JSC-09434
NASA CR-
144355

PROGRAM DOCUMENTATION

SURFACE HEATING RATE OF THIN SKIN MODELS (THNSKN)

Program Q614

Job Order 83-157

(This revision supersedes 07000 dated November 1969)

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Prepared By

Lockheed Electronics Company, Inc.
Aerospace Systems Division
Houston, Texas

Contract NAS 9-12200

For

INSTITUTIONAL DATA SYSTEMS DIVISION

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

April 1975

LEC-5523

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TECHNICAL REPORT INDEX/ABSTRACT

(See instructions on reverse side.)

1. TITLE AND SUBTITLE OF DOCUMENT Program Documentation Surface Heating Rate of Thin Skin Models (THNSKN)	2. JSC NO. JSC-09434
3. CONTRACTOR/ORGANIZATION NAME Lockheed Electronics Company, Inc.	4. CONTRACT OR GRANT NO. NAS 9-12200
5. CONTRACTOR/ORIGINATOR DOCUMENT NO. LEC-5523	6. PUBLICATION DATE (THIS ISSUE) April 1975
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9. LIMITATIONS GOVERNMENT HAS UNLIMITED RIGHTS [X] YES [ ] NO IF NO, STATE LIMITATIONS AND AUTHORITY	10. AUTHOR(S) Jack D. McBryde
11. DOCUMENT CONTRACT REFERENCES	12. HARDWARE CONFIGURATION
WORK BREAKDOWN STRUCTURE NO. N/A	SYSTEM N/A
CONTRACT EXHIBIT NO. N/A	SUBSYSTEM N/A
DRL NO. AND REVISION N/A DRL LINE ITEM NO. N/A	MAJOR EQUIPMENT GROUP N/A

13. ABSTRACT

THNSKN computes the mean heating rate at a maximum of 100 locations on the surface of thin skin transient heating rate models. Output is printed in tabular form and consists of time history tabulation of temperatures, average temperatures, heat loss without conduction correction, mean heating rate, least squares heating rate, and the percent standard error of the least squares heating rates. The input tape used is produced by the program EHTS03.

14. SUBJECT TERMS

ARC JET	THERMOCOUPLES	
HEATING RATE		
THIN SKIN		

JSC Form 833 (Rev Sep 74) NASA-JSC

TABLE OF CONTENTS

LIST OF ATTACHMENTS

UNIT I

PROGRAM ABSTRACT AND HISTORY OF USE

A. ABSTRACT

Program THNSKN computes the mean heating rate at a number of thermocouple locations on the surface of thin skin transient heating rate models. Experimental data, calibrated in engineering units, is obtained from ABEL tape output of the EHTS03 data reduction computer program. The program output consists of time history tabulations in an array by thermocouple locations for each time sample.

B. PROGRAM HISTORY

The original THNSKN program was written in 1969. The current version was written in December 1974 as requested by SCR83-15-30.

UNIT II
PROGRAM USERS INFORMATION

A. IDENTIFICATION

Title:	Surface Heating Rate of Thin Skin Models (THNSKN)
Author:	Jack D. McBryde
Date:	December 1974
Installation:	JSC, Houston, Texas
Authorization:	Contract NAS 9-12200
Source Language:	FORTRAN V
Computer Configuration:	UNIVAC 1108 or 1110, EXEC 8

B. DESCRIPTION OF PROGRAM REQUEST

See attachment 8.

C. USAGE

1. Input Requirements and Data Descriptions:

   The THNSKN input tape is produced by the program EHTS03. It is a FORTRAN-written binary tape containing time in floating-point seconds followed by data in floating point for N channels. The number of channels (N) is fixed for a given tape ($N \leq 259$).

   See attachment 6 for sample input.

2. Lead Card Setup:

   See attachment 1.

3. Deck Setup:

See attachment 2.

4. Tape Assignments:

See attachment 3.

5. Restrictions:

The following list is a summary of the restrictions:

- The input tape must have the format specified in section C.1.
- The array of thermocouples must have no more than 50 rows or columns, and one row or column must contain at least three thermocouples.
- Each specified time slice must contain at least three input records.
- The maximum number of points for thermocouples, which may be used for least squares heat loss computations, is 50.

6. Diagnostic, Normal-Console, and Standard-Output Messages:

See attachment 9.

7. Labels, Save-Tapes, and Output Disposition:

There is printer output only.

8. Output Formats:

See attachment 7.

9. Nonstandard System Requirements:

There are none.

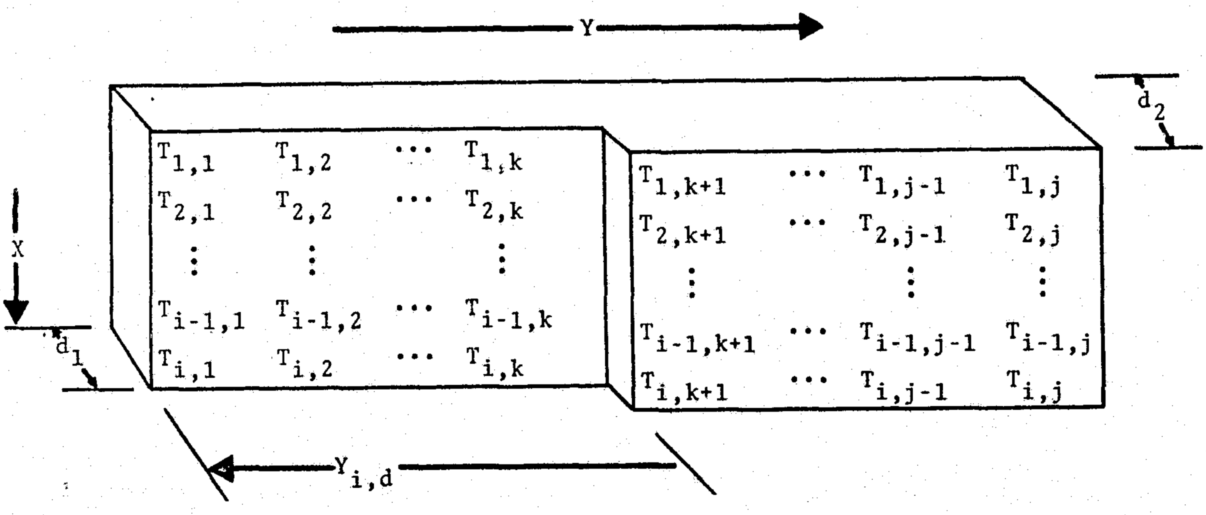
10. Running Time:

THNSKN processes nine thermocouples for 40 time points in less than 1/2 minute.

D. ANALYSIS

1. Description of the Relationship of Variables to the Test Item:

The test item may be considered to be a rectangular plate having, at most, two thicknesses as shown:



- The origin of the x-, y-coordinate system is the upper left corner.

- The variables d_1 and d_2 are the two thicknesses. If the test item has only one thickness, it is represented by d .
- The variable $T_{i,j}$ is the temperature at a thermocouple in degrees Fahrenheit.
- The variables $T_{i,k}$ and $T_{i,k+1}$ are temperatures adjacent to the thickness difference junction.
- The variable $Y_{i,d}$ is the y-coordinate of the junction at row i in inches.
- Each row or column is colinear in the X-, Y-plane so that the coordinates of all the thermocouples (X, Y) can be expressed using i-values of X and j-values of Y . Both X and Y are in inches.

2. Equations:

2.1 Mean temperatures:

The mean temperature $\overline{T}$ for each thermocouple is computed by

$$\overline{T} = \frac{1}{N} \sum_{\ell=1}^{N} T_{\ell} \qquad (1)$$

where N is the number of temperatures read in the time interval processed.

2.2 Mean heat flux without conduction correction:

The mean heat flux without conduction correction $\overline{q}$ is computed by

$$\overline{q}_{i,j} = \frac{\rho C_p d}{24(t_N - t_1)} \frac{N - 1}{N - 2} \left(T^N_{i,j} + T^{N-1}_{i,j} - T^1_{i,j} - T^2_{i,j}\right) \tag{2}$$

where

t_1	= the time for the first scan of data in the interval in seconds.
t_N	= the time for the last scan of data in the interval in seconds.
$T^1_{i,j}$, $T^2_{i,j}$, $T^{N-1}_{i,j}$, $T^N_{i,j}$	= the first, second, next to the last, and last temperatures of the thermocouple in row i and column j.
ρ	= mass density in lb/ft^3.
C_p	= specific heat in BTU/lb°F.
d	= thickness of test material in inches.

If the test item has two thicknesses, then $d = d_1$, for $j \leq k$ (see the figure) and $d = d_2$ for $j > k$.

2.3 Mean lateral heat loss in the X-direction:

The mean lateral heat loss in the X-direction $\overline{q^x}$ is computed by

$$\overline{q^x_{i,j}} = \frac{24Kd}{X_{i+1} - X_{i-1}} \left(\frac{\overline{T}_{i,j} - \overline{T}_{i-1,j}}{X_i - X_{i-1}} - \frac{\overline{T}_{i+1,j} - \overline{T}_{i,j}}{X_{i+1} - X_i} \right) \tag{3}$$

where

K = thermal conductivity in BTU/ft sec°F.

$d = d_1$ for $j \leq k$ (see the figure).

$d = d_2$ for $j > k$.

2.4 Mean lateral heat loss in the Y-direction:

The mean lateral heat loss in the Y-direction $\overline{q^y}$ may be computed by one of three equations, depending on whether the test material has one or two thicknesses and the position of the thermocouple relative to the junction between the thicknesses.

Case 1: The variable $\overline{q^y}$ when the material has one thickness or where it has two and all three thermocouples are the same side of the junction.

$$\overline{q^y_{i,j}} = \frac{24Kd}{Y_{j+1} - Y_{j-1}} \left(\frac{\overline{T}_{i,j} - \overline{T}_{i,j-1}}{Y_j - Y_{j-1}} - \frac{\overline{T}_{i,j+1} - \overline{T}_{i,j}}{Y_{j+1} - Y_j} \right) \tag{4}$$

where

$d = d_1$ when $j + 1 \leq k$.

$d = d_2$ when $j - 1 > k$.

<u>Case 2</u>: The variable $\overline{q^y}$ when the material has two thicknesses and $j = k$ (see the figure).

$$\overline{q^y_{i,j}} = \frac{24Kd_1}{Y_{k+1} - Y_{k-1}}$$

$$\left(\frac{\overline{T}_{i,k} - \overline{T}_{i,k-1}}{Y_k - Y_{k-1}} - \frac{d_2(\overline{T}_{i,k+1} - \overline{T}_{i,k})}{(Y_d - Y_k)d_2 + (Y_{k+1} - Y_d)d_1} \right) \tag{5}$$

where

Y_d = the Y-coordinate of the function at row i (see the figure).

<u>Case 3</u>: The variable $\overline{q^y}$ when the material has two thicknesses and $j = k + 1$.

$$\overline{q^y_{i,j}} = \frac{24Kd_2}{Y_{k+2} - Y_k}$$

$$\left(\frac{d_1(\overline{T}_{i,k+1} - \overline{T}_{i,k})}{(Y_d - Y_k)d_2 + (Y_{k+1} - Y_d)d_1} - \frac{\overline{T}_{i,k+2} - \overline{T}_{i,k+1}}{Y_{k+2} - Y_{k+1}} \right) \tag{6}$$

2.5 Mean heating rate:

The mean heating rate $\bar{\dot{q}}$ is computed from equations 2, 3, and 4, 5, or 6.

$$\bar{\dot{q}}_{i,j} = \bar{q}_{i,j} + \overline{q^x_{i,j}} + \overline{q^y_{i,j}} \qquad (7)$$

3. Special Treatment When the Array Contains Bad Thermocouples:

The variables $\bar{\dot{q}}$, $\bar{q}$, $\overline{q^x}$ and $\overline{q^y}$ are not computed for bad thermocouples. These values are set to zero.

In computing $\overline{q^x}$ for a column containing one or more bad thermocouples, temperatures and x-coordinates of three successive good (but not necessarily adjacent) thermocouples are used.

The same procedure is used in computing $\overline{q^y}$.

4. The Variables $\overline{q^x}$ and $\overline{q^y}$ at Row or Column End Points:

The conduction correction ($\overline{q^x}$ or $\overline{q^y}$) used at the end points (first or last good thermocouple) are the same as those computed for the adjacent thermocouple in the row or column.

5. Linear Least Squares Heating Rate and Percent Standard Error:

The heating rate at each thermocouple $\bar{\dot{Q}}$ is computed from the slope M by

$$\bar{\dot{Q}} = \frac{\rho C_p d}{12} M \qquad (8)$$

The slope M is computed by

$$M = \frac{n\sum t_i T_i - \sum t_i \sum T_i}{n\sum t_i^2 - (\sum t_i)^2} \qquad (9)$$

where

n = the number of scans.

t = time.

T = temperature.

The percent standard error E is computed by

$$E = \frac{S_n(M)}{M} \times 100 \qquad (10)$$

$$S_n(M) = n\sigma_n(T)\left\{(n - 2)\left[n\sum t_i^2 - (\sum t_i)^2\right]\right\}^{1/2} \qquad (11)$$

$$\sigma_n(T) = \frac{1}{n}$$

$$\left\{n\sum T_i^2 - (\sum T_i)^2 - \frac{(n\sum t_i T_i - \sum t_i \sum T_i)^2}{n\sum t_i^2 - (\sum t_i)^2}\right\}^{1/2}$$

$$(12)$$

If the time slice specified contains more than n scans, the last time and corresponding temperatures are used as the first time and temperatures for the next n scans.

E. FLOW CHART

See attachment 4.

F. STORAGE REQUIREMENTS

Forty-three thousand decimal locations are required.

G. LIST OF SUBROUTINES

None.

H. LOCATION OF SOURCE AND BINARY DECKS

The Data Processing Systems Department of Lockheed Electronics Company, Inc., maintains all source and binary decks for this program.

I. PROGRAM LISTING

See attachment 5.

J. CORRESPONDENCE

See attachment 8.

ATTACHMENT 1

LEAD CARD SETUP

LEAD CARD SETUP

CARD NO. 1

JOB

PAGE 1 OF 10

NAME THNSKN

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-72	12A6	TITLE1	First title card.

LEAD CARD SETUP

CARD NO. 2

JOB

PAGE 2 OF 10

NAME THNSKN

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-72	12A6	TITLE2	Second title card.

LEAD CARD SETUP

CARD NO. 3

JOB

NAME THNSKN

PAGE 3 OF 10

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.3	RHO	Mass density (p) of test material in
				lbm/ft^3.
2	11-20	F10.3	CP	Specific heat (Cp) of test material in
				BTU/1bm °F.
3	21-30	F10.3	BIGK	Thermal conductivity (K) of test
				material in BTU/ft sec °F.
4	31-40	F10.3	DD(1)	Test material thickness (d_1) in inches.
				If there is only one thickness in the
				sample, the next field will be left
				blank.
5	41-50	F10.3	DD(2)	The second test material thickness (D_2).
				If a second thickness is supplied,
				card 5 must appear in the deck.
6	51-53	I3	NX	Number* of x-coordinates:
				$1 \leq NV \leq 50$.
7	54-56	I3	NY	Number* of y-coordinates:
				$1 \leq NY \leq 50$.

Comment: *A minimum of a 1×3 or 3×1 array of x, y-coordinates is required.

