINUE
000080            WRITE (6,200)   PT(1), PS(1), PT(2), PS(2), K
000081         40 CONTINUE                                                00330000
000082            RETURN                                                  00332000
000083        100 FORMAT ('0ISOTHERMS PLOTTED'//18X,'R',19X,'Z',19X,'R',19X,'Z',
000084           *  4X,'TEMP'/84X,'NO.'//)
000085        200 FORMAT (1X,4F20.5,I5)
000086            END                                                     00333000
```

```
000001              SUBROUTINE PLTSU (MOVEON,XORIG,  YORIG,  NXPLOT,NYPLOT,XLABLD,
000002             1 YLABLD,NXLAB,NYLAB,NXFRAC,NYFRAC,NXLINE,NYLINE,
000003             2 MAXX,NXSCAL,NYSCAL)
000004              DATA IPLOTF, NPLOTS /0,0/
000005              DIMENSION IBUF(1000)
000006            C-------------------------------------------------------------------
000007              IF(IPLOTF .EQ. 1)       GO TO 10
000008              REWIND 9
000009              CALL PLOTS (IBUF,1000,9)
000010            C-------------------------------------------------------------------
000011            C     CONVERT OFF-SET ORIGIN TO INCHES.
000012            C-------------------------------------------------------------------
000013              IPLOTF = 1
000014              NPLOTS = 0
000015              XCONST = 0.
000016              GO TO 15
000017            C10   XLEN = MAXLEN
000018            C     CALL PLOT (XLEN,0.,998)
000019               10 CONTINUE
000020              IF(MOVEON .EQ. 1)       GO TO 15
000021              XCONST = XCONST + FLOAT(MAXLEN)
000022               15 NPLOTS = NPLOTS+1
000023              SCALEX = 1.
000024              SCALEY = 1.
000025              IF(NXSCAL .NE. 0)       SCALEX = 10.**NXSCAL
000026              IF(NYSCAL .NE. 0)       SCALEY = 10.**NYSCAL
000027              XORIGN = XORIG*SCALEX
000028              YORIGN = YORIG*SCALEY
000029              XORI = FLOAT(NXPLOT)/100.
000030              YORI = FLOAT(NYPLOT)/100.
000031              DXL  = FLOAT(NXLAB )/100.
000032              DYL  = FLOAT(NYLAB )/100.
000033              DELTAX = XLABLD/DXL*SCALEX
000034              DELTAY = YLABLD/DYL*SCALEY
000035              MAXLEN = IABS(MAXX)/100 + 2
000036            C-------------------------------------------------------------------
000037            C     SET-UP NEW LOGICAL ORIGIN.
000038            C-------------------------------------------------------------------
000039              XORIG = XORI+XCONST
000040              CALL PLOT (XORIG,YORI,-3)
000041              LEN  = (IABS(MAXX)-NXPLOT+99)
000042            C-------------------------------------------------------------------
000043            C     CONVERT LENGTH OF X-AXIS TO INCHES.
000044            C-------------------------------------------------------------------
000045              ITICK  = LEN/NXLAB + 1
000046              XLEN = FLOAT(ITICK-1)*DXL
000047              XL   = XLEN + DXL
000048              XV = FLOAT(ITICK)  *XLABLD + XORIGN
000049              HEIGHT = 0.0007*FLOAT(NXLAB)
000050            C-------------------------------------------------------------------
000051            C     DRAW X-AXIS
000052            C-------------------------------------------------------------------
000053              CALL PLOT (0.,0.,3)
000054              CALL PLOT (XLEN,0.,2)
000055            C-------------------------------------------------------------------
000056            C     DRAW TICK MARKS AND LABELS.
```

```
000057      C-------------------------------------------------------------------
000058      C-------------------------------------------------------------------
000059            WRITE (6,6000) NPLOTS, XORI, YORI, XLEN, DXL, XORIGN,  YORIGN,
000060           1   ITICK
000061      C-------------------------------------------------------------------
000062            DO 100  I=1,ITICK
000063            XL = XL - DXL
000064            CALL PLOT (XL,0.,3)
000065            CALL PLOT(XL,-0.14,2)
000066            XV = XV-XLABLD
000067            CALL NUMBER (XL,-.25,HEIGHT,XV,0.,NXFRAC)
000068       100  CONTINUE
000069      C-------------------------------------------------------------------
000070      C     DRAW Y-AXIS.
000071      C-------------------------------------------------------------------
000072            YLEN = 1000.
000073            IF(MAXX .LT. 0)        YLEN = 2850.
000074            YLEN = YLEN - YORI
000075            ITICK = IFIX(YLEN)/NYLAB + 1
000076            YLEN = FLOAT(ITICK-1)*DYL
000077            YL = YLEN+DYL
000078            YV = FLOAT(ITICK)  *YLABLD + YORIGN
000079            HEIGHT = 0.0007*FLOAT(NYLAB)
000080            CALL PLOT (0.,0.,3)
000081            CALL PLOT (0.,YLEN,2)
000082            DO 110  I=1,ITICK
000083            YL = YL - DYL
000084            CALL PLOT (0.,YL,3)
000085            CALL PLOT (-.14,YL,2)
000086            YV = YV-YLABLD
000087            CALL NUMBER (-0.25,YL,HEIGHT,YV,90.,NYFRAC)
000088       110  CONTINUE
000089            RETURN
000090      C-------------------------------------------------------------------
000091            ENTRY PLTBC (BCI,NUMBCI,NXBEGN,NYBEGN,ISIZE,IVERT)
000092      C-------------------------------------------------------------------
000093      C     CONVERT TO INCHES.
000094      C-------------------------------------------------------------------
000095            XPAGE  = FLOAT(NXBEGN)/100.-XORI
000096            YPAGE  = FLOAT(NYBEGN)/100.-YORI
000097            NCHAR  = NUMBCI
000098            ANGLE  = 0.
000099            IF(IVERT .EQ. 1)       ANGLE = 90.
000100            HEIGHT = FLOAT(ISIZE)*0.10
000101            CALL SYMBOL (XPAGE,YPAGE,HEIGHT,BCI,ANGLE,NCHAR)
000102            RETURN
000103      C-------------------------------------------------------------------
000104            ENTRY PLTPT (IPLOT,NUMPT,INCX,INCY,ICODE,INCSYM,X,Y)
000105      C-------------------------------------------------------------------
000106            DIMENSION XARRAY(102),YARRAY(102),X(1), Y(1)
000107      C-------------------------------------------------------------------
000108            INTEQ  = ICODE
000109            LINTYP = INCSYM
000110            IF(IPLOT .EQ. 1)       LINTYP = - LINTYP
000111            ICOUNT = NUMPT
000112            IX = INCX/4
000113            IY = INCY/4
000114            II = 1
000115            JJ = 1
000116            XARRAY(1)  = X(1)*SCALEX
```

```
000117            YARRAY(1)  = Y(1)*SCALEY
000118       200  NPTS = 100
000119            IF(ICOUNT .LT. 100)    NPTS = ICOUNT
000120            ICOUNT = ICOUNT-100
000121            DO 210  I=2,NPTS
000122            II = II+IX
000123            JJ = JJ+IY
000124            XARRAY(I)  = X(II)*SCALEX
000125            YARRAY(I)  = Y(II)*SCALEY
000126       210  CONTINUE
000127            XARRAY(NPTS+1) = XORIGN
000128            XARRAY(NPTS+2) = DELTAX
000129            YARRAY(NPTS+1) = YORIGN
000130            YARRAY(NPTS+2) = DELTAY
000131             CALL LINE (XARRAY,YARRAY,NPTS,1,  LINTYP,INTEG)
000132            XARRAY(1)  = XARRAY(100)
000133            YARRAY(1)  = YARRAY(100)
000134            IF(ICOUNT .GT. 0)      GO TO 200
000135            RETURN
000136       C-------------------------------------------------------------------
000137            ENTRY PLTNU (XLOC,NUMDEC,NXLOC,NYLOC,ISIZE,IVERT)
000138       C-------------------------------------------------------------------
000139            XORR = FLOAT (NXLOC)/100. - XORI
000140            YORR = FLOAT (NYLOC)/100. - YORI
000141            HEIGHT = FLOAT (ISIZE)*.12
000142            ANGLE  = 0.
000143            IF(IVERT .GT. 0)       ANGLE = 90.
000144            CALL NUMBER (XORR,YORR,HEIGHT,XLOC,ANGLE,NUMDEC)
000145            RETURN
000146       C-------------------------------------------------------------------
000147            ENTRY PLTFIN
000148       C-------------------------------------------------------------------
000149            XLEN = MAXLEN
000150            CALL PLOT (XLEN,0.,999)
000151            REWIND 9
000152            WRITE (6,9000)
000153            WRITE (10,9000)
000154       6000 FORMAT ('1 ENTRY PLTSU, PLOT NO.',I3/ '  X-ORIG DIST = ', F10.6/
000155           1 '  Y-ORIG DIST = ', F10.6 / '  PLOT SIZE = ', F10.4, ' INCHES'/
000156           2 '  TICK MARK INCR. = ', F10.6,' INCHES'/ '  1ST TICK MARK AT : '/
000157           3   '  X = ', F10.6, '   Y = ', F10.6 /
000158           4 '  NO. OF TICK MARKS ON X-AXIS = ', I6 )
000159       9000 FORMAT ('0FILE CLOSED ON TAPE H,DISMOUNT AND SEND TO ANSC,SACRAMEN
000160           1TO. THANK YOU.' )
000161            END
```

PROGRAM E12206

```
000001      C-------------------------------------------------------------------
000002            DIMENSION IBC(500), HED(12)
000003            COMMON TA(500), TAB(60,32)
000004            COMMON INTAB(10,3), ISAVE(500,5), KODE(500)
000005            COMMON/PLTTS/ NPT ,NNODE, PTIME(1000), PNODE(1000,10), NODE(10)
000006            REAL*4        HEDING(12), TC(500)
000007            INTEGER*4     ISTOP/0/, IEOF/0/
000008            EQUIVALENCE (KODE(1),IBC(1)),  (KSTOP,TSTOP), (HEDING(1),HED(1))
000009      C-------------------------------------------------------------------
000010         10 NPT = 0
000011            REWIND 2
000012            READ (5,100,END=99,ERR=999) TSTART, TSTOP
000013            IF(KSTOP .EQ.  0)    TSTOP = 1000000.0
000014      C-------------------------------------------------------------------
000015      C     MODIFY INPUT DATA FOR POSSIBLE ROUNDOFF.
000016      C-------------------------------------------------------------------
000017            TSTART = TSTART - 1.0E-6
000018            TSTOP = TSTOP   - 1.0E-6
000019      C-------------------------------------------------------------------
000020      C     READ FIRST RECORD.
000021      C-------------------------------------------------------------------
000022            READ  (2) HED, NUMNP, NUMEL
000023      C-------------------------------------------------------------------
000024      C     READ THE ELEMENT CARDS.
000025      C-------------------------------------------------------------------
000026            DO 4   I=1,NUMEL
000027            READ  (2)
000028          4 CONTINUE
000029      C-------------------------------------------------------------------
000030      C     READ THE B.C.CARDS.
000031      C-------------------------------------------------------------------
000032            READ  (2)
000033            WRITE (6,6000) HEDING, TSTART, TSTOP
000034            CALL PLOTA (HEDING)
000035            IF (ISTOP.GT.0)       GO TO 30
000036         20 READ (2)              TIME, (TC(I),I=1,NUMNP)
000037         30 IF (TIME.LT.TSTART)   GO TO 20
000038            IF (TIME.GT.TSTOP)    GO TO 80
000039            NPT = NPT + 1
000040            PTIME(NPT) = TIME
000041            DO 40 I=1,NNODE
000042            K  = NODE(I)
000043         40 PNODE(NPT,I) = TC(K)
000044            IF (NPT.LT.1000)      GO TO 20
000045            ISTOP = 0
000046         50 CONTINUE
000047            I2 = 0
000048            I3 = (NPT +9)/10
000049            DO 65   II=1,I3
000050            I1 = I2 + 1
000051            I2 = I2+10
000052            IF(I2 .GT. NPT )        I2 = NPT
000053            WRITE (6,200)  (PTIME(I), I=I1,I2)
000054            DO 60  J=1,NNODE
000055         60 WRITE (6,300) (PNODE(I,J), I=I1,I2)
000056         65 CONTINUE
```

```
000057              CALL PLOTB
000058              IF (ISTOP.GT.0)       GO TO 10
000059              IF (IEOF.GT.0)        GO TO 1000
000060              PTIME(1) = PTIME(NPT)
000061              DO 70 I=1,NNODE
000062           70 PNODE(1,I) = PNODE(NPT,I)
000063              NPT = 1
000064              GO TO 20
000065           80 ISTOP = 1
000066              GO TO 50
000067          999 IEOF = 1
000068              GO TO 50
000069         1000 WRITE (6,400)          TIME
000070           99 CALL PLTFIN
000071.             STOP
000072          100 FORMAT (2F10.2)
000073          200 FORMAT ('0TIMES=',10F10.2)
000074          300 FORMAT (' TEMPS=',10F10.2)
000075          400 FORMAT ('0LAST TIME READ FROM TAPE=',F10.2)
000076         6000 FORMAT ('1NODAL PLOTS OF ',12A6/ '0START TIME = ', F12.4 ,
000077             1 '  STOP TIME = ', F12.4 )
000078              END
```

@ ELT NTAB$,1,720218, 54912

```
000001          NTAB$  10
000002          TAPE 2,'R'     . RECALL TAPE FOR ISOTHERMS AND NODAL PLOTS.
000003          READ 5
000004          PRINT 6
000005          TAPE 9,'H'     . LOCAL PLOT
000006          END
```

```
000001              SUBROUTINE PLOTA(TITLE)                                          FEMT1463
000002              DIMENSION BCY(3),ICODE(10),TITLE(10),CODE(3)                     FEMT1464
000003              COMMON/PLTTS/ NPT ,NNODE, PTIME(1000), PNODE(1000,10), NODE(10)
000004              EQUIVALENCE (NXLAB,NYLAB),(INCX,INCY,NXBC)                       FEMT1466
000005              EQUIVALENCE (NYBX,NXLX1)                                         FEMT1467
000006              EQUIVALENCE (MOVE,NXFR,NYFR,NXS,NYS,IVERT,NUMD )                 FEMT1468
000007              EQUIVALENCE (IXLAB,XLAB), (IYLAB,YLAB)
000008              DATA MAXX,MOVE,NXP,NYP,NXLAB,NYL,INCX,INCSYM,ISIZE,NYBC,NXBX,NYBX,FEMT1469
000009             1 NXBY,NYBY,NXLX2,NXL                                             FEMT1470
000010             2 /2400,0,400,100,100,380,4,10,2,12,600,50,350,500,150,80/
000011              DATA ICODE(1),ICODE(2),ICODE(3),ICODE(4),ICODE(5),ICODE(6),      FEMT1472
000012             1 ICODE(7),ICODE(8),ICODE(9),ICODE(10)/0,1,2,3,4,5,6,7,8,9/      FEMT1473
000013              DATA BCX/'TIME'/,BCY(1)/'TEMPER'/,BCY(2)/'ATURE '/
000014              DATA CODE(1)/'CODE N'/, CODE(2)/'ODE   '/
000015            C-------------------------------------------------------------------FEMT1476
000016            C     SETUP PLOT FRAME.                                            FEMT1477
000017            C-------------------------------------------------------------------FEMT1478
000018              READ (5,5000,END=110) XORI,XLAB,YORI,YLAB,(NODE(I), I=1,10)
000019              NNODE  = 0                                                       FEMT1481
000020              DO 10  I=1,10                                                    FEMT1482
000021              IF(NODE(I) .EQ. 0)      GO TO 20                                 FEMT1483
000022           10 NNODE  = NNODE+1                                                 FEMT1484
000023           20 IF(IXLAB .EQ. 0)        XLAB = 10.
000024              IF(IYLAB .EQ. 0)        YLAB = 500.
000025              WRITE (6,6010) XORI, XLAB, YORI, YLAB, (NODE(I), I=1,NNODE)
000026              CALL PLTSU (MOVE,XORI,YORI,NXP,NYP,XLAB,YLAB,NXLAB,NYLAB,NXFR,NYFRFEMT1487
000027             1 ,NXL,NYL,MAXX,NXS,NYS )                                        FEMT1488
000028              CALL PLTBC (BCX,NXBC,NXBX,NYBX,ISIZE,IVERT )                     FEMT1489
000029              CALL PLTBC (BCY,NYBC,NXBY,NYBY,ISIZE,ICODE(2) )                  FEMT1490
000030              CALL PLTBC (TITLE,72,400,1000,ISIZE,IVERT )                      FEMT1491
000031              NYLY   = 800                                                     FEMT1492
000032              CALL PLTBC (CODE,NYBC,NXLX1,NYLY,ISIZE,IVERT )                   FEMT1493
000033            C-------------------------------------------------------------------FEMT1494
000034            C     SETUP CODES FOR NODES.                                       FEMT1495
000035            C-------------------------------------------------------------------FEMT1496
000036              DO 40  NN=1,NNODE                                                FEMT1497
000037              NYLY   = NYLY-NXLX1                                              FEMT1498
000038              CALL PLTBC (ICODE(NN),-1,  NXLX1,NYLY,ISIZE,IVERT)
000039              REAL = NODE(NN)
000040              CALL PLTNU (REAL,    NUMD,NXLX2,NYLY,ISIZE,IVERT )
000041           40 CONTINUE                                                         FEMT1501
000042           50 RETURN                                                           FEMT1502
000043            C-------------------------------------------------------------------FEMT1503
000044            C     PLOT POINTS.                                                 FEMT1504
000045            C-------------------------------------------------------------------FEMT1505
000046              ENTRY PLOTB                                                      FEMT1506
000047              INCSYM = 8
000048              DO 100  NN=1,NNODE                                               FEMT1507
000049              INCSYM = INCSYM+2
000050              NCODE = NN - 1
000051              CALL PLTPT (NUMD,NPT,INCX,INCY,NCODE,    INCSYM,PTIME,
000052             1 PNODE(1,NN) )                                                   FEMT1509
000053          100 CONTINUE                                                         FEMT1510
000054              RETURN
000055          110 CONTINUE
000056              CALL PLTFIN                                                      FEMT1513
```

```
000057            STOP
000058         5000 FORMAT (4F10.4,10I3 )                                    FEMT1480
000059         6010 FORMAT ('0TIME = ', E14.6, '  DELTA-TIME = ', E14.6  /
000060             1 '0TEMPERATURE = ', E14.6, '  DELTA-TEMP. = ', E14.6 /
000061             2 '0NODES TO BE PLOTTED.', 10I5 )
000062            END                                                        FEMT1515
```

```
000001              SUBROUTINE PLTSU (MOVEON,XORIG,  YORIG,  NXPLOT,NYPLOT,XLABLD,
000002             1 YLABLD,NXLAB,NYLAB,NXFRAC,NYFRAC,NXLINE,NYLINE,
000003             2 MAXX,NXSCAL,NYSCAL)
000004              DATA IPLOTF, NPLOTS /0,0/
000005              DIMENSION IBUF(1000)
000006            C-------------------------------------------------------------------
000007              IF(IPLOTF .EQ. 1)      GO TO 10
000008              REWIND 9
000009              CALL PLOTS (IBUF,1000,9)
000010            C-------------------------------------------------------------------
000011            C     CONVERT OFF-SET ORIGIN TO INCHES.
000012            C-------------------------------------------------------------------
000013              IPLOTF = 1
000014              NPLOTS = 0
000015              XCONST = 0.
000016              GO TO 15
000017            C10   XLEN = MAXLEN
000018            C     CALL PLOT (XLEN,0.,998)
000019             10   CONTINUE
000020              IF(MOVEON .EQ. 1)      GO TO 15
000021              XCONST = XCONST + FLOAT(MAXLEN)
000022             15   NPLOTS = NPLOTS+1
000023              SCALEX = 1.
000024              SCALEY = 1.
000025              IF(NXSCAL .NE. 0)      SCALEX = 10.**NXSCAL
000026              IF(NYSCAL .NE. 0)      SCALEY = 10.**NYSCAL
000027              XORIGN = XORIG*SCALEX
000028              YORIGN = YORIG*SCALEY
000029              XORI = FLOAT(NXPLOT)/100.
000030              YORI = FLOAT(NYPLOT)/100.
000031              DXL  = FLOAT(NXLAB )/100.
000032              DYL  = FLOAT(NYLAB )/100.
000033              DELTAX = XLABLD/DXL*SCALEX
000034              DELTAY = YLABLD/DYL*SCALEY
000035              MAXLEN = IABS(MAXX)/100 + 2
000036            C-------------------------------------------------------------------
000037            C     SET-UP NEW LOGICAL ORIGIN.
000038            C-------------------------------------------------------------------
000039              XORIG = XORI+XCONST
000040              CALL PLOT (XORIG,YORI,-3)
000041              LEN  = (IABS(MAXX)-NXPLOT+99)
000042            C-------------------------------------------------------------------
000043            C     CONVERT LENGTH OF X-AXIS TO INCHES.
000044            C-------------------------------------------------------------------
000045              ITICK  = LEN/NXLAB + 1
000046              XLEN = FLOAT(ITICK-1)*DXL
000047              XL   = XLEN + DXL
000048              XV = FLOAT(ITICK)  *XLABLD + XORIGN
000049              HEIGHT = 0.0007*FLOAT(NXLAB)
000050            C-------------------------------------------------------------------
000051            C     DRAW X-AXIS
000052            C-------------------------------------------------------------------
000053              CALL PLOT (0.,0.,3)
000054              CALL PLOT (XLEN,0.,2)
000055            C-------------------------------------------------------------------
000056            C     DRAW TICK MARKS AND LABELS.
```

