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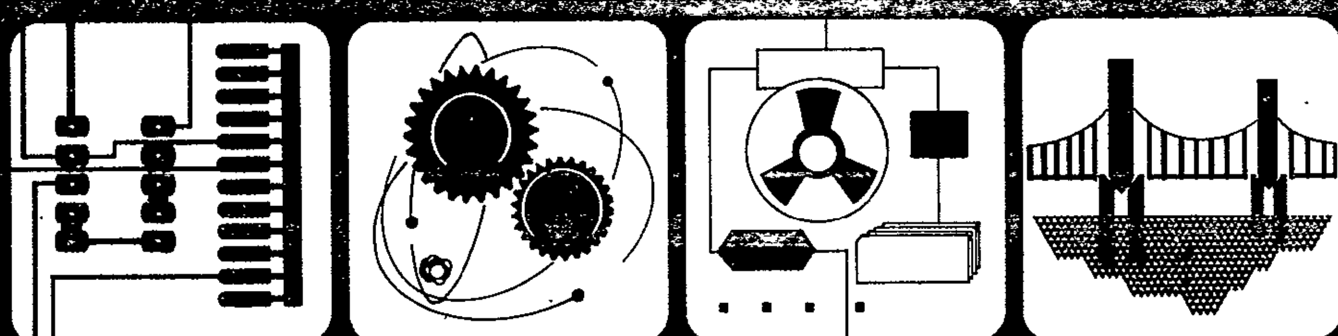

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COMPUTERIZED POWER SUPPLY ANALYSIS: STATE EQUATION GENERATION AND TERMINAL MODELS

Final Report
for the period from 2/2/76 to 4/2/78

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1. Introduction

To aid engineers that design power supply systems, special analytical tools are being introduced. These tools include integration routines that start with the description of a power supply in state-equation form and yield analytical results that include transient performance, steady-state equilibrium stability, and the response of the power supply to spurious inputs (audio susceptability).

The Department of Electrical Engineering at the University of South Florida has worked to develop two analysis tools that can be used with the state-equation analysis package.

The first tool uses a computer program that works with the SUPER*SCEPTRE circuit analysis program and prints the state equations for an electrical network. The state equations developed automatically by the computer program are used to develop an algorithm for reducing the number of state variables required to describe an electrical network. In this way a second tool is obtained in which the order of the network is reduced and a simpler terminal model is obtained. The price of the reduction in order is a reduction in the accuracy with which the model represents the system.

At the conclusion of the first year, the computer program that converts the circuit description of an electrical network to a set of state equations was completed.

In the second year the computer program was modified to accept a larger class of circuits including circuits with mutual inductance. The work on reducing the number of state variables required to describe an electrical network was completed and is described in this report.

The first task that was completed was the development of a computer program that would print the state-equations for an electrical network. The analytical background for the state equations of an electrical network is presented in Chapter 2. From the analysis in Chapter 2, the generality of the approach can be seen together with the reason for the presentation of data as matrices which are inverted in the state equations. The analytical basis for reducing the number of state variables using eigenvalue sensitivities concludes Chapter 2.

In Chapter 3 a description of the steps required to get a set of state equations is given. Chapter 3 is a user's manual for the program to PROduce State Equations (PROSE program). The user begins with an electrical network. By following the directions in Chapter 3, he can obtain the state equations for the network. Additional features of the program are also described in Chapter 3.

The description of the programs as written in FORTRAN is given in Chapter 4 and a complete listing of the program appears in the Appendix.

Several examples are given in Chapter 5 that illustrate the use of the PROSE program in obtaining the state equations for an electrical circuit.

A summary of the work accomplished under this grant appears together with recommendations for continued research in Chapter 6.

2. State Equations

The standard form of the state equations for an electrical or mechanical system is

$$\dot{x} = f(x,u,t)$$

$$y = g(x,u,t)$$

where x is an n x 1 state vector,

y is an m x 1 output vector,

u is a p x 1 input vector,

t is time,

f is the state transition function and

g is output function.

When the system is linear, the equations can be written as

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

where A is n x n transition matrix

B is n x p

C is m x n

D is m x p

The matrices A, B, C, and D may be functions of time. In certain nonlinear problems the matrix representation is possible. The elements of the matrix are given as an algebraic expression in terms of circuit components such as resistors, inductors and capacitors. The value of a component may depend upon a voltage or current (the element may be nonlinear).

The state equations for an electrical circuit can be derived by the following steps:

The circuit diagram is the starting point. The model for each circuit device is obtain as a collection of two terminal elements. The final circuit diagram contains

a. capacitors
b. resistors
c. inductors
d. independent voltage sources
e. dependent voltage sources
f. independent current sources
g. dependent current sources

2. The graph of the circuit is used to obtain a tree with the tree branches selected in the following order:

   a. voltage sources

   b. capacitors

   c. resistors

   d. inductors

All voltage sources are selected before any capacitors are selected; capacitors are selected to add new nodes to the tree before any resistors are added; etc. The circuit elements which are not tree branches are called links.

3. The components are partitioned and listed in Table 1. The groups of components in the tree are listed across the top and the groups of components that are links are listed along the side.

TABLE 1

	C4	R5	L6	E7
C1	F14	0	0	F17
R2	F24	F25	0	F27
L3	F34	F35	F36	F37
J8	F84	F85	F86	F87

where

C1 is a diagonal matrix of capacitor links

R2 is a diagonal matrix of resistor links

L3 is a matrix of inductor links

J8 is a column matrix of current sources and

C4 is a diagonla matrix of capacitor tree branches

R5 is a diagonla matrix of resistor tree branches

L6 is a matrix of inductor tree branches

E7 is a column matrix of voltage sources and

The symbols F_{ij} are matrices that shown the connections between the i links and the j tree branches.

$$F_{ij} = [fpq] \quad \begin{array}{l} 1 \leq p \leq \text{ number of links in class p} \\ 1 \leq q \leq \text{ number of tree branches in class j} \end{array}$$

where

$$fpq = \begin{cases} 1 & \text{if tree branch q is in the loop formed by placing link p back in the tree and if q is in the same direction in the loop as p.} \\ -1 & \text{if tree branch q is in the opposite direction in the loop defined by p.} \\ 0 & \text{if tree branch q is not in the loop defined by p.} \end{cases}$$

The state variables are selected as the column matrix $\begin{matrix} I3 \\ V4 \end{matrix}$.

Inductor Current State Variables

If mutual inductances are allowed, the equations describing the inductor currents are given as

$$L3\ \dot{I}3 + L36\ \dot{I}6 = V3 \qquad (1)$$

$$L63\ \dot{I}3 + L6\ \dot{I}6 = V6 \qquad (2)$$

where L3 is the inductance matrix for the inductor links

L36, L63 } are the inductance matrices for mutual inductance between link inductors and tree-branch inductors and

L6 is the inductance matrix for tree-branch inductor.

Using the connection equations

$$I6 = F_{36}^{T}\ I3 + F_{86}^{T}\ J8 \qquad (3)$$

which may be differentiated to give

$$\dot{I}6 = F_{36}^{T}\ \dot{I}3 + F_{86}^{T}\ \dot{J}8 \qquad (4)$$

Equation (4) may be substituted into Equation (1) to get

$$[L3 + L36\ F_{36}^{T}]\ \dot{I}3 = V3 - L36\ F_{86}^{T}\ \dot{J}8 \qquad (5)$$

The connection equations relating link voltages to tree branch voltages gives

$$V3 = -F_{34}\ V4 - F_{35}\ V5 - F_{36}\ V6 - F_{37}\ E7 \qquad (6)$$

The inductor voltage matrix is removed by the following steps beginning with Equation (2) which is repeated next.

$$V6 = L63\ \dot{I}3 + L6\ \dot{I}6 \qquad (2)$$

$$= L63\ \dot{I}3 + L6\ (F_{36}^{T}\ \dot{I}3 + F_{86}^{T}\ \dot{J}8) \qquad (7)$$

The equation for $\dot{I}3$ becomes

$$[L3 + L36\ F_{36}^{T} + F36\ L63 + F36\ L6\ F_{36}^{T}]\ \dot{I}3$$

$$= -F35\ V4 - F35\ V5 - F37\ E7 \qquad (8)$$

To reduce this equation so that only the state variables I3 and V4 together with independent sources E7, Ey, J8, and Jx appear, the resistor voltages and currents must be obtained as a function of the state variables.

Resistor Links and Tree Branches

The resistor voltages and currents can be expressed by the following matrix equations.

$$\begin{bmatrix} R2 & 0 \\ 0 & G5 \end{bmatrix} \begin{bmatrix} I2 \\ V5 \end{bmatrix} = \begin{bmatrix} V2 \\ I5 \end{bmatrix} = \begin{bmatrix} 0 & -F_{24} \\ F_{35}^{T} & 0 \end{bmatrix} \begin{bmatrix} I3 \\ V4 \end{bmatrix} + \begin{bmatrix} 0 & -F_{25} \\ F_{25}^{T} & 0 \end{bmatrix} \begin{bmatrix} I2 \\ V5 \end{bmatrix} + \begin{bmatrix} 0 & -F_{27} \\ F_{85}^{T} & 0 \end{bmatrix} \begin{bmatrix} J8 \\ E7 \end{bmatrix} \tag{9}$$

Equation (9) can be solved as

$$\begin{bmatrix} I2 \\ V5 \end{bmatrix} = \begin{bmatrix} R2 & F_{25} \\ -F_{25}^{T} & G5 \end{bmatrix}^{-1} \begin{bmatrix} 0 & -F_{24} \\ F_{35}^{T} & 0 \end{bmatrix} \begin{bmatrix} I3 \\ V4 \end{bmatrix} + \begin{bmatrix} 0 & -F_{27} \\ F_{85}^{T} & 0 \end{bmatrix} \begin{bmatrix} J8 \\ E7 \end{bmatrix} \tag{10}$$

If the matrix $M_R^{-1} = \begin{bmatrix} R2 & F_{25} \\ -F_{25}^{T} & G5 \end{bmatrix}^{-1}$ is partitioned as

$$M_R^{-1} = \begin{bmatrix} m1 & m2 \\ m3 & m4 \end{bmatrix},$$

then

$$M_R^{-1} \begin{bmatrix} R2 & F_{25} \\ -F_{25}^{T} & G5 \end{bmatrix} = \begin{bmatrix} m1R2 - m2F_{25}^{T} & m1F_{25} + m2G5 \\ m3R2 - m4F_{25}^{T} & m3F_{25} + m4G5 \end{bmatrix} = \begin{bmatrix} U & 0 \\ 0 & U \end{bmatrix} \tag{11}$$

and

$$\begin{bmatrix} R2 & F_{25} \\ -F_{25}^{T} & G5 \end{bmatrix} M_R^{-1} = \begin{bmatrix} R2m1 + F_{25}m3 & R2m2 + F_{25}m4 \\ -F_{25}^{T}m1 + G5m3 & -F_{25}^{T}m2 + G5m4 \end{bmatrix} = \begin{bmatrix} U & 0 \\ 0 & U \end{bmatrix} \tag{12}$$

where U is a unit matrix of the appropriate size. The solution for the matrix MR^{-1} is obtained from Equation (11) as

$$
\begin{aligned}
m1 &= \left[R2 + F25R5F_{25}^{T}\right]^{-1} \\
m2 &= -m1F25R5 \\
m3 &= R5F_{25}^{T}m1 \\
m4 &= \left[U - R5F_{25}^{T}m1F_{25}\right] R5
\end{aligned}
\tag{13}
$$

Beginning with Equation (12) yields another expression for m_1, m_2, m_3, and m_4 as

$$
\begin{aligned}
m4 &= \left[F_{25}^{T}G2F_{25} + G5\right]^{-1} \\
m3 &= m4F_{25}^{T}G2 \\
m2 &= -G2F_{25}m4 \\
m1 &= G2\left[U - G2F_{25}m4F_{25}^{T}\right]
\end{aligned}
\tag{14}
$$

Solving Equation (10) for V5 yields

$$
V5 = m4F_{35}I3 - m3F_{24}V4 - m3F_{27}E7 + m4F_{85}^{T}J8 \tag{15}
$$

Equation (15) is substituted into Equation (8) and solved to give the solution for state variable I3 as

$$
\begin{aligned}
\dot{I}3 = M_L^{-1}\Big[&-F_{35}m4F_{35}^{T}I_3 - \left[F_{34} - F_{35}m3F_{24}\right] V4 - \left[F_{37} - F_{35}m3F_{27}\right] E7 \\
&-F_{35}m4F_{85}^{T}J_8 - \left[L36F_{86}^{T} + F_{36}L6F_{86}^{T}\right]\dot{J}_8\Big]
\end{aligned}
\tag{16}
$$

Capacitor Voltages

The voltage state equation can be obtained beginning with the capacitor equations

$$
\begin{aligned}
C1\dot{V}1 &= I1 \\
C4\dot{V}4 &= I4
\end{aligned}
\tag{17}
$$

The solution begins with the second equation in (17)

$$
C4\dot{V}4 = I4 = F_{14}^{T}I1 + F_{24}^{T}I2 + F_{34}^{T}I3 + F_{84}^{T}J8 \tag{18}
$$

The variables I1 and I2 must be eliminated in the solution. Beginning with I1

$$
C1^{-1}I1 = \dot{V}1 = [-F_{14}\dot{V}4 - F_{17}\dot{E}7] \tag{19}
$$

$$C1^{-1}I1 = -F_{14}[C4^{-1}\{F_{14}^{T}I1 + F_{24}^{T}I2 + F_{34}^{T}I3 + J8\}] - F_{16}\dot{E}7 \tag{20}$$

Denoting $C1^{-1}$ by S1 and $C4^{-1}$ by S4 and solving gives

$$I1 = M_s^{-1}\{-F_{14}\ S4[F_{24}^{T}I2 + F_{23}^{T}I3 + F_{84}^{T}J8] - F_{17}\dot{E}7\}$$

where $M_s = [S1 + F_{14}S4F_{14}^{T}]$ (21)

Solving Equation (10) for I2 given

$$I2 = -m1[F_{24}V4 + F_{20}E7] + m2\ [F_{35}^{T}\ I3 + F_{86}^{T}J8] \tag{22}$$

When Equations (21) and (22) are substituted into Equation (18) and the result simplified, the result is

$$\begin{aligned}\dot{V}4 = S4\{&[[-[F_{14}^{T}\ M_s^{-1}\ F_{14}\ S4] + U_{44}]\ [F_{24}^{T}m2F_{35}^{T} + F_{34}^{T}]I3\\
&+ [F_{14}^{T}M_s^{-1}\ F_{14}S4F_{24}^{T} - F_{24}^{T}]\ m1F_{24}V4\\
&+ [-[F_{14}^{T}M_s^{-1}\ F_{14}S4 - U_{44}]\ [F_{84}^{T} + F_{24}^{T}\ m2F_{85}^{T}]\ J8\\
&+ [F_{14}^{T}M_s^{-1}\ F_{14}S4 - U_{44}]\ F_{24}^{T}m1F_{27}E7\\
&-F_{14}^{T}M_s^{-1}\ F_{17}\dot{E}7\}\end{aligned} \tag{23}$$

Combining Equation (16) and Equation (23) gives the state equations.

$$\begin{bmatrix}\dot{I}3\\ \dot{V}4\end{bmatrix} = \begin{bmatrix}M_L & 0\\ 0 & C4\end{bmatrix}^{-1}\begin{bmatrix}-F_{35}m4F_{35}^{T} & -F_{34} + F_{35}m3F_{24}\\ [U_{44}-F_{14}^{T}M_s^{-1}F_{14}S_4][F_{24}^{T}M2F_{35}^{T}+F_{34}^{T}] & -[U_{44}-F_{14}^{T}M_s^{-1}F_{14}S_4]F_{24}^{T}m1F_{24}\end{bmatrix}\begin{bmatrix}I3\\ V4\end{bmatrix}$$

$$+\begin{bmatrix}-F_{35}m4F_{85}^{T} & -F_{37} + F_{35}\ m3\ F_{27}\\ [U_{44}-F_{14}M_s^{-1}F_{14}S_4][F_{84}^{T}+F_{24}^{T}m2F_{85}^{T}] & -\ [U_{44}-F_{14}^{T}M_s^{-1}F_{14}S_4]F_{24}^{T}m1F_{27}\end{bmatrix}\begin{bmatrix}J8\\ E7\end{bmatrix}$$

$$+\begin{bmatrix}-L36F_{86}^{T} - F_{36}L6F_{86}^{T} & 0\\ 0 & -F_{14}^{7}\ M_s^{-1}\ F_{17}\end{bmatrix}\begin{bmatrix}\dot{J}8\\ \dot{E}7\end{bmatrix} \tag{24}$$

The state equations are produced as the output of the preprocessor computer program known as SCEPTRE I. These state equations are the input to the computer program SCEPTRE II which performs the integration required to obtain a transient solution.

Notice that Equation (24) appears in matrix form even though each element may depend on time or on another voltage or current that can be obtained at times when the state variables are known.

The state equations are calculated by processing the output of SCEPTRE I to obtain matrix equations in the form similar to Equation (24). While this equation is non-linear, it can be linearized around a quiescent value as specified by initial conditions for the state variables $\begin{bmatrix} I_3 \\ V_4 \end{bmatrix}$.

The linearized state equations are

$$\begin{bmatrix} \dot{I}_3 \\ \dot{V}_4 \end{bmatrix} = A \begin{bmatrix} I_3 \\ V_4 \end{bmatrix} + B \begin{bmatrix} J_8 \\ E_7 \end{bmatrix} + E \begin{bmatrix} \dot{J}_8 \\ \dot{E}_7 \end{bmatrix} \tag{26}$$

The eigenvalues of this equation are eigenvalues of the constant matrix, A.

In the representation of any physical system a compromise is made in choosing the order of the mathmatical model. The order may be order of the differential equation that describes the system or may be the number of poles in the transfer function for a linear system. In any physical system that is modeled with lumped parameters, a decision must be made on how many energy storage elements (capacitors, inductors) are included in the model. More energy storage elements increase accuracy and computational difficulty. The number of independent energy storage elements is equal to the number of state variables required.

As the number of state variables is increased the accuracy can be increased. However, in choosing the equivalent circuit for a physical system such as a power supply, some energy storage elements may be selected that do not affect the accuracy of the model significantly. A simpler description that did not reduce accuracy would give a better model.

In a state variable description of a physical system, when an independent energy storage element is discarded, the number of state variables is reduced by one. Energy storage elements that are incidental to the accurate description of a physical system usually contribute to only the shortest time constants or the largest eigenvalues of the A matrix.

The eigenvalues of the A matrix are obtained using a subroutine. The sensitivity is calculated for each parameter by increasing the parameter by 1% and calculating the eigenvalue. For example the sensitivity to a resistor is given by

$$S_R^P = \frac{R}{P}\frac{\Delta p}{\Delta R} = (100)\frac{\Delta p}{p} \tag{27}$$

where p is the eigenvalue,

Δp is the change in the eigenvalue

ΔR is the change in resistor and

R is the resistor value.

The sensitivities can be used to reduce the number of state variables. First the eigenvalue with the largest magnitude is selected. The sensitivities of this eigenvalue to each parameter is scanned. The circuit parameter (resistance, inductance, or capacitance) to which the largest eigenvalue has a sensitivity with a magnitude within 3 per cent of unity is selected. If the selected circuit parameter does not affect other eigenvalues, it is removed from the network. It is set equal to zero if the sensitivity is negative; if the sensitivity is positive, the circuit parameter is set to infinity.

The desire is to force the eigenvalue to negative infinity. From the equation

$$\frac{\Delta p}{p} = \sum_R S_{R_i}^p \frac{\Delta R}{R} + \sum_C S_c^p \frac{\Delta C}{C} + \sum_L S_L^p \frac{\Delta L}{L} \tag{28}$$

it can be inferred that the per cent change in an eigenvalue can be maximized by selecting a circuit element, ξ, with the largest sensitivity and maximizing

$$S_\xi^p \frac{\Delta \xi}{\xi} \tag{29}$$

for that term.

In every case the eigenvalue will be moved away from the origin toward infinity. If it is moved to infinity, a state variable is eliminated by the removal of a circuit element. The correlation of eigenvalue going to infinity and state variable disappearing can be observed from the characteristic equation:

$$|SI - A| = S^n + a_{n-1}S^{n-1} + \ldots + a_1 S + a_0 \tag{30}$$

In factored form the caharacteristic equation becomes

$$K\left(\frac{S}{p_1} + 1\right)\left(\frac{S}{p_2} + 1\right) \ldots \left(\frac{S}{p_n} + 1\right) \tag{31}$$

Obviously one term disappears if $p_i \to \infty$ for the largest eigenvalue p_i.

If not moved to infinity, the eigenvalue is made larger in magnitude and the process can be repeated so that other circuit elements are deleted and the eigenvalue is moved to infinity.

By considering the characteristic equation again it can be seen that

$$|SI - A| = S^n + a_{n-1}S^{n-1} + \dots + a_0 \tag{32}$$

where

$$a_0 = p_1 \cdots p_n .$$

That is, a_0 is the product of the n eigenvalues. If the derivative of a_0 is taken with respect to a circuit element ξ where ξ is an R, L, or C, the result is

$$\frac{\partial a_0}{\partial \xi} = \sum_{i=1}^{n} (p_1 p_2 \cdots p_{i-1} p_{i+1} \cdots p_n) \frac{\partial p_i}{\partial \xi} \tag{33}$$

A little algebra yields

$$S_\xi^{a_0} = \frac{\xi}{a_0} \frac{\partial a_0}{\partial \xi} = \sum_{i=1}^{n} \frac{\xi}{p_i} \frac{\partial p_i}{\partial n} = \sum_{i=1}^{n} S_\xi^{p_i} . \tag{34}$$

For linearized state equations the constant a_0 has been observed to have the form

$$a_0 = \frac{(C1 + C2) \quad R1R2}{C1C2 \; L1L2(R1 + R2)} \text{ (+ other terms)} \tag{35}$$

clearly

$$|S_\xi^{a_0}| \leq 1 \tag{36}$$

for this case.

In words, the sum of the pole sensitivities to a parameter is less than or equal to 1. For this reason in most cases of interest if the sensitivity of an eigenvalue is nearly equal to one, the sensitivity of other eigenvalues will be very small. Thus, the circuit element is deleted will only cause one eigenvalue to have an appreciable change in magnitude.

The sensitivity calculations are made in the PROSE program for the eigenvalue with the maximum absolute value. If the magnitude of the sensitivity is within three per cent of unity for a circuit parameter, the circuit parameter can be removed from the circuit. In the examples in Chapter 5 the computer output shows how the circuit elements can be removed.

3. User's Manual for PROSE

3.1 Introduction

The user's manual for the computer program to PROduce State Equations is given in this section. The PROSE program can be used to derive the state equations for any electrical network that can be analyzed with the SCEPTRE* circuit analysis program and compute eigenvalue sensitivities with the following restrictions:

1. Each circuit component can be modeled by two-terminal elements which can be represented as either a voltage source, a current source, a resistor, a capacitor, or an inductor.
2. No FORTRAN Subroutines are allowed.
3. No linear, secondary, or primary dependent sources are permitted. (In place of the SCEPTRE dependent sources, voltage or current sources can be defined by expressions which can give a dependent source).

The PROSE program can be used by following these steps:

Step 1. A circuit diagram is drawn for the circuit for which the state equations are desired. Each component in the original circuit has been represented as a collection of two terminal elements in the circuit diagram.

Step 2. The circuit diagram is translated into a listing for tje SUPER*SCEPTRE circuit analysis program.*

Step 3. Input sources are requested under OUTPUTS subheading.

Step 4. After the RUN CONTROLS heading, the instruction EXECUTE SETUP PHASE ONLY is inserted.

Step 5. The control cards are added and the complete program is entered.

The PROSE program responds by outputting the state equations and a state transition matrix for a linear set of equations. In addition the PROSE program computes a set of "sensitivities" of the eigenvalues of the transition matrix that result from a change in each of the circuit elements.

---

* The format for the computer input can be found in one of the following:

1. Extended SCEPTRE Volume I. User's Manual, AD-A009-594.
2. James C. Bowers and Stephen R. Sedore, SCEPTRE: A Computer Program For Circuit Analysis and Systems Analysis, Prentice-Hall, Inc., Englewood, Cliffs, New Jersey 1971
3. User's Manual for SUPER*SCEPTRE, AD-A011-348

3.2 Example

To fix ideas consider as an example obtaining the state equations for the circuit in Figure 1.

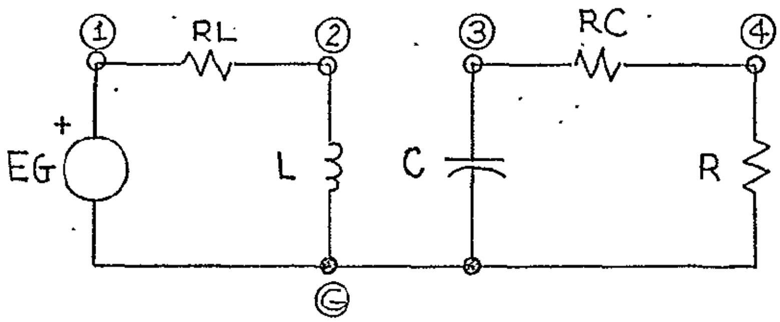

Fig. 1. Boost Power Supply Average Model TD Interval Model

The input description for PROSE use is:

```
//JOB card for 240 k byte region
//STEP1 EXEC PROSE
//INPUT DD *
CIRCUIT DESCRIPTION
BOOST POWER SUPPLY
AVERAGE MODEL
TD INTERVAL
ELEMENTS
EG,G-1=1
RL,1-2=1
L,2-G=2
C,3-G=3
RC,4-3=4
R,4-G=5
OUTPUTS
EG
RUN CONTROLS
EXECUTE SETUP PHASE ONLY
STOP TIME=5
END
```

Fig. 2. PROSE Input Listing for Circuit of Figure 1

The PROSE system output is condensed below.

```
DL=(-IL*RL+EG)/(L)
DC=-VC/((R+RC))/(C)
STATE VARIABLE NAMES
IL
VC

MATRIX A
  -5.00000D-01              -5.00000D-01
   0.0                      -3.70370D-02

INDEPENDENT SOURCE NAMES
EG

MATRIX B
  -5.00000D-01
  -3.70370D-02

EIGENVALUES OF MATRIX A
     REAL PART              IMAG. PART
     -5.0000000D-01         0.0
     -3.7037037D-02         0.0
```

Fig. 3. Summarized PROSE output for input listing of figure 2.

