Atomics International Division
Rockwell International

U

CLASSIFICATION LEVEL
(S, C OR U)

DOCUMENT NO.

TI-652-240-008

COVER SHEET

DOCUMENT TITLE

Fuel Element Computerized Stress Analysis with Core
Force Balance

AUTHOR

R. A. Castle

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

THIS IS AN INTERNAL WORKING
DOCUMENT AND MAY BE
EXPANDED, MODIFIED, OR
WITHDRAWN AT ANY TIME.

~~IT IS INTENDED FOR
INTERNAL USE ONLY.~~

CLASSIFICATION TYPE
(RD OR DI)

~~THIS REPORT MAY NOT BE PUBLISHED WITHOUT THE APPROVAL OF THE PATENT BRANCH, AEC.~~

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

U

CLASSIFICATION LEVEL
(S, C OR U)

MASTER

DO NOT REMOVE THIS SHEET

DISTRIBUTION OF THIS DOCUMENT UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Atomica International
North American Rockwell

SUPPORTING DOCUMENT

NUMBER

TI-652-240-008

REV LTR/CHG NO.

SEE SUMMARY OF CHG

PROGRAM TITLE

5 Kwe Reactor T/E Unmanned System Test

DOCUMENT TYPE

Technical Information

KEY NOUNS

Stress Analysis

DOCUMENT TITLE

Fuel Element Computerized Stress Analysis
with Core Force Balance

ORIGINAL ISSUE DATE

8-25-72

GO NO.

S/A NO.

PAGE 1 OF 45

TOTAL PAGES

PREPARED BY/DATE

R. A. Castle *RC*

DEPT

731

MAIL ADDR

LB25

6531

20520

REL. DATE

10.9.72 *K*

SECURITY CLASSIFICATION

(CHECK ONE BOX ONLY)

UNCL ☒ AEC DOD
CONF. ☐
SECRET ☐

(CHECK ONE BOX ONLY)

RESTRICTED ☐
DATA
DEFENSE ☐
INFO.

APPROVALS

E Donovan

DATE

9/29/72

AUTHORIZED
CLASSIFIER*E Donovan*

DATE

9/29/72

DISTRIBUTION

* NAME	MAIL ADDR
J. Asquith	LB02
R. A. Castle	LB25
R. I. Jetter	LB30
E. J. Donovan	LB25
L. Maki	LB03
E. Moody	LB25
W. Roberts	LB36
R. F. Wilson	LB01
* P. O. File	LB02

ABSTRACT

A computer program was written to compute the fuel element stresses from the GEOM heat transfer code output. The forces on all 85 elements are balanced. Then the detailed bending six theta and local contact load stresses are computed for each element and the associated Margin of Safety calculated.

RESERVED FOR NR PROPRIETARY/LEGAL NOTICES

* TITLE PAGE ONLY

Introduction

This computerized analysis determines the stress levels in the fuel element due to the temperatures generated in the GEOM 85 heat transfer code and the physical core restraints. It accepts temperatures for all 85 elements at 11 stations along the length of the element. For each element at each station the temperatures are analyzed to determine the linear gradient which causes the element to bow, the average temperature, and the six theta temperatures. The amount of thermal bow for each element is then combined with the as manufactured bow, the spacing between elements and the amount of movement allowed for the fuel element relative to the outlet grid plate. These element bows are then analyzed and allowed (analytically) to contact the adjacent elements at a predetermined contact plane. The resulting forces and deflections are then balanced out to find the forces and circumferential location of forces on each of the 85 elements in the core. The stresses are then computed from the six theta effects, bending moments and local contact effects. The theory, computer code listing, and a sample problem are included in the test.

Method of Analysis

Detail Temperature Distribution

The output of the GEOM 85 heat transfer code are defined for each element at eleven stations along the element. At each station the temperatures are defined every 30° at their hot line (nearest proximity

to a fluid channel) positions. The stress analysis requires a finer definition of temperatures. The temperature distribution is assumed to be a skewed cosine distribution and the temperatures calculated every three degrees.

$$T = T_i + \frac{1}{2} \left[\frac{T_{i+2} + T_i}{2} - T_{i+1} \right] \left[\cos \frac{2\theta}{60} - 1 \right] + \left[T_{i+2} - T_i \right] \frac{\theta}{60}$$

where z is the circumferential station from 1 to 12

θ is the circumferential angle from

T is temperature

Linear Temperature Gradient and Six Theta Determination

The previously determined temperatures are then integrated to determine a thermal moment about the x and y axes. The resulting thermal moment was then equated to an equivalent moment caused by a linear gradient.

$$M_x = \frac{\sum_{i=1}^{i=120} T_i y_i \Delta S}{S}$$

$$M_y = \frac{\sum_{i=1}^{i=120} T_i x_i \Delta S}{S}$$

$$\phi = \tan^{-1} (M_y / M_x)$$

WHERE ϕ IS THE ANGLE WHICH LAGS THE BENDING AXIS BY 90°

$$M_R = \sqrt{M_x^2 + M_y^2}$$

The equivalent linear temperatures (T_{Bend}) moment would be

$$T_{\text{BEND} \beta} = \frac{T_{\text{BEND}}}{2} \cdot \frac{z}{R} = \frac{T_{\text{BEND}}}{2} \cos \beta$$

$$dM = T_{\text{BEND} \beta} z = \frac{T_{\text{BEND}}}{2} R^2 \cos^2 \beta ds$$

$$M = 4 \int_0^{\pi/2} \frac{T_{\text{BEND}}}{2} R^2 \cos^2 \beta d\beta$$

$$= \frac{\pi}{2} T_{\text{BEND}} R^2$$

$$T_{\text{BEND}} = \frac{2}{\pi} M_R$$

In order to maintain the right hand rule and to be able to define the temperature in terms of Θ and ϕ the signed is determined by

$$\text{SIGN} = M_x / |M_x|$$

such that

$$T_{i\text{BEND}} = \left\{ \frac{T_{\text{BEND}}}{2} \cos(\theta_i - \phi) \right\} (\text{SIGN})$$

and the six theta temperature components are $T_{6\theta} = T = T_{\text{Avg}} - T_{\text{Bend}}$

and the six theta stress is

$$\sigma_{6\theta} = -\alpha E T_{6\theta}$$

Thermal Deflection

This temperature data is gathered at each of the 11 station (Z/L) of the fuel element. The bending temperature at each station (i) causes the beam to bow and the amount of bow at the pre-defined contact point is

$$\delta_T = \int_0^1 \frac{M_{Ti} m_i ds}{EI}$$

where

M_{Ti} is the restrained moment due to the linear temperature gradient

I is the moment of inertia

m_i is the virtual moment

ds is the incremental length of beam

E is the modulus of elasticity

This becomes somewhat complex when the point of contact is an input variable. EI is a constant and M is the thermal moment previously defined at each of the eleven stations. m is the moment at each station due to the virtual load placed at the point of contact (or point where deflection is wanted) and the produced $M_i \times m_i$ is computed at each station i and the integration performed. The problem arises due to the integral of area under the load missed by considering only the eleven stations where M_i is defined.

The additional area to be added to the integral $\int M_m ds$ is

$$\begin{aligned} & \left\{ (M_m)_i - (M_m)_{k-1} \right\} \left\{ x_k - x_{k-1} \right\} \\ & - \left\{ (M_m)_k - (M_m)_{k-1} \right\} \left\{ (x_k - x_{k-1})/2 \right\} \\ & - \left\{ (M_m)_i - (M_m)_{k-1} \right\} \left\{ (x_i - x_{k-1})/2 \right\} \\ & - \left\{ (M_m)_i - (M_m)_k \right\} \left\{ (x_k - x_i)/2 \right\} \end{aligned}$$

where M_i is defined as

$$M_i = (M_k - M_{k-1}) \left(\frac{x_i - x_{k-1}}{x_k - x_{k-1}} \right) + M_{k-1}$$

and

$$m_i = \frac{x_i}{\text{LENGTH}} (\text{LENGTH} - x_i)$$

The restrained moment due to temperature M_T is derived as follows:

$$\begin{aligned} \text{Moment} &= \int (\text{Force/unit length}) (\text{distance } X) R d\theta \\ M_T &= 4 \int \alpha E (T_B/2) t R \cos\theta R d\theta \\ &= \left(\frac{\pi}{2}\right) \alpha E t R^2 T_B \end{aligned}$$

This makes the assumption that the plane of bending is the same at every station. So far this assumption has been valid within the accuracy of the analysis.

Force Balance

In order to balance the forces due to the various components of deflection for the 85 elements consideration is also given to the reflector. The geometric nomenclature is given in Figure 1. The reflector elements (numbers 86 through 21) are assumed to have a given spring constant but are not considered to bow to the thermal environment.

Each of the elements is force balanced with respect to its neighbors and an iteration technique is adopted to balance the whole core.

The elemental model is shown in Figure 2 for element "N" while the six adjacent elements are noted as NPN (1) through NPN (6).

From Figure 1 it is noted that the angle ϕ of the thermal deflection (δ_t) measured from the y axis. The deflections for use on the mathematical model of Figure 2 are then

$$\delta_{t_1} = \delta_t \cos (\phi_t - 60^\circ) = \delta_{t_4}$$

$$\delta_{t_2} = \delta_t \cos (\phi_t - 120^\circ) = \delta_{t_5}$$

$$\delta_{t_3} = \delta_t \cos (\phi_t) = \delta_{t_6}$$

There is an option to place the manufacturing bow (δ_m) in either the direction of thermal bow or to place it in the direction of the resultant force and if there is no force then in the direction of the thermal bow.