LEAD CARD SETUP

CARD NO. 4

JOB

PAGE 4 OF 10

NAME THNSKN

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-5	I5	NCHS	Number of data channels on input tape*.
2	6-10	I5	NCC	Command channel number*.
3	11-15	I5	IOPT1	0 – Use card 9 to specify start-stop
				times.
				1 – Use card 9A to specify start-stop
				command event levels.
4	16-20	I5	NPAR	The maximum number of parity error
				records per time slice which will be
				permitted. If blank, 2 will be used.
				Parity error records are skipped.
5	21-25	I5	NOTH	If NOTH is blank or zero time, tempera-
				ture data for each scan in the time
				slice will be printed.

Comment: *The input tape record has a time word preceding the data channels. These numbers do not include the time word.

LEAD CARD SETUP

CARD NO. 5

JOB

NAME THNSKN

PAGE 5 OF 10

PROGRAMMER McBryde DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
				NOTE: This card will appear in the
				deck only if DD(2) on card 3
				is used.
1	1-10	F10.3	YDD(1)	The y-coordinate of the junction
				between test material thicknesses when
				the x-coordinate is xx(1) (see card 6).
2	11-20	F10.3	YDD(2)	Same for XX(2).
3	21-30	F10.3	YDD(3)	Same for XX(3).
4	31-40	F10.3	YDD(4)	Same for XX(4).
5	41-50	F10.3	YDD(5)	Same for XX(5).

Comment: Use as many cards as required to define NX values.

LEAD CARD SETUP

CARD NO. 6

JOB

NAME THNSKN

PAGE 6 OF 10

PROGRAMMER McBryde DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.3	XX(1)	X-axis location of first thermocouple
				row in inches.
2	11-20	F10.3	XX(2)	X-axis location of second thermocouple
				row.
3	21-30	F10.3	XX(3)	X-axis location of third thermocouple
				row.
4	31-40	F10.3	XX(4)	X-axis location of fourth thermocouple
				row.
5	41-50	F10.3	XX(5)	X-axis location of fifth thermocouple
				row.

Comment: Enter as many cards as needed to define NX locations ($NX \leq 50$).

LEAD CARD SETUP

CARD NO. 7

JOB

NAME THNSKN

PAGE 7 OF 10

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.3	YY(1)	Y-axis location of first thermocouple
				column in inches.
2	11-20	F10.3	YY(2)	Y-axis location of second thermocouple
				column.
3	21-30	F10.3	YY(3)	Y-axis location of third thermocouple
				column.
4	31-40	F10.3	YY(4)	Y-axis location of fourth thermocouple
				column.
5	41-50	F10.3	YY(5)	Y-axis location of fifth thermocouple
				column.

Comment: Enter as many cards as required to define NY locations ($NY \leq 50$).

LEAD CARD SETUP

CARD NO. 8

JOB

NAME THNSKN

PROGRAMMER McBryde

PAGE 8 OF 10

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-3	I3	IX	Row number (X-direction) of thermocouple.
2	4-6	I3	IY	Column number (Y-direction) of thermocouple.
3	7-10	I4	NTCH (IX,IY)	Channel number for temperature of thermocouple located at IX, IY.
4	11-13	I3	IX	Second thermocouple.
5	14-16	I3	IY	
6	17-20	I4	NTCH (IX,IY)	
7	21-23	I3	IX	Third thermocouple.
8	24-26	I3	IY	
9	27-30	I4	NTCH (IX,IY)	
10	31-33	I3	IX	Fourth thermocouple.
11	34-36	I3	IY	
12	37-40	I4	NTCH (IX,IY)	
13	41-43	I3	IX	Fifth thermocouple.
14	44-46	I3	IY	
15	47-50	I4	NTCH (IX,IY)	

Comment: Enter as many cards as needed to define NX * NY thermocouple locations. Bad thermocouples should be indicated with NTCH (IX,IY) = 0 .

LEAD CARD SETUP

CARD NO. 9

JOB

PAGE 9 OF 10

NAME THNSKN

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.3	TSTRT	Computation start time.
2	11-20	F10.3	TSTOP	Computation stop time.
3	21-30	F10.3	STATME	Start time for least squares curve fit.
				No data will be processed outside of
				the interval from TSTRT to TSTOP.
4	31-35	I5	NTME	The number of points to be curve fit.
				If NTME $\leq$ 2 , no curve fitting will
				be done.
				NOTE: This card will be used if IOPT1
				on card 4 is zero or blank. Card 9A
				will not be used and must not appear
				in the deck. As many start-stop time
				cards may be used as desired but the
				time slices must not overlap; i.e., the
				start time for the current time slice
				must be $\geq$ the stop time for the
				previous time slice.

LEAD CARD SETUP

CARD NO. 9A

JOB

PAGE 10 OF 10

NAME THNSKN

PROGRAMMER McBryde

DATE 12/74

FIELD ID	CARD COLUMNS	FORMAT	SYMBOLIC NAME	IDENTIFICATION
1	1-10	F10.0	CESTRT	Command event start level.
2	11-20	F10.0	CESTOP	Command event stop level.
3	21-30	F10.3	STATME	Start time for least squares curve fit.
				No curve fit computations will be done
				prior to CESTRT or after CESTOP.
4	31-35	I5	NTME	The number of points to be curve fit.
				If NTME $\leq$ 2 , no curve fitting will
				be done.
				NOTE: Card 9A will appear in the deck
				only if IOPT1 on card 4 is 1. Card 9
				must not appear in the decks. As many
				event start-stop cards may be used as
				required, but intervals requested must
				not overlap.

ATTACHMENT 2

DECK SETUP

DECK SETUP FOR PROGRAM THNSKN (EXEC VIII) PAGE NO. 1 OF 1

(Back of deck)

7
8 PMD, E

One or more card 9A's if IOPT1 on card 4 is 1.

One or more card 9's if IOPT1 on card 4 is 0.

CARDS 6 – 8

CARD 5 [Only if DD(2) on card 3 > 0]

THNSKN CARDS 1 – 4

7
8XQT .THNSKN/ABS

7
8MAP,S .THNSKN,THNSKN/ABS

7
8PREP

7
8COPIN PGMTP,TPF$

7
8ASG,T 8,8C,XXXXXX (Input tape number)

7
8ASG,T PGMTP,8C,V02679

7
8MSG,N TWO TAPE DRIVES

7
8RUN

(Front of deck)

ATTACHMENT 3

RUN REQUEST FORM

INSTRUCTIONS FOR CENTRAL COMPUTER COMPLEX COMPUTER RUNS

RUNID (DO NOT FILL IN SHADED AREAS)

PROGRAMMER'S COMMENTS:

EXEC VIII

PROGRAMMER	BADGE NO.	BOX NO.	PHONE NO.	DATE	PRIORITY & INITIALS
XXXXXX	XXXX	XXX	XXX	XXX	

DIVISION CODE	PROG. NO	PROJ. NO.	EST. TIME	MAX. TIME	PAGES OUTPUT	SEG. NO.
FDXX	Q614	XXXX	XX	XX	XX	

OPERATING SYSTEM		TYPE OF RUN	NO. TAPES	NO. FASTR FILES	NO. DRUM FILES
1108 EXEC II [ ]	3200 SCOPE [ ]	PROD [X] TEST [ ]	2	0	0
1108 EXEC VIII [X]	3200 SMARTS [ ]	OTHER (EXPLAIN BELOW)			
1108 COBOL [ ]	3200 OTHER [ ]				

INPUT TAPES UNIT	REEL NO.	FILE NAME	WORKING TAPES	OUTPUT TAPES UNIT	REEL NO.	FILE NAME	SAVE	PERMANENT FASTRAND FILES
A	PROGRAM TAPE							$
								$
F	XXXXXX							$
								$
								$
								$

4060 [ ] 16 MM [ ] 35 MM [ ]	REEL NO	FILE NO	PUNCHED OUTPUT [ ]	REEL NO.	NO. CARDS

CAL COMP PLOT [ ]	REEL NO	NO. PLOTS	ACTUAL TIME USAGE
			STOP
			START

ABNORMAL STOPS

- EXCESS OUTPUT [ ]
- EXCESS TIME [ ]
- OTHER (EXPLAIN BELOW) [ ]

SYSTEM OPERATOR

SYSTEM NO.

PAGES OUTPUT

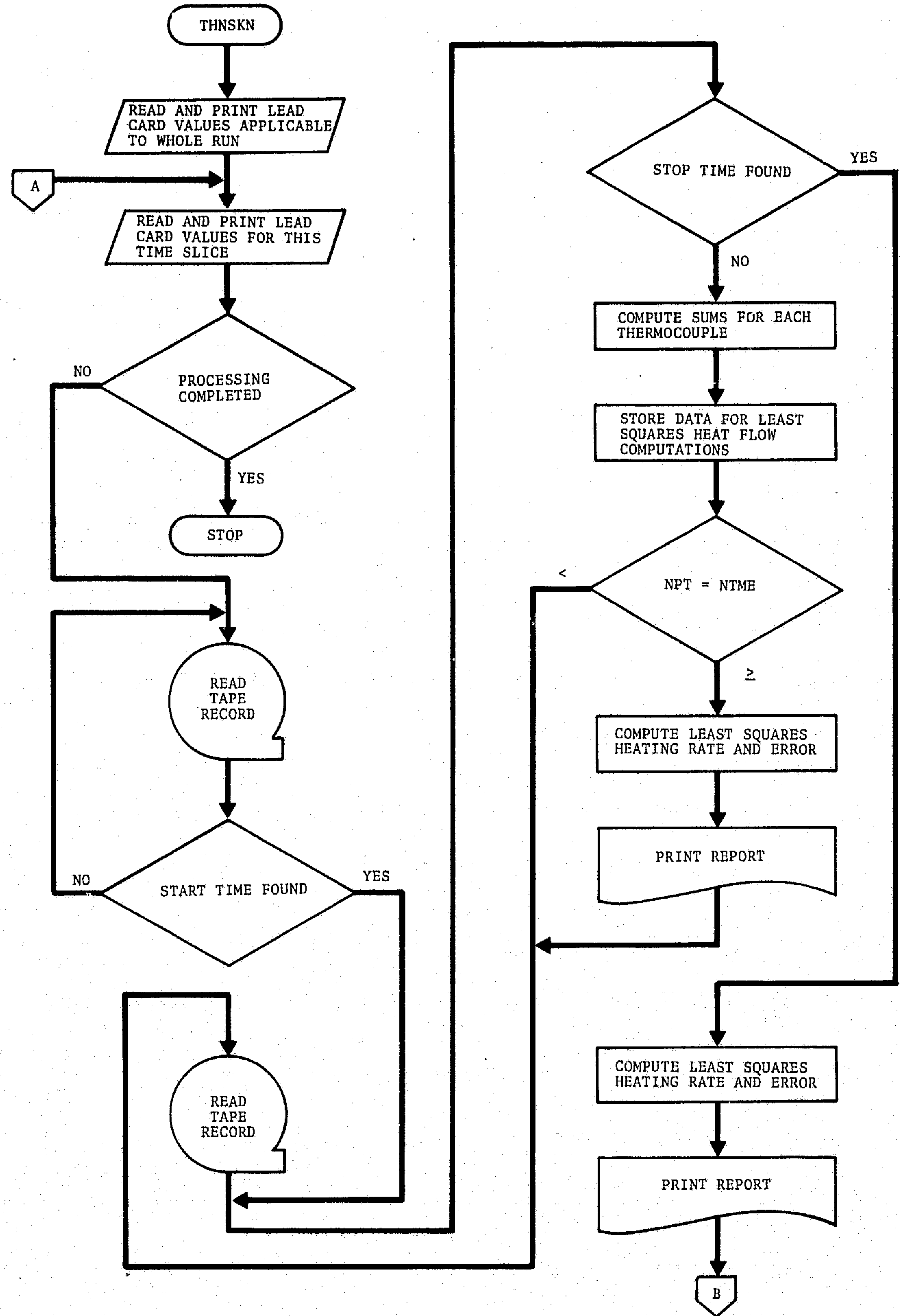
OPERATOR COMMENTS:

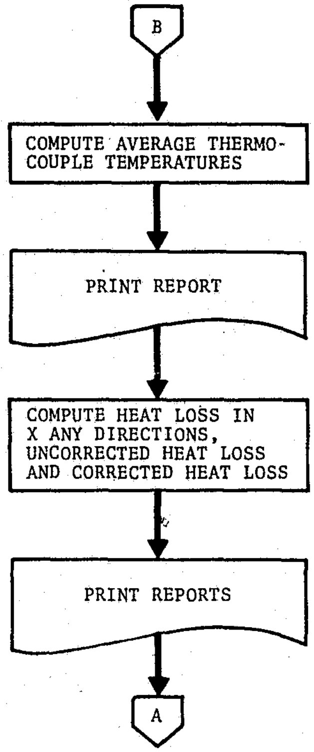
JSC FORM 544A REV MAY 73

U.S. GOVERNMENT PRINTING OFFICE 1974—778 507/278

ATTACHMENT 4

FLOW CHART


THNSKN
READ AND PRINT LEAD CARD VALUES APPLICABLE TO WHOLE RUN
A
READ AND PRINT LEAD CARD VALUES FOR THIS TIME SLICE
PROCESSING COMPLETED
NO
YES
STOP
READ TAPE RECORD
START TIME FOUND
NO
YES
READ TAPE RECORD
STOP TIME FOUND
YES
NO
COMPUTE SUMS FOR EACH THERMOCOUPLE
STORE DATA FOR LEAST SQUARES HEAT FLOW COMPUTATIONS
NPT = NTME
<
≥
COMPUTE LEAST SQUARES HEATING RATE AND ERROR
PRINT REPORT
COMPUTE LEAST SQUARES HEATING RATE AND ERROR
PRINT REPORT
B


B
COMPUTE AVERAGE THERMO-COUPLE TEMPERATURES
PRINT REPORT
COMPUTE HEAT LOSS IN X ANY DIRECTIONS, UNCORRECTED HEAT LOSS AND CORRECTED HEAT LOSS
PRINT REPORTS
A

ATTACHMENT 5

PROGRAM LISTING

```
@FOR,IS .THNSKN,.THNSKN
FOR SE1X-12/20/74-03:02:19 (,0)
```

MAIN PROGRAM

STORAGE USED: CODE(1) 003717; DATA(0) 073316; BLANK COMMON(2) 000000

EXTERNAL REFERENCES (BLOCK, NAME)

```
0003   EXIT
0004   CHERR
0005   NINTR$
0006   NRDU$
0007   NIO3$
0010   NIO2$
0011   NWDU$
0012   NIO1$
0013   NERR2$
0014   NRBU$
0015   NSTOP$
0016   DSQRT
0017   NERR4$
0020   NERR3$
```


STORAGE ASSIGNMENT (BLOCK, TYPE, RELATIVE LOCATION, NAME)