Figure 1 indicates the circuit whose state variable equations are computed. Each element is given a name and each node is labeled with an encircled character.

Figure 2 shows the IBM OS job control language (lines 1 through 3) to execute the system. Lines 4 through 14 in Figure 2 describe the circuit in standard SCEPTRE format.[1] The OUTPUTS request (lines 15 & 16) alerts PROSE to regard EG as an independent source in its determination of the B matrix.

The RUN CONTROLS (lines 17 through 19) include the special line:

[1] See EXTENDED SCEPTRE, Volume I. User's Manual, AD-A009-594

EXECUTE SETUP PHASE ONLY. Both this card and the STOP TIME = number dummy value are required. The END card finishes the PROSE input description.

The output of Figure 3 indicates the state variable equations for DL $(\frac{dIL}{dt})$ and DC $(\frac{dVC}{dt})$ as well as the state variable names (IL and VC), the linear transition matrix A, the independent sources (EG), the input matrix B, and the eigenvalues for the transition matrix.

The matrices are determined from the state variable equations and the element values in the form: $\dot{X} = AX + BU$, where X is the vector of state variables and U is the vector of independent sources.

Additional outputs include the sensitivities which will be further described later in this document.

3.3.0 PROSE Language

The PROSE system input language is the standard SCEPTRE transient solution language. For those unfamiliar with the SCEPTRE language, the reference of note 1 must be consulted.

3.3.1 Descriptions

PROSE will allow all standard SCEPTRE descriptions; i.e. CIRCUIT, MODEL, and RERUN. However, the rerun description is ignored and model description is used only if models under it are called in the circuit description.

3.3.2 Elements

All SCEPTRE elements (E,R,L,C,J) are allowed by PROSE. Element values may be constants, expressions or tables. PROSE will allow defined parameters in expressions but <u>will not</u> allow FORTRAN function subroutines, equations, secondary dependent sources, linear dependent sources, and primary dependent current sources. Voltage and current source derivatives are also allowed.

Models may be called as elements as in standard SCEPTRE, but model elements must also conform to the above rules.

Since PROSE is transient analysis oriented, no AC sources nor elements with bounds are permitted.

3.3.3 Defined Parameters

Standard SCEPTRE transient oriented real defined parameters may be utilized.

3.3.4 Outputs

At least one output request is necessary for proper execution. The OUTPUT requests of voltage or current sources implies that these sources are independent sources and are used in the PROSE computation of the B matrix.

3.3.5 Initial Conditions

Initial conditions may be supplied and sometimes are required since PROSE does not compute a DC operation point prior to matrix computations. The initial conditions are used to set the system operating point when a linear set of state equations are computed. If the initial conditions are not supplied, all initial state variable values are assumed to be zero.

3.3.6 Functions

Only Tables are allowed under functions. PROSE does not permit equations.

3.3.7 Run Controls

PROSE requires the special run control: EXECUTE SETUP PHASE ONLY for execution of the state variable equation generator.

A dummy STOP TIME is also required.

For debugging purposes, PROSE allows the run control: WRITE SIMUL8 DATA

All other run controls are illegal.

3.3.8 End

An END card is required at the end of the input to PROSE

No other heading or subheading cards may be included.

3.4 Features

3.4.1 PROSE system output

The output from PROSE begins with a FORTRAN routine. Within the routine is a listing of the state variable equations. These equations are of the form:

$$\text{DL or DC} = f(\text{elements}, I_L, V_c)$$

where $\text{DL} = \frac{dI_L}{dt}$ and $\text{DC} = \frac{dV_c}{dt}$

where I_L and V_c are the circuit state variables. Also, if any matrices appear in the state equations, the matrix elements will be listed and their inverse elements (elements of the inverted matrix) will be specified by a trailing "I" in the state equations.

Following the subroutine output, the linear circuit sensitivity analysis results are given.

The state variable names are listed, followed by the state transition matrix A. These are followed by the independent source names (if any) and the input matrix B (if any independent sources exist).

The eigenvalues of matrix A are then displayed followed by the sensitivity analysis. This analysis is computed by increasing each element value (except for independent sources) by 1% separately and recomputing the transition matrix eigenvalues.

PROSE lists the sensitivities of each element to the maximum eigenvalue and also gives an indication of elements which may be removed (either short or open circuited) to eliminate a state variable from the system.

3.4.2 Mechanical Systems

The standard SUPER*SCEPTRE mechanical description systems[2] may be used by PROSE giving state variable equations for these systems. Combinations of circuit and mechanical descriptions may also be analyzed.

3.5 Limitations

3.5.1 No equations may be specified

3.5.2 No FORTRAN functions

3.5.3 No linear or secondary or primary dependent sources

3.6 Error Messages

Error	
1	RUN INITIAL CONDITIONS ONLY specified
2	VECTOR EQUATIONS specified
3	RUN IC VIA IMPLICIT specified
4	RUN AC specified
5	EY type elements exist (Linear dependent source)
6	JX type elements exist (Linear dependent source)
7	J8 type elements exist (Primary dependent source)
8	J0 type elements exist (Secondary dependent source)
9	LOWER LIMIT TABLE specified
10	RUN MONTE CARLO specified
11	RUN OPTIMIZATION specified
12	RUN SENSITIVITY specified
13	RUN WORST CASE specified
14	EXECUTE SETUP PHASE ONLY not specified
15	SCEPTRE1 DTASAV dataset empty[3]
16	SCEPTRE1 PGMSAV dataset empty[3]
17	SCEPTRE1 PGMSAV dataset incorrect[3]
18	No state variables exist

[2] See User's Manual for SUPER*SCEPTRE, AD-A011-348

22	Pushdown stack overflow[4,5]
23	Invalid symbol encountered[5]
24	Invalid use of XTABLE format
25	Symbol divided incorrectly in FGMSAV[5]
26	More than 300 elements, tables, expressions, and defined parameters
27	Invalid symbol pushed into stack[5]
28	Invalid expression symbol pushed into stack[5]
29	Pushdown stack overflow[4,5] (same as 22)
30	A TABLE appeared incorrectly in an expression
31	Invalid use of subscript zero[5]
32	A state variable cannot be located[5]
33	Stack KSHUV overflow - possible computational delay
34	Passive element is variable - element set to zero
35	Matrix is too large for display

[3] Probably SCEPTRE1 syntax error

[4] Possibly a computational delay exists

[5] Please notify author; those are system errors.

All errors without note 5 are user errors.

Note: References refer to AD catalog numbers at:

National Technical Information Services
U. S. Department of Commerce
Springfield, VA 22161

4.0 PROSE Principles of Operation

4.1 Introduction

The PROSE system operates in conjunction with the SUPER*SCEPTRE package[6]. The system utilizes a standard unmodified SUPER*SCEPTRE system only as an equation generator, i.e. the execution phase (simulation) of SUPER*SCEPTRE is not required. The PROSE system is a "post-processor" to the equation generator. Thus, the total PROSE system operates in six sequential job steps.

4.2 Steps of the PROSE system

The first two steps of the operation of PROSE are the standard SUPER and SCEPT1 steps of a SUPER*SCEPTRE job. The SUPER step performs any processing required on a standard SUPER*SCEPTRE input stream [6] (i.e. mechanical, digital, transfer function, etc) to produce actual SCEPTRE

[6] See previous reference AD-A011-348

coding. The SCEPT1 step is also standard SCEPTRE input processing and equation generation.[7]. The state variable equations generated are placed in a FORTRAN subroutine (SIMUL8) and written on dataset PGMSAV. Also, data required for execution of the equations is placed on dataset DTASAV by SCEPT1.

With this setup stage performed, the PROSE system begins processing on the PGMSAV and DTASAV files. This third step reads the DTASAV file and verifies its legality according to the criteria setup in the PROSE manual.

After verification, the system searches the PGMSAV file for the state variable equations. The equations are pushed out in an equation stack (NPUSH) with the variable name (left hand side of the equation) and a pointer to its equation in NPUSH placed in array KLOCA. All expressions and state equations are thus saved in memory. During this process, the element names are also saved in array NSYM.

The system next begins writing its FORTRAN routine. The routine is one which can compute the A and B matrices of the linearized, state variable form:

$$\dot{X} = AX + BU$$

where X is the vector of state variables and U is the vector of input sources.

Prior to the state equation generation, the system outputs the elements of any R,G,L, or S matrices which exist in the circuit.

The state equations are now generated by the following process. The symbol table (NSYM) is searched sequentially for state variables, and the equation for the derivative of that variable is initiated. The process involves location of the equation in the stack (NPUSH), popping the equation until a variable name is located, pushing the current equation pointer (onto KSHUV), and then recursively generating the equation for the current variable. At each location of a variable in an equation, either a set of parentheses are forced around the new equation (if the new equation has any sum terms in it), or not (if no sum terms exist); or, possibly, the variable is constant (element value) or a state variable itself, in which case the variable name is entered in the equation. This process may form awkwardly long state equations but decreases as much as paracticable the number of parentheses

[7]SCEPTRE SUPPORT II, VOLUME II, Revised Mathematical Fromulation, AD-882-385

and forces only constant valued variables to appear in the equations. Each state variable equation is thus generated by this same procedure.

The routine has now become a self-contained representation of the state equations of the input circuit.

The next two steps of PROSE perform the compilation of the SIMUL8 subroutine and linkage edit the SIMUL8 object with the object (load module in actuality) of the simulation portion of the PROSE system.

The simulation (GO step) reads the DTASAV file and begins the generation of the A and B matrices by alternately setting one and only one state variable to 1, all others are set to zero. Of course, all constant element values are set to their nominal values as specified in the input description. This A and B matrix generation is performed by subroutine EIGAN which also calls the IBM Scientific Subroutines HSBG and ATEIG to compute the eigenvalues of the real A matrix. Finally, the simulation performs a sensitivity analysis by increasing each constant non-input element value, respectively, by 1% and recomputing new A and B matrices and eigenvalues of the new A matrix.

5. Examples

Three examples are given which illustrate the use of the PROSE program in obtaining state equations for electrical networks. For each example the SCEPTRE listing is given together with the circuit diagram. The state equations are printed as the output. Notice that

DLX represents $\frac{dI_{LX}}{dt}$

and

DCX represents $\frac{dV_{CX}}{dt}$.

5.1 RLC Circuit

A simple RLC circuit is used for the first example. The circuit diagram is shown together with the SCEPTRE input in Figure 5.1a. The state equations produced as the output of the PROSE program is also listed in Figure 5.1b.

In Figure 5.2 the A and B matrices are given. Next the eigenvalues are calculated together with the sensitivities of the maximum eigenvalue of one per cent change in each parameter. If the sensitivity of the circuit element is within 3% of unity, the circuit element can be removed from the network. How the circuit element can be removed (by setting it equal to zero or by setting it equal to infinity) is indicated in several of the examples that follow.

```
SU[redacted]SCE[redacted] SY[redacted] IN[redacted]-- [redacted] VE[redacted]N -[redacted]360[redacted]DS [redacted]ASE [redacted]
*****************************************************************************************************************

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PLEASE REPORT ANY SOFTWARE ERRORS TO DR. JAMES C. BOWERS 813-974-2581

*****************************************************************************************************************


CIRCUIT DESCRIPTION
EXAMPLE 1
ELEMENTS
E,G-1=1
R,1-2=1
L,2-3=1
C,3-G=1
RL,3-G=1
OUTPUTS
E
RUN CONTROLS
STOP TIME=5
EXECUTE SETUP PHASE ONLY
END

END OF PRE-PROCESSOR
```

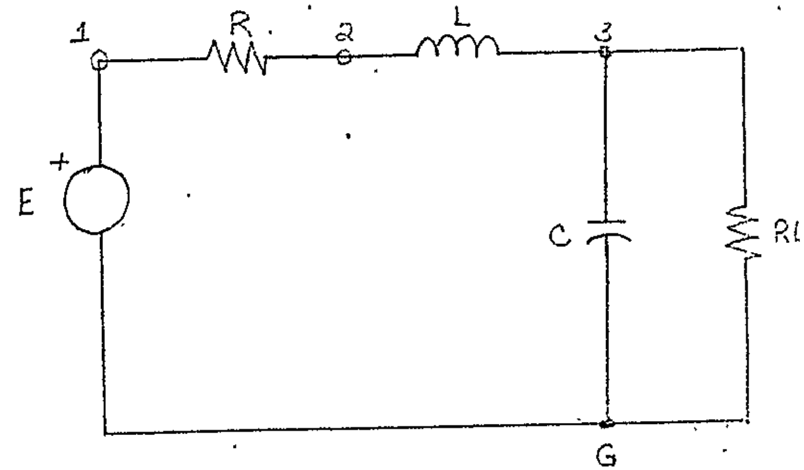

Figure 5.1a. RLC Circuit Example.

```
SIMULATION HAS BEEN DELETED
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
C
C     STATE VARIABLE EQUATIONS
C
      DL=(-VC-IL*R+E)/(L)
      DC=(-VC/(RL)+IL)/(C)
C
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
      END
```

Figure 5.1b. State Equations for Figure 5.1a.

```
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---- ----- -------- ------

     PROSE PROGRAM
     ----- -------
UNIVERSITY OF SOUTH FLORIDA
---------- -- ----- -------

EXAMPLE 1

----- -------- -----
STATE VARIABLE NAMES
----- -------- -----
IL
VC

------ -
MATRIX A
------ -
  -1.000000D+00  -1.000000D+00
   1.000000D+00  -1.000000D+00

----------- -------
INDEPENDENT SOURCES
----------- -------
E

------ -
MATRIX B
------ -
   1.000000D+00
   0.0

----------- -- ------ -
EIGENVALUES OF MATRIX A
----------- -- ------ -
               REAL PART           IMAG. PART
               ---- ----           ----- ----
             -1.0000000D+00       1.0000000D+00
             -1.0000000D+00      -1.0000000D+00

----------- --------
SENSITIVITY ANALYSIS
----------- --------
MAXIMUM EIGENVALUE #  2 MAGNITUDE =  1.4142136D+00

ELEMENT  SENSITIVITY
-------  -----------
 C         -0.496
 R          0.250
 RL        -0.248
 L         -0.496

NO SENSITIVITIES WITHIN 3% OF  1 .
C       MAY BE REMOVED (I.E. SET TO ZERO     IF SENSITIVITY < ZERO
                            SET TO INFINITY IF SENSITIVITY > ZERO.)
```


Figure 5.2. Matrices, Eigenvalues and Sensitivities for RLC Circuit.

5.2 Mutual Inductance

A simple transformer system is shown in Figure 5.3 together with the SUPER*SCEPTRE input. The state equations are given in Figure 5.4. Notice the generation of the inductor matrix equations, XML, and the references to the inverse elements of this matrix, XMLI. In Figure 5.5 the A matrix, B matrix, eigenvalues and sensitivities are listed.

```
SUPER*SCEPTRE SYSTEM INPUT -- 02/75 VERSION -- S/360 -- OS RELEASE 21.8

*****************************************************************************************************

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*****************************************************************************************************

CIRCUIT DESCRIPTION
MUTUAL INDUCTANCE TEST FOR PROSE
ELEMENTS
E,1-2=1
R1,2-3=1
L1,3-1=1
L2,4-5=1
M,L1-L2=0.95
R2,4-5=1
OUTPUTS
E,VL1,VL2,IL1,IL2,IR2
RUN CONTROLS
STOP TIME=5
EXECUTE SETUP PHASE ONLY
END

END OF PRE-PROCESSOR
```

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 5.3. Mutual Inductance Example.

```
SIMULATION HAS BEEN DELETED
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><
C
C
C      MATRIX EQUATIONS
C
       DIMENSION XML(   2,   2)
       XML(1,1)=L1
       XML(2,1)=(+R1)
       XML(1,2)=(+R1)
       XML(2,2)=L2
C
C
C
C      STATE VARIABLE EQUATIONS
C
       DL1=(+XMLI(1,1)*(-IL1*R1+E)+XMLI(1,2)*(-IL2)*R2)
       DL2=(+XMLI(2,1)*(-IL1*R1+E)+XMLI(2,2)*(-IL2)*R2)
C
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><
C
       END
```

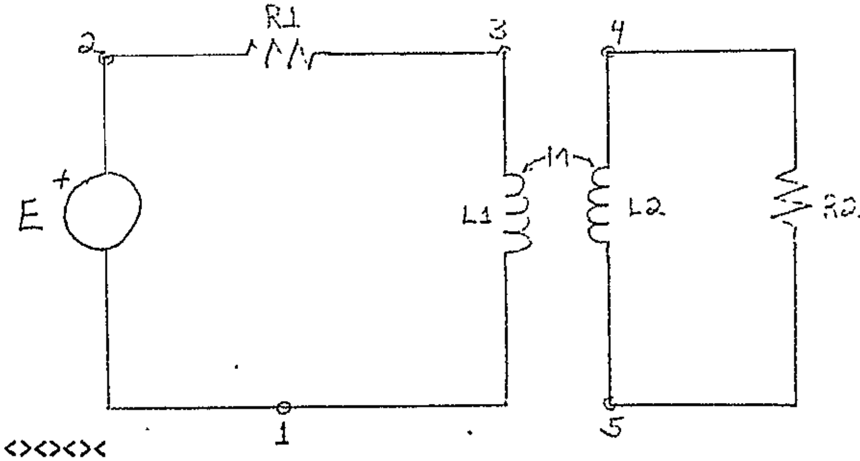

Figure 5.4. State Equations for Mutual Inductance Example.

```
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---- ----- -------- ------

     PROSE PROGRAM
     ----- -------
UNIVERSITY OF SOUTH FLORIDA
---------- -- ----- -------

MUTUAL INDUCTANCE TEST FOR PROSE

----- -------- -----
STATE VARIABLE NAMES
----- -------- -----
IL1
IL2

------ -
MATRIX A
------ -
  -1.02564D+01   9.743590D+00
   9.743590D+00  -1.02564D+01

----------- -------
INDEPENDENT SOURCES
----------- -------
E

------ -
MATRIX B
------ -
   1.02564D+01
  -9.74359D+00

----------- -- ------ -
EIGENVALUES OF MATRIX A
----------- -- ------ -
              REAL PART           IMAG. PART
              ---- ----           ----- ----
            -2.0000000D+01       0.0
            -5.1282051D-01       0.0

----------- --------
SENSITIVITY ANALYSIS
----------- --------
MAXIMUM EIGENVALUE #  1 MAGNITUDE =   2.0000000D+01

ELEMENT   SENSITIVITY
-------   -----------
 R1           0.500
 R2           0.500
 L1          -9.069
 L2          -9.069

NO SENSITIVITIES WITHIN 3% OF  1 .
L1      MAY BE REMOVED (I.E. SET TO ZERO      IF SENSITIVITY < ZERO
                         SET TO INFINITY IF SENSITIVITY > ZERO.)
```


Figure 5.5. Matrices, Eigenvalues and Sensitivities for Mutal Inductance Example.

5.3 Integral Pulse Frequency Modulation Regulator

The circuit model for an integral pulse frequency modulation regulator* is given in Figure 5.5. The state equations follow in Figure 5.7. The A matrix is shown in Figure 5.8 with the eigenvalues for the A matrix. Also shown is the variation in eigenvalues that accompanies a one per cent change in each parameter.

* R. P. Iwens, Y. Yu, and J. Triner, "Time Domain Modeling and Stability Analysis of an Integral Pulse Frequency Modulated DC to DC Power Converter", PESC '75 Record

```
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****************************************************************************************************

CIRCUIT DESCRIPTION
INTEGRAL PFM DC TO DC CONVERTER
OWENS AND YU - PESC 75 RECORD P80-90
NASA LEWIS RESEARCH CENTER
ELEMENTS
EI,G-1=30
R0,1-2=0.015
L0,2-3=250E-6
C0,3-4=300E-6
R5,4-G=0.077
RL,3-G=10
R1,3-5=28.7E3
R2,5-G=13.5E3
C2,3-6=0.022E-6
R3,5-6=1.0E3
R4,6-7=100E3
EX,7A-7=X1((EI-IL0*R0-VRL)*PN)
ER,G-7A=X2((R2/(R1+R2))*PKR)
EOP,7A-6=X4(0.0)
DEOP=0.0
JOP,G-8=X3(IEOP)
C1,8-G=220.0E-12
DEFINED PARAMETERS
PN=0.65
PKR=15
OUTPUTS
EI,VRL(EC),VC1(EC),IL0(I),VC0(VC)
RUN CONTROLS
STOP TIME=1000E-6
EXECUTE SETUP PHASE ONLY
END

END OF PRE-PROCESSOR
```

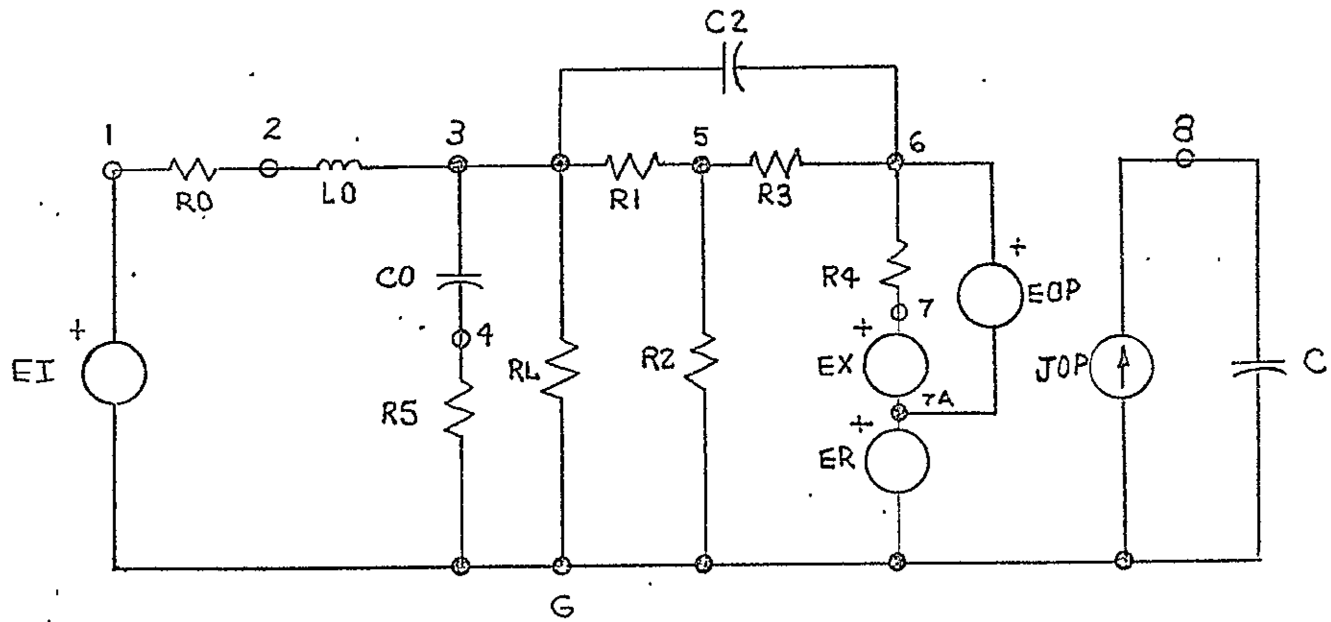

Figure 5.6. Integral Pulse Frequency Modulation Regulator Model.

```
SIMULATION HAS BEEN DELETED
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><<
C
C
C     STATE VARIABLE EQUATIONS
C
      DILO=(-VC2-ILO/(1./(RO))-(((R2/(R1+R2))*PKR))-(0.00)+EI)/(LO)
      DC1=((+(+VC2-VCO+(((R2/(R1+R2))*PKR))+(0.00))/(R5)+(+VC2+(((
     $R2/(R1+R2))*PKR))+(0.00))/(RL)+(+(+1./(R2)*(-(((R2/(R1+R2))*PKR))-
     $(0.00))-1./(R1)*(-VC2))/((1./(R3)+1./(R2)+1./(R1)))+(((R2/(R1+
     $R2))*PKR))+(0.00))/(R2)+(-((((EI-ILO*RO-(+VC2+(((R2/(R1+R2))*PKR))+
     $(0.00)))*PN))+(0.00))/(R4)-ILO))/(C1)
      DC2=(-(+VC2-VCO+(((R2/(R1+R2))*PKR))+(0.00))/(R5)-(+VC2+(((R2/(
     $R1+R2))*PKR))+(0.00))/(RL)-(+VC2-(+1./(R2)*(-(((R2/(R1+R2))*PKR))-
     $(0.00))-1./(R1)*(-VC2))/((1./(R3)+1./(R2)+1./(R1))))/(R1)+ILO)/(
     $C2)
      DCO=(+VC2-VCO+(((R2/(R1+R2))*PKR))+(0.00))/(R5)/(CO)
C
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><<
C
      END
```

Figure 5.7. State Equations for Figure 5.6.

```
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---- ----- -------- ------

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---------- -- ----- -------

INTEGRAL PFM DC TO DC CONVERTER
OWENS AND YU - PESC 79 RECORD P80-90
NASA LEWIS RESEARCH CENTER

----- -------- -----
STATE VARIABLE NAMES
----- -------- -----
ILO
VC1
VC2
VCO

------ -
MATRIX A
------ -
  -6.00000D+01   0.0          -4.00000D+03   0.0
  -4.54545D+06   0.0           5.94863D+09  -5.90319D+09
   4.54545D+07   0.0          -5.94866D+08   5.90319D+08
   0.0           0.0           4.32900D+04  -4.32900D+04

----------- -------
INDEPENDENT SOURCES
----------- -------
EI

------ -
MATRIX B
------ -
   4.30000D+03
  -2.95455D+03
   0.0
   0.0

----------- -- ------ -
EIGENVALUES OF MATRIX A
----------- -- ------ -
              REAL PART            IMAG. PART
              ---- ----            ----- ----
             0.0                  0.0
            -5.94908200+08        0.0
            -3.48229790+02        3.62340460+03
            -3.48229790+02       -3.62340460+03

----------- --------
SENSITIVITY ANALYSIS
----------- --------
MAXIMUM EIGENVALUE #  2 MAGNITUDE =  5.94908200+08

ELEMENT  SENSITIVITY
-------  -----------
 EX          0.0
 ER          0.0
 C1          0.0
 C2         -0.990     *** ELEMENT MAY BE REMOVED BY SETTING TO ZERO.
 CO         -0.000
 RO         -0.000
 R3         -0.000
 R5         -0.983     *** ELEMENT MAY BE REMOVED BY SETTING TO ZERO.
 RL         -0.008
 R2         -0.000
 R1         -0.000
 R4          0.0
 LO          0.000
 JOP         0.0
```

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Figure 5.8. Matrices, Eigenvalues and Sensitivities for Figure 5.6.