FIGURE 1

CORE CONFIGURATION

FIGURE 2
ELEMENTAL MODEL

There is also an input spacing between elements (δ_S) allowing for some bow before contact is made. The finned fuel elements are loose in the outlet grid plate while the natural elements are tight. This is accomplished in the program with a hot end looseness (HEL) input in conjunction with a data statement in the program which is a unity or zero multiplier (EN) depending on the fuel element ($\delta_F = \text{HEL} * \text{EN}$).

For the first iteration the deflections are determined in each of the six directions given in Figure 2 and the bow direction and hot end looseness effect is assumed acting in the direction of the thermal bow.

$$\begin{aligned}\delta_1 &= \delta_4 = (\delta_T + \delta_m - \delta_F) \cos(\phi_t - 60^\circ) \\ \delta_2 &= \delta_5 = (\delta_T + \delta_m - \delta_F) \cos(\phi_t - 120^\circ) \\ \delta_3 &= \delta_6 = (\delta_T + \delta_m - \delta_F) \cos \phi_t\end{aligned}$$

From these deflections the forces are calculated for each element considering only the interference with its neighbor (Figure 2)

The spring constant for each element is determined knowing the plane of contact and fuel element geometry.

$$k = \frac{P}{\delta_B} = \frac{3EI\ell}{a^2b^2}$$

where E is the modulus of elasticity

I is the moment of inertia

a, b, and l are defined above

From these deflections the forces are calculated for each element considering only the interference with its neighbor (Figure 2).

$$P_1 = \left\{ \delta_{1\text{ele}N} - \delta_{4\text{ele}NPN(1)} - \delta_S \right\} \times \frac{k_N \times k_{NPN(1)}}{k_N + k_{NPN(1)}}$$

$$P_2 = \left\{ \delta_{2\text{ele}N} - \delta_{5\text{ele}NPN(2)} - \delta_S \right\} \times \frac{k_N \times k_{NPN(2)}}{k_N + k_{NPN(2)}}$$

$$P_3 = \left\{ \delta_{3\text{ele}N} - \delta_{6\text{ele}NPN(3)} - \delta_S \right\} \times \frac{k_N \times k_{NPN(3)}}{k_N + k_{NPN(3)}}$$

$$P_4 = \left\{ \delta_{4\text{ele}N} - \delta_{1\text{ele}NPN(4)} - \delta_S \right\} \times \frac{k_N \times k_{NPN(4)}}{k_N + k_{NPN(4)}}$$

$$P_5 = \left\{ \delta_{5\text{ele}N} - \delta_{2\text{ele}NPN(5)} - \delta_S \right\} \times \frac{k_N \times k_{NPN(5)}}{k_N + k_{NPN(5)}}$$

$$P_6 = \left\{ \delta_{6\text{ele}N} - \delta_{3\text{ele}NPN(6)} - \delta_S \right\} \times \frac{k_N \times k_{NPN(6)}}{k_N + k_{NPN(6)}}$$

If the force is negative it is set equal to zero and a gap between adjacent elements is assumed to exist.

The resultant force is then found

$$P_y = P_6 - P_3 + .5 (P_1 + P_5 - P_4 - P_2)$$

$$P_x = .866 (P_1 - P_4 + P_2 - P_5)$$

$$P_{RESULT} = \sqrt{P_y^2 + P_x^2}$$

$$\phi_P = \tan^{-1} \left| \frac{F_y}{F_x} \right|$$

Once the forces are developed for the first iteration they are reduced to help convergence later on. Then the deflection due to load (δ_p) is computed for each element (N).

$$\delta_{P_1} = \delta_{P_4} = \{ P_4 - P_1 + .5 (P_5 - P_2 + P_3 - P_6) \} / k_N$$

$$\delta_{P_2} = \delta_{P_5} = \{ P_5 - P_2 + .5 (P_4 - P_1 + P_6 - P_3) \} / k_N$$

$$\delta_{P_3} = \delta_{P_6} = \{ P_3 - P_6 + .5 (P_2 - P_5 + P_4 - P_1) \} / k_N$$

Now that the angle at which the load is acting (ϕ_p) is being determined the direction of the hot end looseness and, depending on the option, the manufactured bow direction can be accounted for on the second and subsequent cycles.

For option 1 where the manufacturing bow is in the direction of the resultant force

$$\delta_1 = \delta_4 = \delta_T \cos(\phi_t - 60^\circ) + (-\delta_m - \delta_p + \delta_F) \cos(\phi_p - 60^\circ)$$

$$\delta_2 = \delta_5 = \delta_T \cos(\phi_t - 120^\circ) + (-\delta_m - \delta_p + \delta_F) \cos(\phi_p - 120^\circ)$$

$$\delta_3 = \delta_6 = \delta_T \cos \phi_t + (-\delta_m - \delta_p + \delta_F) \cos \phi_p$$

and for option 2 where the manufacturing bow is in the direction of the thermal bow

$$\delta_1 = \delta_4 = (\delta_T + \delta_m) \cos(\phi_t - 60^\circ) + (-\delta_p + \delta_F) \cos(\phi_p - 60^\circ)$$

$$\delta_2 = \delta_5 = (\delta_T + \delta_m) \cos(\phi_t - 120^\circ) + (-\delta_p + \delta_F) \cos(\phi_p - 120^\circ)$$

$$\delta_3 = \delta_6 = (\delta_T + \delta_m) \cos \phi_t + (-\delta_p + \delta_F) \cos \phi_p$$

The loads are now recomputed by using the same equation as previously used only with the new deflections which include the load induced deflections. The loads are summed for each iteration and the sum checked each time and if the load is negative it is set equal to zero. When the incremental load approaches zero then the core deflections and forces are in balance.

Stress Analysis

The stresses are computed from the forces computed in the force balance routine and the temperature distribution around the periphery.

The bending moment (M) is determined from the resultant force and the associated stress computed.

$$M = \frac{P a b}{a + b}$$

$$\sigma = \frac{M}{\pi R^2 t} \cos(\theta - \phi_P)$$

The six theta stresses are computed from the six theta temperature which is the temperature in question minus the average temperature minus the equivalent bending temperature adjusted for the distance to the neutral axis.

$$T_{6\theta} = T_i - T_{AVG} - T_{BEND} * \frac{d}{R}$$

The six theta stress is then

$$\sigma_{6\theta} = -E\alpha T_{6\theta}$$

where E is the modulus of elasticity

α is the coefficient of expansion

The local stresses underneath the contact point are computed in both the axial and hoop directions from coefficients input in the program

$$\sigma_{Hoop} = \text{Load} \times AKHOOP$$

$$\sigma_{Axial} = \text{Load} \times AKAXIAL$$

The input values of AKHOOP and AKAXIAL are calculated as described in TR-653-240-006 (Experimental Stresses for a Contact Load on Simulated SPF Reactor Fuel Elements). Since the SCB coating stresses are normally the critical stress zone and the failure mode is assumed to be maximum strain the stresses are combined as follows:

$$\sigma_{\text{equivalent}} = \sigma_{\text{HOOP}} - \mu \sigma_{\text{AXIAL}}$$

OR

$$\sigma_{\text{EQUIVALENT}} = \sigma_{\text{AXIAL}} - \mu \sigma_{\text{HOOP}}$$

whichever produces the higher tensile strain. The axial stress is the combination of the six theta, bending and local contact stresses while the hoop stress is solely due to the local contact.

Margin of Safety

The margin of safety (M. S.) is defined as:

$$\text{M. S.} = \frac{\text{Allowable Stress}}{\text{Applied Stress}} - 1$$

The allowable stress is normally the value of stress at which there becomes gross hydrogen permeation due to failure of the SCB coating. This value is input.

PROGRAM INPUT

1	17.25	10.5	ELEMENT LENGTH	LENGTH - COLD END TO CONTACT POINT
13	.1507	.2434	$\frac{2}{L}(2)$	$\frac{2}{L}(3)$
25	.3362	.4290	$\frac{2}{L}(4)$	$\frac{2}{L}(5)$
37	.5217	.6145	$\frac{2}{L}(6)$	$\frac{2}{L}(7)$
49	.7072	.8	$\frac{2}{L}(8)$	$\frac{2}{L}(9)$
61	.8928	1.	$\frac{2}{L}(10)$	$\frac{2}{L}(11)$
IDENTIFICATION			73	10 80
1	.005		CLEARANCE BETWEEN ELEMENTS.	
13	.006		ELEMENT BOW AT CONTACT PLANE	
25	.000		HOT END LOOSENESS	
37	.024		ELEMENT THICKNESS	
49	.49		MEAN RADIUS	
61	9.4	E-06	COEFFICIENT OF EXPANSION	
IDENTIFICATION			73	20 80
1	22.3	E+06	MODULUS OF ELASTICITY	
13	1516.		LOCAL CONTACT HOOP STRESS LOAD MULTIPLIER	
25	628.		LOCAL CONTACT AXIAL STRESS LOAD MULTIPLIER	
37	34000.		STRESS ALLOWABLE	
49		1	BOW OPTION 1 = DIRECTION OF LOAD 2 = DIR. OF THERM BOW	
61			NOT USED	
IDENTIFICATION			73	30 80

12E6.1

6E12.8

4E12.8

I 12

3A4

FOLLOWED BY

I TITLE CARD (FROM GEOM)

II TEMPERATURE CARDS /ELE * 85 ELEMENTS (FROM GEOM)

Program Listing

1. Main Program
2. Force Subroutine
3. Pin Location Subroutine

Main Program

Reads temperature and geometric data and computes fuel element deflections. It exits to the Force subroutine then takes results and computes stresses and margins of safety.

COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=40,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

	C		00000010
	C	THIS PROGRAM TAKES THE GEOM TEMPERATURES AND COMPUTES A FORCE	00000011
	C	BALANCE OF THE WHOLE CORE. IT THEN CALCULATES THE SIX THETA	00000012
	C	AND BENDING STRESSES.	00000013
	C		00000014
ISN 0002		DIMENSION CLAD(3),TITLE(18),FY(85),FX(85),FR(85),PHI(85),	00000050
		1A(13),T(120,12),AVG(12),T1(12),X(11),VM(11),NDEG(24),ZOL	00000060
		2(11),PHA(12),NEL1(121)	00000070
		3,T6(121),TOTSTR(85,24),PHA1(85,12),SIXT(85,24),PHI1(12),TEM(85,24)	00000080
		4,DELT(85,12),SIGN(85),BEND(85,24)	00000090
		5,SIXS(85,24),DEFMOM(11),TD(11),TD1(11),TD2(11),TD3(11)	00000100
		6,PHI5(11),AMARG(85)	00000110
ISN 0003		INTEGER *4 OPTBOW	00000123
ISN 0004		COMMON/CASTLE/ SPRING(121),DEFL4(85),PHI4(85),P(85,6),D(121,6)	00000125
		1,PHI(85),FR(85),OPTBOW,HEL,CTACT,ENGTH,RAD,THI,ALPHA,E	00000126
		2,BOW	00000127
ISN 0005		READ(5,11) ENGTH,CTACT,(X(I),I=2,11)	00000180
ISN 0006		X(1)=0.	00000190
ISN 0007		M=1	00000191
ISN 0008		DO 16 I=1,11	00000200
ISN 0009		X(I)=ENGTH *(X(I))	00000205
ISN 0010	16	IF((CTACT -X(I)).GT.0.) M=M+1	00000210
ISN 0012		DO 14 I=1,6	00000220
ISN 0013		DO 13 J=1,85	00000230
ISN 0014	13	P(J,I)=0.	00000240
ISN 0015		DO 42 J=1,121	00000250
ISN 0016	42	D(J,I) =0.0	00000260
ISN 0017	14	CONTINUE	00000270
ISN 0018	11	FORMAT (12E6.1)	00000300
ISN 0019		READ(5,705) SPAC,BOW,HEL,THI,RAD,ALPHA	00000310
ISN 0020		READ(5,12) E,AKHOOP,AKAX,ALLOW,OPTBOW,CLAD	00000312
ISN 0021	12	FORMAT (4E12.8,I12,3A4)	00000316
ISN 0022		WRITE(6,350)	00000320
ISN 0023	350	FORMAT ('1 SUMMARY OF INPUT DATA')	00000330
ISN 0024	705	FORMAT(6E12.8)	00000400
ISN 0025	730	FORMAT(3E12.8)	00000440


```

ISN 0026      WRITE(6,351) ENGT,CTACT,(X(I),I=2,11),SPAC,BOW, HEL,THI,RAD,ALPHA00000460
              1,E,AKHOOP,AKAX,ALLOW                                00000470
ISN 0027      351 FORMAT (5X,'ELEMENT LENGTH',F10.3//5X,'CONTACT DISTANCE FROM COLD 00000480
              1END',F10.3//5X,'STATIONS',10F8.4//5X,'SPACING, INITIAL BOW, HOT EN00000482
              2D LOOSENESS',3F10.5//5X,'THICKNESS',F10.5//5X,'RADIUS',F10.5//5X,'A00000484
              3LPHA & MODULUS',2E16.8//5X,'BIJLAARD MULTIPLIERS, HOOP',F10.2//5X,00000486
              4'AXIAL',F10.2//5X,'ALLOWABLE',F10.2)                00000488
ISN 0028      DO 777 I = 1,85                                       00000490
ISN 0029      777 SPRING(I)=E*9.4248*RAD**3*THI*ENGT/CTACT**2/(ENGT-CTACT)**2 00000492
ISN 0030      DO 778 I=86,121                                         00000496
ISN 0031      778 SPRING(I)= 70000.                                   00000497
ISN 0032      70 CONTINUE                                           00000510
ISN 0033      READ(5,82) TITLE                                       00000520
ISN 0034      82 FORMAT(18A4)                                         00000530
ISN 0035      NELCT =0                                               00000540
ISN 0036      ISPAC = 1                                              00000550
ISN 0037      19 CONTINUE                                           00000560
ISN 0038      LOS =1                                                00000570
ISN 0039      NELCT=NELCT +1                                         00000580
ISN 0040      21 CONTINUE                                           00000610
ISN 0041      K=1                                                    00000620
ISN 0042      READ(5,60,END=9999) (A(I),I=1,12),ICASE,NEL,L        00000630
ISN 0043      AVG(L) =0.                                             00000640
ISN 0044      AMOMX=0                                                00000650
ISN 0045      AMOMY=0                                                00000660
ISN 0046      NEL1(NELCT)=NEL                                       00000670
ISN 0047      60 FORMAT(12F6.2,I4,I2,I2)                             00000680
ISN 0048      A(13)=A(1)                                             00000720
ISN 0049      DO160 J=1,120                                          00000730
ISN 0050      T(J,L)=A(K)+.25*(A(K)+A(K+2)-2*(A(K+1)))*(COS((J-10*(K-1))*3.142)-00000740
              11.)+(A(K+2)-A(K))*((J-10*(K-1))/ 20.)                00000750
ISN 0051      AVG(L)= AVG(L) + T(J,L)/120.                          00000760
ISN 0052      IF(J-10*K-10)100,200,100                              00000770
ISN 0053      200 K=K+2                                              00000780
ISN 0054      IF (J-120) 100,180,300                                00000790
ISN 0055      180 T(120,L) = A(13)                                   00000800
ISN 0056      100 AMOMX=.05236*T(J,L)*COS(.05236*J)+ AMOMX         00000810
ISN 0057      160 AMOMY=.05236*T(J,L)*SIN(.05236*J)+AMOMY         00000820

```

ISN 0058	PHI1(L)=ATAN(AMOMY/AMOMX)	00000830
ISN 0059	PHIA =ATAND(ABS(AMOMY/AMOMX))	00000840
ISN 0060	IF(AMOMX.GE.0..AND.AMOMY.LE.0.) PHA(L) =390.-PHIA	00000850
ISN 0062	IF(AMOMX.GE.0..AND.AMOMY.GE.0.) PHA(L) =30. +PHIA	00000860
ISN 0064	IF(AMOMX.LE.0..AND.AMOMY.GE.0.) PHA(L) = 210.-PHIA	00000870
ISN 0066	IF(AMOMX.LE.0..AND.AMOMY.LE.0.) PHA(L) = 210.+PHIA	00000880
ISN 0068	IF(PHA(L).GT.360.) PHA(L)=PHA(L) -360.	00000890
ISN 0070	AMOM=(AMOMX**2+AMOMY**2)	00000910
ISN 0071	AMOM=SQRT(AMOM)	00000920
ISN 0072	T1(L) = .63662*AMOM	00000930
ISN 0073	DELT(NELCT,L) =T1(L)	00000935
ISN 0074	PHAI(NELCT,L) =PHA(L)	00000936
ISN 0075	SIGN(L) = AMOMX / ABS(AMOMX)	00000940
ISN 0076	40 IF(L.LT.11) GO TO 21	00000970
ISN 0078	DO 400 N=1,24	00000980
ISN 0079	T(N,12) = (T(5*N,M)-T(5*N,M-1))*(CTACT-X(M-1))/(X(M)-X(M-1))+	00000982
	1 T(5*N,M-1)	00000984
ISN 0080	TEM(NELCT,N) = T(N,12)	00000985
ISN 0081	AVG(12) =(AVG(M)-(AVG(M-1)))*(CTACT-X(M-1))/(X(M)-X(M-1))+AVG(M-1)	00000986
ISN 0082	PHI1(12)=(PHI1(M)-PHI1(M-1))*(CTACT-X(M-1))/(X(M)-X(M-1))+PHI1(M-1)	00000988
	1)	00000989
ISN 0083	T1(12)=(T1(M)-T1(M-1))*(CTACT-X(M-1))/(X(M)-X(M-1))+T1(M-1)	00000990
ISN 0084	SIXT(NELCT,N)= T(N,12)-AVG(12) -SIGN(7)*(T1(12)/2.)*COS(.2615*N	00001000
	1 -PHI1(12))	00001010
ISN 0085	400 SIXS(NELCT,N)= -E*ALPHA*SIXT(NELCT,N)	00001020
ISN 0086	T6(NELCT)=0.	00001100
ISN 0087	DO 124 I=1,11	00001140
ISN 0088	124 IF(T1(I).GE.T6(NELCT)) T6(NELCT)=T1(I)	00001150
ISN 0090	115 CONTINUE	00001160
ISN 0091	R=RAD	00001180
ISN 0092	THICK = THI	00001190
ISN 0093	CLEAR = SPAC	00001200
ISN 0094	K=2	00001230
ISN 0095	X(1)=0.	00001250
ISN 0096	DEFL=0.	00001260
ISN 0097	DO 73 I=2,10	00001270
ISN 0098	IF(CTACT-X(I)) 71,71,72	00001280
ISN 0099	72 VM(I)=((ENGTH-CTACT)/ ENGTH)* X(I) * T1(I)	00001290