```
000057      C-------------------------------------------------------------------
000058      C-------------------------------------------------------------------
000059            WRITE (6,6000) NPLOTS, XORI, YORI, XLEN, DXL, XORIGN,  YORIGN,
000060           1   ITICK
000061      C-------------------------------------------------------------------
000062            DO 100  I=1,ITICK
000063            XL = XL - DXL
000064            CALL PLOT (XL,0.,3)
000065            CALL PLOT(XL,-0.14,2)
000066            XV = XV-XLABLD
000067            CALL NUMBER (XL,-.25,HEIGHT,XV,0.,NXFRAC)
000068       100  CONTINUE
000069      C-------------------------------------------------------------------
000070      C     DRAW Y-AXIS.
000071      C-------------------------------------------------------------------
000072            YLEN = 1000.
000073            IF(MAXX .LT. 0)         YLEN = 2850.
000074            YLEN = YLEN - YORI
000075            ITICK = IFIX(YLEN)/NYLAB + 1
000076            YLEN = FLOAT(ITICK-1)*DYL
000077            YL = YLEN+DYL
000078            YV = FLOAT(ITICK)  *YLABLD + YORIGN
000079            HEIGHT = 0.0007*FLOAT(NYLAB)
000080            CALL PLOT (0.,0.,3)
000081            CALL PLOT (0.,YLEN,2)
000082            DO 110  I=1,ITICK
000083            YL = YL - DYL
000084            CALL PLOT (0.,YL,3)
000085            CALL PLOT (-.14,YL,2)
000086            YV = YV-YLABLD
000087            CALL NUMBER (-0.25,YL,HEIGHT,YV,90.,NYFRAC)
000088       110  CONTINUE
000089            RETURN
000090      C-------------------------------------------------------------------
000091            ENTRY PLTBC (BCI,NUMBCI,NXBEGN,NYBEGN,ISIZE,IVERT)
000092      C-------------------------------------------------------------------
000093      C     CONVERT TO INCHES.
000094      C-------------------------------------------------------------------
000095            XPAGE  = FLOAT(NXBEGN)/100.-XORI
000096            YPAGE  = FLOAT(NYBEGN)/100.-YORI
000097            NCHAR  = NUMBCI
000098            ANGLE  = 0.
000099            IF(IVERT .EQ. 1)        ANGLE = 90.
000100            HEIGHT = FLOAT(ISIZE)*0.10
000101            CALL SYMBOL (XPAGE,YPAGE,HEIGHT,BCI,ANGLE,NCHAR)
000102            RETURN
000103      C-------------------------------------------------------------------
000104            ENTRY PLTPT (IPLOT,NUMPT,INCX,INCY,ICODE,INCSYM,X,Y)
000105      C-------------------------------------------------------------------
000106            DIMENSION XARRAY(102),YARRAY(102),X(1), Y(1)
000107      C-------------------------------------------------------------------
000108            INTEQ  = ICODE
000109            LINTYP = INCSYM
000110            IF(IPLOT .EQ. 1)        LINTYP = - LINTYP
000111            ICOUNT = NUMPT
000112            IX = INCX/4
000113            IY = INCY/4
000114            II = 1
000115            JJ = 1
000116            XARRAY(1)  = X(1)*SCALEX
```

```
000117            YARRAY(1)  = Y(1)*SCALEY
000118       200  NPTS = 100
000119            IF(ICOUNT .LT. 100)    NPTS = ICOUNT
000120            ICOUNT = ICOUNT-100
000121            DO 210  I=2,NPTS
000122            II = II+IX
000123            JJ = JJ+IY
000124            XARRAY(I)  = X(II)*SCALEX
000125            YARRAY(I)  = Y(II)*SCALEY
000126       210  CONTINUE
000127            XARRAY(NPTS+1) = XORIGN
000128            XARRAY(NPTS+2) = DELTAX
000129            YARRAY(NPTS+1) = YORIGN
000130            YARRAY(NPTS+2) = DELTAY
000131             CALL LINE (XARRAY,YARRAY,NPTS,1,  LINTYP,INTEQ)
000132            XARRAY(1)  = XARRAY(100)
000133            YARRAY(1)  = YARRAY(100)
000134            IF(ICOUNT .GT. 0)      GO TO 200
000135            RETURN
000136          C-------------------------------------------------------------------
000137            ENTRY PLTNU (XLOC,NUMDEC,NXLOC,NYLOC,ISIZE,IVERT)
000138          C-------------------------------------------------------------------
000139            XORR = FLOAT (NXLOC)/100. - XORI
000140            YORR = FLOAT (NYLOC)/100. - YORI
000141            HEIGHT = FLOAT (ISIZE)*.12
000142            ANGLE  = 0.
000143            IF(IVERT .GT. 0)       ANGLE = 90.
000144            CALL NUMBER (XORR,YORR,HEIGHT,XLOC,ANGLE,NUMDEC)
000145            RETURN
000146          C-------------------------------------------------------------------
000147            ENTRY PLTFIN
000148          C-------------------------------------------------------------------
000149            XLEN = MAXLEN
000150            CALL PLOT (XLEN,0.,999)
000151            REWIND 9
000152            WRITE (6,9000)
000153          C     WRITE (10,9000)
000154            RETURN
000155       6000 FORMAT ('1 ENTRY PLTSU, PLOT NO.',I3/ '  X-ORIG DIST = ', F10.6/
000156           1 '  Y-ORIG DIST = ', F10.6 / '  PLOT SIZE = ', F10.4, ' INCHES'/
000157           2 '  TICK MARK INCR. = ', F10.6,' INCHES'/ '  1ST TICK MARK AT : '/
000158           3  '  X = ', F10.6, '   Y = ', F10.6 /
000159           4 '  NO. OF TICK MARKS ON X-AXIS = ', I6 )
000160       9000 FORMAT ('0FILE CLOSED ON TAPE H,DISMOUNT AND SEND TO ANSC,SACRAMEN
000161           1TO. THANK YOU.' )
000162            END
```

PROGRAM E12207

```
@ ELT CONMAT,1,720427, 33985

000001                SUBROUTINE CONMAT
000002                DIMENSION TC(500)
000003                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005                COMMON QZZS(900), TAB(60,32)
000006                COMMON XCOND(10), DENS(10), QX(10)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(900), INTAB(10,3)
000015                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000016              C                (TEM(4),XTEM4)
000017                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000018              C                (ITEM(4),MTYPE)
000019                EQUIVALENCE (TI(1),TC(1))
000020              C-------------------------------------------------------------------
000021                DO 120 I=1,5
000022                DD(I)=0.0
000023                P(I)=0.0
000024                DO 120  J=1,5
000025               120  S(I,J)=0.0
000026                I=LM(1)
000027                J=LM(2)
000028                K=LM(3)
000029                L=LM(4)
000030                LM(5)=I
000031                   TEMPX = (TC(I)+TC(J)+TC(K)+TC(L) )/4.0
000032                   FAC = 1.0
000033              C-------------------------------------------------------------------
000034              C     ITABQ .LT. 0      Q VS. TIME TABLE.
000035              C     ITABQ .EQ. 0      NO TABLE.
000036              C     ITABQ .GT. 0      Q VS X OR Y TABLE.
000037              C-------------------------------------------------------------------
000038                IF(ITABQ)    128,130,129
000039               128  ITABQ  = -ITABQ
000040                CALL LINT (TIME,TAB(1,ITABQ),QZZ,DX)
000041                GO TO 130
000042               129  CONTINUE
000043                LOC  = ITFAC(ITABQ)
000044                     IF(LOC .GT. 0) CALL LINT(TIME,TAB(1,LOC),FAC,DX)
000045               130  QXX  = QZZ*FAC
000046                XX = (X(I)+X(J)+X(K)+X(L))/4.0
000047                YY = (Y(I)+Y(J)+Y(K)+Y(L))/4.0
000048              C-------------------------------------------------------------------
000049              C     COMPUTE GEOMETRICAL CHARACTERISTIC
000050              C-------------------------------------------------------------------
000051                DO 152 K=1,4
000052              C
000053                I = LM(K)
000054                J = LM(K+1)
000055                IF(I .EQ. J)       GO TO 152
000056                 135 AJ=X(J)-X(I)
```

```
000057              AK=XX-X(I)
000058              BJ=Y(J)-Y(I)
000059              BK=YY-Y(I)
000060              C=BJ-BK
000061              DX=AK-AJ
000062              XMUL=1.0
000063              IF (KAT) 136,137,136
000064          136 XMUL=XMUL*(X(I)+X(J)+XX)/3.0
000065            C
000066          137 XLAM=AJ*BK-AK*BJ
000067              XTEM1 = .5*XMUL/XLAM
000068              XTEM2 = XLAM*XMUL/4.0
000069              Z1        =(C*C+DX*DX) * XTEM1
000070              Z2        =(BK*C-AK*DX) * XTEM1
000071              Z3        =(-BJ*C+AJ*DX) * XTEM1
000072              Z4        =(BK*BK+AK*AK) * XTEM1
000073              Z5        =(-BJ*BK-AJ*AK) * XTEM1
000074              Z6        =(BJ*BJ+AJ*AJ) * XTEM1
000075              Z7        = XTEM2
000076              XTEM3 = (TC(I)+TC(J)+TEMPX)/3.
000077              IF(ITABK .GT. 0)        CALL LINT (XTEM3,TAB(1,ITABK),COND,DX)
000078              FAC  = 1.0
000079              LOC = ITFAC(ITABK)
000080              IF(LOC .GT. 0)          CALL LINT (TIME,TAB(1,LOC),FAC,DX)
000081              COND = COND*FAC
000082              IF(ITABR .GT. 0)        CALL LINT (XTEM3,TAB(1,ITABR),RHO,DX)
000083              FAC  = 1.0
000084              LOC = ITFAC(ITABR)
000085              IF(LOC .GT. 0)          CALL LINT (TIME,TAB(1,LOC),FAC,DX)
000086              RHO  = RHO*FAC
000087              QQ   =  Z7*QXX
000088              QSTORE = Z7*RHO
000089              E(1,1)  = Z1
000090              E(1,2)  = Z2
000091              E(1,3)  = Z3
000092              E(2,1)  = E(1,2)
000093              E(2,2)  = Z4
000094              E(2,3)  = Z5
000095              E(3,1)  = E(1,3)
000096              E(3,2)  = E(2,3)
000097              E(3,3)  = Z6
000098              IX(1)=K
000099              IX(2)=K+1
000100              IF (K-4) 145,140,145
000101          140 IX(2)=1
000102          145 IX(3)=5
000103            C
000104              DO 151 I=1,3
000105              II=IX(I)
000106              P(II)=P(II)+QQ
000107              DD(II)=DD(II)+QSTORE
000108              DO 151 J=1,3
000109              JJ=IX(J)
000110          151 S(II,JJ)  = S(II,JJ) + E(I,J)*COND
000111            C
000112          152 CONTINUE
000113            C
000114              DO 155 I=1,4
000115              DO 155 J=1,4
000116          155 S(I,J)=S(I,J)-S(I,5)*S(J,5)/S(5,5)
```

```
000057              AK=XX-X(I)
000058              BJ=Y(J)-Y(I)
000059              BK=YY-Y(I)
000060              C=BJ-BK
000061              DX=AK-AJ
000062              XMUL=1.0
000063              IF (KAT) 136,137,136
000064          136 XMUL=XMUL*(X(I)+X(J)+XX)/3.0
000065          C
000066          137 XLAM=AJ*BK-AK*BJ
000067              XTEM1 = .5*XMUL/XLAM
000068              XTEM2 = XLAM*XMUL/4.0
000069              Z1        =(C*C+DX*DX) * XTEM1
000070              Z2        =(BK*C-AK*DX) * XTEM1
000071              Z3        =(-BJ*C+AJ*DX) * XTEM1
000072              Z4        =(BK*BK+AK*AK) * XTEM1
000073              Z5        =(-BJ*BK-AJ*AK) * XTEM1
000074              Z6        =(BJ*BJ+AJ*AJ) * XTEM1
000075              Z7        = XTEM2
000076              XTEM3 = (TC(I)+TC(J)+TEMPX)/3.
000077              IF(ITABK .GT. 0)        CALL LINT (XTEM3,TAB(1,ITABK),COND,DX)
000078              FAC  = 1.0
000079              LOC = ITFAC(ITABK)
000080              IF(LOC .GT. 0)          CALL LINT (TIME,TAB(1,LOC),FAC,DX)
000081              COND = COND*FAC
000082              IF(ITABR .GT. 0)        CALL LINT (XTEM3,TAB(1,ITABR),RHO,DX)
000083              FAC  = 1.0
000084              LOC = ITFAC(ITABR)
000085              IF(LOC .GT. 0)          CALL LINT (TIME,TAB(1,LOC),FAC,DX)
000086              RHO  = RHO*FAC
000087              QQ   =  Z7*QXX
000088              QSTORE = Z7*RHO
000089              E(1,1)  = Z1
000090              E(1,2)  = Z2
000091              E(1,3)  = Z3
000092              E(2,1)  = E(1,2)
000093              E(2,2)  = Z4
000094              E(2,3)  = Z5
000095              E(3,1)  = E(1,3)
000096              E(3,2)  = E(2,3)
000097              E(3,3)  = Z6
000098              IX(1)=K
000099              IX(2)=K+1
000100              IF (K-4) 145,140,145
000101          140 IX(2)=1
000102          145 IX(3)=5
000103          C
000104              DO 151 I=1,3
000105              II=IX(I)
000106              P(II)=P(II)+QQ
000107              DD(II)=DD(II)+QSTORE
000108              DO 151 J=1,3
000109              JJ=IX(J)
000110          151 S(II,JJ)  = S(II,JJ) + E(I,J)*COND
000111          C
000112          152 CONTINUE
000113          C
000114              DO 155 I=1,4
000115              DO 155 J=1,4
000116          155 S(I,J)=S(I,J)-S(I,5)*S(J,5)/S(5,5)
```

```
000117          C
000118          C       3. ADD ELEMENT CONDUCTIVITY TO COMPLETE CONDUCTIVITY MATRIX
000119          C
000120                DO 175 L=1,4
000121                I=LM(L)
000122                D(I)=D(I)+DD(L)
000123                B(I)=B(I)+P(L)
000124                DO 175 M=1,4
000125                J=LM(M)-I+1
000126                IF(NDIM-J)    185,158,158
000127           158  IF(MBAND-J) 160,165,165
000128           160  MBAND=J
000129           165  IF(J) 175,175,170
000130           170  A(I,J)=A(I,J)+S(L,M)
000131           175  CONTINUE
000132          C
000133           180  CONTINUE
000134                RETURN
000135           185  WRITE (6,2021) NUM
000136                GO TO 180
000137           2021 FORMAT ('0BAD CARD NO.' I4 )
000138                END
```

```
@ ELT CONVBC,1,720427, 33989

000001                SUBROUTINE CONVBC (III, JJJ, NNN)
000002                DIMENSION TC(500)
000003                DIMENSION IEPS(250)
000004                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000005                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000006                COMMON QZZS(900), TAB(60,32)
000007                COMMON XCOND(10), DENS(10), QX(10)
000008                COMMON TEM(10)
000009                COMMON COND,RHO,QXX,QZZ
000010                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000011                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000012                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000013                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000014                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000015                COMMON IKODE(900), INTAB(10,3)
000016                COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000017               1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000018                COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000019               1 ,FN(250), BQ(40), KTEM(40), TS(250)
000020                COMMON /SAVEFM/ FM(40,40)
000021                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000022               C                (TEM(4),XTEM4)
000023                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000024               C                (ITEM(4),MTYPE)
000025                EQUIVALENCE (TI(1),TC(1))
000026                EQUIVALENCE (H,IHH), (EPS(1),IEPS(1))
000027           C     I = II
000028           C     J = JJ
000029           C     TEMP   = H*XL*TEMP/2.0
000030           C     B(I)=B(I)+TEMP
000031           C     B(J)=B(J)+TEMP
000032                 I  = III
000033                 J  = JJJ
000034                 N  = NNN
000035                 IF(IHH .EQ. 0)          GO TO 215
000036                 TEMPI  = TEMEBC(N)
000037                 TEMPJ  = TEMPI
000038                 II = IIBC(N)
000039                 JJ = JJBC(N)
000040                 IF(II .GT. 0)           TEMPI = (TEMPI+TEMEBC(II))/2.0
000041                 IF(JJ .GT. 0)           TEMPJ = (TEMPJ+TEMEBC(JJ))/2.0
000042                 TEMPI  = H*XL*TEMPI/2.0
000043                 TEMPJ  = H*XL*TEMPJ/2.0
000044                 B(I) = B(I)+TEMPI
000045                 B(J) = B(J)+TEMPJ
000046           C     H=H*XL/4.
000047                 H=H*XL/2.
000048                 A(I,1)=A(I,1)+H
000049                 A(J,1)=A(J,1)+H
000050           C     K=J-I+1
000051           C     IF (K) 212,212,210
000052           C 210 A(I,K)=A(I,K)+H
000053           C     GO TO 215
000054           C 212 K=I-J+1
000055           C     A(J,K)=A(J,K)+H
000056             215 CONTINUE
```

```
000057            IF(IEPS(N) .EQ. 0)     GO TO 220
000058            T1 = TC(I)*TC(I)
000059            T2 = TC(J)*TC(J)
000060            T3 = TC(I)*TC(J)
000061            TR = (T1*T1+T1*T3+T1*T2+T2*T3+T2*T2)/5.0
000062            TEMP = TS(N)
000063            TEMX = FN(N) *EPS(N)*SIGMA*(TEMP**4-TR)/2.0
000064            TEMX = TEMX*XL
000065            B(I) = TEMX+B(I)
000066            B(J) = TEMX+B(J)
000067     220    CONTINUE
000068            RETURN
000069          C-------------------------------------------------------------
000070          C     BERQUAM'S RADIATION CALCULATION FOR SURFACE TO SURFACE.
000071          C-------------------------------------------------------------
000072            ENTRY RAD
000073            DO 2200  I=1,40
000074            DO 2200  J=1,40
000075     2200   FM(I,J) = F(I,J)
000076            M  = 0
000077            DO 221   N=1,NUMBC
000078            NRFI = NRF(N)
000079            IF(NRFI .EQ. 0)        GO TO 221
000080            I  = IBC(N)
000081            M  = M+1
000082            J  = JBC(N)
000083            TK = TC(I)
000084            TL = TC(J)
000085            T2 = TL*TL
000086            T4 = T2*T2
000087            TR = TK*(TK*(TK*(TK+TL)+T2)+T2*TL) + T4
000088            BQ(M)    = EPS(N)*SIGMA*TR/5.0
000089     221    CONTINUE
000090            CALL SIMEQ(FM, BQ, NRFI, 1, 40, KTEM, DET, ND, KERR)
000091            M  = 0
000092            DO 222  N=1,NUMBC
000093            IF(NRF(N) .EQ. 0)      GO TO 222
000094            I  = IBC(N)
000095            J  = JBC(N)
000096            XL = XLBC(N)
000097            M  = M+1
000098            TEMP = EPS(N)/(1.-EPS(N))*XL/2.0
000099            T1 = TC(I)*TC(I)
000100            T2 = TC(J)*TC(J)
000101            T3 = TC(I)*TC(J)
000102            TR = (T1*T1+T1*T3+T1*T2+T2*T3+T2*T2)/5.0
000103            TEMP = TEMP*(BQ(M)-SIGMA*TR)
000104            B(I) = TEMP+B(I)
000105            B(J) = TEMP+B(J)
000106     222    CONTINUE
000107            RETURN
000108          C-------------------------------------------------------------
000109            ENTRY TEMPBC
000110          C
000111          C     2.  TEMPERATURE BOUNDARY CONDITIONS
000112          C
000113            DO 300 N=1,NUMNP
000114            LOC = IKODE(N)
000115            IF(LOC .GT. 0)         CALL LINT (TIME, TAB(1,LOC), T(N), DX)
000116            B(N) = B(N)+T(N)
```