6. Summary and Conclusions

The work during the two years of the NASA Grant NSG-3096 has resulted in a computer program which will convert a SCEPTRE listing for an electrical or mechanical system into a set of state equations for the network. Additional features of the program to PROduce State Equations include subroutines to:

1. linearize the state equations about an operating point as specified by the initial conditions
2. obtain the eigenvalues for the linearized state equations
3. obtain the sensitivities of the eigenvalue with the maximum magnitude
4. use the sensitivity calculations to indicate which circuit element can be removed from the network without adversely affecting the systems dynamic operation

At the end of the first year the PROSE program had limitations on the type of networks it would accept. In the second year several of these limitations were removed at a great cost in programming manpower. The most significant improvement is the ability PROSE now has to accept networks with mutual inductance.

Additional research and development could profitably be spent in applying the PROSE program to the design of automatic control systems. Using SUPER*SCEPTRE an electromechanical description of the plant to be controlled would be reduced to the state equations for the systems. The state equations could be used in an algorithm to automatically compute the control matrix.

Appendix

This appendix gives the Fortran listing for the computer program that PROduces State Equations.

```
      C      PROSE1
      C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
      C
      C
      C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
      C      COPYRIGHT 1977 BY JOHN E. O'REILLY, JR.
      C      10/18/77
      C      COPYRIGHT 1978 BY JOHN E. O'REILLY, JR.
      C      05/13/78
      C
      C
      C      TRICENTENNIAL VERSION OF P-R-O-S-E
      C
      C
      C          *  *  *  *  *  *//////////////////////////////////////////
      C           *  *  *  *  *  //////////////////////////////////////////
      C          *  *  *  *  *  *
      C           *  *  *  *  *  //////////////////////////////////////////
      C          *  *  *  *  *  *//////////////////////////////////////////
      C           *  *  *  *  *
      C          *  *  *  *  *  *//////////////////////////////////////////
      C           *  *  *  *  *  //////////////////////////////////////////
      C          *  *  *  *  *  *
      C          ///////////////////////////////////////////////////////////
      C          ///////////////////////////////////////////////////////////
      C
      C          ///////////////////////////////////////////////////////////
      C          ///////////////////////////////////////////////////////////
      C
      C          ///////////////////////////////////////////////////////////
      C          ///////////////////////////////////////////////////////////
      C
      C          ///////////////////////////////////////////////////////////
      C          ///////////////////////////////////////////////////////////
      C
      C
0001         BLOCK DATA
      C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
      C
      C
      C      P-R-O-S-E - GENERATE STATE EQUATIONS FROM SCEPTRE
      C                  BUILT PGMSAV AND DTASAV FILES. THE ROUTINES
      C                  COMPUTE THE STATE VARIABLE EQUATIONS AND A AND B
      C                  MATRICES.
      C
      C
      C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
0002         IMPLICIT REAL*8(A-H,O-Z)
```

```
              C
              C
              C      VARIABLE DEFINITIONS - NASA
              C      NSYM   - ELEMENTS SYMBOL STORAGE ARRAY
              C      KSYM   - NUMBER OF SYMBOLS IN NSYM
              C      NRAY   - INPUT AND OUTPUT 80 BYTE ARRAY
              C      KRAY   - CURRENT LOCATION POINTER IN NRAY
              C      NLEN   - ARRAY OF LENGTHS OF EACH TYPE OF ELEMENT
              C      NPT    - POINTERS TO ELEMENT TYPES IN NSYM
              C      NT     - TYPE OF ELEMENT VALUE(=0 IS NOT EJ TYPE)
              C
 0003                COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
                    1)
              C
              C
              C      VARIABLE DEFINITIONS - PUSHED
              C      KLOCA  - ARRAY OF LEFT HAND SIDE ENCODED NAMES AND
              C               LOCATION OF EQUATION IN NPUSH AND
              C               SUM TERMS FLAGS
              C      KLOC   - LENGTH OF KLOCA
              C      NPUSH  - EQUATION ARRAY
              C      KPUSH  - LENGTH OF EQUATION ARRAY NPUSH
              C      KPMAX  - MAXIMUM LENGTH OF NPUSH(1000)
              C
 0004                COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
              C
              C
              C      VARIABLE DEFINITIONS - SHGR
              C      NSHUV  - PUSH DOWN STACK(FIFO TYPE)
              C      KSHUV  - CURRENT POINTER INTO NPUSH STACK
              C      KST    - START OF CURRENT EQUATION IN NPUSH
              C      KEND   - END OF CURRENT EQUATION IN NPUSH
              C      KSUB   - CURRENT VARIABLE'S SUBSCRIPT VALUE
              C      KEXTD  - CURRENT VARIABLE'S EXTENDED VALUE
              C      KPAR   - PARENTHESIS FLAG
              C
 0005                COMMON /SHGR/ NSHUV(500),KSHUV,KST,KEND,KSUB,KEXTD,KPAR
              C
              C
              C      VARIABLE DEFINITIONS - CNTRL
              C      LIST   - DEBUG FLAG
              C      L1     - RESERVED WORD
              C      CTROL  - CONTROLS FROM DTASAV
              C      KXM    - XML, XMRC, AND XMS ARRAY SIZES
              C
 0006                COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
              C
              C
```

```
      C     VARIABLE DEFINITIONS - FILES                                    PR1 0097
      C     NPRINT - PRINTER FILE NUMBER                                    PR1 0098
      C     NPGM   - SCEPTRE PROGRAM FILE NUMBER                            PR1 0099
      C     NDTA   - SCEPTRE DATA FILE NUMBER                               PR1 0100
      C                                                                     PR1 0101
0007        COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU                            PR1 0102
      C                                                                     PR1 0103
      C                                                                     PR1 0104
      C     VARIABLE DEFINITIONS - CHARS                                    PR1 0105
      C     NSP    - SPACE                                                  PR1 0106
      C     NLP    - LEFT PARNTHESIS                                        PR1 0107
      C     NRP    - RIGHT PARENTHESIS                                      PR1 0108
      C     NCOM   - COMMA                                                  PR1 0109
      C     NEQ    - EQUAL SIGN                                             PR1 0110
      C     ND     - ALPHA LETTER "D"                                       PR1 0111
      C     NPLUS  - PLUS SIGN                                              PR1 0112
      C     NMINUS - MINUS SIGN                                             PR1 0113
      C     NSL    - SLASH                                                  PR1 0114
      C     NZER   - ZERO NUMERIC                                           PR1 0115
      C     NXM(3)- ALPHA 'L','R','S'                                       PR1 0116
      C     NUM(10)- NUMERICS                                               PR1 0117
      C                                                                     PR1 0118
0008        COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3PR1 0119
           1),NUM(10)                                                       PR1 0120
      C                                                                     PR1 0121
      C                                                                     PR1 0122
      C     VARIABLE DEFINITIONS - HOLDIT                                   PR1 0123
      C     HEAD   - HEADING CARD BUFFER                                    PR1 0124
      C     KHEAD  - NUMBER HEADING CARDS                                   PR1 0125
      C     NDUM1  - RESERVED WORD 1                                        PR1 0126
      C     ELTS   - ELEMENT VALUES                                         PR1 0127
      C     KELTS  - NUMBER OF ELEMENTS                                     PR1 0128
      C     KEL    - NUMBER ELEMENTS-NUMBER EJ ELEMENTS                     PR1 0129
      C     SDR    - SOURCE DERIVATIVE VALUES                               PR1 0130
      C     NSDR   - SOURCE DERIVATIVE NAMES                                PR1 0131
      C     KSDR   - NUMBER SOURCE DERIVATIVES                              PR1 0132
      C     NDUM3  - RESERVED WORD 3                                        PR1 0133
      C     XIC    - INITAL STATE VARIABLE VALUES                           PR1 0134
      C     KSV    - NUMBER STATE VARIABLES                                 PR1 0135
      C     NDUM4  - RESERVED WORD 4                                        PR1 0136
      C     PAR    - DEFINED PARAMETER VALUES                               PR1 0137
      C     NPAR   - DEFINED PARAMETER NAMES                                PR1 0138
      C     KDP    - NUMBER DEFINED PARAMETERS                              PR1 0139
      C     NDUM5  - RESERVED WORD 5                                        PR1 0140
      C     XTAB   - TABULAR FUNCTION VALUES                                PR1 0141
      C     NTAB   - TABLE NAMES                                            PR1 0142
      C     KTAB   - NUMBER ENTRIES IN XTAB                                 PR1 0143
      C     KTAB2  - NUMBER OF TABLES                                       PR1 0144
```

```
                C      KEJ    - NUMBER OF INPUT(INDEPENDENT) SOURCES                    PR1 0145
                C                                                                       PR1 0146
                C                                                                       PR1 0147
 0009                  COMMON /HOLDIT/ HEAD(9,11),KHEAD,NDUM1,ELTS(300),KELTS,KEL,SDR(50)PR1 0148
                      1,NSDR(6,50),KSDR,NDUM3,XIC(50),KSV,NDUM4,PAR(100),NPAR(6,100),KDP,PR1 0149
                      2NDUM5,XTAB(500),NTAB(7,50),KTAB,KTAB2,KEJ                        PR1 0150
                C                                                                       PR1 0151
                C                                                                       PR1 0152
                C      SET CONSTANTS                                                    PR1 0153
                C      PUSHED                                                           PR1 0154
 0010                  DATA KLOC/0/                                                     PR1 0155
 0011                  DATA KPUSH/1/,KPMAX/1000/                                        PR1 0156
                C      FILES                                                            PR1 0157
 0012                  DATA NPRINT/6/,NPGM/1/,NDTA/2/,NEQU/3/                           PR1 0158
                C      CHARS                                                            PR1 0159
 0013                  DATA NSP/1H /,NLP/1H(/,NRP/1H)/,NCOM/1H,/                        PR1 0160
 0014                  DATA NEQ/1H=/,ND/1HD/,NPLUS/1H+/,NMINUS/1H-/                     PR1 0161
 0015                  DATA NSL/1H//,NZER/1H0/                                          PR1 0162
 0016                  DATA NXM/1HL,1HR,1HS/                                            PR1 0163
 0017                  DATA NUM/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/                PR1 0164
                C      HOLDIT                                                           PR1 0165
 0018                  DATA KTAB/0/,KTAB2/0/,KSDR/0/,KELTS/0/,KDP/0/                    PR1 0166
                C                                                                       PR1 0167
 0019                  DATA KXM/3*0/                                                    PR1 0168
 0020                  END                                                              PR1 0169
```

```
      C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
      C      BEGIN MAIN ROUTINE
      C
      C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
      C
0001         IMPLICIT REAL*8(A-H,O-Z)
0002         COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
            1)
0003         COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0004         COMMON /FILES/ NPRINT,NPGM,NCTA,NEQU
      C
      C      GET SYMBOLS
0005         CALL SETUP
      C
      C
      C      GENERATE STATE EQUATIONS HEADER
0006         CALL MICUP
      C      BUILD EQUATIONS
0007         CALL BILD
      C
      C
      C      FIN
0008         CALL FINIE
0009         STOP 0
0010         END
```

```
      SUBROUTINE BACK (NAME,NCHAR)
C
C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
C     CHANGE NAME TO NCHAR IN MECHANICAL FORMAT
C     CHANGES
C     GP=TP     DXXX=ZXXX AND CHANGE XXX
C     I=F EXCEPT ICW=TJ
C     V=V EXCEPT VCW=WJ
C     ELEMENTS
C     CU=M    EU=U    JU=R    LU=K    RU=D
C     CW=J    EW=G    JW=C
C
C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
      DIMENSION NEL(5), NELF(8), NST(2), NSTF(4), NCHAR(6), NAME(6)
      EQUIVALENCE (NG,NELF(7)), (ND,NELF(5)), (NT,NSTF(3))
      EQUIVALENCE (NU,NELF(2)), (NC,NELF(8)), (NW,NSTF(4))
      DATA NEL/1HC,1HE,1HJ,1HL,1HR/
      DATA NELF/1HM,1HU,1HR,1HK,1HD,1HJ,1HG,1HC/
      DATA NST/1HI,1HV/
      DATA NSTF/1HF,1HV,1HT,1HW/
      DATA NZ/1HZ/,NP/1HP/,NBL/1H /
      KST=1
      KN=0
      DO 1 I=1,6
      IF(NAME(I).NE.NBL) KN=KN+1
    1 NCHAR(I)=NAME(I)
      IF(KN.LE.1) RETURN
      IF(NCHAR(1).NE.NG.OR.NCHAR(2).NE.NP) GO TO 3
      NCHAR(1)=NT
    2 RETURN
    3 DO 4 KINS=1,4
      KLOC=KN-KINS+1
      IF(KLOC.LE.1) RETURN
      IF(NCHAR(KLOC).EQ.NU.OR.NCHAR(KLOC).EQ.NW) GO TO 5
    4 CONTINUE
      RETURN
    5 IF(NCHAR(1).NE.ND) GO TO 6
      NCHAR(1)=NZ
      KST=2
    6 DO 7 K1=1,2
      IF(NCHAR(KST).NE.NST(K1)) GO TO 7
      NCHAR(KST)=NSTF(K1)
      KST=KST+1
      IF(NCHAR(KST).EQ.NC.AND.NCHAR(KLOC).EQ.NW) NCHAR(KST-1)=NSTF(K1+2)
      GO TO 8
    7 CONTINUE
```

```
 8    KEL=5
      KELF=0
      IF(NCHAR(KLOC).EQ.NU) GO TO 9
      KEL=3
      KELF=5
 9    DO 10 K1=1,KEL
      IF(NCHAR(KST).NE.NEL(K1)) GO TO 10
      NCHAR(KST)=NELF(K1+KELF)
      GO TO 11
 10   CONTINUE
      RETURN
 11   IF(KLOC.EQ.KN) GO TO 13
      KELF=KN-KLOC
      DO 12 K1=1,KELF
 12   NCHAR(KLOC+K1-1)=NCHAR(KLOC+K1)
 13   NCHAR(KN)=NBL
      GO TO 2
      END
```

```
0001                 SUBROUTINE BCDOUT (KVAL)
               C
               C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
               C     PUT THE BCD CHARS FOR (KVAL) INTO OUTPUT STRING
               C
               C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
0002                 COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                    1),KNUMS(10)
               C
0003                 MVAL=KVAL
0004                 NLEN=INT(ALOG10(AMAX0(MVAL,1)))+1
0005                 MDIV=10**(NLEN-1)
0006                 KFL=0
0007                 DO 1 I=1,NLEN
0008                 MPTR=MVAL/MDIV+1
0009                 IF(MPTR.EQ.1.AND.KFL.EQ.0) GO TO 1
0010                 CALL PUTCHR (KNUMS(MPTR))
0011                 KFL=1
0012                 MVAL=MVAL-(MPTR-1)*MDIV
0013             1   MDIV=MDIV/10
0014                 RETURN
0015                 END
```

```
0001                SUBROUTINE BILD
               C
               C    <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
               C    BUILD THE STATE VARIABLE EQUATIONS
               C
               C    <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
0002                IMPLICIT REAL*8(A-H,O-Z)
0003                COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
                   1)
0004                COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0005                COMMON /CHARS/ NSP,NLP,NRP,NCCM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                   1),NUM(10)
0006                COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0007                COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0008                DIMENSION MRAY(6), LXM(6)
0009                DATA MRAY(1)/1HC/
0010                DATA LXM/1HX,1HM,1H ,1H(,1H ,1H /
0011                KFL=0
               C    CLEAR OUT ARRAY ONCE ONLY
0012                DO 1 I=1,72
0013            1   NRAY(I)=NSP
0014                KRAY=7
               C    OUTPUT ANY MATRICES
0015                DO 4 I=1,3
0016                IF(KXM(I).EQ.0) GO TO 4
0017                IF(KFL.EQ.0) WRITE (NEQU,2)
0018                KFL=1
0019            2   FORMAT (22HC      MATRIX EQUATIONS,58X,/,1HC,79X)
0020                WRITE (NEQU,3) NXM(I),KXM(I),KXM(I)
0021            3   FORMAT (6X,12HDIMENSION XM,A1,1H(,I3,1H,,I3,1H),52X)
0022            4   CONTINUE
0023                DO 6 I=1,3
0024                IF(KXM(I).EQ.0) GO TO 6
0025                JN=KXM(I)
0026                JNN=JN*JN
0027                LXM(3)=NXM(I)
0028                DO 5 J=1,JNN
0029                NB=1+(J-1)/JN
0030                NA=J-(NB-1)*JN
0031                IF(NA.GT.NB) KVAL=100000*I+(NA-1)*JN+NB
0032                IF(NA.LE.NB) KVAL=100000*I+(NB-1)*JN+NA
0033                CALL PUTNAM (LXM)
0034                CALL BCDOUT (NA)
0035                CALL PUTCHR (NCCM)
0036                CALL BCDOUT (NB)
0037                CALL PUTCHR (NRP)
0038                CALL PUTCHR (NEQ)
```

```
0039                CALL POP (KVAL)
0040          5     CALL PUTLIN
0041          6     CONTINUE
0042                IF(KFL.EQ.1) WRITE (NEQU,7)
0043          7     FORMAT (1HC,79X,/,1HC,79X,/,1HC,79X)
0044                WRITE (NEQU,8)
0045          8     FORMAT (30HC      STATE VARIABLE EQUATIONS,50X,/,1HC,79X)
              C     LOOP ON STATE VARIABLES
0046                DO 11 KSVPT=3,4
0047                KSV=NLEN(KSVPT)
0048                IF(KSV.EQ.0) GO TO 11
0049                LSV=NPT(KSVPT)-1
0050                DO 10 JSV=1,KSV
              C     POINT TO STATE VARIABLE NAME
0051                LJSV=LSV+JSV
              C     PUT THE NAME
0052                DO 9 I=1,5
0053          9     MRAY(I+1)=NSYM(I,LJSV)
0054                CALL PUTNAM (MRAY)
              C     AND AN EQUALS SIGN
0055                NRAY(KRAY)=NEQ
0056                KRAY=KRAY+1
              C     DECODE THE NAME
0057                CALL DECNAM (NSYM(1,LJSV),0,JLCC,KVAL)
              C     MAKE HER LOOK LIKE STATE VARIABLE DERIV.
0058                KVALSV=KVAL+10000
              C     POP THE EQUATION FOR THIS DERIV.
0059                CALL POP (KVALSV)
              C     FORCE THE LINE OUT
0060         10     CALL PUTLIN
0061         11     CONTINUE
0062                RETURN
0063                END
```

```
0001          SUBROUTINE DECNAM (NAME,KSUB,KLOC,KVAL)
        C
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
        C
        C     DECODE (NAME) INTO SUBSCRIPT LOCATION AND VALUE
        C
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
        C
0002          IMPLICIT REAL*8(A-H,O-Z)
0003          COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
             1)
0004          COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,NO,NPLUS,NMINUS,NSL,NZER,NXM(3
             1),NUM(10)
0005          COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0006          COMMON /FILES/ NPRINT,NPGM,NDTA,NEOU
0007          DIMENSION NAME(6), NELTS(7), NTYPE(6)
0008          DIMENSION NXTAB(5)
0009          DATA NELTS/1HC,1HR,1HL,1HE,1HJ,1HP/
0010          DATA NTYPE/1HD,1HV,1HI,1HS,1HG,1HX/
0011          DATA NN/1HN/,NM/1HM/
0012          DATA NXTAB/1HT,1HA,1HB,1HL,1HE/
0013          EQUIVALENCE (NI,NTYPE(3)), (NP,NELTS(6))
0014          EQUIVALENCE (NXTAB(1),NELTS(7)), (NCHART,NXTAB(1))
        C
0015          KLOC=0
0016          KELTS=0
0017          KTYPE=0
0018          KEXTD=0
        C     LOCATE SYMBOL TYPE
0019          DO 1 I=1,6
0020          IF(NAME(1).EQ.NTYPE(I)) GO TO 7
0021     1    CONTINUE
0022          KST=1
        C     LOCATE SYMBOL ELEMENT
0023     2    DO 3 I=1,7
0024          IF(NAME(KST).EQ.NELTS(I)) GO TO 8
0025     3    CONTINUE
        C     MUTUAL TYPE?
0026          IF(NAME(KST).NE.NM) GO TO 4
0027          KELTS=9
0028          GO TO 9
        C     VOLTAGE/CURRENT TYPE
0029     4    IF(KTYPE.EQ.2.OR.KTYPE.EQ.3) GO TO 12
        C     FORM SYMBOL VALUE
0030     5    KVAL=KLOC+1000*KELTS+10000*KTYPE+100000*KEXTD
0031          IF(LIST.EQ.1) WRITE (NPRINT,6) NAME,KLOC,KELTS,KTYPE,KEXTD
0032     6    FORMAT (8H DECNAM=,6A1,6H KLOC=,I3,7H KELTS=,I3,7H KTYPE=,I3,7H KE
             1XTD=,I3)
```

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```
0033            RETURN
          C     GOTTA TYPE NAME
          C     XPRESSION IS SPECIAL
0034       7    IF(I.EQ.6) GO TO 17
          C     NOT AN "X"-TYPE
0035            KST=2
0036            KTYPE=I
0037            GO TO 2
          C     GOTTA ELEMENT
0038       8    KELTS=I
          C     PARAMETER IS SPECIAL
0039            IF(KELTS.EQ.7) GO TO 5
          C     LOCATE NAME IN SYMBOL TABLE
0040       9    DO 11 I=1,KSYM
0041            DO 10 J=1,5
0042            KSTJM=KST+J-1
0043            IF(NAME(KSTJM).NE.NSYM(J,I)) GO TO 11
0044      10    CONTINUE
          C     FOUND NAME IN STABLE
0045            KLOC=I
0046            GO TO 5
0047      11    CONTINUE
          C     NOT IN STABLE OR V/I TYPE
0048      12    KSTAR=2
          C     V#/I# TYPE
0049            IF(LPUMP(NAME,KSTAR,1,KSTYL).EQ.1) GO TO 5
          C     V#D/I#D TYPE - STATE VARIABLE DERIV.
0050            IF(NAME(KSTAR).EQ.ND) GO TO 15
          C     V#P/I#P TYPE
0051            IF(NAME(KSTAR).EQ.NP) GO TO 16
          C     FORM LOCATION OF SYMBOL
0052      13    KLOC=NPT(KSTYL)+KSUB-1
0053            IF(KSUB.EQ.1000000) KLOC=KLOC+1
0054            KPL=KLOC
0055            IF(KPL.GE.1000000) KPL=KPL-1000000
          C     X-ELEMENT TYPE
0056            DO 14 KELTS=1,5
0057            IF(NSYM(1,KPL).EQ.NELTS(KELTS)) GO TO 5
0058      14    CONTINUE
0059            KELTS=0
0060            GO TO 5
          C     STATE VARIABLES
0061      15    KTYPE=1
0062            GO TO 13
          C     V2P, V3P, XI1P, OR XI5P
0063      16    KEXTD=KSTYL+3
0064            KTYPE=0
0065            KLOC=KSUB
```

```
0066            GO TO 5
          C     "X"-TYPE
0067       17   KSTAR=2
          C     "XM" TYPE
0068            IF(NAME(KSTAR).EQ.NM) GO TO 18
          C     "XI" TYPE
0069            IF(NAME(KSTAR).NE.NI) GO TO 21
0070            KSTAR=3
          C     "XI#" TYPE
0071            IF(LPUMP(NAME,KSTAR,1,KSTYL).EQ.1) GO TO 5
0072            GO TO 16
0073       18   KLOC=KSUB
          C     "XM"-ELEMENT TYPE
0074            DO 19 KEXTD=1,3
0075            IF(NAME(3).EQ.NXM(KEXTD)) GO TO 20
0076       19   CONTINUE
0077            KEXTD=0
0078            KLOC=0
0079            GO TO 5
          C     XM$I - TYPE
0080       20   IF(NAME(4).EQ.NI.OR.NAME(5).EQ.NI) KTYPE=6
0081            GO TO 5
          C     X TYPE, NON SPECIAL - "XTABLE"?
0082       21   IF(LOCATE(NAME,NXTAB,2,5).EQ.0) GO TO 22
          C     "XT" TYPE?
0083            IF(NAME(2).EQ.NCHART) GO TO 23
          C     "XN##" TYPE
0084            KSTAR=3
0085            KPUMP=LPUMP(NAME,KSTAR,2,KSTYL)
0086            KSTYL=KSTYL/10
0087            IF(KPUMP.EQ.0.AND.KSTYL.NE.0) GO TO 13
0088            KEXTD=7
0089            KST=1
0090            GO TO 9
          C     "XTABLE"
0091       22   KELTS=8
0092            KTYPE=0
0093            GO TO 5
          C     ERRORS
          C
          C     TABLE APPEARED IN XPRESSION ILLEGALLY
0094       23   CALL ERROR (30)
0095            END
```