ISN 0100	K=K+1	00001300
ISN 0101	GO TO 73	00001310
ISN 0102	71 VM(I)=(CTACT/ ENGTH)*(ENGTH-X(I))*T1(I)	00001320
ISN 0103	73 DEFL= DEFL +(VM(I)*(X(I+1)-X(I-1))/2.)	00001330
ISN 0104	VMP=(CTACT/ENGTH)*(ENGTH-CTACT)*((T1(K)-T1(K-1))*((CTACT-X(K-1)) /00001340 I(X(K)-X(K-1))) + T1(K-1))	00001350
ISN 0105	DEFL1=(VMP*(X(K)-X(K-1))+VM(K-1)*(CTACT-X(K))+VM(K)*(X(K-1)-CTACT)00001360 1)/2.	00001370
ISN 0106	DEFL4(NELCT) =(DEFL1+DEFL)*ALPHA /(2*RAD)	00001385
ISN 0107	PHI4(NELCT) = PHA(7) /57.3	00001387
ISN 0108	IF (NELCT.NE.85) GO TO 19	00001388
ISN 0110	CALL FORCE (SPAC)	00001389
ISN 0111	DO 510 K=1,85	00001390
ISN 0112	PHI4(K) = PHI4(K)*57.3	00001400
ISN 0113	DO 402 N =1,24	00001444
ISN 0114	BEND(K,N) = FR(K)*CTACT*(ENGTH-CTACT)*COS((15.*N -PHI(K))/57.3) 00001446 1 / (3.1416*RAD**2*THICK*ENGTH)	00001448
ISN 0115	402 TOTSTR(K ,N) = SIXS(K ,N)+ BEND(K,N)	00001449
ISN 0116	510 CONTINUE	00001455
ISN 0117	WRITE (6,511) (I,PHI4(I),PHI(I),FR(I),I=1,85)	00001460
ISN 0118	511 FORMAT ('1'/45X,'FORCE BALANCE RESULTS'/5(' I PHI4 PHI FR '00001470 1))/(5(I4,F6.0,F6.0,F6.1)))	00001480
ISN 0119	DO 410 J=1,85	00002000
ISN 0120	WRITE (6,412) TITLE,J	00002010
ISN 0121	412 FORMAT ('1'/19X,18A4//10X,'ELEMENT NO',I4,4X,'CONTACT PLANE STRESS00002020 1 AND DEFL SUMMARY' // 15X,'6TH ',6X,'6 TH ',5X,'BEND',5X,'TOTAL', 00002030 25X,'CONTACT',3X,'HOOP',4X,'AXIAL',6X,'EQUIV',5X,'SAFETY' / 2X,'DEG00002040 3',3X,'TEMP',3X,'TEMP',5X,'STRESS',3X,'STRESS',3X,'STRESS',6X,'LOAD00002050 4',4X,'STRESS',3X,'STRESS',5X,'STRESS',4X,'MARGIN') 00002060	
ISN 0122	K=1	00002065
ISN 0123	AMSMIN = 999.	00002066
ISN 0124	DO 422 N=1,24	00002070
ISN 0125	IDEG =15*N	00002080
ISN 0126	IF (IDEG.EQ.60.OR.IDEG.EQ.120.OR. IDEG.EQ.180.OR.IDEG.EQ.240.OR.IDE00002090 1G.EQ.300.OR.IDEG.EQ.360) GO TO 416	00002091
ISN 0128	WRITE(6,414) IDEG,TEM(J,N),SIXT(J,N),SIXS(J,N),BEND(J,N),TOTSTR(J,00002095 1N)	00002096
ISN 0129	GO TO 420	00002101

ISN 0130	416	HOOP = P(J,K)*AKHOOP	00002102
ISN 0131		AXIAL= P(J,K)*AKAX	00002104
ISN 0132		EQSTR1 = (TOTSTR(J,N)+AXIAL)-.3* HOOP	00002105
ISN 0133		EQSTR= HOOP - .3*(TOTSTR(J,N)+AXIAL)	00002106
ISN 0134		IF(EQSTR1.GT.EQSTR) EQSTR= EQSTR1	00002107
ISN 0136		AMS =(ALLOW/(ABS(EQSTR)))-1.	00002108
ISN 0137		IF(AMS.LT.AMSMIN) AMSMIN = AMS	00002109
ISN 0139		WRITE(6,418) IDEG,TEM(J,N),SIXT(J,N),SIXS(J,N),BEND(J,N),TOTSTR(J,1N),P(J,K),HOOP,AXIAL,EQSTR,AMS	00002110
ISN 0140	414	FORMAT (2X,I3,F8.1,F7.1,3(F10.0))	00002111
ISN 0141	418	FORMAT (2X,I3,F8.1,F7.1,3(F10.0),F10.2,3(F10.0),F10.3)	00002120
ISN 0142		K=K+1	00002130
ISN 0143	420	CONTINUE	00002190
ISN 0144	422	CONTINUE	00002200
ISN 0145		AMARG(J)= AMSMIN	00002210
ISN 0146		DO 424 I=1,11	00002212
ISN 0147	424	ZOL(I)= X(I)/ENGTH	00002220
ISN 0148		WRITE(6,426) ZOL	00002230
ISN 0149	426	FORMAT(6X,'Z/L',4X,11(F8.2))	00002240
ISN 0150		WRITE(6,428) (DELT(J,I),I=1,11)	00002250
ISN 0151	428	FORMAT(2X,'TEMP GRAD',2X,11(F8.2))	00002260
ISN 0152		WRITE(6,430) (PHA1(J,I),I=1,11)	00002270
ISN 0153	430	FORMAT(2X , 'ANGLE ',5X,11(F8.2))	00002280
ISN 0154		DO 460 I=1,11	00002290
ISN 0155	460	DEFMOM(I)=DELT(J,I)*E*ALPHA*THI* RAD**2*3.1416/2.	00002300
ISN 0156		DO 461 I=1,10	00002310
ISN 0157	461	TD(I+1)=(DEFMOM(I)+DEFMOM(I+1))* (X(I+1)-X(I))/2.	00002320
ISN 0158		TD(1) = 0.	00002330
ISN 0159		DO 462 I=2,11	00002340
ISN 0160	462	TD(I)=TD(I-1)+TD(I)	00002350
ISN 0161		DO 463 I=1,10	00002360
ISN 0162	463	TD1(I+1)=(TD(I)+TD(I+1))*(X(I+1)-X(I))/2.	00002370
ISN 0163		TD1(1) =0.	00002380
ISN 0164		DO464 I=2,11	00002390
ISN 0165	464	TD1(I)= TD1(I-1)+ TD1(I)	00002400
ISN 0166		DO 465 I=1,11	00002410
ISN 0167	465	TD2(I) =(-TD1(I)+(TD1(11)*(X(I)/ ENGTH)))/(.00314*E*THI*RAD**3)	00002420
ISN 0168		WRITE(6,432) (TD2(I),I=1,11)	00002430
			00002440

ISN 0169	432	FORMAT(2X,'THERM DEFL ',11(F8.2))	00002450
ISN 0170		DO 433 I=1,11	00002452
ISN 0171	433	PHI5(I)= PHI(J)	00002454
ISN 0172		WRITE(6,434)(PHI5(I),I=1,11)	00002460
ISN 0173	434	FORMAT(2X,'MECH ANGLE ',11(F8.2))	00002470
ISN 0174		DO 436 I=1,11	00002480
ISN 0175		IF (CTACT -X(I)) 438,440,440	00002490
ISN 0176	440	TD3(I)=(FR(J)*(ENGTH-CTACT)*X(I)/(E*3.142*RAD**3*THI*6.))* (2.*ENGTH	00002500
		1TH*(ENGTH-X(I))-(ENGTH-CTACT)**2 -(ENGTH-X(I))**2)/ENGTH	00002510
ISN 0177		GO TO 436	00002520
ISN 0178	438	TD3(I)=(FR(J)*CTACT*(ENGTH-X(I))/(E*18.8496*RAD**3*THI))*(2.*ENGTH	00002530
		1*(ENGTH-CTACT)-(ENGTH-CTACT)**2 -(ENGTH-X(I))**2)/ENGTH	00002540
ISN 0179	436	TD3(I)=TD3(I)*1000.	00002550
ISN 0180		WRITE(6,444) (TD3(I),I=1,11)	00002560
ISN 0181	444	FORMAT(2X,'MECH DEFL ',11(F8.2))	00002570
ISN 0182		WRITE(6,446) FR(J),ALLOW,AMSMIN	00002580
ISN 0183	446	FORMAT(/ 8X,'CONTACT LOAD',F10.2,' ALLOW STRESS',F10.0,'	00002800
		IMINIMUM M.S. ',F10.2)	00002810
ISN 0184	410	CONTINUE	00003060
ISN 0185		WRITE(6,450)(I,FR(I),AMARG(I),I= 1,85)	00003062
ISN 0186	450	FORMAT('1' /45X,'MARGIN OF SAFETY SUMMARY'/3(' ELEMENT F00003064	
		1RCE MARGIN ')// (3(I11,F12.2,F12.3)))	00003066
ISN 0187		GO TO 70	00003070
ISN 0188	300	CONTINUE	00003075
ISN 0189	9999	CALL EXIT	00003080
ISN 0190		STOP	00003090
ISN 0191		END	00003100

Subroutine Force

Balances the force interactions between all 85 elements.

COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=40,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

C		01000010
C	SUBROUTINE FORCE CALCULATES THE FORCES AND DEFLECTIONS FOR	01000020
C	ALL 85 ELEMENTS. IT ASSUMES A CONSTANT SPACING BETWEEN	01000030
C	ELEMENTS AND ELEMENT REFLECTORS	01000040
C		01000050
ISN 0002	SUBROUTINE FORCE(SPACE)	01000055
ISN 0003	DIMENSION COR(85),BETA(85),AL3(85),FOLD(85)	01000068
ISN 0004	DIMENSION NPN(6),NCHN(6),PSV(85,6),DM(85,6),EN(85),FY(85),FX(85)	01000071
ISN 0005	INTEGER *4 CPTBOW	01000072
ISN 0006	COMMON /CASTLE/ SPRING(121),DEFL4(85),PHI4(85),P(85,6),D(121,6)	01000073
	1,PHI(85),FR(85),OPTBOW,HEL,CTACT,ENGTH,RAD,THI,ALPHA,E	01000074
	2,BOW	01000075
ISN 0007	DATA EN/ 0.,7*1.,0.,1.,0.,1.,0.,1.,0.,1.,0.,1.,2*0.,2*1.,0.,2*1.,0.	01000076
	1.,2*1.,0.,2*1.,0.,2*1.,0.,4*1.,0.,3*1.,0.,3*1.,0.,3*1.,0.,3*1.,0.,	01000077
	23*1.,0.,1.,0.,2*1.,2*0.,2*1.,2*0.,2*1.,2*0.,2*1.,2*0.,2*1.,2*0.,2*0.	01000078
	31.,0. /	01000079
ISN 0008	WRITE (6,10)	01000086
ISN 0009	10 FORMAT ('1')	01000088
ISN 0010	DO 100 N=1,85	01000090
ISN 0011	COR(N)=0.	01000091
ISN 0012	AL3(N)=0.	01000092
ISN 0013	BETA(N)=1.	01000093
ISN 0014	PSV(N,1) = 0.	01000095
ISN 0015	D(N,1)=DEFL4(N)*COS(PHI4(N)-1.0472)	01000100
	1+(BOW -HEL*EN(N)*CTACT/ENGTH)* COS(PHI4(N)-1.0472)	01000101
ISN 0016	PSV(N,2) = 0.	01000105
ISN 0017	D(N,2)=DEFL4(N)*COS(PHI4(N)-2.0944)	01000110
	1+(BOW -HEL*EN(N)*CTACT/ENGTH)* COS(PHI4(N)-2.0944)	01000111
ISN 0018	PSV(N,3) = 0.	01000115
ISN 0019	D(N,3)=DEFL4(N)*COS(PHI4(N))	01000120
	1+(BOW -HEL*EN(N)*CTACT/ENGTH)* COS(PHI4(N))	01000121
ISN 0020	PSV(N,4) = 0.	01000125
ISN 0021	D(N,4)= D(N,1)	01000130
ISN 0022	PSV(N,5) = 0.	01000135
ISN 0023	D(N,5)= D(N,2)	01000140
ISN 0024	PSV(N,6) = 0.	01000145

ISN 0025	100	D(N,6)= D(N,3)	01000150
ISN 0026		DO 110 N=86,121	01000160
ISN 0027		DO 120 I=1,6	01000170
ISN 0028	120	D(N,I) =0.	01000180
ISN 0029	110	CONTINUE	01000190
ISN 0030		K1=0	01000191
ISN 0031		DO 230 N=1,85	01000192
ISN 0032	230	WRITE(6,779) K1,N,(PSV(N,I),D(N,I), I=1,6)	01000193
ISN 0033	115	K1=K1+1	01000195
ISN 0034		XK = K1	
ISN 0035		DEL =0.	01000196
ISN 0036		WRITE(6,240) K1	01000200
ISN 0037	240	FORMAT(I10)	01000201
ISN 0038		DO 130 N=1,85	01000210
ISN 0039		CALL PINLOC (N,NPN,NCHN)	01000220
ISN 0040		DO 140 J=1,2	01000230
ISN 0041		L= J+3	01000235
ISN 0042		P(N,J)=(D(N,J)-D(NPN(J),L)-SPACE)*(SPRING(N)*SPRING(NPN(J))	01000240
		1/(SPRING(N)+SPRING(NPN(J)))) *.5	01000250
		2/XK	
ISN 0043		PSV(N,J) = P(N,J)+PSV(N,J)	01000252
ISN 0044		IF(PSV(N,J).LE.0.) PSV(N,J)=0.	01000254
ISN 0046		IF(P(N,J).GT.0.) DEL=AMAX1(DEL,P(N,J))	01000256
ISN 0048	140	CONTINUE	01000265
ISN 0049		DO 150 J=3,5	01000270
ISN 0050		L=6	01000275
ISN 0051		IF(J.GT.3) L=J-3	01000276
ISN 0053		P(N,J)=(D(NPN(J),L)-D(N,J)-SPACE)*(SPRING(N)*SPRING(NPN(J))	01000280
		1/(SPRING(N)+SPRING(NPN(J))))*.5	01000290
		2/XK	
ISN 0054		PSV(N,J) = PSV(N,J)+ P(N,J)	01000292
ISN 0055		IF(PSV(N,J).LE.0.) PSV(N,J)=0.	01000294
ISN 0057		IF(P(N,J).GT.0.) DEL=AMAX1(DEL,P(N,J))	01000296
ISN 0059	150	CONTINUE	01000305
ISN 0060		P(N,6)=(D(N,6)-D(NPN(6),3)-SPACE)*(SPRING(N)*SPRING(NPN(6))	01000310
		1/(SPRING(N)+SPRING(NPN(6))))*.5	01000320
		2/XK	
ISN 0061		PSV(N,6) = P(N,6)+PSV(N,6)	01000322

ISN 0062	IF(P(V(N,6).LE.0.)	PSV(N,6)=0.	01000324
ISN 0064	IF(P(N,6).GT.0)	DEL=AMAX1(DEL,P(N,6))	01000326
ISN 0066	DEL2 = AMAX1(P(N,1),P(N,2),P(N,3),P(N,4),P(N,5),P(N,6))		01000330
ISN 0067	IF(DEL2.GT..05.OR.K1.GT.70)WRITE(6,779)K1,N,(P(N,I),D(N,I),I=1,6)		01000331
ISN 0069	130 CONTINUE		01000335
ISN 0070	DO 160 N=1,85		01000340
ISN 0071	DM(N,1)=((PSV(N,4)-PSV(N,1)+.5*(PSV(N,5)-PSV(N,2)+PSV(N,3)-PSV(N,6)		01000350
	1))) / SPRING (N))		01000351
ISN 0072	DM(N,2)=((PSV(N,5)-PSV(N,2)+.5*(PSV(N,4)-PSV(N,1)+PSV(N,6)-PSV(N,3)		01000360
	1))) / SPRING (N))		01000361
ISN 0073	IF(COR(N).LT.0.) WRITE(6,290) N,COR(N), PHI(N)		01000362
ISN 0075	290 FORMAT(' ELE NO.',I6,'COR(N) IS',F10.6,' ANGLE OF CONTACT',F9.1)		01000363
ISN 0076	DM(N,3)=((PSV(N,3)-PSV(N,6)+.5*(PSV(N,2)-PSV(N,5)+PSV(N,4)-PSV(N,1)		01000370
	1))) / SPRING (N))		01000371
ISN 0077	160 CONTINUE		01000372
ISN 0078	DO 510 K=1,85		01000380
ISN 0079	FY(K)= PSV(K,6)-PSV(K,3) +.5*(PSV(K,1)+PSV(K,5)-PSV(K,4)-PSV(K,2))		01000390
ISN 0080	FX(K)= .866*(PSV(K,1)-PSV(K,4)+PSV(K,2)-PSV(K,5))		01000400
ISN 0081	FOLD(K) = FR(K)		01000402
ISN 0082	FR(K)= SQRT(FY(K)**2 + FX(K)**2)		01000410
ISN 0083	IF(K1.EQ.1) PHI(K)= PHI4(K)*57.3+180.		01000420
ISN 0085	IF(FR(K).EQ.0.) GO TO 510		01000430
ISN 0087	779 FORMAT (2I10/5X,6(F6.1,F10.4))		01000432
ISN 0088	IF(FX(K).EQ.0.) GO TO 509		01000440
ISN 0090	PHI(K) = ATAND(ABS(FY(K)/FX(K)))		01000450
ISN 0091	IF(FX(K).GT.0.AND.FY(K).LT.0.)	PHI(K) = 270. +PHI(K)	01000460
ISN 0093	IF(FX(K).LT.0.AND.FY(K).LT.0.)	PHI(K) = 90. -PHI(K)	01000470
ISN 0095	IF(FX(K).GT.0.AND.FY(K).GT.0.)	PHI(K) = 270. -PHI(K)	01000480
ISN 0097	IF(FX(K).LT.0.AND.FY(K).GT.0.)	PHI(K) = 90. +PHI(K)	01000490
ISN 0099	GO TO 510		01000500
ISN 0100	509 PHI(K) = 0.		01000510
ISN 0101	IF(FY(K).GT.0.)	PHI(K)= 180.	01000520
ISN 0103	510 CONTINUE		01000521
ISN 0104	DO 260 N=1,85		01000530
ISN 0105	COR(N) =0.		01000531
ISN 0106	IF(K1.LT.10) GO TO 260		
ISN 0108	IF(FOLD(N).GT.0.) GO TO 260		
ISN 0110	DO 270 J=1,6		01000533