```
000117            IF(KODE(N)) 225,300,225
000118       225  DO 250 M=2,MBAND
000119            K=N-M+1
000120            IF(K) 235,235,230
000121       230  B(K)=B(K)-A(K,M)*T(N)
000122            A(K,M)=0.0
000123       235  L=N+M-1
000124            IF(NUMNP-L) 245,240,240
000125       240  B(L)=B(L)-A(N,M)*T(N)
000126       245  A(N,M)   = 0.0
000127       250  CONTINUE
000128            A(N,1)=1.0
000129            B(N)=T(N)
000130       300  CONTINUE
000131            RETURN
000132          C-------------------------------------------------------------
000133            ENTRY CONVBI
000134            DO 405  II=1,NUMBC
000135            IIBC(II) = 0
000136       405  JJBC(II) = 0
000137            DO 415  II=1,NUMBC
000138            I  = IBC(II)
000139            J  = JBC(II)
000140            DO 410  JJ=1,NUMBC
000141            IF(I .EQ. JBC(JJ))      IIBC(II)  = JJ
000142            IF(J .EQ. IBC(JJ))      JJBC(II)  = JJ
000143       410  CONTINUE
000144       415  CONTINUE
000145            RETURN
000146            END
```

```
@ ELT DATA,1,720427, 33989

000001          JACK,S MODEL CONVECTION BOUNDARY ,CONDUCTION,AND SURF-SINK RADIATION
000002            40   28   08                1                          .5      2      20.
000003             1    1.01                      0.01
000004             2     .000001          .000004
000005            -1
000006             1    5           CONDUCTIVITY
000007                   0.          .01
000008                   9000000.    .01
000009        -1
000010        -1
000011             1                                                  2000.
000012             5     2.                                           2000.
000013             6                 .5                             2000.
000014            10     2.          .5                             2000.
000015            11                 1.0                            2000.
000016            15     2.          1.                             2000.
000017            16                 1.5                            2000.
000018            20     2.          1.5                            2000.
000019            21                 1.51                           3000.
000020            25     2.          1.51                           3000.
000021            26                 2.01                           3000.
000022            30     2.          2.01                           3000.
000023            31                 2.51                           3000.
000024            35     2.          2.51                           3000.
000025            36                 3.01                           3000.
000026            40     2.          3.01                           3000.
000027             1    1    2    7    6    1
000028             5    6    7   12   11    1
000029             9   11   12   17   16    1
000030            13   16   17   22   21    2
000031            17   21   22   27   26    1
000032            21   26   27   32   31    1
000033           25.   31   32   37   36    1
000034            28   34   35   40   39    1
000035             1    2                                                    .5      .7
000036                  3                                                    .5      .7
000037                  4                                                    .5      .7
000038                  5                                                    .5      .7
000039            36   37 .0001    4957.
000040                 38 .0001    4957.
000041                 39 .0001    4957.
000042                 40 .0001    4957.
000043          D12207 RADIANT INTERCHANGE 4 SURFACES
000044            12    4    4
000045             1              .01
000046             2             .001
000047            -1
000048             1    1         0.          4.      3000.
000049             2              0.          3.
000050             3              0.          1.
000051             4    1         0.          0.      2000.
000052             5    1         2.          4.      3000.
000053             6              2.          3.
000054             7              2.          1.
000055             8    1         2.          0.      2000.
000056             9    1         4.          4.      3000.
```

```
 10                4.    3.
 11                4.    1.
 12    1           4.    0.     2000.
  1    1     2     6     5     1
  2    3     4     8     7     2
  3    5     6    10     9     1
  4    7     8    12    11     2
  2    6                                          .9                4    1
      10                                          .9                4    2
  3    7                                          .5                4    3
      11                                          .5                4    4
  1                                     .7        .3
  2                                     .3        .7
  3                .7          .3
  4                .3          .7
SAMPLE PROBLEMS,   CASE 1', K1=.01,   STEADY STATE, RAD.+ COND. ACROSS GAP
  40   28   16                 1                                              TTTT
1.        200.      1.          200.      .3          200.
  1    1.01                    .001
  2     .000001             .000004
 -1
  1    5           CONDUCTIVITY
        0.          .01
        9000000.    .01
 -1
  2    1        H VS. TEMP.
                    .0003
        9000000.    .0003
 -1
 -1
  1
  5     2.
  6                 .5
 10     2.          .5
 11                 1.0
 15     2.          1.
 16                 1.5
 20     2.          1.5
 21                 1.51
 25     2.          1.51
 26                 2.01
 30     2.          2.01
 31                 2.51
 35     2.          2.51
 36                 3.01
 40     2.          3.01
  1    1     2     7     6     1
  5    6     7    12    11     1
  9   11    12    17    16     1
 13   16    17    22    21     2
 17   21    22    27    26     1
 21   26    27    32    31     1
 25   31    32    37    36     1
 28   34    35    40    39     1
  1    2            1348.          2
       3            1348.          2
       4            1348.          2
       5            1348.          2
 36   37 .0001      4957.
      38 .0001      4957.
```

```
        39 .0001    4957.
        40 .0001    4957.
   16   17                              .5                      8   1
   17   18                              .5                      8   2
   18   19                              .5                      8   3
   19   20                              .5                      8   4
   21   22                              .8                      8   5
   22   23                              .8                      8   6
   23   24                              .8                      8   7
   24   25                              .8                      8   8
    1                                             1.
0.
    2                                                       1.
0.
    3                                                                 1.
0.
    4
1.
    5     1.
0.
    6               1.
0.
    7                         1.
0.
    8                                   1.0
0.
1ST EXAMPLE PROBLEM FOR STEADY STATE CASE. PROGRAM D12202. SEPT 10,1971
   56   40    2    1                                       3
    1     1.0
-   1
    1    1      1.0       2.0      1000.                                12401499
   10           4.0       3.0                                           12401500
   11    1      1.1       1.7      1000.                                12401501
   20           4.0       2.5                                           12401502
   21    1      1.2       1.4      1000.                                12401503
   30           4.0       2.0                                           12401504
   31    1      4.6       1.8        75.                                12401505
   32    1      5.0       1.7        75.                                12401506
   33    1      1.3       1.1      1000.                                12401507
   44    1      5.0       1.2        75.                                12401508
   45    1      1.4       0.8      1000.                                12401509
   56    1      5.0       1.0        75.                                12401510
    1   11   12    2    1    1                                          12401511
   10   21   22   12   11    1                                          12401512
   19   33   34   22   21    1                                          12401513
   30   45   46   34   33    1                                          12401514
   40   55   56   44   43    1                                          12401515
   10   20      2.0       75.
   20   30      2.0       75.
 TEST CASE 2.  CONVECTION DANPING OF E12207.
   54   40    8              1                            50                 T T
                           .10  0.1                         0.005
    1            .4991-3                      .07608
   -1
    1    1      NATURAL CONVECTION & SUBCOOLED BOILING IN 140F H2O A1.5 ATM
                  0.      9.-5
                140.      9.-5
                150.   9.292-6
                180.   1.475-5
                210.   1.778-5
```

```
000177                                232.    1.947-5
000178                                236.    3.416-5
000179                                240.    7.137-5
000180                                242.    1.097-4
000181                                244.    1.336-4
000182                                246.     1.82-4
000183                                248.    2.581-4
000184                                250.    2.981-4
000185                                254.    5.246-4
000186                                258.    8.500-4
000187                                262.    1.581-3
000188                                266.    2.679-3
000189                                270.    4.748-3
000190                                275.    9.289-3
000191                          900000000.    9.289-3
000192      -1
000193      -1
000194       1                  0.5         0.0                 250.
000195       9                  2.5         0.0                 250.
000196      10                  0.5         0.1                 250.
000197      18                  2.5         0.1                 250.
000198      19                  0.5         0.2                 250.
000199      27                  2.5         0.2                 250.
000200      28                  0.5         0.3                 250.
000201      36                  2.5         0.3                 250.
000202      37                  0.5         0.4                 250.
000203      45                  2.5         0.4                 250.
000204      46                  0.5         0.5                 250.
000205      54                  2.5         0.5                 250.
000206       1    1    2   11   10    1
000207       9   10   11   20   19    1
000208      17   19   20   29   28    1
000209      25   28   29   38   37    1
000210      33   37   38   47   46    1
000211      40   44   45   54   53    1
000212      46   47                  140.    1
000213           48                  140.    1
000214           49                  140.    1
000215           50                  140.    1
000216           51                  140.    1
000217           52                  140.    1
000218           53                  140.    1
000219           54                  140.    1
000220          TEST CASE 3   H = 0.000050      E = 0.0
000221      10    4    1
000222       1       0.00020
000223      -1
000224       1    1 0.          0.          3000.
000225       2      1.          0.
000226       5      4.          0.
000227       6    1 0.          1.          3000.
000228       7      1.          1.
000229      10      4.          1.
000230       1    1    2    7    6    1
000231       4    4    5   10    9    1
000232       5   10 0.000050   0.
000233          TEST CASE 4   H = 0.0           E = 1.0
000234      10    4    1                                          TT
000235                                          0.5       200.      0.0005
000236       1       0.00020
```

```
000237      -1
000238       1    1 0.          0.          3000.
000239       2      1.          0.
000240       5      4.          0.
000241       6    1 0.          1.          3000.
000242       7      1.          1.
000243      10      4.          1.
000244       1    1    2    7    6    1
000245       4    4    5   10    9    1
000246       5   10              0.                      1.          1.
000247          TEST CASE 5   H = 0.00005      E = 1.0
000248      10    4    2                                                        TT
000249                                                  0.5         200.        0.0005
000250       1       0.00020
000251      -1
000252       1    1 0.          0.          3000.
000253       2      1.          0.
000254       5      4.          0.
000255       6    1 0.          1.          3000.
000256       7      1.          1.
000257      10      4.          1.
000258       1    1    2    7    6    1
000259       4    4    5   10    9    1
000260       5   10 0.000050   0.
000261       5   10              0.                      1.          1.
```

@ ELT LINT,1,720427, 33991

```
000001            SUBROUTINE LINT (X,TABLE,Y,DY)
000002          C-------------------------------------------------------------------
000003          C     LINEAR INTERPOLATION WITH INDEPENDENT VARIABLE IN ASCENDING ORDER.
000004          C     THIS SUBROUTINE IS NOT THE ORGINAL LINT/LINTS.
000005          C     THIS IS A SPECIAL SUBROUTINE FOR E12202 AND E12401.
000006          C     THE SUBROUTINE WILL STOP THE PROGRAM IF THE INPUT-X
000007          C     IS NOT WITHIN THE TABLE RANGE.
000008          C-------------------------------------------------------------------
000009                DIMENSION TABLE(2)
000010          C-------------------------------------------------------------------
000011                IF(X .LT. TABLE(1)-.05)          GO TO 15
000012                DO 10   I=3,60,2
000013                IF (X .LE. TABLE(I))   GO TO 20
000014           10   CONTINUE
000015           15   WRITE (6,6000) X
000016           6000 FORMAT ('0X = ', E14.6, ' IS BEYOND THE TABLE RANGE OF THE FOLLOWI
000017               1NG TABLE.' // )
000018                WRITE (6,6005)  (TABLE(I), I=1,60)
000019           6005 FORMAT (1X, 2E14.6)
000020                STOP
000021           20   X1 = TABLE(I-2)
000022                X2 = TABLE(I)
000023                Y1 = TABLE(I-1)
000024                Y2 = TABLE(I+1)
000025                DY = (Y2-Y1)/(X2-X1)
000026                Y  = Y1+DY*(X-X1)
000027           30   RETURN
000028                ENTRY LINTS (TABLE,N)
000029                NN = N+N+1
000030                IF(NN .GT. 58 )         NN = 59
000031                DO 70   I=NN,60
000032           70   TABLE(I) = 0.
000033                GO TO 30
000034          C-------------------------------------------------------------------
000035                END
```

```
@ ELT MAIN,1,720427, 33993

000001          C-------------------------------------------------------------------
000002          C     A(500,30)     CONDUCTIVITY MATRIX
000003          C     B(500)        Q-HEAT (FROM NODE I) VECTOR
000004          C     D(500)        HEAT CAPACITANCE (FOR NODE I) VECTOR
000005          C     DD(5)         TEMPORARY STORAGES FOR Q-HEAT FOR 5 NODES
000006          C     E(3,3)        GEOMETRICAL PARAMETERS OF ELEMENT
000007          C     HED(18)       TITLE STORAGE
000008          C     P(5)          TEMPORARY STORAGES FOR HEAT CAPACITANCE FOR 5 NODES.
000009          C     Q(500)        INTERMEDIATE STORAGE OF TEMPERATURE DISTRIBUTION
000010          C     S(5,5)        ITERMEDIATE STORAGE FOR CONDUCTIVITY ELEMENT
000011          C     T(500)        TEMPERATURE DISTRIBUTION VECTOR
000012          C     X(500)        X OR R-ORDINATE
000013          C     Y(500)        Y OR Z-ORDINATE
000014          C     HBC(200)
000015          C     TBC(200)
000016          C     TAB(60,32)    PARAMETER TABLES STORAGES
000017          C     TI(500)       INITIAL TEMPERATURES
000018          C     COND          CONDUCTIVITY
000019          C     RHO           RHO-CP
000020          C     QXX           RATE OF HEAT GENERATED/UNIT VOLUME OF ELEMENT
000021          C     QZZ           = FAC*QXX WHERE FAC = TIME FACTOR
000022          C     TIME          TIME OF TEMPERATURE PROFILE
000023          C     DT            DELTA TIME FOR INTEGRATING TIME
000024          C     DT2           1./DT
000025          C     H             FILM COEFFICIENT
000026          C     TEMP          EXTERNAL TEMPERATURE
000027          C     XL
000028          C     XX
000029          C     YY
000030          C     TMAX          MAXIMUM TIME OR CUT-OFF TIME
000031          C     TINIT         INITIAL TIME
000032          C     NUMBC         NO./COUNDARY CONDITION CARDS
000033          C     NUMMT         NO./DIFFERENT MATERIALS
000034          C     NDT
000035          C     INTER         PRINT INTERVAL
000036          C     MBAND         BAND WIDTH
000037          C     NUM           ELEMENT NUMBER
000038          C     NTAB          NO./INPUT TABLES
000039          C     NDIM          MAXIMUM BAND WIDTH
000040          C     IVARH         FLAG FOR VARIABLE ELEMENT PROPERTIES
000041          C     IVARC         FLAG FOR VARIABLE BOUNDARY CONDITIONS
000042          C     IPT           PLOT FLAG
000043          C     IDT           DELTA TIME TABLE NO.
000044          C     KODE(500,     FLAG FOR NODE POINT
000045          C     IX(3)         ITERMEDIATE STORAGE
000046          C     KX(4)         INPUT NODE NUMBERS OF ELEMENT
000047          C     LM(5)         WORKING STORAGE OF NODAL NOS. OF ELEMENT
000048          C     KAT           = 0,FOR PLANE SOLID
000049          C                   =1 ,FOR AXISYMMETRIC SOLID
000050          C     NUMNP         NO. OF NODAL POINT
000051          C     NUMEL         NO. OF ELEMENTS
000052          C     TEM(10)       TEMPORARY WORKING STORAGES FOR REAL NUMBERS
000053          C     ITEM(10)      TEMPORARY WORKING STORAGES FOR INTEGERS
000054          C     IDTAB(32)     STORAGE FOR STORING TABLE CODES
000055          C     ITFAC(32)     STORAGE FOR STORING TIME FACTOR TABLE
000056          C-------------------------------------------------------------------
```

```
000057      C     SUBROUTINE SUBRO
000058      C               READS AND PRINTS CONTROL INFORMATION.
000059      C               READS OR GENERATE NODAL POINT INFORMATION.
000060      C     SUBROUTINE SUBR1
000061      C               FORMS CONDUCTIVITY MATRIX FOR WHOLE BODY.
000062      C     SUBROUTINE SUBR2
000063      C               HANDLES THE BOUNDARY CONDITION INPUT.
000064      C     SUBROUTINE SUBR3
000065      C               SOLVES FOR THE TEMPERATURE DISTRIBUTION FOR A 2-DIMENSION
000066      C               BODY WITH CONSTANT PROPERTIES.
000067      C     SUBROUTINE SUBR4
000068      C               BODY WITH VARIABLE BOUNDARY CONDITIONS.
000069      C     SUBROUTINE SUBR5
000070      C               BODY WITH VARIABLE ELEMENT PROPERTIES - THIS INCLUDES
000071      C               THE BOUNDARY CONDITIONS.
000072      C     SUBROUTINE SUBR6
000073      C               HANDLES THE VARIABLE ELEMENT PROPERTIES AND BOUNDARY
000074      C               CONDITIONS FOR SUBROUTINE SUBR5.
000075      C     SUBROUTINE SUBR7
000076      C               HANDLES VARIATIONS IN BOUNDARY CONDITIONS.
000077      C     SUBROUTINE SUBR8
000078      C               HANDLES STEADY-STATE CASE.
000079      C     SUBROUTINE RETAB
000080      C               READS AND INITIALIZES THE INPUT TABLES.
000081      C     SUBROUTINE CONMAT
000082      C               HANDLES THE ACTUAL CONSTRUCTION OF ELEMENT CONDUCTIVITY
000083      C               MATRIX AND ADDS IT TO THE COMPLETE CONDUCTIVITY MATRIX.
000084      C     SUBROUTINE CONVBC
000085      C               HANDLES THE BOUNDARY CONDITION COMPUTATIONS.
000086      C     SUBROUTINE SYMSO
000087      C               SOLVES THE BAND MATRIX EQUATION -  A*B = Q
000088      C-----------------------------------------------------------------------
000089            DIMENSION TC(500)
000090             COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000091            COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000092            COMMON QZZS(900), TAB(60,32)
000093            COMMON XCOND(10), DENS(10), QX(10)
000094            COMMON TEM(10)
000095            COMMON COND,RHO,QXX,QZZ
000096            COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000097            COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000098            COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000099            COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000100            COMMON ITEM(10), IDTAB(32), ITFAC(32)
000101            COMMON IKODE(900), INTAB(10,3)
000102            COMMON /IJK/ IPTC
000103            COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000104           1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000105            COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000106            COMMON /TAPE/  ITAPE, ISTART, ISS
000107               EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000108           C                (TEM(4),XTEM4)
000109               EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000110           C                (ITEM(4),MTYPE)
000111            EQUIVALENCE (TI(1),TC(1))
000112      C-----------------------------------------------------------------------
000113            IPTC = 0
000114            NDIM = 30
000115            IF(ITAPE .EQ. 1)       END FILE 2
000116            REWIND 4
```

```
000117            REWIND 8
000118            SIGMA  = .33E-14
000119       50   CONTINUE
000120             IVARH = 0
000121             IVARC = 0
000122            REWIND 1
000123            DO 52  I=1,32
000124            ITFAC(I) = 0
000125       52   IDTAB(I) = 0
000126            DO 60    I=1,10
000127            DO 60    J=1,3
000128       60   INTAB(I,J)    = 0
000129            ISS  = 0
000130            CALL SUBR0
000131            IF(ISTART .NE. 1)       GO TO 100
000132            CALL SUBRIN
000133            GO TO 180
000134       100  CALL SUBR1
000135           C-------------------------------------------------------------------
000136           C     IF IVARC IS NON-ZERO, CONDUCTIVITY IS VARIABLE WITH TEMPERATURE.
000137           C     OTHERWISE, ONLY THE H ON THE BOUNDARY ARE VARIABLE WITH TEMPERATURE
000138           C-------------------------------------------------------------------
000139            CALL SUBR2
000140       180  CONTINUE
000141           C-------------------------------------------------------------------
000142           C     IPT  = 0,     NO PLOTS.
000143           C     IPT .GT. 0    GEOMETRY PLOTS.
000144           C     IPT .LT. 0    GEOMETRY PLOTS ONLY, PROGRAM WILL CYCLE TO NEXT CASE
000145           C                   IF ANY.
000146           C-------------------------------------------------------------------
000147           C     IF(IPT .NE. 0)          CALL PDATA
000148           C     IF(IPT .LT. 0)          GO TO 420
000149           C-------------------------------------------------------------------
000150           C     TEST FOR STEADY-STATE CASE.
000151           C-------------------------------------------------------------------
000152            IF(ISS .EQ. 1)          GO TO 430
000153            IF(NTAB+IFLAGR)         400,200,400
000154       200  CALL SUBR3
000155            GO TO 420
000156       400  CONTINUE
000157            IF(IVARC .NE. 0)        GO TO 410
000158            CALL SUBR4
000159            GO TO 420
000160       410  CONTINUE
000161            CALL SUBR5
000162       420  WRITE (6,6000)  HED
000163            GO TO 50
000164       430  CONTINUE
000165           C-------------------------------------------------------------------
000166           C     STEADY-STATE PROBLEM.
000167           C-------------------------------------------------------------------
000168            CALL SUBR8
000169            GO TO 420
000170           C-------------------------------------------------------------------
000171       6000 FORMAT ('1',14X,'END OF PROBLEM--',12A6 )
000172            END
```

@ ELT NTAB$,1,720427, 33995