```
0001              SUBROUTINE ERROR (NUM)                                        PR1 0505
            C                                                                   PR1 0506
            C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 0507
            C                                                                   PR1 0508
            C     PUT ERROR NUMBER                                              PR1 0509
            C                                                                   PR1 0510
            C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 0511
            C                                                                   PR1 0512
0002              COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU                          PR1 0513
            C                                                                   PR1 0514
0003              DIMENSION NBAD(34)                                            PR1 0515
0004              DATA NBADL/18/                                                PR1 0516
0005              DATA NBAD/1,4,5,6,7,8,17,18,19,20,23,24,27,28,30,31,32,34/    PR1 0517
0006              WRITE (NPRINT,1) NUM                                          PR1 0518
0007          1.  FORMAT (//,14H ERROR NUMBER ,I2,20H SEE ERROR LIST.....,//)   PR1 0519
0008              DO 2 I=1,NBADL                                                PR1 0520
0009              IF(NUM.EQ.NBAD(I)) GO TO 4                                    PR1 0521
0010          2   CONTINUE                                                      PR1 0522
0011              WRITE (NPRINT,3)                                              PR1 0523
0012          3   FORMAT (38H STATE VARIABLE PRODUCTION SUPPRESSED.)            PR1 0524
0013              STOP 0                                                        PR1 0525
0014          4   WRITE (NPRINT,5)                                              PR1 0526
0015          5   FORMAT (48H SEVERE ERROR - SENSITIVITY ANALYSIS SUPPRESSED.)  PR1 0527
0016              STOP 8                                                        PR1 0528
0017              END                                                           PR1 0529
```

```
0001            SUBROUTINE FINIE                                              PR1 0530
          C                                                                   PR1 0531
          C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 0532
          C                                                                   PR1 0533
          C     FINISH UP THE STATE EQUATIONS PRODUCTION.                     PR1 0534
          C                                                                   PR1 0535
          C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 0536
          C                                                                   PR1 0537
0002            COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU                          PR1 0538
          C                                                                   PR1 0539
0003            WRITE (NEQU,1)                                                PR1 0540
0004          1 FORMAT (1HC,79X,/,1HC,79X,/,1HC,35(2H<>),1H<,8X,/,1HC,79X,/,9H PR1 0541
             1   END,71X)                                                     PR1 0542
0005            RETURN                                                        PR1 0543
0006            END                                                           PR1 0544
```

```
0001             SUBROUTINE GETEQS
           C
           C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
           C
           C     GET EQUATIONS FROM SIMTR INTO (NPUSH) POINTED TO BY
           C     (KLOCA) AND KLOC
           C
           C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
           C
0002             IMPLICIT REAL*8(A-H,O-Z)
0003             COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0004             COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
                1)
0005             COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0006             COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0007             COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                1),NUM(10)
0008             DIMENSION NAME(6), NAUGM(6), NIONBX(6)
0009             DATA NO/1HO/,NM/1HM/
0010             DATA NC/1HC/,NP/1HP/,NX/1HX/,NI/1HI/
0011             DATA NAUGM/1H/,1HA,1HU,1HG,1HM,1H//
0012             DATA NIONBX/1HI,1HO,1HN,1H ,1HX,1HM/
           C
0013             KSUBSV=0
           C     GIT NEXT CARD
0014         1   NEOF=LREAD(NPGM,0)
0015         2   IF(NRAY(1).EQ.NC) GO TO 1
           C     CHECK FOR "="
0016             DO 3 KEQ=8,50
0017             IF(NRAY(KEQ).EQ.NEQ) GO TO 5
0018         3   CONTINUE
0019             IF(LOCATE(NRAY,NAUGM,13,6).EQ.0) GO TO 14
0020             IF(LOCATE(NRAY,NIONBX,13,6).EQ.0) GO TO 18
           C     TEST "END"
0021         4   IF(NEOF.EQ.0) GO TO 1
0022             KLOC1=KLOC+1
0023             KLOCA(1,KLOC1)=0
0024             KLOCA(2,KLOC1)=KPUSH
0025             RETURN
           C     FOUND "="
0026         5   IF(LIST.EQ.1) WRITE (NPRINT,6) NRAY
0027         6   FORMAT (1X,80A1)
           C     GO ON PARAMETER OR XPRESSION
0028             IF(NRAY(7).EQ.NP.OR.(NRAY(7).EQ.NX.AND.NRAY(8).NE.NI.AND.NRAY(8).N
                1E.NM)) GO TO 7
           C     IGNORE "DO" LOOPS
0029             IF(NRAY(7).EQ.ND.AND.NRAY(8).EQ.NO) GO TO 11
0030             KRAY=7
```

```
0031                KSUB=0
0032                KEQ1=KEQ+1
             C      IGNORE ZERO VALUES
0033                IF(NRAY(KEQ1).EQ.NZER) GO TO 1
             C      GET SYMBOL
0034                IF(LPULL(NRAY,KRAY,NAME,0,KSUB).EQ.-1) GO TO 12
             C      PUSH EQUATION
0035                KRAY=KEQ+1
0036                IF(KSUBSV.NE.0.AND.KSUB.EQ.1000000) KSUB=KSUBSV
0037                KPSHSV=KPUSH
0038                CALL PUSH (NAME,KSUB)
0039                KSUBSV=0
             C      CHECK FOR NOTHING PUSHED
0040                IF(KPSHSV.EQ.KPUSH) KLOC=KLOC-1
             C      GIT NEXT STUFF
0041                GO TO 2
             C      PARM. OR XPRESSION - SAVE NAME IN SYMBOL TABLE
0042          7     KSTAR=7
0043                KSYM=KSYM+1
0044                IF(KSYM.GT.300) GO TO 13
0045                DO 8 I=1,6
0046          8     NSYM(I,KSYM)=NSP
0047                DO 9 I=1,6
0048                IF(NRAY(KSTAR).EQ.NLP.OR.NRAY(KSTAR).EQ.NEQ) GO TO 10
0049                NSYM(I,KSYM)=NRAY(KSTAR)
0050                KSTAR=KSTAR+1
0051          9     CONTINUE
0052         10     KRAY=KEQ+1
             C      PUSH EQUATION
0053                KPSHSV=KPUSH
0054                CALL PUSH (NSYM(1,KSYM),0)
0055                IF(KPSHSV.EQ.KPUSH) KLOC=KLOC-1
0056                GO TO 2
             C      DETERMINE IF ONE PASS DO LOOP
0057         11     KSUBSV=NUMB(NRAY,18,20,II)
0058                KSBSV1=NUMB(NRAY,24,26,II)
0059                IF(KSUBSV.NE.KSBSV1.OR.KSUBSV.EQ.1) KSUBSV=0
0060                GO TO 1
             C      ERRORS
             C
             C      BAD SYMBOL
0061         12     CALL ERROR (25)
             C      SYMBOL TABLE OVERFLOW
0062         13     CALL ERROR (26)
             C      PARSE OUT XML, XMR, AND XMS LENGTHS
0063         14     IF(NRAY(31).NE.NCOM) GO TO 4
0064                DO 15 I=1,3
0065                IF(NRAY(22).EQ.NXM(I)) GO TO 16
```

```
 15   CONTINUE
      GO TO 4
 16   NEN=30
      NST=28
 17   KXM(I)=NUMB(NRAY,NST,NEN,II)
      IF(KXM(I).GT.7) CALL ERROR (35)
      GO TO 4
 18   IF(NRAY(28).NE.NCOM) GO TO 4
      DO 19 I=1,3
      IF(NRAY(19).EQ.NXM(I)) GO TO 20
 19   CONTINUE
      GO TO 4
 20   NEN=27
      NST=25
      GO TO 17
      END
```

```
0001                SUBROUTINE MIDUP
              C
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
              C     WRITE DEBUG, MATRICES, AND HEADER
              C
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
0002                IMPLICIT REAL*8(A-H,O-Z)
0003                COMMON /HOLDIT/ HEAD(9,11),KHEAD,NDUM1,ELTS(300),KELTS,KEL,SDR(50)
                   1,NSDR(6,50),KSDR,NDUM3,XIC(50),KSV,NDUM4,PAR(100),NPAR(6,100),KDP,
                   2NDUM5,XTAB(500),NTAB(7,50),KTAB,KTAB2,KEJ
0004                COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                   1),NUM(10)
0005                COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0006                COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0007                COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
                   1)
0008                COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0009                EQUIVALENCE (TIME,CTROL(1))
0010                DATA NE/1HE/,NJ/1HJ/
              C
              C     PUT DEBUG
0011                IF(LIST.NE.1) GO TO 19
              C     DEBUG FACILITY
0012                WRITE (NPRINT,1) NPT,NLEN,KSYM
0013          1     FORMAT (18H POINTERS TO NAMES,8I7,/,18H LENGTHS OF NAMES ,8I7,/,7H
                   1 LIMIT=,I7)
0014                DO 2 I=1,KSYM
0015          2     WRITE (NPRINT,3) I,(NSYM(J,I),J=1,6)
0016          3     FORMAT (1H ,I4,2H  ,6A1)
              C
              C
0017                WRITE (NPRINT,4) (I,NPUSH(I),NPUSH(I),I=1,KPUSH)
0018          4     FORMAT (200(/,1X,4(2I9,8X,A1,3X)))
0019                WRITE (NPRINT,5) (I,KLOCA(1,I),KLOCA(2,I),KLOCA(3,I),I=1,KLOC)
0020          5     FORMAT (200(/,1X,3(4I9,3X)))
0021                WRITE (NPRINT,6) KXM
0022          6     FORMAT (6H #XML=,I3,7H #XMRG=,I3,6H #XMS=,I3)
0023                WRITE (NPRINT,7) TIME,KELTS,KSV,KDP,KSDR,KTAB
0024          7     FORMAT (12H <><><>TIME=,1PD14.7,/,7H KELTS=,I3,5H KSV=,I3,5H KDP=,
                   1I3,6H KSDR=,I3,6H KTAB=,I3,//)
0025                DO 10 I=1,KELTS
0026                IF(NSYM(1,I).NE.NE.AND.NSYM(1,I).NE.NJ) GO TO 8
0027                IF(NT(I).EQ.0) GO TO 10
0028          8     WRITE (NPRINT,9) I,ELTS(I)
0029          9     FORMAT (12H <><><>ELNO=,I3,7H ELVAL=,1PD14.7)
0030         10     CONTINUE
```

```
              C     PUT DEFINED PARAMETER VALUES                                        PR1 0705
0031                IF(KDP.EQ.0) GO TO 13                                               PR1 0706
0032                DO 11 I=1,KDP                                                       PR1 0707
0033            11  WRITE (NPRINT,12) I,PAR(I)                                          PR1 0708
0034            12  FORMAT (13H <><><>DPNUM=,I3,7H DPVAL=,1PD14.7)                      PR1 0709
              C     PUT SOURCE DERIVATIVE VALUES                                        PR1 0710
0035            13  IF(KSDR.EQ.0) GO TO 16                                              PR1 0711
0036                DO 14 I=1,KSDR                                                      PR1 0712
0037            14  WRITE (NPRINT,15) I,SDR(I)                                          PR1 0713
0038            15  FORMAT (14H <><><>SDRNUM=,I3,8H SDRVAL=,1PD14.7)                    PR1 0714
              C     PUT TABLE VALUES                                                    PR1 0715
0039            16  IF(KTAB.EQ.0) GO TO 19                                              PR1 0716
0040                DO 17 I=1,KTAB                                                      PR1 0717
0041            17  WRITE (NPRINT,18) I,XTAB(I)                                         PR1 0718
0042            18  FORMAT (14H <><><>TABNUM=,I3,8H TABVAL=,1PD14.7)                    PR1 0719
              C     PUT STATE VARIABLE EQUATION SEPARATOR                               PR1 0720
0043            19  WRITE (NEQU,20)                                                     PR1 0721
0044            20  FORMAT (1HC,79X,/,1HC,35(2H<>),1H<,8X,/,1HC,79X,/,1HC,79X)          PR1 0722
0045                RETURN                                                              PR1 0723
0046                END                                                                 PR1 0724
```

```
0001          SUBROUTINE POP (KPOPO)
        C
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
        C
        C     POP THE EQUATION POINTED TO BY VALUE (KPOPO) FROM (NPUSH)
        C
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
        C
0002          IMPLICIT REAL*8(A-H,O-Z)
0003          COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
             1)
0004          COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0005          COMMON /SFGR/ NSHUV(500),KSHUV,KST,KEND,KSUB,KEXTD,KPAR
0006          COMMON /FILES/ NPRINT,NPGM,NCTA,NEQU
0007          COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,NC,NPLUS,NMINUS,NSL,NZER,NXM(3
             1),NUM(10)
0008          COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0009          DIMENSION NDVI(3)
0010          DATA NDVI/1HD,1HV,1HI/
        C
0011          KSHUV=0
0012          KSUBNI=0
        C     LOCATE THIS SYMBOL VALUE IN STACK
0013          IF(LOCTST(ILOC,KPOPO).NE.0) GO TO 20
        C     CHECK IF PARENS. AROUND SUM TERMS REQUIRED
0014     1    KPAR=KLOCA(3,ILOC)
0015          IF(KPAR.EQ.1.OR.NRAY(KRAY-1).EQ.NSL) CALL PUTCHR (NLP)
        C     FORM POP LOCATERS
0016     2    KST=KLOCA(2,ILOC)
0017          ILOCP=ILOC+1
0018          KEND=KLOCA(2,ILOCP)-1
        C     POINT TO VALUE - NOT NAME/CHAR
0019     3    IF(NPUSH(KST).GT.0.AND.NPUSH(KST).LT.100000000) GO TO 7
        C     NAME/CHAR FOUND
0020          IF(KPAR.NE.0.OR.NPUSH(KST).NE.NPLUS) CALL PUTCHR (NPUSH(KST))
0021          KST=KST+1
        C     END OF POPPING?
0022     4    IF(KST.LE.KEND) GO TO 3
        C     YES - PUT RIGHT PAREN IF LEFT ONE PUT
0023          IF(KPAR.EQ.1) CALL PUTCHR (NRP)
        C     CHECK FOR MORE EQUATIONS THIS ITEM
0024     5    DO 6 ILOSV=2,KLOC
0025          IF(KEND+1.EQ.KLOCA(2,ILOSV).AND.KLOCA(1,ILOSV-1).EQ.KLOCA(1,ILOSV)
             1) GO TO 19
0026     6    CONTINUE
        C     ANYTHING LEFT ON STACK?
0027          IF(LGRAB(KPOP).EQ.0) GO TO 17
        C     NO - WE DONE?
```

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0028            IF(KST.LE.KEND) GO TO 3
          C     YES
0029            RETURN
          C     SYMBOL VALUE GIVEN
0030       7    KPOP=NPUSH(KST)
          C     PUT PARENS. IF DIVIDE
0031            IF(NRAY(KRAY-1).NE.NSL) GO TO 8
0032            KPAR=1
0033            CALL PUTCHR (NLP)
          C     CHECK FOR INVERTED ARRAY
0034       8    KMX=MOD(KPOP,1000000)/10000
0035            IF(KMX.EQ.16.OR.KMX.EQ.26.OR.KMX.EQ.36) GO TO 16
          C     FORM CORRECT VALUES FROM SUBSCRIPT
0036       9    IF(KSUB.NE.0.AND.KPOP.GT.1000000) KPOP=KPOP+KSUB-1000001
0037            IF(KPOP/100000.NE.0.AND.KPOP/100000.NE.7) KPOP=KPOP+1
0038            KST=KST+1
          C     PUSH THIS VALUE AND POINT TO NEXT EQUATION
0039            IF(LSHUV(KPOP,ILOC,KPOPO).EQ.0) GO TO 12
          C     GET NEXT EQUATION
0040      10    KPOS=MOD(KPOPO,1000)
          C     LOCATION NON-EXISTENT - ZERO VALUE THEN
0041            IF(KPOS.EQ.0) GO TO 15
0042            KTYP=MOD(KPOPO,1000000)/10000
          C     EXTENDED SYMBOL AT BAD LOCATION
0043            IF(MOD(KPOPO,1000000)/100000.NE.0) GO TO 15
          C     NOT ENOUGH ROOM TO PUT SYMBOL - PUT THE LINE
0044            IF(KRAY+6.GT.72) CALL PUTLIN
          C     PUT "V/I" IF NECESSARY
0045            IF(KTYP.LE.0) GO TO 11
0046            CALL PUTCHR (NDVI(KTYP))
          C     PUT NAME
0047      11    CALL PUTNAM (NSYM(1,KPOS))
0048            GO TO 4
          C     NAME FOUND - PUT ELEMENT
0049      12    IF(KPOP.LT.4000) GO TO 10
0050            IF(KPOP/1000.EQ.9) GO TO 10
0051            IF(ILOC.EQ.0) GO TO 4
          C     FORCE EQUATION IF NOT EXTENDED SYMBOL
0052            IF(KEXTD.EQ.0) GO TO 1
0053            IF(KSHUV.EQ.0) GO TO 21
          C     LOCATE THIS EQUATION SUBSCRIPT IN STACK
0054            DO 13 IS=1,KSHUV,5
0055            IT=KSHUV-IS-3
0056            IF(NSHUV(IT).NE.0) GO TO 14
0057      13    CONTINUE
          C     SUBSCRIPT NOT IN STACK
0058            GO TO 21
          C     GET SUBSCRIPT
```

```
0059      14   KPOP=NPUSH(KST-1)+NSHUV(IT)
0060           GO TO 1
          C    PUT ZERO VALUE
0061      15   CALL PUTCHR (NZER)
0062           GO TO 4
          C    START ARRAY MULTIPLY LOOP
          C    INVALID SUBSCRIPT ON INVERTED GUY
0063      16   IF(KSUBN1.GT.1) GO TO 9
0064           IF(KPOP.LT.1000000) GO TO 21
          C    SAVE OLD SUBSCR AND GEN NEW ONE
0065           KSUBN=KSUB
0066           KSUBN1=1
          C    PUT INVERTED ARRAY NAME
0067           KMXA=KMX/10
0068           KSUB=KSUBN1
0069           CALL PUTMX (KMXA,KSUBN,KSUB)
0070           GO TO 9
          C    CONTINUE MATRIX MULTIPLY
0071      17   KMXB=KPOP/10000
0072           IF(KMXB.NE.16.AND.KMXB.NE.26.AND.KMXB.NE.36) GO TO 4
          C    INCREMENT SUBSCRIPT 2
0073           IF(KSUBN1.EQ.KXM(KMXA)) GO TO 18
0074           KSUBN1=KSUBN1+1
0075           KSUB=KSUBN1
0076           KST=NSHUV(KSHUV-3)
0077           NSHUV(KSHUV-4)=KSUB
0078           KPOPC=KPOP
          C    PUT NEW INV. ARRAY NAME
0079           CALL PUTMX (KMXA,KSUBN,KSUB)
0080           GO TO 4
          C    END OF MATRIX MPY
0081      18   KSUB=KSUBN
0082           NSHUV(KSHUV-3)=NSHUV(KSHUV-2)+1
0083           KSUBN1=0
0084           GO TO 5
0085      19   ILOC=ILCSV
0086           IF(KPAR.EQ.1) KRAY=KRAY-1
0087           KPAR=KLOCA(3,ILOC)
0088           GO TO 2
          C    CHECK FOR INVALID STATE VARIABLE
0089      20   IF(KPOPC/100000.LT.1.OR.KPOPC/100000.GT.3) GO TO 22
          C    SIMPLY A ZERO VALUE ARRAY ELEMENT
0090           CALL PUTCHR (NZER)
0091           RETURN
          C    ERRORS
          C
          C    INVALID SUBSCRIPT
0092      21   CALL ERROR (31)
```

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      C     INVALID NAME TO POP                                PR1 0869
0093  22    CALL ERROR (32)                                    PR1 0870
0094        END                                                PR1 0871
```

```
0001                 SUBROUTINE PUSH (NAME,KSUB)
               C
               C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
               C     PUSH THE EQUATION POINTED TO BY (NAME) INTO (NPUSH)
               C
               C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
0002                 COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
                    1)
0003                 COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0004                 COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0005                 COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                    1),NUM(10)
0006                 DIMENSION NAME(6), NAM1(6)
               C
0007                 KGO=0
               C     DECODE NAME - POINT TO SYMBOL TABLE
0008                 CALL DECNAM (NAME,KSUB,KLOC1,KVAL)
               C     BAD NAME - I.E. NOT IN SYMBOL TABLE
0009                 IF(KVAL.EQ.0) GO TO 4
               C     PUSH VALUE EQUATION
0010                 KLOC=KLOC+1
0011                 KLOCA(1,KLOC)=KVAL
0012                 KLOCA(2,KLOC)=KPUSH
0013                 KLOCA(3,KLOC)=0
0014           1     KGO=1
0015                 KSHSV=KPUSH
               C     GET EQUATION SYMBOL
0016                 IF(LPULL(NRAY,KRAY,NAM1,KGO,KSUB1).EQ.-1) RETURN
               C     FORM SUM OF PRODUCTS FLAG
0017                 IF(KGO.EQ.2.AND.(KGO.EQ.1.OR.NPUSH(KSHSV).EQ.NMINUS)) KLOCA(3,KLOC
                    1)=1
0018                 KGO=1
               C     DECODE EQUATION SYMBOL
0019                 CALL DECNAM (NAM1,KSUB1,KLOC1,KVAL)
               C     INVALID SYMBOL
0020                 IF(KVAL.EQ.0) GO TO 5
               C     CHECK TO PUSH FULL NAME
0021                 IF(KVAL.EQ.6000.OR.KVAL.EQ.7000.OR.KVAL.EQ.8000) GO TO 2
               C     "X=X+" FORMAT - IGNORE
0022                 IF(KVAL.EQ.KLOCA(1,KLOC)) GO TO 1
               C     PUSH EQUATION SYMBOL VALUE ONLY
0023                 NPUSH(KPUSH)=KVAL
0024                 KPUSH=KPUSH+1
0025                 IF(KPUSH.GT.KPMAX) GO TO 6
0026                 GO TO 1
               C     PUSH FULL NAME
```

```
0027      2    KS=1
0028      3    NPUSH(KPUSH)=NAM1(KS)
0029           KPUSH=KPUSH+1
0030           KS=KS+1
0031           IF(KPUSH.GT.KPMAX) GO TO 6
          C    END OF NAME?
0032           IF(NAM1(KS).EQ.NSP) GO TO 1
0033           IF(KS.GT.6) GO TO 1
0034           GO TO 3
          C    ERRORS
          C
          C    PUSHED NAME NOT IN SYMBOL TABLE
0035      4    CALL ERROR (27)
          C    EQUATION NAME NOT IN SYMBOL TABLE
0036      5    CALL ERROR (28)
          C    STACK OVERFLOW
0037      6    CALL ERROR (29)
0038           END
```

```
0001          SUBROUTINE PUTCHR (NCHAR)
         C
         C    <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
         C
         C    PLACE THE CHARACTER (NCHAR) INTO THE OUTPUT ARRAY (NRAY)
         C    IF (NRAY) LONGER THAN 72, PUT (NRAY) ON FT02F001 AS FORTRAN
         C
         C    <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
         C
0002          COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
             1)
         C
0003          IF(KRAY.GT.72) CALL PUTLIN
0004          NRAY(KRAY)=NCHAR
0005          KRAY=KRAY+1
0006          RETURN
0007          END
```

```
0001              SUBROUTINE PUTIT (KGO,KSTOP,NCHAR,KLEN,KNT,KPT)                  PR1 0955
           C                                                                       PR1 0956
           C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 0957
           C                                                                       PR1 0958
           C      PUT THE NAMES FROM ELEMENT LIST STARTING AT TYPE (KGO)           PR1 0959
           C      TO TYPE (KSTOP) IN OUTPUT, PRECEDE BY (NCHAR) IF                 PR1 0960
           C      KLEN NE ZERO AND SET NUMBER ELTS IN (KNT)                        PR1 0961
           C      AND POINTER OF FIRST NAME IN (KPT)                               PR1 0962
           C                                                                       PR1 0963
           C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 0964
           C                                                                       PR1 0965
0002              COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3PR1 0966
                 1),NUM(10)                                                        PR1 0967
0003              COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300PR1 0968
                 1)                                                                PR1 0969
0004              COMMON /HOLDIT/ HEAD(9,11),KHEAD,NDUM1,ELTS(300),KELTS,KEL,SOR(50)PR1 0970
                 1,NSDR(6,50),KSOR,NDUM3,XIC(50),KSV,NDUM4,PAR(100),NPAR(6,100),KDP,PR1 0971
                 2NDUM5,XTAB(500),NTAB(7,50),KTAB,KTAB2,KEJ                        PR1 0972
0005              DIMENSION MRAY(6)                                                PR1 0973
           C                                                                       PR1 0974
           C      ZERO POINTER AND COUNT                                           PR1 0975
0006              KPT=0                                                            PR1 0976
0007              KNT=0                                                            PR1 0977
           C      LOOP THRU TYPES                                                  PR1 0978
0008              DO 4 IPT=KGO,KSTOP                                               PR1 0979
           C      FIND LENGTH OF THIS TYPE                                         PR1 0980
0009              MPT=NLEN(IPT)                                                    PR1 0981
           C      ZERO LENGTH IS NO PUTSKIS                                        PR1 0982
0010              IF(MPT.EQ.0) GO TO 4                                             PR1 0983
           C      FIND THIS GUYS POINTER LESS ONE                                  PR1 0984
0011              LPT=NPT(IPT)-1                                                   PR1 0985
           C      LOOP ON THAT COUNT                                               PR1 0986
0012              DO 3 JPT=1,MPT                                                   PR1 0987
           C      PUT THE EXTRA CHAR IF ONE                                        PR1 0988
0013              NNPT=0                                                           PR1 0989
0014              IF(KLEN.NE.1) GO TO 1                                            PR1 0990
0015              MRAY(1)=NCHAR                                                    PR1 0991
0016              NNPT=1                                                           PR1 0992
           C      FORM THIS GUYS ABSOLUTE POINTER                                  PR1 0993
0017        1     LJPT=LPT+JPT                                                     PR1 0994
           C      BUILD FIRST POINTER                                              PR1 0995
0018              IF(KPT.EQ.0) KPT=LJPT                                            PR1 0996
           C      PUT THIS NAME                                                    PR1 0997
0019              MS=6-NNPT                                                        PR1 0998
0020              DO 2 M=1,MS                                                      PR1 0999
0021        2     MRAY(M+NNPT)=NSYM(M,LJPT)                                        PR1 1000
0022              CALL PUTNAM (MRAY)                                               PR1 1001
           C      UPDATE COUNT                                                     PR1 1002
```