0001	000150 10L	0000	072335 1000F	0000	072336 1001F	0000	072340 1002F	0000	072341 1003F
0000	072343 1004F	0000	072346 1005F	0000	072350 1007F	0000	072352 1008F	0001	001727 1014G
0001	001741 1022G	0001	001750 1027G	0001	001774 1041G	0001	002006 1047G	0001	002015 1054G
0001	000677 110L	0001	002105 1103G	0001	002117 1111G	0001	002122 1114G	0001	002141 1126G
0001	002154 1134G	0001	002155 1137G	0001	002175 1153G	0001	000705 120L	0001	002375 1236G
0001	002407 1244G	0001	002416 1251G	0001	002446 1264G	0001	000724 130L	0001	003005 1371G
0001	003017 1377G	0001	000732 140L	0001	003026 1404G	0001	003072 1415G	0001	003076 1421G
0001	003157 1453G	0001	003171 1461G	0001	003200 1466G	0001	000743 150L	0001	003224 1500G
0001	003236 1506G	0001	003245 1513G	0001	003331 1537G	0001	003352 1550G	0001	003354 1553G
0001	003366 1562G	0001	000752 160L	0001	003446 1647G	0001	003504 1660G	0001	003513 1663G
0001	003545 1677G	0001	000757 170L	0001	003630 175L	0001	001003 190L	0001	000227 20L
0001	003632 200L	0000	072354 2000F	0000	072360 2001F	0000	072455 2002F	0000	072527 2003F
0000	072564 2004F	0000	072624 2005F	0000	072634 2006F	0000	072644 2007F	0000	072654 2008F
0000	072663 2009F	0000	072675 2010F	0000	072704 2011F	0000	072716 2012F	0000	072724 2013F
0000	072736 2014F	0000	072751 2015F	0000	072770 2016F	0000	072777 2017F	0000	073010 2018F
0000	073034 2019F	0000	073051 2020F	0000	073066 2021F	0000	073067 2022F	0000	073107 2023F
0001	001056 220L	0001	000243 221G	0001	000255 227G	0001	001075 230L	0001	000304 236G
0001	001112 240L	0001	000316 244G	0001	001121 250L	0001	000330 252G	0001	000342 260G
0001	001126 260L	0001	000353 266G	0001	001152 280L	0001	000261 30L	0001	000401 300G
0001	001170 300L	0001	000413 306G	0001	000422 313G	0001	001242 330L	0001	001267 340L
0001	001363 365L	0001	001424 370L	0001	001572 395L	0001	001614 400L	0000	073127 4001F
0000	073135 4002F	0000	073145 4003F	0000	073154 4004F	0000	073165 4005F	0001	000610 404G
0001	000611 407G	0001	001653 410L	0001	000654 426G	0001	002026 440L	0001	000717 444G
0001	001010 476G	0001	002207 480L	0001	002227 490L	0001	000445 50L	0001	002247 500L
0001	002355 510L	0001	001052 512G	0001	001070 523G	0001	002427 530L	0001	002453 540L
0001	002473 550L	0001	001165 560G	0001	002513 560L	0001	001175 566G	0001	002544 570L
0001	002557 575L	0001	002614 580L	0001	002656 590L	0001	000502 60L	0001	001235 600G
0001	002717 600L	0001	002761 610L	0001	001315 627G	0001	003037 630L	0001	001332 636G
0001	003131 640L	0001	001335 641G	0001	003137 650L	0001	001352 651G	0001	003256 680L