```
000001          NTAB$  10
000002          DRUM 1,40000
000003          TAPE 2,'R'      . RECALL TAPE
000004          TAPE 3,'S'      . RESTART TAPE
000005          DRUM 4,20000
000006          READ 5
000007          PRINT 6
000008          PUNCH 7
000009          DRUM 8,20000
000010          TAPE 9,'H'      . ANSC PLOT TAPE
000011          END
```

```
@ ELT RTAB,1,720427, 33998
000001                SUBROUTINE RTAB
000002                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000003                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000004                COMMON QZZS(900), TAB(60,32)
000005                COMMON XCOND(10), DENS(10), QX(10)
000006                COMMON TEM(10)
000007                COMMON COND,RHO,QXX,QZZ
000008                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000009                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000010                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000011                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000012                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000013                COMMON IKODE(900), INTAB(10,3)
000014                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000015              C                (TEM(4),XTEM4)
000016                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000017              C                (ITEM(4),MTYPE)
000018                EQUIVALENCE (TI(1),TC(1))
000019             C-----------------------------------------------------------------
000020             C     READ AND WRITE INPUT TABLES FOR VARIABLE PROPERTIES,B.C.,AND TIME
000021             C     FUNCTION.
000022             C-----------------------------------------------------------------
000023             C   TABLE CODE NO. CODE
000024             C     1             H (CONVECTION COEFFICIENT)
000025             C     2             TEMP. OF EXTERNAL BOUNDARY.
000026             C     5             K (CONDUCTIVITY)
000027             C     6             RHO-CP
000028             C     7             Q(X)
000029             C     8             Q(Y)
000030             C     9             HEAT FLUX INTO NODE
000031             C    10             TEMPERATURE OF NODE
000032             C     -N            TABLE N HAS A TIME FUNCTION WHOSE LOCATION IS
000033             C                   IN ITFAC(N)
000034             C-----------------------------------------------------------------
000035                   IVARH = 1
000036                   DO 5 I=1,32
000037              5    ITFAC(I) = 0
000038                   LINE   = 60
000039             10    IF(LINE+20.LE.60)      GO TO 20
000040                   WRITE (6,9000)
000041                   WRITE (6,6000)
000042                   LINE = 1
000043             20    READ (5,5000)  ID,IC, TEM
000044                   IF(ID .LE. 0)    GO TO 70
000045                   IF(ID .GT. 32)     GO TO 90
000046                   IF(IC .GT. 4)          IVARC =1
000047                   IDTAB(ID)  = IC
000048                   WRITE (6,6010) ID,IC,TEM
000049                   IF(IC.GE.0)            GO TO 30
000050                   IC   = -IC
000051                   ITFAC(IC)  = ID
000052             30    N  = 0
000053                   K  = 1
000054             40    READ (5,5010) IEND,XTEM,YTEM
000055                   IF(IEND)     60,50,50
000056             50    WRITE (6,6020) XTEM,YTEM
```

```
000057                LINE   = LINE+1
000058                N  = N+1
000059                IF(N .GT. 30)  GO TO 80
000060                TAB(K,ID)  = XTEM
000061                TAB(K+1,ID)  = YTEM
000062                K  = K+2
000063                GO TO 40
000064           60   IF(IC .EQ. 0)    GO TO 65
000065           62   CALL LINTS (TAB(1,ID),N )
000066                GO TO 10
000067           65   TAB(K,ID) = TMAX+1.
000068                TAB(K+1,ID)  = TAB(K-1,ID)
000069                N  = N+1
000070                GO TO 62
000071           70   RETURN
000072           80   WRITE (6,6030) ID
000073                GO TO 40
000074           90   WRITE (6,6040) ID
000075           95   READ (5,5010) IEND,XTEM,YTEM
000076                IF(IEND .LT. 0)  GO TO 10
000077                WRITE (6,6020) XTEM,YTEM
000078                GO TO 95
000079          C-------------------------------------------------------------
000080          C     FORMAT STATEMENTS
000081          C-------------------------------------------------------------
000082           5000 FORMAT (2I5,5X,10A6 )
000083           5010 FORMAT (I5,5X,2E10.4)
000084           6000 FORMAT ('0',53X,'INPUT TABLES')
000085           6010 FORMAT ('0TABLE NO.',I5,3X,'TYPE',I5,5X,10A6/8X,'X',14X,'F(X)'/ )
000086           6020 FORMAT (1X,2E16.6)
000087           6030 FORMAT ('/TABLE',I4,' HAS EXCEEDED 30 POINTS OR THERE NO -1 CARD T
                     CO END THE TABLE'        )
000089           6040 FORMAT ('0TABLE NO.',I5,'EXCEEDS 32. PROGRAM WILL SKIP TABLE.' )
000090           9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000091              1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000092              2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000093                END
```

@ ELT SIMEQ,1,720427, 34001

```
000001            SUBROUTINE SIMEQ(A,B,NN,MM,NA ,ITEM,DD,NND,KERR)                61210002
000002          C-------------------------------------------------------------------
000003          C     SOLVES MATRIX EQUATIONS - AX = B                             61210004
000004          C     GAUSS ELIMINATION WITH COMPLETE PIVOTING ON ABSOLUTE LARGEST  61210005
000005          C     ELEMENT TO FORM TRIANGULAR MATRIX,WITH BACK SUBSTITUTION FOR  61210006
000006          C     SOLUTION VECTORS.                                            61210007
000007          C-------------------------------------------------------------------
000008          C                                                                  61210009
000009          C     CALL SIMEQ (A,B,NN,MM,NA ,ITEM,DD,NND,KERR )                 61210010
000010          C     A         =    A(1,1) OF INPUT MATRIX                        61210011
000011          C     B         =    INPUT VECTORS                                 61210012
000012          C     NN        = NUMBER OF SIMULTANEOUS EQUATIONS.                61210013
000013          C     MM        = NUMBER OF B-VECTORS.                             61210014
000014          C     NA        = DIMENSION OF MATRIX A,THAT IS, A(NA,--)          61210015
000015          C     ITEM      = TEMPORARY STORAGE (FOR PERMUTATION VECTOR)       61210016
000016          C                 WITH DIMENSION - ITEM(NA)                        61210017
000017          C     DD        = DETERMINANT                                      61210018
000018          C     NND       = POWER OF TEN TO MULTIPLY DETERMINANT             61210019
000019          C     ND        = POWERS OF TENS FACTOR FOR DETERMINANT.           61210025
000020          C     KERR      = ERROR CODE,  =K, SINGULAR RANK , =-1 SOLVED EQUATIONS 61210020
000021          C-------------------------------------------------------------------
000022                DIMENSION         A(NA,NA),B(NA,1 )                          61210021
000023                DIMENSION ITEM(2)                                            61210022
000024                EQUIVALENCE (ID,D)
000025          C-------------------------------------------------------------------
000026                D         = 1.0                                              61210024
000027                ND        = 0                                                61210026
000028                N=NN                                                         61210027
000029                M=MM                                                         61210028
000030          C-------------------------------------------------------------------
000031          C     TEST FOR TRIVIAL CASE N=1.
000032          C-------------------------------------------------------------------
000033                IF(N .EQ. 1)            GO TO 110
000034          C-------------------------------------------------------------------
000035          C     SET-UP THE PERMUTATION VECTOR.                               61210030
000036          C-------------------------------------------------------------------
000037                DO 1      I=1,N                                              61210031
000038           1    ITEM(I)   = I                                                61210032
000039                N1        = N-1                                              61210033
000040                DO 60     K=1,N                                              61210034
000041          C-------------------------------------------------------------------
000042          C     SEARCH AND SET THE ABSOLUTE LARGEST ELEMENT AS THE PIVOT.    61210036
000043          C-------------------------------------------------------------------
000044                PIVOT     = 0.                                               61210038
000045                DO 10     I=K,N                                              61210039
000046                DO 9      J=K,N                                              61210040
000047                XTEM      = A(I,J)                                           61210041
000048                IF( ABS(XTEM) .LE.  ABS(PIVOT))  GO TO 9                     61210042
000049                PIVOT     = XTEM                                             61210043
000050                IS        = I                                                61210044
000051                IT        = J                                                61210045
000052           9    CONTINUE                                                     61210046
000053           10   CONTINUE                                                     61210047
000054          C-------------------------------------------------------------------
000055          C     COMPUTE DETERMINANT AND TEST FOR SINGULAR MATRIX.            61210048
000056          C-------------------------------------------------------------------
```

```
000057          D         = D*PIVOT                                          61210051
000058          IF(ID .NE. 0)             GO TO 11                         61210052
000059        C-------------------------------------------------------------
000060        C     IF MATRIX IS SINGULAR,SET THE RANK OF MATRIX A IN KERR    AND EXIT61210053
000061        C-------------------------------------------------------------
000062          KERR      =    K-1                                          61210054
000063          GO TO 100                                                   61210055
000064       11 XTEM      =     ABS(D)                                       61210056
000065          IF(XTEM.LE.1.0 )          GO TO 13                         61210057
000066          D         = D/10.                                           61210058
000067          ND        = ND+1                                            61210059
000068          GO TO 11                                                    61210060
000069       13 IF(XTEM.GE.0.1)           GO TO 14                         61210061
000070          D         = D*10.0                                          61210062
000071          ND        = ND-1                                            61210063
000072          GO TO 11                                                    61210064
000073       14 CONTINUE                                                    61210065
000074          IF(K.EQ.IS)               GO TO 30                         61210066
000075        C-------------------------------------------------------------
000076        C     IF THE PIVOT IS NOT IN THE RIGHT ROW,INTERCHANGE ROWS.    61210068
000077        C-------------------------------------------------------------
000078          DO 20     J=1,N                                             61210070
000079          XTEM      = A(IS,J)                                         61210071
000080          A(IS,J)   = A(K,J)                                          61210072
000081          A(K ,J)   = XTEM                                            61210073
000082       20 CONTINUE                                                    61210074
000083          DO 21     J=1,M                                             61210075
000084          XTEM      = B(IS,J)                                         61210076
000085          B(IS,J)   = B(K ,J)                                         61210077
000086          B(K ,J)   = XTEM                                            61210078
000087       21 CONTINUE                                                    61210079
000088          D         = -D                                              61210080
000089       30 IF(K.EQ.IT)               GO TO 40                         61210081
000090        C-------------------------------------------------------------
000091        C     IF THE PIVOT IS NOT IN THE RIGHT COL.,EXCHANGE COLS AND RECORD 61210083
000092        C     THIS IN THE PERMUTATION VECTOR.                           61210084
000093        C-------------------------------------------------------------
000094          DO 31     I=1,N                                             61210086
000095          XTEM      = A(I,IT)                                         61210087
000096          A(I,IT)   = A(I,K )                                         61210088
000097          A(I,K )   = XTEM                                            61210089
000098       31 CONTINUE                                                    61210090
000099          D         = -D                                              61210091
000100        C                                                             61210092
000101        C     SET PERMUTATION VECTOR                                  61210093
000102        C                                                             61210094
000103          I         = ITEM(IT)                                        61210095
000104          ITEM(IT)  = ITEM(K )                                        61210096
000105          ITEM(K )  = I                                               61210097
000106        C-------------------------------------------------------------
000107       40 CONTINUE                                                    61210099
000108          K1        = K+1                                             61210100
000109          IF(K1.GT.N)               GO TO 60                         61210101
000110        C-------------------------------------------------------------
000111        C     MULTIPLY THE K-TH ROW BY -A(I,K)/PIVOT AND ADD TO THE I-TH ROW 61210103
000112        C-------------------------------------------------------------
000113          DO 50     I=K1,N                                            61210104
000114          DO 50     J=K1,N                                            61210105
000115          A(I,J)    = A(I,J) - A(K,J)/PIVOT * A(I,K)                  61210106
000116       50 CONTINUE                                                    61210107
```

```
000117            DO 51    I=K1,N                                          61210108
000118            DO 51    J=1,M                                           61210109
000119            B(I,J)   = B(I,J) - A(I,K)/PIVOT*B(K,J)                  61210110
000120       51   CONTINUE                                                 61210111
000121       60   CONTINUE                                                 61210112
000122           C-------------------------------------------------------
000123           C    BACKSUBSTITUTION FOLLOWS.                           61210114
000124           C-------------------------------------------------------
000125            DO 70    J=1,M                                           61210116
000126            B(N,J)   = B(N,J)/A(N,N)                                 61210117
000127       70   CONTINUE                                                 61210118
000128            I        = N                                             61210119
000129            DO 73    K=2,N                                           61210120
000130            I1       = I                                             61210121
000131            I        = I-1                                           61210122
000132            PIVOT    = A(I,I)                                        61210123
000133            DO 72    IT=1,M                                          61210124
000134            XTEM     = 0.D0                                          61210125
000135            DO 71    J=I1,N                                          61210126
000136       71   XTEM     = A(I,J)*B(J,IT) + XTEM                         61210127
000137       72   B(I,IT)  = (B(I,IT) - XTEM)/PIVOT                        61210128
000138       73   CONTINUE                                                 61210129
000139           C-------------------------------------------------------
000140           C    USE PERMUTATION VECTOR TO EXCHANGE ROWS OF B-MATRIX.  61210131
000141           C-------------------------------------------------------
000142            DO 81    I=1,N                                           61210133
000143       79   IF(ITEM(I).EQ.I)         GO TO 81                        61210134
000144            K        = ITEM(I)                                       61210135
000145            DO 80    J=1,M                                           61210136
000146            XTEM     = B(K,J)                                        61210137
000147            B(K,J)   = B(I,J)                                        61210138
000148            B(I,J)   = XTEM                                          61210139
000149       80   CONTINUE                                                 61210140
000150            ITEM(I)  = ITEM(K)                                       61210141
000151            ITEM(K)  = K                                             61210142
000152            GO TO 79                                                 61210143
000153       81   CONTINUE                                                 61210144
000154       82   KERR=-1                                                  61210145
000155            DD       =    D                                          61210146
000156            NND      =    ND                                         61210147
000157       100  RETURN                                                   61210148
000158       110  DO 115 J=1,M
000159       115  B(1,J) = B(1,J)/A(1,1)
000160            D  = A(1,1)
000161            GO TO 82
000162            END                                                      61210149
```

```
@ ELT SUBRIN,1,720427, 34004

000001                SUBROUTINE SUBRIN
000002              C-----------------------------------------------------------------
000003              C     SUBROUTINE TO READ RECALL(RESTART OR HISTORY) TAPE.
000004              C-----------------------------------------------------------------
000005                DIMENSION TC(500)
000006                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000007                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000008                COMMON QZZS(900), TAB(60,32)
000009                COMMON XCOND(10), DENS(10), QX(10)
000010                COMMON TEM(10)
000011                COMMON COND,RHO,QXX,QZZ
000012                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000013                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000014                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000015                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000016                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000017                COMMON IKODE(900), INTAB(10,3)
000018                COMMON JNODE(900)
000019                COMMON /IJK/ IPTC
000020                COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000021               1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000022                COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000023               1 , FN(250), BQ(40), KTEM(40), TS(250)
000024                COMMON /TAPE/  ITAPE, ISTART, ISS
000025                LOGICAL DAMP, DF1, DF2, DF3, TOL4
000026                COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000027                COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000028                EQUIVALENCE (IDMP1,DMP1), (IDMP2,DMP2), (IDMP3,DMP3),
000029               1   (IMAX1,DMAX1), (IMAX2,DMAX2), (IMAX3,DMAX3), (ITOL,TOLN)
000030                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000031              C                (TEM(4),XTEM4)
000032                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000033              C                (ITEM(4),MTYPE)
000034                EQUIVALENCE (TI(1),TC(1)), (DT,INTDT)
000035              C-----------------------------------------------------------------
000036                REWIND 3
000037                READ  (3) HED, NUMNP, NUMEL, KAT, NUMMT, NTAB, ISS, IVARC
000038               1 , ((INTAB(I,J), J=1,3), XCOND(I), DENS(I), QX(I),  I=1,NUMMT),
000039               2   ((TAB(K,L), K=1,60), IDTAB(L), ITFAC(L), L=1,32),
000040               3 (MM,KODE(M),IKODE(M),X(M),Y(M),T(M),TI(M),QZZS(M), M=1,NUMNP)
000041               4   ,       DAMP, DF1, DF2, DF3, TOL4,  DMP1, DMAX1, DMP2, DMAX2,
000042               5 DMP3, DMAX3, TOLN
000043                WRITE (6,2000) HED,NUMNP,NUMEL,NUMBC,NUMMT,INTER,DT,TINIT,TMAX
000044                 WRITE (6,2009) (M,INTAB(M,1),XCOND(M),INTAB(M,2),DENS(M),
000045               1   INTAB(M,3),QX(M),M=1,NUMMT )
000046                DO 7060  N=1,NUMEL
000047                READ  (3) NN, I1, I2, I3, I4, I5
000048                WRITE (4) NN, I1, I2, I3, I4, I5
000049             7060 CONTINUE
000050                READ  (3) NUMBC, MBAND, IFLAGR, IDF, SIGMA,
000051               1 (IBC(I), JBC(I), IHBC(I), ITBC(I),  HBBC(I), TEMEBC(I), XLBC(I),
000052               2 IIBC(I), JJBC(I), EPS(I), NRF(I), TS(I), FN(I), I=1,NUMBC),
000053               3 ((F(I,J), J=1,IDF), I=1,IDF), (JNODE(I), I=1,NUMNP)
000054             7065 READ (3) TIME, (TC(N), N=1,NUMNP)
000055                IF(TINIT .GT. TIME)    GO TO 7065
000056                CALL SUBR6
```

```
000057            WRITE (1) ((A(I,J),J=1,MBAND),I=1,NUMNP)
000058            WRITE (1)  (T(I), B(I), D(I), I=1,NUMNP)
000059            REWIND 1
000060            LL = 0
000061            CALL SUBR7 (LL)
000062            RETURN
000063         2000 FORMAT (1H0 12A6// 25H0NUMBER OF NODAL POINTS-- I4/
000064           1 25H NUMBER OF ELEMENTS------ I4 / 25H NUMBER OF CONVECTION BC-I4/
000065           2 25H NUMBER OF MATERIALS----- I4 /
000066           3 25H OUTPUT INTERVAL-------- I4 / 20H TIME INTERVAL------ F10.3/
000067           4 20H INITIAL TIME------- F10.3/ 20H MAXIMUM TIME------- F10.3 )
000068         2009 FORMAT ('0  M',10X,'TABLE-K',14X,'K',10X,'TABLE-R',9X,'RHO-CP',10X
000069           1   ,   'TABLE-Q',14X,'Q'/ 10(I4,3(10X,I7,E15.6)/) )
000070            END
```

```
@ ELT SUBR0,1,720427, 34008

000001            SUBROUTINE SUBR0
000002          C
000003            DIMENSION TC(500)
000004             COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000005            COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000006            COMMON QZZS(900), TAB(60,32)
000007            COMMON XCOND(10), DENS(10), QX(10)
000008            COMMON TEM(10)
000009            COMMON COND,RHO,QXX,QZZ
000010            COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000011            COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000012            COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000013            COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000014            COMMON ITEM(10), IDTAB(32), ITFAC(32)
000015            COMMON IKODE(900), INTAB(10,3)
000016            COMMON JNODE(900)
000017            COMMON /IJK/ IPTC
000018            COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000019           1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000020            COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000021           1 , FN(250), BQ(40), KTEM(40), TS(250)
000022            COMMON /TAPE/  ITAPE, ISTART, ISS
000023            LOGICAL DAMP, DF1, DF2, DF3, TOL4
000024            COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000025            COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000026            EQUIVALENCE (IDMP1,DMP1), (IDMP2,DMP2), (IDMP3,DMP3),
000027           1   (IMAX1,DMAX1), (IMAX2,DMAX2), (IMAX3,DMAX3), (ITOL,TOLN)
000028               EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000029          C                (TEM(4),XTEM4)
000030               EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000031          C                (ITEM(4),MTYPE)
000032            EQUIVALENCE (TI(1),TC(1)), (DT,INTDT)
000033          C*****************************************************************
000034          C     READ AND PRINT OF CONTROL INFORMATION
000035          C*****************************************************************
000036            REWIND 4
000037            REWIND 8
000038            IDMP1 = 0
000039            IDMP2 = 0
000040            IDMP3 = 0
000041            IDMAX1 = 0
000042            IDMAX2 = 0
000043            IDMAX3 = 0
000044            ITOL = 0
000045           50   READ (5,1000,ERR=7010,END=7000)
000046           1 HED,ISTART,JTAPE,NUMNP,NUMEL,NUMBC,KAT,IPT,NTAB,TINIT,IDT,DT,
000047           2 INTER, TMAX, IPUNCH, DF1, DF2, DF3, TOL4, IDUM
000048            TIME = TINIT
000049            IF(INTDT .GT. 0)       DT2 = 1./DT
000050          C-----------------------------------------------------------------
000051          C     IF ISTART = 1, RETURN TO MAIN PROGRAM TO READ REST OF DATA&RESTART
000052          C-----------------------------------------------------------------
000053            IF(ISTART .EQ. 1)      GO TO 120
000054            ITAPE  = JTAPE
000055            IF(IPT .NE. 0)         IPTC = 1
000056            WRITE (6,9000)
```