```
0023               KNT=KNT+1                          PR1 1003
              C    PUT A COMMA BETWIXT EM             PR1 1004
0024               CALL PUTCHR (NCOM)                 PR1 1005
0025             3 CONTINUE                           PR1 1006
0026             4 CONTINUE                           PR1 1007
0027               RETURN                             PR1 1008
0028               END                                PR1 1009
```

```
0001            SUBROUTINE PUTLIN
              C
              C <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
              C WRITE THE CHARACTER STRING (NRAY) IN FORTRAN FORMAT
              C AFTER BLANKING END OF LINE. CONTINUATIONS ADDED
              C
              C <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
0002            COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
               1)
0003            COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0004            COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
               1),NUM(10)
0005            DIMENSION NCOMM(6)
0006            DATA NCOMM/1HC,1HO,1HM,1HM,1HO,1HN/
0007            DATA NAST/1H$/
              C
              C NOTHING ON LINE NOW
0008            IF(KRAY.EQ.7) RETURN
0009            NRAY(6)=NSP
              C IF "COMMON " OR "=" APPEARS, THEN NO CONTINUATION
0010            IF(LOCATE(NRAY,NCOMM,7,6).EQ.0) GO TO 2
0011            KND=MIN0(20,KRAY)
0012            DO 1 I=8,KND
0013            IF(NRAY(I).EQ.NEQ) GO TO 2
0014          1 CONTINUE
0015            NRAY(6)=NAST
              C BLANK TO END OF LINE AND PUT LINE
0016          2 DO 3 I=KRAY,73
0017          3 NRAY(I)=NSP
0018            WRITE (NEQU,4) (NRAY(I),I=1,72)
0019          4 FORMAT (72A1,8X)
0020            KRAY=7
0021            RETURN
0022            END
```

```
0001            SUBROUTINE PUTMX (KMX,KSUBN,KSUBN1)
          C
          C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
          C
          C     PUT 'XM%I(##1,##2)' WHERE % IS 'L','R', OR 'S' AND
          C     ##1 IS KSUBN, AND ##2 IS KSUBN1
          C
          C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
          C
0002            COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
               1),NUM(10)
0003            DIMENSION NAMX(6)
0004            DATA NAMX/1HX,1HM,1H ,1HI,1H(,1H /
          C
0005            NAMX(3)=NXM(KMX)
0006            IF(KSUBN1.GT.1) CALL PUTCHR (NPLUS)
0007            CALL PUTNAM (NAMX)
0008            CALL BCDOUT (KSUBN)
0009            CALL PUTCHR (NCOM)
0010            CALL BCDOUT (KSUBN1)
0011            CALL PUTCHR (NRP)
0012            RETURN
0013            END
```

```
0001            SUBROUTINE PUTNAM (NAME)
           C
           C    <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
           C
           C    PUT THE (UP TO) SIX CHARACTER LIST (NAME) IN THE OUTPUT
           C    STRING (NRAY). WRITE (NRAY) IF OVER 72 CHARS. LONG
           C
           C    <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
           C
0002            COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
               1)
0003            COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
               1),NUM(10)
0004            DIMENSION NAME(6), NEW(6)
           C
           C    RE-FORM MECHANICAL NAME
0005            CALL BACK (NAME,NEW)
0006            LEN=1
0007         1  IF(KRAY.GT.72) CALL PUTLIN
0008            NRAY(KRAY)=NEW(LEN)
0009            KRAY=KRAY+1
           C    END OF LINE?
0010            LEN=LEN+1
0011            IF(LEN.GT.6) RETURN
0012            IF(NEW(LEN).EQ.NSP) RETURN
0013            GO TO 1
0014            END
```

```
0001          SUBROUTINE SETUP
        C
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
        C
        C     GET ELEMENT NAMES AND POINTERS INTO (NSYM),(NPT),(NLEN), AND
        C     FROM SCEPTRE ROUTINE "SIMUL8"
        C
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
        C
0002          IMPLICIT REAL*8(A-H,O-Z)
0003          COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0004          COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
             1)
0005          COMMON /CNTRL/ LIST,L1,TIME,S1(21),XNOPRQ,S2,XNHEAD,S3(6),XRUNNO,S
             14(11),XWRTSM,S5,XWPDBG,S6(16),XEXSTP,S7(27),XNEY,XNE7DT,XNBC,XNBR,
             2XNBL,XNLC,XNLR,XNLL,XNJX,XNJ8DT,XNJO,XNJ9,S8(2),XNM33,XNM36,XNM66,
             3XNDP,XNDPC,XNELTS,S9(50),KXM(3)
0006          COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
             1),NUM(10)
0007          COMMON /HOLDIT/ HEAD(9,11),KHEAD,NDUM1,ELTS(300),KELTS,KEL,SDR(50)
             1,NSDR(6,50),KSDR,NDUM3,XIC(50),KSV,NDUM4,PAR(100),NPAR(6,100),KDP,
             2NDUM5,XTAB(500),NTAB(7,50),KTAB,KTAB2,KEJ
        C
0008          DIMENSION NBAD(13), NELS(8), NLOC(8)
0009          DIMENSION DUM(300), NMUT(6,50)
0010          DIMENSION NSIMTR(5), NSRCDR(6), NTABLE(6), NMATB(6)
0011          DIMENSION NXMUTL(5), NNAMES(5), NPRMTR(6), NDERIV(6)
0012          DIMENSION NIONBX(5), NOUTPT(6), NNDPD(3), NDUM(6)
0013          DIMENSION CTROL(160)
0014          EQUIVALENCE (CTROL(1),TIME)
0015          DATA NBAD/34,45,55,71,91,99,101,102,111,121,131,141,151/
0016          DATA NELS/96,97,98,93,94,95,92,100/
0017          DATA NLOC/7,4,5,6,1,2,3,8/
0018          DATA NSIMTR/1HS,1HI,1HM,1HT,1HR/
0019          DATA NNAMES/1HN,1HA,1HM,1HE,1HS/
0020          DATA NPRMTR/1HP,1HR,1HM,1HT,1HR,1HS/
0021          DATA NDERIV/1HD,1HE,1HR,1HI,1HV,1HS/
0022          DATA NIONBX/1HI,1HO,1HN,1H ,1HX/
0023          DATA NOUTPT/1HO,1HU,1HT,1HP,1HT,1HS/
0024          DATA NAST/1H*/
0025          DATA NNDPD/1H,,1HD,1HP/
0026          DATA NSRCDR/1HS,1HR,1HC,1HD,1HR,1HV/
0027          DATA NTABLE/1HT,1HA,1HB,1HL,1HE,1HS/
0028          DATA NXMUTL/1HX,1HM,1HU,1HT,1HL/
        C
        C     GET DATA
        C     READ TILL SUBROUTINE SIMTR FOUND
0029          KMUT=0
```

```
0030      1    READ (NPGM,2,END=39) NRAY                              PR1 1144
0031      2    FORMAT (80A1)                                          PR1 1145
0032           IF(LOCATE(NRAY,NSIMTR,9,5).EQ.1) GO TO 1               PR1 1146
          C    CHECK WHICH SCEPTRE IS USED                            PR1 1147
0033           READ (NPGM,3) NRAY                                     PR1 1148
0034      3    FORMAT (////////,80A1)                                 PR1 1149
0035           NAC=70                                                 PR1 1150
0036           IF(NRAY(6).EQ.NAST) NAC=160                            PR1 1151
          C    READ CONTROLS                                          PR1 1152
0037           READ (NDTA,4,END=38) (CTROL(I),I=1,NAC)                PR1 1153
0038      4    FORMAT (1P5D14.7)                                      PR1 1154
0039           IF(NAC.EQ.160) GO TO 6                                 PR1 1155
0040           DO 5 I=71,160                                          PR1 1156
0041      5    CTROL(I)=0.0D0                                         PR1 1157
          C    LOCATE CERTAIN STRINGS                                 PR1 1158
0042      6    IF(LREAD(NPGM,0).EQ.1) GO TO 40                        PR1 1159
0043      7    IF(LOCATE(NRAY,NSRCDR,15,6).EQ.0) GO TO 20             PR1 1160
0044           IF(LOCATE(NRAY,NTABLE,15,6).EQ.0) GO TO 22             PR1 1161
0045           IF(LOCATE(NRAY,NXMUTL,15,5).EQ.0) GO TO 24             PR1 1162
0046           IF(NAC.EQ.160) GO TO 8                                 PR1 1163
0047           IF(LOCATE(NRAY,NNAMES,15,5).EQ.0) GO TO 26             PR1 1164
0048           IF(LOCATE(NRAY,NPRMTR,15,6).EQ.0) GO TO 28             PR1 1165
0049           IF(LOCATE(NRAY,NDERIV,15,6).EQ.0) GO TO 30             PR1 1166
0050           IF(LOCATE(NRAY,NIONBX,13,5).EQ.0) GO TO 32             PR1 1167
0051      8    IF(LOCATE(NRAY,NOUTPT,15,6).EQ.0) GO TO 9              PR1 1168
0052           GO TO 6                                                PR1 1169
          C    CHECK FOR INVALID FLAGS IN CONTROLS.                   PR1 1170
0053      9    DO 10 IER=1,13                                         PR1 1171
0054           KLOC=NBAD(IER)                                         PR1 1172
0055           IF(CTROL(KLOC).NE.0.0D0) GO TO 36                      PR1 1173
0056     10    CONTINUE                                               PR1 1174
          C    FORM DEBUG FLAG                                        PR1 1175
0057           LIST=XWRDBG+XWRTSM                                     PR1 1176
0058           IF(LIST.GT.0) LIST=1                                   PR1 1177
          C    "EXECUTE SETUP PHASE ONLY MUST BE FLAGGED              PR1 1178
0059           IF(XEXSTP.NE.1D0) GO TO 37                             PR1 1179
          C    FORMA ELEMENT TYPE POINTERS AND LENGTHS                PR1 1180
0060           NPT(7)=1                                               PR1 1181
0061           DO 11 I=1,8                                            PR1 1182
0062           MPT=NLOC(I)                                            PR1 1183
0063           KLOC=NELS(MPT)                                         PR1 1184
0064           NLEN(MPT)=CTROL(KLOC)                                  PR1 1185
0065           IF(MPT.EQ.7) GO TO 11                                  PR1 1186
0066           MPTM=NLOC(I-1)                                         PR1 1187
0067           NPT(MPT)=NPT(MPTM)+NLEN(MPTM)                          PR1 1188
0068     11    CONTINUE                                               PR1 1189
0069           DO 12 I=1,8                                            PR1 1190
0070           IF(NLEN(I).EQ.0) NPT(I)=0                              PR1 1191
```

```
0071       12  CONTINUE
          C    GIT HEADING CARDS
0072           KHEAD=XNHEAD
0073           IF(KHEAD.NE.0) READ (NDTA,13) HEAD
0074       13  FORMAT (9A8)
          C    GIT ELEMENT VALUES AND NAMES
0075           KELTS=XNELTS
0076           READ (NDTA,14) (ELTS(I),I=1,KELTS)
0077       14  FORMAT (5D14.7)
0078           IF(NAC.EQ.160) READ (NDTA,15) ((NSYM(I,J),I=1,6),J=1,KELTS)
0079       15  FORMAT (72A1)
0080           KSYM=KELTS
          C    SKIP OVER ELEMENT IC VALUES
0081           READ (NDTA,14) (DUM(I),I=1,KELTS)
0082           READ (NDTA,14) (DUM(I),I=1,KELTS)
0083           IF(KMUT.NE.0) READ (NDTA,14) (DUM(I),I=1,KMUT)
          C    GIT SOURCE DERV VALUES
0084           IF(KSDR.NE.0) READ (NDTA,14) (SDR(I),I=I,KSDR)
          C    SKIP OVER VNICT AND INICT VALUES
0085           NSAVE=NLEN(1)+NLEN(3)+NLEN(4)+NLEN(6)
0086           IF(NSAVE.NE.0) READ (NDTA,14) (DUM(I),I=1,NSAVE)
          C    SKIP OVER DEF PARM DERIVS VALUES
0087           NDPD=XNDPD
0088           IF(NDPD.NE.0) READ (NDTA,14) (DUM(I),I=1,NDPD)
          C    GIT I3DOT AND V4DOT VALUES
0089           KSV=NLEN(3)+NLEN(4)
0090           IF(KSV.EQ.0) GO TO 41
0091           K2=NLEN(3)
0092           IF(K2.NE.0) READ (NDTA,14) (XIC(I),I=1,K2)
0093           K1=K2+1
0094           K2=NLEN(4)+K2
0095           IF(K2.NE.NLEN(3)) READ (NDTA,14) (XIC(I),I=K1,K2)
          C    GIT DP NAMES AND VALUES
0096           KDP=XNDP
0097           IF(KDP.NE.0) READ (NDTA,14) (PAR(I),I=1,KDP)
0098           IF(KDP.NE.0.AND.NAC.EQ.160) READ (NDTA,15) ((NPAR(I,J),I=1,6),J=1,
              1KDP)
          C    GIT TABLES
0099           IF(KTAB.NE.0) READ (NDTA,14) (XTAB(I),I=1,KTAB)
          C    COPY MUTUAL NAMES TO NSYM
0100           DO 17 I=1,KMUT
0101           KSYM=KSYM+1
0102           DO 16 J=1,6
0103       16  NSYM(J,KSYM)=NMUT(J,I)
0104       17  CONTINUE
          C    PUSH EQUATIONS-->STACK
0105           CALL GETEQS
          C    FORM ELEMENT TYPE ARRAY
```

```
0106              DO 19 I=1,KELTS
0107              IF(ELTS(I).NE.0.D00) GO TO 18
0108              CALL DECNAM (NSYM(1,I),0,IXLOC,IVAL)
0109              NT(I)=1-LOCTST(IXLOC,IVAL)
0110              GO TO 19
0111         18   NT(I)=1
0112         19   CONTINUE
0113              RETURN
           C      SOURCE DERIVATIVES EXIST - GIT THEM
0114         20   KRAY=22
0115              KSDR=0
0116         21   IF(LPULL(NRAY,KRAY,NSDR(1,KSDR+1),0,KSB).EQ.-1) GO TO 7
0117              KSDR=KSDR+1
0118              GO TO 21
           C      TABLES EXIST-GIT THEM TOO
0119         22   KRAY=22
0120              KTAB=0
0121              KTAB2=0
0122         23   IF(LPULL(NRAY,KRAY,NTAB(1,KTAB+1),0,NTAB(7,KTAB+1)).EQ.-1) GO TO 7
0123              KTAB=KTAB+NTAB(7,KTAB2)
0124              KTAB2=KTAB2+1
0125              GO TO 23
           C      GET MUTUALS
0126         24   KRAY=21
0127         25   IF(LPULL(NRAY,KRAY,NSYM(1,KMUT+1),0,KSB).EQ.-1) GO TO 7
0128              KMUT=KMUT+1
0129              GO TO 25
           C      GET ELEMENT NAMES AND NUMBERS
0130         26   KRAY=21
0131         27   IF(LPULL(NRAY,KRAY,NSYM(1,KELTS+1),0,KSB).EQ.-1) GO TO 7
0132              KELTS=KELTS+1
0133              XNELTS=KELTS
0134              GO TO 27
           C      GGT NUMBER AND NAMES OF DPS
0135         28   KRAY=22
0136         29   IF(LPULL(NRAY,KRAY,NPAR(1,KDP+1),0,KSB).EQ.-1) GO TO 7
0137              KDP=KDP+1
0138              NXDP=KDP
0139              GO TO 29
           C      GET NUMBER OF DEFINED PARAMETER DERIVS
0140         30   DO 31 I=22,70
0141              IF(LOCATE(NRAY,NNDPD,I,3).EQ.0) XNDPD=XNDPD+1
0142         31   CONTINUE
0143              GO TO 6
           C      GET NUMBER OF ELEMENT TYPES
0144         32   IF(NRAY(18).EQ.NRAY(9)) GO TO 6
0145              KRAY=17
0146         33   IF(LPULL(NRAY,KRAY,NDUM,0,KSB).EQ.-1) GO TO 7
```

```
              DO 34 I=2,10
              IF(NDUM(3).EQ.NUM(I)) GO TO 35
        34    CONTINUE
              I=2
        35    CTROL(NELS(I-1))=KSB
              GO TO 33
      C       ERRORS
      C
      C       INVALID FLAG ERRORS
        36    CALL ERROR (IEP)
      C       EXECUTE SETUP PHASE ONLY NOT SPECIFIED
        37    CALL ERROR (14)
      C       NO CONTROLS(NO DTASAV)
        38    CALL ERROR (17)
      C       NO PROGRAM SIMTR(NO PGMSAV)
        39    CALL ERROR (18)
      C       NO TRANSIENT EQUATIONS IN SIMTR
        40    CALL ERROR (19)
      C       NO STATE VARS
        41    CALL ERROR (20)
              END
```

```
0001                FUNCTION LGRAB (KPOP)
              C
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
              C     PULL THE PAST LOCATORS FROM (KSHUV)
              C
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
0002                IMPLICIT REAL*8(A-H,O-Z)
0003                COMMON /SHGR/ NSHUV(500),KSHUV,KST,KEND,KSUB,KEXTD,KPAR
0004                COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0005                COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
              C
0006                IF(LIST.EQ.1) WRITE (NPRINT,1)
0007            1   FORMAT (9H LGRABBED)
0008                LGRAB=1
0009                IF(KSHUV.EQ.0) RETURN
0010                LGRAB=0
0011                KPAR=NSHUV(KSHUV)
0012                KSHUV=KSHUV-1
0013                KPOP=NSHUV(KSHUV)
0014                KSHUV=KSHUV-1
0015                KEND=NSHUV(KSHUV)
0016                KSHUV=KSHUV-1
0017                KST=NSHUV(KSHUV)
0018                KSHUV=KSHUV-1
0019                KSUB=NSHUV(KSHUV)
0020                KSHUV=KSHUV-1
0021                RETURN
0022                END
```

```
0001             FUNCTION LOCATE (NRAY,NSTR,KSTR,KLEN)
           C
           C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
           C
           C     LOCATE STRING (NSTR) IN ARRAY (NRAY) WITH
           C     LENGTH (KLEN) STARTING AT (KSTR).
           C     LOCATE=0 IF STRING FOUND
           C     LOCATE=1 IF STRING NOT FOUND
           C
           C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
           C
0002             DIMENSION NRAY(80), NSTR(80)
           C
0003             LOCATE=1
0004             DO 1 I=1,KLEN
0005             KSTRIM=KSTR+I-1
0006             IF(NRAY(KSTRIM).NE.NSTR(I)) RETURN
0007        1    CONTINUE
0008             LOCATE=0
0009             RETURN
0010             END
```

```
0001           FUNCTION LOCTST (ILOC,IPOP)
         C
         C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
         C
         C     DETERMINE IF THE LOCATOR (IPOP) IS A VALID SYMBOL
         C     AND FIND ITS POINTER (ILOC) IN (KLOCA) AND SET LOCTST=0
         C     IF INVALID SET LOCTST=1.
         C
         C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
         C
0002           IMPLICIT REAL*8(A-H,O-Z)
0003           COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
              1)
0004           COMMON /PLSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0005           COMMON /SHGR/ NSHUV(500),KSHUV,KST,KEND,KSUB,KEXTD,KPAR
0006           COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0007           COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0008           DIMENSION MPT(8)
0009           DATA MPT/7,4,5,6,1,2,3,8/
         C
         C     FORM POINTERS
0010           KEXTD=0
0011           LOCTST=0
0012           ILOC=0
0013           MPOP=MOD(IPOP,1000000)
0014           MLOC=MOD(IPOP,1000)
         C     NO LOCATION GIVEN
0015           IF(MLOC.EQ.0) GO TO 5
0016           MMID=MPOP-MLOC
         C     CHECK FOR INVERTED ARRAYS
0017           MMIDA=MMID/10000
0018           IF(MMIDA.EQ.16.OR.MMIDA.EQ.26.OR.MMIDA.EQ.36) GO TO 8
0019           DO 4 ILOC=1,KLOC
         C     SEARCH STACK FOR EQUATION POINTERS
0020           JPOP=MOD(KLOCA(1,ILOC),1000000)
0021           JLOC=MOD(JPOP,1000)
         C     ALL BUT SUBSCRIPT MATCH
0022           IF(MPOP.EQ.JPOP) GO TO 6
         C     EXTENDED AND TYPE MATCH ONLY
0023           IF(MMID.NE.(JPOP-JLOC)) GO TO 4
         C     NOT EXTENDED
0024           IF(JPOP.LT.100000) GO TO 1
         C     NO POSSIBLE MATCH - TRY AGAIN
0025           IF(KLOCA(1,ILOC).LT.1000000) GO TO 4
         C     FOUND A MATCH
0026           KEXTD=JPOP/100000
0027           GO TO 7
         C     DETERMINE SUBSCRIPT POSSIBLE MATCH
```

```
0028       1    IF(IPOP.LT.1000000.AND.KLOCA(1,ILOC).LT.1000000) GO TO 4
0029            IF(MLOC.LT.JLOC) GO TO 4
           C    FIND SUBSCRIPT POSSIBLE RANGE
0030            DO 2 J=1,8
0031            JMPT=MPT(J)
0032            IF(JLOC.LT.NPT(JMPT)) GO TO 3
0033       2    CONTINUE
0034            J=9
0035       3    J=J-1
           C    CHECK SUBSCRIPT WITHIN RANGE
0036            IF(J.LE.0) GO TO 4
0037            JMPT=MPT(J)
0038            IF(NLEN(JMPT).EQ.0) GO TO 3
0039            IF((MLOC-JLOC).LE.NLEN(JMPT)-1) GO TO 6
0040       4    CONTINUE
           C    NO POSSIBLE MATCH
0041       5    LOCTST=1
0042            GO TO 7
           C    FORM SUBSCRIPT FROM GIVEN RANGE
0043       6    IF(IPOP.GT.1000000.OR.KLOCA(1,ILOC).GT.1000000.OR.KEXTD.NE.0) KSUB
               1=MLOC-JLOC+1
0044       7    IF(IPOP.LT.4000.AND.LOCTST.EQ.0) GO TO 10
0045       8    IF(LIST.EQ.1) WRITE (NPRINT,9) LOCTST
0046       9    FORMAT (13H LOCTST VALUE,I2)
0047            RETURN
           C    INVALID VARIABLE ELEMENT
0048      10    CALL ERROR (34)
0049            END
```

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```
0001               FUNCTION LPULL (NRAY,KSTR,NSYM,KDO,KSUB)
             C
             C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
             C
             C     PULL NEXT SYMBOL FROM (NRAY) BEGINNING AT (KSTR)
             C     UP TO COLUMN 72 INTO (NSYM) LEFT JUSTIFIED.  READ
             C     NEXT CARD IF END OF LINE FOUND AND CONTINUE
             C     NEXT CARD MUST BE CONTINUATION CARD, ELSE LPULL.NE.0
             C     UPDATE (KSTR) TO NEXT LOCATION.
             C     LPULL=0  GOT SYMBOL
             C     LPULL=1  GOT SYMBUL AND GOT NEXT CARD
             C     LPULL=-1 DID NOT GET SYMBOL BUT GOT NEXT CARD
             C
             C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
             C
0002               IMPLICIT REAL*8(A-H,O-Z)
0003               COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0004               COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0005               COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0006               COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                  1),NUM(10)
0007               DIMENSION NRAY(80), NSYM(6), NALPHA(36), NXTAB(5)
0008               DATA NALPHA/1HA,1HB,1HC,1HD,1HE,1HF,1HG,1HH,1HI,1HJ,1HK,1HL,1HM,1H
                  1N,1HO,1HP,1HQ,1HR,1HS,1HT,1HU,1HV,1HW,1HX,1HY,1HZ,1H0,1H1,1H2,1H3,
                  21H4,1H5,1H6,1H7,1H8,1H9/
0009               DATA NXTAB/1HT,1HA,1HB,1HL,1HE/
0010               DATA NPER/1H./
0011               EQUIVALENCE (NN,NALPHA(14)), (NX,NALPHA(24))
             C
0012               LPULL=0
             C     FIND BEGINNING (ALPHA) CHAR OF SYMBOL
0013          1    IF(NRAY(KSTR).EQ.NSP) GO TO 3
0014               DO 2 I=1,26
0015               IF(NRAY(KSTR).EQ.NALPHA(I)) GO TO 8
0016          2    CONTINUE
             C     NOT A SYMBOL
0017          3    IF(KDO.EQ.0) GO TO 4
             C     PUSH NON-SYMBOL CHARACTER
0018               IF(NRAY(KSTR).EQ.NSP) GO TO 4
0019               NPUSH(KPUSH)=NRAY(KSTR)
0020               KPUSH=KPUSH+1
             C     SET KDO TO 2 IF SUM OF PRODUCTS TERM
0021               IF(NRAY(KSTR).EQ.NPLUS.OR.NRAY(KSTR).EQ.NMINUS) KDO=2
0022               IF(KPUSH.GT.KPMAX) GO TO 27
0023          4    KSTR=KSTR+1
             C     TRY TO FIND THE SYMBOL AGAIN
0024               IF(KSTR.LE.72) GO TO 1
             C     END OF RECORD-GET ANOTHER
```

```
0025                NEOF=LREAD(NPGM,0)
0026          5     FORMAT (1X,80A1)
              C     CHECK CONTINUATION CHARACTER
0027                IF(NRAY(6).EQ.NSP) GO TO 6
0028                IF(LIST.EQ.1) WRITE (NPRINT,5) NRAY
              C     FIND SYMBOL IN NEW RECORD
0029                KSTR=7
0030                GO TO 1
              C     SYMBOL NOT IN THIS RECORD-NO CONTINUATION FOUND
0031          6     LPULL=-1
0032          7     KSTR=7
0033                RETURN
              C     IF SYMBOL IS "CCC" IGNORE IT
0034          8     IF(I.EQ.4.AND.NRAY(KSTR-1).EQ.NPER) GO TO 3
              C     CLEAR SYMBOL
0035                DO 9 I=1,6
0036          9     NSYM(I)=NSP
              C     GET SYMBOL
0037                DO 14 I=1,6
              C     IGNORE SPACES IN SYMBOL
0038         10     IF(NRAY(KSTR).NE.NSP) GO TO 11
0039                KSTR=KSTR+1
0040                IF(KSTR.LE.72) GO TO 10
              C     END OF RECORD - FAKE END OF SYMBOL
0041                KSTR=KSTR-1
0042                GO TO 15
              C     CHECK ALPHANUMERIC CHAR. HERE
0043         11     DO 12 J=1,36
0044                IF(NRAY(KSTR).EQ.NALPHA(J)) GO TO 13
0045         12     CONTINUE
              C     END OF SYMBOL
0046                GO TO 14
              C     GOT AN ALPHANUM CHAR. - SAVE IT
0047         13     NSYM(I)=NRAY(KSTR)
0048                KSTR=KSTR+1
              C     CHECK FOR END OF RECORD
0049                IF(KSTR.LE.72) GO TO 14
              C     END OF RECORD - GET NEW RECORD
0050                NEOF=LREAD(NPGM,0)
              C     CHECK FOR CONTINUATION FLAG
0051                IF(NRAY(6).EQ.NSP) GO TO 25
0052                IF(LIST.EQ.1) WRITE (NPRINT,5) NRAY
              C     OK CONTINUE RECORD-FIND SYMBOL
0053                KSTR=7
0054         14     CONTINUE
              C     CHECK FOR SUBSCRIPT
0055         15     IF(NRAY(KSTR).NE.NLP) RETURN
0056                KSTR=KSTR+1
```