ISN 0111		P(N,J)= P(N,J)*2.*K1+HEL*EN(N)*CTACT*SPRING(N)/(2.*ENGTH)	01000534
ISN 0112		IF(P(N,J).LE.0.) P(N,J)=0.	01000535
ISN 0114	270	CONTINUE	01000536
ISN 0115		FY(N)= P(N,6)-P(N,3)+.5*(P(N,1)+ P(N,5)-P(N,4)-P(N,2))	01000537
ISN 0116		FX(N)= .866*(P(N,1)-P(N,4)+P(N,2)-P(N,5))	01000538
ISN 0117		FR(N)= SQRT(FY(N)**2 +FX(N)**2)	01000539
ISN 0118		IF(FX(N).EQ.0.) GO TO 280	01000540
ISN 0120		PHI(N) = ATAND(ABS(FY(N)/ FX(N)))	01000541
ISN 0121		IF(FX(N).GT.0.AND.FY(N).LT.0.) PHI(N) = 270.+PHI(N)	01000542
ISN 0123		IF(FX(N).LT.0.AND.FY(N).LT.0.) PHI(N) = 90.-PHI(N)	01000543
ISN 0125		IF(FX(N).GT.0.AND.FY(N).GT.0.) PHI(N) = 270.-PHI(N)	01000544
ISN 0127		IF(FX(N).LT.0.AND.FY(N).GT.0.) PHI(N) = 90.+PHI(N)	01000545
ISN 0129		GO TO 285	01000546
ISN 0130	280	PHI(N)= 0.	01000547
ISN 0131		IF(FY(N).GT.0.) PHI(N) =180.	01000548
ISN 0133	285	COR(N)=(-HEL*EN(N)+FR(N)*ENGTH/(SPRING(N)*CTACT)+AL3(N))/BETA(N)	01000549
ISN 0134		AL3(N)=AL3(N) +COR(N)	01000550
ISN 0135		BETA(N) = BETA(N)+1.	01000550
ISN 0136		FR(N)=0.	01000550
ISN 0137		IF(COR(N).GE.0.) COR(N)=0.	01000550
ISN 0139	260	CONTINUE	01000551
ISN 0140		DO 210 N=1,85	01000552
ISN 0141		IF(OPTBOW.EQ.2) PHIBOW = PHI4(N)	01000553
ISN 0143		IF(OPTBOW.EQ.1) PHIBOW = PHI(N) /57.3 + 3.1416	01000554
ISN 0145		D(N,1)=(DEFL4(N)*COS(PHI4(N)-1.0472)+BOW*COS(PHIBOW-1.0472)+HEL*EN(N)*CTACT/ENGTH*COSD(PHI(N)-60.))+DM(N,1)	01000560
		2+COR(N)*EN(N)*CTACT/ENGTH*COSD(PHI(N)-60.)	01000570
ISN 0146		D(N,2)=(DEFL4(N)*COS(PHI4(N)-2.0944)+BOW*COS(PHIBOW-2.0944)+HEL*EN(N)*CTACT/ENGTH*COSD(PHI(N)-120.))+DM(N,2)	01000571
		2+COR(N)*EN(N)*CTACT/ENGTH*COSD(PHI(N)-120.)	01000580
ISN 0147		D(N,3)=(DEFL4(N)*COS(PHI4(N))+BOW*COS(PHIBOW)+HEL*EN(N)*CTACT/ENGTH*COSD(PHI(N))+DM(N,3)	01000591
		2+COR(N)*EN(N)*CTACT/ENGTH*COSD(PHI(N))	01000600
ISN 0148		D(N,4) = D(N,1)	01000610
ISN 0149		D(N,5) = D(N,2)	01000611
ISN 0150		D(N,6) = D(N,3)	01000620
ISN 0151	210	CONTINUE	01000630
ISN 0152		IF(K1.GT.100) GO TO 190	01000640
			01000650
			01000670

ISN 0154	IF(K1.LT.10)	GO TO 115	01000675
ISN 0156	IF(DEL.GT..005)	GO TO 115	01000680
ISN 0158	GO TO 220		01000685
ISN 0159	190 WRITE(6,200)		01000690
ISN 0160	200 FORMAT('1 FORCES DID NOT CONVERGE AFTER 100 CYCLES LAST VALUES I WERE USED')		01000700
ISN 0161	220 DO 170 N=1,85		01000710
ISN 0162	DO 180 J=1,6		01000720
ISN 0163	180 P(N,J) =PSV(N,J)		01000730
ISN 0164	170 CONTINUE		01000740
ISN 0165	RETURN		01000750
ISN 0166	END		01000760

Subroutine PinLoc

Used in the force subroutine to locate the six adjacent
elements around any given element.

COMPILER OPTIONS - NAME= MAIN,OPT=01,LINECNT=40,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,DECK,LOAD,MAP,NOEDIT,ID,XREF

C PINL0010
C THIS ROUTINE GIVES PIN & CHANNEL NUMBERS CORRESPONDING TO SEGMENT PINL0020
C NUMBER FOR INPUT PIN NUMBER - *GEOM 85* (PIN STARTS AT 1/2 LINE) PINL0030

C PINL0040
ISN 0002 SUBROUTINE PINLOC (N,NPN,NCHN) PINL0050
C PINL0060

ISN 0003 DIMENSION NPN(6),NCHN(6),NPIN(6,50),NCHAN(6,50),NPN1(6,35),NCHN1(6,35) PINL0070
1,35) PINL0080
C PINL0090

ISN 0004 DATA NPIN /2,3,4,5,6,7, 8,9,3,1,7,19, 9,10,11,4,1,2, 3,11,12,13,5, PINL0100
11, 1,4,13,14,15,6, 7,1,5,15,16,17, 19,2,1,6,17,18, 20,21,9,2,19,37 PINL0110
2, 21,22,10,3,2,8, 22,23,24,11,3,9, 10,24,25,12,4,3, 11,25,26,27,13 PINL0120
3,4, 4,12,27,28,14,5, 5,13,28,29,30,15, 6,5,14,30,31,16, 17,6,15,31 PINL0130
4,32,33, 18,7,6,16,33,34, 36,19,7,17,34,35, 37,8,2,7,18,36, 38,39,2 PINL0140
51,8,37,61, 39,40,22,9,8,20, 40,41,23,10,9,21, 41,42,43,24,10,22, 2 PINL0150
63,43,44,25,11,10, 24,44,45,26,12,11, 25,45,46,47,27,12, 12,26,47,4 PINL0160
78,28,13, 13,27,48,49,29,14, 14,28,49,50,51,30, 15,14,29,51,52,31, PINL0170
816,15,30,52,53,32, 33,16,31,53,54,55, 34,17,16,32,55,56, 35,18,17, PINL0180
933,56,57, 59,36,18,34,57,58, 60,37,19,18,35,59, 61,20,8,19,36,60, PINL0190
186,62,39,20,61,85, 62,63,40,21,20,38, 63,64,41,22,21,39, 64,65,42, PINL0200
223,22,40, 65,92,66,43,23,41, 42,66,67,44,24,23, 43,67,68,45,25,24, PINL0210
3 44,68,69,46,26,25, 45,69,98,70,47,26, 26,46,70,71,48,27, 27,47,71 PINL0220
4,72,49,28, 28,48,72,73,50,29, 29,49,73,104,74,51/ PINL0230

C PINL0240

ISN 0005 DATA NCHAN /6,1,2,3,4,5, 23,24,7,1,6,22, 7,8,9,10,2,1, 2,10,11,12, PINL0250
113,3, 4,3,13,14,15,16, 19,5,4,16,17,18, 21,22,6,5,19,20, 53,54,25, PINL0260
224,23,52, 25,26,27,8,7,24, 27,28,29,30,9,8, 9,30,31,32,11,10, 11,3 PINL0270
32,33,34,35,12, 13,12,35,36,37,14, 15,14,37,38,39,40, 17,16,15,40,4 PINL0280
41,42, 45,18,17,42,43,44, 47,20,19,18,45,46, 49,50,21,20,47,48, 51, PINL0290
552,23,22,21,50, 95,96,55,54,53,94, 55,56,57,26,25,54, 57,58,59,28, PINL0300
527,26, 59,60,61,62,29,28, 29,62,63,64,31,30, 31,64,65,66,33,32, 33 PINL0310
7,66,67,68,69,34, 35,34,69,70,71,36, 37,36,71,72,73,38, 39,38,73,74 PINL0320
8,75,76, 41,40,39,76,77,78, 43,42,41,78,79,80, 83,44,43,80,81,82, 8 PINL0330
95,46,45,44,83,84, 87,48,47,46,85,86, 89,90,49,48,87,88, 91,92,51,5 PINL0340
10,49,90, 93,94,53,52,51,92, 149,150,97,96,95,148, 97,98,99,56,55,9 PINL0350
26, 99,100,101,58,57,56, 101,102,103,60,59,58, 103,104,105,106,61,6 PINL0360