```
000057            IF(IDT .EQ. 0  .AND.  INTDT .EQ. 0)          ISS=1
000058            NUMMT  = 0
000059            DAMP = DF1 .OR. DF2 .OR. DF3
000060            IF(DAMP .OR. TOL4)      READ (5,5010) DMP1, DMAX1, DMP2, DMAX2,
000061           1                 DMP3, DMAX3, TOLN
000062          C-------------------------------------------------------------------
000063          C     SET DEFAULT VALUES.
000064          C-------------------------------------------------------------------
000065            IF(IDMP1 .EQ. 0)        DMP1 = 0.5
000066            IF(IDMP2 .EQ. 0)        DMP2 = 0.5
000067            IF(IDMP3 .EQ. 0)        DMP3 = 0.5
000068            IF(IMAX1 .EQ. 0)        DMAX1 = 10.
000069            IF(IMAX2 .EQ. 0)        DMAX2 = 10.
000070            IF(IMAX3 .EQ. 0)        DMAX3 = 200.
000071            IF(ITOL .EQ. 0)         TOLN=0.00005
000072          C-------------------------------------------------------------------
000073           51   READ (5,1003,ERR=7010,END=7000)
000074               1                          M,ITABK,XTEM1,ITABR,XTEM2,ITABQ,XTEM3
000075            IF(M.LE.0)   GO TO 52
000076            NUMMT  = NUMMT+1
000077            XCOND(M) = XTEM1
000078            DENS(M)  = XTEM2
000079            QX(M)    = XTEM3
000080            IF(ITABK .GT. 32)       ITABK = 0
000081            IF(ITABR .GT. 32)       ITABR = 0
000082            IF(ITABQ .GT. 32)       ITABQ = 0
000083               INTAB(M,1)  = ITABK
000084               INTAB(M,2)  = ITABR
000085               INTAB(M,3)  = ITABQ
000086             GO TO 51
000087           52   IF(NUMNP) 900,900,53
000088           53   IF(KAT) 54,56,54
000089             54 WRITE (6,2010)
000090            GO TO 58
000091             56 WRITE (6,2011)
000092           58   IF(ISS .EQ. 1)          WRITE (6,6000)
000093            WRITE (6,2000) HED,NUMNP,NUMEL,NUMBC,NUMMT,INTER,DT,TINIT,TMAX
000094            IF(DAMP .OR. TOL4)      WRITE (6,2012) DMP1, DMAX1, DMP2, DMAX2,
000095           1                          DMP3, DMAX3, TOLN
000096             WRITE (6,2009) (M,INTAB(M,1),XCOND(M),INTAB(M,2),DENS(M),
000097           C   INTAB(M,3),QX(M),M=1,NUMMT )
000098            IF(NTAB.NE.0)           CALL RTAB
000099            IF(IPT .NE. 0)          WRITE (6,2013)
000100            IF(JTAPE .EQ. 1)        WRITE (6,2014)
000101          C
000102          C*******************************************************************
000103          C     READ OR GENERATE NODAL POINT INFORMATION
000104          C*******************************************************************
000105            WRITE (6,9000)
000106            WRITE (6,2001)
000107            L=1
000108          C
000109             60 READ  (5,1001,ERR=7010,END=7000)
000110              1 N, ITEM(1), XTEM1, XTEM2, XTEM3, XTEM4, ITEM(2)
000111             KODE(N)  = ITEM(1)
000112             X(N) = XTEM1
000113             Y(N) = XTEM2
000114             T(N) = XTEM3
000115             TI(N)  = XTEM4
000116             DIFF=N+1-L
```

```
000117            IF (N-L) 65,80,70
000118         65 WRITE (6,2020) N
000119            GO TO 60
000120         70 DX=(X(N)-X(L-1))/DIFF
000121            DY=(Y(N)-Y(L-1))/DIFF
000122         75 KODE(L)=0
000123            X(L)=X(L-1)+DX
000124            Y(L)=Y(L-1)+DY
000125            T(L)=0.0
000126            TI(L)  = TI(L-1)
000127         80 WRITE (6,2002) L, KODE(L), X(L), Y(L), T(L), TI(L)
000128            L  = L+1
000129            IF (N-L) 90,80,75
000130         90 IF (NUMNP+1-L) 100,100,60
000131        100 CONTINUE
000132            DO 110 I=1,NUMNP
000133            D(I)=0.
000134            B(I)=0.
000135            WRITE (8) T(I), D(I), B(I)
000136            DO 110 J=1,NDIM
000137        110 A(I,J)=0.
000138            MBAND=0
000139            NUM=0
000140            WRITE (6,9000)
000141            WRITE (6,2003)
000142            DO 115 I = 1,4
000143        115 LM(I) = 0
000144        120 CONTINUE
000145            RETURN
000146        900 WRITE (6,3000)
000147            GO TO 120
000148           C-------------------------------------------------------------------
000149           C     END OF FILE RETURN.
000150        7000 CONTINUE
000151            IF(ITAPE .GT. 0)       END FILE 2
000152            STOP
000153        7010 WRITE (6,3005)
000154            READ (5,3010,END=7000)  (HED(I),I=1,12)
000155            WRITE (6,3010) (HED(I), I=1,12)
000156            GO TO 7000
000157           C-------------------------------------------------------------------
000158           C     FORMAT STATEMENTS
000159           C-------------------------------------------------------------------
000160        1000 FORMAT (12A6, 6X, 2I1/ 6I5, E10.4, I5, E10.4,I5,E10.4,I5,4L1,I1)
000161        1001 FORMAT (2I5,4F10.0,I5)
000162        1003 FORMAT (I5,4(I5,E10.4) )
000163        2000 FORMAT (1H0 12A6// 25H0NUMBER OF NODAL POINTS-- I4/
000164            1 25H NUMBER OF ELEMENTS------ I4 / 25H NUMBER OF CONVECTION BC-I4/
000165            2 25H NUMBER OF MATERIALS----- I4 /
000166            3 25H OUTPUT INTERVAL--------- I4 / 20H TIME INTERVAL------ F10.3/
000167            4 20H INITIAL TIME------- F10.3/ 20H MAXIMUM TIME-------- F10.3 )
000168        2001 FORMAT (20H0 N.P. NO.      CODE 14X,1HX,14X,1HY,14X,1HT,13X,2HT0,
000169            1   12H  CODE TABLE   )
000170        2002 FORMAT (2I10,4F15.4,I12 )
000171        2003 FORMAT (35H0   N    I    J    K    L  MATERIAL )
000172        2009 FORMAT ('0  M',10X,'TABLE-K',14X,'K',10X,'TABLE-R',9X,'RHO-CP',10X
000173            C   ,   'TABLE-Q',14X,'Q'/ 10(I4,3(10X,I7,E15.6)/) )                12200258
000174        2010 FORMAT (24H0AXISYMMETRIC SOLID BODY )
000175        2011 FORMAT ('0TWO DIMENSIONAL PLANE BODY' )
000176        2012 FORMAT ('0DMP1 = ', E14.6, '  DMAX1 = ', E14.6/ ' DMP2 = ', E14.6,
```

```
000177            1  '  DMAX2 = ', E14.6/ ' DMP3 = ', E14.6, '  DMAX3 = ', E14.6/
000178            2 ' TOLN = ', E14.6 )
000179         2013 FORMAT ('0OUTPUT INCLUDES GEOMETRY PLOT')
000180         2014 FORMAT ('0OUTPUT INCLUDES RECALL TAPE' )
000181         2020 FORMAT (10H0CARD NO. I4, 13H OUT OF ORDER )
000182         3000 FORMAT (16H0ERROR.NUMNP = 0  )
000183         3005 FORMAT ('0INPUT ERROR. NEXT CARD,IF ANY,IS'//)
000184         3010 FORMAT (1X, 12A6 )
000185         5010 FORMAT (8F10.4)
000186         6000 FORMAT ('0***** STEADY-STATE CASE FOLLOWS *****'  )
000187         9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000188            1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000189            2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000190              END
```

```
@ ELT SUBR1,1,720427, 34011

000001            SUBROUTINE SUBR1
000002          C*********************************************************************
000003          C     FORM CONDUCTIVITY MATRIX FOR COMPLETE BODY
000004          C*********************************************************************
000005            DIMENSION TC(500)
000006             COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000007            COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000008            COMMON QZZS(900), TAB(60,32)
000009            COMMON XCOND(10), DENS(10), QX(10)
000010            COMMON TEM(10)
000011            COMMON COND,RHO,QXX,QZZ
000012            COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000013            COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000014            COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000015            COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000016            COMMON ITEM(10), IDTAB(32), ITFAC(32)
000017            COMMON IKODE(900), INTAB(10,3)
000018            COMMON /SAVE3/ IOFF
000019            LOGICAL DAMP, DF1, DF2, DF3, TOL4
000020            COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000021            COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000022            EQUIVALENCE (IDMP1,DMP1), (IDMP2,DMP2), (IDMP3,DMP3),
000023           1   (IMAX1,DMAX1), (IMAX2,DMAX2), (IMAX3,DMAX3), (ITOL,TOLN)
000024              EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000025           C                  (TEM(4),XTEM4)
000026              EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000027           C                  (ITEM(4),MTYPE)
000028            EQUIVALENCE (I1,ITEM(5)), (I2,ITEM(6)), (I3,ITEM(7)), (I4,ITEM(8))
000029            EQUIVALENCE (TI(1),TC(1))
000030            COMMON /TAPE/ ITAPE, ISTART, ISS
000031          C---------------------------------------------------------------------
000032          C     GENERATE RECALL TAPE IF ITAPE IS NONZERO.
000033          C---------------------------------------------------------------------
000034            ITRA = 1
000035            IF (ITAPE.EQ.0)         GO TO 70
000036            WRITE (2) HED, NUMNP, NUMEL, KAT, NUMMT, NTAB, ISS, IVARC
000037           1 , ((INTAB(I,J), J=1,3), XCOND(I), DENS(I), QX(I),  I=1,NUMMT),
000038           2   ((TAB(K,L), K=1,60), IDTAB(L), ITFAC(L), L=1,32),
000039           3 (M, KODE(M),IKODE(M),X(M),Y(M),T(M),TI(M),QZZS(M), M=1,NUMNP)
000040           4   ,       DAMP, DF1, DF2, DF3, TOL4,  DMP1, DMAX1, DMP2, DMAX2,
000041           5 DMP3, DMAX3, TOLN
000042            ITRA = 2
000043         70   CONTINUE
000044          C---------------------------------------------------------------------
000045            DO 200 N=1,NUMEL
000046          C---------------------------------------------------------------------
000047          C       1. READ OR GENERATE ELEMENT PROPERTIES
000048          C---------------------------------------------------------------------
000049            IF (NUM-N) 120,121,121
000050         120 READ (5,1002) NUM,KX(1),KX(2),KX(3),KX(4),MTYPE
000051            IERR = 0
000052            DO 90   I=1,3
000053            DO 90   J=I,3
000054            IF( IABS(KX(I)-KX(J+1)) .GT. 40) IERR = 1
000055         90   CONTINUE
000056            IF(IERR .EQ. 1)         WRITE (6,8005)
```

```
000057      C-------------------------------------------------------------------
000058      C     CHECK INPUT FOR COUNTER-CLOCKWISE DIRECTION.
000059      C-------------------------------------------------------------------
000060            AREA = 0.
000061            DO 100  I=1,4
000062            J  = I+1
000063            IF(J .GT. 4)            J = 1
000064            K  = KX(I)
000065            L  = KX(J)
000066            YB = (Y(K)+Y(L))/2.0
000067            DX = X(L) - X(K)
000068       100  AREA = YB*DX+AREA
000069            IF(AREA .GT. 0.)        WRITE (6,8000) NUM
000070       121  DO 122 I=1,4
000071       122  LM(I)=LM(I)+1
000072            IF (NUM-N) 123,124,126
000073       123  WRITE (6,2021) NUM
000074            GO TO 120
000075       124  DO 125 I=1,4
000076       125  LM(I)=KX(I)
000077            ITYPE  = MTYPE
000078            IF(ITYPE .EQ. 0)        ITYPE = 1
000079            COND = XCOND(ITYPE)
000080            RHO  = DENS(ITYPE)
000081            QZZ  = QX(ITYPE)
000082            ITABK  = INTAB(ITYPE,1)
000083            ITABR  = INTAB(ITYPE,2)
000084            ITABQ  = INTAB(ITYPE,3)
000085       126  CONTINUE
000086       127  CONTINUE
000087            WRITE (6,2004) N, (LM(M), M=1,4), ITYPE
000088            WRITE (4)      N, (LM(M), M=1,4), ITYPE
000089            GO TO (142,140), ITRA
000090       140  WRITE (2) N, (LM(M), M=1,4), ITYPE
000091       142  CONTINUE
000092      C-------------------------------------------------------------------
000093      C       2. FORM ELEMENT CONDUCTIVITY MATRIX
000094      C-------------------------------------------------------------------
000095            I=LM(1)
000096            J=LM(2)
000097            K=LM(3)
000098            L=LM(4)
000099            LM(5)=I
000100      C
000101            XX=(X(I)+X(J)+X(K)+X(L))/4.
000102            YY=(Y(I)+Y(J)+Y(K)+Y(L))/4.
000103      C-------------------------------------------------------------------
000104      C     ITABQ .LT. 0      Q VS. TIME TABLE.
000105      C     ITABQ .EQ. 0      NO TABLE.
000106      C     ITABQ .GT. 0      Q VS X OR Y TABLE.
000107      C-------------------------------------------------------------------
000108            IF(ITABQ)    128,130,129
000109       128  ITABQ  = -ITABQ
000110            CALL LINT (TIME,TAB(1,ITABQ),QZZ,DX)
000111            GO TO 130
000112       129  CONTINUE
000113            ZZ   = XX
000114            IF(IDTAB(ITABQ).EQ.8)  ZZ = YY
000115            CALL LINT (ZZ,TAB(1,ITABQ),QZZ,DX)
000116       130  CONTINUE
```

```
000117            QZZS(N)  = QZZ
000118          C
000119            CALL CONMAT
000120       200  CONTINUE
000121            WRITE (1) ((A(I,J),J=1,MBAND),I=1,NUMNP)
000122            WRITE (1)  (T(I), B(I), D(I), I=1,NUMNP)
000123            REWIND 1
000124            RETURN
000125          C-------------------------------------------------------------------
000126          C     FORMAT STATEMENTS
000127          C-------------------------------------------------------------------
000128       1002 FORMAT (10I5)
000129       2021 FORMAT (13H0BAD CARD NO. I4)
000130       2004 FORMAT (5I5,I10)
000131       8000 FORMAT ('0POSSIBLE ERROR IN ELEMENT',I4,'.CHECK FOR CLOCKWISE NODA
000132           1L INPUT.' )
000133       8005 FORMAT ('0CHECK NEXT CARD FOR NODAL WIDTH ERROR. ')
000134            END
```

```
@ ELT SUBR2,1,720427, 34014

000001                SUBROUTINE SUBR2
000002                DIMENSION TC(500)
000003                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005                COMMON QZZS(900), TAB(60,32)
000006                COMMON XCOND(10), DENS(10), QX(10)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(900), INTAB(10,3)
000015                COMMON JNODE(900)
000016                COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000017               1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000018                COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000019               1 , FN(250), BQ(40), KTEM(40), TS(250)
000020                COMMON /TAPE/  ITAPE, ISTART, ISS
000021                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000022               C                (TEM(4),XTEM4)
000023                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000024               C                (ITEM(4),MTYPE)
000025                EQUIVALENCE (TI(1), TC(1)), (IEPSI,EPSI)
000026                DATA IDF/40/
000027              C*********************************************************************
000028              C     BOUNDARY CONDITIONS
000029              C*********************************************************************
000030              C---------------------------------------------------------------------
000031              C     SIGMA         STEFAN-BOLTZMAN CONSTANT.
000032              C---------------------------------------------------------------------
000033                      DO 180  I=1,NUMNP
000034               180    JNODE(I) = 0
000035                      IFLAGR = 0
000036                      WRITE (6,9000)
000037               602    CONTINUE
000038              C
000039              C     1. CONVECTION BOUNDARY CONDITIONS
000040              C
000041                      INBC = 0
000042                      IF(NUMBC .EQ. 0)       GO TO 225
000043               203    WRITE (6,2006)
000044                      ISAV  = 0
000045                      JSAV  = 0
000046              C---------------------------------------------------------------------
000047              C     INPUT CONTROL BY EITHER NUMBC = EXACT NUMBER OF CONVECTION CARDS
000048              C     OR SET NUMBC = NUMNP AND END CONVECTION BOUNDARY INPUT BY A
000049              C     NEGATIVE INTEGER
000050              C---------------------------------------------------------------------
000051                      DO 215  N=1,NUMBC
000052                      READ (5,5001) I,J,H,TEME,IH,ITEMP,EPSI,FI,NRFI,IS,ITS,TEMS
000053                      IF(I)         217,206,206
000054               206    INBC =INBC+1
000055                         TEMP = TEME
000056                      IF(I.EQ.0)    I=JSAV
```

```
000057            IF(J.EQ.0)   J=ISAV
000058            ISAV   = I
000059            JSAV   = J
000060          C     CORRECT FOR NODAL OFF-SET.
000061            XL=SQRT((X(J)-X(I))**2+(Y(J)-Y(I))**2)
000062            IF (KAT)     207,208,207
000063           207  XL=XL*(X(I)+X(J))/2.
000064           208  CONTINUE
000065          C-----------------------------------------------------------------
000066          C     SET NODE FLAGS.
000067          C     JNODE(I) = 0, CONDUCTION NODE.
000068          C     JNODE(I) = 1, CONVECTION NODE.
000069          C     JNODE(I) = 2, RADIATION NODE.
000070          C-----------------------------------------------------------------
000071            NI = 0
000072            IF(IEPSI .NE. 0)       NI = 1
000073            JNODE(I) = 1+NI
000074            JNODE(J) = 1+NI
000075            IBC(N) = I
000076            JBC(N) = J
000077            IHBC(N)  = IH
000078            ITBC(N)  = ITEMP
000079            XLBC(N)  = XL
000080            EPS(N) = EPSI
000081            FN(N)  = FI
000082            NRF(N) = NRFI
000083            IF(NRFI .NE. 0)        IFLAGR = 1
000084          C-----------------------------------------------------------------
000085          C     CHECK FOR H AND TEMP TABLES.
000086          C-----------------------------------------------------------------
000087            IF(NTAB .EQ. 0)  GO TO 210
000088            IF(ITEMP .GT. 32)      ITEMP = 0
000089            IF(IH .GT. 32)         IH = 0
000090          C-----------------------------------------------------------------
000091          C     IH .LT. 0    H VS. TIME TABLE.
000092          C     IH .EQ. 0    NO H-TABLE.
000093          C     IH .GT. 0    H VS. TEMP. TABLE.
000094          C-----------------------------------------------------------------
000095            IF(IH)         201,204,202
000096           201  IH = -IH
000097            CALL LINT (TIME,TAB(1,IH),H,DX)
000098            GO TO 204
000099           202  CONTINUE
000100            TEMPX  = (TI(I)+TI(J))/2.0
000101                       CALL LINT (TEMPX,TAB(1,IH),H, DX)
000102                  LOC = ITFAC(IH)
000103                  FAC = 1.0
000104               IF(LOC .GT. 0) CALL LINT(TIME,TAB(1,LOC),FAC,DX)
000105            H  = H*FAC
000106           204  CONTINUE
000107            IF(ITEMP .GT. 0)       CALL LINT(TIME,TAB(1,ITEMP),TEMP,DX)
000108           210  CONTINUE
000109          C-----------------------------------------------------------------
000110          C     CHECK VALUE OF EXTERNAL TEMPERATURE.
000111          C-----------------------------------------------------------------
000112            HBBC(N)  = H
000113            TEMEBC(N)  = TEMP
000114            TS(N) = TEMS
000115            IF(ITS .EQ. 0)         TS(N) = TEMP
000116            WRITE (6,6007) I,J,H,TEMP,IH,ITEMP,EPSI,FI,NRFI,IS,TS(N)
```