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```
                 C      FAKE AN "N" SUBSCRIPT
 0057                   KSUB=1000000
 0058                   IF(NRAY(KSTR).EQ.NN) GO TO 19
                 C      IF NOT "N", GET SUBSCRIPT NUMBER
 0059                   IF(LPUMP2(NRAY,KSTR,KV1).EQ.1) GO TO 22
 0060                   IF(NRAY(KSTR).EQ.NCOM) GO TO 16
 0061                   KSUB=KV1
 0062                   GO TO 19
 0063             16    DO 17 II=1,3
 0064                   IF(NSYM(3).EQ.NXM(II)) GO TO 18
 0065             17    CONTINUE
 0066                   GO TO 22
 0067             18    IF(KXM(II).EQ.0) GO TO 22
 0068                   KSTR=KSTR+1
 0069                   IF(LPUMP2(NRAY,KSTR,KV2).EQ.1) GO TO 22
 0070                   KSUB=KXM(II)*(KV2-1)+KV1
 0071             19    KSTR=KSTR+1
 0072                   IF(KSUB.NE.1000000) GO TO 21
 0073             20    IF(NRAY(KSTR-1).EQ.NRP) GO TO 21
 0074                   KSTR=KSTR+1
 0075                   GO TO 20
 0076             21    RETURN
                 C      INVALID SUBSCRIPT NUMBER-CHECK EXPRESSION
 0077             22    IF(NSYM(1).NE.NX) GO TO 28
 0078                   KSUB=0
                 C      CHECK FOR "XTABLE"
 0079                   IF(LOCATE(NSYM,NXTAB,2,5).EQ.0) GO TO 26
                 C      LOCATE END OF ARG STRING IN XPRESSION
 0080                   DO 23 I=KSTR,50
 0081                   IF(NRAY(I).EQ.NRP) GO TO 24
 0082             23    CONTINUE
                 C      NO END OF ARG. FOUND.
 0083                   GO TO 29
 0084             24    KSTR=I+1
 0085                   RETURN
 0086             25    LPULL=1
 0087                   GO TO 7
                 C      "XTABLE" FOUND
 0088             26    KSTR=KSTR-1
 0089                   RETURN
                 C      ERRORS
                 C
                 C      STACK OVERFLOW
 0090             27    CALL ERROR (22)
                 C      BAD SUBSCRIPT
 0091             28    CALL ERROR (23)
                 C      BAD EXPRESSION ARGUMENT STRING
 0092             29    CALL ERROR (24)
```

```
                                                                          PR1 1580
 0093                END
```

```
0001                FUNCTION LPUMP (NRAY,KRAY,KLEN,KVAL)
              C
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
              C     PUMP OUT THE INTEGER VALUE (KVAL) FROM BCD ARRAY (NRAY)
              C     STARTING AT (KRAY) FOR LENGTH (KLEN). UPDATE (KRAY) AND
              C     IGNORE BLANKS.  LPUMP=0 IF OKAY CONVERSION
              C                     LPUMP=1 IF ERROR IN CONVERSION
              C
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
              C
0002                COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,NO,NPLUS,NMINUS,NSL,NZER,NXM(3
                   1),NNUM(10)
0003                DIMENSION NRAY(80)
              C
0004                KVAL=0
0005                LPUMP=0
0006                DO 3 I=1,KLEN
0007                IF(NRAY(KRAY).EQ.NSP) GO TO 3
0008                DO 1 J=1,10
0009                IF(NRAY(KRAY).EQ.NNUM(J)) GO TO 2
0010          1     CONTINUE
0011                LPUMP=1
0012                RETURN
0013          2     KVAL=KVAL*10+(J-1)
0014          3     KRAY=KRAY+1
0015                RETURN
0016                END
```

```
0001              FUNCTION LPUMP2 (NRAY,KRAY,KVAL)                                    PR1 1609
            C                                                                         PR1 1610
            C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 1611
            C                                                                         PR1 1612
            C     PUMP THE NEXT SUBSCRIPT SURROUNDED NUMBER FROM NRAY                 PR1 1613
            C     RETURN VALUE AS LPUMP                                               PR1 1614
            C                                                                         PR1 1615
            C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR1 1616
            C                                                                         PR1 1617
0002              COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3PR1 1618
                 1),NUM(10)                                                           PR1 1619
0003              DIMENSION NRAY(80)                                                  PR1 1620
            C                                                                         PR1 1621
0004              LPUMP2=1                                                            PR1 1622
0005              LRAY=KRAY                                                           PR1 1623
0006          1   LRAY=LRAY+1                                                         PR1 1624
0007              IF(LRAY.GT.72) RETURN                                               PR1 1625
0008              IF(NRAY(LRAY).NE.NRP.AND.NRAY(LRAY).NE.NCOM) GO TO 1                PR1 1626
0009              KXRAY=LRAY-KRAY                                                     PR1 1627
0010              LPUMP2=LPUMP(NRAY,KRAY,KXRAY,KVAL)                                  PR1 1628
0011              RETURN                                                              PR1 1629
0012              END                                                                 PR1 1630
```

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```
0001                 FUNCTION LREAD (NFIL,LIST)
               C
               C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
               C     READ A RECORD FROM FILE (NFIL) INTO (NRAY)
               C     LIST IF (LIST) IS =1. RETURN CODES:
               C     LREAD=0 NO END OF FILE AND "END" NOT IN COLS 7-9
               C          =1 END OF FILE OR "END" IN COLS 7-9
               C
               C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
               C
0002                 COMMON /NASA/ NSYM(6,300),KSYM,NRAY(80),KRAY,NLEN(8),NPT(8),NT(300
                    1)
0003                 COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0004                 DIMENSION NEND(3)
0005                 DATA NEND/1HE,1HN,1HD/
               C
               C     SET POINTER AND FLAG
0006                 KRAY=7
0007                 LREAD=0
               C     READ NEW LINE
0008                 READ (NFIL,1,END=3,ERR=3) NRAY
0009             1   FORMAT (80A1)
0010                 IF(LIST.EQ.1) WRITE (NPRINT,2) NRAY
0011             2   FORMAT (1X,80A1)
               C     "END" APPEARS?
0012                 IF(LOCATE(NRAY,NEND,7,3).EQ.0) LREAD=1
0013                 RETURN
0014             3   LREAD=1
0015                 RETURN
0016                 END
```

```
0001          FUNCTION LSHUV (KPOP,IPOS,KPCPC)
       C
       C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
       C
       C      PUSH THE CURRENT SYMBOL LOCATORS INTO (KSHUV) IF THE
       C      NEXT SYMBOL IS LOCATED IN THE LIST (KLOCA) OF SYMBOLS
       C
       C      <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
       C
0002          IMPLICIT REAL*8 (A-H,O-Z)
0003          COMMON /PUSHED/ KLOCA(3,400),KLOC,NPUSH(1000),KPUSH,KPMAX
0004          COMMON /SHGR/ NSHUV(500),KSHUV,KST,KEND,KSUB,KEXTD,KPAR
0005          COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0006          COMMON /FILES/ NPRINT,NPOM,NCTA,NEQU
       C
0007          LSHUV=1
0008          KMOD=MOD(KPCP,1000)
       C      GO IF EQUATION FOUND
0009          IF(LOCTST(IPOS,KPOP).EQ.0) GO TO 1
       C      NO EQUATION FOR THIS VALUE
       C      USE LAST VALUE
0010          IPOS=KMOD
0011          KPCPO=KPOP
0012          GO TO 2
       C      PUSH SUBSCRIPT, POINTERS, VALUE AND SUM-PRODUCTS FLAG
0013     1    LSHUV=0
0014          IF(KSHUV+5.GT.500) GO TO 5
0015          KSHUV=KSHUV+1
0016          NSHUV(KSHUV)=KSUB
0017          KSHUV=KSHUV+1
0018          NSHUV(KSHUV)=KST
0019          KSHUV=KSHUV+1
0020          NSHUV(KSHUV)=KEND
0021          KSHUV=KSHUV+1
0022          NSHUV(KSHUV)=KPCPC
0023          KSHUV=KSHUV+1
0024          NSHUV(KSHUV)=KPAR
0025          KPCPC=KPOP
0026     2    IF(LIST.EQ.0) RETURN
0027          KS5=KSHUV-4
0028          WRITE (NPRINT,3) IPOS,KPOP,KSUB,KEXTD,LSHUV,KSHUV
0029          IF(KS5.GT.0) WRITE (NPRINT,4) (NSHUV(I),I=KS5,KSHUV)
0030     3    FORMAT (7H LSHUV ,6I9)
0031     4    FORMAT (1X,5I10)
0032          RETURN
       C      ERRORS
       C
       C      SHUV STACK OVERFLOW
```

```
0033       5    CALL ERROR (33)                                          PR1 1710
0034            END                                                      PR1 1711
```

```
0001               FUNCTION NUMB (NRAY,KST,KEN,I)
             C
             C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
             C
             C     DECODE NUMBER AT KST IN NRAY UNITL KEN
             C
             C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
             C
0002               COMMON /FILES/ NPRINT,NPGM,NDTA,NEQU
0003               COMMON /CNTRL/ LIST,L1,CTROL(160),KXM(3)
0004               COMMON /CHARS/ NSP,NLP,NRP,NCOM,NEQ,ND,NPLUS,NMINUS,NSL,NZER,NXM(3
                  1),NUMS(10)
0005               DIMENSION NRAY(80)
0006               NUMB=0
0007               DO 4 I=KST,KEN
0008               IF(I.LE.72) GO TO 2
0009               READ (NPGM,1) NRAY
0010         1     FORMAT (80A1)
0011               I=7
0012               KEN=KEN-72+6
0013         2     CONTINUE
0014               IF(NRAY(I).EQ.NSP) GO TO 4
0015               DO 3 J=1,10
0016               IF(NRAY(I).NE.NUMS(J)) GO TO 3
0017               NUMB=NUMB*10+J-1
0018         3     CONTINUE
0019         4     CONTINUE
0020               RETURN
0021               END
```

```
           C     PROSE2
           C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
           C
           C     PROSE PART TWO
           C
           C     COPYRIGHT JOHN E. O'REILLY, JR. 1977
           C     10/17/77
           C     COPYRIGHT JOHN E. O'REILLY, JR. 1978
           C     04/05/78
           C
           C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
           C
 0001            IMPLICIT REAL*8(A-H,O-Z)
           C     STANDARD SCEPTRE COMMON AREAS
 0002            COMMON /CNTRLS/ TIME,S1(21),XNCPRC,S2,XNHEAD,S3(6),XRUNNO,S4(11),X
                1WRTSM,S5(46),XNEY,XNE7DT,XNBC,XNBR,XNBL,XNLC,XNLR,XNLL,XNJX,XNJ8DT
                2,XNJO,XNJ9,S6(2),XNM33,XNM36,XNM66,XNDP,XNDPD,XNELTS,S7(50)
 0003            COMMON /CURNTS/ C(1)
 0004            COMMON /DERIVS/ D(1)
 0005            COMMON /DPNAMS/ DPS(1)
 0006            COMMON /ELNAMS/ LELS(6,300)
 0007            COMMON /HDCRDS/ HEAD(9,11)
 0008            COMMON /NAMES/ XN(1)
 0009            COMMON /OUTPTS/ OUTR(5,1)
 0010            COMMON /OUTPUT/ NOUTP(6,50)
 0011            COMMON /PRMTRS/ P(1)
 0012            COMMON /SAVICT/ CICT(1)
 0013            COMMON /SRCDRV/ S(1)
 0014            COMMON /TABLES/ T(1)
 0015            COMMON /TAPES/ NPRT,NDTA,NPGM
 0016            COMMON /VOLTGS/ V(1)
 0017            COMMON /XMUTL/ XM(1)
           C     PROSE2 COMMON AREA
 0018            COMMON /PROSE/ A(50,50),B(50,50),L3P,L3S,L4P,L4S,NSV,NEJ,NEL,NIND(
                1300),IPERF(50)
           C
 0019            DIMENSION CTROLS(160), ER(50), EI(50), XER(50), XEI(50)
 0020            DIMENSION NLIN(80), NSRCDR(6), NTABLE(6), NOUTPT(6), NUMS(10)
 0021            DIMENSION NUT(6), NUT2(6)
 0022            DATA NSRCDR/1HS,1HR,1HC,1HD,1HR,1HV/
 0023            DATA NTABLE/1HT,1HA,1HB,1HL,1HE,1HS/
 0024            DATA NOUTPT/1HO,1HU,1HT,1HP,1HT,1HS/
 0025            DATA NCOM/1H,/,NBL/1H /
 0026            DATA NUMS/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
 0027            DATA NI/1HI/,NV/1HV/
 0028            EQUIVALENCE (TIME,CTROLS(1))
           C
           C     BEGIN MAINLINE CODE
```

```
                C
                C    SET I/O DEVICE CODES
0029                 NPRT=6
0030                 NDTA=1
0031                 NPGM=2
0032                 CALL SETUP2 (NAC,LELS,NSRC,NTAB)
                C
0033                 IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,1) CTROLS
0034            1    FORMAT (21H <><><>CONTROLS<><><>,/,32(1X,1P5D14.7,/))
0035            2    FORMAT (1P5D14.7)
                C    READ HEADING CARDS
0036                 NHEAD=XNHEAD
0037                 IF(NHEAD.NE.0) READ (NDTA,4) HEAD
0038                 IF(XWRTSM.EQ.1.0D0.AND.NHEAD.NE.0) WRITE (NPRT,3) ((HEAD(I,J),I=1,
                    19),J=1,NHEAD)
0039            3    FORMAT (26H <><><>HEADING CARDS<><><>,/,11(1X,9A8,/))
0040            4    FORMAT (9A8)
                C    READ ELEMENT VALUES
0041                 NEL=XNELTS
0042                 READ (NDTA,2) (XN(I),I=1,NEL)
0043                 IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,5) (XN(I),I=1,NEL)
0044            5    FORMAT (27H <><><>ELEMENT VALUES<><><>,/,60(1X,1P5D14.7,/))
                C    READ ELEMENTS NAMES
0045                 IF(NAC.EQ.160) READ (NDTA,7) ((LELS(I,J),I=1,6),J=1,NEL)
0046                 IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,6) ((LELS(I,J),I=1,6),J=1,NEL)
0047            6    FORMAT (26H <><><>ELEMENT NAMES<><><>,/,30(1X,72A1,/))
0048            7    FORMAT (72A1)
                C    READ ELEMENTS VOLTAGES AND CURRENTS (INITIAL CONDITIONS)
0049                 READ (NDTA,2) (V(I),I=1,NEL)
0050                 IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,8) (V(I),I=1,NEL)
0051            8    FORMAT (25H <><><>I/C VOLTAGES<><><>,/,60(1X,1P5D14.7,/))
0052                 READ (NDTA,2) (C(I),I=1,NEL)
0053                 IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,9) (C(I),I=1,NEL)
0054            9    FORMAT (25H <><><>I/C CURRENTS<><><>,/,60(1X,1P5D14.7,/))
                C    READ MUTUAL VALUES
0055                 NMUT=XNM33+XNM36+XNM66
0056                 IF(NMUT.NE.0) READ (NDTA,2) (XM(I),I=1,NMUT)
0057                 IF(XWRTSM.EQ.1.0D0.AND.NMUT.NE.0) WRITE (NPRT,10) (XM(I),I=1,NMUT)
0058           10    FORMAT (20H <><><>MUTUALS<><><>,/,10(1X,1P5D14.7,/))
                C    READ SOURCE DERIVATIVES
0059                 IF(NSRC.NE.0) READ (NDTA,2) (S(I),I=1,NSRC)
0060                 IF(XWRTSM.EQ.1.0D0.AND.NSRC.NE.0) WRITE (NPRT,11) (S(I),I=1,NSRC)
0061           11    FORMAT (25H <><><>SRC. DERIVS.<><><>,/,10(1X,1P5E14.7,/))
                C    READ STATE VARIABLE SAVES I/C'S
0062                 NIC=XNLC+XNLL+XNBC+XNBL
0063                 IF(NIC.NE.0) READ (NDTA,2) (CICT(I),I=1,NIC)
0064                 IF(XWRTSM.EQ.1.0D0.AND.NIC.NE.0) WRITE (NPRT,12) (CICT(I),I=1,NIC)
0065           12    FORMAT (22H <><><>STATE I/C<><><>,/,10(1X,1P5D14.7,/))
```

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              C     COMPUTE NUMBER OF STATE VARIABLES                                  PR2 0097
 0066               NSV=XNBC+XNLL                                                      PR2 0098
              C     READ DEFINED PARAMETER DERIVATIVES                                 PR2 0099
 0067               NDPD=XNDPD                                                         PR2 0100
 0068               IF(NDPD.NE.0) READ (NDTA,2) (D(I+NSV-1),I=1,NDPD)                  PR2 0101
 0069               IF(XWRTSM.EQ.1.0D0.AND.NDPD.NE.0) WRITE (NPRT,13) (D(I+NSV-1),I=1,PR2 0102
                   1NDPD)                                                              PR2 0103
 0070          13   FORMAT (31H <><><>DEF. PARM. DERIVS.<><><>,/,10(1X,1P5D14.7,/))    PR2 0104
              C     READ STATE VARIABLE I/C'S                                          PR2 0105
 0071               NLL=XNLL                                                           PR2 0106
 0072               IF(NLL.NE.0) READ (NDTA,2) (CICT(I),I=1,NLL)                       PR2 0107
 0073               IF(XWRTSM.EQ.1.0D0.AND.NLL.NE.0) WRITE (NPRT,14) (CICT(I),I=1,NLL)PR2 0108
 0074          14   FORMAT (19H <><><>LL I/C<><><>,/,10(1X,1P5D14.7,/))                PR2 0109
 0075               NI=NLL-1                                                           PR2 0110
 0076               NBC=XNBC                                                           PR2 0111
 0077               IF(NBC.NE.0) READ (NDTA,2) (CICT(I+NI),I=1,NBC)                    PR2 0112
 0078               IF(XWRTSM.EQ.1.0D0.AND.NBC.NE.0) WRITE (NPRT,15) (CICT(I+NI),I=1,NPR2 0113
                   1BC)                                                                PR2 0114
 0079          15   FORMAT (19H <><><>BC I/C<><><>,/,10(1X,1P5D14.7,/))                PR2 0115
              C     READ DEFINED PARAMETERS                                            PR2 0116
 0080               NDP=XNDP                                                           PR2 0117
 0081               IF(NDP.NE.0) READ (NDTA,2) (P(I),I=1,NDP)                          PR2 0118
 0082               IF(XWRTSM.EQ.1.0D0.AND.NDP.NE.0) WRITE (NPRT,16) (P(I),I=1,NDP)    PR2 0119
 0083          16   FORMAT (24H <><><>DEF. PARMS.<><><>,/,20(1X,1P5D14.7,/))           PR2 0120
 0084               IF(NDP.NE.0.AND.NAC.EQ.160) READ (NDTA,17) (DPS(I),I=1,NDP)        PR2 0121
 0085               IF(XWRTSM.EQ.1.0D0.AND.NDP.NE.0.AND.NAC.EQ.160) WRITE (NPRT,18) (DPR2 0122
                   1PS(I),I=1,NDP)                                                     PR2 0123
 0086          17   FORMAT (12A6)                                                      PR2 0124
 0087          18   FORMAT (29H <><><>DEF. PARM. NAMES<><><>,/,9(1X,12A6,/))           PR2 0125
              C     READ TABLES                                                        PR2 0126
 0088               IF(NTAB.NE.0) READ (NDTA,2) (T(I),I=1,NTAB)                        PR2 0127
 0089               IF(XWRTSM.EQ.1.0D0.AND.NTAB.NE.0) WRITE (NPRT,19) (T(I),I=1,NTAB)  PR2 0128
 0090          19   FORMAT (19H <><><>TABLES<><><>,/,50(1X,1P5D14.7,/))                PR2 0129
              C     READ OUTPUT REQUESTS                                               PR2 0130
 0091               NOPRQ=XNOPRQ                                                       PR2 0131
 0092               READ (NDTA,17) ((OUTR(I,J),I=1,5),J=1,NOPRQ)                       PR2 0132
 0093               IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,20) ((OUTR(I,J),I=1,5),J=1,NOPRQ)  PR2 0133
 0094          20   FORMAT (28H <><><>OUTPUT REQUESTS<><><>,/,10(1X,12A6,/))           PR2 0134
 0095               NOPRQ=NOPRQ+1                                                      PR2 0135
 0096               READ (NDTA,7) ((NOUTP(I,J),I=1,6),J=1,NOPRQ)                       PR2 0136
 0097               IF(XWRTSM.EQ.1.0D0) WRITE (NPRT,21) ((NOUTP(I,J),I=1,6),J=1,NOPRQ)PR2 0137
 0098          21   FORMAT (20H <><><>OUTPUTS<><><>,/,10(1X,72A1,/))                   PR2 0138
              C     ZERO OUT DERIVATIVES                                               PR2 0139
 0099               DO 22 I=1,NSV                                                      PR2 0140
 0100          22   D(I)=0.0D0                                                         PR2 0141
              C     CLEAR INDEPENDENT VARIABLE TABLE                                   PR2 0142
 0101               DO 23 I=1,NEL                                                      PR2 0143
 0102          23   NIND(I)=0                                                          PR2 0144
```