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0001     003270 690L      0001     000536 70L       0001     001473 705G      0001     001505 713G      0001     001514 720G
0001     003404 730L      0001     001540 732G      0001     001552 740G      0001     001561 745G      0001     001606 756G
0001     000555 80L       0001     003642 999L      0000     073210 9999F     0000 R 072255 BIGK      0000 R 072301 CESTOP
0000 R 072300 CESTRT      0000 R 072303 CON12     0000 R 072304 CON24     0000 R 072302 CON6      0000 R 072259 CP
0000 R 072130 DD          0000 R 065224 ERR       0000 R 072333 FAC       0000 I 072266 I         0000 I 072245 IBL
0000 I 072317 IDD         0000 I 072250 IEOF      0000 I 072311 IESTOP    0000 I 072310 IESTRT    0000 I 072315 IEVNT
0000 I 072320 IGOOD       0000   073247 INJPS     0000 I 072273 IOPT      0000 I 072263 IOPT1     0000 I 072305 IPAR
0000 I 072270 IX          0000 I 072271 IY        0000 I 072314 IYDD      0000 I 072321 I1        0000 I 072323 I2
0000 I 072325 I3          0000 I 072267 J         0000 I 072247 JEQ       0000 I 072327 J1        0000 I 072330 J2
0000 I 072331 J3          0000 I 072252 LCDERR    0000 I 072313 LINES     0000 I 072307 LTEMP     0000 I 072251 LUIN
0000 I 072334 M           0000 I 072272 N         0000 I 072262 NCC       0000 I 072261 NCHS      0000 I 072316 NN
0000 I 072322 NN1         0000 I 072324 NN2       0000 I 072326 NN3       0000 I 072265 NOTH      0000 I 072264 NPAR
0000 I 072312 NPT         0000 I 072306 NSCN      0000 I 000174 NTCH      0000 I 072260 NTCLOC    0000 I 072277 NTME
0000 I 072246 NTSL        0000 I 072256 NX        0000 I 072257 NY        0000 R 022022 QDOT      0000 R 026726 QDOTMN
0000 R 010212 QX          0000 R 015116 QY        0000 R 072253 RHO       0000 D 072243 SERR      0000 D 072241 SIGMA
0000 D 072237 SLOPE       0000 R 072276 STATME    0000 D 072217 SUM1      0000 D 072221 SUM2      0000 D 072223 SUM3
0000 D 072225 SUM4        0000 D 072227 SUM5      0000 D 072231 SUM6      0000 D 072233 SUM7      0000 D 072235 SUM8
0000 R 005100 TEMP        0000 R 033632 TIM       0000 R 072132 TIME      0000 R 000000 TITLE1    0000 R 000014 TITLE2
0000 R 033714 TMP         0000 R 072275 TSTOP     0000 R 072274 TSTRT     0000 R 010130 WORD      0000 R 000030 XX
0000 R 072135 YDD         0000 R 000112 YY        0000 R 072332 YYD
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00100   C      PROGRAM  THNSKN                                                          000000
00100   C                                                                               000000
00100   C   IDENTIFICATION                                                              000000
00100   C      TITLE         - SURFACE HEATING RATE OF THIN SKIN MODELS                 000000
00100   C      PROGRAMMER    - JACK D. MCBRYDE, LOCKHEED ELECTRONICS CO.                000000
00100   C      DATE          - OCTOBER 1969, REWRITTEN DECEMBER 1974                    000000
00100   C      INSTALLATION  - NASA JSC    HOUSTON TEXAS                                000000
00100   C                                                                               000000
00100   C   DESCRIPTION                                                                 000000
00100   C      THE PROGRAM COMPUTES THE HEATING RATE AT A NUMBER OF LOCATIONS           000000
00100   C      ON THE SURFACE OF THIN SKIN TRANSIENT HEATING RATE MODELS.               000000
00100   C                                                                               000000
00100   C      EXPERIMENTAL DATA, CALIBRATED IN ENGINEERING UNITS, IS OBTAINED          000000
00100   C      FROM THE ABEL TAPE OUTPUT OF THE EHTS03 DATA REDUCTION COMPUTER          000000
00100   C      PROGRAM.  THE PROGRAM OUTPUT CONSISTS OF TIME HISTORY TABULATIO          000000
00100   C      IN AN ARRAY BY THERMOCOUPLE LOCATIONS.                                   000000
00100   C                                                                               000000
00100   C                                                                               000000
00100   C   BIGK   - THERMAL CONDUCTIVITY (K) OF TEST MATERIAL (BTU/FT.SEC F)           000000
00100   C   CESTOP - COMMAND EVENT CHANNEL STOP LEVEL INPUT (FLOATING POINT)            000000
00100   C   CESTRT - COMMAND EVENT CHANNEL START LEVEL INPUT (FLOATING POINT)           000000
00100   C   CON12  - RHO * CP / 12.                                                     000000
00100   C   CON24  - 24. * BIGK                                                         000000
00100   C   CON6   - RHO * CP / 6.                                                      000000
00100   C   CP     - SPECIFIC HEAT OF TEST MATERIAL (BTU/FT**2 SEC)                     000000
00100   C   DD(1)  - SKIN THICKNESS OF TEST MATERIAL (INCHES)                           000000
00100   C   DD(2)  - THE SECOND THICKNESS WHEN THE TEST MATERIAL HAS TWO                000000
00100   C   ERR    - PERCENT ERROR IN THE SLOPE                                         000000
00100   C   I      - USED TO DESIGNATE COORDINATE IN X-DIRECTION                        000000
00100   C   IDD    - INDEX USED TO SPECIFY WHICH THICKNESS (DD) APPLIES                 000000
00100   C   IEOF   - END OF FILE INDICATOR                                              000000
00100   C   IESTOP - COMMAND EVENT CHANNEL STOP LEVEL (FIXED POINT)                     000000
00100   C   IESTRT - COMMAND EVENT CHANNEL START LEVEL (FIXED POINT)                    000000
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00100   C   IEVNT   - CURRENT COMMAND EVENT CHANNEL VALUE                                000000
00100   C   IGOOD   - IGOOD = 1 INDICATES WHEN THE FIRST SET OF 3 GOOD THERMO-           000000
00100   C             COUPLES IN A ROW OR COLUMN HAS BEEN FOUND IN LOGIC FOR             000000
00100   C             COMPUTING QX OR QY                                                 000000
00100   C   IOPT    - RUN CONTROLLED BY  0 - START-STOP TIMES                            000000
00100   C                                1 - COMMAND CHANNEL EVENTS                      000000
00100   C   IOPT1   - IOPT + 1                                                           000000
00100   C   IPAR    - PARITY ERROR RECORD COUNTER                                        000000
00100   C   IX      - X-COORDINATE OF THERMOCOUPLE BEING DEFINED BY CHANNEL NO.          000000
00100   C   IY      - Y-COORDINATE OF THERMOCOUPLE BEING DEFINED BY CHANNEL NO.          000000
00100   C   IYDD    - THE Y COORDINATE INDEX JUST PRIOR TO THE CHANGE IN                 000000
00100   C             MATERIAL THICKNESS                                                 000000
00100   C   I1,I2,I3 - THE INDICES FOR 3 SUCCESSIVE (BUT NOT NECESSARILY                 000000
00100   C             ADJACENT) LOCATIONS OF GOOD THERMOCOUPLES IN THE X                 000000
00100   C             DIRECTION                                                          000000
00100   C   J       - USED TO DESIGNATE COORDINATES IN Y-DIRECTION                       000000
00100   C   J1,J2,J3 - SAME AS I1,I2,I3 BUT IN Y DIRECTION                               000000
00100   C   LCDERR  - LEAD CARD ERROR INDICATOR                                          000000
00100   C   LINES   - LINE COUNTER FOR PAGE EJECT CONTROL                                000000
00100   C   LTEMP   - NUMBER OF LINES REQUIRED FOR ONE NX X NY ARRAY                     000000
00100   C   LUIN    - LOGICAL UNIT FOR INPUT TAPE                                        000000
00100   C   NC      - THE MAXIMUM NUMBER OF CHANNELS THE INPUT TAPE MAY HAVE             000000
00100   C   NCC     - NUMBER OF COMMAND CHANNEL                                          000000
00100   C   NCHS    - NUMBER OF CHANNELS ON TAPE                                         000000
00100   C   NLS     - THE MAXIMUM NUMBER OF SCANS FOR WHICH LEAST SQUARES                000000
00100   C             COMPUTATIONS MAY BE DONE                                           000000
00100   C   NN      - CHANNEL NUMBER OF THERMOCOUPLE BEING PROCESSED                     000000
00100   C   NN1,NN2,NN3 - CHANNEL NUMBERS OF THREE SUCCESSIVE GOOD THERMO-               000000
00100   C             COUPLES (QX OR QY COMPUTATIONS)                                    000000
00100   C   NOTH    - TIME HISTORY TAB OPTION.  IF NOTH = 0, EACH SCAN OF DATA           000000
00100   C             FROM THE INPUT TAPE IN THE TIME INTERVAL WILL BE PRINTED.          000000
00100   C   NPAR    - MAXIMUM PERMISSIBLE NUMBER OF PARITY ERRORS PER TIME               000000
00100   C             SLICE                                                              000000
00100   C   NPT     - NUMBER OF POINTS USED IN THE CURVE FIT                             000000
00100   C   NSCN    - NUMBER OF SCANS OF DATA PROCESSED IN THE CURRENT TIME              000000
00100   C             SLICE                                                              000000
00100   C   NTCH    - ARRAY OF THERMOCOUPLE CHANNEL NUMBERS                              000000
00100   C   NTCLOC  - TOTAL NUMBER OF THERMOCOUPLE LOCATIONS (NX * NY)                   000000
00100   C   NTME    - NUMBER OF POINTS REQUESTED FOR CURVE FIT                           000000
00100   C   NTSL    - NUMBER OF TIME SLICES PROCESSED                                    000000
00100   C   NX      - NUMBER OF X-COORDINATE LOCATIONS                                   000000
00100   C   NY      - NUMBER OF Y-COORDINATE LOCATIONS                                   000000
00100   C   QDOT    - USED FOR MEAN HEATING RATE AND LEAST SQUARES HEATING RATE AT       000000
00100   C             DIFFERENT TIMES                                                    000000
00100   C   QDOTMM  - THE SUMS (OR AVERAGES) OF THE QDOT VALUES FOR NTSL TIME            000000
00100   C             SLICES                                                             000000
00100   C   QX      - MEAN LATERAL HEAT LOSS IN X DIRECTION                              000000
00100   C   QY      - MEAN LATERAL HEAT LOSS IN Y DIRECTION                              000000
00100   C   RHO     - MASS DENSITY OF TEST MATERIAL (LBM/FT**3)                          000000
00100   C   SERR    - STANDARD ERROR OF THE SLOPE                                        000000
00100   C   SIGMA   - STANDARD DIVIATION SIGMA                                           000000
00100   C   SLOPE   - LEAST SQUARE SLOPE OR HEATING RATE                                 000000
00100   C   STATME  - START TIME FOR CURVE FIT                                           000000
00100   C   SUM1    - SUM X(I)*Y(I)                                                      000000
00100   C   SUM2    - SUM X(I)                                                           000000
00100   C   SUM3    - SUM Y(I)                                                           000000
00100   C   SUM4    - SUM (X(I)**2)                                                      000000
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00100    C        SUM5    - SUM (Y(I)**2)                                              000000
00100    C        SUM6    - (SUM X(I))**2                                              000000
00100    C        SUM7    - SUM X(I) * SUM Y(I)                                        000000
00100    C        SUM8    - NPT * SUM4 - SUM6                                          000000
00100    C        TEMP    - TEMP( ,1) CONTAINS SUMMED (OR AVERAGED) TEMPERATURES       000000
00100    C                  TEMP( ,2) CONTAINS THE TEMPERATURES FOR SCAN 1             000000
00100    C                  TEMP( ,3) CONTAINS THE TEMPERATURES FOR SCAN 2             000000
00100    C                  TEMP( ,4) CONTAINS THE TEMPERATURES FOR SCAN NSCN - 1      000000
00100    C                  TEMP( ,5) CONTAINS THE TEMPERATURES FOR SCAN NSCN          000000
00100    C                  TEMP( ,6) CONTAINS THE TEMPERATURES JUST READ FROM TAPE    000000
00100    C        TIM     - SAVED TIMES FOR CURVE FIT                                  000000
00100    C        TIME    - TIME(1) IS THE FIRST TIME IN THE TIME SLICE                000000
00100    C                  TIME(2) IS THE LAST  TIME IN THE TIME SLICE                000000
00100    C                  TIME(3) IS THE LAST  TIME READ FROM TAPE                   000000
00100    C        TITLE1 - 1ST TITLE CARD                                              000000
00100    C        TITLE2 - 2ND TITLE CARD                                              000000
00100    C        TMP     - SAVED TEMPERATURES FOR CURVE FIT                           000000
00100    C        TSTOP   - COMPUTATIONAL STOP TIME                                    000000
00100    C        TSTRT   - COMPUTATIONAL START TIME                                   000000
00100    C        WORD    - INPUT TEMPERATURE VALUES FOR TAB OUTPUT                    000000
00100    C        XX      - X-COORDINATE LOCATIONS (INCHES)                            000000
00100    C        YDD     - THE Y COORDINATES OF JUNCTION POINTS BETWEEN THE TWO       000000
00100    C                  THICKNESSES OF TEST MATERIAL                               000000
00100    C        YY      - Y-COORDINATE LOCATIONS (INCHES)                            000000
00100    C                                                                             000000
00101             PARAMETER NC=260,NLS=50                                              000000
00101    C                                                                             000000
00103             DIMENSION TITLE1(12), TITLE2(12), XX(50), YY(50), NTCH(50,50)        000001
00104             DIMENSION TEMP(NC,6),WORD(50),QX(50,50),QY(50,50),QDOT(50,50)        000001
00105             DIMENSION QDOTMM(50,50),TIM(NLS),TMP(NC,NLS),ERR(50,50),DD(2)        000001
00106             DIMENSION TIME(3),YDD(50)                                            000001
00106    C                                                                             000001
00107             DOUBLE PRECISION SUM1, SUM2, SUM3, SUM4, SUM5, SUM6, SUM7, SUM8      000001
00107            1 ,                SLOPE, SIGMA, SERR                                 000001
00107    C                                                                             000001
00110             DATA IBL /5H     /, NTSL /0/, JEQ /3HJ =/, IEOF /0/                  000001
00115             DATA LUIN/8/                                                         000001
00115    C                                                                             000001
00115    C        INPUT SECTION                                                        000001
00115    C                                                                             000001
00115    C           READ TITLE CARDS                                                  000001
00117             READ (5,1000)TITLE1                                                  000001
00122             READ (5,1000)TITLE2                                                  000011
00125             WRITE (6,2000)TITLE1,TITLE2                                          000021
00125    C           READ CONSTANTS                                                    000021
00131             LCDERR = 0                                                           000034
00132             READ (5,1001)RHO,CP,BIGK,DD,NX,NY                                    000035
00142             WRITE (6,2001)RHO,CP,BIGK,DD,NX,NY                                   000053
00152             NTCLOC = NX * NY                                                     000071
00153             IF (NTCLOC.GT.3.AND.(NX.GE.3.OR.NY.GE.3).AND.NX.LE.50.AND.NY.LE.50   000074
00153            .) GO TO 10                                                           000074
00155             WRITE (6,9001)                                                       000140
00157             LCDERR = 1                                                           000145
00157    C           READ TAPE INFORMATION                                             000145
00160          10 READ(5,1002)  NCHS,NCC,IOPT1,NPAR,NOTH                               000150
00167             READ(30,1008) I                                                      000161
00172             IF(I.EQ.IBL) NPAR = 2                                                000167
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00174          IF(IOPT1.NE.0) IOPT1 = 1                              000175
00176          WRITE(6,2002) NCHS,NCC,IOPT1,NPAR,NOTH                000201
00205          IF (NCHS-(NC-1)) 20,20,                               000213
00210          LCDERR = 1                                            000217
00211          WRITE (6,4003)                                        000221
00213       20 CONTINUE                                              000227
00214          IF (DD(2)) 30,30,                                     000230
00217          READ (5,1005)(YDD(I),I=1,NX)                          000233
00225          WRITE (6,2019)(YDD(I),I=1,NX)                         000246
00233       30 CONTINUE                                              000261
00233     C       READ X AND Y COORDINATE LOCATIONS                  000261
00234          READ (5,1005)(XX(I),I=1,NX)                           000261
00242          READ (5,1005)(YY(J),J=1,NY)                           000307
00250          WRITE (6,2005)(XX(I),I=1,NX)                          000321
00256          WRITE (6,2006)(YY(J),J=1,NY)                          000333
00256     C       READ THERMOCOUPLE CHANNEL NUMBER  AND              000333
00256     C       CORRESPONDING X-Y COORDINATES                      000333
00264          READ (5,1007)(IX,IY,NTCH(IX,IY),N=1,NTCLOC)           000345
00274          WRITE(6,2007)                                         000365
00276          WRITE(6,2022) (JEQ,J,J=1,NY)                          000372
00305          DO 40 I=1,NX                                          000413
00310          WRITE (6,2008)I,(NTCH(I,J),J=1,NY)                    000413
00317       40 CONTINUE                                              000432
00317     C       READ START STOP TIMES OR EVENT LEVELS              000432
00321          IOPT = IOPT1 + 1                                      000432
00322          GO TO (50,60),IOPT                                    000435
00323       50 READ (5,1003,END=690)TSTRT,TSTOP,STATME,NTME          000445
00331          IF(NTSL.GT.0) WRITE(6,2021)                           000456
00334          WRITE (6,2003)TSTRT,TSTOP,STATME,NTME                 000467
00342          GO TO 70                                              000500
00343       60 READ (5,1004,END=690)CESTRT,CESTOP,STATME,NTME        000502
00351          IF(NTSL.GT.0) WRITE(6,2021)                           000513
00354          WRITE (6,2004)CESTRT,CESTOP,STATME,NTME               000524
00362       70 IF (NTME.LE.NLS) GO TO 80                             000536
00364          I = NLS                                               000542
00365          WRITE (6,4002)I                                       000544
00370          LCDERR = 1                                            000552
00371       80 CONTINUE                                              000555
00372          IF (LCDERR) ,,730                                     000555
00372     C                                                          000555
00372     C    INITIALIZE AND DEFINE CONSTANTS                       000555
00372     C                                                          000555
00375          CON6   = RHO * CP /24.                                000557
00376          CON12  = RHO * CP / 12.                               000564
00377          CON24  = BIGK * 24.                                   000567
00400          IPAR   = 0                                            000572
00401          NSCN = 0                                              000573
00402          LTEMP =((NY+9) / 10) * NX + 5                         000574
00403          DO 90 I=1,NCHS                                        000611
00406          DO 90 J=2,5                                           000611
00411       90 TEMP(I,J) = 0.                                        000611
00414          IESTRT = CESTRT                                       000616
00415          IESTOP = CESTOP                                       000625
00416          NPT = 0                                               000634
00417          LINES = 1000                                          000635
00420          IYDD = NY + 1                                         000637
00421          IF (DD(2)) 110,110,                                   000642
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00424              I = NY - 1                                                     000645
00425              DO 100 J = 1, I                                                000650
00430              IF(YY(J).LE.YDD(1).AND.YY(J+1).GT.YDD(1)) IYDD = J             000654
00432          100 CONTINUE                                                       000677
00434          110 CONTINUE                                                       000677
00435              TIME(1) = TIME(3)                                              000677
00436              IF (NTSL-1) ,150,150                                           000700
00436        C                                                                    000700
00436        C     READ INPUT TAPE                                                000700
00436        C                                                                    000700
00441          120 READ (LUIN,ERR=130,END=140)TIME(1),(TEMP(I,6),I=1,NCHS)        000705
00450              GO TO 150                                                      000722
00451          130 WRITE (6,4004)                                                 000724
00453              GO TO 120                                                      000730
00454          140 WRITE (6,4005)LUIN                                             000732
00457              IEOF = 1                                                       000737
00460              GO TO 400                                                      000741
00461          150 CONTINUE                                                       000743
00462              GO TO (160,170),IOPT                                           000743
00463          160 IF (TIME(1)-TSTRT) 120,190,190                                 000752
00466          170 IEVNT = TEMP(NCC,6) + 0.5                                      000757
00467              IF (IEVNT-(IESTRT+2)) 180,190,120                              000770
00472          180 IF (IEVNT-(IESTRT-2)) 120,190,190                              000775
00472        C        STARTING TIME FOUND                                         000775
00475          190 DO 200 I=1,NCHS                                                001003
00500              TEMP(I,1) = TEMP(I,6)                                          001010
00501          200 TEMP(I,2) = TEMP(I,6)                                          001011
00503              TIME(2) = TIME(1)                                              001014
00504              NSCN = 1                                                       001016
00505              IF(NTME.LE.2.OR.TIME(1).LT.STATME) GO TO 330                   001020
00507              NPT = NPT + 1                                                  001035
00510              TIM(NPT) = TIME(1)                                             001040
00511              DO 210 I=1,NCHS                                                001052
00514          210 TMP(I,NPT) = TEMP(I,6)                                         001052
00516              GO TO 330                                                      001054
00517          220 CONTINUE                                                       001056
00520              READ (LUIN,ERR=230,END=140)TIME(3),(TEMP(I,6),I=1,NCHS)        001056
00527              GO TO 240                                                      001073
00530          230 IPAR = IPAR + 1                                                001075
00531              WRITE (6,4004)                                                 001077
00533              IF (IPAR-NPAR) 220,220,730                                     001104
00536          240 CONTINUE                                                       001112
00537              GO TO (250,260),IOPT                                           001112
00540          250 IF (TIME(3)-TSTOP) 280,280,400                                 001121
00543          260 IEVNT = TEMP(NCC,6) + .5                                       001126
00544              IF (IEVNT-(IESTOP+2)) 270,270,280                              001137
00547          270 IF (IEVNT-(IESTOP-2)) 280,400,400                              001144
00552          280 TIME(2) = TIME(3)                                              001152
00553              NSCN = NSCN + 1                                                001153
00554              IF (NSCN-2) 300,,300                                           001156
00557              DO 290 I=1,NCHS                                                001165
00562          290 TEMP(I,3) = TEMP(I,6)                                          001165
00564          300 CONTINUE                                                       001170
00565              DO 310 I=1,NCHS                                                001170
00570              TEMP(I,4) = TEMP(I,5)                                          001175
00571              TEMP(I,5) = TEMP(I,6)                                          001176
00572          310 TEMP(I,1) = TEMP(I,1) + TEMP(I,6)                              001200
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00574          IF(NTME.LE.2.OR.TIME(2).LT.STATME) GO TO 330             001204
00576          NPT = NPT + 1                                            001222
00577          DO 320 I=1,NCHS                                          001225
00602      320 TMP(I,NPT) = TEMP(I,6)                                   001235
00604          TIM(NPT) = TIME(2)                                       001237
00605      330 CONTINUE                                                 001242
00606          IF(NOTH)    ,    ,365                                    001242
00611          IF (LINES+LTEMP-55) 340,340,                             001244
00614          WRITE (6,2000)TITLE1,TITLE2                              001251
00620          LINES = 3                                                001264
00621      340 CONTINUE                                                 001267
00622          WRITE (6,2013)TIME(2)                                    001267
00625          WRITE(6,2023) (JEQ,J,J=1,NY)                             001303
00634          LINES = LINES + LTEMP                                    001323
00635          DO 360 I=1,NX                                            001335
00640          DO 350 J=1,NY                                            001335
00643          NN = NTCH(I,J)                                           001335
00644      350 WORD(J) = TEMP(NN,6)                                     001336
00646          WRITE (6,2010)I,(WORD(J),J=1,NY)                         001342
00655      360 CONTINUE                                                 001363
00657      365 CONTINUE                                                 001363
00657    C                                                              001363
00657    C     DO ERROR ANALYSIS IF 'NTME' POINTS HAVE BEEN SAVED       001363
00657    C                                                              001363
00660          IF(NTME.LE.2.OR.NPT.LT.NTME) GO TO 220                   001363
00662          IF (LINES+2*LTEMP-59) 370,370,                           001363
00665          LINES = 3                                                001400
00666          WRITE (6,2000)TITLE1,TITLE2                              001406
00672      370 WRITE (6,2015)NPT,TIM(1),TIM(NPT)                        001410
00677          LINES = LINES + 2 * LTEMP - 3                            001424
00700          CALL ERRFIT($395)                                        001435
00700    C                                                              001442
00700    C     OUTPUT HEATING RATE - QDOT  AND PERCENT ERROR - ERR      001442
00700    C                                                              001442
00701          WRITE(6,2012)                                            001442
00703          WRITE(6,2023) (JEQ,J,J=1,NY)                             001445
00712          DO 380 I=1,NX                                            001452
00715          WRITE (6,2010)I,(QDOT(I,J),J=1,NY)                       001505
00724      380 CONTINUE                                                 001505
00726          WRITE (6,2016)                                           001524
00730          WRITE(6,2023) (JEQ,J,J=1,NY)                             001524
00737          DO 390 I=1,NX                                            001531
00742          WRITE (6,2010)I,(ERR(I,J),J=1,NY)                        001552
00751      390 CONTINUE                                                 001552
00753      395 CONTINUE                                                 001572
00754          TIM(1) = TIM(NPT)                                        001572
00755          DO 396 I = 1, NCHS                                       001572
00760      396 TMP(I,1) = TMP(I,NPT)                                    001606
00762          NPT = 1                                                  001606
00763          GO TO 220                                                001610
00763    C                                                              001612
00763    C     THE TIME SLICE HAS BEEN COMPLETED OR AN END OF FILE ENCOUNTERED   001612
00763    C                                                              001612
00764      400 CONTINUE                                                 001612
00765          IF(NTME.LE.2.OR.NPT.LT.3) GO TO 440                      001614
00767          IF (LINES+2*LTEMP-59) 410,,                              001614
00772          WRITE (6,2000)TITLE1,TITLE2                              001631
                                                                        001637
```