```
000117          215  CONTINUE
000118          217  NUMBC  = INBC
000119               WRITE (6,2010) NUMBC
000120               CALL CONVBI
000121          C-------------------------------------------------------------------
000122          C    CALL CONVBC TO CALCULATE THE CONVECTION EFFECTS.
000123          C-------------------------------------------------------------------
000124               DO 218   N=1,NUMBC
000125               I  = IBC(N)
000126               J  = JBC(N)
000127               H  = HBBC(N)
000128               TEMP = TEMEBC(N)
000129               XL = XLBC(N)
000130          218  CALL CONVBC(I,J,N)
000131          C-------------------------------------------------------------------
000132          C    CHECK FOR SURFACE-TO-SURFACE RADIATION COMPUTATIONS.
000133          C    MORE DATA IS REQUIRED FOR THE LATTER OPTION.
000134          C-------------------------------------------------------------------
000135               IF(IFLAGR .EQ. 0)       GO TO 225
000136               DO 220  N=1,NUMBC
000137               NRFI = NRF(N)
000138               IF(NRFI .EQ. 0)         GO TO 220
000139               READ (5,5005,END=800) IS, (F(IS,I), I=1,NRFI)
000140               WRITE (6,6005) IS, (F(IS,I), I=1,NRFI)
000141          6005 FORMAT (1X, I5, 8E14.6 / (1X,5X, 8E14.6) )
000142               DO 219   I=1,NRFI
000143               F(IS,I)  = (EPS(N)-1.0)*F(IS,I)
000144               IF(IS .EQ. I)           F(IS,I) = F(IS,I)+1.
000145          219  CONTINUE
000146          220  CONTINUE
000147               CALL RAD
000148          225  CONTINUE
000149          C-------------------------------------------------------------------
000150          C    CALCULATE THE TEMPERATURE BOUNDARY CONDITIONS.
000151          C-------------------------------------------------------------------
000152               CALL TEMPBC
000153          C-------------------------------------------------------------------
000154          C    GENERATE RECALL TAPE IF ITAPE IS NONZERO.
000155          C-------------------------------------------------------------------
000156               IF(ITAPE .EQ. 0)        GO TO 250
000157               WRITE (2) NUMBC, MBAND, IFLAGR, IDF, SIGMA,
000158              1 (IBC(I), JBC(I), IHBC(I), ITBC(I),  HBBC(I), TEMEBC(I), XLBC(I),
000159              2 IIBC(I), JJBC(I), EPS(I), NRF(I), TS(I), FN(I), I=1,NUMBC),
000160              3 ((F(I,J), J=1,IDF), I=1,IDF), (JNODE(I), I=1,NUMNP)
000161          250  RETURN
000162          800  WRITE (6,8000)
000163               STOP
000164          5005 FORMAT (I5,5X,7E10.4 / (8E10.4) )
000165          8000 FORMAT ('0 EOF DURING THE READING OF RADIATION CARDS.' )
000166          C-------------------------------------------------------------------
000167          C    FORMAT STATEMENTS
000168          C-------------------------------------------------------------------
000169          5001 FORMAT (2I5, 2F10.0, 2I5, 2E10.4, 2I4, I2, F10.0 )
000170          6007 FORMAT (1X, 2I5, 2E15.6, I5, I6, 7X, E15.6, E17.6,2I5, 1X, E14.6)
000171          2006 FORMAT ('0    I    J',14X,'H    TEMPERATURE H-TAB T-TAB RADIATION
000172              1EPSILON         F-FACTOR     F-TABLE NO. ' )
000173          2007 FORMAT (1X,2I5,2E15.6,I5,I6, 7X,E15.6,E17.6,I5, 1X, 2A6 )
000174          2010 FORMAT ('0NUMBER OF CONVECTION BOUNDARY CARDS - - -',I5 )
000175          9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000176              1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
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```
000177      2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000178        END
000179
```

```
@ ELT SUBR3,1,720427, 34017
```

```
000001              SUBROUTINE SUBR3
000002              DIMENSION TC(500)
000003               COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004              COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005              COMMON QZZS(900), TAB(60,32)
000006              COMMON XCOND(10), DENS(10), QX(10)
000007              COMMON TEM(10)
000008              COMMON COND,RHO,QXX,QZZ
000009              COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010              COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011              COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012              COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013              COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014              COMMON IKODE(900), INTAB(10,3)
000015              COMMON /TAPE/  ITAPE
000016                 EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000017            C                (TEM(4),XTEM4)
000018                 EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000019            C                (ITEM(4),MTYPE)
000020              EQUIVALENCE (TI(1),TC(1))
000021           C-------------------------------------------------------------------
000022              LL = 1
000023              NPT  = 0
000024           C      2. SOLVE FOR TEMPERATURES
000025           C*********************************************************************
000026           C     SOLVE FOR NODAL POINT TEMPERATURES
000027           C*********************************************************************
000028           C     FORM EFFECTIVE CONDUCTIVITY MATRIX FOR TIME INCREMENT
000029           C-------------------------------------------------------------------
000030              DO 320 N=1,NUMNP
000031              IF (KODE(N)) 320,305,320
000032            305 IF (D(N)) 310,320,310
000033            310 D(N)=DT2*D(N)
000034              A(N,1)=A(N,1)+D(N)
000035            320 CONTINUE
000036              WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000037              CALL SYMSO (1)
000038           C
000039           C     CALCULATE TEMPERATURE AT THE END OF EACH TIME INCREMENT
000040           C
000041           C
000042            340     CONTINUE
000043           C
000044           C      1. CALCULATE EFFECTIVE LOAD MATRIX
000045           C
000046              DO 400 I=1,NUMNP
000047              Q(I)=B(I)
000048              IF (KODE(I)) 400,395,400
000049            395 Q(I)=B(I)+D(I)*TC(I)
000050            400 CONTINUE
000051           C
000052              CALL SYMSO (2)
000053           C
000054              DO 500 I=1,NUMNP
000055            500  TC(I) = Q(I)
000056           C
```

```
000057              TIME =TIME+DT
000058                 IF(TIME .GE. TMAX)  GO TO 550
000059              LL=LL+1
000060              IF(LL-INTER) 600,550,550
000061       550    WRITE (6,2005) TIME,(N,TC(N),N=1,NUMNP )
000062              LL=0
000063            C
000064       600  CONTINUE
000065              IF (ITAPE.GT.0)
000066             *WRITE (2)  TIME,(TC(N),N=1,NUMNP)
000067              IF(TIME .LT. TMAX)      GO TO 340
000068       50     CONTINUE
000069              IF(IPUNCH .EQ. 0)       GO TO 710
000070            C-----------------------------------------------------------------
000071            C     PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000072            C-----------------------------------------------------------------
000073              DO 700 N=1,NUMNP
000074       700    WRITE (7,7000) N, X(N), Y(N), TC(N)
000075       710    CONTINUE
000076              RETURN
000077            C
000078            C     FORMAT STATEMENTS
000079            C
000080            C
000081       2005 FORMAT (6HOTIME= F12.5/ ( 6(I6,F14.4) )  )
000082       7000 FORMAT (I5, 5X, 2F10.4, 20X, F10.2 )
000083            C
000084            C
000085              END
```

```
@ ELT SUBR4,1,720427, 34019

000001                SUBROUTINE SUBR4
000002                DIMENSION TC(500)
000003                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005                COMMON QZZS(900), TAB(60,32)
000006                COMMON XCOND(10), DENS(10), QX(10)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(900), INTAB(10,3)
000015                COMMON /TAPE/  ITAPE, ISTART
000016                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000017              C                (TEM(4),XTEM4)
000018                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000019              C                (ITEM(4),MTYPE)
000020                EQUIVALENCE (TI(1),TC(1))
000021                LL = 1
000022                NPT  = 0
000023            C     IF(ISTART .EQ. 0)       GO TO 301
000024            C300  READ (3) TIME, (TC(N), N=1,NUMNP)
000025            C     IF(TINIT .GT. TIME)     GO TO 300
000026             301   WRITE (6,2005) TIME, (N,TC(N),N=1,NUMNP )
000027                   M  = 1
000028                   GO TO 304
000029            C
000030            C      2. SOLVE FOR TEMPERATURES
000031            C
000032            C*********************************************************************
000033            C     SOLVE FOR NODAL POINT TEMPERATURES
000034            C*********************************************************************
000035            C     FORM EFFECTIVE CONDUCTIVITY MATRIX FOR TIME INCREMENT
000036            C
000037             302  CONTINUE
000038                  READ (1) ((A(I,J), J=1,MBAND),I=1,NUMNP)
000039                  READ (1) (T(I), B(I), D(I), I=1,NUMNP)
000040                  REWIND 1
000041                  LL=LL+1
000042                  CALL SUBR7(LL)
000043             304  IF(IDT .EQ. 0)   GO TO 305
000044                  IF(TIME .LT. TAB(M,IDT) )   GO TO 305
000045                  DT = TAB(M+1,IDT)
000046                  DT2  = 1./DT
000047                  M  = M+2
000048                  GO TO 304
000049             305  DO 320 N=1,NUMNP
000050                  IF(KODE(N))  320,308,320
000051             308  IF(D(N))     310,320,310
000052              310 D(N)=DT2*D(N)
000053                  A(N,1)=A(N,1)+D(N)
000054              320 CONTINUE
000055                  CALL SYMSO (1)
000056            C
```

```
000057      C     CALCULATE TEMPERATURE AT THE END OF EACH TIME INCREMENT
000058      C
000059      C
000060      C
000061      C      1. CALCULATE EFFECTIVE LOAD MATRIX
000062      C
000063            DO 400 I=1,NUMNP
000064            Q(I)=B(I)
000065            IF (KODE(I)) 400,395,400
000066       395  Q(I)=B(I)+D(I)*TC(I)
000067       400  CONTINUE
000068      C
000069            CALL SYMSO (2)
000070      C
000071            DO 500 I=1,NUMNP
000072       500  TC(I) = Q(I)
000073      C
000074            TIME =TIME+DT
000075               IF(TIME .GE. TMAX)  GO TO 550
000076      C
000077            IF(LL-INTER) 555,550,550
000078       550  WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000079            LL=0
000080       555  CONTINUE
000081            IF (ITAPE.GT.0)
000082           *WRITE (2)  TIME,(TC(N),N=1,NUMNP)
000083            IF(TIME .LT. TMAX)      GO TO 302
000084       50   CONTINUE
000085            IF(IPUNCH .EQ. 0)       GO TO 710
000086      C-----------------------------------------------------------------------
000087      C     PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000088            DO 700 N=1,NUMNP
000089       700  WRITE (7,7000) N, X(N), Y(N), TC(N)
000090       710  CONTINUE
000091            RETURN
000092      C
000093      C     FORMAT STATEMENTS
000094      C
000095      C
000096       1007 FORMAT (2I5,2F10.4,2I5 )
000097       2005 FORMAT (6H0TIME= F12.5/ ( 6(I6,F14.4) )  )
000098       2007 FORMAT (2I5,2E15.6,2I5 )
000099       7000 FORMAT (I5, 5X, 2F10.4, 20X, F10.2 )
000100      C
000101      C
000102            END
```

```
@ ELT SUBR5,1,720427, 34022

000001                SUBROUTINE SUBR5
000002                DIMENSION TC(500)
000003                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005                COMMON QZZS(900), TAB(60,32)
000006                COMMON XCOND(10), DENS(10), QX(10)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(900), INTAB(10,3)
000015                COMMON /TAPE/  ITAPE, ISTART
000016                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000017               C                (TEM(4),XTEM4)
000018                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000019               C                (ITEM(4),MTYPE)
000020                EQUIVALENCE (TI(1),TC(1))
000021                NPT  = 0
000022                M  = 1
000023                LL = 1
000024              C     IF(ISTART .EQ. 0)      GO TO 301
000025              C300  READ (3) TIME, (TC(N), N=1,NUMNP)
000026              C     IF(TINIT .GT. TIME)    GO TO 300
000027               301  WRITE (6,2005) TIME,(N,TC(N),N=1,NUMNP )
000028                    GO TO 304
000029               303     CONTINUE
000030                    CALL SUBR6
000031                    LL=LL+1
000032                    CALL SUBR7(LL)
000033              C
000034              C      2. SOLVE FOR TEMPERATURES
000035              C
000036              C*************************************************************************
000037              C     SOLVE FOR NODAL POINT TEMPERATURES
000038              C*************************************************************************
000039              C     FORM EFFECTIVE CONDUCTIVITY MATRIX FOR TIME INCREMENT
000040              C
000041               304  IF(IDT .EQ. 0)   GO TO 305
000042                    IF(TIME .LT. TAB(M,IDT) )   GO TO 305
000043                    DT = TAB(M+1,IDT)
000044                    DT2  = 1./DT
000045                    M  = M+2
000046                    GO TO 304
000047               305  DO 320 N=1,NUMNP
000048                    IF(KODE(N))  320,308,320
000049               308  IF(D(N))     310,320,310
000050                310 D(N)=DT2*D(N)
000051                    A(N,1)=A(N,1)+D(N)
000052                320 CONTINUE
000053              C-------------------------------------------------------------------------
000054              C     OPTIONAL DUMP OF VECTOR D AND MATRIX A.
000055              C-------------------------------------------------------------------------
000056                    IF(IDUM .EQ. 0)        GO TO 330
```

```
000057            WRITE (6,6011)
000058            WRITE (6,6000) (D(I),I=1,NUMNP)
000059            DO 325 I=1,NUMNP
000060          325  WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000061         6000 FORMAT (1X,10E12.4 )
000062         6011 FORMAT ('0VECTOR D' )
000063         6013 FORMAT ('0VECTOR Q' )
000064         6600 FORMAT ('0ROW',I5/ 3(1X,10E12.4/) )
000065            C-------------------------------------------------------------------
000066          330  CONTINUE
000067               CALL SYMSO (1)
000068            C
000069            C     CALCULATE TEMPERATURE AT THE END OF EACH TIME INCREMENT
000070            C
000071            C
000072            C
000073            C      1. CALCULATE EFFECTIVE LOAD MATRIX
000074            C
000075               DO 400 I=1,NUMNP
000076               Q(I)=B(I)
000077               IF (KODE(I)) 400,395,400
000078          395 Q(I)=B(I)+D(I)*TC(I)
000079          400 CONTINUE
000080            C
000081            C-------------------------------------------------------------------
000082            C     OPTIONAL DUMP OF VECTOR Q AND MATRIX A.
000083            C-------------------------------------------------------------------
000084               IF(IDUM .EQ. 0)        GO TO 340
000085               IDUM = 0
000086               WRITE (6,6013)
000087               WRITE (6,6000) (Q(I),I=1,NUMNP)
000088               DO 335 I=1,NUMNP
000089          335  WRITE (6,6600) I,(A(I,J),J=1,NDIM )
000090            C-------------------------------------------------------------------
000091          340  CONTINUE
000092               CALL SYMSO (2)
000093            C
000094               DO 500 I=1,NUMNP
000095          500  TC(I) = Q(I)
000096            C
000097               TIME =TIME+DT
000098                  IF(TIME .GE. TMAX)  GO TO 550
000099            C
000100               IF(LL-INTER) 555,550,550
000101          550  WRITE (6,2005) TIME, (N, TC(N), N=1,NUMNP)
000102               LL = 0
000103          555  CONTINUE
000104               IF (ITAPE.GT.0)
000105              *WRITE (2)  TIME,(TC(N),N=1,NUMNP)
000106               IF(TIME .LT. TMAX)     GO TO 303
000107          50   CONTINUE
000108               IF(IPUNCH .EQ. 0)      GO TO 710
000109            C-------------------------------------------------------------------
000110            C    PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000111            C-------------------------------------------------------------------
000112               DO 700 N=1,NUMNP
000113          700  WRITE (7,7000) N, X(N), Y(N), TC(N)
000114          710  CONTINUE
000115               RETURN
000116            C
```

```
000117      C     FORMAT STATEMENTS
000118      C
000119      C
000120       1007 FORMAT (2I5,2F10.4,2I5 )
000121       2005 FORMAT (6H0TIME= F12.5/ ( 6(I6,F14.4) )  )
000122       2006 FORMAT (40H0    I     J                    H     TEMPERATURE )
000123       2007 FORMAT (2I5,2E15.6,2I5 )
000124       7000 FORMAT (I5, 5X, 2F10.4, 20X, F10.2 )
000125            END
```

```
@ ELT SUBR6,1,720427, 34024
000001              SUBROUTINE SUBR6
000002              DIMENSION TC(500)
000003               COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004              COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005              COMMON QZZS(900), TAB(60,32)
000006              COMMON XCOND(10), DENS(10), QX(10)
000007              COMMON TEM(10)
000008              COMMON COND,RHO,QXX,QZZ
000009              COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010              COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011              COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012              COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013              COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014              COMMON IKODE(900), INTAB(10,3)
000015                 EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000016             C               (TEM(4),XTEM4)
000017                 EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000018             C               (ITEM(4),MTYPE)
000019              EQUIVALENCE (TI(1),TC(1))
000020            C-------------------------------------------------------------------
000021              REWIND 4
000022              DO 110 I=1,NUMNP
000023              D(I)=0.
000024              B(I)=0.
000025              DO 110 J=1,NDIM
000026          110 A(I,J)=0.
000027            C*******************************************************************
000028            C     FORM CONDUCTIVITY MATRIX FOR COMPLETE BODY
000029            C*******************************************************************
000030              DO 200 N=1,NUMEL
000031            C-------------------------------------------------------------------
000032            C       1. READ OR GENERATE ELEMENT PROPERTIES
000033            C-------------------------------------------------------------------
000034              READ (4)  NN, (LM(I), I=1,4), MTYPE
000035              QZZ    = QZZS(N)
000036              COND   = XCOND(MTYPE)
000037              RHO    = DENS(MTYPE)
000038                 ITABK = INTAB(MTYPE,1)
000039                 ITABR = INTAB(MTYPE,2)
000040                 ITABQ = INTAB(MTYPE,3)
000041            C-------------------------------------------------------------------
000042            C       2. FORM ELEMENT CONDUCTIVITY MATRIX
000043            C-------------------------------------------------------------------
000044              CALL CONMAT
000045          200 CONTINUE
000046              RETURN
000047              END
```

@ ELT SUBR7,1,720427, 34026

```
000001                SUBROUTINE SUBR7(LL)
000002                DIMENSION TC(500)
000003                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000004                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000005                COMMON QZZS(900), TAB(60,32)
000006                COMMON XCOND(10), DENS(10), QX(10)
000007                COMMON TEM(10)
000008                COMMON COND,RHO,QXX,QZZ
000009                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000010                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000011                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000012                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000013                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000014                COMMON IKODE(900), INTAB(10,3)
000015                COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000016               1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000017                COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000018                COMMON /SAVE3/ IOFF
000019                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000020               C                (TEM(4),XTEM4)
000021                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000022               C                (ITEM(4),MTYPE)
000023                EQUIVALENCE (TI(1),TC(1))
000024              C-------------------------------------------------------------------
000025                IF(NUMBC .LE. 0)       GO TO 220
000026                IF(LL .LT. INTER)      GO TO 200
000027                WRITE (6,9000)
000028                WRITE (6,2006)
000029               200  CONTINUE
000030                DO 210   N=1,NUMBC
000031                IH = IHBC(N)
000032                ITEMP  = ITBC(N)
000033                H  = HBBC(N)
000034                TEMP = TEMEBC(N)
000035                I  = IBC(N)
000036                J  = JBC(N)
000037              C-------------------------------------------------------------------
000038              C     IH .LT. 0    H VS. TIME TABLE.
000039              C     IH .EQ. 0    NO H-TABLE.
000040              C     IH .GT. 0    H VS. TEMP. TABLE.
000041              C-------------------------------------------------------------------
000042                IF(IH)       201,204,202
000043               201  IH = -IH
000044                CALL LINT (TIME,TAB(1,IH),H,DX)
000045                GO TO 204
000046               202  CONTINUE
000047                TEMPX  = (TC(I)+TC(J))/2.0
000048                                CALL LINT (TEMPX,TAB(1,IH),H, DX )
000049                LOC  = ITFAC(IH)
000050                     FAC = 1.0
000051                IF(LOC .GT. 0) CALL LINT(TIME,TAB(1,LOC),FAC,DX)
000052                H  = H*FAC
000053               204  CONTINUE
000054                IF(ITEMP .LE. 0)       GO TO 205
000055                CALL LINT (TIME,TAB(1,ITEMP),TEMP,DX)
000056                LOC  = ITFAC(ITEMP)
```