30, 61,106,107,108,63,62, 63,108,109,110,65,64, 65,110,111,112,67,6PINL0370
 46, 67,112,113,114,115,68, 69,68,115,116,117,70, 71,70,117,118,119,PINL0380
 572, 73,72,119,120,121,74, 75,74,121,122,123,124/ PINL0390

C

ISN 0006

DATA NPN1/30,29,50,74,75,52, 31,30,51,75,76,53, 32,31,52,76,77,54,PINL0410
 1 55,32,53,77,110,78, 55,33,32,54,78,79, 57,34,33,55,79,80, 58,35,3PINL0420
 24,56,80,81, 82,59,35,57,81,115, 83,60,36,35,58,82, 84,61,37,36,59,PINL0430
 383, 85,38,20,37,60,84, 87,88,63,39,38,86, 88,89,64,40,39,62, 89,90PINL0440
 4,65,41,40,63, 90,91,92,42,41,64, 92,93,94,67,43,42, 66,94,95,68,44PINL0450
 5,43, 67,95,96,69,45,44, 68,96,97,98,46,45, 46,98,99,100,71,47, 47,PINL0460
 670,100,101,72,48, 48,71,101,102,73,49, 49,72,102,103,104,50, 51,50PINL0470
 7,104,105,106,75, 52,51,74,106,107,76, 53,52,75,107,108,77, 54,53,7PINL0480
 86,108,109,110, 79,55,54,110,111,112, 80,56,55,78,112,113, 81,57,56PINL0490
 9,79,113,114, 115,58,57,80,114,115, 118,83,59,58,116,117, 119,84,60PINL0500
 1,59,82,118, 120,85,61,60,83,119, 121,86,38,61,84,120/ PINL0510

C

ISN 0007

DATA NCHN1/77,76,75,124,125,126, 79,78,77,126,127,128, 81,80,79,12PINL0530
 18,129,130, 133,82,81,130,131,132, 135,84,83,82,133,134, 137,86,85,PINL0540
 284,135,136, 139,88,87,86,137,138, 141,142,89,88,139,140, 143,144,9PINL0550
 31,90,89,142, 145,146,93,92,91,144, 147,148,95,94,93,146, 151,152,1PINL0560
 453,98,97,150, 153,154,155,100,99,98, 155,156,157,102,101,100, 157,PINL0570
 5158,159,104,103,102, 105,160,161,162,107,106, 107,162,163,164,109,PINL0580
 6108, 109,164,165,166,111,110, 111,166,167,168,113,112, 115,114,169PINL0590
 7,170,171,116, 117,116,171,172,173,118, 119,118,173,174,175,120, 12PINL0600
 81,120,175,176,177,122, 125,124,123,178,179,180, 127,126,125,180,18PINL0610
 91,182, 129,128,127,182,183,184, 131,130,129,184,185,186, 189,134,1PINL0620
 133,132,187,188, 191,136,135,134,189,190, PINL0630
 2193,138,137,136,191,192, 195,140,139,138,193,194, 197,198,143,142,PINL0640
 3141,196, 199,200,145,144,143,198, 201,202,147,146,145,200, 203,204PINL0650
 4,149,148,147,202/ PINL0660

C

ISN 0008

IF (N.GT.50)

GO TO 20

ISN 0010

DO 10 I = 1,6

ISN 0011

NPN(I) = NPIN(I,N)

ISN 0012

10 NCHN(I) = NCHAN(I,N)

ISN 0013

RETURN

ISN 0014

20 DO 30 I = 1,6

ISN 0015

NPN(I) = NPN1(I,N-50)

ISN 0016
ISN 0017
ISN 0018

30 NCHN(I) = NCHN1(I,N-50)
RETURN
END

PINL0750
PINL9998
PINL9999

Sample Output

1. Summary of Input.
2. Resultant force on all elements.
3. Detail stresses and forces on each element (only 3 included herein).
4. Margin of Safety Summary.

SUMMARY INPUT DATA

ELEMENT LENGTH 17.250

CONTACT DISTANCE FROM COLD END 10.500

STATIONS 2.5996 4.1986 5.7994 7.4002 8.9993 10.6001 12.1992 13.8000 15.4008 17.2500

SPACING, INITIAL BOW, HOT END LOOSENESS 0.00500 0.00600 0.0

THICKNESS 0.02400

RADIUS 0.49000

ALPHA & MODULUS 0.93999997E-05 0.22300000E 08

BIJLAARD MULTIPLIERS, HOOP 1516.00

AXIAL 628.00

ALLOWABLE 34000.00

FORCE BALANCE RESULTS

I	PHI4	PHI	FR	I	PHI4	PHI	FR	I	PHI4	PHI	FR	I	PHI4	PHI	FR	I	PHI4	PHI	FR
1	100.	281.	11.6	2	248.	85.	8.6	3	290.	96.	10.1	4	49.	258.	8.9	5	300.	103.	10.
6	246.	83.	10.7	7	139.	300.	6.4	8	275.	129.	10.1	9	264.	49.	4.3	10	337.	216.	6.
11	334.	128.	4.8	12	328.	60.	0.9	13	351.	120.	4.6	14	73.	275.	7.0	15	92.	272.	11.
16	104.	259.	8.9	17	188.	59.	4.5	18	222.	120.	2.4	19	149.	289.	10.7	20	245.	63.	1.
21	281.	171.	1.4	22	264.	41.	6.0	23	308.	180.	2.3	24	295.	60.	6.0	25	19.	240.	6.
26	316.	60.	5.1	27	12.	240.	0.9	28	39.	60.	0.9	29	53.	196.	0.9	30	72.	193.	1.
31	121.	36.	2.6	32	137.	60.	1.9	33	153.	0.	2.3	34	123.	254.	8.3	35	238.	70.	7.
36	167.	300.	5.6	37	224.	81.	5.8	38	303.	180.	7.2	39	148.	309.	18.2	40	327.	180.	10.
41	318.	0.	0.0	42	173.	0.	4.2	43	195.	341.	9.1	44	171.	353.	14.5	45	59.	280.	8.
46	329.	120.	6.7	47	73.	294.	11.2	48	22.	120.	2.7	49	59.	286.	3.2	50	111.	0.	0.
51	83.	300.	0.7	52	85.	240.	1.9	53	99.	240.	1.9	54	118.	240.	5.0	55	182.	60.	5.
56	99.	241.	12.4	57	226.	81.	15.6	58	221.	113.	6.0	59	345.	173.	6.5	60	132.	291.	14.
61	306.	151.	17.4	62	233.	36.	10.9	63	303.	141.	12.0	64	314.	180.	0.2	65	188.	0.	11.
66	280.	148.	7.7	67	294.	134.	12.1	68	342.	168.	9.7	69	5.	198.	4.7	70	355.	147.	7.
71	46.	300.	3.8	72	74.	300.	0.9	73	268.	87.	14.4	74	239.	60.	10.9	75	81.	0.	0.
76	335.	180.	9.1	77	163.	0.	9.1	78	71.	240.	8.8	79	280.	77.	11.2	80	120.	299.	8.
81	145.	301.	6.4	82	119.	317.	18.0	83	299.	120.	14.2	84	189.	350.	10.9	85	236.	48.	9.

CASE 1, 5 KWE B.O.L., RANDOM ASYMMETRY, PIN END BOW, 6/15/72

ELEMENT NO 1 CONTACT PLANE STRESS AND DEFL SUMMARY

DEG	TEMP	6TH TEMP	6 TH STRESS	BEND STRESS	TOTAL STRESS	CONTACT LOAD	HOOP STRESS	AXIAL STRESS	EQUIV STRESS	SAFETY MARGIN		
15	1143.8	0.6	-130.	-194.	-325.							
30	1149.7	5.8	-1226.	-869.	-2094.							
45	1144.2	-0.2	47.	-1484.	-1437.							
60	1138.7	-6.0	1267.	-1999.	-731.	5.68	8610.	3567.	7759.	3.382		
75	1144.3	-0.6	120.	-2377.	-2257.							
90	1149.8	5.2	-1084.	-2593.	-3677.							
105	1144.8	0.6	-126.	-2632.	-2759.							
120	1139.7	-3.7	783.	-2492.	-1710.	7.51	11388.	4717.	10486.	2.243		
135	1143.3	0.7	-140.	-2183.	-2323.							
150	1146.8	5.2	-1086.	-1724.	-2811.							
165	1139.3	-1.3	263.	-1148.	-886.							
180	1131.9	-7.7	1614.	-494.	1120.	1.26	1914.	793.	1341.	24.364		
195	1137.9	-0.8	162.	194.	355.							
210	1143.9	6.0	-1258.	868.	-390.							
225	1138.4	1.1	-225.	1484.	1259.							
240	1132.9	-4.1	859.	1998.	2857.	0.0	0.	0.	2857.	10.901		
255	1138.3	1.4	-301.	2376.	2076.							
270	1143.8	6.7	-1403.	2593.	1190.							
285	1136.8	-0.7	156.	2632.	2788.							
300	1129.9	-8.4	1760.	2493.	4253.	0.0	0.	0.	4253.	6.995		
315	1137.8	-1.3	271.	2183.	2454.							
330	1145.8	5.7	-1193.	1725.	532.							
345	1141.8	0.6	-130.	1149.	1019.							
360	1137.7	-4.4	928.	495.	1423.	0.0	0.	0.	1423.	22.901		
Z/L		0.0	0.15	0.24	0.34	0.52	0.61	0.71	0.80	0.89	1.00	
TEMP GRAD		0.01	0.89	0.50	2.88	3.83	6.33	8.07	8.36	7.83	7.05	5.55
ANGLE		357.25	89.26	4.62	92.12	105.77	106.20	100.27	98.29	101.82	102.16	105.51
THERM DEFL		0.0	0.65	1.03	1.38	1.67	1.86	1.89	1.74	1.38	0.84	0.0
MECH ANGLE		280.80	280.80	280.80	280.80	280.80	280.80	280.80	280.80	280.80	280.80	280.80
MECH DEFL		0.0	2.44	3.77	4.86	5.60	5.90	5.68	4.87	3.61	2.03	0.0