```
      C     FORM INDEPENEDENT VARIABLE TABLE                            PR2 0145
0103        NEJ=0                                                       PR2 0146
0104        DO 26 I=2,NOPRQ                                             PR2 0147
0105        DO 25 J=1,NEL                                               PR2 0148
0106        DO 24 K=1,6                                                 PR2 0149
0107        IF(NOLTP(K,I).NE.LELS(K,J)) GO TO 25                        PR2 0150
0108     24 CONTINUE                                                    PR2 0151
0109        NIND(J)=1                                                   PR2 0152
0110        NEJ=NEJ+1                                                   PR2 0153
0111        XN(J)=0.0D0                                                 PR2 0154
0112        GO TO 26                                                    PR2 0155
0113     25 CONTINUE                                                    PR2 0156
0114     26 CONTINUE                                                    PR2 0157
      C     COMPUTE OFFSETS TO STATE VARIABLE NAMES                     PR2 0158
0115        L4S=XNE7OT+1                                                PR2 0159
0116        L4P=XNBC+L4S-1                                              PR2 0160
0117        L3S=XNE7OT+XNBC+XNBR+XNBL+XNLC+XNLR+1                       PR2 0161
0118        L3P=XNLL+L3S-1                                              PR2 0162
      C     CLEAR STATE VARIABLES                                       PR2 0163
0119        IF(L3S.GT.L3P) GO TO 28                                     PR2 0164
0120        DO 27 I=L3S,L3P                                             PR2 0165
0121     27 C(I)=0.0                                                    PR2 0166
0122     28 IF(L4S.GT.L4P) GO TO 30                                     PR2 0167
0123        DO 29 I=L4S,L4P                                             PR2 0168
0124     29 V(I)=0.0D0                                                  PR2 0169
      C     PERFORM EIGAN ANALYSIS                                      PR2 0170
0125     30 CALL EIGAN (ER,EI)                                          PR2 0171
      C     PRINT HEADER                                                PR2 0172
0126        WRITE (NPRT,31)                                             PR2 0173
0127     31 FORMAT (27H1NASA-LEWIS RESEARCH CENTER,/,27H ---- ----- --------PR2 0174
           1-----,//,27H       PROSE PROGRAM          ,/,27H    ----- -------PR2 0175
           2       ,/,28H UNIVERSITY OF SOUTH FLORIDA,/,28H ---------- -- -----PR2 0176
           3 -------,/)                                                 PR2 0177
0128        IF(NHEAD.NE.0) WRITE (NPRT,32) ((HEAD(I,J),I=1,9),J=1,NHEAD) PR2 0178
0129     32 FORMAT (11(1X,9A8,/))                                       PR2 0179
0130        WRITE (NPRT,33)                                             PR2 0180
0131     33 FORMAT (21H ----- --------- -----,/,21H STATE VARIABLE NAMES,/,21H PR2 0181
           1----- -------- -----)                                       PR2 0182
      C     WRITE I3 STATE VARIABLE NAMES                               PR2 0183
0132        IF(L3S.GT.L3P) GO TO 37                                     PR2 0184
0133        DO 35 I=L3S,L3P                                             PR2 0185
0134        DO 34 II=1,5                                                PR2 0186
0135     34 NUT2(II+1)=LELS(II,I)                                       PR2 0187
0136        NUT2(1)=NI                                                  PR2 0188
0137        CALL BACK (NUT2,NUT)                                        PR2 0189
0138     35 WRITE (NPRT,36) NUT                                         PR2 0190
0139     36 FORMAT (1X,6A1)                                             PR2 0191
      C     WRITE C4 STATE VARIABLE NAMES                               PR2 0192
```

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```
0140          37     IF(L4S.GT.L4P) GO TO 41                                              PR2 0193
0141                 DO 39 I=L4S,L4P                                                      PR2 0194
0142                 DO 38 II=1,5                                                         PR2 0195
0143          38     NUT2(II+1)=LELS(II,I)                                                PR2 0196
0144                 NUT2(1)=NV                                                           PR2 0197
0145                 CALL BACK (NUT2,NUT)                                                 PR2 0198
0146          39     WRITE (NPRT,40) NUT                                                  PR2 0199
0147          40     FORMAT (1X,6A1)                                                      PR2 0200
              C      WRITE A MATRIX HEADER                                                PR2 0201
0148          41     WRITE (NPRT,42)                                                      PR2 0202
0149          42     FORMAT (/,9H ------ -,/,9H MATRIX A,/,9H ------ -)                   PR2 0203
              C      WRITE A MATRIX                                                       PR2 0204
0150                 DO 43 I=1,NSV                                                        PR2 0205
0151          43     WRITE (NPRT,44) (A(I,J),J=1,NSV)                                     PR2 0206
0152          44     FORMAT (1X,1P7D14.5)                                                 PR2 0207
              C      WRITE INDEPENDENT SOURCE HEADER                                      PR2 0208
0153                 IF(NEJ.EQ.0) GO TO 50                                                PR2 0209
0154                 WRITE (NPRT,45)                                                      PR2 0210
0155          45     FORMAT (/,20H ----------- -------,/,20H INDEPENDENT SOURCES,/,20H PR2 0211
                    1----------- -------)                                                 PR2 0212
0156                 DO 47 I=1,NEL                                                        PR2 0213
0157                 IF(NIND(I).NE.1) GO TO 47                                            PR2 0214
0158                 CALL BACK (LELS(1,I),NUT)                                            PR2 0215
0159                 WRITE (NPRT,46) NUT                                                  PR2 0216
0160          46     FORMAT (1X,6A1)                                                      PR2 0217
0161          47     CONTINUE                                                             PR2 0218
              C      WRITE B MATRIX HEADER                                                PR2 0219
0162                 WRITE (NPRT,48)                                                      PR2 0220
0163          48     FORMAT (/,9H ------ -,/,9H MATRIX B,/,9H ------ -)                   PR2 0221
              C      WRITE B MATRIX                                                       PR2 0222
0164                 DO 49 I=1,NSV                                                        PR2 0223
0165          49     WRITE (NPRT,44) (B(I,J),J=1,NEJ)                                     PR2 0224
              C      WRITE EIGENVALUES                                                    PR2 0225
0166          50     WRITE (NPRT,51)                                                      PR2 0226
0167          51     FORMAT (/,24H ----------- -- ------ -,/,24H EIGENVALUES OF MATRIX PR2 0227
                    1A,/,24H ----------- -- ------ -,/,14X,9HREAL PART,10X,10HIMAG. PARPR2 0228
                    2T,/,14X,9H---- ----,10X,10H----- ----)                               PR2 0229
              C      FORM LARGEST EIGENVALUE AND PRINT THEM                               PR2 0230
0168                 XL=0.D0                                                              PR2 0231
0169                 DO 53 I=1,NSV                                                        PR2 0232
0170                 WRITE (NPRT,52) ER(I),EI(I)                                          PR2 0233
0171          52     FORMAT (12X,1PE14.7,5X,1PE14.7)                                      PR2 0234
0172                 XV=DSQRT(ER(I)*ER(I)+EI(I)*EI(I))                                    PR2 0235
0173                 IF(DABS(XL).GT.DABS(XV)) GO TO 53                                    PR2 0236
0174                 XL=XV                                                                PR2 0237
0175                 IL=I                                                                 PR2 0238
0176          53     CONTINUE                                                             PR2 0239
              C      DC SENSITIVITY ANALYSIS                                              PR2 0240
```

```
0177            WRITE (NPRT,54) IL,XL
0178        54  FORMAT (/,21H ----------- --------,/,21H SENSITIVITY ANALYSIS,/,21
               1H ----------- --------,/,21H MAXIMUM EIGENVALUE #,I3,13H MAGNITUDE
               2 = ,1PE14.7,//,21H ELEMENT  SENSITIVITY,/,21H -------  -----------
               3)
0179            EGL=0.0D0
0180            IX=0
0181            DO 61 I=1,NEL
            C   IGNORE IF INDEP. SOURCE
0182            IF(NIND(I).EQ.1) GO TO 61
            C   IGNORE IF ZERO VALUED
0183            IF(XN(I).EQ.0.0D0) GO TO 61
            C   SAVE OLD VALUE
0184            SV=XN(I)
            C   BUMP VALUE BY 10 PER CENT
0185            XN(I)=XN(I)*1.01D0
0186            CALL EIGAN (XER,XEI)
            C   COMPUTE SENSITIVITIES
0187            EGU=DSQRT(XER(IL)*XER(IL)+XEI(IL)*XEI(IL))-XL
0188            EG=EGL*100.0D0/XL
0189            IF(EG.GE.-1.03D0.AND.EG.LE.-0.97D0) GO TO 56
0190            IF(EG.GE.0.97D0.AND.EG.LE.1.03D0) GO TO 58
0191            CALL BACK (LELS(1,I),NUT)
0192            WRITE (NPRT,55) NUT,EG
0193        55  FORMAT (2X,6A1,5X,F6.3)
0194            IF(DABS(EG).LE.DABS(EGL)) GO TO 60
0195            EGL=EG
0196            NL=I
0197            GO TO 60
            C   GOT SENS APPROX. -1
0198        56  CALL BACK (LELS(1,I),NUT)
0199            WRITE (NPRT,57) NUT,EG
0200        57  FORMAT (2X,6A1,5X,F6.3,5X,46H*** ELEMENT MAY BE REMOVED BY SETTING
               1 TO ZERO.)
0201            NIND(I)=-2
0202            IX=1
0203            GO TO 60
            C   GOT SENS. APPROX 1
0204        58  CALL BACK (LELS(1,I),NUT)
0205            WRITE (NPRT,59) NUT,EG
0206        59  FORMAT (2X,6A1,5X,F6.3,5X,50H*** ELEMENT MAY BE REMOVED BY SETTING
               1 TO INFINITY.)
0207            NIND(I)=2
0208            IX=1
            C   RESTORE VALUE
0209        60  XN(I)=SV
0210        61  CONTINUE
0211            IF(IX.EQ.1) STOP
```

```
0212              CALL BACK (LELS(1,NL),NUT)                                     PR2 0289
0213              WRITE (NPRT,62) NUT                                            PR2 0290
0214          62  FORMAT (/,35H NO SENSITIVITIES WITHIN 3% OF  1 .,/,1X,6A1,40H MAY PR2 0291
                 1BE REMOVEC (I.E. SET TO ZERC     IF,19H SENSITIVITY < ZERO,/,29X,3PR2 0292
                 29HSET TO INFINITY IF SENSITIVITY > ZERO.))                     PR2 0293
0215              STOP                                                           PR2 0294
0216              END                                                            PR2 0295
```

```
0001          SUBROUTINE ATEIG (M,A,RR,RI,IANA,IA)
        C
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
        C
        C        COMPUTE EIGENVALUES OF UPPER HESSENBERG MATRIX A
        C        M=ORDER OF MATRIX A
        C        RR=REAL EIGENVALUE RESULTS ARRAY
        C        RI=IMAGINARY EIGENVALUE ARRAY
        C        IANA=COMPUTE METHID ARRAY(0 OR 2=DIRECT)
        C        IA=FIRST DIMENSION OF A MATRIX
        C
        C        IBM SSP ROUTINE
        C
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
        C
0002          IMPLICIT REAL*8(A-H,O-Z)
0003          DIMENSION A(1), RR(1), RI(1), PRR(2), PRI(2), IANA(1)
0004          INTEGER*4 P,P1,Q
        C
0005          E7=1.0E-8
0006          E6=1.0E-6
0007          E10=1.0E-10
0008          DELTA=0.5
0009          MAXIT=30
        C
        C        INITIALIZATION
        C
0010          N=M
0011     1    N1=N-1
0012          IN=N1*IA
0013          NN=IN+N
0014          IF(N1) 2,69,2
0015     2    NP=N+1
        C
        C        ITERATION COUNTER
        C
0016          IT=0
        C
        C        ROOTS OF THE 2ND ORDER MAIN SUBMATRIX AT THE PREVIOUS
        C        ITERATION
        C
0017          DO 3 I=1,2
0018          PRR(I)=0.0
0019     3    PRI(I)=0.0
        C
        C        LAST TWO SUBDIAGONAL ELEMENTS AT THE PREVIOUS ITERATION
        C
0020          PAN=0.0
```

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```
0021                PAN1=0.0
              C
              C        ORIGIN SHIFT
              C
0022                R=0.0
0023                S=0.0
              C
              C        ROOTS OF THE LOWER MAIN 2 BY 2 SUBMATRIX
              C
0024                N2=N1-1
0025                IN1=IN-IA
0026                NN1=IN1+N
0027                N1N=IN+N1
0028                N1N1=IN1+N1
0029           4    T=A(N1N1)-A(NN)
0030                U=T*T
0031                V=4.0*A(N1N)*A(NN1)
0032                IF(DABS(V)-U*E7) 11,11,5
0033           5    T=U+V
0034                IF(DABS(T)-DMAX1(U,DABS(V))*E6) 6,6,7
0035           6    T=0.0
0036           7    U=(A(N1N1)+A(NN))/2.0
0037                V=DSQRT(DABS(T))/2.0
0038                IF(T) 15,8,8
0039           8    IF(U) 10,9,9
0040           9    RR(N1)=U+V
0041                RR(N)=U-V
0042                GO TO 14
0043          10    RR(N1)=U-V
0044                RR(N)=U+V
0045                GO TO 14
0046          11    IF(T) 13,12,12
0047          12    RR(N1)=A(N1N1)
0048                RR(N)=A(NN)
0049                GO TO 14
0050          13    RR(N1)=A(NN)
0051                RR(N)=A(N1N1)
0052          14    RI(N)=0.0
0053                RI(N1)=0.0
0054                GO TO 16
0055          15    RR(N1)=U
0056                RR(N)=U
0057                RI(N1)=V
0058                RI(N)=-V
0059          16    IF(N2) 68,68,17
              C
              C        TESTS OF CONVERGENCE
              C
```

```
0060      17   N1N2=N1N1-IA
0061           RMOD=RR(N1)*RR(N1)+RI(N1)*RI(N1)
0062           EPS=E10*DSQRT(RMOD)
0063           IF(DABS(A(N1N2))-EPS) 68,68,18
0064      18   IF(DABS(A(NN1))-E10*DABS(A(NN))) 69,69,19
0065      19   IF(DABS(PAN1-A(N1N2))-DABS(A(N1N2))*E6) 67,67,20
0066      20   IF(DABS(PAN-A(NN1))-DABS(A(NN1))*E6) 67,67,21
0067      21   IF(IT-MAXIT) 22,67,67
         C
         C        COMPUTE THE SHIFT
         C
0068      22   J=1
0069           DO 24 I=1,2
0070           K=NP-I
0071           IF(DABS(RR(K)-PRR(I))+DABS(RI(K)-PRI(I))-DELTA*(DABS(RR(K))+DABS(R
              1I(K)))) 23,24,24
0072      23   J=J+I
0073      24   CONTINUE
0074           GO TO (25,26,26,27), J
0075      25   R=0.0
0076           S=0.0
0077           GO TO 28
0078      26   J=N+2-J
0079           R=RR(J)*RR(J)
0080           S=RR(J)+RR(J)
0081           GO TO 28
0082      27   R=RR(N)*RR(N1)-RI(N)*RI(N1)
0083           S=RR(N)+RR(N1)
         C
         C        SAVE THE LAST TWO SUBDIAGONAL TERMS AND THE ROOTS OF THE
         C        SUBMATRIX BEFORE ITERATION
         C
0084      28   PAN=A(NN1)
0085           PAN1=A(N1N2)
0086           DO 29 I=1,2
0087           K=NP-I
0088           PRR(I)=RR(K)
0089      29   PRI(I)=RI(K)
         C
         C        SEARCH FOR A PARTITION OF THE MATRIX, DEFINED BY P AND Q
         C
0090           P=N2
0091           IF(N-3) 35,35,30
0092      30   IPI=N1N2
0093           DO 34 J=2,N2
0094           IPI=IPI-IA-1
0095           IF(DABS(A(IPI))-EPS) 35,35,31
0096      31   IPIP=IPI+IA
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```
0097          IPIP2=IPIP+IA
0098          D=A(IPIP)*(A(IPIP)-S)+A(IPIP2)*A(IPIP+1)+R
0099          IF(D) 32,33,32
0100      32  IF(DABS(A(IPI)*A(IPIP+1))*(DABS(A(IPIP)+A(IPIP2+1)-S)+DABS(A(IPIP2
             1+2)))-DABS(D)*EPS) 36,36,33
0101      33  P=N1-J
0102      34  CONTINUE
0103      35  Q=P
0104          GO TO 39
0105      36  P1=P-1
0106          Q=P1
0107          IF(P1-1) 39,39,37
0108      37  DO 38 I=2,P1
0109          IPI=IPI-IA-1
0110          IF(DABS(A(IPI))-EPS) 39,39,38
0111      38  Q=Q-1
        C
        C        QR DOUBLE ITERATION
        C
0112      39  II=(P-1)*IA+P
0113          DO 66 I=P,N1
0114          II1=II-IA
0115          IIP=II+IA
0116          IF(I-P) 41,40,41
0117      40  IPI=II+1
0118          IPIP=IIP+1
        C
        C        INITIALIZATION OF THE TRANSFORMATION
        C
0119          G1=A(II)*(A(II)-S)+A(IIP)*A(IPI)+R
0120          G2=A(IPI)*(A(IPIP)+A(II)-S)
0121          G3=A(IPI)*A(IPIP+1)
0122          A(IPI+1)=0.0
0123          GO TO 44
0124      41  G1=A(II1)
0125          G2=A(II1+1)
0126          IF(I-N2) 42,42,43
0127      42  G3=A(II1+2)
0128          GO TO 44
0129      43  G3=0.0
0130      44  CAP=DSQRT(G1*G1+G2*G2+G3*G3)
0131          IF(CAP) 45,48,45
0132      45  IF(G1) 46,47,47
0133      46  CAP=-CAP
0134      47  T=G1+CAP
0135          PSI1=G2/T
0136          PSI2=G3/T
0137          ALPHA=2.0/(1.0+PSI1*PSI1+PSI2*PSI2)
```

```
0138                GO TO 49                                      PR2 0488
0139          48    ALPHA=2.0                                     PR2 0489
0140                PSI1=0.0                                      PR2 0490
0141                PSI2=0.0                                      PR2 0491
0142          49    IF(I-Q) 50,53,50                              PR2 0492
0143          50    IF(I-P) 51,52,51                              PR2 0493
0144          51    A(III)=-CAP                                   PR2 0494
0145                GO TO 53                                      PR2 0495
0146          52    A(III)=-A(III)                                PR2 0496
              C                                                   PR2 0497
              C        ROW OPERATION                              PR2 0498
              C                                                   PR2 0499
0147          53    IJ=II                                         PR2 0500
0148                DO 57 J=I,N                                   PR2 0501
0149                T=PSI1*A(IJ+1)                                PR2 0502
0150                IF(I-N1) 54,55,55                             PR2 0503
0151          54    IP2J=IJ+2                                     PR2 0504
0152                T=T+PSI2*A(IP2J)                              PR2 0505
[illegible]   55    ETA=ALPHA*(T+A(IJ))                           PR2 0506
[illegible]         A(IJ)=A(IJ)-ETA                               PR2 0507
[illegible]         A(IJ+1)=A(IJ+1)-PSI1*ETA                      PR2 0508
[illegible]         IF(I-N1) 56,57,57                             PR2 0509
0157          56    A(IP2J)=A(IP2J)-PSI2*ETA                      PR2 0510
0158          57    IJ=IJ+IA                                      PR2 0511
              C                                                   PR2 0512
              C        COLUMN OPERATION                           PR2 0513
              C                                                   PR2 0514
0159                IF(I-N1) 59,58,58                             PR2 0515
0160          58    K=N                                           PR2 0516
0161                GO TO 60                                      PR2 0517
0162          59    K=I+2                                         PR2 0518
0163          60    IP=IIP-I                                      PR2 0519
0164                DO 64 J=Q,K                                   PR2 0520
0165                JIP=IP+J                                      PR2 0521
0166                JI=JIP-IA                                     PR2 0522
0167                T=PSI1*A(JIP)                                 PR2 0523
0168                IF(I-N1) 61,62,62                             PR2 0524
0169          61    JIP2=JIP+IA                                   PR2 0525
0170                T=T+PSI2*A(JIP2)                              PR2 0526
0171          62    ETA=ALPHA*(T+A(JI))                           PR2 0527
0172                A(JI)=A(JI)-ETA                               PR2 0528
0173                A(JIP)=A(JIP)-ETA*PSI1                        PR2 0529
0174                IF(I-N1) 63,64,64                             PR2 0530
0175          63    A(JIP2)=A(JIP2)-ETA*PSI2                      PR2 0531
0176          64    CONTINUE                                      PR2 0532
0177                IF(I-N2) 65,66,66                             PR2 0533
0178          65    JI=II+3                                       PR2 0534
0179                JIP=JI+IA                                     PR2 0535
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```
0180           JIP2=JIP+IA
0181           ETA=ALPHA*PSI2*A(JIP2)
0182           A(JI)=-ETA
0183           A(JIP)=-ETA*PSI1
0184           A(JIP2)=A(JIP2)-ETA*PSI2
0185     66    II=IIP+1
0186           IT=IT+1
0187           GO TO 4
        C
        C         END OF ITERATION
        C
0188     67    IF(DABS(A(NN1))-DABS(A(N1N2))) 69,68,68
        C
        C         TWO EIGENVALUES HAVE BEEN FOUND
        C
0189     68    IANA(N)=0
0190           IANA(N1)=2
0191           N=N2
0192           IF(N2) 71,71,1
        C
        C         ONE EIGENVALUE HAS BEEN FOUND
        C
0193     69    RR(N)=A(NN)
0194           RI(N)=0.0
0195           IANA(N)=1
0196           IF(N1) 71,71,70
0197     70    N=N1
0198           GO TO 1
0199     71    RETURN
0200           END
```

```
      SUBROUTINE BACK (NAME,NCHAR)
C
C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
C     CHANGE NAME TO NCHAR IN MECHANICAL FORMAT .
C     CHANGES
C     GP=TP      DXXX=ZXXX AND CHANGE XXX
C     I=F EXCEPT ICW=TJ
C     V=V EXCEPT VCW=WJ
C     ELEMENTS
C     CU=M    EU=U    JU=R    LU=K    RU=D
C     CW=J    EW=G    JW=C
C
C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
      DIMENSION NEL(5), NELF(8), NST(2), NSTF(4), NCHAR(6), NAME(6)
      EQUIVALENCE (NG,NELF(7)), (ND,NELF(5)), (NT,NSTF(3))
      EQUIVALENCE (NU,NELF(2)), (NC,NELF(8)), (NW,NSTF(4))
      DATA NEL/1HC,1HE,1HJ,1HL,1HR/
      DATA NELF/1HM,1HU,1HR,1HK,1HD,1HJ,1HG,1HC/
      DATA NST/1HI,1HV/
      DATA NSTF/1HF,1HV,1HT,1HW/
      DATA NZ/1HZ/,NP/1HP/,NBL/1H /
      KST=1
      KN=0
      DO 1 I=1,6
      IF(NAME(I).NE.NBL) KN=KN+1
    1 NCHAR(I)=NAME(I)
      IF(KN.LE.1) RETURN
      IF(NCHAR(1).NE.NG.OR.NCHAR(2).NE.NP) GO TO 3
      NCHAR(1)=NT
    2 RETURN
    3 DO 4 KINS=1,4
      KLOC=KN-KINS+1
      IF(KLOC.LE.1) RETURN
      IF(NCHAR(KLOC).EQ.NU.OR.NCHAR(KLOC).EQ.NW) GO TO 5
    4 CONTINUE
      RETURN
    5 IF(NCHAR(1).NE.ND) GO TO 6
      NCHAR(1)=NZ
      KST=2
    6 DO 7 K1=1,2
      IF(NCHAR(KST).NE.NST(K1)) GO TO 7
      NCHAR(KST)=NSTF(K1)
      KST=KST+1
      IF(NCHAR(KST).EQ.NC.AND.NCHAR(KLOC).EQ.NW) NCHAR(KST-1)=NSTF(K1+2)
      GO TO 8
    7 CONTINUE
```

```
 8    KEL=5                                                   PR2 0614
      KELF=0                                                  PR2 0615
      IF(NCHAR(KLOC).EQ.NU) GO TO 9                           PR2 0616
      KEL=3                                                   PR2 0617
      KELF=5                                                  PR2 0618
 9    DO 10 K1=1,KEL                                          PR2 0619
      IF(NCHAR(KST).NE.NEL(K1)) GO TO 10                      PR2 0620
      NCHAR(KST)=NELF(K1+KELF)                                PR2 0621
      GO TO 11                                                PR2 0622
 10   CONTINUE                                                PR2 0623
      RETURN                                                  PR2 0624
 11   IF(KLOC.EQ.KN) GO TO 13                                 PR2 0625
      KELF=KN-KLOC                                            PR2 0626
      DO 12 K1=1,KELF                                         PR2 0627
 12   NCHAR(KLOC+K1-1)=NCHAR(KLOC+K1)                         PR2 0628
 13   NCHAR(KN)=NBL                                           PR2 0629
      GO TO 2                                                 PR2 0630
      END                                                     PR2 0631
```

```
0001              SUBROUTINE EIGAN (ER,EI)
            C
            C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
            C
            C     SUPERVISE COMPUTATION OF EIGENVALUES
            C     FROM SCEPTRE ROUTINE SIMTR
            C
            C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
            C
0002              IMPLICIT REAL*8(A-H,0-Z)
0003              COMMON /CNTRLS/ TIME,S1(21),XNCPRQ,S2,XNHEAD,S3(6),XRUNNO,S4(11),XP
                 1WRTSM,S5(46),XNEY,XNE7DT,XNBC,XNBR,XNBL,XNLC,XNLR,XNLL,XNJX,XNJ8DT
                 2,XNJ3,XNJ9,S6(2),XNM33,XNM36,XNM66,XNDP,XNDPD,XNELTS,S7(50)
0004              COMMON /CURNTS/ C(1)
0005              COMMON /DERIVS/ D(1)
0006              COMMON /NAMES/ XN(1)
0007              COMMON /OUTPUT/ OUTP(1)
0008              COMMON /TAPES/ NPRT,NDTA,NPGM
0009              COMMON /VOLTGS/ V(1)
0010              COMMON /PROSE/ A(50,50),B(50,50),L3P,L3S,L4P,L4S,NSV,NEJ,NEL,NIND(
                 1300),IPERM(50)
            C
0011              DIMENSION ER(50), EI(50), XA(50,50), SSV(50)
            C
            C     BEGIN CODE
            C
            C     SET UP INITIAL CONSTANT OFFSETS
0012              CALL SIMTR (KDUM,0)
0013              DO 1 I=1,NSV
0014          1   SSV(I)=D(I)
            C     LOOP THRU STATE VARIABLES
            C     THRU TYPE 3'S FIRST
0015              IF(L3S.GT.L3P) GO TO 4
0016              DO 3 I=L3S,L3P
0017              C(I)=1.D0
            C     COMPUTE DERIVATIVES
0018              CALL SIMTR (KDUM,0)
            C     FORM AN A MATRIX ROW
0019              DO 2 J=1,NSV
0020          2   A(J,I-L3S+1)=D(J)-SSV(J)
0021          3   C(I)=0.D0
            C     THRU TYPE 4 STATE VARIABLES
0022          4   IF(L4S.GT.L4P) GO TO 7
0023              DO 6 I=L4S,L4P
0024              V(I)=1.D0
0025              CALL SIMTR (KDUM,0)
0026              DO 5 J=1,NSV
0027          5   A(J,I+L3P-L3S-L4S+2)=D(J)-SSV(J)
```

```
      6   V(I)=0.0D0                                             PR2 0680
C         FORM B MATRIX IF NECESSARY                             PR2 0681
      7   IF(NEJ.EQ.0) GO TO 10                                  PR2 0682
          II=1                                                   PR2 0683
          DO 9 I=1,NEL                                           PR2 0684
          IF(NIND(I).NE.1) GO TO 9                               PR2 0685
          XN(I)=1.0D0                                            PR2 0686
          CALL SIMTR (KOUM,0)                                    PR2 0687
          DO 8 J=1,NSV                                           PR2 0688
      8   B(J,II)=D(J)-SSV(J)                                    PR2 0689
          II=II+1                                                PR2 0690
          XN(I)=0.0D0                                            PR2 0691
      9   CONTINUE                                               PR2 0692
C         FORM EIGEN VALUES                                      PR2 0693
C         USE ANOTHER ARRAY (SINCE A IS DESTROYED BY HSBG)       PR2 0694
     10   DO 11 I=1,NSV                                          PR2 0695
          DO 11 J=1,NSV                                          PR2 0696
     11   XA(I,J)=A(I,J)                                         PR2 0697
          CALL HSBG (NSV,XA,50)                                  PR2 0698
          CALL ATEIG (NSV,XA,ER,EI,IPERF,50)                     PR2 0699
          RETURN                                                 PR2 0700
          END                                                    PR2 0701
```