```
000057            FAC  = 1.0
000058            IF(LOC .GT. 0)   CALL LINT (TIME,TAB(1,LOC),FAC,DX)
000059            TEMP = FAC*TEMP
000060       205  CONTINUE
000061            HBBC(N)  = H
000062            TEMEBC(N)  = TEMP
000063           C-------------------------------------------------------------------
000064       210  CONTINUE
000065            DO 215   N=1,NUMBC
000066           C     CORRECT FOR NODAL OFF-SET.
000067            I  = IBC(N) + IOFF
000068            J  = JBC(N)+ IOFF
000069            H  = HBBC(N)
000070            TEMP = TEMEBC(N)
000071            XL = XLBC(N)
000072            IF(LL .GE. INTER)      WRITE (6,2007) I, J, H, TEMP
000073           C     CALL CONVBC TO CALCULATE THE CONVECTION EFFECTS.
000074           C-------------------------------------------------------------------
000075            CALL CONVBC (I,J,N)
000076       215  CONTINUE
000077            IF(IFLAGR .EQ. 1)      CALL RAD
000078            REWIND 1
000079       220  CONTINUE
000080           C-------------------------------------------------------------------
000081           C     CALCULATE THE TEMPERATURE BOUNDARY CONDITIONS.
000082           C-------------------------------------------------------------------
000083            CALL TEMPBC
000084            RETURN
000085       2006 FORMAT (40H0   I    J              H    TEMPERATURE )
000086       2007 FORMAT (2I5,2E15.6)
000087       9000 FORMAT ('1',46X,'AEROJET-GENERAL CORPORATION' /
000088          1 50X,'SACRAMENTO,CALIFORNIA' / '0***** PROGRAM E12202 *****',
000089          2 5X,'FEM TWO-DIMENSIONAL TEMPERATURE ANALYSIS PROGRAM' )
000090            END
```

```
@ ELT SUBR8,1,720427, 34029

000001                SUBROUTINE SUBR8
000002              C-----------------------------------------------------------------
000003              C     STEADY-STATE PROBLEM.
000004              C-----------------------------------------------------------------
000005                DIMENSION TC(500), NTC(500)
000006                DIMENSION IEPS(250)
000007                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000008                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000009                COMMON QZZS(900), TAB(60,32)
000010                COMMON XCOND(10), DENS(10), QX(10)
000011                COMMON TEM(10)
000012                COMMON COND,RHO,QXX,QZZ
000013                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000014                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000015                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000016                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000017                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000018                COMMON IKODE(900), INTAB(10,3)
000019                COMMON JNODE(900)
000020                COMMON /SAVE3/IOFF
000021                COMMON /TAPE/ ITAPE
000022                COMMON /BC/ IBC(250), JBC(250), IHBC(250), ITBC(250), HBBC(250),
000023               1 TEMEBC(250), XLBC(250), IIBC(250), JJBC(250)
000024                LOGICAL DAMP, DF1, DF2, DF3, TOL4
000025                COMMON /LOGIC/ DAMP, DF1, DF2, DF3, TOL4
000026                COMMON /DMPING/ DMP1, DMAX1, DMP2, DMAX2, DMP3, DMAX3, TOLN
000027                COMMON /RADCON/EPS(250), F(40,40),  SIGMA, NRF(250), IFLAGR
000028               1 , FN(250), BQ(40), KTEM(40)
000029                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000030              C                (TEM(4),XTEM4)
000031                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000032              C                (ITEM(4),MTYPE)
000033                EQUIVALENCE (TI(1),TC(1),NTC(1))
000034                EQUIVALENCE (IEPS(1),EPS(1))
000035              C-----------------------------------------------------------------
000036                IRAD = 0
000037                IRAD1  = 0
000038                DO 290  I=1,NUMBC
000039                IF(IEPS(I) .EQ. 0)      GO TO 290
000040                IRAD = 1
000041                GO TO 292
000042             290  CONTINUE
000043             292  CONTINUE
000044                IF(INTER .LE. 0)        INTER = 20
000045                ICONV  = 0
000046                ITER = IVARC+NTAB+IRAD
000047                NITER  = 1
000048                LL   = 0
000049                GO TO 305
000050             300  CONTINUE
000051              C-----------------------------------------------------------------
000052              C     IF IVARC IS NON-ZERO, CONDUCTIVITY IS VARIABLE WITH TEMPERATURE.
000053              C     OTHERWISE, ONLY THE H ON THE BOUNDARY ARE VARIABLE WITH TEMPERATURE
000054              C-----------------------------------------------------------------
000055                IF(IVARC .GT. 0)        GO TO 302
000056                IF(IRAD .GT. 0)         GO TO 304
```

```
000057            IF(NTAB .EQ. 0)        GO TO 303
000058       304  CONTINUE
000059            READ (1) ((A(I,J), J=1,MBAND),'I=1,NUMNP)
000060            READ (1) (T(I), B(I), D(I), I=1,NUMNP)
000061            REWIND 1
000062            GO TO 303
000063       302  CONTINUE
000064            CALL SUBR6
000065       303  CONTINUE
000066            LL = LL+1
000067            CALL SUBR7(LL)
000068       305  CONTINUE
000069            DO 310  I=1,NUMNP
000070       310  Q(I) = B(I)
000071            CALL SYMSO(1)
000072            CALL SYMSO(2)
000073            IF(ITER  .EQ. 0)       GO TO 350
000074            IF(NITER .EQ. 1)       GO TO 460
000075          C-------------------------------------------------------------------
000076          C     CHECK FOR DAMPING.
000077          C-------------------------------------------------------------------
000078            IF(DAMP)     GO TO 400
000079       311  CONTINUE
000080            DO 312   I=1,NUMNP
000081            IF(NTC(I) .EQ. 0)      GO TO 312
000082            TEMP = ABS((TC(I)-Q(I))/TC(I) )
000083            IF(TEMP .GT. TOLN)     GO TO 314
000084       312  CONTINUE
000085            GO TO 350
000086       314  CONTINUE
000087            IF(NITER .GE. INTER)   GO TO 350
000088          C     IF(NITER .GE. INTER-2 )
000089          C    1WRITE (6,2005) NITER, (N,Q(N), N=1,NUMNP)
000090            WRITE (6,2005) NITER, (N, Q(N), N=1,NUMNP)
000091            DO 320  I=1,NUMNP
000092       320  TC(I)  = Q(I)
000093            NITER  = NITER+1
000094            GO TO 300
000095       350  CONTINUE
000096            WRITE (6,2005) NITER, (N,Q(N), N=1,NUMNP)
000097            RITER  = NITER
000098            IF(ITAPE .GT. 0)       WRITE (2) RITER, (Q(N), N=1,NUMNP)
000099            IF(IPUNCH .EQ. 0)      GO TO 710
000100          C-------------------------------------------------------------------
000101          C    PUNCH OUTPUT CARDS FOR RESTART OPTION OR STRESS ANALYSIS.
000102          C-------------------------------------------------------------------
000103            DO 700 N=1,NUMNP
000104       700  WRITE (7,7000) N, X(N), Y(N), Q(N)
000105       710  CONTINUE
000106            RETURN
000107       400  CONTINUE
000108          C-------------------------------------------------------------------
000109          C     DAMP ITERATED VALUES.
000110          C-------------------------------------------------------------------
000111            DO 450  N=1,NUMNP
000112            ITRA = JNODE(N)+1
000113          C-------------------------------------------------------------------
000114          C     IF ITRA EQUAL 1, CONDUCTION NODE.
000115          C     IF ITRA EQUAL 2, CONVECTION NODE.
000116          C     IF ITRA EQUAL 3, RADIATION NODE.
```

```
000117      C-----------------------------------------------------------------------
000118            GO TO (410, 415, 420), ITRA
000119       410  IF( .NOT. DF1)          GO TO 450
000120      C-----------------------------------------------------------------------
000121      C     DAMP CONDUCTION NODES.
000122      C-----------------------------------------------------------------------
000123            DMP  = DMP1
000124            DMAX = DMAX1
000125            GO TO 425
000126       415  IF( .NOT. DF2)          GO TO 450
000127      C-----------------------------------------------------------------------
000128      C     DAMP CONVECTION NODES.
000129      C-----------------------------------------------------------------------
000130            DMP  = DMP2
000131            DMAX = DMAX2
000132            GO TO 425
000133       420  IF( .NOT. DF3)          GO TO 450
000134      C-----------------------------------------------------------------------
000135      C     DAMP RADIATION NODES.
000136      C-----------------------------------------------------------------------
000137            DMP  = DMP3
000138            DMAX = DMAX3
000139       425  DIFF = Q(N)-TC(N)
000140            XTEM = DIFF*DMP
000141            Q(N) = TC(N)+XTEM
000142            IF(ABS(XTEM) .GT. DMAX)          Q(N) = TC(N)+SIGN(DMAX,DIFF)
000143       450  CONTINUE
000144            GO TO 311
000145       460  CONTINUE
000146      C-----------------------------------------------------------------------
000147      C     CHECK FOR INITIAL GUESSES.
000148      C     INIT = 0,    NO INITIAL GUESSES.
000149      C     INIT = 1,    INITIAL GUESSES ARE GIVEN FOR SOME OR ALL NODES.
000150      C-----------------------------------------------------------------------
000151            INIT = 0
000152            DO 465  N=1,NUMNP
000153            IF(NTC(N) .GT. 0)        INIT = 1
000154       465  CONTINUE
000155            DO 470   N=1,NUMBC
000156            IF(NTC(N) .GT. 0)        GO TO 470
000157            TC(N)  = Q(N)
000158       470  CONTINUE
000159            IF(INIT .EQ. 1)          GO TO 400
000160            GO TO 314
000161      C
000162      C     FORMAT STATEMENTS
000163      C
000164      C
000165       2005 FORMAT ('0ITERATION NO.', I4/ ( 6(I6,F14.4) ) )
000166       7000 FORMAT (I5, 5X, 2F10.4, 20X, F10.2 )
000167            END
```

@ ELT SYMSO,1,720427, 34031

```
000001                SUBROUTINE SYMSO (KKK)
000002          C
000003                DIMENSION TC(500), IA(900,30)
000004                 COMMON A(900,30), B(900), D(900), DD(5), E(3,3), HED(12), P(5)
000005                COMMON Q(900), S(5,5), T(900), X(900), Y(900), TI(900)
000006                COMMON QZZS(900), TAB(60,32)
000007                COMMON XCOND(10), DENS(10), QX(10)
000008                COMMON TEM(10)
000009                COMMON COND,RHO,QXX,QZZ
000010                COMMON TIME, DT, DT2, H, TEMP, XL, XX, YY, TMAX, TINIT
000011                COMMON NUMBC,  NUMMT,  NDT,  INTER,       MBAND,  NUM, NTAB
000012                COMMON NDIM,IVARH,IVARC,IPT,IDT,IPUNCH,IDUM
000013                COMMON KODE(900), IX(3),  KX(4),  LM(5),  KAT,  NUMNP,  NUMEL
000014                COMMON ITEM(10), IDTAB(32), ITFAC(32)
000015                COMMON IKODE(900), INTAB(10,3)
000016                   EQUIVALENCE (TEM(1),XTEM1), (TEM(2),XTEM2), (TEM(3),XTEM3),
000017          C                    (TEM(4),XTEM4)
000018                   EQUIVALENCE (ITEM(1),ITABK), (ITEM(2),ITABR), (ITEM(3),ITABQ),
000019          C                    (ITEM(4),MTYPE)
000020                EQUIVALENCE (TI(1),TC(1))
000021                EQUIVALENCE (A(1,1),IA(1,1))
000022                EQUIVALENCE (NN,NUMNP),(MM,MBAND)
000023                DATA NAZ/0/
000024                GO TO (1000,2000),KKK
000025          C
000026          C     REDUCE MATRIX
000027          C
000028           1000 DO 280 N=1,NN
000029                DO 270 L=2,MM
000030                IF(IA(N,L) .EQ. 0)     GO TO 270
000031                C=A(N,L)/A(N,1)
000032                I = N+L-1
000033                IF(NN-I) 260,240,240
000034            240 J=0
000035                DO 250 K=L,MM
000036                J=J+1
000037            250 A(I,J)=A(I,J)-C*A(N,K)
000038            260 A(N,L)=C
000039            270 CONTINUE
000040            280 CONTINUE
000041                GO TO 500
000042          C
000043          C     REDUCE VECTOR
000044          C
000045           2000 DO 295 N=1,NN
000046                DO 285 L=2,MM
000047                I=N+L-1
000048                IF(NN-I) 290,285,285
000049            285 Q(I)=Q(I)-A(N,L)*Q(N)
000050            290  CONTINUE
000051                IF(IA(N,1) .NE. 0)     GO TO 295
000052          C-----------------------------------------------------------------
000053          C     IF A(N,1) = 0.,PRINT ERROR MESSAGE.
000054          C
000055                NAZ  = NAZ+1
000056                IF(NAZ .GT. 100)       GO TO 295
```

```
000057              A(N,1) = 1.0
000058              WRITE (6,6000) N
000059         6000 FORMAT ('0A(',I3,',1) = 0.' )
000060             C-----------------------------------------------------------------
000061          295 Q(N) = Q(N)/A(N,1)
000062             C
000063             C     BACK SUBSTITUTION
000064             C
000065              N=NN
000066          300 N = N-1
000067              IF(N) 350,500,350
000068          350 DO 400 K=2,MM
000069              L = N+K-1
000070              IF(NN-L) 400,370,370
000071          370 Q(N) = Q(N) - A(N,K) * Q(L)
000072          400 CONTINUE
000073              GO TO 300
000074             C
000075          500 RETURN
000076             C
000077              END
```

4. 09:52:07

END CUR

```
<*****1*****2*****3*****4*****5*****6*****7*****8*****9*****0*****1*****2*****3*
**********************************ISD-28.03:INFORMATION-SYSTEMS-DESIGN:02-MAY-1972**********************************
***Δ***1***Δ***2***Δ***3***Δ***4***Δ***5***Δ***6***Δ***7***Δ***0***Δ***1***Δ***2***Δ***3***Δ***4***Δ***5***Δ***6***Δ***7***Δ***0***Δ
[ ]#Δ ABCDEFGHIJKLMNOPQRSTUVWXYZ)-+<=>&$*(%:?!,\0123456789';/.\ @[ ]#Δ ABCDEFGHIJKLMNOPQRSTUVWXYZ)-+<=>&$*(%:?!,\0123456789';/.\ @[ ]#Δ
```

04 MAY 72 N 09:52:08 IDENT=FYEE ACCOUNT=428235 CARDS IN= 9, OUT= 0

PAGES= 52, LINES= 2385. TIME=00:00:09 (HMS)

*** USER NOTICES - MAY 1, 1972 ***

(1) ISD 1108 TERMINAL SERVICE WILL BE AVAILABLE AS SCHEDULED BELOW UNLESS OTHERWISE SPECIFIED IN A USER NOTICE.

MON :	07:00 - 24:00	
TUE - FRI :	00:00 - 03:00 ;	07:00 - 24:00
SAT :	00:00 - 22:00	
SUN :	04:00 - 22:00	

*** ISD'S 1108 WILL BE UNAVAILABLE FOR TERMINAL SERVICE FROM 2:00 - 7:00 ON 5/3/72. ***

(2) LARGE-CORE (LCR) PRODUCTION JOBS ARE BEING RUN ON AN OVERNIGHT BASIS.

(3) ISD HAS AVAILABLE REMOTE-BATCH JOB ENTRY VIA LOW-SPEED TELETYPE COMPATIBLE TERMINALS USING DIAL-UP COMMUNICATION LINES. THE DIAL-UP TELEPHONE NUMBERS AND TRANSMISSION RATES ARE LISTED BELOW.

10 CHAR/SEC 415-635-1051 (4 PORTS AVAILABLE ON A ROTARY BASIS)

30 CHAR/SEC 415-562-4294

(4) ISD'S SECOND PUBLIC TERMINAL IN SAN FRANCISCO IS LOCATED AT # 1 CALIFORNIA ST., ROOM 2555.

(5) EFFECTIVE MONDAY - FRIDAY TURNAROUND TIME SHOULD BE REDUCED BETWEEN THE HOURS OF 10:30 - 11:30 AND 14:00 - 17:00 FOR USERS SUBMITTING NON-TAPE JOBS WITH RUN TIMES ESTIMATED AT LESS THAN 6 MINUTES.

(6) EFFECTIVE 5/4/72 THE 1004 DIAL-UP PHONE NUMBERS WILL BE CHANGED AS LISTED BELOW.

415-562-0809 WILL BE CHANGED TO 415-562-4266
415-562-0810 WILL BE CHANGED TO 415-562-4309

ADDITIONAL INFORMATION ON (2) & (3) IS NOW AVAILABLE TO ALL INTERESTED USERS BY CONTACTING YOUR SALESMAN AT 415-562-4204.

APPENDIX C

BERGQUAM'S ANALYSIS FOR RADIATIVE TRANSFER EFFECTS

AEROJET NUCLEAR SYSTEMS COMPANY

SACRAMENTO, CALIFORNIA

TO: W. R. Thompson

22 February 1971
DTB:jm:N4320:M1641

FROM: J. B. Bergquam

SUBJECT: Development of a Subroutine to Account for the Effects of Radiative Transfer in Heat Conduction Analyses

DISTRIBUTION: D. T. Buchanan, E. L. Geery, J. O. Sane, K. Sato, L. Shenfil
J. R. Smith, E. A. Thomas, Fan Yee

ENCLOSURE:
(1) Listing of J. Bergquam Subroutine for Calculating Radiation Effects

(2) Sample Load Sheet

(3) Printout, Example Problem

(4) Shape Factor Template

I. INTRODUCTION

In many cases the problem of determining the temperature distribution in a body is complicated by the fact that there is radiative transfer at the surface(s) of the body. The programs which are presently being used by the Thermodynamics Section for calculating temperature distributions, e.g. E12203, E12401, and E12202, have an option whereby the effect of radiative transfer can be included in the analysis. However, this option is restricted to those problems where the surface either transfers energy to a constant temperature sink or receives energy from a constant temperature source. In addition, if there is both convective and radiative transfer at the surface, the calculation procedure is in error. In the case of the finite element programs, there is also a node follower option which can be used to account for radiative transfer among elements on the surface. However, the procedure for making this calculation is questionable in some cases and incorrect in others.

The purpose of this analysis is to develop a subroutine which could be incorporated into the above mentioned programs and used in those cases when an

accurate accounting of the radiative transport is necessary in order to obtain a reasonable prediction of the temperature distribution in a body.

II. ANALYSIS

The analysis presented in this section is applicable to radiant interchange among isothermal, gray surfaces that are diffuse reflectors of radiation. Nonisothermal surfaces should be subdivided until the temperature variation across all surfaces is not more than approximately $50^{\circ}R$. In most problems the regions where radiative transfer should be accounted for are restricted to those sections of a body which are thin and are heated convectively from one side and exposed to vacuum on the other or where high nuclear heating rates cause the temperature of a particular section to rise above $1000\text{-}1500^{\circ}R$. One of the most important factors in utilizing this subroutine is identifying those regions where radiative transfer is important.

For those cases when there is radiative transfer between a surface element and a constant temperature source or sink, the equation which gives the radiative flux is

$$q_R = F\epsilon\sigma\ (T^4 - T_s^4) \qquad (1)$$

where T is the temperature of the element and T_s is the temperature of the source or sink.

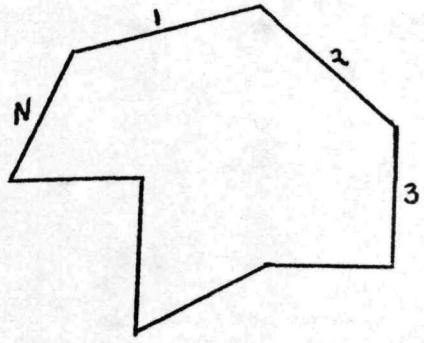

Figure 1

For the general case of an enclosure consisting of N surfaces, as indicated in Figure 1, the radiosities (B) of the surfaces are described by the following set of equations:

$$\begin{aligned}
&\left[1-(1-\epsilon_1)F_{1-1}\right] B_1 - (1-\epsilon_1)F_{1-2}\ B_2 - \cdots - (1-\epsilon_1)F_{1-N}\ B_N = \epsilon_1 \sigma T_1^4 \\
&-(1-\epsilon_2)F_{2-1}\ B_2 + \left[1-(1-\epsilon_2)F_{2-2}\right] B_2 - \cdots - (1-\epsilon_2)F_{2-N}\ B_N = \epsilon_2 \sigma T_2^4 \\
&\vdots \\
&-(1-\epsilon_N)F_{N-1}\ B_1 - (1-\epsilon_N)F_{N-2}\ B_2 - \cdots - \left[1-(1-\epsilon_N)F_{N-N}\right] B_N = \epsilon_N \sigma T_N^4
\end{aligned} \tag{2}$$

If the temperature* and emittance of each surface and the shape factors from each surface to the other surfaces of the enclosure are known, then this system of equations can be solved for the radiosities of the surfaces. Once the radiosities have been obtained the radiant fluxes can be found by using the following equation:

$$q_r = \frac{\epsilon_N}{(1-\epsilon_N)} \left(\sigma T_N^4 - B_N\right) \tag{3}$$

Note that according to the usual sign convention q_r is positive for those surfaces which lose energy by radiation and negative for those surfaces which gain energy. It should also be pointed out that all of the surfaces do not have to actively participate in the heat transfer process. For example, one element of the enclosure could be a fictitious surface which represents a sink in the surroundings at an effective temperature of $0^\circ R$. In this case the radiosity of the fictitious surface would equal zero and it does not have to be considered in the analysis. This will be made clear by the examples which are presented in a later section.

A program which solves equations (2) and (3) has been developed and in the next section the procedure for using the subroutine is discussed; following

---

*The problem of selecting surface temperatures for the general situation when they are unknown is discussed in Section V of this memo.

this discussion, two examples are presented. A listing of this program is given in Enclosure (1).

III. INPUT

There are two types of input cards required. These are:

1. Identification Card. FORMAT (I5, E10.4, 8A8)

   Col(s) 1-5 N. The number of active surfaces making up the enclosure. Maximum N = 22.

   6-15 Stefan-Boltzman constant ($.33 \times 10^{-14}$ Btu/in^{2}sec$^\circ$R^4)

   16-72 HEAD. Identifies the case being run.

2. Surface Property Cards. FORMAT (8E10.4)

   At least one card is required for each surface.

   Col(s) 1-10 Emittance of surface.

   11-20 Temperature of surface, $^\circ$R

   21-80 First six shape factors, i.e., F_{N-1}, F_{N-2}---F_{N-6}.

If there are more than six surfaces, the additional shape factors are input, 8 per card, by adding no more than two additional cards. A sample load sheet for the example given later is illustrated in Enclosure (2).

IV. EXAMPLES

Consider the following situation: on a particular body there is a 2470°R AGCarb surface "1" (ϵ = 0.9) that sees a 1080°R stainless steel surface "2" (ϵ = 0.65). The two surfaces are oriented such that they form an approximate 45° wedge. The region surrounding the enclosure is at 0°R (see Figure 2).

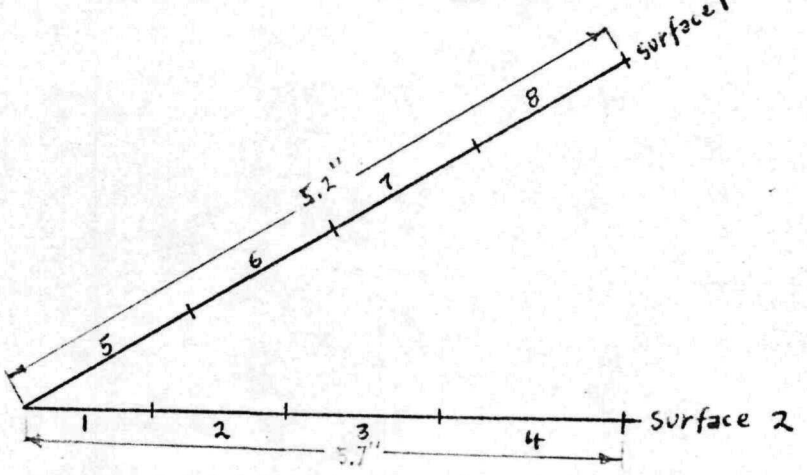

Figure 2

The heat fluxes at the surfaces will be calculated in two ways. In the first treatment it is assumed that the radiosity is constant along the entire AGCarb surface 1 as is the radiosity of the stainless steel surface 2, the shape factors are: $F_{1-1} = F_{2-2} = 0$, $F_{1-2} = .59$, $F_{2-1} = .645$. These shape factors were calculated using the string rule although a template, such as given in Enclosure (4), can also be used. The format for the input data is indicated on the next page. In this case the radiosities computed by the subroutine are, as given in Enclosure (3)

$$B_1 = .112 \text{ Btu/in}^2\text{sec}, \quad B_2 = .02825 \text{ Btu/in}^2\text{sec}.$$

and the surface heat fluxes are:

$$(Q/A)_1 = .0955 \text{ Btu/in}^2\text{sec}, \quad (Q/A)_2 = -.04413 \text{ Btu/in}^2\text{sec}.$$

In the second treatment of this problem, the same surface temperatures are used but account is taken of the fact that the radiosities of the surfaces are not constant. This is done by dividing each of the surfaces into four equal parts as indicated in Figure 2. The shape factors for all of the eight surfaces together with the other input data are given in Enclosure (2). In this case the shape factors were obtained with the template (see Enclosure (4)). The radiosities for this example are, as given in Enclosure (3)

$B_1 = .1133$ Btu/in^{2}sec.	$B_5 = .03538$ Btu/in^{2}sec.
$B_2 = .1126$ "	$B_6 = .03146$ "
$B_3 = .1119$ "	$B_7 = .02626$ "
$B_4 = .1114$ "	$B_8 = .01995$ "

and the local heat fluxes are:

$_1 = .08582$ Btu/in^{2}sec.	$_5 = -.05736$ Btu/in^{2}sec.
$_2 = .09224$ "	$_6 = -.05009$ "
$_3 = .09840$ "	$_7 = -.04043$ "
$_4 = .1032$ "	$_8 = -.02872$ "

V. CONCLUSION

A program for calculating the radiant heat flux at the surface of a body has been developed. In order to incorporate this program, as a subroutine, into existing programs, e.g., E12202, the following modifications would have to be made:

1. Eliminate the calculation of h_r, the radiative heat transfer coefficient, from subroutine SUBR 2.

2. In those cases when there is radiative transfer between a surface element and a constant temperature source or sink, use Equation (1) to calculate the radiative flux. The element temperature for use in Equation (1) should be the fourth power average of the corner temperatures.

3. In those cases when there is radiative transfer among elements on the surface, use the subroutine developed in this memo to calculate the radiative flux.

4. Independently calculate the convective flux, if present, by the methods of subroutine CONVBC.

5. Add the radiative and convective heat fluxes. This sum is then used in solving for the temperature distribution.

Finally, it should be noted that for the examples worked in this memo the surface temperatures are assumed to be known. In general, however, the temperature distribution is the desired result of the calculation and is obtained by an iterative calculation procedure. Since surface temperatures must be known in order to calculate the radiant fluxes, the question arises as to what temperature should be used during the iteration process. Because of the fact that each surface element is bounded by two nodes whose temperatures are calculated during each iteration, it is recommended that the fourth power average of these temperatures, obtained from one iteration, be used as the surface temperature for the following iteration.

$$T_r = \frac{T_i^4 + T_i^3 T_j + T_i^2 T_j^2 + T_i T_j^3 + T_j^4}{5}$$

for J. B. Bergquam