```
00776          410 CONTINUE                                                          001653
00777              WRITE (6,2015)NPT,TIM(1),TIM(NPT)                                 001653
01004              IF (NPT.LT.NTME) WRITE (6,2017)                                   001664
01004    C                                                                           001664
01004    C         COMPUTE AND PRINT LEAST SQUARES HEATING RATE (QDOT) AND PERCENT   001664
01004    C         ERROR (ERR)                                                       001664
01007              CALL ERRFIT($440)                                                 001676
01010              WRITE(6,2012)                                                     001701
01012              WRITE(6,2023) (JEQ,J,J=1,NY)                                      001706
01021              DO 420 I=1,NX                                                     001741
01024              WRITE (6,2010)I,(QDOT(I,J),J=1,NY)                                001741
01033          420 CONTINUE                                                          001760
01035              WRITE (6,2016)                                                    001760
01037              WRITE(6,2023) (JEQ,J,J=1,NY)                                      001765
01046              DO 430 I=1,NX                                                     002006
01051              WRITE (6,2010)I,(ERR(I,J),J=1,NY)                                 002006
01060          430 CONTINUE                                                          002026
01060    C                                                                           002026
01062          440 CONTINUE                                                          002026
01063              IF (NSCN-3) 680,,                                                 002026
01066              NTSL = NTSL + 1                                                   002031
01067              LINES = 1000                                                      002045
01070              WRITE (6,2000)TITLE1,TITLE2                                       002047
01074              WRITE (6,2018)NSCN,TIME(1),TIME(2)                                002064
01101              WRITE(6,2023) (JEQ,J,J=1,NY)                                      002074
01110              DO 460 I=1,NX                                                     002122
01113              DO 450 J=1,NY                                                     002122
01116              NN = NTCH(I,J)                                                    002122
01117              TEMP(NN,1) = TEMP(NN,1) / NSCN                                    002123
01120          450 WORD(J) = TEMP(NN,1)                                              002127
01122              WRITE (6,2010)I,(WORD(J),J=1,NY)                                  002131
01131          460 CONTINUE                                                          002155
01131    C                                                                           002155
01131    C         PROCESS LATERAL HEAT LOSS IN X-DIRECTION (EQUATION 3)             002155
01131    C                                                                           002155
01133              DO 470 I=1,NX                                                     002155
01136              DO 470 J=1,NY                                                     002155
01141              QX(I,J) = 0.                                                      002155
01142              QY(I,J) = 0.                                                      002155
01143          470 QDOT(I,J) = 0.                                                    002156
01146              IF (NX-2) 530,530,                                                002164
01151              IDD = 1                                                           002170
01152              DO 510 J=1,NY                                                     002175
01155              IGOOD = 0                                                         002175
01156              IF(J.GT.IYDD) IDD = 2                                             002176
01160              I1 = 0                                                            002205
01161          480 I1 = I1 + 1                                                       002207
01162              IF (I1+2-NX) ,,510                                                002211
01165              NN1= NTCH(I1,J)                                                   002215
01166              IF (NN1) 480,480,                                                 002222
01171              I2 = I1                                                           002224
01172          490 I2 = I2 + 1                                                       002227
01173              IF (I2+1-NX) ,,510                                                002231
01176              NN2 = NTCH(I2,J)                                                  002235
01177              IF (NN2) 490,490,                                                 002242
01202              I3 = I2                                                           002244
01203          500 I3 = I3 + 1                                                       002247
```

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01204         IF (I3-NX) ,,510                                                          002251
01207         NN3 = NTCH(I3,J)                                                          002254
01210         IF (NN3) 500,500,                                                         002262
01213         IGOOD = IGOOD + 1                                                         002264
01214         QX(I2,J) = CON24 * DD(IDD) / (XX(I3) - XX(I1)) * ((TEMP(NN2,1) -          002267
01214        *             TEMP(NN1,1)) / (XX(I2) - XX(I1)) - (TEMP(NN3,1) -            002267
01214        *             TEMP(NN2,1))/ (XX(I3) - XX(I2)))                             002267
01215         QX(I3,J) = QX(I2,J)                                                       002322
01216         IF(IGOOD.EQ.1) QX(I1,J) = QX(I2,J)                                        002323
01220         IF (I3-NX) ,510,510                                                       002337
01223         NN1 = NN2                                                                 002343
01224         NN2 = NN3                                                                 002345
01225         I1 = I2                                                                   002347
01226         I2 = I3                                                                   002351
01227         GO TO 500                                                                 002353
01230     510 CONTINUE                                                                  002356
01232         WRITE (6,2009)                                                            002356
01234         WRITE(6,2023) (JEQ,J,J=1,NY)                                              002363
01243         DO 520 I=1,NX                                                             002407
01246         WRITE (6,2010)I,(QX(I,J),J=1,NY)                                          002407
01255     520 CONTINUE                                                                  002427
01257     530 CONTINUE                                                                  002427
01257   C                                                                               002427
01257   C     PROCESS LATERAL HEAT LOSS IN Y-DIRECTION                                  002427
01257   C                                                                               002427
01260         IF (NY-2) 630,630,                                                        002427
01263         DO 610 I=1,NX                                                             002446
01266         IGOOD = 0                                                                 002446
01267         IDD = 1                                                                   002447
01270         J1 = 0                                                                    002451
01271     540 J1 = J1 + 1                                                               002453
01272         IF (J1+2-NY) ,,610                                                        002455
01275         NN1 = NTCH(I,J1)                                                          002461
01276         IF (NN1) 540,540,                                                         002466
01301         J2 = J1                                                                   002470
01302     550 J2 = J2 + 1                                                               002473
01303         IF (J2+1-NY) ,,610                                                        002475
01306         NN2 = NTCH(I,J2)                                                          002501
01307         IF (NN2) 550,550,                                                         002506
01312         J3 = J2                                                                   002510
01313     560 J3 = J3 + 1                                                               002513
01314         IF (J3-NY) ,,610                                                          002515
01317         NN3 = NTCH(I,J3)                                                          002520
01320         IF (NN3) 560,560,                                                         002525
01323         IGOOD = IGOOD + 1                                                         002527
01324         IF (J2-IYDD) ,580,570                                                     002532
01327         IF (J3-IYDD) 575,575,580                                                  002536
01332     570 IF (J2-(IYDD+1)) 590,590,                                                 002544
01335         IF (J1-IYDD) 590,590,                                                     002550
01340         IDD = 2                                                                   002554
01341     575 QY(I,J2) = CON24 * DD(IDD) / (YY(J3) - YY(J1)) * ((TEMP(NN2,1) -          002557
01341        *             TEMP(NN1,1)) / (YY(J2) - YY(J1)) - (TEMP(NN3,1) -            002557
01341        *             TEMP(NN2,1)) / (YY(J3) - YY(J2)))                            002557
01342         GO TO 600                                                                 002612
01343     580 YYD = YDD(I)                                                              002614
01344         QY(I,J2) = CON24 * DD(1) / (YY(J3)-YY(J1)) * ((TEMP(NN2,1) -              002615
01344        *             TEMP(NN1,1)) / (YY(J2)-YY(J1)) - DD(2)*(TEMP(NN3,1) -        002615
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01344         .              TEMP(NN2,1)) / (DD(2)*(YYD - YY(J2)) + DD(1)*(YY(J3)      002615
01344         .              - YYD)))                                                   002615
01345               GO TO 600                                                           002615
01346           590 YYD = YDD(I)                                                        002654
01347               QY(I,J2) = CON24 * DD(2) / (YY(J3)-YY(J1)) * (DD(1)*(TEMP(NN2,1) -  002656
01347         .              TEMP(NN1,I)) / (DD(2)*(YYD - YY(J1)) + DD(1)*(YY(J2) -     002657
01347         .              YYD)) - (TEMP(NN3,1) - TEMP(NN2,1)) / (YY(J3)-YY(J2)))     002657
01350           600 QY(I,J3) = QY(I,J2)                                                 002657
01351               IF(IGOOD.EQ.1) QY(I,J1) = QY(I,J2)                                  002717
01353               IF (J3-NY) ,610,610                                                 002726
01356               NN1 = NN2                                                           002743
01357               NN2 = NN3                                                           002747
01360               J1 = J2                                                             002751
01361               J2 = J3                                                             002753
01362               GO TO 560                                                           002755
01363           610 CONTINUE                                                            002757
01365               WRITE (6,2011)                                                      002762
01367               WRITE(6,2023) (JEQ,J,J=1,NY)                                        002762
01376               DO 620 I=1,NX                                                       002767
01401               WRITE (6,2010)I,(QY(I,J),J=1,NY)                                    003017
01410           620 CONTINUE                                                            003017
01412           630 CONTINUE                                                            003037
01412         C                                                                         003037
01412         C     COMPUTE Q (ARRAY ERR IS USED) IF QX AND QY NOT BOTH ZERO            003037
01412         C                                                                         003037
01413               FAC = CON6 / (TIME(2) - TIME(1)) * (NSCN-1) / (NSCN-2)              003037
01414               DO 650 I=1,NX                                                       003037
01417               IDD = 1                                                             003072
01420               DO 650 J=1,NY                                                       003072
01423               IF(J.GT.IYDD) IDD = 2                                               003076
01425               NN = NTCH(I,J)                                                      003076
01426               ERR(I,J) = 0.                                                       003105
01427               IF (NN) 650,650,                                                    003110
01432               ERR(I,J) = FAC * DD(IDD) * (TEMP(NN,5) + TEMP(NN,4) - TEMP(NN,2) -  003111
01432         .              TEMP(NN,3))                                                003114
01433               IF (QX(I,J)) 640,,640                                               003114
01436               IF (QY(I,J)) 640,650,640                                            003124
01441           640 CONTINUE                                                            003126
01442               QDOT(I,J) = ERR(I,J) + QX(I,J) + QY(I,J)                            003131
01443               QDOTMM(I,J) = QDOTMM(I,J) + QDOT(I,J)                               003131
01444           650 CONTINUE                                                            003134
01447               WRITE (6,2014)                                                      003143
01451               WRITE(6,2023) (JEQ,J,J=1,NY)                                        003143
01460               DO 660 I=1,NX                                                       003150
01463               WRITE (6,2010)I,(ERR(I,J),J=1,NY)                                   003171
01472           660 CONTINUE                                                            003171
01474               WRITE (6,2012)                                                      003210
01476               WRITE(6,2023) (JEQ,J,J=1,NY)                                        003210
01505               DO 670 I=1,NX                                                       003215
01510               WRITE (6,2010)I,(QDOT(I,J),J=1,NY)                                  003236
01517           670 CONTINUE                                                            003236
01521           680 IF (IEOF) ,,690                                                     003256
01524               GO TO (50,60),IOPT                                                  003256
01524         C                                                                         003260
01524         C     COMPUTE AND PRINT MEANS OF MEAN HEATING RATES.                      003260
01524         C                                                                         003260
01525           690 CONTINUE                                                            003260