```
0001              SUBROUTINE HSBG (N,A,IA)
          C
          C       <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
          C
          C       REDUCE A MATRIX TO UPPER HESSENBERG FORM
          C       N=ORDER OF A, IA=FIRST DIMENSION OF A
          C       IBM SSP ROUTINE
          C
          C       <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
          C
0002              IMPLICIT REAL*8(A-H,O-Z)
0003              DIMENSION A(1)
0004              L=N
0005              NIA=L*IA
0006              LIA=NIA-IA
          C
          C          L IS THE ROW INDEX OF THE ELIMINATION
          C
0007          1   IF(L-3) 19,2,2
0008          2   LIA=LIA-IA
0009              L1=L-1
0010              L2=L1-1
          C
          C          SEARCH FOR THE PIVOTAL ELEMENT IN THE LTH ROW
          C
0011              ISUB=LIA+L
0012              IPIV=ISUB-IA
0013              PIV=DABS(A(IPIV))
0014              IF(L-3) 6,6,3
0015          3   M=IPIV-IA
0016              DO 5 I=L,M,IA
0017              T=DABS(A(I))
0018              IF(T-PIV) 5,5,4
0019          4   IPIV=I
0020              PIV=T
0021          5   CONTINUE
0022          6   IF(PIV) 7,18,7
0023          7   IF(PIV-DABS(A(ISUB))) 11,11,8
          C
          C          INTERCHANGE THE COLUMNS
          C
0024          8   M=IPIV-L
0025              DO 9 I=1,L
0026              J=M+I
0027              T=A(J)
0028              K=LIA+I
0029              A(J)=A(K)
0030          9   A(K)=T
```

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```
                C
                C       INTERCHANGE THE ROWS
                C
 0031                 M=L2-M/IA
 0032                 DO 10 I=L1,NIA,IA
 0033                 T=A(I)
 0034                 J=I-M
 0035                 A(I)=A(J)
 0036             10  A(J)=T
                C
                C       TERMS OF THE ELEMENTARY TRANSFORMATION
                C
 0037             11  DO 12 I=L,LIA,IA
 0038             12  A(I)=A(I)/A(ISUB)
                C
                C       RIGHT TRANSFORMATION
                C
 0039                 J=-IA
 0040                 DO 14 I=1,L2
 0041                 J=J+IA
 0042                 LJ=L+J
 0043                 DO 13 K=1,L1
 0044                 KJ=K+J
 0045                 KL=K+LIA
 0046             13  A(KJ)=A(KJ)-A(LJ)*A(KL)
 0047             14  CONTINUE
                C
                C       LEFT TRANSFORMATION
                C
 0048                 K=-IA
 0049                 DO 16 I=1,N
 0050                 K=K+IA
 0051                 LK=K+L1
 0052                 S=A(LK)
 0053                 LJ=L-IA
 0054                 DO 15 J=1,L2
 0055                 JK=K+J
 0056                 LJ=LJ+IA
 0057             15  S=S+A(LJ)*A(JK)*1.0D0
 0058             16  A(LK)=S
                C
                C       SET THE LOWER PART OF THE MATRIX TO ZERO
                C
 0059                 DO 17 I=L,LIA,IA
 0060             17  A(I)=0.0
 0061             18  L=L1
 0062                 GO TO 1
 0063             19  RETURN
```

```
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 0064                END                                                        PR2 0798
```

```
0001              SUBROUTINE INTGR8                                                       PR2 0799
             C    <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 0800
             C                                                                            PR2 0801
             C    DUMMY INTGR8 ROUTINE                                                    PR2 0802
             C                                                                            PR2 0803
             C    <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 0804
0002              RETURN                                                                  PR2 0805
0003              END                                                                     PR2 0806
```

```
0001             SUBROUTINE INVERS (NAMMAT,AMAT,NR,NC,IERROR)
0002             IMPLICIT REAL*8(A-H,O-Z),INTEGER*4(I-N)
           C
           C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
           C
           C                   INNAMMAT = NAME OF MATRIX TO BE OPERATED ON
           C                       AMAT = THE MATRIX TO BE SOLVED OR INVERTED
           C                         NR = THE NUMBER OF ROWS IN AMAT
           C                         NC = THE NUMBER OF COLUMNS IN AMAT
           C                                   A( NC = NR + 1 FOR EQUATION SOULUION
           C                                   B( NC = 2 * NR FOR MATRIX INVERSION
           C                     IERROR = ONE IF THE MATRIX IS SINGULAR,OTHERWISE ZERO
           C
           C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
           C
0003             REAL*4 NAMMAT
0004             COMMON /TAPES/ NOUTTP,INTAPE,LIBTP,INOUTP,NEDITP,NSAVTP
0005             COMMON /CNTRLS/ TIME,XSTOPT,XMXERT,XIR,XTISSS,XMNISS,XMXISS,XMNAIE
                1,XMXAIE,XIC,XRERNO,XMXPAS,XMNRIE,XMXRIE,XMNISC,XMXICP,XICRER,XICAE
                2R,XMXCTP,XXDIMS,XYDIMS,XICPAS,XNOPRQ,XNTNDX,XNHEAD,XNOFEQ,XERT,XNRP
                3ERN,XCNTNL,XSTPNC,XPASNO,XRUNNC,XSTPSZ
0006             DIMENSION AMAT(NR,NC)
0007             EQUIVALENCE (NOUTTP,OUTAPE)
0008             INTEGER OUTAPE
0009             IF(XICPAS.LE.XMXICP) GO TO 2
0010             WRITE (NOUTTP,1) XMXICP
0011       1     FORMAT (34H1THE NEWTON-RAPHSON PASS LIMIT OF ,F5.0,48H HAS BEEN EX
                1CEEDED WITHOUT ATTAINING CONVERGENCE)
0012             IERROR=10
0013             GO TO 20
0014       2     IERROR=0
0015             NRX2=2*NR
0016             INK=NR
0017             IF(NRX2.NE.NC) INK=NC
           C      CHECK FOR 1X1 MATRIX AND SOLVE IF FOUND
0018             IF(NR.NE.1) GO TO 3
0019             AMAT(1,2)=AMAT(1,2)/AMAT(1,1)
0020             GO TO 20
0021       3     NR2=2*NR
           C      IF MATRIX INVERSION DESIRED, GENERATE IDENTITY MATRIX
0022             IF(NC.LT.NR2) GO TO 6
0023             JINC=NR+1
0024             DO 5 INCR=1,NR
0025             INCROW=INCR+NR
0026             DO 5 INCOLM=JINC,NC
0027             IF(INCOLM.EQ.INCROW) GO TO 4
0028             AMAT(INCR,INCOLM)=0.
0029             GO TO 5
```

```fortran
    4    AMAT(INCR,INCOLM)=1.
    5    CONTINUE
    6    DO 19 I=1,NR
         M=I+1
         J=I
C         CHECK FOR LAST DIAGONAL ELEMENT
         IF(I.EQ.NR) GO TO 9
C         FIND THE LARGEST VALUE BELOW DIAGONAL ELEMENT IN THIS COLUMN
         DO 8 N=M,NR
         IF(DABS(AMAT(J,I))-DABS(AMAT(N,I))) 7,8,8
    7    J=N
    8    CONTINUE
C         SEE IF THE LARGEST ELEMENT IN ROW IS ZERO
    9    IF(AMAT(J,I)) 12,10,12
C         INDICATES THAT MATRIX IS SINGULAR
   10    IERROR=11
         WRITE (NOUTTP,11) NAMMAT
   11    FORMAT (8H MATRIX ,A4,12H IS SINGULAR)
         GO TO 20
C         SEE IF ROW INTERCHANGE IS NEEDED TO GET LARGEST ELEMENT ON DIAG.
   12    IF(J-I) 15,15,13
C         INTERCHANGE ROWS OF DIAGONAL AND THOSE TO THE RIGHT OF IT
   13    DO 14 N=I,NC
         SAVE=AMAT(I,N)
         AMAT(I,N)=AMAT(J,N)
   14    AMAT(J,N)=SAVE
   15    DIAG=AMAT(I,I)
C         DIVIDE ALL ELEMENTS TO RIGHT OF DIAG. IN DIAG. ROW BY DIAG. ELEM.
         DO 16 J=M,NC
   16    AMAT(I,J)=AMAT(I,J)/DIAG
         AMAT(I,I)=0.
         DO 18 K=1,NR
         IF(AMAT(K,I).EQ.0.) GO TO 18
         IP=I+1
         DO 17 J=IP,NC
   17    AMAT(K,J)=AMAT(K,J)-AMAT(K,I)*AMAT(I,J)
   18    CONTINUE
   19    CONTINUE
   20    CONTINUE
         RETURN
         END
```

```
0001             SUBROUTINE OUTP                                                PR2 0896
           C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 0897
           C                                                                    PR2 0898
           C     DUMMY OUTP ROUTINE                                             PR2 0899
           C                                                                    PR2 0900
           C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 0901
0002             RETURN                                                         PR2 0902
0003             END                                                            PR2 0903
```

```
0001          SUBROUTINE SAVEPD
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
        C
        C     DUMMY SAVEPD ROUTINE
        C
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
0002          RETURN
0003          END
```

```
0001          SUBROUTINE SETUP2 (NAC,LELS,NSRC,NTAB)                            PR2 0912
        C                                                                       PR2 0913
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 0914
        C                                                                       PR2 0915
        C     SETUP ROUTINE                                                     PR2 0916
        C                                                                       PR2 0917
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 0918
        C                                                                       PR2 0919
0002          IMPLICIT REAL*8(A-H,O-Z)                                          PR2 0920
0003          COMMON /CNTRLS/ TIME,S1(21),XNCPRQ,S2,XNHEAD,S3(6),XRUNNO,S4(11),XPR2 0921
             1WRTSM,S5(46),XNEY,XNE7DT,XNBC,XNBR,XNBL,XNLC,XNLR,XNLL,XNJX,XNJ8DTPR2 0922
             2,XNJO,XNJ9,S6(2),XNM33,XNM36,XNM66,XNDP,XNDPD,XNELTS,S7(50)       PR2 0923
0004          COMMON /TAPES/ NPRT,NDTA,NPGM                                     PR2 0924
0005          DIMENSION LELS(6,300)                                             PR2 0925
0006          DIMENSION NSIMTR(5), NSRCDR(6), NTABLE(6), NNDPD(3)               PR2 0926
0007          DIMENSION NCUTPT(6), NXMUTL(5), NNAMES(5), NPRMTR(6)              PR2 0927
0008          DIMENSION NIONBX(5), NDERIV(6), NRAY(80), CTROLS(160)             PR2 0928
0009          DIMENSION NUMS(10), LOCS(8)                                       PR2 0929
0010          DATA NSIMTR/1HS,1HI,1HM,1HT,1HR/                                  PR2 0930
0011          DATA NSRCDR/1HS,1HR,1HC,1HD,1HR,1HV/                              PR2 0931
0012          DATA NTABLE/1HT,1HA,1HB,1HL,1HE,1HS/                              PR2 0932
0013          DATA NNDPD/1H ,1HD,1HP/                                           PR2 0933
0014          DATA NCUTPT/1HC,1HU,1HT,1HP,1HT,1HS/                              PR2 0934
0015          DATA NXMUTL/1HX,1HM,1HU,1HT,1HL/                                  PR2 0935
0016          DATA NNAMES/1HN,1HA,1HM,1HE,1HS/                                  PR2 0936
0017          DATA NPRMTR/1HP,1HR,1HM,1HT,1HR,1HS/                              PR2 0937
0018          DATA NIONBX/1HI,1HO,1HN,1H ,1HX/                                  PR2 0938
0019          DATA NDERIV/1HD,1HE,1HR,1HI,1HV,1HS/                              PR2 0939
0020          DATA LOCS/96,97,98,93,94,95,92,100/                               PR2 0940
0021          DATA NUMS/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/                PR2 0941
0022          DATA NAST/1H*/                                                    PR2 0942
0023          EQUIVALENCE (TIME,CTROLS(1))                                      PR2 0943
0024          EQUIVALENCE (NCOM,NNDPD(1))                                       PR2 0944
0025          EQUIVALENCE (NBLK,NIONBX(4))                                      PR2 0945
0026          NTAB=0                                                            PR2 0946
0027          NSRC=0                                                            PR2 0947
0028        1 READ (NPGM,2,END=33) NRAY                                         PR2 0948
0029        2 FORMAT (80A1)                                                     PR2 0949
0030          IF(LOCATE(NRAY,NSIMTR,9,5).EQ.1) GO TO 1                          PR2 0950
0031          READ (NPGM,3) NRAY                                                PR2 0951
0032        3 FORMAT (////////,80A1)                                            PR2 0952
0033          NAC=70                                                            PR2 0953
0034          IF(NRAY(6).EQ.NAST) NAC=160                                       PR2 0954
0035          READ (NDTA,4,END=35) (CTROLS(I),I=1,NAC)                          PR2 0955
0036        4 FORMAT (1P5D14.7)                                                 PR2 0956
0037          IF(NAC.EQ.160) GO TO 6                                            PR2 0957
0038          DO 5 I=71,160                                                     PR2 0958
0039        5 CTROLS(I)=0.0D0                                                   PR2 0959
```

```
    6     READ (NPGM,2) NRAY                                   PR2 0960
    7     IF(LOCATE(NRAY,NSRCDR,15,6).EQ.0) GO TO 9            PR2 0961
          IF(LOCATE(NRAY,NTABLE,15,6).EQ.0) GO TO 11           PR2 0962
          IF(NAC.EQ.160) GO TO 8                               PR2 0963
          IF(LOCATE(NRAY,NXMUTL,15,5).EQ.0) GO TO 12           PR2 0964
          IF(LOCATE(NRAY,NNAMES,15,5).EQ.0) GO TO 14           PR2 0965
          IF(LOCATE(NRAY,NPRMTR,15,6).EQ.0) GO TO 21           PR2 0966
          IF(LOCATE(NRAY,NDERIV,15,6).EQ.0) GO TO 23           PR2 0967
          IF(LOCATE(NRAY,NIONBX,13,5).EQ.0) GO TO 25           PR2 0968
    8     IF(LOCATE(NRAY,NCUTPT,15,6).EQ.0) GO TO 32           PR2 0969
          GO TO 6                                              PR2 0970
    9     K=22                                                 PR2 0971
   10     NHOL=NCNT(NRAY,K)                                    PR2 0972
          NSRC=NSRC+NHOL                                       PR2 0973
          IF(NRAY(72).EQ.NBLK) GO TO 6                         PR2 0974
          READ (NPGM,2) NRAY                                   PR2 0975
          IF(NRAY(6).NE.NAST) GO TO 7                          PR2 0976
          K=7                                                  PR2 0977
          GO TO 10                                             PR2 0978
   11     NTAB=NUMB(NRAY,25,27,K)                              PR2 0979
          GO TO 6                                              PR2 0980
   12     K=21                                                 PR2 0981
   13     NHOL=NCNT(NRAY,K)                                    PR2 0982
          XNM33=XNM33+NHOL                                     PR2 0983
          IF(NRAY(72).EQ.NBLK) GO TO 6                         PR2 0984
          READ (NPGM,2) NRAY                                   PR2 0985
          IF(NRAY(6).NE.NAST) GO TO 7                          PR2 0986
          K=7                                                  PR2 0987
          GO TO 13                                             PR2 0988
   14     NELTS=0                                              PR2 0989
          I=21                                                 PR2 0990
          N=1                                                  PR2 0991
   15     DO 16 J=1,6                                          PR2 0992
   16     LELS(J,NELTS+1)=NBLK                                 PR2 0993
   17     IF(NRAY(I).EQ.NCOM) GO TO 18                         PR2 0994
          LELS(N,NELTS+1)=NRAY(I)                              PR2 0995
          IF(NRAY(I).EQ.NBLK) GO TO 19                         PR2 0996
          N=N+1                                                PR2 0997
          I=I+1                                                PR2 0998
          IF(I.LE.72) GO TO 17                                 PR2 0999
          READ (NPGM,2) NRAY                                   PR2 1000
          IF(NRAY(6).NE.NAST) GO TO 20                         PR2 1001
          I=7                                                  PR2 1002
          GO TO 17                                             PR2 1003
   18     NELTS=NELTS+1                                        PR2 1004
          XNELTS=NELTS                                         PR2 1005
          N=1                                                  PR2 1006
          I=I+1                                                PR2 1007
```

```
0088          IF(I.LE.72) GO TO 15                                              PR2 1008
0089          READ (NPGM,2) NRAY                                                PR2 1009
0090          IF(NRAY(6).NE.NAST) GO TO 7                                       PR2 1010
0091          I=7                                                               PR2 1011
0092          GO TO 15                                                          PR2 1012
0093    19    NELTS=NELTS+1                                                     PR2 1013
0094          XNELTS=NELTS                                                      PR2 1014
0095          GO TO 6                                                           PR2 1015
0096    20    NELTS=NELTS+1                                                     PR2 1016
0097          XNELTS=NELTS                                                      PR2 1017
0098          GO TO 7                                                           PR2 1018
0099    21    K=22                                                              PR2 1019
0100    22    NHOL=NCNT(NRAY,K)                                                 PR2 1020
0101          XNDP=XNDP+NHOL                                                    PR2 1021
0102          IF(NRAY(72).EQ.NBLK) GO TO 6                                      PR2 1022
0103          READ (NPGM,2) NRAY                                                PR2 1023
0104          IF(NRAY(6).NE.NAST) GO TO 7                                       PR2 1024
0105          K=7                                                               PR2 1025
0106          GO TO 22                                                          PR2 1026
0107    23    DO 24 I=22,70                                                     PR2 1027
0108          IF(LOCATE(NRAY,NNDPD,I,3).EQ.0) XNDPD=XNDPD+1                     PR2 1028
0109    24    CONTINUE                                                          PR2 1029
0110          GO TO 6                                                           PR2 1030
0111    25    IF(NRAY(18).EQ.NRAY(9)) GO TO 6                                   PR2 1031
0112          K=19                                                              PR2 1032
0113    26    IF(NRAY(K).EQ.NBLK) GO TO 6                                       PR2 1033
0114          DO 27 I=2,10                                                      PR2 1034
0115          IF(NRAY(K).EQ.NUMS(I)) GO TO 29                                   PR2 1035
0116    27    CONTINUE                                                          PR2 1036
0117          WRITE (NPRT,28) NRAY,K                                            PR2 1037
0118    28    FORMAT (42H *** ERROR *** - - INVALID NUMBER IN SIMTR,/,80A1,6H  CPR2 1038
             1OL=,I3)                                                           PR2 1039
0119          STOP 8                                                            PR2 1040
0120    29    J=I-1                                                             PR2 1041
0121          K=K+2                                                             PR2 1042
0122    30    IF(K.GT.72) READ (NPGM,2) NRAY                                    PR2 1043
0123          IF(K.GT.72) K=K-72+6                                              PR2 1044
0124          IF(NRAY(K).EQ.NBLK) GO TO 31                                      PR2 1045
0125          K=K+2                                                             PR2 1046
0126          GO TO 30                                                          PR2 1047
0127    31    KST=K                                                             PR2 1048
0128          KEN=K+2                                                           PR2 1049
0129          CTROLS(LOCS(J))=NUMB(NRAY,KST,KEN,K)                              PR2 1050
0130          K=KEN+5                                                           PR2 1051
0131          IF(K.LE.72) GO TO 26                                              PR2 1052
0132          READ (NPGM,2) NRAY                                                PR2 1053
0133          IF(NRAY(6).NE.NAST) GO TO 7                                       PR2 1054
0134          K=K-72+6                                                          PR2 1055
```

```
              GO TO 26                                                PR2 1056
       32     RETURN                                                  PR2 1057
       33     WRITE (NPRT,34)                                         PR2 1058
       34     FORMAT (39H *** ERROR *** - - END OF FILE IN SIMTR)     PR2 1059
              STOP 8                                                  PR2 1060
       35     WRITE (NPRT,36)                                         PR2 1061
       36     FORMAT (40H *** ERROR *** - - END OF FILE ON DTASAV)    PR2 1062
              STOP 8                                                  PR2 1063
              END                                                     PR2 1064
```

```
0001          SUBROUTINE TPHEAD                                                   PR2 1065
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 1066
        C                                                                         PR2 1067
        C     DUMMY TPHEAD ROUTINE                                                PR2 1068
        C                                                                         PR2 1069
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 1070
0002          RETURN                                                              PR2 1071
0003          END                                                                 PR2 1072
```

```
0001                SUBROUTINE XLOAD                                                       PR2 1073
             C      <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 1074
             C                                                                             PR2 1075
             C      DUMMY XLOAD ROUTINE                                                    PR2 1076
             C                                                                             PR2 1077
             C      <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PR2 1078
0002                RETURN                                                                 PR2 1079
0003                END                                                                    PR2 1080
```

```
0001                FUNCTION LOCATE (NRAY,NSTR,KSTR,KLEN)                         PR2 1081
              C                                                                   PR2 1082
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR2 1083
              C                                                                   PR2 1084
              C     LOCATE STRING (NSTR) IN ARRAY (NRAY) WITH                     PR2 1085
              C     LENGTH (KLEN) STARTING AT (KSTR).                             PR2 1086
              C     LOCATE=0 IF STRING FOUND                                      PR2 1087
              C     LOCATE=1 IF STRING NOT FOUND                                  PR2 1088
              C                                                                   PR2 1089
              C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR2 1090
              C                                                                   PR2 1091
0002                DIMENSION NRAY(80), NSTR(80)                                  PR2 1092
              C                                                                   PR2 1093
0003                LOCATE=1                                                      PR2 1094
0004                DO 1 I=1,KLEN                                                 PR2 1095
0005                KSTRIM=KSTR+I-1                                               PR2 1096
0006                IF(NRAY(KSTRIM).NE.NSTR(I)) RETURN                            PR2 1097
0007           1    CONTINUE                                                      PR2 1098
0008                LOCATE=0                                                      PR2 1099
0009                RETURN                                                        PR2 1100
0010                END                                                           PR2 1101
```

```
0001          FUNCTION NCNT (NRAY,NST)
      C
      C       <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
      C
      C       COUNT NUMBER OF COMMAS+1 IN ARRAY NRAY
      C       STARTING AT NST
      C
      C       <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
      C
0002          DIMENSION NRAY(80)
0003          DATA NBLK/1H /,NCOM/1H,/
0004          NCNT=1
0005          DO 1 I=NST,72
0006          IF(NRAY(I).EQ.NCOM) NCNT=NCNT+1
0007          IF(NRAY(I).EQ.NBLK) RETURN
0008          CONTINUE
0009          RETURN
0010          END
```

```
0001          FUNCTION NUMB (NRAY,KST,KEN,I)
        C
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
        C
        C     DECODE NUMBER AT KST IN NRAY UNITL KEN
        C
        C     <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
        C
0002          COMMON /TAPES/ NPRT,NDTA,NPGM
0003          DIMENSION NRAY(80), NUMS(10)
0004          DATA NUMS/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
0005          DATA NBLK/1H /
0006          NUMB=0
0007          DO 4 I=KST,KEN
0008          IF(I.LE.72) GO TO 2
0009          READ (NPGM,1) NRAY
0010        1 FORMAT (80A1)
0011          I=7
0012          KEN=KEN-72+6
0013        2 CONTINUE
0014          IF(NRAY(I).EQ.NBLK) GO TO 4
0015          DO 3 J=1,10
0016          IF(NRAY(I).NE.NUMS(J)) GO TO 3
0017          NUMB=NUMB*10+J-1
0018        3 CONTINUE
0019        4 CONTINUE
0020          RETURN
0021          END
```

```
0001          FUNCTION XTABLE (TABLE,X)                                   PR2 1148
0002          IMPLICIT REAL*8(A-H,O-Z),INTEGER*4(I-N)                     PR2 1149
        C                                                                 PR2 1150
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR2 1151
        C                                                                 PR2 1152
        C     FUNCTION TO PERFORM STRAIGHT LINE EXTRAPOLATION OF TABULAR DATA  PR2 1153
        C                                                                 PR2 1154
        C     <><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>PR2 1155
        C                                                                 PR2 1156
0003          DIMENSION TABLE(2)                                          PR2 1157
0004          LOOP=TABLE(1)-2.                                            PR2 1158
        C     LOOK FOR INTERVAL OR EXACT VALUE OF INDEPENDENT VARIABLE    PR2 1159
0005          DO 4 INDX=3,LOOP,2                                          PR2 1160
        C     TEST LOWER COORDINATE                                       PR2 1161
0006          IF(TABLE(INDX)-X) 1,2,5                                     PR2 1162
        C     TEST UPPER COORDINATE                                       PR2 1163
0007     1    IF(TABLE(INDX+2)-X) 4,3,5                                   PR2 1164
        C     EXACT MATCH TO LOW COORDINATE - EQUAT  AND RETURN           PR2 1165
0008     2    Y=TABLE(INDX+1)                                             PR2 1166
0009          GO TO 6                                                     PR2 1167
        C     EXACT MATCH TO UPPER COORDINATE - EQUAT AND RETURN          PR2 1168
0010     3    Y=TABLE(INDX+3)                                             PR2 1169
0011          GO TO 6                                                     PR2 1170
0012     4    CONTINUE                                                    PR2 1171
0013          INDX=LOOP-1                                                 PR2 1172
        C     PEFORM STRAIGHT LINE EXTRAPOLATION                          PR2 1173
        C     CALCULATE SLOPE                                             PR2 1174
0014     5    SLOPE=(TABLE(INDX+3)-TABLE(INDX+1))/(TABLE(INDX+2)-TABLE(INDX))  PR2 1175
        C     CALCULATE Y INTERCEPT                                       PR2 1176
0015          YINTR=TABLE(INDX+1)-SLOPE*TABLE(INDX)                       PR2 1177
        C     CALCULATE DEPENDENT VARIABLE                                PR2 1178
0016          Y=SLOPE*X+YINTR                                             PR2 1179
        C     OUTPUT PERTINANT VARIABLES                                  PR2 1180
0017     6    XTABLE=Y                                                    PR2 1181
0018          RETURN                                                      PR2 1182
0019          END                                                         PR2 1183
```