```
SEPT 69 )                          OS/360  FORTRAN H

COMPILER OPTIONS - NAME=  MAIN,OPT=00,LINECNT=72,SOURCE,BCD,NOLIST,NODECK,LOAD,MAP,NO
C-----------------------------------------------------------------------
C      JIM BERGQUAM'S SUBROUTINE FOR CALCULATING RADIATION EFFECTS. X6638
C-----------------------------------------------------------------------
       IMPLICIT REAL*8 (A-H,O-Z)
       DIMENSION HEAD(8),FC(22,22),EPS(22),TEMP(22),BQ(22),ITEM(22)
C-----------------------------------------------------------------------
C      READ IN N, SIGMA AND HEADER.
C-----------------------------------------------------------------------
 5     READ (5,5000,END=90) N,SIGMA,HEAD
C-----------------------------------------------------------------------
C      PRINT THE 1ST CARD.
C-----------------------------------------------------------------------
       WRITE (6,6000) HEAD, N, SIGMA
C-----------------------------------------------------------------------
C      READ IN EPSILONS, TEMPERATURES AND THE F-COEFFICIENTS.
C-----------------------------------------------------------------------
       DO 10  I=1,N
       READ (5,5010) EPS(I), TEMP(I),  (FC(I,J),J=1,N)
       WRITE (6,6010) I,EPS(I),I,TEMP(I), (FC(I,J),J=1,N)
       BQ(I)  = EPS(I)*SIGMA*TEMP(I)**4
 10    CONTINUE
C-----------------------------------------------------------------------
C      FORM THE COEFFICIENTS.
C-----------------------------------------------------------------------
       DO 30  I=1,N
       DO 30  J=1,N
       FC(I,J)  = (EPS(I)-1.)*FC(I,J)
       IF(I .EQ. J)              FC(I,I) = 1.+FC(I,I)
 30    CONTINUE
       DO 35 I=1,N
 35    WRITE (6,6010) I,EPS(I),I,TEMP(I), (FC(I,J),J=1,N)
C-----------------------------------------------------------------------
C      SOLVE FOR THE B-UNKNOWNS.
C-----------------------------------------------------------------------
       CALL SIMEQ (FC,BQ,  N,1,22,ITEM,DET,ND,KERR)
       IF(KERR .GE. 0)          GO TO 100
       WRITE (6,6030)
C-----------------------------------------------------------------------
C      PRINT THE SOLUTIONS.
       DO 40  I=1,N
 40    WRITE (6,6020) I,BQ(I)
C-----------------------------------------------------------------------
C      CALCULATE AND PRINT Q(N).
C-----------------------------------------------------------------------
       DO 50  I=1,N
 50    BQ(I)= EPS(I)/(1.-EPS(I))*(SIGMA*TEMP(I)**4 - BQ(I))
       WRITE (6,6030)
       DO 60  I=1,N
 60    WRITE (6,6025) I,BQ(I)
       GO TO 5
 90    STOP
 100   CONTINUE
       WRITE (6,9000) N
       GO TO 90
C-----------------------------------------------------------------------
 5000  FORMAT (I5,E10.4,8A8)
 5010  FORMAT (8E10.4)
 6000  FORMAT ('1',8A8, /'0 N = ',I5,' SIGMA = ',E16.6 )
 6010  FORMAT ('0 EPS(',I5,') = ',E16.6,' TEMP(',I2,') = ',E16.6/
     1 1X, 8E16.8/ 1X, 8E16.8/ 1X,8E16.8 )
 6020  FORMAT (' B(',I2,') = ',E16.8 )
 6025  FORMAT (' Q(',I2,') = ',E16.8 )
 6030  FORMAT ('0')
 9000  FORMAT ('0 MATRIX IS SINGULAR. RANK = ',I3 )
       END
```

ENCLOSURE 1

IBM

FORTRAN Coding Form

GX28-7327-6 U/M050
Printed in U.S.A.

PROGRAM		PUNCHING INSTRUCTIONS	GRAPHIC									PAGE OF
PROGRAMMER	DATE		PUNCH									CARD ELECTRO NUMBER*

C	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
	2		0.33 -14 EXAMPLE 1 45° WEDGE-2 CONST RADIOSITY SURFACES	
			0.9 2470. 0. 0.59	
			0.65 1080. 0.645 0.	
	8		0.33 -14 EXAMPLE 2 45° WEDGE-8 CONST RADIOSITY SURFACES	
			0.9 2470. 0. 0. 0. 0. 0.60 0.16	
			0.035 0.015	
			0.9 2470. 0. 0. 0. 0. 0.105 0.32	
			0.185 0.085	
			0.9 2470. 0. 0. 0. 0. 0.03 0.13	
			0.20 0.155	
			0.9 2470. 0. 0. 0. 0. 0.01 0.06	
			0.115 0.145	
			0.65 1080. 0.65 0.125 0.03 0.015 0. 0.	
			0. 0.	
			0.65 1080. 0.15 0.36 0.155 0.06 0. 0.	
			0. 0.	
			0.65 1080. 0.04 0.195 0.22 0.14 0. 0.	
			0. 0.	
			0.65 1080. 0.02 0.085 0.165 0.165 0. 0.	
			0. 0.	
			/*	

*A standard card form, IBM electro 886157, is available for punching statements from this form

Enclosure 2

```
                BERGQUAM'S 1ST CASE.
 N =       2 SIGMA =       0.330000D-14

 EPS(      1) =        0.9000000D 00 TEMP(  1) =       0.2470000D 04
  0.0                  0.59000000D 00

 EPS(      2) =        0.6500000D 00 TEMP(  2) =       0.1080000D 04
  0.64500000D 00       0.0

 EPS(      1) =        0.9000000D 00 TEMP(  1) =       0.2470000D 04
  0.10000000D 01      -0.59000000D-01

 EPS(      2) =        0.6500000D 00 TEMP(  2) =       0.1080000D 04
-0.22575000D 00       0.10000000D 01


 B(  1) =    0.11221308D 00
 B(  2) =    0.28250352D-01


 Q(  1) =    0.95545376D-01
 Q(  2) =   -0.44127087D-01
```

ENCLOSURE 3

BERGQUAM'S 2ND CASE.

N = 8 SIG = 0.3300000D-14

EPS(1) = 0.9000000D 00 TEMP(1) = 0.2470000D 04
0.0 0.0 0.0 0.0 0.60000000D 00 0.16000000D 00 0.35000000D-01 0.15000000D-01

EPS(2) = 0.9000000D 00 TEMP(2) = 0.2470000D 04
0.0 0.0 0.0 0.0 0.10500000D 00 0.32000000D 00 0.18500000D 00 0.85000000D-01

EPS(3) = 0.9000000D 00 TEMP(3) = 0.2470000D 04
0.0 0.0 0.0 0.0 0.30000000D-01 0.13000000D 00 0.20000000D 00 0.15500000D 00

EPS(4) = 0.9000000D 00 TEMP(4) = 0.2470000D 04
0.0 0.0 0.0 0.0 0.10000000D-01 0.60000000D-01 0.11500000D 00 0.14500000D 00

EPS(5) = 0.6500000D 00 TEMP(5) = 0.1080000D 04
0.65000000D 00 0.12500000D 00 0.30000000D-01 0.15000000D-01 0.0 0.0 0.0 0.0

EPS(6) = 0.6500000D 00 TEMP(6) = 0.1080000D 04
0.15000000D 00 0.36000000D 00 0.15500000D 00 0.60000000D-01 0.0 0.0 0.0 0.0

EPS(7) = 0.6500000D 00 TEMP(7) = 0.1080000D 04
0.40000000D-01 0.19500000D 00 0.22000000D 00 0.14000000D 00 0.0 0.0 0.0 0.0

EPS(8) = 0.6500000D 00 TEMP(8) = 0.1080000D 04
0.20000000D-01 0.85000000D-01 0.16500000D 00 0.16500000D 00 0.0 0.0 0.0 0.0

EPS(1) = 0.9000000D 00 TEMP(1) = 0.2470000D 04
0.10000000D 01 0.0 0.0 0.0 -0.60000000D-01 -0.16000000D-01 -0.35000000D-02 -0.15000000D-02

EPS(2) = 0.9000000D 00 TEMP(2) = 0.2470000D 04
0.0 0.10000000D 01 0.0 0.0 -0.10500000D-01 -0.32000000D-01 -0.18500000D-01 -0.85000000D-02

EPS(3) = 0.9000000D 00 TEMP(3) = 0.2470000D 04
0.0 0.0 0.10000000D 01 0.0 -0.30000000D-02 -0.13000000D-01 -0.20000000D-01 -0.15500000D-01

EPS(4) = 0.9000000D 00 TEMP(4) = 0.2470000D 04
0.0 0.0 0.0 0.10000000D 01 -0.10000000D-02 -0.60000000D-02 -0.11500000D-01 -0.14500000D-01

EPS(5) = 0.6500000D 00 TEMP(5) = 0.1080000D 04
-0.22750000D 00 -0.43750000D-01 -0.10500000D-01 -0.52500000D-02 0.10000000D 01 0.0 0.0 0.0

EPS(6) = 0.6500000D 00 TEMP(6) = 0.1080000D 04
-0.52500000D-01 -0.12600000D 00 -0.54250000D-01 -0.21000000D-01 0.0 0.10000000D 01 0.0 0.0

EPS(7) = 0.6500000D 00 TEMP(7) = 0.1080000D 04
-0.14000000D-01 -0.68250000D-01 -0.77000000D-01 -0.49000000D-01 0.0 0.0 0.10000000D 01 0.0

EPS(8) = 0.6500000D 00 TEMP(8) = 0.1080000D 04
-0.70000000D-02 -0.29750000D-01 -0.57750000D-01 -0.57750000D-01 0.0 0.0 0.0 0.10000000D 01

B(1) = 0.11329418D 00
B(2) = 0.11257993D 00
B(3) = 0.11189592D 00
B(4) = 0.11136178D 00
B(5) = 0.35377602D-01
B(6) = 0.31460216D-01
B(7) = 0.26260661D-01
B(8) = 0.19953693D-01

Q(1) = 0.85815551D-01
Q(2) = 0.92243730D-01
Q(3) = 0.98399813D-01
Q(4) = 0.10320713D 00
Q(5) = -0.57363408D-01
Q(6) = -0.50088261D-01
Q(7) = -0.40431945D-01
Q(8) = -0.28719005D-01

ENCLOSURE 3a

SLOPE FACTORS FOR RADIATION

DOME METHOD

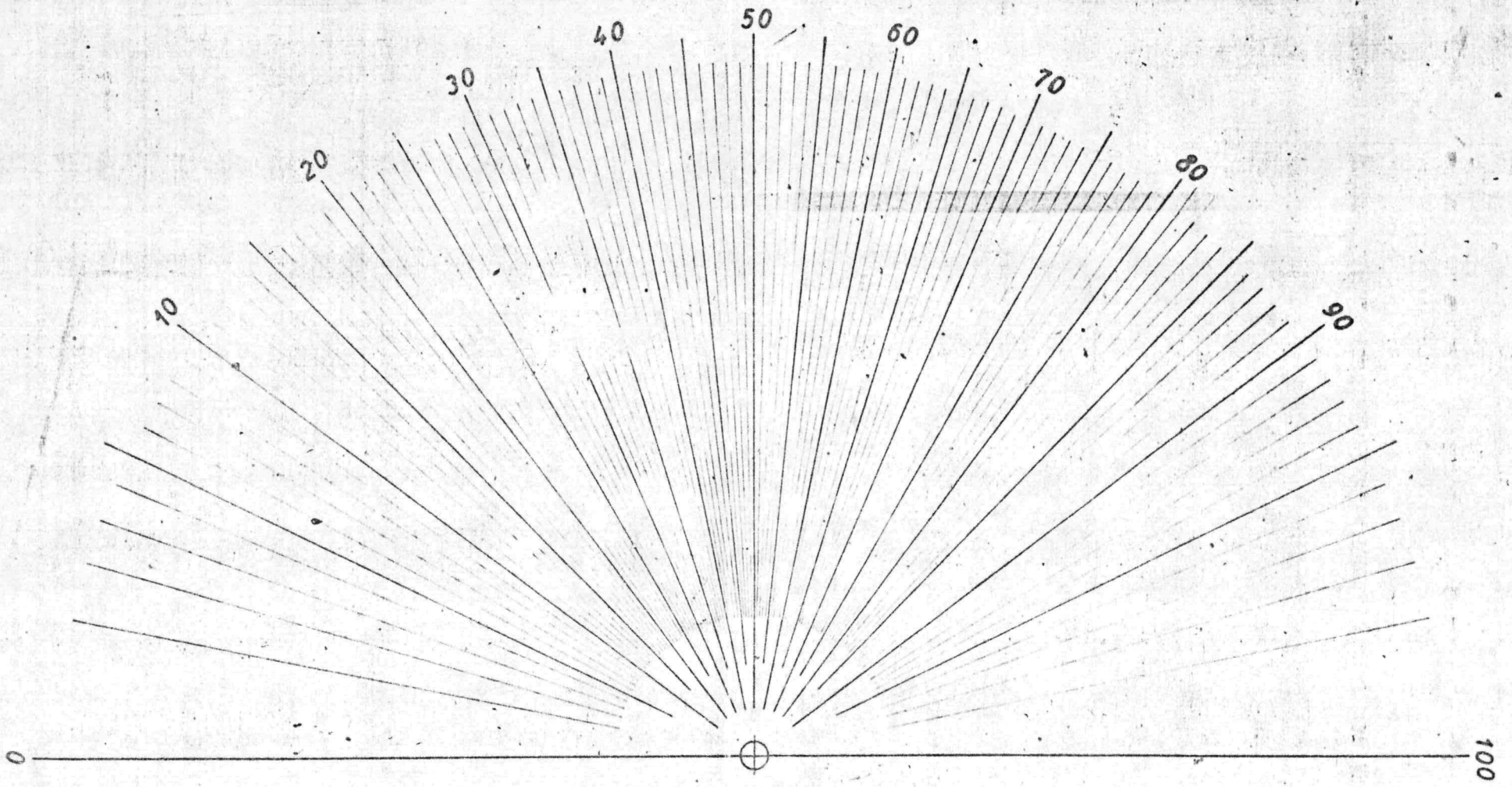

FIG. 10

Enclosure 4

O. VICK