                                                                                        003270
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01526            WRITE (6,2000)TITLE1,TITLE2                                      003270
01532            WRITE (6,2020)NTSL                                               003302
01535            WRITE(6,2023) (JEQ,J,J=1,NY)                                     003317
01544            IF (NTSL) 730,730,                                               003337
01547            DO 710 I=1,NX                                                    003342
01552            DO 700 J=1,NY                                                    003354
01555        700 QDOTMM(I,J) = QDOTMM(I,J) / NTSL                                 003354
01557            WRITE (6,2010)I,(QDOTMM(I,J),J=1,NY)                             003357
01566        710 CONTINUE                                                         003401
01570        720 CALL EXIT                                                        003401
01570     C                                                                       003401
01571        730 CALL CHERR                                                       003404
01571     C                                                                       003404
01571     C      FORMAT STATEMENTS                                                003404
01571     C                                                                       003404
01572       1000 FORMAT (12A6)                                                    003407
01573       1001 FORMAT(5F10.3,2I3)                                               003407
01574       1002 FORMAT (7I5)                                                     003407
01575       1003 FORMAT(3F10.3,I5)                                                003407
01576       1004 FORMAT(2F10.0,F10.3,I5)                                          003407
01577       1005 FORMAT (5F10.3)                                                  003407
01600       1007 FORMAT (5(2I3,I4))                                               003407
01601       1008 FORMAT(15X,A5)                                                   003407
01602       2000 FORMAT (1H1/16X,12A6/16X,12A6)                                   003407
01603       2001 FORMAT(1H0,15X,'MASS DENSITY OF TEST MATERIAL (RHO) =',F12.4     003407
01603          .                ,5X,'SPECIFIC HEAT OF TEST MATERIAL (CP) =',F12.4 003407
01603          .              / 16X,'THERMAL CONDUCTIVITY          (BIGK) =',F12.4 003407
01603          .                ,5X,'THICKNESS OF TEST MATERIAL     (DD1) =',F12.4 003407
01603          .              / 16X,'THICKNESS OF TEST MATERIAL     (DD2) =',F12.4 003407
01603          .                ,5X,'NUMBER OF X-COORDINATES          (NX) =',I12 003407
01603          .              / 16X,'NUMBER OF Y-COORDINATES          (NY) =',I12 003407
01603          ./)                                                                003407
01604       2002 FORMAT(     16X,'NUMBER OF CHANNELS ON TAPE   (NCHS) =',I12       003407
01604          .                ,5X,'COMMAND CHANNEL NUMBER          (NCC) =',I12 003407
01604          .              / 16X,'TIME INTERVAL OR EVENT CODE (IOPT1) =',I12   003407
01604          .                ,5X,'ACCEPTABLE NO. OF PARITIES    (NPAR) =',I12  003407
01604          .              / 16X,'TIME HISTORY TAB OPTION       (NOTH) =',I12  003407
01604          ./)                                                                003407
01605       2003 FORMAT(1H0,15X,'START TIME =',F10.3,'      STOP TIME =',F10.3 /  003407
01605          .16X,'LEAST SQUARES START TIME =',F10.3,'     NO OF POINTS FOR ',  003407
01605          .'LEAST SQUARES COMPUTATIONS (NTME) =',I10)                        003407
01606       2004 FORMAT(1H0,15X,'COMMAND EVENT START LEVEL =',F12.4,5X,'STOP LEVEL' 003407
01606          .,' =',F12.4/                                                      003407
01606          .16X,'LEAST SQUARES START TIME =',F10.3,'     NO OF POINTS FOR ',  003407
01606          .'LEAST SQUARES COMPUTATIONS (NTME) =',I10)                        003407
01607       2005 FORMAT (1H0,15X,'X-COORDINATES ...'(/21X,10F10.3))               003407
01610       2006 FORMAT (1H0,15X,'Y-COORDINATES ...'(/21X,10F10.3))               003407
01611       2007 FORMAT (1H0,15X,'INPUT TAPE CHANNEL NUMBERS ...')                003407
01612       2008 FORMAT (1H ,15X,'I = ',I2,10I10,(/22X,10I10))                    003407
01613       2009 FORMAT(1H0,10X,'MEAN LATERAL HEAT LOSS IN X-DIRECTION ...')      003407
01614       2010 FORMAT (1H ,5X,'I =',I3,10F10.3/(12X,10F10.3/))                  003407
01615       2011 FORMAT(1H0,10X,'MEAN LATERAL HEAT LOSS IN Y-DIRECTION ...')      003407
01616       2012 FORMAT(1H0,10X,'MEAN HEATING RATE ...')                          003407
01617       2013 FORMAT (1H0,10X,'TIME = ',F10.3//11X,'CURRENT TEMPERATURE ...')  003407
01620       2014 FORMAT(1H0,10X,'MEAN HEAT FLUX WITHOUT CONDUCTION CORRECTION ...') 003407
01621       2015 FORMAT (1H0,10X,'LINEAR CURVE FIT USING ',I3,' POINTS.  TIME =', 003407
01621          .F10.3,' TO',F10.3,' SEC')                                         003407
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01622      2016 FORMAT (1H0,10X,'PERCENT STANDARD ERROR ...')                                  003407
01623      2017 FORMAT (1H+,T89,'*** FEWER POINTS THAN REQUESTED ***')                         003407
01624      2018 FORMAT(1H0,10X,'TEMPERATURES AVERAGED OVER',I5,' POINTS.  TIME IN'             003407
01624          .,'TERVAL PROCESSED',F10.3,' TO',F10.3,' SEC')                                  003407
01625      2019 FORMAT(1H0,15X,'Y-COORDINATES OF THICKNESS DIFFERENCE JUNCTION...'             003407
01625          .,(/21X,10F10.3))                                                               003407
01626      2020 FORMAT(1H0,10X,'MEANS OF MEAN HEATING RATES FOR',I3,' TIME PERIOD'             003407
01626          .,'S...')                                                                       003407
01627      2021 FORMAT(1H1)                                                                    003407
01630      2022 FORMAT                                                                         003407
01630          .( 28X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,             003407
01630          .5X,A3,I2,5X,A3,I2,5X,A3,I2)                                                    003407
01631      2023 FORMAT                                                                         003407
01631          .( 17X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,5X,A3,I2,             003407
01631          .5X,A3,I2,5X,A3,I2,5X,A3,I2)                                                    003407
01632      4001 FORMAT(1X,'*** ERROR - NX OR NY IS BAD')                                       003407
01633      4002 FORMAT(1X,'*** ERROR - NTME IS LARGER THAN ',I3)                               003407
01634      4003 FORMAT(1X,'*** ERROR - TOO MANY CHANNELS')                                     003407
01635      4004 FORMAT(1H0,10X,'* * * PARITY ERROR RECORD DELETED * * *')                      003407
01636      4005 FORMAT(1H0,10X,'END OF FILE ENCOUNTERED ON UNIT ',I2,' PROCESSING'             003407
01636          .,' OF ACCUMULATED DATA WILL BE ATTEMPTED.')                                    003407
01636      C                                                                                   003407
01636      C***********************************************************************           003407
01636      C***********************************************************************           003407
01636      C                                                                                   003407
01637            SUBROUTINE ERRFIT(S)                                                          003407
01637      C                                                                                   003407
01637      C     SUBROUTINE TO COMPUTE THE HEATING RATE BY FITTING A GIVEN TIME                003407
01637      C     INTERVAL OF DATA TO A FIRST DEGREE POLYNOMIAL AND TO COMPUTE                  003407
01637      C     THE STANDARD AND PERCENT ERROR OF THIS HEATING RATE.                          003407
01637      C                                                                                   003407
01642            IF (NPT.LE.2) GO TO 999                                                       003407
01642      C                                                                                   003407
01644            SUM2 = 0.0                                                                    003414
01645          4 SUM4 = 0.0                                                                    003416
01646            DO 125 M = 1,NPT                                                              003446
01646      C        SUM X(I)                                                                   003446
01651            SUM2 = SUM2 + TIM(M)                                                          003446
01651      C        SUM (X(I)**2)                                                              003446
01652            SUM4 = SUM4 + TIM(M)**2                                                       003451
01653        125 CONTINUE                                                                      003456
01653      C        (SUM X(I))**2                                                              003456
01655            SUM6 = SUM2**2                                                                003456
01656            SUM8 = NPT * SUM4 - SUM6                                                      003460
01656      C                                                                                   003460
01657            DO 200 I = 1,NX                                                               003464
01662            DO 200 J = 1,NY                                                               003513
01665            IDD = 1                                                                       003513
01666            IF(J.GT.IYDD) IDD = 2                                                         003515
01670            NN = NTCH(I,J)                                                                003524
01671            IF (NN.LE.0) GO TO 175                                                        003526
01673            SUM1 = 0.0                                                                    003532
01674            SUM3 = 0.0                                                                    003534
01675            SUM5 = 0.0                                                                    003535
01676            DO 150 M = 1,NPT                                                              003545
01676      C        SUM Y(I)*Y(I)                                                              003545
01701            SUM1 = SUM1 + TIM(M) * TMP(NN,M)                                              003545
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01701     C          SUM Y(I)                                          003545
01702           SUM3 = SUM3 + TMP(NN,M)                                003552
01702     C          SUM (Y(I)**2)                                     003552
01703           SUM5 = SUM5 + TMP(NN,M)**2                             003555
01704       150 CONTINUE                                               003562
01704     C          SUM X(I) * SUM Y(I)                               003562
01706           SUM7 = SUM2 * SUM3                                     003562
01706     C          SLOPE                                             003562
01707           SLOPE = (NPT * SUM1 - SUM7) / SUM8                     003564
01707     C          SIGMA                                             003564
01710           SIGMA = 1.0 / NPT * SQRT(NPT * SUM5 - SUM3**2          003573
01710          1         - (NPT * SUM1 - SUM7)**2 / SUM8)              003573
01710     C          STANDARD ERROR                                    003573
01711           SERR = NPT * SIGMA / SQRT((NPT-2) * SUM8)              003612
01711     C          PERCENT ERROR                                     003612
01712           ERR(I,J) = SERR / SLOPE * 100.0                        003615
01712     C          HEATING RATE                                      003615
01713           QDOT(I,J) = CON12 * DD(IDD) * SLOPE                    003621
01714           GO TO 200                                              003626
01715       175 ERR(I,J) = 0.0                                         003630
01716           QDOT(I,J) = 0.0                                        003630
01717       200 CONTINUE                                               003636
01722           RETURN                                                 003636
01722     C                                                            003636
01723       999 WRITE (6,9999)                                         003642
01725      9999 FORMAT (1H0,10X,'TOO FEW POINTS AVAILABLE FOR CURVE FIT.')   003646
01726           RETURN 1                                               003646
01726     C                                                            003646
01727           END                                                    003716

     END OF COMPILATION:        NO  DIAGNOSTICS.


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ATTACHMENT 6

SAMPLE INPUT

(TO BE SUPPLIED LATER)

ATTACHMENT 7

SAMPLE OUTPUT

(TO BE SUPPLIED LATER)

ATTACHMENT 8

CORRESPONDENCE

THIS FORM MUST BE COMPLETED BY TYPEWRITER

JSC COMPUTER PROGRAM ABSTRACT

01 4	JSC
01 7 PROGRAM NO	Q614
01 14 DATE (MMDDYY)	1-21-75
01 20 TITLE OF PROGRAM (62 CHARACTERS MAXIMUM)	SURFACE HEATING RATE OF THIN SKIN MODELS
01 72 SYMBOLIC NAME (9 CHARACTERS MAXIMUM)	THNSKN
PARENT PROGRAM: 02 14 CATEGORY	
PARENT PROGRAM: 02 16 SITE	
PARENT PROGRAM: 02 19 PROGRAM NO	
02 26 CATEGORY	
02 27 LANGUAGE NO. 1	FOR V
02 32 LANGUAGE NO. 2	
02 37 KEY WORDS (8 MAXIMUM SEPARATED BY COMMAS)	Arc Jet, Heat Rate, Thin Skin, Thermocouples

WHOM TO CONTACT ABOUT THE PROGRAM

05 14 CONTACT (LAST NAME)	05 28 SITE	05 31 ORGN CODE	05 39 PROJECT NO	05 45 NASA CENTER
Stephenson	JSC	FD57	4300	

05 48 STATUS

- ☐ A. UNDER DEVELOPMENT
- ☐ B. OPERATIONAL
- ☒ C. COMPLETED

05 49

- ☐ A. THIS PROGRAM IS NOT FOR SHARING
- ☐ B. LIMITED SHARING (SEE ABSTRACT)

DATES

05 50 INITIATED MMYY	05 54 COMPLETED MMYY
11-74	12-74

05 58 REVISION CODE

- ☒ A. REVISION
- ☐ B. CANCELLATION

TIME AND COST FOR DEVELPOMENT

05 59 MAN-MONTHS	05 64 MACHINE HOURS	05 69 COMPUTER TYPE	05 74 TOTAL COST (DOLLARS)
.8	2.0	1108	.

CARD NUMBER	ABSTRACT
06	THNSKN computes the mean heating rate at up to 100
07	locations on the surface of thin skin transient
08	heating rate models. Output is printed in tabular
09	form and consists of time history tabulation of
10	temperatures, average temperatures, heat loss
11	without conduction correction, mean heating rate,
12	least squares heating rate, and the percent standard
13	error of the least squares heating rates. The input
14	tape used is produced by the program EHTS03.
15	(SCR 83-15-30/McBryde)
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RELATED DOCUMENTATION (66 CHARACTERS MAXIMUM SEPARATE EACH REF BY COMMAS)

42	

JSC Form 142 (Aug 73)

NASA-JSC

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

Computation and Analysis Division
NASA Manned Spacecraft Center
Houston, Texas 77058

TO : LEC/Manager, Test Data Reduction Department, 672-10

DATE: October 27, 1969

In reply refer to: 11-69-622

FROM : ED5/Acting Chief, Data Processing Branch

SUBJECT: Requirements for a Thin Skin Transient Heating Rate Model Program

Programing support is required to develop a program to compute heating rates of thin skin transient heating rate models. This program will be developed for the Experimental Heat Transfer Section of the Structures and Mechanics Division. The program will be used to support definition of the aerothermodynamic design of the MSC space shuttle vehicle.