CONTACT LOAD 11.63 ALLOW STRESS 34000. MINIMUM M.S. 2.24

CASE 1, 5 KWE B.O.L., RANDOM ASYMMETRY, PIN END BOW, 6/15/72

ELEMENT NO 35 CONTACT PLANE STRESS AND DEFL SUMMARY

DEG	TEMP	6TH TEMP	6 TH STRESS	BEND STRESS	TOTAL STRESS	CONTACT LOAD	HOOP STRESS	AXIAL STRESS	EQUIV STRESS	SAFETY MARGIN		
15	1114.2	1.6	-330.	1018.	688.							
30	1118.2	5.7	-1200.	1360.	161.							
45	1111.2	-1.5	323.	1610.	1933.							
60	1104.2	-9.3	1940.	1750.	3690.	0.0	0.	0.	3690.	8.214		
75	1111.7	-2.9	616.	1771.	2386.							
90	1119.2	3.1	-640.	1671.	1031.							
105	1117.7	-0.2	38.	1457.	1495.							
120	1116.1	-3.5	738.	1145.	1882.	0.0	0.	0.	1882.	17.065		
135	1122.6	1.1	-235.	754.	518.							
150	1129.0	5.9	-1236.	311.	-925.							
165	1127.0	2.5	-514.	-152.	-666.							
180	1124.9	-0.6	135.	-605.	-471.	0.0	0.	0.	141.	239.741		
195	1127.5	1.2	-260.	-1017.	-1277.							
210	1130.0	3.6	-751.	-1360.	-2111.							
225	1124.0	-2.1	441.	-1610.	-1169.							
240	1118.1	-7.3	1536.	-1750.	-214.	6.92	10490.	4346.	9251.	2.675		
255	1122.1	-2.2	457.	-1771.	-1314.							
270	1126.1	3.3	-690.	-1671.	-2361.							
285	1120.1	-1.0	199.	-1458.	-1259.							
300	1114.2	-5.1	1064.	-1145.	-81.	1.58	2399.	994.	2126.	14.996		
315	1118.7	1.2	-257.	-754.	-1010.							
330	1123.2	7.4	-1548.	-312.	-1860.							
345	1116.7	2.3	-488.	152.	-337.							
360	1110.2	-3.1	642.	605.	1247.	0.0	0.	0.	1247.	26.262		
Z/L		0.0	0.15	0.24	0.34	0.43	0.52	0.61	0.71	0.80	0.89	1.00
TEMP GRAD		0.32	0.77	2.26	4.76	7.65	10.16	14.21	16.34	17.18	17.84	17.39
ANGLE		241.79	219.23	239.22	227.84	240.99	242.35	237.92	236.20	233.80	226.64	223.09
THERM DEFL		0.0	1.24	1.97	2.64	3.19	3.55	3.65	3.42	2.80	1.75	0.0
MECH ANGLE		70.08	70.08	70.08	70.08	70.08	70.08	70.08	70.08	70.08	70.08	70.08
MECH DEFL		0.0	1.65	2.54	3.27	3.77	3.97	3.82	3.28	2.43	1.37	0.0

CONTACT LOAD 7.83 ALLOW STRESS 34000. MINIMUM M.S. 2.68

ELEMENT NO 83 CONTACT PLANE STRESS AND DEFL SUMMARY

DEG	TEMP	6TH TEMP	6 TH STRESS	BEND STRESS	TOTAL STRESS	CONTACT LOAD	HOOP STRESS	AXIAL STRESS	EQUIV STRESS	SAFETY MARGIN		
15	1106.8	-1.7	357.	-837.	-479.							
30	1110.4	3.3	-682.	0.	-682.							
45	1105.8	-0.2	39.	837.	876.							
60	1101.2	-4.0	838.	1617.	2455.	0.0	0.	0.	2455.	12.847		
75	1105.3	0.3	-73.	2287.	2214.							
90	1109.3	4.2	-890.	2801.	1911.							
105	1108.2	2.6	-546.	3124.	2578.							
120	1107.2	0.6	-118.	3234.	3116.	0.0	0.	0.	3116.	9.911		
135	1109.2	1.3	-268.	3124.	2856.							
150	1111.2	1.7	-366.	2801.	2435.							
165	1108.7	-2.5	522.	2287.	2809.							
180	1106.2	-6.8	1415.	1617.	3032.	0.0	0.	0.	3032.	10.213		
195	1110.7	-3.9	814.	837.	1652.							
210	1115.2	-0.8	171.	0.	172.							
225	1114.7	-2.4	513.	-837.	-323.							
240	1114.2	-3.7	775.	-1617.	-841.	0.0	0.	0.	252.	133.750		
255	1118.7	0.5	-107.	-2286.	-2393.							
270	1123.2	5.2	-1084.	-2800.	-3884.							
285	1120.2	2.7	-567.	-3124.	-3691.							
300	1117.2	0.7	-137.	-3234.	-3371.	14.25	21602.	8949.	19929.	0.706		
315	1118.8	3.5	-740.	-3124.	-3864.							
330	1120.3	6.7	-1394.	-2801.	-4195.							
345	1111.8	-0.1	31.	-2287.	-2256.							
360	1103.3	-6.9	1450.	-1618.	-168.	0.0	0.	0.	50.	673.337		
Z/L		0.0	0.15	0.24	0.34	0.43	0.52	0.61	0.71	0.80	0.89	1.00
TEMP GRAD		0.99	2.81	5.82	8.64	11.33	12.52	13.35	12.40	10.39	7.93	6.31
ANGLE		359.98	334.37	326.58	320.67	312.22	307.48	298.64	290.82	284.66	265.51	246.73
THERM DEFL		0.0	1.47	2.29	2.97	3.43	3.62	3.51	3.08	2.36	1.38	0.0
MECH ANGLE		120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
MECH DEFL		0.0	2.99	4.62	5.95	6.86	7.23	6.95	5.97	4.42	2.49	0.0
CONTACT LOAD			14.25	ALLOW STRESS		34000.	MINIMUM M. S.		0.71			

MARGIN OF SAFETY SUMMARY

ELEMENT	FORCE	MARGIN	ELEMENT	FORCE	MARGIN	ELEMENT	FORCE	MARGIN
1	11.63	2.243	2	8.60	2.916	3	10.10	2.315
4	8.87	3.357	5	10.25	2.470	6	10.66	2.774
7	6.44	2.871	8	10.14	1.644	9	4.26	7.365
10	6.67	4.411	11	4.83	4.537	12	0.92	19.469
13	4.59	4.466	14	7.01	4.547	15	11.48	2.458
16	8.89	3.404	17	4.50	4.730	18	2.39	9.705
19	10.67	1.690	20	1.32	19.720	21	1.43	17.445
22	6.02	4.489	23	2.31	10.905	24	6.03	3.181
25	6.03	3.241	26	5.10	4.061	27	0.92	20.310
28	0.87	19.806	29	0.87	13.731	30	1.28	17.277
31	2.62	13.408	32	1.88	13.296	33	2.33	9.905
34	8.29	2.581	35	7.83	2.675	36	5.63	3.343
37	5.82	3.594	38	7.17	2.484	39	18.17	1.266
40	10.85	1.261	41	0.0	25.455	42	4.23	4.958
43	9.14	3.243	44	14.53	2.124	45	8.78	2.604
46	6.70	2.664	47	11.21	2.652	48	2.68	8.272
49	3.21	8.725	50	0.0	19.522	51	0.70	30.869
52	1.92	12.143	53	1.88	12.765	54	4.99	4.085
55	4.99	4.134	56	12.38	1.013	57	15.64	1.003
58	6.02	2.821	59	6.48	3.136	60	14.53	0.907
61	17.37	0.875	62	10.92	2.387	63	12.03	1.756
64	0.25	29.513	65	11.14	1.232	66	7.71	4.253
67	12.10	2.141	68	9.73	2.144	69	4.65	5.977
70	7.36	4.396	71	3.79	4.264	72	0.90	27.992
73	14.36	1.678	74	10.95	1.199	75	0.0	25.885
76	9.06	1.755	77	9.06	1.699	78	8.84	1.822
79	11.19	1.780	80	7.96	2.059	81	6.43	2.919
82	17.99	0.726	83	14.25	0.706	84	10.91	2.353
85	9.57	2.525						

HC900I EXECUTION TERMINATING DUE TO ERROR COUNT FOR ERROR NUMBER 217

HC217I FIOCS - END OF DATA SET ON UNIT 5

TRACEBACK	ROUTINE	CALLED FROM	ISN	REG. 14	REG. 15	REG. 0	REG. 1
	IBCOM			00177FA4	0017E1D0	00000056	00000168
	MAIN			0001E802	01169730	FD000008	0019A7F8