It is necessary that the program, specified by the attached requirements document, be operation by October 31, 1969. Preliminary requirements have been reviewed by Dr. Carl D. Scott, project engineer, and forwarded to Mrs. Yvonne Chempinski. Work on this task should be charged to project number 4556. For further information, please contact Mr. E. O. Grice, extension 5533.

Fred Fulton

Enclosure

cc:
ES56/Dr. C. D. Scott

ED57:EOGrice(LEC:JMRandal):ddc 10-27-69

OCT 29 1969
LEC/HASD
TEST DATA REDUCTION

DATA PROCESSING REQUIREMENTS

for a

THIN SKIN TRANSIENT HEATING RATE MODEL PROGRAM

Prepared by: J. M. Randal 22 Oct 69
LEC Requirements & Analysis

Approved by: K. J. Langenberg 10-24
LEC Requirements & Analysis

Concurrence by: E. O. Grice 10/23/69
CAD Requirements & Analysis

Concurrence by: Carl D. Scott 10/22/69
Experimental Heat Transfer Section

I PROJECT DISCUSSION

The Experimental Heat Transfer Section of the Structures and Mechanics Division has requirements for a digital computer program to compute heating rates of thin skin transient heating rate models. These models will be tested in either the 1.5 Megawatt or the 10 Megawatt Arc-Heater facility. The tests in which such models will be used will be directly related to current MSC space shuttle vehicle activities. The program outputs will be used to support definition of the aerothermodynamic design of the MSC space shuttle vehicle configuration.

II TEST CONFIGURATION

The thin skin transient heating rate models will be constructed with a thin metal skin. Thermocouple instrumentation will be attached to the back side of the skin in rectangular arrays and used to measure temperature. When these models are subjected to a non-uniform constant heat flux by the arc-heater equipment, the surface temperature of the skin will increase according to the laws of heat conduction and capacitance. The skin will be sufficiently thin so that the temperature gradient normal to the skin will be negligible. Therefore, it will be assumed that the thermocouples attached to the back surface actually measure the temperature of the skin at each location.

The analog signals output by the thermocouple array will be digitized by use of either the 160 channel data acquisition system located in Building 222 or the 50 channel data acquisition located in Building 262. The digital data tape output by either of these systems will be compatible with the CAD UNIVAC 1108 digital computer system. The existing EHTS03 (Q566) program will be used to calibrate the experimental data in engineering units and output a data tape for input to the required thin skin transient heating rate model program. See Figure 1 for a diagram of the data flow and test configuration.

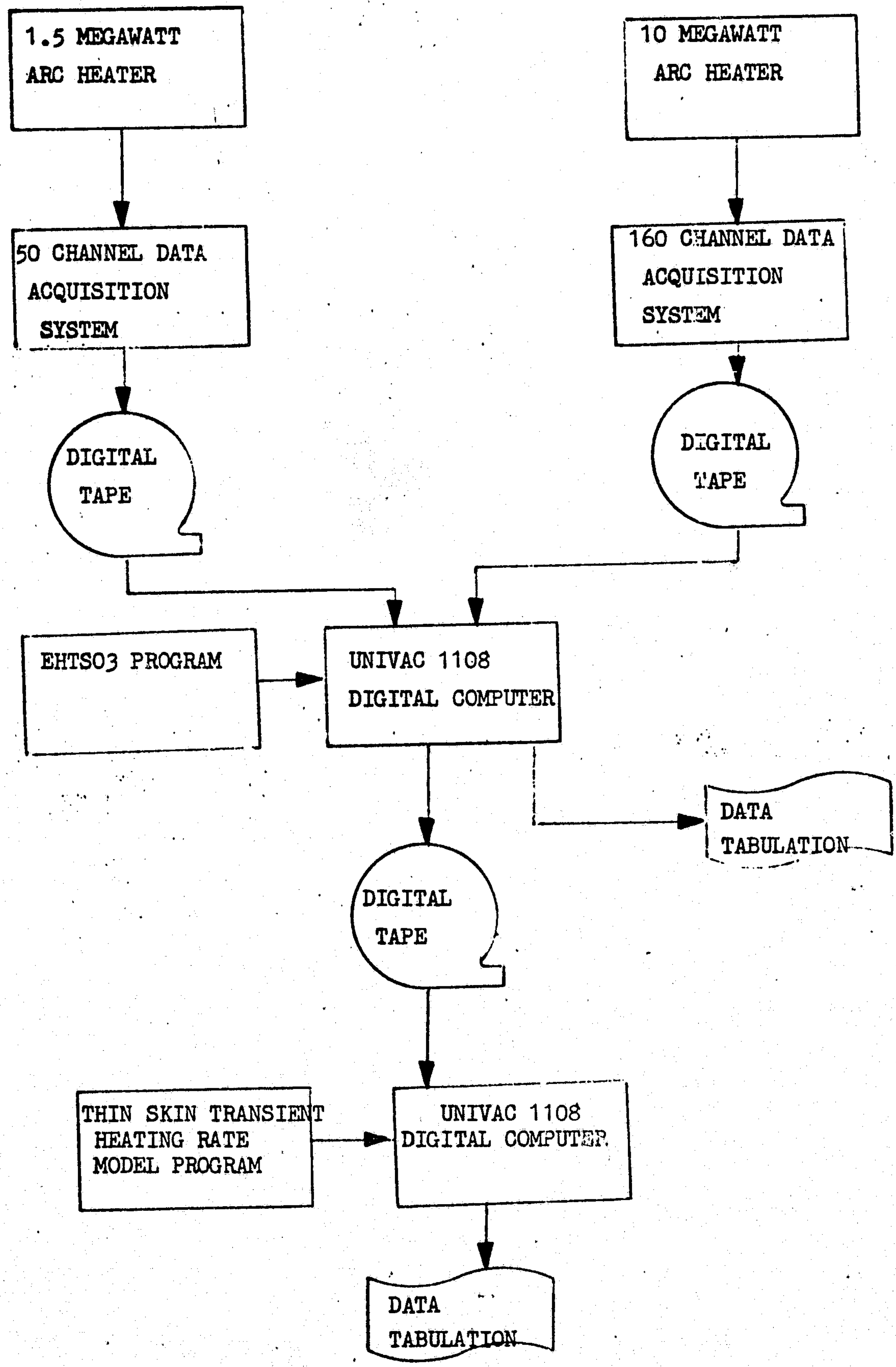

Figure 1
TEST CONFIGURATION

III DATA PROCESSING REQUIREMENTS

The hardware required to accomplish the data processing task will be the UNIVAC 1108 digital computer. The software required will be the existing EHTS03 (Q566) program and the Thin Skin Transient Heating Rate Model Program specified in Appendix A.

The data processing procedure will consist of the steps listed below:

1. The project engineer will have the data tape and the lead card input for the EHTS03 program delivered to the test data coordinator in Room 228 of Building 12.

2. The data coordinator will issue instructions for computer processing and notify the project engineer when the processing is complete.

3. The project engineer will review the EHTS03 data and provide lead card setups for the thin skin transient heating rate model program.

4. The data coordinator will issue instructions for computer processing and notify the project engineer when the processing is complete.

IV TECHNICAL REFERENCES

1. Memo: ES5/9-24(9)/249M, Memorandum to: ED/Chief, Computation and Analysis Division; from: ES/Chief, Structures and Mechanics Division; Subject: Requirements for a computer program to calculate heating rates using thin skin models.

2. Program Documentation, Experimental Heat Transfer Data Reduction Package #3 (EHTS03), Program Q566, Project 4556, August 1969.

APPENDIX A

PROGRAMING SPECIFICATION
for
THIN SKIN TRANSIENT HEATING RATE MODEL PROGRAM

I PURPOSE

The purpose of this program will be to compute the heating rate at each of a number of locations on the surface of thin skin transient heating rate models. Experimental data, calibrated in engineering units, will be obtained from the ABEL tape output by the EHTS03 computer program. The program output will consist of time history tabulations of computed data with options for input and intermediate computation tabulations.

II INPUT

The program inputs will be the ABEL time history data tape output by the EHTS03 program and the lead card inputs necessary to specify computational constants, input data channels, command channels, options, and command event levels. The magnetic input data tape will consist of FORTRAN written data records in a single data file. The first data word in each record will be the time word. The remaining words will be the data channel words ordered by channel number. The tape will be written with 800 bit per inch density and odd parity using the UNIVAC 1108 computer.

The lead card inputs will include, but not be limited to, the following items. The exact card formats will be determined by the programer.

1. Two cards, each containing at least sixty column alphanumeric entries will be used to identify the data contained in the output tabulation. This input will appear in the title of each page of the tabulation.

2. Coordinate positions for each thermocouple with a maximum array of 50x50 positions. The upper left hand position will be designated $T_{xy} = T_{11}$ as shown by Table 1 in Section III.

3. Input tape data channel number for each thermocouple in T_{xy} array.

4. Physical locations of each row and column. All locations will be determined from the row and column containing $T_{xy} = T_{11}$ in inches.

5. Input tape data channel number for the command channel.

6. Command channel signal level used to start computations. Millivolt level.

7. Command channel signal level used to terminate computations. Millivolt level.

8. Input tape data channel number for the time channel. Normally channel 1.

9. Start computation time.

10. Stop computation time.

11. Coordinate positions of known erroneous thermocouple data.

12. Option to tabulate tape input temperatures.

13. Option to tabulate intermediate computation results.

14. Computational constants:

a. Mass density (ρ) of the test material in pounds mass per cubic foot. (lbm/ft^3)

b. Specific heat (C_p) of the test material in Btu/lbm °F

c. Material thickness (d) in inches

d. Thermal conductivity (K) in Btu/ft sec°F

III TABLES

The thermocouple instrumentation used to measure the temperatures on the thin skin transient heating model will be arrayed in the rectangular coordinate system shown by Table 1. The maximum size of the array will be 50x50. The minimum array will be 3x1 or 1x3. Only line, rectangular or square arrays will be defined. Other array configurations may be computed if dummy data is input to fill out the array. Even though the thermocouple array will generally be rectangular, the spacing between rows and columns will not normally be the same. Therefore, the distance of each row and column from T_{11} will be a separate card input. The array will be computed as for a planar surface regardless of the actual configuration of the model. That is, the last row will not be adjacent to the first row as in the case of a clyinderical surface, etc. Spherical and conical surfaces will not be defined other than as rectangular arrays.

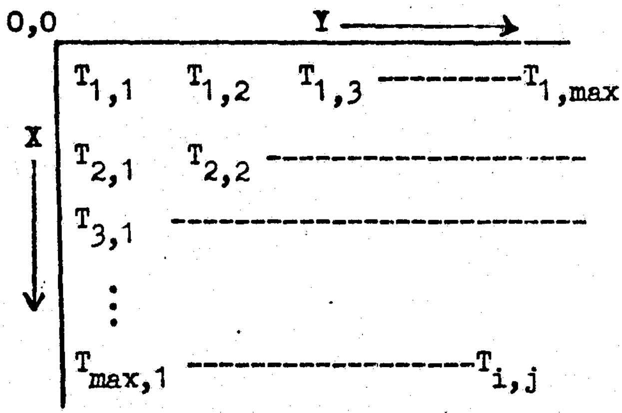

TABLE 1

THERMOCOUPLE ARRAY

IV COMPUTATIONS

Equation 1 will be the energy balance equation used to describe the heating applied to the model surface at each coordinate (x_i, y_j) for each data time sample (t_k).

Equation 1:

$$\dot{q}_{ij} = \left(\frac{\rho_d C_p}{12}\right)\left(\frac{\partial T_{ij}}{\partial t}\right) + \left(\dot{q}^x_{ij}\right) + \left(\dot{q}^y_{ij}\right)$$

where:

$\dot{q}_{ij}$: Heating rate to the model surface X_i, Y_j

ρ: Mass density of surface material

d: Material thickness of surface material

C_p: Specific heat of surface material

$\left(\frac{\partial T_{ij}}{\partial t}\right)$: Derivative computed by the use of equation 2

$\left(\dot{q}^x_{ij}\right)$: Derivative computed by the use of equation 4

$\left(\dot{q}^y_{ij}\right)$: Derivative computed by the use of equation 5

Equation 2 will be used to compute the partial derivative of temperature with respect to time for the thermal mass around the thermocouple test point for each data time sample (t_k).

Equation 2:

$$\frac{\partial T_{ij}}{\partial t} = b_k + 2C_k \, t_k$$

Where:

b_k: Determined by solution of equations 3a, 3b, and 3c

C_k: Determined by solution of equations 3a, 3b and 3c

Equations 3a, 3b and 3c will be solved for b_k and C_k by the use of the Gauss-Jordan or other appropriate method for the solution of simultaneous equations.

$$T_{ij} \, (t_{k-1}) = a_k + b_k t_{k-1} + C_k \, (t_{k-1})^2$$

$$T_{ij} \, (t_k) = a_k + b_k t_k + C_k (t_k)^2$$

$$T_{ij} (t_{k+1}) = a_k + b_k t_{k+1} + C_k \, (t_{k+1})^2$$

Where:

a_k, b_k, c_k : Coefficients of a second degree polynomial

t_{k-1} : Time of preceeding data sample from ABEL input tape

t_k : Time of current data sample

t_{k+1} : Time of succeeding data sample

Equation 4 will be used to compute the lateral heat loss in the X direction for input to equation 1 for each time sample (t_k).

Equation 4:

$$\dot{q}^{x}_{ij} = 24\, kd \left[\left(\frac{1}{X_{i+1} - X_{i-1}} \right) \left(\frac{T_{ij} - T_{i-1,j}}{X_i - X_{i-1}} + \frac{T_{i+1,j} - T_{ij}}{X_{i+1} - X_i} \right) \right]$$

Where:

k : Thermal conductivity (card input)

d : Material thickness (card input)

$X_{i+1} - X_{i-1}$: Distance between thermocouples located on either side of X_i thermocouple, etc.

$T_{ij} - T_{i-1\,j}$: Input data temperature difference between thermocouples.

Equation 5 will be used in the same manner as equation 4 to determine the lateral heat loss in the Y direction for each data time sample.

Equation 5:

$$\dot{q}^{Y}_{ij} = 24\, kd \left[\left(\frac{1}{y_{j+1} - y_{j-1}} \right) \left(\frac{T_{ij} - T_{i,j-1}}{y_j - y_{j-1}} + \frac{T_{i,j+1} - T_{ij}}{y_{j+1} - y_j} \right) \right]$$

Equation 1 will be set to zero for the two end points in a test array consisting of a single line of thermocouples. Further, equation 1 will be set to zero for the four corner transducers in a square or rectangular array. That is:

$$2 \leq i \leq I-1,$$
$$2 \leq j \leq J-1$$

where: I and J are defined as the greatest i and j limits, respectively, of the transducer array.

Equation 1 will be computed for the test points in the transducer array that lie on the four sides of 3x2, 2x3 or larger arrays. Either equation 4 or equation 5 will be modified as required to prevent erroneous results due to lack of valid inputs for the transducers located on the sides of the test array. For test points located on the upper side of the test point array, equation 6 will be used instead of equation 4.

Equation 6:

$$\dot{q}_{ij} = 24\ kd \left(\frac{2}{X_2 - X_1} \right) \left(\frac{T_{2j} - T_{ij}}{X_2 - X_1} \right)$$

For test points located in the lower side of the array, equation 7 will be used in lieu of equation 4.

Equation 7:

$$\dot{q}^{x}_{Ij} = 24\ kd \left(\frac{2}{X_I - X_{I-1}}\right)\left(\frac{T_{Ij} - T_{I-1,j}}{X_I - X_{I-1}}\right)$$

Equation 5 will be valid regardless of whether equations 6 or 7 are used for upper and lower limit test points.

For test points located on the left side of the array shown in Table 1, equation 8 will be used in lieu of equation 5.

Equation 8:

$$\dot{q}^{Y}_{i1} = 24\ kd \left(\frac{2}{Y_2 - Y_1}\right) \left(\frac{T_{i2} - T_{i1}}{Y_2 - Y_1}\right)$$

For test points located on the right side of the array, equation 9 will be used in lieu of equation 5.

Equation 9:

$$\dot{q}^{Y}_{iJ} = 24\ kd \left(\frac{2}{Y_J - Y_{J-1}}\right) \left(\frac{T_{i,J} - T_{i,J-1}}{Y_J - Y_{J-1}}\right)$$

Equation 4 will be valid regardless of whether equations 8 or 9 are used for left or right test points. Note that the end points of a linear array and corner points of a rectangular array will not be computed, as previously stated.

Card input will be used to specify which if any, of the input test points have invalid tape data input due to hardware malfunction in the test hardware or the data acquisition system. Computations for the test points on the four sides of the invalid points will be made by using the input temperature from and the distance to the thermocouple on the opposite side of the faulty point. For example, if $T_{2,2}$ were faulty (see Table 1), $\dot{q}^{Y}_{2,1}$ would be computed using $T_{2,3}$ for the temperature input and Y_3-Y_1 for the distance input to equation 5. Note that the program will be designed to salvage data only for points within the array. A bad point at any edge or corner of the array will be eliminated by deleting that row or column from the program input. Substitution of data from a similar point may also be done by card input. No provision will be made for computing data around specified bad input points that are separated by at least one row or column of good input data.

Computations will be controlled by card input start-stop times or by card input command channel levels. Either one or the other may be used, but not both. Start-stop times will be input inseconds and milliseconds. Command Channel start and stop levels will be input at the same levels used in the ETHS03 program. These levels will be 30,35,40,45,50,55,60,65,70,75,80,85,90 and 95 millivolts plus or minus 2.5 millivolts.

V PROGRAM OUTPUT

The program output will consist of tabulations of the input lead cards, thermocouple array format, computed and input data. No data tape will be output. Each page of the tabulated output will be identified by the card input identification title in addition to any other identification, column headings, etc. The tabulations will include:

1. Tabulation of all input card data.
2. Row by row tabulation of input tape data channels: This tabulation will start with the channel number for $T_{xy} = T_{11}$ and list the input data channels in 10 columns across the page. See Table 1 for a typical format. Channel numbers assigned will be set to zero for those channels specified as erroneous by card input.
3. Row by row tabulation of computed heating rate ($\dot{q}_{ij}$) for each time history slice. The time of each sample will precede each beginning row of computed data. Time will be output in seconds and milliseconds.
4. Optional row by row tabulation of tape input data temperatures for each time history slice as tabulated in 3, above.
5. Optional row by row tabulation of computed X and Y heat losses ($\dot{q}_{ij}^{X}$ and $\dot{q}_{ij}^{Y}$) as in 3, above.

Note that tabulated data outputs for non-computed end points, corner points and bad data points will set to zero.

LEC

HOUSTON AEROSPACE SYSTEMS
16811 EL CAMINO REAL
HOUSTON, TEXAS 77058
TELEPHONE: (AREA CODE 713) 488-0080

LOCKHEED ELECTRONICS COMPANY

In reply refer to:
TDR#2247

October 31, 1969

TO: ED5/Chief, Data Processing Branch

FROM: LEC/Manager, Test Data Reduction Department

SUBJECT: Technical Memorandum 11-69-622, October 27, 1969, Requirements for a Thin Skin Transient Heating Rate Model Program

Subject Technical Memorandum was received by the Test Data Reduction Department on October 29, 1969.

Responsibility for the requested programming support has been assigned to Mrs. Yvonne Chempinski. Mrs. Chempinski has been working from preliminary requirements documents. The program has been completed on schedule with test output delivered to Doctor Scott. Two minor additions were requested by Doctor Scott and will be completed shortly.

Please direct any additional communications regarding this project to Mrs. Chempinski at HU8-0080, extension 345 or Mr. Len Martin, ext. 336.

Unless otherwise directed, all effort expended on this task will continue to be charged to Project Number 4556.

Doyle L. Johnson

DLJ:JDG:pm
Distribution: J. Fisher/ED57
E. Grice/ED57
J. Randall/C18
Y. Chempinski/B11
L. Martin/B11
D. Garrett/B11

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

Computation and Analysis Division
NASA Manned Spacecraft Center
Houston, Texas 77058

11/24

TO : LEC/Manager, Test Data Reduction Department, 672-10

DATE: November 18, 1969

In reply refer to: 11-69-634

FROM : ED5/Chief, Data Processing Branch

SUBJECT: Requirements for modification of the THNSKN (Q614) program

Programing support is required to modify the Thin Skin Transient Heating Rate Model Program. The modifications requested by Dr. C. D. Scott of the Experimental Heat Transfer Section of the Structures and Mechanics Division are listed below:

a. Change the card input format for X and Y coordinates from F 5.1 to F 10.3.

b. Change the data output print format to F 10.3.

c. Make the tabulation of tape input data temperatures, X and Y lateral heat losses as standard output rather than optional.

d. Compute end point and corner point data for the thermocouple array rather than setting this data to zero.

It is understood that Mrs. Yvonne Chempinski has started work on these modifications in response to a verbal request from Dr. Scott. Work on this task should be a continuing charge to project number 4556. For further information, please contact E. O. Grice, extension 5533.

Fred Fulton

cc:
ES56/Dr. C. D. Scott
ED57/J. L. Fisher

ED57:EOGrice(LEC:JMRandal):ddc 11-18-69

NOV 21 1969
LEC/HASD
TEST DATA REDUCTION

HOUSTON AEROSPACE SYSTEMS
16811 EL CAMINO REAL
HOUSTON, TEXAS 77058
TELEPHONE: (AREA CODE 713) 488-0080

LOCKHEED ELECTRONICS COMPANY

In reply refer to:
TDR#2267

November 25, 1969

TO: ED5/Chief, Data Processing Branch

FROM: LEC/Manager, Test Data Reduction Department

SUBJECT: Technical Memorandum 11-69-634, November 18, 1969 Requirements for Modification of the THNSKN (Q614) Program

Subject Technical Memorandum was received by the Test Data Reduction Department on November 21, 1969.

Responsibility for maintenance of the THNSKN program has been assigned to Mrs. Yvonne Chempinski. The program modifications specified in the subject Technical Memorandum have been completed, and the modified program has been validated.

Please direct any further communications regarding this task to Mrs. Chempinski, HU8-0080, extension 345.

As directed, all effort expended on this task will continue to be charged to Project Number 4556.

Doyle L. Johnson

DLJ:JDG:pm
Distribution: J. L. Fisher/ED57
E. O. Grice/ED57
J. M. Randal/C18
Y. Chempinski/B11
J. D. Garrett/B11

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS 77058

IN REPLY REFER TO: 11-69-636

24 NOV 1969

TO : LEC/Manager, Test Data Reduction Department 672-10

FROM : ED5/Chief, Data Processing Branch

SUBJECT: Requirements for modification of the THNSKN (Q614) program

Programing support is required to modify the Thin Skin Transient Heating Rate Model Program. Equations 4 and 5 are to be changed to the form shown below:

Equation 4:

$$\dot{q}_{ij}^{X} = 24kd \left[\left(\frac{1}{X_{i+1} - X_{i-1}} \right) \left(\frac{T_{ij} - T_{i-1,j}}{X_i - X_{i-1}} - \frac{T_{i+1,j} - T_{ij}}{X_{i+1} - X_i} \right) \right]$$

Equation 5:

$$\dot{q}_{ij}^{X} = 24kd \left[\left(\frac{1}{Y_{j+1} - Y_{j-1}} \right) \left(\frac{T_{ij} - T_{i,j-1}}{Y_j - Y_{j-1}} - \frac{T_{i,j+1} - T_{ij}}{Y_{j+1} - Y_j} \right) \right]$$

Mrs. Yvonne Chempinski has started work on these changes in response to a verbal request from Dr. Scott. Work on this task should be a continuing charge to project number 4556. For further information, please contact E. O. Grice, extension 5533.

Fred Fulton

cc:
ES56:Dr. C. D. Scott

ED57/EOGrice(LEC:JMRandal):bc 11-20-69

HOUSTON AEROSPACE SYSTEMS
16811 EL CAMINO REAL
HOUSTON, TEXAS 77058
TELEPHONE: (AREA CODE 713) 488-0080

LOCKHEED ELECTRONICS COMPANY

In reply refer to:
TDR#2272

December 1, 1969

TO: ED5/Chief, Data Processing Branch

FROM: LEC/Manager, Test Data Reduction Department

SUBJECT: Technical Memorandum 11-69-636, November 24, 1969
Requirements for Modification of the THNSKN Program (Q614)

Subject Technical Memorandum was received by the Test Data Reduction Department on November 28, 1969.

Programming support for the subject program has been assigned to Mrs. Yvonne Chempinski of the Data Acquisition Systems programming group. Mrs. Chempinski has completed the requested program modifications having worked from a verbal request from Doctor Carl Scott.

Please direct any additional communications regarding this project to Mrs. Chempinski, HU8-0080, extension 345, or to Mr. Len Martin, the Engineering Applications Programming team leader, at extension 336.

As directed, all work expended on this task will continue to be charged to Project Number 4556.

Doyle L. Johnson

DLJ:JDG:pm
Distribution: J. L. Fisher/ED57
E. O. Grice/ED57
J. M. Randal/C18
Y. Chempinski/B11
L. Martin/B11
J. D. Garrett/B11

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

REPLY TO ATTN OF: ES35

December 23, 1974

Lockheed Electronics Co. Inc.
Attn: Mr. James Brose
Mail Stop C-30
16811 El Camino Real
Houston, TX 77058

Dear Mr. Brose:

A software change request was issued by Mr. E. J. Jung and ~~one~~ me on October 23, 1974, to incorporate changes into the thin skin heating rate data reduction computer program (THNSKN). Equation (2) of that document should be

$$q = \frac{\frac{1}{24}\rho C_p d}{t_N - t_1} \frac{N-1}{N-2} \left(T_{ij}^{N} - T_{ij}^{N-1} - T_{ij}^{1} - T_{ij}^{2}\right)$$

The expressions in equations (5) and (6) should be carrying a negative sign.

Please incorporate these corrections into the program.

Carl Scott
C. D. Scott

LOCKHEED ELECTRONICS COMPANY, INC
AEROSPACE SYSTEMS DIVISION
16811 EL CAMINO REAL • HOUSTON, TEXAS 77058 • TELEPHONE (AREA CODE 713) 488 0080

In reply refer to:
#121-8315-199
J.O. #83-157

December 31, 1974

TO: FD5/Chief, Data Processing Branch

FROM: LEC/Manager, Data Processing Systems Department

SUBJECT: Transmittal of EXEC VIII Version of the THNSKN Program

Transmitted herewith is the EXEC VIII version of THNSKN program for the Structures and Mechanics System. This version replaces the EXEC II version.

Results from the validation runs, after being checked for correctness with the use of LEC generated test data, were submitted to the customer, Dr. Carl Scott. Upon his acceptance, the Software Change Request was signed by the SIC and NASA Project Leader. The Software Change Request form is attached giving the descriptive reason for program modification.

W. N. Fitzpatrick

WNF:JEM:jlb
Attachments

cc: H. Stephenson/FD53
D. L. McCormick/FD52
C. Scott/ES3
E. J. Jung/ES3
C. E. Hutchinson/C30
C. F. Iven/C11
[redacted]
J. Brose/C30
J. E. McFarland/C30
J. O. File

LOCKHEED ELECTRONICS COMPANY, INC.
AEROSPACE SYSTEMS DIVISION
16811 EL CAMINO REAL • HOUSTON, TEXAS 77058 • TELEPHONE (AREA CODE 713) 488 0080

In reply refer to:
#121-8315-199
J.O. #83-157

December 31, 1974

TO: FD5/Chief, Data Processing Branch

FROM: LEC/Manager, Data Processing Systems Department

SUBJECT: Transmittal of EXEC VIII Version of the THNSKN Program

Transmitted herewith is the EXEC VIII version of THNSKN program for the Structures and Mechanics System. This version replaces the EXEC II version.

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W. N. Fitzpatrick

WNF:JEM:jlb
Attachments

cc: H. Stephenson/FD53
D. L. McCormick/FD52
C. Scott/ES3
E. J. Jung/ES3
C. E. Hutchinson/C30
C. F. Iven/C11
[redacted]
J. Brose/C30
J. E. McFarland/C30
J. O. File

SOFTWARE CHANGE REQUEST

Date Oct. 23, 1974

Requester/ Organization E.J.Jung/C.Scott/JSC-ES

Need Date Dec. 31, 1974

To Be Completed By Responsible Organizatio

Job Order 83-15 SCR No. 83-15-30

Program Name THNSKN

Program No. Q614

Project No. 4300

Target Date 12/31/74

REASON FOR CHANGE:

To improve the accuracy and automation of the computer program THNSKN used to calculate heat fluxes from temperature time histories measured on thin skin heat transfer models tested in JSC arc tunnel facilities.

CHANGE DESCRIPTION (attach extra sheet if necessary):

See the attached description.

TO BE COMPLETED BY RESPONSIBLE ORGANIZATION

ESTIMATED RESOURCES:

Man-Hours 120

Computer Hours 2.0

APPROVALS BY:

Task Manager — Date 11/11/74

Technical Monitor — Date 11-12-74

Branch Chief — Date 11/14/74

TRANSMITTAL TO PRODUCTION:

Submitted by:

Programmer Date

Validation approved by:

System Integration Coordinator Date 12-30-74

NASA, Project Leader Date

___ Operating system
___ New program decks have been submitted to production
___ Transmittal tape replaces current system CUR, PUR
___ Overlay production CUR/PUR with transmittal CUR/P
___ Symbolic elements are contained in file number
___ Relocatable elements are contained in file number
___ No changes are required in execution deck setup
___ Changes in run instructions are attached
___ Transmitted program tape number

ACCEPTANCE BY PRODUCTION:

Date test run completed

Project Leader Date

SOFTWARE CHANGE REQUEST

Date Oct. 23, 1974

Requester/ Organization E.J.Jung/C.Scott/JSC-ES

Need Date Dec. 31, 1974

To Be Completed By Responsible Organization

Job Order 83-15 SCR No. 83-15-30

Program Name THNSKN

Program No. Q614

Project No. 4300

Target Date 12/31/74

REASON FOR CHANGE:

To improve the accuracy and automation of the computer program THNSKN used to calculate heat fluxes from temperature time histories measured on thin skin heat transfer models tested in JSC arc tunnel facilities.

CHANGE DESCRIPTION (attach extra sheet if necessary):

See the attached description.

TO BE COMPLETED BY RESPONSIBLE ORGANIZATION

ESTIMATED RESOURCES:

Man-Hours 120

Computer Hours 2.0

APPROVALS BY:

Task Manager — Date 11/11/74

Technical Monitor — Date 11-12-74

Branch Chief — Date 11/14/74

TRANSMITTAL TO PRODUCTION:

Submitted by:

Programmer — Date

Validation approved by:

System Integration Coordinator — Date 12-30-74

NASA, Project Leader — Date

- Operating system
- New program decks have been submitted to production
- Transmittal tape replaces current system CUR, PUR
- Overlay production CUR/PUR with transmittal CUR/F
- Symbolic elements are contained in file number
- Relocatable elements are contained in file number
- No changes are required in execution deck setup
- Changes in run instructions are attached
- Transmitted program tape number

ACCEPTANCE BY PRODUCTION:

Date test run completed

Project Leader — Date

THIN SKIN PROGRAM MODIFICATION

Code modifications are required to improve the accuracy and automation of the computer program THNSKN used to calculate heat fluxes from temperature time histories measured on thin skin heat transfer models tested in the JSC arc tunnel facilities. The modification described here will also allow one discontinuity in the skin thickness (in one direction only) and uses finite difference expressions which are approximately second order accurate (except at end points) in both the space and time derivatives of the heat conduction equation.

The following modifications are required:

1) At present the computer program calculates heat fluxes only during one time period. Modify the program so that the number of time periods that heat fluxes are calculated during a run from may be specified in the input.

2) Comput the average heat fluxes for each time period and print the average for each location.

3) Remove the restriction that if bad thermocouples are at end points of rows or columns of thermocouples, the computation is aborted ~~absorbed.~~ Use the next good thermocouple as ~~on~~ the end point.

4) Compute the conduction correction at end points (last good thermocouple) using the same conduction correction as at points adjacent to the end point. e.g., $\bar{q}^{y}_{i1} = \bar{q}^{y}_{i2}$

5) Allowance for discontinuity in skin thickness. In the input two skin thicknesses, d_1 and d_2, are to be specified along with

the position y_d of the junction between the two thicknesses

$d = d_1$ for $y < y_d$ and $d = d_2$ for $y > y_d$

Use the appropriate thickness d for each location.

6) Compute the mean heat flux for each time interval using the formula

$$\bar{q}_{ij} = \bar{\dot{q}}_{ij} + \bar{q}^{x}_{ij} + \bar{q}^{y}_{ij} \qquad (1)$$

where:

$$\bar{\dot{q}}_{ij} = \frac{1/6\,\rho\, c_p d}{t_N - t_1}\,\frac{N}{N-2}\left(T^{N}_{ij} + T^{N-1}_{ij} - T^{1}_{ij} - T^{2}_{ij}\right) \qquad (2)$$

$$\bar{q}^{x}_{ij} = \frac{24\,Kd}{X_{i+1,j} - X_{i-1,j}}\left(\frac{\bar{T}_{ij} - \bar{T}_{i-1,j}}{X_i - X_{i-1}} - \frac{\bar{T}_{i+1,j} - \bar{T}_{ij}}{X_{i+1} - X_i}\right) \qquad (3)$$

$$\bar{q}^{y}_{ij} = \frac{24\,Kd}{y_{i,j+1} - y_{i,j-1}}\left(\frac{\bar{T}_{ij} - \bar{T}_{i,j-1}}{y_j - y_{j-1}} - \frac{\bar{T}_{i,j+1} - \bar{T}_{ij}}{y_{j+1} - y_j}\right) \qquad (4)$$

To compute $\bar{q}^{y}_{ij}$ at thermocouple locations adjacent to the skin thickness jump (y_d) use the following formulas for $y_k < y_d < y_{k+1}$ instead of (4).

$$\bar{q}^{y}_{ik} = \frac{24\,kd_1}{y_{k+1} - y_{k-1}}\left(\frac{\bar{T}_{i,k-1} - \bar{T}_{ik}}{y_k - y_{k-1}} + \frac{d_2\left(\bar{T}_{i,k+1} - \bar{T}_{ik}\right)}{(y_d - y_k)d_2 + (y_{k+1} - y_d)d_1}\right) \qquad (5)$$

$$\bar{q}^{y}_{i,k+1} = \frac{24\,kd_2}{y_{k+2} - y_k}\left(\frac{d_1\left(\bar{T}_{ik} - \bar{T}_{i,k+1}\right)}{(y_d - y_k)d_2 + (y_{k+1} - y_d)d_1} + \frac{\bar{T}_{i,k+2} - \bar{T}_{i,k+1}}{y_{k+2} - y_{k+1}}\right) \qquad (6)$$

The bars over the T's denote time average of the temperatures throughout a given interval. The superscripts on the T's in the first term denote the first, second, last, and next to last temperatures in the time interval. The number of samples in a time interval is N. The first time in the interval is t, and the last is t_N. The latter two terms in equations (3) and (4) are the lateral heat loss terms as used previously except now they are averages over the time interval. This procedure will replace the one currently used in the code.

7) Output - Print the start and stop times for each time interval. Print out the number of times N in each interval, the times t_n and temperatures T^n_{ij} at each time. No longer print the heat flux terms at each time since these are no longer calculated. Print each of the terms in equation (1): $\bar{q}_{b_{ij}}$, $\bar{q}^{x}_{b_{ij}}$, $\bar{q}^{y}_{b_{ij}}$

and the net heat flux $\bar{q}_{b_{ij}}$. Continue to compute and print the linear least squares heat flux in the revised program. Finally, print the mean of $\bar{q}_{b_{ij}}$ averaged over the number of time intervals specified in the input.

8) Ammend program documentation to reflect these and any previous changes.

ATTACHMENT 9

DIAGNOSTIC MESSAGES

DIAGNOSTIC MESSAGES

FEWER POINTS THAN REQUESTED

This message occurs at the end of a time slice when the number of points accumulated for least squares heat flux computations is less than the requested (NTME). This is not necessarily abnormal.

PARITY ERROR RECORD DELETED

An input record has been skipped because of parity errors.

END OF FILE ENCOUNTERED ON UNIT 8. PROCESSING OF ACCUMULATED DATA WILL BE ATTEMPTED.

Normally, stop times or stop event levels should be chosen so that the end-of-file is never encountered. If at least three scans of data have been accumulated, processing will be done.

TOO FEW POINTS AVAILABLE FOR CURVE FIT

Fewer than three data points have been stored so no least squares heat flux computations can be done.

***ERROR - NX OR NY IS BAD

Either one or both of NX and NY are too large or too small. Currently, the maximum size for either is 50. Either NX or NY must have a minimum value of 3.

Examples:	NX	NY	
	1	3	Valid
	3	1	Valid
	2	2	Invalid
	1	50	Valid
	51	51	Invalid

***ERROR - NTME IS LARGER THAN NN

The requested number of points to be used for least squares heat flow computations exceeds array dimensions (NN). Currently NN is 50.

***ERROR - TOO MANY CHANNELS

The number of channels specified for the input tape is too large for the array dimensions. Currently, the maximum number of channels which can be processed is 260.